TEMPLATE

CONCEPT OF OPERATIONS
SYSTEM REQUIREMENTS
VERIFICATION PLAN
VALIDATION PLAN
NJ RT XX Traffic Signal System Contract No. XX (20XX)

CITY

COUNTY, NEW JERSEY

Month 20XX

Prepared For

New Jersey Department of Transportation

P.O. Box 600

Trenton, NJ 08625

Prepared By

Consultant Logo

Consultant Name
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1.0 Scope

1.1 Document Purpose and Scope

This document illustrates user-oriented operational description (i.e. existing operational condition, proposed improvements to a Controlled Traffic Signal System (CTSS) with clearly defined goals and objectives), operational needs, envisioned adaptive traffic signal system overview, adaptive operational environment, support environment, and various operational scenarios. The intended audience of this document includes system operators, administrators, decision-makers, elected officials, other nontechnical readers and stakeholders who will share the operation of the system or be directly affected by it.

This document describes and provides a rationale for the expected operations of the proposed CTSS. It documents the outcome of stakeholder discussions that have been undertaken to ensure that the adaptive system that is implemented is operationally feasible and has the support of stakeholders.

Systems Engineering (SE) is a project management method that provides a prescriptive approach to developing the framework for complex systems. It is a logical process that ensures that all activities are conducted in an efficient and economical manner. System Engineering simplifies the process by combining management and technical activities within a single process.

This Concept of Operations Plan was developed with guidance from the Federal Highway Administration (FHWA) Model Systems Engineering Documents for Adaptive Signal Control Technology (ASCT) Systems. This is the first step in the process to identify, design, procure, build, operate, and maintain a CTSS. The general work flow of the System Engineering process is shown in **Exhibit 1**.

This Concept of Operations plan provides a technical overview of implementing a CTSS on any state roadway and explains how the system will detect, verify, and automatically respond to changes in traffic in real-time. The installation of a CTSS is intended to improve the movement of traffic, as well as respond to non-reoccurring congestion caused by incidents on any signalized corridor. The CTSS should have the capabilities to be monitored and adjusted remotely.

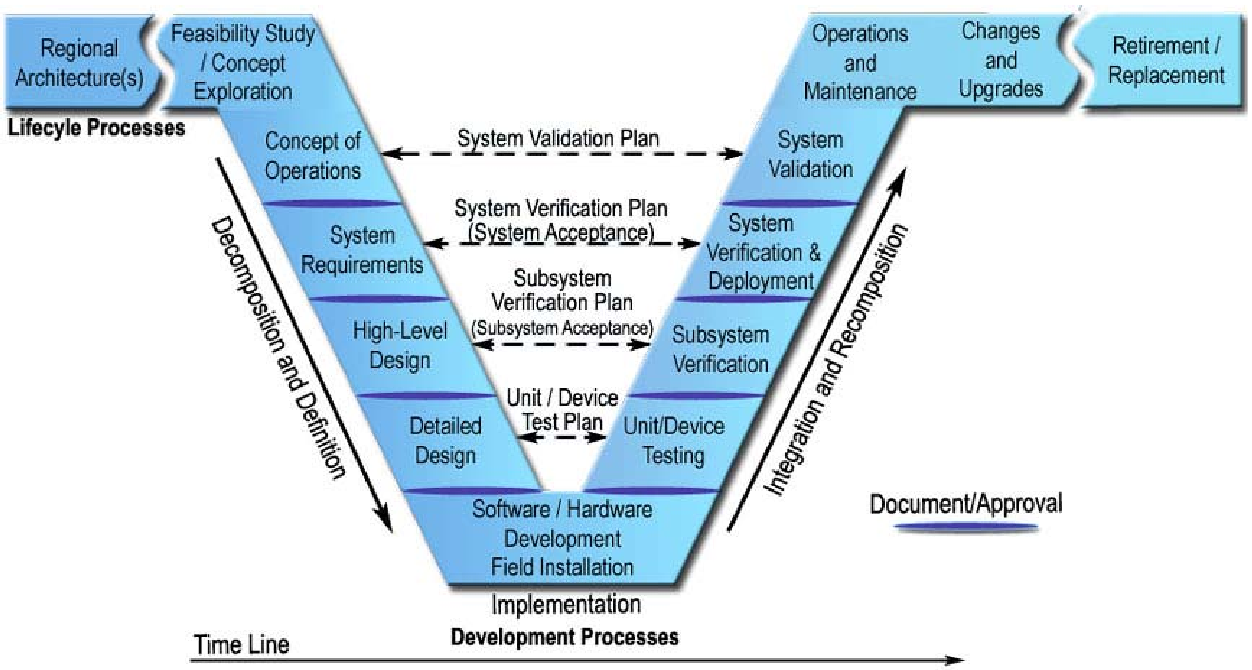


Exhibit 1. System Engineering "V" Diagram

1.2 Project Purpose and Scope

A Computerized Traffic Signal System (CTSS) is planned as part of an enhancement to existing traffic signal systems to provide responsive or adaptive capabilities in real-time to traffic demand. The enhancement project will include traffic signal equipment upgrades and the installation of interconnected communications between intersections as well as midblock system detection. The intersections and system detection will utilize the existing or proposed fiber optic and/or wireless communication system that connects to the statewide transportation communications network. All signalized intersections to be included within the CTSS should be listed in the following order:

- Corridor Name (MP XX)
- Corridor Name (MP XX)Corridor Name (MP XX)

The midblock system detection sites to be included within the CTSS should be listed as follows:

- Between Minor Street Name & Main Street Name(Lat XX-Log XX)
- 1,000' North of XX Street(Lat xx –Log xx)

One of the main purposes of providing computerized control on a corridor is to optimize the use of existing roadway capacity by providing more efficient traffic signal operation while maintaining safety. The causes of intermittent congestion and delay are varied and change throughout the length of the study corridor. Reoccurring congestion and delay is typically caused by commuter traffic. The general commuter traffic trend in NJ has approximately a XX/XX split with peak AM traffic heading northbound and peak PM traffic heading southbound. Abutting land uses also affect the traffic patterns on the corridor and place conflicting demands on the roadway and traffic signals.

Additional intersections beyond the initial installation may also be included on a CTSS system in the future. The proposed CTSS will be accessed and maintained from the NJDOT Arterial Management Center (AMC) located in Trenton. The proposed system will communicate to the AMC through an existing and/or proposed fiber optic/wireless communications system tied into the existing statewide fiber optic cable network.

1.3 Procurement

The CTSS will be procured using a low-bid process based on detailed plans and technical specifications with consideration of best-value system elements. Field equipment and system hardware (parts and labor) will be procured using a low-bid process based on detailed plans and technical specifications. The detailed procurement plan will be prepared after the system requirements have been finalized.

2.0 Reference Documents

This section provides a list of documents related to the CTSS Systems Engineering analysis. Related documents are not directly referenced within the narrative of this report, but all related documents have been used to develop the Concept of Operations Report. Some of these documents provide NJDOT policy guidance, some are technical standards and protocols 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.

- *Model System Engineering Document for Adaptive Signal Control Technology (ASCT) Systems*, August 2012, Federal Highway Administration.
- *NCHRP Synthesis 403 – Adaptive Traffic Control Systems: Domestic and Foreign State of Practice*, 2010, Transportation Research Board.
- *Developing and Using a Concept of Operations in Transportation Management Systems*, December 2004, Federal Highway Administration.
- *New Jersey Statewide Intelligent Transportation Systems (ITS) Architecture*, February 18, 2005, New Jersey Department of transportation-Division of Statewide Traffic Operations
- *Institutional Coordination of Intelligent Transportation Systems in the Delaware Valley – Regional ITS Architecture,* March 2001, Delaware Valley Regional Planning Commission.
- *National Transportation Communications for ITS Protocols (NTCIP) – The NTCIP Guide*, July 2009, AASHTO, ITE, NEMA.
- *Standardization Policies and Procedures of the National Electrical Manufactures Association (NEMA)*, December 31, 2009, NEMA.
- *Manual on Uniform Traffic Control Devices (MUTCD), 2009, revised through May 2012,* Federal Highway Administration.
- *Highway Capacity Manual, 2010, Transportation Research Board.*
- *National Electrical Safety Code (NESC) and Handbook Set, 2012, Institute of Electrical and Electronics Engineers (IEEE).*
- *NFPA 70: National Electrical Code, 2014, National Fire Protection Association.*

3.0 User-Oriented Operation Description

This section presents the current conditions of the existing traffic signal system, a brief non-technical comparison between the existing traffic signal system and the proposed CTSS as well as NJDOT's goals and objectives for the future traffic signal system operations.

3.1 The Existing Situation

This sections details the existing traffic signal system infrastructure conditions including:

- Intersection geometry (lane configuration)
- Type of traffic signal cabinet

3.1.1 Network Characteristics

This sections describes the physical and functional characteristics of the existing traffic signal system including:

- The roadway network (Arterial, Grid or crossing arterials)
- Isolated or coordinated intersections
- Peak and off peak directional traffic flow
- On-street parking

3.1.1.1 Arterial

The limits of the project should be delineated from a system detector site at milepost XX.XX to a system detector site at milepost XX.XX. The limits include all existing traffic signals on the corridor from milepost XX.XX to milepost XX.XX. The corridor designation, number of lanes, general orientation, etc. should be included. Any access driveway located between signalized intersections should also listed. The total length of the CTSS installation is should be listed in this section along with intersection spacing and approximate free flow travel times. The table below is a template for intersection spacing and travel time.

Table XX. Route NJ XX Intersection Spacing and Free Flow Speeds

Cross Street	Milepost	Intersection Spacing		Travel Time between Intersections (Free Flow Speeds in seconds)
		Miles	Feet	
XX Street	XX	XX	XX	XX
XX Street	XX	XX	XX	XX

3.1.1.2 Isolated Intersection or Small Group

If there is more than one critical intersection in the project area and the timing of adjacent intersections mainly needs the ability to accommodate progression for the platoons serviced by the critical intersection.

The system will also be used to improve operation at isolated intersections that do not operate efficiently with typical vehicle-actuated operation. Under user constraints, it requires the ability to have:

- Different phase sequences at different times of the day
- Phase re-service to prevent queue overflow in turn bays
- Different cycle lengths for different periods
- Different splits (phase maximums) for different periods

3.1.1.3 Highway Interchange

Highway interchanges typically have several closely spaced intersections with major turning movements which It require careful management of queue lengths on some approaches. Queuing from on-ramps affects the distribution of traffic across the lanes on the arterial. Queuing from on-ramps affects the saturation flow of some movements during green.

3.1.2 Traffic Characteristics

Available historic traffic information for the AM, mid-day, and PM peaks, as well as daily traffic should be included in **Appendix X**. The traffic counts demonstrate how the traffic conditions vary throughout the length of the corridor. In addition to AM and PM peak commuter traffic; there are also commercial related peaks on weekends and holidays. Additionally, pedestrian data should be examined from the manual count locations for weekday and weekends. The traffic data should also capture routinely diverts from major highways to signalized corridors during peak traffic conditions, sporting events, shopping malls during the holiday season, and include special traffic conditions due to climate related incidents. A general overview of typical existing traffic conditions are described below:

Southern Portion: XX Street

The roadway conveys approximately XX vehicles per day. During the AM peak hour, there are XX vehicles with XX% of the traffic heading in the northbound direction. The flow of traffic is balanced during the midday. The PM peak hour conveys XX vehicles with XX% traveling in the southbound direction.

Middle Portion: Between XX Avenue and XX Street

The roadway conveys approximately XX vehicles per day. During the AM peak hour, there are approximately XX vehicles an hour with XX% of the traffic heading in the northbound direction. The southbound direction increases in volume throughout the day until reaching the PM peak hour. This is most likely due to the large quantities of retail and services industries along the corridor. The PM peak hour conveys approximately XX vehicles an hour with XX% traveling in the southbound direction.

Between XX Avenue and XX Street

The roadway conveys approximately XX vehicles per day. During the AM peak hour, there are XX vehicles an hour with XX% of the traffic heading in the northbound direction. The southbound direction increases in volume throughout the day until reaching the PM peak hour. The PM peak hour conveys XX vehicles an hour balanced between the northbound and southbound directions.

Northern Portion: Between XX Avenue and XX Street

The roadway conveys approximately XX vehicles per day. During the AM peak hour, there are XX vehicles an hour with XX% of the traffic heading in the northbound direction. The southbound direction decreases slightly in volume after the AM peak before increasing at the PM peak. The PM peak hour conveys XX vehicles an hour balanced between the northbound and southbound directions.

Weekends – Daily traffic on Saturdays is approximately X% lower than weekdays. Sunday traffic is approximately XX% lower than weekdays. Route NJ XX has a high quantity of retail frontage resulting in traffic volumes closer to weekday conditions on Saturdays.

3.1.3 Signal Grouping

Because of the different traffic demands on a corridor and the varied traffic signal spacing, grouping of the signals into smaller signal groups may be appropriate. Traffic signal models and data should be analyzed in order to find the logical break between the traffic signal groups are along a corridor. While it is anticipated that the corridor will likely run on smaller signal groups during normal conditions, there may be occasions when the groups should operate as one coordinated unit.

3.1.4 Adjacent Land Characteristics

This sections describes the land uses in the vicinity of the corridor that can cause major impact to the roadway network currently or in the future (e.g. schools, shopping malls, etc.)

3.1.4.1 Existing Land Uses

The land use in the vicinity of the corridor should be described in this section. For example, is it residential, commercial, retail, industrial or mix use site? Any major traffic generator in the area and its traffic trend should identified.

3.1.4.2 Future Land Use Changes

Any major changes in land uses that could impact the traffic during the likely expected life of the proposed CTSS should be identified and incorporated into the CTSS design.

3.1.4.3 Pedestrians and Public Transit

A pedestrian activity reconnaissance should be conducted where required to create a profile of the pedestrian activity in the vicinity and along the corridor. The following key parameters should be included in the field reconnaissance:

- Major pedestrian generators (e.g. schools)
- Sidewalks, crosswalks, etc.
- manual pedestrian counts (where required)
- pedestrian phases
- Push buttons

A public transit reconnaissance should be conducted to identify any existing and future transit priority services along the corridor. The following key parameters should be included in the reconnaissance:

- Existing and/or future public transit priority
- Existing and/or future bus stops along the corridor
- Are existing and/or future bus stops within travel lanes or turn-out stops

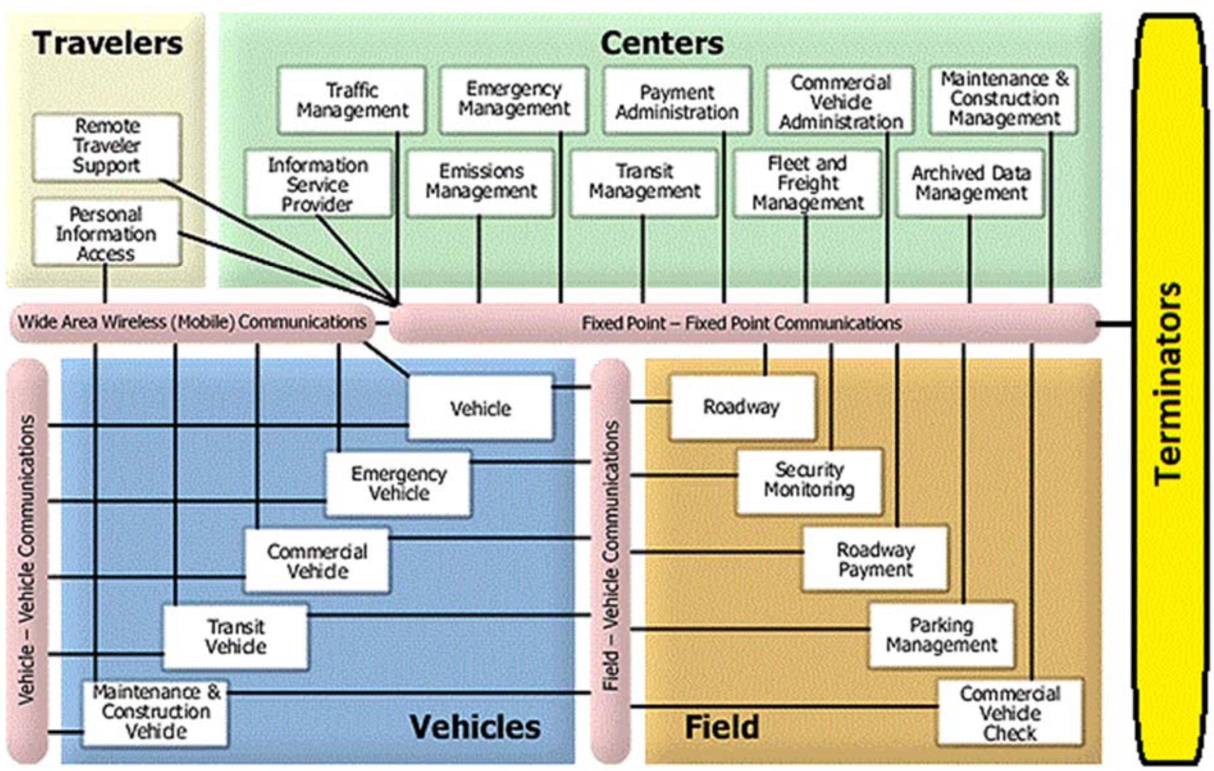
3.1.4.4 Government Agencies

NJDOT, any secondary stakeholders with jurisdiction over the minor street as well as other government agencies (police and fire department) that have emergency vehicle preemption at some traffic signals or that could be impacted by the implementation of the system should be identified and included in the planning process of the system as the system should have the ability to share data and information with those agencies.

3.1.4.5 Existing Architecture

The ITS Architecture for this project involves different government agencies and stakeholders, transportation and communication sub-systems. The ITS Architecture is developed from the New Jersey Statewide ITS Architecture and Deployment Plan. The regional and statewide ITS Architecture are living documents, consequently the market packages and architecture flows for the project should be correctly linked to the statewide ITS Architecture. The interaction between the transportation elements and communication methods are illustrated in the following figure.

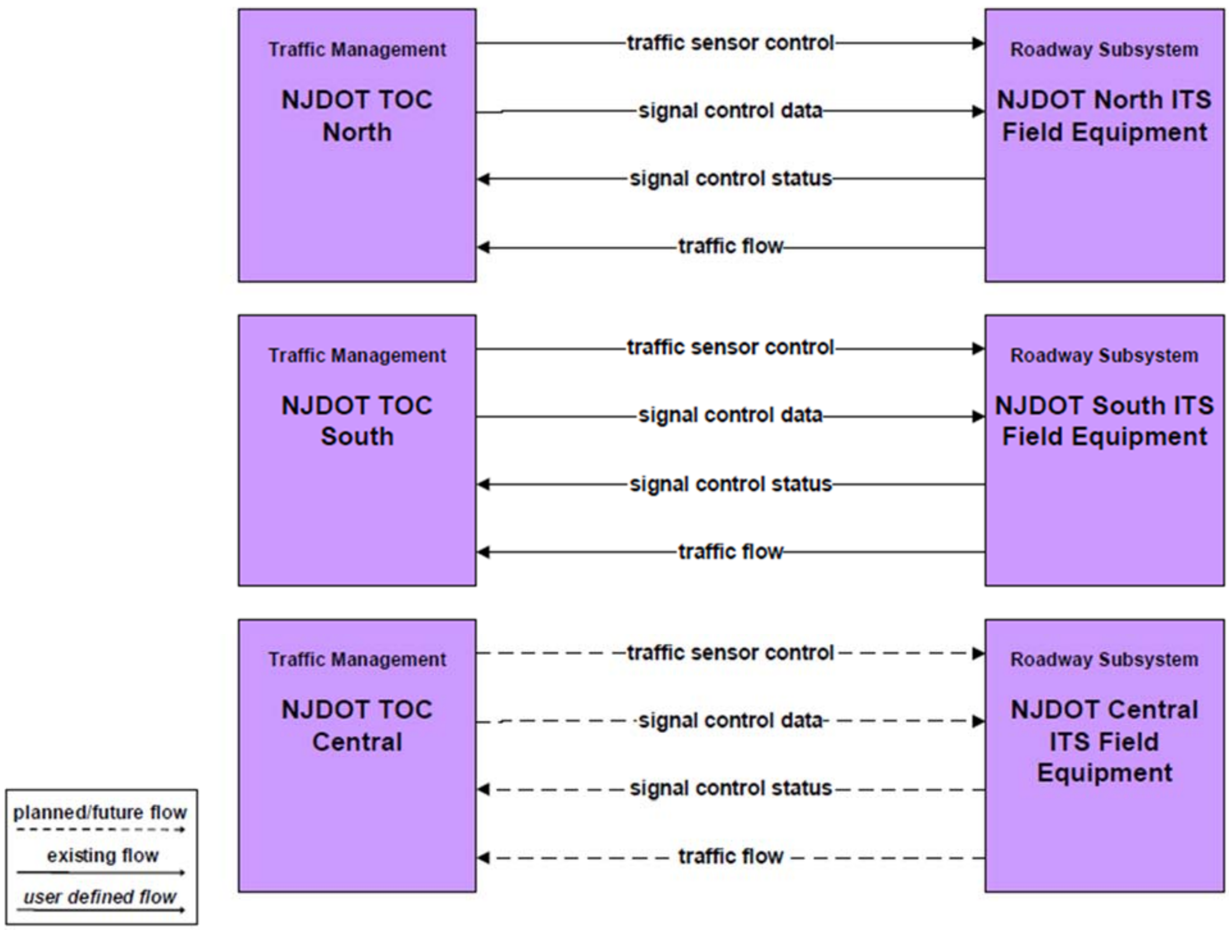
New Jersey ITS Architecture "Sausage Diagram"



Source: New Jersey Statewide ITS Architecture and Deployment Plan

The existing and future planned data flows between the centers are illustrated in the Market Package included in the NJDOT's New Jersey Statewide Intelligent Transportation Systems Architecture Final Report, as depicted below:

ATMS03 – Surface Street Control NJDOT



Source: New Jersey Statewide Intelligent Transportation Systems Architecture Final Report

Security for ITS systems is represented in two forms through the National ITS Architectures, "Securing ITS" and "ITS Security Areas." Securing ITS is defined as the security portion of all subsystems included in the project. ITS Security Areas are additional functions ITS can support to maintain a secure surface transportation system. Deployment of the adaptive system does create the need for addressing an ITS Security Area. Security of the adaptive central control is critical to the safe performance of the signal system. The needs for security of the central system are discussed further in section 4.4 of this document.

3.2 Limitations of the Existing System

A verbal description of the existing traffic signal system limitations should be provided including:

- The system lacks the ability to monitor and adjust to changing traffic demands automatically throughout the day or as the result of incidents on adjacent roadways.
- The system cannot recognize the onset of peak periods, so the start time of peak period coordination plan are set conservatively to ensure they cover the normal variation in duration and intensity of the peak. This means that the timing may be less efficient during the early and late parts of the peak periods.
- The peak direction of traffic may fluctuate during the peak, so the peak period timing plan is a compromise.
- The existing traffic signal system is not capable of recognizing the direction of heaviest flow in real time and automatically react accordingly, rather than using a plan that is less efficient but can accommodate a range of flows.

3.3 Proposed Improvements to the System

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:

- Recognize changes in traffic conditions and react quickly and automatically to accommodate those changes
- Improve the management of queues within the network
- Recognize the existence of differing traffic conditions in various parts of the network and react in each section appropriately
- Keep signal timing current rather than letting its efficiency deteriorate between periodic signal re-timing efforts
- Provide the ability to monitor the system remotely and make adjustments as necessary

3.4 Vision, Goals, and Objectives for the Proposed System

3.4.1 Vision

The vision for the planned CTSS is to provide an advanced traffic control system that responds to changing traffic conditions, reduces delays and corridor travel times, and improves the environment and quality of life for New Jersey residents and motorists. Connecting the CTSS to the NJDOT Arterial Management Center (AMC) will allow remote monitoring of this corridor, but also will provide information that can be used to better operate other regional assets. The CTSS will also allow existing staff resources to be better utilized by maximizing the duration between timing revisions.

3.4.2 Goals

The goals of the CTSS are:

- Improve safety
- Optimize the available roadway network
- Support vehicle, pedestrian and transit traffic mobility (safety given higher priority)

- Provide performance measurable improvements in personal mobility
- Support interoperability between agencies (municipal, county, other)
- Support regional systems
- Support congestion and environment policy objectives
- Meet a timely project implementation schedule

3.4.3 User Objectives

The objectives of the adaptive system that support the stated goals are:

- To support vehicle, pedestrian and transit traffic mobility
  - Be capable of supporting priority operations for transit
  - Allow effective use of all controller features currently in use or proposed to be used
  - Minimize adverse effects caused by preemption and unexpected events
- To support measurable improvements in personal mobility
  - Adjust operations to changing conditions
  - Reduce delays
  - Reduce travel times
  - Provide the same or higher level of safety provided by the existing system to vehicles, pedestrians and transit
- To support NJDOT interoperability
  - Provide facilities for data exchange and control between systems such as the Data Development System and the ITS Readiness System, nearby systems
  - Allow remote monitoring and control from AMC, STMC, MM.
  - Adhere to applicable traffic signal and ITS design standards
- To support regional systems
  - Be compliant with the regional ITS architecture
  - Allow center-to-center and system-to-system communication such as Data Fusion for travel time.
  - Connect to regional traffic control systems such as STMC
  - Report traffic conditions to regional traffic conditions information systems
  - Reduce vehicle emissions through improvements in appropriate determinants such as vehicle stops and delays to support environmental objectives
- Be sufficiently mature and robust that risk is low and little or no development time will be required
- Be ready for full operation by an NJDOT-specified date

3.4.4 Operational Objectives

The operational objectives of the CTSS could be a combination of the following:

- Smooth the flow of traffic along coordinated routes
- Maximize the throughput of traffic along coordinated routes
- Equitably serve adjacent land uses
- Manage queues, to prevent excessive queuing from reducing efficiency

- Control operation using a combination of these objectives
- Control operation by changing the objectives under various circumstances
- For a critical isolated intersection, maximize intersection efficiency
- Enhance safety

3.5 Strategies to be Applied by the Improved Traffic Signal System

Adaptive coordination and control strategies that may be employed to achieve the operational objectives are a combination of the following:

- Provide a pipeline along a coordinated route to maximize the throughput during periods of high demand
- Provide a pipeline along a coordinated route to smooth the flow of traffic in one or both directions
- Distribute phase times in a way that equitably shares the green time between various movements and minimizes the risk of phase failures
- Manage queues so they do not exceed the available storage capacity and are located so they do not affect the capacity of other movements
- Manage the distribution of green times for vehicles and pedestrians in an equitable manner
- Employ a combination of these strategies when they are compatible

3.6 Alternatives Non-Adaptive Strategies Considered

Alternative strategies to Adaptive Signal Control Technology should be evaluated in order to access the limitations and challenges of the corridor under analysis. The following provides a brief summary of the possible system strategies:

Updated Time-Based Coordination – This strategy evaluates an enhancement to the existing time-based system currently in use that allows the controllers to implement pre-defined traffic-signal timing plans and sequences (cycles/offsets/splits) based on the time of day, day of week, and/or time of year.
The most important aspect of time-based coordination is ensuring all of the local traffic signal controller clocks are in synchronization. To achieve this task GPS time synchronization components can be installed at each traffic signal controller. In addition to the equipment upgrades, new traffic counts and new timing plans will be required with regular timing maintenance to remain current.

While a minor upgrade to the existing system is the least costly improvement, the benefit is minimal. Without upgraded communication and detection equipment, the signal system cannot adjust to real-time, changing traffic demands. Also, pre-defined timing plans are very conservative to accommodate large traffic variations and are not very efficient, thus resulting in wasted green time. The progression is fixed and does not allow for deployment of efficient incident management plans when conditions warrant.

Closed-Loop System – A closed-loop system is a distributed processor traffic-control system with control logic distributed among the local controllers, the on-street master, and the central computer. A closed-loop system is similar to time-based coordination except that the intersections can communicate with the master controller/central computer. The central computer and master controller provide the time synchronization and have other features that allow remote monitoring and access to manually adjust traffic signal timing. Similar to the time-based coordination, new traffic counts and timing plans will be required, as well as regular timing maintenance. The central computer enables the system operator to monitor and control the system's operations, when necessary.

A closed-loop system has the same disadvantages as the time-based system in that the system does not respond in real-time to changing traffic patterns and the timing plans need to be updated regularly. The system can be monitored remotely and an operator can change the timing remotely based on changing traffic conditions, but it cannot automatically adjust based on real-time information. Another major disadvantage of a closed-loop system is the inability to control intersections connected to different local area masters in a unified manner. Because of these issues, this strategy might not satisfy all of the system vision and goals.

Traffic Responsive – A traffic responsive system is a closed-loop system with additional decision making logic built into a central computer and master controller to choose specific time-of-day plans and routines. A central computer and master controller use vehicle detectors to "measure" the number of vehicles on the roadway and select pre-defined timing plans based on user-defined thresholds to accommodate the current traffic conditions. The pattern selection and implementation is accomplished through a traffic flow data matching technique, typically executed every 5-10 minutes. Once selected, the central computer and master controller communicate a timing plan change to all of the local controllers and they each individually transition to the new timing plan. The local controllers can then take multiple cycles to transition to a new timing plan. Typically, the new plan will remain in place for a minimum of 3-4 cycles or about 10 minutes.

The disadvantage of a traffic responsive system is that it is slower to react to changes in traffic conditions than an adaptive system and requires periodic traffic signal plan retiming to stay up-to-date. The master controller will collect data for several minutes to ensure the heavy vehicular demand is constant, communicate to the local controllers, transition to the new timing plan, then hold the longer plan for a user-defined time. Under ideal conditions the new timing plan is operating within 10 minutes of the start of the higher traffic demand. If the system changes too often then it will always be in transition between plans and have minimal progression. Historically, the determination of inbound and outbound thresholds to prevent undesired transitions is a tedious and repetitive process that has not provided significant gains in measured performance.

3.6.1 Complex Coordination Features

The CTSS must not inhibit the following features, subject to user constraints:

- Multiple (repeat) phases or phase re-service with user constraints
- Variable phase sequence with user constraints
- Omit phase under some circumstances with user constraints
- Detector switching
- Coordinate different phases and turning movement at different times of the day

- Coordinate beginning or end of green or yellow
- Early release of hold
- Hold the position of uncoordinated phases
- Late phase introduction
- Stop-in-walk
- Dynamic max
- Double cycle or half cycle

4.0 Operational Needs

This chapter describes the operational needs of the users that should be satisfied by the proposed CTSS. Each of these statements describes something that the system operators (who will program and operate the CTSS) need to be able to achieve. Each of these needs will be satisfied by compliance with one or more system requirements. The needs are defined below for adaptive strategies, network characteristics, coordination across boundaries, security, pedestrians, non-adaptive situations, system responsiveness, complex coordination and controller features, monitoring and control, performance reporting, failure notification, preemption and priority, failure and fallback, constraints, training and support, external interfaces, and maintenance. Below is a summary of typical operational needs which are further detailed in the Concept of Operations Appendix X.

4.1 Adaptive Strategies

The system operator should be able to implement different strategies, individually or in combination, to suit different prevailing traffic conditions. These strategies include:

- Maximize the throughput on coordinated routes
- Provide smooth flow along coordinated routes
- Distribute phase times in an equitable fashion
- Manage the lengths of queues
- Manage the locations of queues within the network
- Manage the preemption event efficiently
- At an isolated intersection, optimize operation with a minimum of phase failures
- Manage the coordination in small groups of signals to link phase service at some intersections with phase service at adjacent intersections
- Change the operational strategy (e.g., from smooth flow to maximizing throughput or managing queues) based on changing traffic conditions
- Detect repeated phase failures and control signal timing to prevent phase failures building up queues
- Minimize the chance that a queue forms at a specified location
- Modify the sequence of phases to support the various operational strategies
- Fix the sequence of phases at any specified location
- Designate the coordinated route based on traffic conditions and the selected operational strategy
- Set signal timing parameters (i.e., minimum green, maximum green and extension time) to comply with NJDOT policies
- Set special event and incident plans

4.2 Network Characteristics

The CTSS should have the ability to accommodate conditions such as the following:

- With the initial installation, the system needs to control XX intersections, up to XX miles from the AMC.

- The CTSS system needs to have the ability to expand the control up to XX traffic signals.
- The CTSS needs to be able to control each individual signal as one independent group. The CTSS needs the ability to support grouping of signals and each group will operate independently. Signal group boundaries need to be either user defined, by time of day scheduled, or controlled by traffic demand.
- The CTSS system needs to be able to communicate with any one of the intersections at all times. The CTSS system needs the ability to communicate with the operator through the provided redundant network communications.

4.3 Coordination across Boundaries

The study area intersections should be operated by one government agency as agreed in a memorandum of agreement and understanding MOA and MOU, respectively. Especially when traffic signals are maintained and operated by different agencies along the same corridor.

- The system needs to control signals operated by NJDOT
- The system needs to have the ability to coordinate signals on two crossing routes simultaneously

4.4 Security

The system operator needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by an administrator, and conform to the NJDOT and NJ-OIT's access and network infrastructure security policies. The CTSS needs to be implemented with a security policy that addresses the following selected elements:

- Local access to the CTSS
- Remote access to the CTSS
- System monitoring
- System manual override
- Development
- Operations
- User login
- User password
- Administration of the system
- System controller group access
- System parameters
- Report generation
- Configuration
- Security alerts
- Security logging
- Hierarchical rights structure

4.5 Queuing Interactions

The system needs to be able to manage the queues to prevent queue backup in the system.

- The system needs to be able to detect queues within the system's boundaries and modify the CTSS operation to accommodate the queuing.
- The system needs to be able to prevent queues forming at user-specified locations. The queue backup can be detected using a queue detector at the back of an exit ramp. The adaptive system needs to monitor the queue detectors and adjust operations when the occupancy of the detector reaches a user specified threshold.

4.6 Pedestrians

The CTSS needs to accommodate infrequent pedestrian operation while maintaining adaptive operation. When a pedestrian phase is called, the CTSS needs to accommodate pedestrian crossing times during adaptive operations when possible and return to coordination within one (X) cycle when not possible. The CTSS needs to not interfere with the operation of countdown pedestrian indications. The CTSS need the ability to not preclude future exclusive pedestrian phases and leading pedestrian intervals. The system needs to operate under pedestrian recall at all non-actuated pedestrian crossings.

4.7 Non-Adaptive Situations

The CTSS needs the ability to schedule pre-determined operation by time of day. The CTSS needs the ability to operate non-adaptively in accordance with a user-defined time-of-day schedule. The system needs the ability to run non-adaptively when a user manually commands the CTSS to cease adaptive operation. The CTSS also needs the ability to operate non-adaptively in accordance with a user-defined time-of-day schedule or a demand responsive plan.

4.8 System Responsiveness

The CTSS should be able to modify the adaptive operation to closely follow changes in traffic conditions. The system must respond quickly to sudden large shifts in traffic conditions. The system needs the ability to evaluate timing updates no less than X per cycle.

The CTSS should have the ability to not interfere with emergency vehicle pre-emption. At the conclusion of emergency vehicle pre-emption, the CTSS needs to have the capability to recover and continue adaptive operation.

4.9 Complex Coordination and Controller Features

The system needs the ability to implement the following advanced controller features while maintaining adaptive operation:

- Service a phase more than once per cycle based on user-defined constraints
- Operate at least X overlap phases
- Operate up to X rings, XX phases and X phases per ring
- Permit different phase sequences under different traffic conditions
- Allow one or more phases to be omitted (disabled) under certain traffic conditions or signal states.
- Prevent one or more phases being skipped under certain traffic conditions or signal states
- Allow detector logic at an intersection to be varied depending on local signal states
- Accommodate the custom features used by NJDOT
- Allow any phase to be designated as the coordinated phase
- Allow the operator to specify which phase receives unused time from a preceding phase
- Allow the controller to respond independently to individual lanes of an approach
    - This may be implemented in the signal controller using up to X 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
- Allow the coordinated phase to terminate early under prescribed traffic conditions
- Allow flexible timing of non-coordinated phases (such as late start of a phase) while maintaining coordination
- Protected/permissive phasing and alternate left turn phase sequences
- 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

4.10 Monitoring and Control

The ATSS should have the capability to be monitored and controlled from the NJDOT AMC, other NJDOT Traffic Operations Centers, and STMC remotely. The ability to connect to the system locally at any controller cabinet via a Windows based laptop needs be provided.

The operator needs the ability to access the database management, monitoring, and reporting features and functions of the signal controllers and any related signal management system as per his/her defined privilege level from the access points defined for those system components.

The system should have an integrated user-friendly graphic user interface (GUI) to provide graphic displays, import and generation of graphic images, and automatic update of maps and graphics.

4.11 Performance Reporting

The CTSS needs to store and report data used to calculate signal timing and have the data available for subsequent analysis. The CTSS needs to store results of all signal timing parameter calculations for a minimum of XX days. The CTSS needs store the following measured data in the form used as input to the adaptive algorithm and midblock system detectors for a minimum of XX days:

- Volume
- Occupancy and/or Queue length by lane or lane group
- Number of stops or stopped vehicle delay
- Green band efficiency or equivalent

The CTSS needs to store the following data in XX minute increments:

- Volume
- Queue length by lane or lane group
- Occupancy

The system needs to store and report data that can be used to measure traffic performance under adaptive control. The CTSS needs to store results of all signal timing parameter calculations for a minimum of XX days. The system needs to have a process to backup stored data to an external server or hard drive.

The system should be able to immediately notify maintenance and operations staff of alarms and alerts. In the event of a detector failure, communications failure, or adaptive processor failure, the CTSS needs the ability to issue an alarm to user-specified recipients. The system should have email and/or text message capabilities with the ability to identify up to five (X) unique recipients.

The system must maintain a complete log of alarms and failure events. In the event of a failure, the CTSS needs to automatically log details of the failure in a permanent log.

The CTSS shall provide diagnosis for the following detector failure types:

- Maximum presence - if an active detector exhibits continuous detection over an operator-defined time interval
- No activity - if an active detector does not exhibit any actuation during an operator-defined elapsed time interval
- Erratic output - if an active detector exhibits excessive actuation (i.e., field count over an operator-defined elapsed time interval exceeds user programmed threshold)
- Failed communication - failed detectors shall not be available for traffic control strategies

4.12 Failure and Fallback

The CTSS needs to fall back to time-of-day or vehicle actuated operation constrained by coordination, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications and software failure. In the event of a CTSS equipment or communication failure, the CTSS needs to release the local intersection to operate under its own time-of-day schedule or vehicle actuated constrained by coordination operation. With the absence of real-time vehicle data caused by a vehicle detector failure, the CTSS system needs to use adjacent lane detector data or use stored historic traffic count data to select appropriate timing patterns. The CTSS should be able to switch to the alternate operation in real time without operator intervention.

4.13 Preemption and priority

The system needs the ability to accommodate emergency vehicle preemption. The system also needs the ability to accommodate potential future transit signal priority for NJTransit.

4.14 Failure and fallback

The system should have the ability to fall back to TOD or actuated operation constrained by coordination, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications and software failure.

4.15 Constraints

The jurisdictional agency should be able to maximize the use of their existing infrastructure (i.e., cabinets, controllers, detectors, communication network) with the new CTSS system. However, NJDOT is open to replace their equipment if an appropriate CTSS that meets the operational needs and requirements requires installing new equipment. The procurement of the CTSS, communication upgrade, and equipment upgrade must be within budget constraints. The system needs the ability to use equipment and software acceptable under current NJ OIT policies and procedures.

4.16 Training and Support

NJDOT will need all staff involved in operation and maintenance to receive appropriate training. The vendor needs to provide training on the operations of the adaptive system. The vendor needs to provide a minimum of xx hours training to a minimum of xx staff. The vendor needs to provide a minimum of x training sessions.

The vendor needs to provide the following training:

- Installation
- Troubleshooting the system
- Preventive maintenance and repair of equipment
- System configuration
- Administration of the system
- System calibration

The vendor's training delivery needs to include printed course materials and references, as well as electronic copies of presentations and references. NJDOT will provide a location to conduct the training session(s).

NJDOT 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.

Replacement or repair of defective or failed field equipment will be covered for x years by the manufacturers' warranties. The labor cost of replacement during this period will be included in the purchase price. The ability for an on-going contract will be available thereafter.

The NJDOT expects maintenance of parts and field equipment for a period of x years after acceptance will be included in the purchase price. The ability for an on-going contract will be available thereafter.
The NJDOT expects maintenance of all adaptive system servers and software for a period of x years after acceptance will be included in the purchase price. The ability for an on-going maintenance contract will be available thereafter.

The NJDOT expects to operate this system using the latest software for a period of x years after acceptance. The NJDOT will seek technical support from the vendor for assistance in using the adaptive software for x years after acceptance. The ability for an on-going contract will be available thereafter.
Operations and maintenance staff will have the ability to log in to the system from remote locations via a secured-connection and have full functionality consistent with their access level.

The CTSS'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. The NJDOT's experienced operators will be able to write customized routines using the CTSS's API. The NJDOT needs a refresher training course on-site at NJDOT XX months into the software support period.

4.17 External Interfaces

The CTSS needs the ability to interact with external interfaces to support the following:

- The system 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
- The system needs to react to traffic volume and traffic operation condition change due to special events
- The system needs the ability to be capable of responding to commands issued by the Traffic Management System

4.18 Maintenance

NJDOT needs all applicable equipment to be readily accessible. NJDOT needs to have spare parts for critical equipment. The initial cost of all equipment needs to include maintenance for a minimum of XX (X) years from the date of installation.

4.19 System Detection

The system should have the ability to interface with midblock system detectors. The location of system detectors are as follows:

- Downstream of confluence points that are likely to contribute notable traffic volumes including entering/exiting coordination zones
- Outside of the dilemma zones
- Downstream of major traffic generators/land uses

The data collected by the system detectors is as follows:

- Volume
- Speed
- Classification
- Travel Time
- Occupancy

The adaptive system needs the ability to integrate the system detection data into adaptive operation. The adaptive system needs the ability to integrate the system detection data into the adaptive system GUI. The historical system detection data needs to be stored locally and pushed remotely.

4.20 Traffic Signal Detection

The traffic signal detection needs the following capabilities:

- Detect a minimum of X lanes of traffic per device
- Detect a minimum of X detection zone per lane
- Utilize power/communication cables greater than XXX feet in length
- Utilize a CCD sensor for image detectors
- Utilize an integrated processor

5.0 Envisioned Adaptive System Overview

This section describes the envisioned CTSS for NJDOT. The envisioned system is defined by the size and grouping of intersections, operational objectives, fallback operation, crossing routes and adjacent systems, operator access, and complex coordination and controller operation.

5.1 Size and Grouping

This Concept of Operations defines the envisioned system for the full XX intersections. The traffic signal systems will connect individual traffic signals into groups that operate cooperatively to improve traffic flow and reduce delay. The system will combine groups of intersections when traffic conditions warrant.

5.2 Operational Objectives

The objective of the coordination will be to provide for smooth flow along the arterial road, minimizing the number of stops experienced by vehicles traveling along the road. Where "natural" cycle lengths exist that permit two-way progression, the system will generally operate at one of those cycle lengths unless longer phase lengths are required to accommodate the demand.

The objective of the coordination will be to maximize the throughput along the coordinated route and thereby enhance mobility and safety. This may involve a tradeoff that increases delay to cross streets and turning movements in order to maximize the green time provided to coordinated traffic flows.

The objective of the coordination will be to control traffic in a manner that equitably serves the adjacent land uses. The delays experienced by the traffic entering and leaving the coordinated route will be balanced with the delays and stops experienced by other traffic traveling along the route.

The objective of the coordination will be to manage the lengths of queues stored at critical locations within the coordinated group so that long queues do not block upstream intersections or otherwise reduce the capacity available during the green phases. This will involve controlling phase lengths so that the size of platoons entering a downstream block does not exceed the storage length if the platoon will be stopped. It will also involve control of offsets and phase lengths so that queues may be stored in locations where they will not adversely affect capacity of the system.

The system, or the operator, will select the appropriate coordination objective, depending on the current traffic conditions. For example, during commuter peaks the primary objective may be to maximize the throughput along the road in the peak direction. Then during the business hours the objective may be to balance delays between traffic associated with the adjacent activity and traffic simply traveling through the system.

The operator will be able to define for each group of intersections the appropriate operational objective. For example, near a freeway interchange or in a location with heavy turning movements, the queue management strategy may be specified, while on an arterial with long signal spacing the smooth flow objective may be specified.

During moderate to light traffic conditions, one or more phases may be omitted (e.g., a protected phase if protected/permissive left turns are operated), in order to more efficiently serve other movements, provided it is safe to do so. This may be accomplished through a time of day schedule or based on the measured traffic conditions.

Within these operational objectives, the system will change its operation to accommodate the rise and fall of volumes through the peaks and the changing patterns of flow throughout the day and week. However, there is also a stochastic element to traffic in the short term, with the number of arrivals for a phase varying from cycle to cycle, and pedestrians not being present on all phases in all cycles. It is therefore desirable for the system to have some local tactical control. While vehicle-actuated coordination typically allows phases to run longer or shorter from cycle to cycle to match the actual number of vehicles using the phase, the system will also allow the operator to decide where the unused time will be used. If a phase is to be skipped, the operator can specify that the spare time will be added to the existing phase, the following phase or the next coordinated phase.

At an isolated intersection with widely varying traffic patterns and a high degree of saturation during peak times, the system will calculate the optimum cycle length, phase sequence and phase times in real time to match the changing traffic conditions.

At a small group of intersections, with the user defining one as being critical, while the adjacent intersections require a lower cycle length or progression must be provided for specific phases to minimize the formation of queues on the approaches to the critical intersection, the phase lengths of the critical intersection will be determined by the system based on the current traffic conditions. The operation of the adjacent intersections will then be set so that platoons departing the critical intersection are progressed through the non-critical intersections, or platoons arriving at the critical intersection do so at a time when they will have little or no delay waiting for the appropriate phase.

The CTSS needs to provide the ability to collect actual traffic conditions, analyze, and adjust traffic signal timing using the adaptive algorithm and transmit the updated timing parameters to the traffic signal controllers through the provided communication network. The CTSS can better accommodate changing traffic patterns associated with typical daily variation, as well as non-reoccurring traffic demand created by incidents. The overall objective of the coordination will be to provide for smooth flow along NJ signalized corridors, minimizing the number of stops experienced by vehicles traveling along the road during all traffic conditions, and maintaining the same or higher level of safety than currently exists. An additional priority is to monitor queues to prevent queue spillback and blockage of the through lanes.

5.3 Fallback Operation

The system needs the ability to have a fail-safe fallback condition that allows coordination using time-of-day plans stored in the local intersection. Alternately, the system need the ability to revert to actuated operation constrained by coordination until communications or equipment failures are resolved. The system will have a fallback state that allows one or more intersections to be unmarried from a critical intersection in the event of failures of the adaptive processor software or hardware, detectors or communication.

5.4 Crossing Routes and Adjacent Systems

The CTSS needs the ability to be able to coordinate with future systems including crossing routes.

5.5 Operator Access

Observation and updates of the CTSS will be performed from the NJDOT AMC. The CTSS needs the ability to assign operators, engineers, and maintenance staff different access rights based on their role and responsibility. These access rights will allow the users to control, monitor, and analyze the operation of the system as needed. The system will be connected to the NJDOT's Statewide Network allowing access to all authorized users. The system will allow access by authorized users outside the NJDOT (such as system vendor) utilizing OIT's VPN process.

5.6 Complex Coordination and Controller Operation

The NJDOT needs the ability to use the following complex coordination and controller features:

- The ability to repeat a phase, such as running a left turn phase before and after its opposing through movement
- Provisions for the required number of rings, phases, phases per ring, and overlap phases
- The ability to omit a phase under some traffic conditions or based on external input to allow a shorter cycle length to operate, or to provide additional time to other phases
- Special features unique to the NJDOT such as detector switching, dynamic max, coordination beginning of yellow
- The ability to maintain coordination with external movements by preventing phases from being skipped, or by omitting phases, based on time-of-day, external input or when certain phase sequences are in operation
- The NJDOT will permit phases or overlaps by time-of-day schedule or external input
- The ability to designate specific phases as coordinated phases
- The ability to separately monitor each lane on an approach and take different action depending on the conditions measured in each lane
- The ability to allow the coordinated phase to terminate early if the coordinated platoon is short
- The ability to introduce a non-coordinated phase later than its normal starting point within a cycle, if it can be served with minimum green within the remaining time available
- Protected/permissive and permissive only phasing
- Prevent flashing yellow protected/permissive and permissive only phasing
- The NJDOT may operate external devices using discrete signal outputs from the CTSS including occupancy on a detector, cycle length, and time-of-day
- The ability for a coordinated phase to be released early

6.0 Adaptive Operational Environment

6.1 Stakeholders

Stakeholders of the traffic signal system typically include:

- NJDOT
    - Electrical Maintenance
    - ITS Maintenance
    - Mobility and Systems Engineering
    - Traffic Engineering
- Neighboring jurisdictions that operate signals
    - County
    - Municipality
- Fire departments
- Police departments
- NJTA
- NJ Transit
- FHWA

6.2 Operating Environment and Equipment

The system could be operated and monitored from the NJDOT Arterial Management Center (AMC) located in Trenton. The system will have the capability to be operated and maintained via workstations at the AMC, as well as via a laptop connected directly to the local controllers. All field equipment will integrate with local traffic signal controllers and video vehicle detection.

6.2.1 System Access

Operations and maintenance staff will have the ability to log into the system from remote locations via the Internet, and have full functionality consistent with their assigned access level. The operation of the CTSS will be able to be customized to suit the different situations and the different areas of operation.

6.2.2 Ongoing Support and Equipment Upgrades

NJ OIT will specify equipment/software compatibility constraints. The central server needs to be a standard platform (maintained by the NJ–OIT) and able to be replaced independently from the software.

The NJDOT selection of local traffic signal controllers will not be constrained by the adaptive software. The vendor will be able to provide customized routines that take advantage of the CTSS's API. The vendor will setup and fine tune the adaptive system prior to handover to the NJDOT. The NJDOT operators will require training specific to the adaptive system, sufficient to allow them to set up, adjust and fine tune all aspects of the system post-support period. The set up and fine tuning of the system will be contracted out. A review of the system's operation will be performed quarterly. Complaints or requests for changes in operation will be handled by the in-house operators on an as-needed basis. Complaints or requests for changes in operation will be handled by on-call contract staff on an as-needed basis. Maintenance of all field equipment will be performed by in-house staff. Replacement or repair of defective or failed field equipment will be covered for X years by the manufacturers' warranties. The labor cost of replacement during this period will be included in the purchase price. The ability for an on-going contract will be available thereafter. The NJDOT expects maintenance of parts and field equipment for a period of X years after acceptance will be included in the purchase price. The ability for an on-going contract will be available thereafter. The NJDOT expects maintenance of all adaptive system servers and software for a period of X years after acceptance will be included in the purchase price. The ability for an on-going contract will be available thereafter. The NJDOT expects to operate this system using the latest software for a period of X years after acceptance. The NJDOT will seek technical support from the vendor for assistance in using the adaptive software for X years after acceptance. The ability for an on-going contract will be available thereafter. Operations and maintenance staff will have the ability to log in to the system from remote locations via a secured-connection and have full functionality consistent with their access level. The CTSS'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. It is anticipated that the NJDOT's experienced operators will be trained to write customized routines using the CTSS's API. The NJDOT needs a refresher training course on-site at NJDOT XX months into the software support period.

7.0 Adaptive Support Environment

Control of the CTSS will reside in the NJDOT Arterial Management Center (AMC) located in Trenton, New Jersey or another climate controlled location to be determined. CTSS control software will be either web-based or through a contractor provided software system that must be integrated into the NJDOT AMC system and function through the agency's firewall. CTSS software will be installed on existing workstations. Any required server will be located at the NJDOT AMC or in another environmentally controlled location to be determined. The CTSS will be compatible with the New Jersey regional ITS architecture.

Monitoring and maintenance of the CTSS system will be performed by existing NJDOT personnel. It is not anticipated that any additional staffing will be required.

7.1 System Architecture Constraints

The adaptive processor/server will be protected within the NJDOT's firewalls. NJ-OIT 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. The communications media available for use by the system will be fiber optic, with the potential for wireless system detection media where necessary. The adaptive system will operate within the local ITS Architecture of NJDOT. It will interact with the Regional ITS Architecture as previously depicted in the ATMS03 – Surface Street Control NJDOT Market Package diagram.

7.2 Utilities

Electrical utilities for field devices will be the responsibility of the municipality.

7.4 Computing hardware

Additional computing equipment required to support the operation include workstations. NJ-OIT is responsible for maintenance and repair of the computing equipment. NJ-OIT is responsible for replacement of the computing equipment when it reaches the end of its useful life.

7.5 Software

The vendor is responsible for keeping system software up to date as per the terms of the contract. The vendor is responsible for keeping system software licenses current as per the terms of the contract. NJ-OIT governs software use and availability on workstations, support computers, and Operating Systems. The adaptive system, detection system, and system detection software needs to have the ability to operate on a virtual server.

7.6 Personnel

The system will need the ability to handle up to XX concurrent operators (local and remote) at any time in order to accommodate high and extended usage that might occur during special events with no increase in latency. The system will need the ability to handle up to XX user profiles. Operators will be available at the AMC X hours a day, X days a week and at the STMC XX/X. System, maintenance, and administrator training will be needed.

7.7 Operating procedures

NJ-OIT will be responsible for backing up databases. The vendor will specify how often backups will be needed and where they will be stored.

7.8 Maintenance

Maintenance will be handled in-house by NJDOT.

7.9 Disposal

Material and/or equipment will need to be disposed of during the life of the project, and will be disposed as per NJDOT standard operating procedures. System components will be disposed of at the end of their useful life as per NJDOT standard operating procedures.

8.0 Operational Scenarios for Traffic Events

8.1 Overview

The following operational scenarios describe how the system is expected to operate under various conditions. The proposed CTSS is expected to be able to manage the following operational scenarios and issues envisioned for both the current and future intersection locations. Scenarios are described for the following operational conditions:

- Peak Period - Typical heavy uncongested conditions (unsaturated)
- Peak Period - Typical heavy congested conditions (oversaturated)
- Moderate balanced flows
- Non-reoccurring events, incidents and other unexpected events
- Fault conditions (communications, detection, adaptive processor)
- Signal priority and preemption
- Pedestrians
- Installation
- Scheduled Event
- Monitoring and Reporting

8.2 Peak period (unsaturated traffic conditions), off-peak and weekends

During typical unsaturated conditions, the CTSS will monitor traffic conditions and select appropriate signal timing parameters, such as cycle length, green time, phasing sequence, offsets, and/or double servicing specific phases where conditions permit. The CTSS will determine intersection grouping and establish timing to smooth traffic and provide progression. It is expected that timing parameters will vary cycle to cycle based on changing traffic conditions. The CTSS system will monitor traffic volumes and adjust progression based on traffic demands. The CTSS system will monitor minor approach left turns for queue spillback and automatically increase left turn green time or double service to minimize queue length, constrained by coordination.

8.3 Peak period (oversaturated traffic conditions)

During periods of oversaturated traffic conditions the system will have the ability to automatically change goals to provide maximum throughput. The system will continue to monitor traffic conditions and select appropriate signal timing parameters, cycle length, green time, phasing sequence, offsets, and/or double servicing specific phases where conditions permit. The system will determine intersection grouping and establish timing to maximize the movement of vehicles on the corridor. It is expected that timing parameters will vary cycle to cycle based on changing traffic conditions. The system will monitor traffic volumes and adjust progression based on traffic demands. The system needs to be able to monitor minor approach left turns for queue spillback and automatically increase left turn green time or double service to minimize queue length, constrained by coordination. The entire corridor should have the flexibility to be coordinated as one group or have the freedom to operate as separate groups as set by the operators or as dictated by traffic demand. The AMC will monitor and adjust the system, if required

8.4 Moderate balanced flows

During periods of moderate, balance flows, the system needs to select phase times or offsets that provide smooth flow along the corridor in both directions. Provide signal timing that prevents phase failures at all intersections and serves all turning traffic. At specified intersections, select phase times that will accommodate frequent use of pedestrian phases. At other intersections, select phase times that will accommodate occasional use of pedestrian phases.

8.5 Non-recurring events, incidents and other unexpected events

During unexpected events caused by incidents, accidents, construction, or weather, the system needs the ability to automatically adjust to changing traffic conditions. The system will continue to monitor traffic conditions and select appropriate signal timing parameters, such as cycle length, green time, phasing sequence, offsets, and/or double servicing specific phases where conditions permit. The system will need to be able to determine whether to smooth traffic progression or to provide maximum throughput. It is expected that timing parameters will vary cycle to cycle based on changing traffic conditions. The system will monitor traffic volumes and adjust progression based on traffic demands. The system will monitor minor approach left turns for queue spillback and automatically increase left turn green time or double service to minimize queue length, constrained by coordination. The entire corridor should have the flexibility to be coordinated as one group or have the freedom to operate as separate groups as set by the operators or as dictated by traffic demand. The AMC will have the ability to monitor and adjust the system based on event parameters.

8.6 Communications Fault Condition

During failure conditions, the CTSS will need the ability to recognize the failure and notify the NJDOT AMC and/or maintenance staff. The AMC will direct appropriate repair crews to address the failure. The CTSS needs to automatically change to a user-specified fallback configuration. For failure of communications, the local intersection needs to either fallback to time-of-day or vehicle actuated operation construed by coordination as defined by the user. For failure of the system equipment, the local intersection will fall back to a specific mode of operation as defined by the user.

8.7 Detection Fault Condition

During failure conditions, the CTSS will need the ability to recognize the failure and notify the NJDOT AMC and/or maintenance staff. The AMC will direct appropriate repair crews to address the failure. For vehicle detector failures, the system needs to take appropriate action to accommodate the missing data. Appropriate action may be to use an adjacent lane's detection or to use historic traffic information. For failure of the system equipment, the local intersection will fall back to a specific mode of operation as defined by the user.

8.8 Priority and Preemption

When a signal responds to emergency vehicle preemption or a transit signal priority call, other signals within the coordinated group continue to operate adaptively. The preempted signal will return to adaptive control once the preemption is released. The system will have the ability to restrict transit signal priority based on user constraints and thresholds.

8.9 Scheduled Events

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. The system will then return to normal operation.

8.10 Pedestrians

Pedestrian crossing times must be accommodated. 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. 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.

8.11 Installation

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. 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 that has a heavy U-turn volume.

Appendix X – Existing Traffic Data

Appendix X – Land Use Map

Appendix X – Concept of Operations Need Statements

Need Statements

Reference Number	Concept of Operations Statement
1	**1 Chapter 1: Scope**
1.1	**1.1 Document Purpose and Scope**
1.1-1	The scope of this document covers the consideration of a Controlled Traffic Signal System (CTSS)
1.2	**1.2 Project Purpose and Scope**
1.2-2	The purpose of providing Controlled Traffic Signals in this area is to overcome congestion and stopping delays.
1.2-3	This project will add Computerized Control capabilities to an existing coordinated signal system.
1.2-4	This project will maintain the existing coordinated traffic signal capabilities and add additional Computerized Control capabilities.
1.2-5	The adaptive capability will be provided for signals operated by NJDOT.
1.2-6	The signal system will have the ability to interface with a regional traffic conditions map or an Integrated Corridor Management system.
1.2-7	The adaptive system software will coexist with NJDOT's **[existing ATMS name]** system.
1.2-8	The adaptive system image detection feeds will be integrated with NJDOT's Genetec software.
1.3	**1.3 Procurement**
1.3.0-1	The CTSS/ASCT system will be procured using:
1.3.0-1.0-1	A low-bid process based on detailed plans and technical specifications with consideration of best value elements.
1.3.0-1.0-2	Field equipment (parts and labor) will be procured using a low-bid process based on detailed plans and technical specifications with consideration of best value processes
1.3.0-1.0-3	A detailed procurement plan will be prepared after the system requirements have been determined.
2	**2 Chapter 2: Referenced Documents/Standards**
2.0-1.0-1	Adaptive Signals • NCHRP Synthesis 403: "Adaptive Traffic Control Systems: Domestic and Foreign State of Practice" (http://onlinepubs.trb.org/online pubs/nchrp/nchrp_syn_403.pdf)
2.0-1.0-2	ITS, Operations, Architecture, Other:
2.0-1.0-3	• FHWA Rule 940, Federal Register / Vol. 66, No. 5 / Monday, January 8, 2001 / Rules and Regulations, DEPARTMENT OF TRANSPORTATION, Federal Highway Administration 23 CFR Parts 655 and 940, (FHWA Docket No. FHWA–99–5899] RIN 2125–AE65 Intelligent Transportation System Architecture and Standards
2.0-1.0-4	• Regional ITS Architecture Guidance Document; “Developing, Using, and Maintaining an ITS Architecture for your Region; National ITS Architecture Team; October, 2001

Need Statements	
Reference Number	Concept of Operations Statement
2.0-1.0-5	NTCIP • NTCIP standards
2.0-1.0-6	NEMA • NEMA standards
2.0-1.0-7	MUTCD
2.0-1.0-8	HCM
2.0-1.0-9	IEEE
2.0-1.0-10	NEC
2.0-1.0-11	NJDOT ITS Guidelines
3	**3 Chapter 3: User-Oriented Operational Description**
3.1	**3.1 The Existing Situation**
3.1.1	***3.1.1 Network Characteristics***
3.1.1.1	**3.1.1.1 Arterial**
3.1.1.1.0-1	The arterial has irregularly spaced signalized intersections. The spacing between major intersections ranges from approximately **X,XXX'** to **XXX'.**
3.1.1.1.0-2	The free-flow travel time between major intersections is approximately **XX** seconds.
3.1.1.1.0-3	The arterial has irregularly spaced signalized intersections, and there is no “natural” cycle length that allows two-way progression.
3.1.1.1.0-4	During the peak periods, the cycle length is generally determined by the needs of one or more critical intersections.
3.1.1.2	**3.1.1.2 Isolated intersection or Small Group**
3.1.1.2.0-1	Field equipment (parts and labor) will be procured using a low-bid process based on detailed plans and technical specifications with consideration of best value processes
3.1.1.2.0-2	The system will be used to improve operation at isolated intersections that do not operate efficiently with typical vehicle-actuated operation. Under user constraints, it requires the ability to have:
3.1.1.2.0-3	• Different phase sequences at different times of the day
3.1.1.2.0-4	• Phase re-service to prevent queue overflow in turn bays
3.1.1.2.0-5	• Different cycle lengths for different periods
3.1.1.2.0-6	• Different splits (phase maximums) for different periods
3.1.1.3	**3.1.1.3 Highway Interchange**
3.1.1.3.0-1	The project location has several closely spaced intersections with major turning movements at a highway interchange. It requires careful management of queue lengths on some approaches.
3.1.1.3.0-2	Queuing from on-ramps affects the distribution of traffic across the lanes on the arterial.

Need Statements

Reference Number	Concept of Operations Statement
3.1.1.3.0-3	Queuing from on-ramps affects the saturation flow of some movements during green.
3.1.2	**3.1.2 Traffic Characteristics**
3.1.2.1	**3.1.2.1 Overview**
3.1.2.1.0-1	The traffic characteristics are illustrated in **Appendix A.**
3.1.2.2	**3.1.2.2 Peak Periods**
3.1.2.2.0-1	There are heavily directional commuter peaks in the vicinity of M.P. **XX** to **XX**
3.1.2.2.0-2	Traffic is directional during commuter peaks from M.P. **XX** to **XX,** Northbound in the AM and Southbound in the PM.
3.1.2.2.0-3	Traffic conditions vary during the commuter peaks.
3.1.2.2.0-4	Major traffic generators such as the various shopping malls, **XXX,** and **XXXX** are close to the intersections to be coordinated have non-cyclical peaks. The direction and magnitude of the peak hour flows is unpredictable and non-uniform.
3.1.2.3	**3.1.2.3 Business Hours**
3.1.2.3.0-1	Business hours volumes are not light between the peaks.
3.1.2.3.0-2	Business hours volumes in the two directions are not balanced between the peaks.
3.1.2.3.0-3	Business hours flows are predominantly in the **X** direction in the **AM** and the **Y** in the **PM.**
3.1.2.3.0-4	Business hours flows are directional, but vary during the day.
3.1.2.3.0-5	During the lunchtime period, there are minor peaks.
3.1.2.4	**3.1.2.4 Evenings**
3.1.2.4.0-1	During the evenings after the PM peak, the flows are:
3.1.2.4.0-1.0-1	• Directional
3.1.2.4.0-1.0-2	• Heavy
3.1.2.5	**3.1.2.5 Weekends**
3.1.2.5.0-1	During the weekends, the flows are:
3.1.2.5.0-1.0-1	• Balanced weekend flows
3.1.2.5.0-1.0-2	• Changing weekend patterns
3.1.2.5.0-1.0-3	• Saturday or Sunday peaks (Related to retail, recreation, worship and other factors.)
3.1.2.5.0-1.0-4	• Weekend retail traffic
3.1.2.5.0-1.0-5	• Weekend recreational traffic
3.1.2.6	**3.1.2.6 Events and Incidents**
3.1.2.6.0-1	Heavily directional event traffic is experienced in this area **(such as time of events, duration, day of week, volumes).**

Need Statements

Reference Number	Concept of Operations Statement
3.1.2.6.0-2	Heavily directional incident-related traffic is experienced in this area **(E.g., during peak periods, during off-peak period, during weekends).**
3.1.2.7	**3.1.2.7 General**
3.1.2.7.0-1	There is a high proportion of turning traffic along the arterial or within the network at some intersections such as **XXX Place** and **YYY Lane.**
3.1.2.7.0-2	Queues often overflow from turn bays from spillback and demand starvation.
3.1.2.7.0-3	Traffic along the arterial is predominantly through traffic.
3.1.2.7.0-4	There are significant turning movements onto and off the coordinated route at select intersections.
3.1.2.7.0-5	Traffic conditions change quickly.
3.1.2.8	**3.1.2.8 Future Traffic Conditions**
3.1.2.8.0-1	Changes in traffic conditions are anticipated to occur within the likely expected life of the proposed ASCT system due to **XXX.** Future improvements to **YYY** may also be in development.
3.1.3	**3.1.3 Signal Grouping**
3.1.3.0-1	While the signals are relatively close, the traffic conditions are such that they will normally be coordinated as two (or more) separate and independent groups.
3.1.3.0-2	While the signals are relatively close, the traffic conditions vary and sometimes they would be expected to be coordinated as one group, while at other times they may be coordinated as two (or more) separate and independent groups.
3.1.3.0-3	Although the signals are all on the one route, the distance between them is sufficiently great that they will normally be coordinated as two (or more) separate and independent groups.
3.1.3.0-4	While the signals will normally be operated as two (or more) separate and independent groups, there are occasions (such as when there is a major incident) when they should operate as one coordinated unit.
3.1.4	**3.1.4 Land Use Characteristics**
3.1.4.1	**3.1.4.1 Existing Land Uses**
3.1.4.1.0-1	The arterial:
3.1.4.1.0-1.0-1	• Frontage land uses are mainly retail (e.g., strip malls with numerous driveways, shopping mall with several signalized driveways, big box outlet).
3.1.4.1.0-1.0-2	• Frontage land uses are mainly **offices.**
3.1.4.1.0-1.0-3	• Frontage land uses are mainly **commercial.**
3.1.4.1.0-1.0-4	• Frontage land uses are mainly **service trades**.
3.1.4.1.0-1.0-5	• Frontage land uses are mainly **manufacturing.**

Need Statements	
Reference Number	Concept of Operations Statement
3.1.4.1.0-1.0-6	• Serves a mixture of land uses, including **(delete those not applicable)** residential, office, commercial, retail, service trades, manufacturing, education (specify high school, elementary school, junior college, university, etc.).
3.1.4.1.0-1.0-7	• Serves a major event center. (stadium, park/open space, market, etc.)
3.1.4.1.0-1.0-8	• Provides a parallel route to a freeway.
3.1.4.1.0-1.0-9	• Provides access to a highway interchange
3.1.4.2	**3.1.4.2 Future Land Use Changes**
3.1.4.2.0-1	Changes in land use are expected to occur within the likely expected life of the proposed ASCT.
3.1.4.3	**3.1.4.3 Pedestrians and Public Transit**
3.1.4.3.0-1.0-1	Pedestrian delays are a factor in choosing phasing and timing parameters at locations such as **X Street**.
3.1.4.3.0-1.0-2	Pedestrians impede turning movements.
3.1.4.3.0-1.0-3	The potential for pedestrians to be present at most cycles.
3.1.4.3.0-2.0-1	There are **X** bus lines operating along the route (or within the network). The buses operate at a frequency of **~XX minutes** per hour during peak periods.
3.1.4.3.0-2.0-2	Buses enter, leave, and cross the coordinated route.
3.1.4.4	**3.1.4.4 Agencies**
3.1.4.4.0-2	The effectiveness of transit and fire department is affected by the operation of the signal system.
3.1.4.5	**3.1.4.5 Existing Architecture**
3.1.4.5.0-1	The existing system architecture is illustrated in the NJ ITS Architecture Sausage Diagram and ATMS03 - Traffic Signal Control.
3.1.4.5.0-1.0-1	Arterial Management Center (AMC) in Trenton, Statewide Traffic Management Center (STMC) in Woodbridge, TOC-**X** in **XXXX.**
3.1.4.5.0-1.0-2	Local hub in **XX** Communication Hut.
3.1.4.5.0-1.0-3	Communications infrastructure is fiber optic cable with serial conversion.
3.1.4.5.0-1.0-4	Stop bar image and loop detection location as well as advance and mid-block loop detection that is currently not fully operational.
3.2	**3.2 Limitations of the Existing System**
3.2.0-1	The following statements summarize the limitations of the existing system that prevent it from satisfactorily accommodating the traffic situations described above:
3.2.0-2	• The existing system cannot recognize the onset of peak periods, so the peak period coordination plan introduction times are set conservatively to ensure they cover the normal variation in duration and intensity of the peak. This means that the timing is often less efficient during the early and late parts of the peak periods.

Need Statements

Reference Number	Concept of Operations Statement
3.2.0-3	• The peak direction fluctuates during the peak, so the peak period plan is a compromise. An adaptive system would be expected to recognize the direction of heaviest flow in real time and react accordingly, rather than use a plan that is less efficient but can accommodate a range of flows.
3.2.0-4	• The coordinated signal operation is sometimes disrupted by emergency vehicle or bus preemption at some intersections. An adaptive system may be expected to recover from these disruptions more quickly than the existing system.
3.2.0-5	• The existing system cannot detect unexpected changes in traffic demand as a result of incidents on the adjacent freeway. As a result, the congestion on the arterials is greater than would be the case if the signal timing could automatically adjust to the unexpected conditions. This would also reduce the need for manual intervention by operators when the incident is brought to their attention.
3.2.0-6	• The existing system cannot detect the changes in traffic conditions before and after special events. As a result, the coordination plan introduction times are set very conservatively, and they generally begin operating before they are needed, and continue until well after the traffic disperses. An adaptive system could be expected to reduce this inefficiency and match the signal timing more closely to the actual traffic patterns.
3.3	**3.3 Proposed Improvements to the System**
3.3.0-1	This section describes in broad terms the improvements that are desirable in order to address the limitations described above. The improvements desired are:
3.3.0-2	• Recognize changes in traffic conditions and react quickly and automatically to accommodate those changes.
3.3.0-3	• Overcome the institutional boundaries that currently prevent the signals under the control of the different jurisdictions from operating in a coordinated fashion.
3.3.0-4	• More efficiently accommodate emergency vehicles and transit vehicles, and more quickly recover from preemption and priority.
3.3.0-5	• Improve the management of queues within the network.
3.3.0-6	• Recognize the existence of differing traffic conditions in various parts of the network and react in each section appropriately.
3.3.0-7	• Improve the productivity of staff by automating many of the routine processes.
3.3.0-8	• Keep signal timing current rather than letting its efficiency deteriorate between periodic signal re-timing efforts.
3.4	**3.4 Vision, Goals and Objectives for the Proposed System**
3.4.1	**3.4.1 Vision**
3.4.1-1	The vision of the ASCT system 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.
3.4.2	**3.4.2 Goals**

Need Statements

Reference Number	Concept of Operations Statement
3.4.2-1	The goals of the ASCT system are
3.4.2-1.0-1	• Support vehicle, pedestrian, and transit traffic mobility (safety given higher priority)
3.4.2-1.0-2	• Provide performance measurable improvements in personal mobility
3.4.2-1.0-3	• Support interoperability between **Municipality, County, Authority, etc.**
3.4.2-1.0-4	• Support regional systems
3.4.2-1.0-5	• Support congestion and environment policy objectives
3.4.2-1.0-6	• Meet a timely project implementation schedule
3.4.3	**3.4.3 User Objectives**
3.4.3.0-1	The objectives of the adaptive system that support the stated goals are:
3.4.3.0-1.0-1	To support vehicle, pedestrian, and transit traffic mobility
	• Be capable of supporting priority operations for transit
	• Allow effective use of all controller features currently in use or proposed to be used
	• Minimize adverse effects caused by preemption and unexpected events
3.4.3.0-1.0-2	To support measurable improvements in personal mobility
	• Adjust operations to changing conditions
	• Reduce delays
	• Reduce travel times
	• Provide the same or higher level of safety provided by the existing system to vehicles, pedestrians and transit.
3.4.3.0-1.0-3	To support NJDOT interoperability:
	• Provide capabilities for data exchange and control between systems such as the Data Development System (SQL Server) and the ITS Readiness System, nearby systems.
	• Allow remote monitoring and control from Arterial Management Center (AMC), Statewide Traffic Management Center (STMC), Traffic Operation Center **X**.
	• Adhere to applicable traffic signal and ITS design standards.
3.4.3.0-1.0-4	To support regional systems:
	• Be compliant with the regional ITS architecture
	• Allow center-to-center and system-to-system communication such as Data Fusion for travel time
	• Connect to regional traffic control systems such as Statewide Traffic Management Center (STMC)
	• Report traffic conditions to regional traffic conditions information systems
3.4.3.0-1.0-5	• Reduce vehicle emissions through improvements in appropriate determinants, such as vehicle stops and delays to support environmental objectives:
3.4.3.0-1.0-6	To support a timely schedule:

Need Statements

Reference Number	Concept of Operations Statement
	• Be a mature and robust system that represents little or no software development time (not a pilot or experimental system).
	• Be a system that has been in continuous operation for at least 5 years and on more than 20 corridors in the United States (not a pilot or experimental system).
	• Be ready for full operation by (specify an appropriate date if you have an imposed deadline)
3.4.4	**3.4.4 Operational Objectives**
3.4.4.0-1	The operational objectives of the ASCT system will be to:
3.4.4.0-1.0-1	• Smooth the flow of traffic along coordinated routes
3.4.4.0-1.0-2	• Maximize the throughput of traffic along coordinated routes
3.4.4.0-1.0-3	• Equitably serve adjacent land uses
3.4.4.0-1.0-4	• Manage queues, to prevent excessive queuing from reducing efficiency
3.4.4.0-1.0-5	• Control operation using a combination of these objectives
3.4.4.0-1.0-6	• Control operation by changing the objectives under various circumstances
3.4.4.0-1.0-7	• For a critical isolated intersection, maximize intersection efficiency.
3.5	**3.5 Strategies to be Applied by the Improved System**
3.5.0-1	The adaptive coordination and control strategies that may be employed with user constraints to achieve the operational objectives are:
3.5.0-1.0-1	• Provide a pipeline along a coordinated route to maximize the throughput during periods of high demand;
3.5.0-1.0-2	• Provide a pipeline along a coordinated route to smooth the flow of traffic in one or both directions;
3.5.0-1.0-3	• Distribute phase times in a way that equitably shares the green time between various movements and minimizes the risk of phase failures;
3.5.0-1.0-4	• Manage queues so they do not exceed the available storage capacity and are located so they do not affect the capacity of other movements;
3.5.0-1.0-5	• Manage the distribution of green times for vehicles and pedestrians in an equitable manner;
3.5.0-1.0-6	• Employ a combination of these strategies when they are compatible.
3.6	**3.6 Alternative Non-Adaptive Strategies Considered**
3.6.0.0-1	Updated Time-Based Coordination
3.6.0.0-2	Closed-Loop System
3.6.0.0-3	**Traffic Responsive Pattern Selection**
3.6.1	**3.6.1 Complex Coordination Features**
3.6.1.0-1	The following features are currently used in coordination patterns or are desired. These features will need to remain available in fallback operation should the ASCT fail:

Need Statements

Reference Number	Concept of Operations Statement
	• Multiple (repeat) phases or phase re-service with user constraints
	• Omit phase under some circumstances with user constraints
	• Detector switching
	• Coordinate different phases at different times of day
	• Coordinate turning movement phases
	• Coordinate beginning or end of green or yellow
	• Early release of hold
	• Hold the position of uncoordinated phases
	• Late phase introduction
	• Stop-in-walk
	• Dynamic max
	• Double cycle or half cycle
4	**4 Chapter 4: Operational Needs**
4.1	**4.1 Adaptive Strategies**
4.0-1	The system needs to have ability to operate under user-defined constraints to the sequence based operation.
4.1.0-1	The system needs the ability to implement different strategies individually or in combination to suit different prevailing traffic conditions. These strategies include:
4.1.0-1.0-1	Maximize the throughput on coordinated routes.
4.1.0-1.0-2	Provide smooth flow along coordinated routes.
4.1.0-1.0-3	Distribute phase times in an equitable fashion.
4.1.0-1.0-4	Manage the length of queues.
4.1.0-1.0-5	Manage the locations of queues within the network.
4.1.0-1.0-6	At an isolated intersection, optimize operation with a minimum of phase failures (based on the optimization objectives).
4.1.0-2	The system needs the ability to manage the coordination in small groups of signals to link phase service at some intersections with phase service at adjacent intersections.
4.1.0-3	The system needs the ability to change the operational strategy (for example, from smooth flow to maximizing throughput or managing queues) based on changing traffic conditions.
4.1.0-4	The system needs the ability to detect repeated phase failures and control signal timing to prevent phase failures building up queues.
4.1.0-5	The system needs to minimize the chance that a queue forms at a specified location.
4.1.0-6	The system needs the ability to fix the sequence of phases at any specified location.

Need Statements

Reference Number	Concept of Operations Statement
4.1.0-7	The system needs the ability to designate the coordinated route based on traffic conditions and the selected operational strategy
4.1.0-8	The system needs the ability to set signal timing parameters to comply with NJDOT policies.
4.2	**4.2 Network characteristics**
4.2.0-1	The system needs the ability to eventually adaptively control up to **XX** signalized intersections, up to **XX** miles from **XXX** (TMC, TOC, etc.).
4.2.0-2	The system needs the ability to be able to eventually adaptively control up to **XX** independent groups of signalized intersections.
4.2.0-3	The system needs the ability to vary the number of signals in an adaptively controlled group to accommodate the prevailing traffic conditions.
4.3	**4.3 Coordination across boundaries**
4.3.0-1	The system needs the ability to adaptively control signals operated by NJDOT.
4.3.0-2	The system needs the ability to send data to another system that would allow the other system to coordinate with the ASCT system.
4.3.0-3	The system needs the ability to adaptively coordinate signals on two crossing routes simultaneously.
4.3.0-4	The system needs the ability to receive data from another system that will allow the ASCT system to coordinate its operation with the adjacent system.
4.3.0-5	The system needs the ability to constrain the adaptive system to operate a cycle length compatible with the crossing arterial.
4.3.0-6	The system needs the ability to detect traffic approaching from a neighboring system and coordinate the ASCT operation with the adjacent system.
4.4	**4.4 Security**
4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies.
4.5	**4.5 Queuing interactions**
4.5.0-1	The system needs the ability to detect queues from outside the system and modify the ASCT operation to accommodate the queuing.
4.5.0-2	The system needs the ability to detect queues within the system's boundaries and modify the ASCT operation to accommodate the queuing.
4.5.0-3	The system needs the ability to detect queues propagating outside its boundaries from within the ASCT boundaries, and modify its operation to accommodate the queuing.

Need Statements

Reference Number	Concept of Operations Statement
4.5.0-4	The system needs the ability to store queues in locations where they can be accommodated without adversely affecting adaptive operation.
4.5.0-5	The system needs the ability to prevent queues forming at user specified locations.
4.6	**4.6 Pedestrians**
4.6.0-1	Infrequent pedestrian actuated calls: The system needs the ability to accommodate infrequent pedestrian operation and then adaptively recover.
4.6.0-2	Infrequent pedestrian actuated calls: The system needs the ability to accommodate infrequent pedestrian operation while maintaining adaptive operation.
4.6.0-3	Frequent pedestrian actuated calls: The system needs the ability to incorporate frequent pedestrian operation into routine adaptive operation.
4.6.0-4	Pedestrian nonactuated calls: Nonactuated pedestrian phases are always on recall.
4.6.0-5	The system needs the ability to accommodate custom pedestrian features.
4.6.0-6	The system needs to the ability to accommodate early start of walk and exclusive pedestrian phases.
4.7	**4.7 Non-adaptive situations**
4.7.0-1	The system needs the ability to detect traffic conditions during which adaptive control is not the preferred operation, and implement some pre-defined operation while that condition is present.
4.7.0-2	The system needs the ability to schedule pre-determined operation by time of day.
4.7.0-3	The system needs the ability to over-ride adaptive operation.
4.8	**4.8 System responsiveness**
4.8.0-1	The system needs the ability to modify the ASCT operation to closely follow changes in traffic conditions.
4.8.0-2	The system needs the ability to constrain the selection of cycle lengths to those that provide acceptable operations, such as when resonant progression solutions are desired.
4.8.0-3	The system needs to respond within a user-defined amount of cycles to sudden large shift in traffic conditions.
4.9	**4.9 Complex coordination and controller features**
4.9.0-1	The system needs the ability to implement the following advanced controller features while maintaining adaptive operation:
4.9.0-1.0-1	• Service a phase more than once per cycle based on user-defined constraints.
4.9.0-1.0-2	• Operate at least X overlap phases.
4.9.0-1.0-3	• Operate up to **X** rings, **X** phases and **X** phases per ring.
4.9.0-1.0-4	• Allow one or more phases to be omitted (disabled) under certain traffic conditions or signal states.

Need Statements	
Reference Number	Concept of Operations Statement
4.9.0-1.0-5	• Prevent one or more phases being skipped under certain traffic conditions or signal states.
4.9.0-1.0-6	• Allow detector logic at an intersection to be varied depending on local signal states.
4.9.0-1.0-7	• Accommodate the custom features used by NJDOT.
4.9.0-1.0-8	• Allow any phase to be designated as the coordinated phase.
4.9.0-1.0-9	• Allow the operator to specify which phase receives unused time from a preceding phase.
4.9.0-1.0-10	• Allow the controller to respond independently to individual lanes of an approach. This may be implemented in the signal controller using up to **X** 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.
4.9.0-1.0-11	• Allow the coordinated phase to terminate early under prescribed traffic conditions
4.9.0-1.0-12	• Allow flexible timing of non-coordinated phases (such as late start of a phase) while maintaining coordination.
4.9.0-1.0-13	• Protected/permissive phasing and alternate left turn phase sequences.
4.9.0-1.0-14	• 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.
4.1	**4.10 Monitoring and control**
4.10.0-1	The system needs the ability to monitor and control all required features of adaptive operation from the following locations:
4.10.0-1.01	• Traffic Operation Center **XXX**
4.10.0-1.02	• Arterial Management Center (AMC)
4.10.0-1.03	• Statewide Traffic Management Center (STMC)
4.10.0-1.04	• Local Controller Cabinets
4.10.0-1.05	• Maintenance Vehicles
4.10.0-2	The operator needs the ability to access to the database management, monitoring and reporting features and functions of the signal controllers and any related signal management system as per his/her defined privilege level from the access points defined for those system components.
4.10.0-3	The system needs to have an integrated user-friendly graphic user interface (GUI) to provide graphic displays, import and generation of graphic images, automatic updating of maps and graphics, and update this data in real time (at least once per second).
4.11	**4.11 Performance reporting**
4.11-0.1	The NJDOT needs the ability for the Traffic Management System to be able to coexist with or monitor the adaptive system.

Need Statements

Reference Number	Concept of Operations Statement
4.11-0.2	The system needs the ability to store and report data used to calculate signal timing and have the data available for subsequent analysis.
4.11-0.3	The system needs the ability to store and report data that can be used to measure traffic performance under adaptive control.
4.11-0.4	The system needs the ability to store all operational data and signal timing parameters calculated by the adaptive system, and export selected data.
4.11-0.5	The system needs the ability to report performance data at least once a minute.
4.11-0.6	The system needs the ability to be able to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation
4.11-0.7	Have the ability to generate historic and real-time reports that effectively support operation, maintenance, and reporting of system performance and traffic conditions.
4.11-0.8	Have the ability to continuously monitor and diagnose the status of stopline and system detectors.
4.12	**4.12 Failure notification**
4.12.0-1	The system needs the ability to immediately notify maintenance and operations staff of alarms and alerts.
4.12.0-2	The system needs the ability to immediately and automatically pass alarms and alerts.
4.12.0-3	The system needs the ability to maintain a complete log of alarms and failure events.
4.13	**4.13 Preemption and priority**
4.13.0-1	The system needs the ability to accommodate emergency vehicle preemption.
4.13.0-2	The system needs the ability to accommodate transit signal priority.
4.14	**4.14 Failure and fallback**
4.14.0-1	The system needs the ability to fall back to TOD or actuated operation constrained by coordination, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications, and software failure.
4.15	**4.15 Constraints**
4.15.0-1	The system is constrained to use the following equipment:
4.15.0-1.0-1	• **Naztec 2070N controllers are utilized by not a mandatory constraints**
4.15.0-1.0-2	• **Non roadway-intrusive detectors (stopbar and system)**
4.15.0-1.0-3	• **Fiber optic communication system**
4.15.0-1.0-4	• **Cabinet type and size (list acceptable equipment)**
4.15.0-1.0-5	• **Coexist with the Traffic Management System**
4.15.0-1.0-6	The system needs the ability to use equipment and software acceptable under current NJ OIT policies and procedures.

Need Statements

Reference Number	Concept of Operations Statement
4.15.0-4	**4.16 Training and support**
4.16.0-1	The NJDOT needs all staff involved in operation and maintenance to receive appropriate training.
4.16.0-2	The NJDOT needs the system to fulfill all requirements for the life of the system. Therefore, NJDOT needs the system to be maintained to repair faults that are not defects in materials and workmanship.
4.16.0-3	The NJDOT needs the system to fulfill all requirements for the life of the system. Therefore, NJDOT needs the system to remain free of defects in materials and workmanship that result in requirements no longer being fulfilled.
4.16.0-4	The agency needs the system to fulfill all requirements for the life of the system. Therefore, NJDOT needs support to keep software and software environment updated as necessary to prevent requirements no longer being fulfilled.
4.17	**4.17 External interfaces**
4.17.0-1	The system needs the ability 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
4.17.0-2	The system needs to react to traffic volume and traffic operation condition change due to special events.
4.17.0-3	The system needs the ability to be capable of responding to commands issued by the Traffic Management System.
4.18	**4.18 Maintenance**
4.18.0-1	Each maintaining unit needs all applicable equipment to be readily accessible.
4.18.0-2	NJDOT needs to have spare parts for critical equipment. The initial cost of all equipment needs to include maintenance for a minimum of XX (X) years from the date of installation.
4.19	**4.19 System Detection**
4.19.0-1	The system needs the ability to interface with midblock system detectors.
4.19.0-2	The location of system detectors are as follows:
4.19.0-2.01	• Downstream of confluence points that are likely to contribute notable traffic volumes, including entering/exit coordination zones.
4.19.0-2.02	• Outside of the dilemma zones.
4.19.0-2.03	• Downstream of major traffic generators/land uses.
4.19.0-2.04	The data collected by the system detectors is as follows:
4.19.0-2.05	• Volume
4.19.0-2.06	• Speed
4.19.0-2.07	• Classification
4.19.0-2.08	• Travel Time
4.19.0-2.09	• Occupancy
4.19.0-3	The adaptive system needs the ability to integrate the system detection data into adaptive operation.

Need Statements

Reference Number	Concept of Operations Statement
4.19.0-4	The adaptive system needs the ability to integrate the system detection data into the adaptive system GUI.
4.19.0-5	The historical system detection data needs to be stored locally and pushed remotely.
4.20	**4.20 Traffic Signal Detection**
4.20.0-1	The traffic signal detection needs the following capabilities:
4.20.0-2.01	• Detect a minimum of X lanes of traffic per device
4.20.0-2.02	• Detect a minimum of X detection zone per lane
4.20.0-2.03	• Utilize power/communication cables greater than XX feet in length
4.20.0-2.04	• Utilize a CCD sensor for image detectors
4.20.0-2.05	• Utilize an integrated processor
5	**5 Chapter 5: Envisioned Adaptive System Overview**
5.1	Sizing and Grouping
5.1.0-1	The NJDOT has plans to adaptively control a total of **XX** intersections.
5.1.0-2	The system will control intersections in groups that are defined by the operator.
5.1.0-3	A group of intersections may be comprised of simply one intersection, or up to the total number of intersections that are sufficiently close to warrant coordination under the prevailing traffic conditions.
5.1.0-4	During some traffic conditions, there may be separate groups of intersections operating with different characteristics (e.g., different cycle lengths, some coordinated some not, offsets in different directions).
5.1.0-5	During periods when traffic conditions are similar or operating characteristics (such as cycle length) are similar, or traffic volumes on the coordinated route are heavier, different groups may be formed or specified by the operator.
5.2	**5.2 Operational objectives**
5.2.0-1	The objective of the coordination will be to provide for smooth flow along the arterial road, minimizing the number of stops experienced by vehicles traveling along the road. Where "natural" cycle lengths exist that permit two-way progression, the system will generally operate at one of those cycle lengths unless longer phase lengths, are required to accommodate the demand.
5.2.0-2	The objective of the coordination will be to maximize the throughput along the coordinated route. This may involve a tradeoff that increases delay to cross streets and turning movements, in order to maximize the green time provided to coordinated traffic flows.
5.2.0-3	The objective of the coordination will be to control traffic in a manner that equitably serves the adjacent land uses. The delays experienced by the traffic entering and leaving the coordinated route will be balanced with the delays and stops experienced by other traffic traveling along the route.

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Reference Number	Concept of Operations Statement
5.2.0-4	The objective of the coordination will be to manage the lengths of queues stored at critical locations within the coordinated group so that long queues do not block upstream intersections or otherwise reduce the capacity available during the green phases. This will involve controlling phase lengths so that the size of platoons entering a downstream block does not exceed the storage length if the platoon will be stopped. It will also involve control of offsets and phase lengths so that queues may be stored in locations where they will not adversely affect capacity of the system.
5.2.0-5	The system, or the operator, will select the appropriate coordination objective, depending on the current traffic conditions. For example, during commuter peaks the primary objective may be to maximize the throughput along the road in the peak direction. Then during the business hours the objective may be to balance delays between traffic associated with the adjacent activity and traffic simply traveling through the system.
5.2.0-6	The operator will be able to define for each group of intersections the appropriate operational objective. For example, near a freeway interchange or in a location with heavy turning movements, the queue management strategy may be specified, while on an arterial with long signal spacing the smooth flow objective may be specified.
5.2.0-7	During moderate to light traffic conditions, one or more phases may be omitted (e.g., a protected phase if protected/ permissive left turns are operated), in order to more efficiently serve other movements, provided it is safe to do so. This may be accomplished through a time of day schedule or based on the measured traffic conditions.
5.2.0-8	Within these operational objectives, the ASCT system will change its operation to accommodate the rise and fall of volumes through the peaks, and the changing patterns of flow throughout the day and week. However, there is also a stochastic element to traffic in the short term, with the number of arrivals for a phase varying from cycle to cycle, and pedestrians not being present on all phases in all cycles. It is therefore desirable for the system to have some local tactical control. While vehicle-actuated coordination typically allows phases to run longer or shorter from cycle to cycle to match the actual number of vehicles using the phase, the system will also allow the operator to decide where the unused time will be used. If a phase is to be skipped, the operator can specify that the spare time will be added to the existing phase, the following phase, or the next coordinated phase.
5.2.0-9	At an isolated intersection with widely varying traffic patterns and a high degree of saturation during peak times, the system will calculate the optimum cycle length, and phase times in real time to match the changing traffic conditions.
5.2.0-10	At a small group of intersections, with the user defining one as being critical, while the adjacent intersections require a lower cycle length or progression must be provided for specific phases to minimize the formation of queues on the approaches to the critical intersection, the phase lengths of the critical intersection will be determined by the system based on the current traffic conditions. The operation of the adjacent intersections will then be set so that platoons departing the critical intersection are progressed through the non-critical intersections, or platoons arriving at the critical intersection do so at a time when they will have little or no delay waiting for the appropriate phase.
5.3	**5.3 Fallback operation**

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Reference Number	Concept of Operations Statement
5.3.0-1	The system will have a fallback state that allows coordination using a common cycle length for all signals within a coordinated group when falling back to TOD plans.
5.3.0-2	The system will have a fallback state that allows individual intersections to operate in a vehicle-actuated mode constrained by coordination in the event of failures of the adaptive software or hardware, detectors or communication.
5.3.0-3	The system will have a fallback state that allows one or more intersections to be unmarried from a critical intersection in the event of failures of the adaptive software or hardware, detectors or communication.
5.4	**5.4 Crossing routes and adjacent systems**
5.4.0-1	A coordinated group will be able to include more than one coordinated route, such as two crossing arterials. The system will be able to maintain coordination along both roads.
5.4.0-2	The NJDOT needs the adaptive system to maintain coordination with another adjacent system either by sensing arriving traffic or by using constraints on cycle length.
5.4.0-3	The system will accept data from a neighboring system that allows it to stay in coordination with the adjacent system while still operating in adaptive mode.
5.5	**5.5 Operator access**
5.5.0-1	Operators, traffic engineering, and maintenance staff will be assigned different levels of authority, and access to equipment for which they are authorized, based on their roles and responsibilities. This will allow them to control, view, monitor, and analyze the operation of the system as appropriate.
5.5.0-3	The system will be connected to the NJDOT's Statewide Network allowing access to all authorized users.
5.5.0-4	The system will allow access by authorized users outside the NJDOT (such as system vendor) utilizing OIT's VPN interface
5.6	**5.6 Complex coordination and controller operation**
5.6.0-1	The NJDOT will use the following complex coordination and controller features:
5.6.0-2	• The ability to repeat a phase, such as running a left turn phase before and after its opposing through movement.
5.6.0-3	• Provision for the required number of rings, phases, phases per ring, and overlap phases.
5.6.0-4	• The ability to omit a phase under some traffic conditions, or based on external input, to allow a shorter cycle length to operate, or to provide additional time to other phases.
5.6.0-5	• Special features unique to the NJDOT such as detector switching, dynamic max, coordination beginning of yellow.
5.6.0-6	• The ability to maintain coordination with external movements by preventing phases from being skipped, based on time-of-day, external input or when certain phase sequences are in operation.
5.6.0-7	• The NJDOT will permit phases or overlaps by time-of-day schedule or external input.
5.6.0-8	• The ability to designate specific phases as coordinated phases.

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Reference Number	Concept of Operations Statement
5.6.0-9	• The ability to separately monitor each lane on an approach and take different action depending on the conditions measured in each lane.
5.6.0-10	• The ability to allow the coordinated phase to terminate early if the coordinated platoon is short.
5.6.0-11	• The ability to introduce a non-coordinated phase later than its normal starting point within a cycle, if it can be served with minimum green within the remaining time available.
5.6.0-12	• Protected/permissive and permissive only phasing.
5.6.0-13	• Prevent flashing yellow protected/permissive and permissive only phasing.
5.6.0-14	• The NJDOT may operate external devices using discrete signal outputs from the ASCT including occupancy on a detector, cycle length, and time-of-day.
5.6.0-15	• The ability for a coordinated phase to be released early.
6	**6 Chapter 6: Adaptive Operational Environment**
6.1.0-1	Stakeholders of the traffic signal system include:
	• NJDOT
	• Neighboring jurisdictions that operate signals
	• Municipality **XXX**
	• Municipality **XXX**
	• Municipality **XXX**
	• Fire Departments
	• Police Departments
	• **XXX** Authority
	• Transit Agency
6.1.0-2	Stakeholders who will be affected by or have a direct interest in the adaptive system include **XXX, XXX,** and **XXX.**
6.1.0-3	The activities that will be undertaken by the adaptive system stakeholders include:
	• Preparation of timing parameters
	• Implementation and fine tuning
	• System monitoring and adjustment
	• Education and outreach
	• System performance monitoring
	• Third-party system evaluation

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Reference Number	Concept of Operations Statement
6.1.0-4	The organizational structures of the units responsible for installation, operation and maintenance are illustrated in the attached organizational chart. http://www.state.nj.us/transportation/about/pdf/orgchart.pdf
6.2	**6.2 Physical Environment**
	Operating Environment and Equipment
6.2.0-1	The current and/or proposed Traffic Management Center (TMC) is **XXX.**
6.2.0-2	Statewide Traffic Management Center (STMC) will be a satellite Traffic Management Center (TMC) .
6.2.0-3	Access will be required from NJDOT Maintenance Personnel laptops connected to controller cabinets.
6.2.0-4	Is air-conditioning required?
6.2.0-5	The central server will be located at **XXX** in an air-conditioned environment taking latency issues into account.
6.2.0-6	NJ-OIT is responsible for secure network access to the Traffic Management Center (TMC) , workshop, or office with adaptive system workstations.
6.2.1.0-1	The system will be operated and monitored from the NJDOT Arterial Management Center (AMC).
6.2.1.0-2	The system will be operated and monitored from workstations located at **XXX.**
6.2.1.0-3	An operator will not be able to have full access to the system from each local controller or on-street master.
6.2.1.0-4	NJ-OIT will specify equipment/software compatibility constraints.
6.2.1.0-5	The central server will be a standard platform (maintained by the NJ–OIT) and able to be replaced independently from the software.
6.2.1.0-6	The NJDOT selection of controller will not be constrained by the adaptive software.
6.2.1.0-7	The vendor will be able to provide customized routines that take advantage of the ASCT's API.
6.2.1.0-8	The vendor will setup and fine tune the adaptive system prior to handover to the NJDOT.
6.2.1.0-9	The NJDOT operators will require training specific to the adaptive system, sufficient to allow them to set up, adjust, and fine tune all aspects of the system post-support period.
6.2.1.0-10	The set up and fine tuning of the system will be contracted out. A review of the system's operation will be performed quarterly.
6.2.1.0-11	Complaints or requests for changes in operation will be handled by the in-house operators on an as-needed basis.
6.2.1.0-12	Complaints or requests for changes in operation will be handled by on-call contract staff on an as-needed basis.
6.2.1.0-13	Maintenance of all field equipment will be performed by in-house staff.
6.2.1.0-14	Replacement or repair of defective or failed field equipment will be covered for **X** years by the manufacturers' warranties. The labor cost of replacement during this period will be included in the purchase price. The ability for an on-going contract will be available thereafter.

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Reference Number	Concept of Operations Statement
6.2.1.0-15	The NJDOT expects maintenance of parts and field equipment for a period of **X** years after acceptance will be included in the purchase price. The ability for an on-going contract will be available thereafter.
6.2.1.0-16	The NJDOT expects maintenance of all adaptive system servers and software for a period of **X** years after acceptance will be included in the purchase price. The ability for an on-going maintenance contract will be available thereafter.
6.2.1.0-17	The NJDOT expects to operate this system using the latest software for a period of **X** years after acceptance.
6.2.1.0-18	The NJDOT will seek technical support from the vendor for assistance in using the adaptive software for **X** years after acceptance. The ability for an on-going contract will be available thereafter.
6.2.1.0-19	Operations and maintenance staff will have the ability to log in to the system from remote locations via a secured-connection and have full functionality consistent with their access level.
6.2.1.0-20	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.
6.2.1.0-21	The NJDOT's experienced operators will be able to write customized routines using the ASCT's API.
6.2.1.0-22	The NJDOT needs a refresher training course on-site at NJDOT **XX** months into the software support period.
7	**7 Chapter 7: Adaptive Support Environment**
7.1	**7.1 System Architecture Constraints**
7.1.0-1	The adaptive processor/server will be protected within the NJDOT'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.
7.1.0-2	The communications media available for use by the system will be fiber optic, with the potential for wireless system detection media where necessary.
7.1.0-3	The adaptive system will operate within the local ITS Architecture of NJDOT. It will interact with the Regional ITS Architecture in the following manner.
7.2	**7.2 Utilities**
7.2.0-1	Electrical utilities for field devices are the responsibility of the municipality.
7.3	**7.3 Equipment**
7.3.0-1	Is existing test equipment available to support the adaptive system (e.g., communications testers, fiber testers, controller testers).
7.3.0-2	Will current maintenance vehicles be sufficient?
7.4	**7.4 Computing hardware**
7.4.0-1	Additional computing equipment required to support the operation include workstations.
7.4.0-2	NJ-OIT is responsible for maintenance and repair of the computing equipment.

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Reference Number	Concept of Operations Statement
7.4.0-3	NJ-OIT is responsible for replacement of the computing equipment when it reaches the end of its useful life.
7.5	**7.5 Software**
7.5.0-1	The vendor is responsible for keeping system software up to date as per the terms of the contract.
7.5.0-2	The vendor is responsible for keeping system software licenses current as per the terms of the contract.
7.5.0-3	NJ-OIT governs software use and availability on workstations, support computers, and OSes.
7.5.0-4	The adaptive system, detection system, and system detection software needs to have the ability to operate on a virtual server.
7.6	**7.6 Personnel**
7.6.0-1	The system will need the ability to handle up to XX concurrent operators.
7.6.0-2	The system will need the ability to handle up to XX user profiles.
7.6.0-3	Operators will be available at the Arterial Management Center (AMC), **XXX,** and at the **XXX).**
7.6.0-4	System, maintenance, and administrator training will be needed.
7.6.0-5	Maintenance staff levels are currently sufficient.
7.6.0-6	Maintenance staff is current qualified.
7.7	**7.7 Operating procedures**
7.7.0-1	NJ-OIT will be responsible for backing up databases. The vendor will specify how often backups are required and where they will be stored.
7.8	**7.8 Maintenance**
7.8.0-1	Maintenance will be handled in-house by NJDOT.
7.9	**7.9 Disposal**
7.9.0-1	Material and/or equipment will need to be disposed of during the life of the project, and will be disposed as per NJDOT standard operating procedures.
7.9.0-2	System components will be disposed of at the end of their useful life as per NJDOT standard operating procedures.
8	**8 Chapter 8: Operational Scenarios**
8.1	**8.1 Overview**
	The following operational scenarios describe how the system is expected to operate under various conditions:
	• Peak Period. Typical heavy uncongested conditions (unsaturated)
	• Peak Period. Typical heavy congested conditions (oversaturated)
	• Moderate balanced flows
	• Non-reoccurring events, incidents and other unexpected events
	• Fault conditions (communications, detection, adaptive processor)
	• Signal priority and preemption

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Reference Number	Concept of Operations Statement
	• Pedestrians
	• Installation
	• Scheduled Event
	• Monitoring and Reporting
8.2	**8.2 Peak Period. Typical heavy uncongested conditions (unsaturated)**
8.2.1	**8.2.1 Arterial with highway interchange**
8.2.1.1	Have the ability to monitor traffic conditions and select appropriate signal timing parameters, such as cycle length, green time, offsets, and/or double servicing specific phases where conditions permit.
8.2.1.2	Have the ability to determine intersection grouping and establish timing to smooth traffic and provide progression.
8.2.1.3	Have the ability to for timing parameters will vary cycle to cycle based on changing traffic conditions.
8.2.1.4	Have the ability to monitor traffic volumes and adjust progression based on traffic demands.
8.2.1.5	Have the ability to monitor minor approach left turns for queue spillback and automatically increase left turn green time or double service to minimize queue length, constrained by coordination.
8.2.1.6	Have the flexibility to be coordinated as one group or have the freedom to operate as separate groups as set by the operators or as dictated by traffic demand.
8.2.2	**8.2.2 Arterial with one critical intersection**
8.2.2.1	Have the ability to monitor traffic conditions and select appropriate signal timing parameters, such as cycle length, green time, offsets, and/or double servicing specific phases where conditions permit.
8.2.2.2	Have the ability to determine intersection grouping and establish timing to smooth traffic and provide progression.
8.2.2.3	Have the ability to for timing parameters will vary cycle to cycle based on changing traffic conditions.
8.2.2.4	Have the ability to monitor traffic volumes and adjust progression based on traffic demands.
8.2.2.5	Have the ability to monitor minor approach left turns for queue spillback and automatically increase left turn green time or double service to minimize queue length, constrained by coordination.
8.2.2.6	Have the flexibility to be coordinated as one group or have the freedom to operate as separate groups as set by the operators or as dictated by traffic demand.
8.2.3	**8.2.3 Arterial with several critical intersections**
8.2.3.1	Have the ability to monitor traffic conditions and select appropriate signal timing parameters, such as cycle length, green time, offsets, and/or double servicing specific phases where conditions permit.
8.2.3.2	Have the ability to determine intersection grouping and establish timing to smooth traffic and provide progression.
8.2.3.3	Have the ability to for timing parameters will vary cycle to cycle based on changing traffic conditions.
8.2.3.4	Have the ability to monitor traffic volumes and adjust progression based on traffic demands.

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Reference Number	Concept of Operations Statement
8.2.3.5	Have the ability to monitor minor approach left turns for queue spillback and automatically increase left turn green time or double service to minimize queue length, constrained by coordination.
8.2.3.6	Have the flexibility to be coordinated as one group or have the freedom to operate as separate groups as set by the operators or as dictated by traffic demand.
8.3	**8.3 Peak Period. Typical heavy congested conditions (oversaturated)**
8.3.1	**8.3.1 Arterial with highway interchange**
8.3.1.1	Have the ability to automatically change goals to provide maximum throughput.
8.3.1.2	Have the ability to monitor traffic conditions and select appropriate signal timing parameters, cycle length, green time, offsets, and/or double servicing specific phases where conditions permit.
8.3.1.3	Have the ability to determine intersection grouping and establish timing to maximize the movement of vehicles
8.3.1.4	Have the ability for timing parameters to vary cycle to cycle based on changing traffic conditions.
8.3.1.5	Have the ability to monitor traffic volumes and adjust progression based on traffic demands.
8.3.1.6	Have the ability to monitor minor approach left turns for queue spillback and automatically increase left turn green time or double service to minimize queue length, constrained by coordination.
8.3.1.7	Have the flexibility to be coordinated as one group or have the freedom to operate as separate groups as set by the operators or as dictated by traffic demand
8.3.2	**8.3.2 Arterial with one critical intersection**
8.3.2.1	Have the ability to automatically change goals to provide maximum throughput.
8.3.2.2	Have the ability to monitor traffic conditions and select appropriate signal timing parameters, cycle length, green time, offsets, and/or double servicing specific phases where conditions permit.
8.3.2.3	Have the ability to determine intersection grouping and establish timing to maximize the movement of vehicles
8.3.2.4	Have the ability for timing parameters to vary cycle to cycle based on changing traffic conditions.
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8.3.2.6	Have the ability to monitor minor approach left turns for queue spillback and automatically increase left turn green time or double service to minimize queue length, constrained by coordination.
8.3.2.7	Have the flexibility to be coordinated as one group or have the freedom to operate as separate groups as set by the operators or as dictated by traffic demand
8.3.3	**8.3.3 Arterial with several critical intersections**
8.3.3.1	Have the ability to automatically change goals to provide maximum throughput.
8.3.3.2	Have the ability to monitor traffic conditions and select appropriate signal timing parameters, cycle length, green time, offsets, and/or double servicing specific phases where conditions permit.
8.3.3.3	Have the ability to determine intersection grouping and establish timing to maximize the movement of vehicles

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Reference Number	Concept of Operations Statement
8.3.3.4	Have the ability for timing parameters to vary cycle to cycle based on changing traffic conditions.
8.3.3.5	Have the ability to monitor traffic volumes and adjust progression based on traffic demands.
8.3.3.6	Have the ability to monitor minor approach left turns for queue spillback and automatically increase left turn green time or double service to minimize queue length, constrained by coordination.
8.3.3.7	Have the flexibility to be coordinated as one group or have the freedom to operate as separate groups as set by the operators or as dictated by traffic demand
8.4	**8.4 Moderate balanced flows**
8.4.1.1	Select phase times or offsets that provide smooth flow along the corridor in both directions.
8.4.1.2	Provide signal timing that prevents phase failures at all intersections and serves all turning traffic.
8.4.1.3	At specified intersections, select phase times that will accommodate frequent use of pedestrian phases.
8.4.1.4	At other intersections, select phase times that will accommodate occasional use of pedestrian phases.
8.5	**8.5 Non-reoccurring events, incidents and other unexpected events**
8.5.1.1	If there is heavily direction traffic before or after an event, the system will determine the predominate direction and coordinate accordingly, with appropriate cycle length and offset.
8.5.1.2	If the event is not as heavy as peak hours, but the traffic is still highly directional, then the system will recognize this and provide the coordination predominantly in the heaviest direction, even though the cycle length may be similar to peak hour cycle lengths.
8.5.1.3	The entire corridor may be set by the operator to operate as one or more coordinated groups, or the system may have the freedom to operate it as one of more groups subject to user-specified criteria, such as similar required cycle lengths in different parts of the corridor, of the volume of traffic at key locations exceeds a threshold.
8.5.1.4	If downstream signals experience lighter traffic as a result of an incident blocking and restricting traffic, those signal should be coordinate as a group, with cycle length, splits and offsets that react to the measured traffic.
8.5.1.5	If a detected blockage is in the peak direction, then the system may coordinate in the opposite direction if that traffic is similar to or greater than normal peak direction.
8.5.1.6	The system needs to recognize the presence of an abnormal obstruction, modify the signal operation to react to the change traffic conditions in an efficient manner, and report the abnormal condition to the operator.
8.6.1	**8.6 Communications Fault Condition**
8.6.1-1	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.

Need Statements	
Reference Number	Concept of Operations Statement
8.7.1	**8.7 Detection Fault Condition**
8.7.1-1	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.
8.8	**8.8 Priority and Preemption**
8.8.1-1	When an intersection responds to preemption, other signals within the coordinate group continue to operate adaptively. The preempted signal returns to adaptive control once the preemption is released.
8.9	**8.9 Scheduled Events**
8.9.1-1	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. The system will then return to normal operation.

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Reference Number	Concept of Operations Statement
8.10	**8.10 Pedestrians**
8.10.0-1	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. 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). 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.
8.11	**8.11 Installation**
8.11.0-1	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. 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 that has a heavy U-turn volume.

System Requirements
for
NJ RT XX Traffic Signal System Contract No. XX (20XX)

CITY

COUNTY, NEW JERSEY

Month 20XX

Prepared For

New Jersey Department of Transportation

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Table of Contents

1.0 Scope of System

This document describes the system requirements for an Adaptive Computerized/Controlled Traffic Signal System (CTSS) and related subsystem components. The CTSS is composed of a complex, integrated blend of hardware, software, and processes performing a range of functions. These functions include data acquisition, command and control, data processing and analysis, and communications. This document describes the requirements traced from the needs and scenarios developed in the Concept of Operations.

The Systems Engineering documents used to develop the Systems Requirements were developed with guidance from the Federal Highway Administration (FHWA) Model Systems Engineering Documents for Adaptive Signal Control Technology (ASCT) Systems.

The intended audience of this document typically includes the following stakeholders:

- NJDOT
- Neighboring jurisdictions that operate signals
    - XX County
    - XX Municipality
- Fire departments
- Police departments
- NJTA
- NJ Transit
- FHWA

The control of the CTSS will reside in the NJDOT Arterial Management Center (AMC) located in Trenton, New Jersey or another climate controlled location to be determined. CTSS control software will be either web-based or through a contractor provided software system that must be integrated into the NJDOT AMC system and function through the agency's firewall. CTSS software will be installed on existing workstations. Any required server will be located at the NJDOT AMC or in another environmentally controlled location to be determined. The CTSS will be compatible with the New Jersey regional ITS architecture.

Exhibit 1. CTSS Location

2.0 Reference Documents

This section provides a list of documents related to the development of the CTSS system requirements which includes technical standards, NJDOT policies, Concept of Operations and protocols. The following list provides typical sample reference documents:

- *Concept of Operations for Route NJ XX Computerized Traffic Signal System Milepost XX to Milepost XX*, July XX.
- *Model System Engineering Document for Adaptive Signal Control Technology (ASCT) Systems*, August 2012, Federal Highway Administration.
- *Gap Analysis for Route NJ XX Computerized Traffic Signal System Milepost XX to Milepost XX*, July XX.
- *NCHRP Synthesis 403 – Adaptive Traffic Control Systems: Domestic and Foreign State of Practice*, 2010, Transportation Research Board.
- *Developing and Using a Concept of Operations in Transportation Management Systems*, December 2004, Federal Highway Administration.
- *New Jersey Statewide Intelligent Transportation Systems (ITS) Architecture*, February 18, 2005, New Jersey Department of transportation-Division of Statewide Traffic Operations
- *Institutional Coordination of Intelligent Transportation Systems in the Delaware Valley – Regional ITS Architecture,* March 2001, Delaware Valley Regional Planning Commission.
- *National Transportation Communications for ITS Protocols (NTCIP) – The NTCIP Guide*, July 2009, AASHTO, ITE, NEMA.
- *Standardization Policies and Procedures of the National Electrical Manufactures Association (NEMA)*, December 31, 2009, NEMA.
- *Manual on Uniform Traffic Control Devices (MUTCD), 2009, revised through May 2012,* Federal Highway Administration.
- *Highway Capacity Manual, 2010, Transportation Research Board.*
- *National Electrical Safety Code (NESC) and Handbook Set, 2012, Institute of Electrical and Electronics Engineers (IEEE).*
- *NFPA 70: National Electrical Code, 2014, National Fire Protection Association.*

3.0 Requirements

This section describes the System Requirements for the Adaptive Controlled Traffic Signal System (CTSS) and related subsystem components. The system requirements are directly related to one of more of the need statements in the project's Concept of Operations. The system requirements are ranked based on the Department's determined level of importance to the project. The system requirements ratings range from "Mandatory" to "Desirable" to "Optional".

The contractor/system vendor shall provide a Requirements Matrix submission at the Kickoff Meeting that outlines and explains how the vendor's proposed system can meet the 'desirable and optional' requirements of the project, as well as how they will be traced to an indicated quantifiable performance measures of effectiveness (i.e. percent decrease in stopping delays, travel time, throughput, etc.), where applicable. (System Requirements that require the contractor to provide a verification measure of effectiveness are indicated with an asterisk (*) in the Systems Requirements Matrix). The Requirements Matrix will be used by the contractor to trace the Requirements Matrix document into the Verification Matrix included in the Verification Plan, Attachment of the project's Special Provisions. A sample system requirement statement template is provided in Appendix X.

During the configuration and set-up of the Adaptive CTSS, user-specified criteria and parameters shall be inputted into the system by the contractor. The contractor shall coordinate values for user-specified criteria and parameters in accordance with the Special Provisions for Department review prior to Adaptive CTSS Turn On.

The contractor/system vendor shall determine the daily volume at each traffic signal, average corridor travel time, and the average intersection delay per vehicle prior to Adaptive CTSS Turn On. The baseline conditions shall be determined for an average of two (2) typical weeks and weekends. The method for determination of baseline performance conditions shall be performed in accordance with Mobility and Systems Engineering's Data Collection Guidelines and coordination with the project's Resident Engineer, and shall be reviewed and approved by the Department prior to the start of construction.

The system requirements statements template is depicted in Appendix X of this document and as an attachment in the project's Special Provisions specifications. The Special Provisions shall govern over the requirement statements of this document in the case of a discrepancy. The system requirements are organized under the following headings:

1.0 Network characteristics
2.0 Type of operation
3.0 External/Internal interfaces
4.0 Crossing arterials and boundaries
5.0 Access and security
6.0 Data log
7.0 Advanced Controller operation
8.0 Pedestrians
9.0 Special functions

Each of the requirements fall into one of the following categories:

• Functional requirements (Describes what the system shall do)
• Performance requirements (Describes how the requirements shall perform)
• Non-Functional requirements (Reliability, safety, environmental)
• Enabling requirements (Production, development, testing, training, support, deployment, and disposal). This can be done through references to other documents or can be explicitly defined in these requirements.
• Constraints (e.g., Technology, design, tools, and/or standards)
• Interface requirements (Definition of the interfaces)
• Data requirements (Data elements and definitions)

4.0 Verification Methods

Each of the system requirements will be traced to a particular verification method. The Verification Plan further discusses how, when, or where verification will be performed. At the Kickoff Meeting the contractor/system vendor shall provide a document that outlines and describes how they will verify each system requirement. Verification activities will include the following:

Demonstration

Demonstration is the functional Verification that a specification requirement is met by observing the qualitative results of an operation or exercise performed under specific condition without the need for external test equipment. This includes content and accuracy of displays, comparison of system outputs with independently derived test cases, and system recovery from induced failure conditions. For requirements that are intended for future capabilities or expansion of the Adaptive CTSS and cannot be demonstration based on the proposed Adaptive CTSS depicted in the Plans and Special Provisions, the contractor may utilize the demonstration of other similarly deployed Adaptive CTSS or through documentation, subject to written pre-approval of the Department prior to commencement of construction activities.

Testing

Formal testing is the Verification that a requirement has been met by measuring, recording, or evaluating qualitative and quantitative data obtained during controlled exercises under all appropriate conditions using real and/or simulated stimulus with test equipment. This includes Verification of system performance, system functionality, and correct data distribution.

Testing shall be performed, where applicable, by comparing baseline performance data, as indicated above, to post Adaptive CTSS Turn On collected data. The data shall be quantitatively verified against the performance measures of effectiveness as indicated by the contractor in the submittal documents (ie. percent decrease in stopping delays, decrease in travel time, increase in throughput, etc.).

For requirements that are intended for future capabilities or expansion of the Adaptive CTSS and cannot be tested based on the proposed Adaptive CTSS depicted in the Plans and Special Provisions, the contractor may utilize the testing of other similarly deployed Adaptive CTSS, subject to written pre-approval of the Department prior to commencement of construction activities.

Analysis

Analysis is used for a requirement that is met indirectly through a logical conclusion or mathematical analysis of a result. Analysis is the Verification by evaluation or simulation using mathematical representations, charts, graphs, circuit diagrams, calculation, or data reduction. This includes analysis of algorithms independent of computer implementation, analytical conclusions drawn from test data, and extension of test-produced data to untested conditions. This is often used to extrapolate past performance (which was accurately measured) to a scaled up deployment.

Inspection

Inspection is used for a requirement that is met through visual comparison. Inspection is the Verification by physical and visual examinations of the item, reviewing descriptive documentation, and comparing the appropriate characteristics with all the referenced standards to determine compliance with the requirements. Examples include measuring cabinets sizes, matching paint color samples, observing printed circuit boards to inspect component mounting and construction techniques.

5.0 Support Documentation

A gap assessment should be performed to access the implementation of the CTSS on the corridor. It identifies the gaps between the current conditions and the future state. The purposed of the Gap Analysis is to determine solutions that address the goals and objectives and result in closing the identified gaps. This report was utilized to develop the System Requirements.

6.0 Traceability Matrix

A traceability matrix was created to trace the need statements identified in the Concept of Operations to the System Requirements. The Traceability Matrix template can be found in Appendix X of this document.

7.0 Glossary

ASC	Adaptive Split Control
ASCT	Adaptive Signal Control Technology
Child	Child requirement that is associated with an over-arching requirement called a parent
CIC	Critical Intersection Control
CFR	Code of Federal Regulations
COTS	Commercially available Off-The-Shelf
CTSS	Controlled/Computerized Traffic Control System
FAR	Federal Acquisition Regulation
ICM	Integrated Corridor Mobility
ITS	Intelligent Transportation System
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.
Parent	Parent requirement that has associated sub-requirements called child requirements.
PIF	Public interest finding
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.
Resonant cycle length	A cycle length that accommodates good two-way progression.
RFI	Request for information
RFP	Request for proposal
RFQ	Request for qualifications
Synch point	Reference point in signal phase or cycle used to synchronize operation of adjacent signals.
TBC	Time base coordination
TMC	Transportation Management Center
TOC	Traffic Operations Center
TOD	Time of Day
TRPS	Traffic Responsive Pattern Selection

Appendix X – System Requirements

System Requirements Reference Number	System Requirement Description	ConOps Needs	ConOps Statement	Mandatory	Desirable	Optional
	* requires a verification measure of effectiveness					
1	**1 Network Characteristics**					
1.0-1	The ASCT shall have the ability to control a minimum of XX ASCT signalized intersections concurrently.	4.2.0-1 4.10.0-1 4.10.0-1.01 4.10.0-1.02 4.10.0-1.03 4.10.0-1.04 4.10.0-1.05 5.5.0-3 5.5.0-4	The system needs the ability to eventually adaptively control up to XX signalized intersections, up to XX miles from XXX (TMC, TOC, etc.). The system needs the ability to monitor and control all required features of adaptive operation from the following locations: • Traffic Operation Center XXX • Arterial Management Center (AMC) • Statewide Traffic Management Center (STMC) • Local Controller Cabinets • Maintenance Vehicles The system will be connected to the NJDOT's Statewide Network allowing access to all authorized users. The system will allow access by authorized users outside the NJDOT (such as system vendor) utilizing OIT's VPN interface	X		
1.0-2	The ASCT shall support XX groups of signalized intersections.	4.2.0-2 4.2.0-3	The system needs the ability to be able to eventually adaptively control up to XX independent groups of signalized intersections. The system needs the ability to vary the number of signals in an adaptively controlled group to accommodate the prevailing traffic conditions.	X		
1.0-2.0-1	The boundaries surrounding signal controllers that operate in a coordinated fashion shall be defined by the user.	4.1.0-2	The system needs the ability to manage the coordination in small groups of signals to link phase service at some intersections with phase service at adjacent intersections.	X		
1.0-2.0-2	The ASCT shall control a minimum of XX groups of adaptive signals.	4.2.0-2	The system needs the ability to be able to eventually adaptively control up to XX independent groups of signalized intersections.	X		
1.0-2.0-3	The size of a group shall range from 1 to XX adaptive signals.	4.2.0-3	The system needs the ability to vary the number of signals in an adaptively controlled group to accommodate the prevailing traffic conditions.	X		
1.0-2.0-4	Each group shall operate independently.	4.2.0-2	The system needs the ability to be able to eventually adaptively control up to XX independent groups of signalized intersections.	X		
1.0-2.0-5	The boundaries surrounding signal controllers that operate in a coordinated fashion shall be altered by the system according to configured parameters.	4.2.0-3	The system needs the ability to vary the number of signals in an adaptively controlled group to accommodate the prevailing traffic conditions.	X		
1.0-2.0-5.0-1	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.)	4.2.0-3	The system needs the ability to vary the number of signals in an adaptively controlled group to accommodate the prevailing traffic conditions.	X		
1.0-2.0-5.0-2	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.)	4.2.0-3	The system needs the ability to vary the number of signals in an adaptively controlled group to accommodate the prevailing traffic conditions.	X		
1.0-2.0-5.0-3	The boundaries surrounding signal controllers that operate in a coordinated fashion shall be altered by the system when commanded by the user.	4.2.0-3	The system needs the ability to vary the number of signals in an adaptively controlled group to accommodate the prevailing traffic conditions.	X		
1.0-3	The local traffic signal controller ASCT software/firmware shall have the ability to coexist with the NJDOT's existing Traffic Management System local traffic signal controller software/firmware (It is acceptable to have separate controller boot sequences).	4.15.0-1.0-5 4.11-0.1 4.15.0-1.0-1	• Coexist with the Traffic Management System The NJDOT needs the ability for the Traffic Management System to be able to coexist with or monitor the adaptive system. • Naztec 2070N controllers are utilized by not a mandatory constraints	X		
2	**2 Type of Operation**					
2.1	**2.1 General**					
2.1.1	**2.1.1 Mode of Operation**					
2.1.1.0-1	The ASCT shall operate non-adaptively during the presence of a defined condition.	4.7.0-1	The system needs the ability to detect traffic conditions during which adaptive control is not the preferred operation, and implement some pre-defined operation while that condition is present.	X		

System Requirements Reference Number	System Requirement Description	ConOps Needs	ConOps Statement	Mandatory	Desirable	Optional
2.1.1.0-2	The ASCT shall operate non-adaptively when adaptive control equipment fails.	4.14.0-1	The system needs the ability to fall back to TOD or actuated operation constrained by coordination, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications, and software failure.	X		
2.1.1.0-2.0-1	The ASCT shall be capable of operating non-adaptively when the number of failed detectors connected to a signal controller exceeds a user-defined value.	4.14.0-1	The system needs the ability to fall back to TOD or actuated operation constrained by coordination, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications, and software failure.	X		
2.1.1.0-2.0-2	The ASCT shall be capable of operating non-adaptively when a user manually commands the ASCT to cease adaptively controlling a group of signals.	4.14.0-1	The system needs the ability to fall back to TOD or actuated operation constrained by coordination, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications, and software failure.	X		
2.1.1.0-2.0-3	The ASCT shall be capable of operating non-adaptively when a user-defined communications link fails.	4.14.0-1	The system needs the ability to fall back to TOD or actuated operation constrained by coordination, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications, and software failure.	X		
2.1.1.0-3	The ASCT shall be capable of operating non-adaptively when a user manually commands the ASCT to cease adaptively controlling a group of signals.	4.7.0-3	The system needs the ability to over-ride adaptive operation.	X		
2.1.1.0-4	The ASCT shall be capable of operating non-adaptively when a user manually commands the ASCT to cease adaptive operation.	4.7.0-3	The system needs the ability to fall back to TOD or actuated operation constrained by coordination, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications, and software failure.	X		
2.1.1.0-5	The ASCT shall be capable of operating non-adaptively in accordance with a user-defined time-of-day schedule such as AM/PM peaks.	4.7.0-2 4.7.0-3	The system needs the ability to schedule pre-determined operation by time of day. The system needs the ability to fall back to TOD or actuated operation constrained by coordination, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications, and software failure.	X		
2.1.1.0-6	The ASCT shall be capable of operating non-adaptively when commanded by an external system process.	4.17.0-3	The system needs the ability to be capable of responding to commands issued by the Traffic Management System.		X	
2.1.1.0-7	The ASCT be capable of altering the adaptive operation by adjusting parameters or by directly controlling the state of signal controllers.*	4.1.0-1.0-1 4.1.0-1.0-3 4.1.0-3 8.2.1.1 8.2.1.2 8.2.1.3 8.2.1.4 8.2.1.5 8.2.1.6 8.2.2.1 8.2.2.2 8.2.2.3	Maximize the throughput on coordinated routes. Distribute phase times in an equitable fashion. The system needs the ability to change the operational strategy (for example, from smooth flow to maximizing throughput or managing queues) based on changing traffic conditions. Have the ability to monitor traffic conditions and select appropriate signal timing parameters, such as cycle length, green time, offsets, and/or double servicing specific phases where conditions permit. Have the ability to determine intersection grouping and establish timing to smooth traffic and provide progression. Have the ability to for timing parameters will vary cycle to cycle based on changing traffic conditions. Have the ability to monitor traffic volumes and adjust progression based on traffic demands. Have the ability to monitor minor approach left turns for queue spillback and automatically increase left turn green time or double service to minimize queue length, constrained by coordination. Have the flexibility to be coordinated as one group or have the freedom to operate as separate groups as set by the operators or as dictated by traffic demand. Have the ability to monitor traffic conditions and select appropriate signal timing parameters, such as cycle length, green time, offsets, and/or double servicing specific phases where conditions permit. Have the ability to determine intersection grouping and establish timing to smooth traffic and provide progression. Have the ability to for timing parameters will vary cycle to cycle based on changing traffic conditions.			

System Requirements Reference Number	System Requirement Description	ConOps Needs	ConOps Statement	Mandatory	Desirable	Optional
		8.2.2.4	Have the ability to monitor traffic volumes and adjust progression based on traffic demands.			
		8.2.2.5	Have the ability to monitor minor approach left turns for queue spillback and automatically increase left turn green time or double service to minimize queue length, constrained by coordination.			
		8.2.2.6	Have the flexibility to be coordinated as one group or have the freedom to operate as separate groups as set by the operators or as dictated by traffic demand.			
		8.2.3.1	Have the ability to monitor traffic conditions and select appropriate signal timing parameters, such as cycle length, green time, offsets, and/or double servicing specific phases where conditions permit.			
		8.2.3.2	Have the ability to determine intersection grouping and establish timing to smooth traffic and provide progression.			
		8.2.3.3	Have the ability to for timing parameters will vary cycle to cycle based on changing traffic conditions.			
		8.2.3.4	Have the ability to monitor traffic volumes and adjust progression based on traffic demands.			
		8.2.3.5	Have the ability to monitor minor approach left turns for queue spillback and automatically increase left turn green time or double service to minimize queue length, constrained by coordination.			
		8.2.3.6	Have the flexibility to be coordinated as one group or have the freedom to operate as separate groups as set by the operators or as dictated by traffic demand.			
		8.3.1.1	Have the ability to automatically change goals to provide maximum throughput.			
		8.3.1.2	Have the ability to monitor traffic conditions and select appropriate signal timing parameters, cycle length, green time, offsets, and/or double servicing specific phases where conditions permit.			
		8.3.1.3	Have the ability to determine intersection grouping and establish timing to maximize the movement of vehicles			
		8.3.1.4	Have the ability for timing parameters to vary cycle to cycle based on changing traffic conditions.			
		8.3.1.5	Have the ability to monitor traffic volumes and adjust progression based on traffic demands.			
		8.3.1.6	Have the ability to monitor minor approach left turns for queue spillback and automatically increase left turn green time or double service to minimize queue length, constrained by coordination.			
		8.3.1.7	Have the flexibility to be coordinated as one group or have the freedom to operate as separate groups as set by the operators or as dictated by traffic demand			
		8.3.2.1	Have the ability to automatically change goals to provide maximum throughput.			
		8.3.2.2	Have the ability to monitor traffic conditions and select appropriate signal timing parameters, cycle length, green time, offsets, and/or double servicing specific phases where conditions permit.		X	
		8.3.2.3	Have the ability to determine intersection grouping and establish timing to maximize the movement of vehicles			
		8.3.2.4	Have the ability for timing parameters to vary cycle to cycle based on changing traffic conditions.			
		8.3.2.5	Have the ability to monitor traffic volumes and adjust progression based on traffic demands.			
		8.3.2.6	Have the ability to monitor minor approach left turns for queue spillback and automatically increase left turn green time or double service to minimize queue length, constrained by coordination.			
		8.3.2.7	Have the flexibility to be coordinated as one group or have the freedom to operate as separate groups as set by the operators or as dictated by traffic demand			
		8.3.3.1	Have the ability to automatically change goals to provide maximum throughput.			

System Requirements Reference Number	System Requirement Description	ConOps Needs	ConOps Statement	Mandatory	Desirable	Optional
		8.3.3.2	Have the ability to monitor traffic conditions and select appropriate signal timing parameters, cycle length, green time, offsets, and/or double servicing specific phases where conditions permit.			
		8.3.3.3	Have the ability to determine intersection grouping and establish timing to maximize the movement of vehicles			
		8.3.3.4	Have the ability for timing parameters to vary cycle to cycle based on changing traffic conditions.			
		8.3.3.5	Have the ability to monitor traffic volumes and adjust progression based on traffic demands.			
		8.3.3.6	Have the ability to monitor minor approach left turns for queue spillback and automatically increase left turn green time or double service to minimize queue length, constrained by coordination.			
		8.3.3.7	Have the flexibility to be coordinated as one group or have the freedom to operate as separate groups as set by the operators or as dictated by traffic demand			
		8.4.1.1	Select phase times or offsets that provide smooth flow along the corridor in both directions.			
		8.4.1.2	Provide signal timing that prevents phase failures at all intersections and serves all turning traffic.			
		8.4.1.3	At specified intersections, select phase times that will accommodate frequent use of pedestrian phases.			
		8.4.1.4	At other intersections, select phase times that will accommodate occasional use of pedestrian phases.			
		8.5.1.1	If there is heavily direction traffic before or after an event, the system will determine the predominate direction and coordinate accordingly, with appropriate cycle length and offset.			
		8.5.1.2	If the event is not as heavy as peak hours, but the traffic is still highly directional, then the system will recognize this and provide the coordination predominantly in the heaviest direction, even though the cycle length may be similar to peak hour cycle lengths.			
		8.5.1.3	The entire corridor may be set by the operator to operate as one or more coordinated groups, or the system may have the freedom to operate it as one of more groups subject to user-specified criteria, such as similar required cycle lengths in different parts of the corridor, of the volume of traffic at key locations exceeds a threshold.			
		8.5.1.4	If downstream signals experience lighter traffic as a result of an incident blocking and restricting traffic, those signal should be coordinate as a group, with cycle length, splits and offsets that react to the measured traffic.			
		8.5.1.5	If a detected blockage is in the peak direction, then the system may coordinate in the opposite direction if that traffic is similar to or greater than normal peak direction.			
		8.5.1.6	The system needs to recognize the presence of an abnormal obstruction, modify the signal operation to react to the change traffic conditions in an efficient manner, and report the abnormal condition to the operator.			
		8.6.1-1	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.			
2.1.1.0-7.0-1	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.	4.1.0-1.0-1	Maximize the throughput on coordinated routes.			

System Requirements Reference Number	System Requirement Description	ConOps Needs	ConOps Statement	Mandatory	Desirable	Optional
		4.1.0-3	The system needs the ability to change the operational strategy (for example, from smooth flow to maximizing throughput or managing queues) based on changing traffic conditions.	X		
2.1.1.0-7.0-2	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.	4.1.0-1.0-4 4.1.0-3	Manage the length of queues. The system needs the ability to change the operational strategy (for example, from smooth flow to maximizing throughput or managing queues) based on changing traffic conditions.	X		
2.1.1.0-7.0-3	When current measured traffic conditions meet user-specified criteria, the ASCT shall alter the state of signal controllers providing equitable distribution of green times.*	4.1.0-1.0-3 4.1.0-3 5.2.0-3	Distribute phase times in an equitable fashion. The system needs the ability to change the operational strategy (for example, from smooth flow to maximizing throughput or managing queues) based on changing traffic conditions. The objective of the coordination will be to control traffic in a manner that equitably serves the adjacent land uses. The delays experienced by the traffic entering and leaving the coordinated route will be balanced with the delays and stops experienced by other traffic traveling along the route.	X		
2.1.1.0-7.0-4	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.	4.1.0-1.0-2 4.1.0-3	Provide smooth flow along coordinated routes. The system needs the ability to change the operational strategy (for example, from smooth flow to maximizing throughput or managing queues) based on changing traffic conditions.	X		
2.1.1.0-7.0-5	The ASCT shall operate non-adaptively when user constraints command the ASCT to cease adaptive operation.	4.7.0-1	The system needs the ability to detect traffic conditions during which adaptive control is not the preferred operation, and implement some pre-defined operation while that condition is present.		X	
2.1.1.0-8	The ASCT shall provide maximum and minimum phase times.	4.1.0-1.0-3 4.1.0-1.0-6	Distribute phase times in an equitable fashion. At an isolated intersection, optimize operation with a minimum of phase failures (based on the optimization objectives).	X		
2.1.1.0-8.0-1	The ASCT shall provide a user-specified maximum value for each phase at each signal controller.	4.1.0-1.0-3 4.1.0-1.0-6	Distribute phase times in an equitable fashion. At an isolated intersection, optimize operation with a minimum of phase failures (based on the optimization objectives).	X		
2.1.1.0-8.0-1.0-1	The ASCT shall not provide a phase length longer than the maximum value.*	4.1.0-1.0-3 4.1.0-1.0-6	Distribute phase times in an equitable fashion. At an isolated intersection, optimize operation with a minimum of phase failures (based on the optimization objectives).			X
2.1.1.0-8.0-2	The ASCT shall provide a user-specified minimum value for each phase at each signal controller.*	4.1.0-1.0-3 4.1.0-1.0-6	Distribute phase times in an equitable fashion. At an isolated intersection, optimize operation with a minimum of phase failures (based on the optimization objectives).	X		
2.1.1.0-8.0-2.0-1	The ASCT shall not provide a phase length shorter than the minimum value.	4.1.0-1.0-3 4.1.0-1.0-6	Distribute phase times in an equitable fashion. At an isolated intersection, optimize operation with a minimum of phase failures (based on the optimization objectives).	X		
2.1.1.0-9	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.)*	4.1.0-4	The system needs the ability to detect repeated phase failures and control signal timing to prevent phase failures building up queues.	X		
2.1.1.0-9.0-1	The ASCT shall alter operations to minimize phase failures if it detects repeated phases that do not serve all waiting vehicles.*	4.1.0-4	The system needs the ability to detect repeated phase failures and control signal timing to prevent phase failures building up queues.		X	
2.1.1.0-10	The ASCT shall provide coordination along a route.*	4.1.0-7	The system needs the ability to designate the coordinated route based on traffic conditions and the selected operational strategy	X		
2.1.1.0-10.0-1	The ASCT shall coordinate along a user-defined route.	4.1.0-7	The system needs the ability to designate the coordinated route based on traffic conditions and the selected operational strategy	X		
2.1.1.0-10.0-2	The ASCT shall determine the coordinated route based on traffic conditions.	4.1.0-7	The system needs the ability to designate the coordinated route based on traffic conditions and the selected operational strategy		X	

System Requirements Reference Number	System Requirement Description	ConOps Needs	ConOps Statement	Mandatory	Desirable	Optional
2.1.1.0-10.0-3	The ASCT shall determine the coordinated route based on a user-defined schedule.	4.1.0-7	The system needs the ability to designate the coordinated route based on traffic conditions and the selected operational strategy	X		
2.1.1.0-10.0-4	The ASCT shall store user-defined coordination routes.	4.1.0-7	The system needs the ability to designate the coordinated route based on traffic conditions and the selected operational strategy	X		
2.1.1.0-10.0-4.0-1	The ASCT shall implement a stored coordinated route by operator command.	4.1.0-7	The system needs the ability to designate the coordinated route based on traffic conditions and the selected operational strategy	X		
2.1.1.0-10.0-4.0-2	The ASCT shall implement a stored coordinated route based on traffic conditions.	4.1.0-7	The system needs the ability to designate the coordinated route based on traffic conditions and the selected operational strategy	X		
2.1.1.0-10.0-4.0-3	The ASCT shall implement a stored coordinated route based on a user-defined schedule.	4.1.0-7	The system needs the ability to designate the coordinated route based on traffic conditions and the selected operational strategy	X		
2.1.1.0-11	The ASCT shall not prevent the use of phase timings in the local controller set by NJDOT policy.	4.1.0-8	The system needs the ability to set signal timing parameters to comply with NJDOT policies.	X		
2.1.2	**2.1.2 Allowable Phases**					
2.1.2.0-1	The ASCT shall allow protected/permissive left turn phase operation.	4.9.0-1.0-13 5.6.0-12	• Protected/permissive phasing and alternate left turn phase sequences. • Protected/permissive and permissive only phasing.	X		
2.1.2.0-2	The ASCT shall allow the protected left turn phase to lead or lag the opposing through phase based upon user-specified conditions.	4.9.0-1.0-13	• Protected/permissive phasing and alternate left turn phase sequences.		X	
2.1.2.0-3	The ASCT shall prevent skipping a user-specified phase when the user-specified phase sequence is operating.	4.9.0-1.0-5	• Prevent one or more phases being skipped under certain traffic conditions or signal states.	X		
2.1.2.0-4	The ASCT shall prevent skipping a user-specified phase based on a user-specified external input.	4.9.0-1.0-5 4.17.0-3 5.6.0-7	• Prevent one or more phases being skipped under certain traffic conditions or signal states. The system needs the ability to be capable of responding to commands issued by the Traffic Management System. • The NJDOT will permit phases or overlaps by time-of-day schedule or external input.		X	
2.1.2.0-5	The ASCT shall prevent skipping a user-specified phase according to a time of day schedule.	4.9.0-1.0-5	• Prevent one or more phases being skipped under certain traffic conditions or signal states.	X		
2.1.2.0-6	The ASCT shall have the ability, subject to user constraints, to omit a user-specified phase when the cycle length is below a user-specified value.	4.9.0-1.0-4 5.6.0-4	• Allow one or more phases to be omitted (disabled) under certain traffic conditions or signal states. • The ability to omit a phase under some traffic conditions, or based on external input, to allow a shorter cycle length to operate, or to provide additional time to other phases.			X
2.1.2.0-7	The ASCT shall have the ability to omit a user-specified phase based on measured traffic conditions.	4.9.0-1.0-4 4.17.0-3 5.2.0-6	• Allow one or more phases to be omitted (disabled) under certain traffic conditions or signal states. The system needs the ability to be capable of responding to commands issued by the Traffic Management System. The operator will be able to define for each group of intersections the appropriate operational objective. For example, near a freeway interchange or in a location with heavy turning movements, the queue management strategy may be specified, while on an arterial with long signal spacing the smooth flow objective may be specified.			X
2.1.2.0-8	The ASCT shall have the ability to omit a user-specified phase according to a time of day schedule	4.9.0-1.0-4	• Allow one or more phases to be omitted (disabled) under certain traffic conditions or signal states.			X
2.1.2.0-9	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.	4.9.0-1.0-9 5.6.0-10 5.6.0-11	• Allow the operator to specify which phase receives unused time from a preceding phase. • The ability to allow the coordinated phase to terminate early if the coordinated platoon is short. • The ability to introduce a non-coordinated phase later than its normal starting point within a cycle, if it can be served with minimum green within the remaining time available.	X		
2.1.2.0-10	The ASCT shall assign unused time from a preceding phase that is skipped to a user-specified phase as follows:	4.9.0-1.0-9	• Allow the operator to specify which phase receives unused time from a preceding phase.			

System Requirements Reference Number	System Requirement Description	ConOps Needs	ConOps Statement	Mandatory	Desirable	Optional
	• Previous phase • Next phase • Next coordinated phase • User-specified phase.			X		
2.1.2.0-11	The ASCT shall have the ability to not alter the order of phases at a user-specified intersection.	4.1.0-6	The system needs the ability to fix the sequence of phases at any specified location.	X		
2.1.2.0-12	The ASCT shall prevent, without the use of wired jumpers in the cabinet, controller phase change sequences that would create a “Yellow Trap” condition for left turn.	3.4.3.0-1.0-2	• Provide the same or higher level of safety provided by the existing system to vehicles, pedestrians and transit.	X		
2.1.3	**2.1.3 Oversaturation**					
2.1.3.0-1	The ASCT shall detect the presence of queues at preconfigured locations.	4.1.0-1.0-4 4.1.0-1.0-5 4.1.0-4 4.5.0-1 4.5.0-2 4.5.0-3 4.5.0-4 4.5.0-5	Manage the length of queues. Manage the locations of queues within the network. The system needs the ability to detect repeated phase failures and control signal timing to prevent phase failures building up queues. The system needs the ability to detect queues from outside the system and modify the ASCT operation to accommodate the queuing. The system needs the ability to detect queues within the system's boundaries and modify the ASCT operation to accommodate the queuing. The system needs the ability to detect queues propagating outside its boundaries from within the ASCT boundaries, and modify its operation to accommodate the queuing. The system needs the ability to store queues in locations where they can be accommodated without adversely affecting adaptive operation. The system needs the ability to prevent queues forming at user specified locations.	X		
2.1.3.0-2	When queues are detected at user-specified locations, the ASCT shall execute user-specified timing plan/operational mode.	4.1.0-1.0-4 4.1.0-1.0-5 4.5.0-1 4.2.0-2 4.6.0-3 4.6.0-4	Manage the length of queues. Manage the locations of queues within the network. The system needs the ability to detect queues from outside the system and modify the ASCT operation to accommodate the queuing. The system needs the ability to be able to eventually adaptively control up to XX independent groups of signalized intersections. Frequent pedestrian actuated calls: The system needs the ability to incorporate frequent pedestrian operation into routine adaptive operation. Pedestrian nonactuated calls: Nonactuated pedestrian phases are always on recall.	X		
2.1.3.0-3	When queues are detected at user-specified locations, the ASCT shall execute user-specified adaptive strategy.*	4.1.0-1.0-4 4.1.0-1.0-5 4.5.0-1 4.5.0-2 4.5.0-3 4.5.0-4 4.5.0-5	Manage the length of queues. Manage the locations of queues within the network. The system needs the ability to detect queues from outside the system and modify the ASCT operation to accommodate the queuing. The system needs the ability to detect queues within the system's boundaries and modify the ASCT operation to accommodate the queuing. The system needs the ability to detect queues propagating outside its boundaries from within the ASCT boundaries, and modify its operation to accommodate the queuing. The system needs the ability to store queues in locations where they can be accommodated without adversely affecting adaptive operation. The system needs the ability to prevent queues forming at user specified locations.	X		

System Requirements Reference Number	System Requirement Description	ConOps Needs	ConOps Statement	Mandatory	Desirable	Optional
		5.2.0-4 5.2.0-9	The objective of the coordination will be to manage the lengths of queues stored at critical locations within the coordinated group so that long queues do not block upstream intersections or otherwise reduce the capacity available during the green phases. This will involve controlling phase lengths so that the size of platoons entering a downstream block does not exceed the storage length if the platoon will be stopped. It will also involve control of offsets and phase lengths so that queues may be stored in locations where they will not adversely affect capacity of the system. At an isolated intersection with widely varying traffic patterns and a high degree of saturation during peak times, the system will calculate the optimum cycle length, and phase times in real time to match the changing traffic conditions.			
2.1.3.0-4	When queues are detected at user-specified locations, the ASCT shall omit a user-specified phase at a user-specified signal controller.	4.1.0-1.0-4 4.1.0-1.0-5 4.5.0-1 4.5.0-2 4.5.0-3 4.5.0-4 4.5.0-5	Manage the length of queues. Manage the locations of queues within the network. The system needs the ability to detect queues from outside the system and modify the ASCT operation to accommodate the queuing. The system needs the ability to detect queues within the system's boundaries and modify the ASCT operation to accommodate the queuing. The system needs the ability to detect queues propagating outside its boundaries from within the ASCT boundaries, and modify its operation to accommodate the queuing. The system needs the ability to store queues in locations where they can be accommodated without adversely affecting adaptive operation. The system needs the ability to prevent queues forming at user specified locations.			X
2.1.3.0-5	When queues are detected at user-specified locations, the ASCT shall limit the cycle length of the group to a user-specified value.*	4.1.0-1.0-4	Manage the length of queues.	X		
2.2	**2.2 Sequence-based Adaptive Coordination**					
2.2.0-1	The ASCT shall calculate appropriate cycle length for a signal group based on existing traffic conditions.	4.1.0-1.0-1 4.1.0-1.0-2 4.1.0-1.0-3 4.1.0-1.0-4	Maximize the throughput on coordinated routes. Provide smooth flow along coordinated routes. Distribute phase times in an equitable fashion. Manage the length of queues.	X		
2.2.0-2	The ASCT shall have the ability to select a cycle/period length based on a time of day schedule.	4.1.0-1.0-1 4.1.0-1.0-2 4.1.0-1.0-3 4.1.0-1.0-4	Maximize the throughput on coordinated routes. Provide smooth flow along coordinated routes. Distribute phase times in an equitable fashion. Manage the length of queues.		X	
2.2.0-3	The ASCT shall calculate phase lengths for all phases at each signal controller to suit the current coordination strategy.	4.1.0-1.0-3 4.1.0-1.0-5 4.1.0-4	Distribute phase times in an equitable fashion. Manage the locations of queues within the network. The system needs the ability to detect repeated phase failures and control signal timing to prevent phase failures building up queues.	X		
2.2.0-4	The ASCT shall calculate and vary offsets to suit the current coordination strategy for the user-specified reference point for each signal controller along a coordinated route within a group.	4.1.0-1.0-1 4.1.0-1.0-2 4.1.0-1.0-4	Maximize the throughput on coordinated routes. Provide smooth flow along coordinated routes. Manage the length of queues.			

System Requirements Reference Number	System Requirement Description	ConOps Needs	ConOps Statement	Mandatory	Desirable	Optional
		5.2.0-5	The system, or the operator, will select the appropriate coordination objective, depending on the current traffic conditions. For example, during commuter peaks the primary objective may be to maximize the throughput along the road in the peak direction. Then during the business hours the objective may be to balance delays between traffic associated with the adjacent activity and traffic simply traveling through the system.	X		
2.2.0-4.0-1	The ASCT shall apply offsets for the user-specified reference point of each signal controller along a coordinated route.	4.1.0-1.0-1	Maximize the throughput on coordinated routes.	X		
2.2.0-5	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).	4.1.0-1.0-1 4.1.0-1.0-2 4.1.0-1.0-3 4.1.0-1.0-4 5.2.0-2 5.2.0-6	Maximize the throughput on coordinated routes. Provide smooth flow along coordinated routes. Distribute phase times in an equitable fashion. Manage the length of queues. The objective of the coordination will be to maximize the throughput along the coordinated route. This may involve a tradeoff that increases delay to cross streets and turning movements, in order to maximize the green time provided to coordinated traffic flows. The operator will be able to define for each group of intersections the appropriate operational objective. For example, near a freeway interchange or in a location with heavy turning movements, the queue management strategy may be specified, while on an arterial with long signal spacing the smooth flow objective may be specified.	X		
2.2.0-5.0-1	The ASCT shall limit cycle lengths to user-specified values.	4.1.0-1.0-1 4.1.0-1.0-2 4.1.0-1.0-3 4.1.0-1.0-4	Maximize the throughput on coordinated routes. Provide smooth flow along coordinated routes. Distribute phase times in an equitable fashion. Manage the length of queues.	X		
2.2.0-5.0-2	The ASCT shall limit cycle lengths to a user-specified range.	4.1.0-1.0-1 4.1.0-1.0-2 4.1.0-1.0-3 4.1.0-1.0-4 5.2.0-2	Maximize the throughput on coordinated routes. Provide smooth flow along coordinated routes. Distribute phase times in an equitable fashion. Manage the length of queues. The objective of the coordination will be to maximize the throughput along the coordinated route. This may involve a tradeoff that increases delay to cross streets and turning movements, in order to maximize the green time provided to coordinated traffic flows.	X		
2.2.0-5.0-3	The ASCT shall calculate optimum cycle length according to the user-specified coordination strategy.	4.1.0-1.0-1 4.1.0-1.0-2 4.1.0-1.0-3 4.1.0-1.0-4	Maximize the throughput on coordinated routes. Provide smooth flow along coordinated routes. Distribute phase times in an equitable fashion. Manage the length of queues.	X		
2.2.0-5.0-4	The ASCT shall limit changes in cycle length to not exceed a user-specified value for user-specified time-of-day schedule.	4.1.0-1.0-1 4.1.0-1.0-2 4.1.0-1.0-3 4.1.0-1.0-4	Maximize the throughput on coordinated routes. Provide smooth flow along coordinated routes. Distribute phase times in an equitable fashion. Manage the length of queues.	X		
2.2.0-5.0-5	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.	4.1.0-5	The system needs to minimize the chance that a queue forms at a specified location.	X		
2.3	**Non-sequence-based adaptive coordination**					
2.4	**Single intersection adaptive operation**					
2.4.0-1	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.)	4.1.0-1.0-6	At an isolated intersection, optimize operation with a minimum of phase failures (based on the optimization objectives).	X		
2.4.0-2	The ASCT shall calculate optimum phase lengths of a single intersection, based on current measured traffic conditions. (The calculation is based on the optimization objectives.)	4.1.0-1.0-3	Distribute phase times in an equitable fashion.	X		
2.4.0-2.0-1	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.	4.1.0-1.0-3 4.1.0-1.0-6	Distribute phase times in an equitable fashion. At an isolated intersection, optimize operation with a minimum of phase failures (based on the optimization objectives).			X

System Requirements Reference Number	System Requirement Description	ConOps Needs	ConOps Statement	Mandatory	Desirable	Optional
2.4.0-3	The ASCT shall calculate phase order based on current measured traffic conditions and the optimization objectives, while constrained by user-input.	4.1.0-1.0-6	At an isolated intersection, optimize operation with a minimum of phase failures (based on the optimization objectives).			X
2.5	**Phase-based adaptive coordination**					
2.5.0-1	The ASCT shall alter the state of the signal controller for all phases at the user-specified intersection.	4.1.0-2	The system needs the ability to manage the coordination in small groups of signals to link phase service at some intersections with phase service at adjacent intersections.	X		
2.5.0-2	The ASCT shall calculate the time at which a user-specified phase shall be green at an intersection.*	4.1.0-2	The system needs the ability to manage the coordination in small groups of signals to link phase service at some intersections with phase service at adjacent intersections.	X		
2.5.0-3	When demand is present, the ASCT shall implement a user-specified maximum time between successive displays of each phase at each intersection.	4.1.0-2	The system needs the ability to manage the coordination in small groups of signals to link phase service at some intersections with phase service at adjacent intersections.	X		
2.5.0-4	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.*	4.1.0-2 4.17.0-2 5.2.0-10	The system needs the ability to manage the coordination in small groups of signals to link phase service at some intersections with phase service at adjacent intersections. The system needs to react to traffic volume and traffic operation condition change due to special events. At a small group of intersections, with the user defining one as being critical, while the adjacent intersections require a lower cycle length or progression must be provided for specific phases to minimize the formation of queues on the approaches to the critical intersection, the phase lengths of the critical intersection will be determined by the system based on the current traffic conditions. The operation of the adjacent intersections will then be set so that platoons departing the critical intersection are progressed through the non-critical intersections, or platoons arriving at the critical intersection do so at a time when they will have little or no delay waiting for the appropriate phase.		X	
2.5.0-5	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.*	4.1.0-2	The system needs the ability to manage the coordination in small groups of signals to link phase service at some intersections with phase service at adjacent intersections.		X	
2.5.0-6	The ASCT shall allow flexible assignment of the coordinated phases based on a user-specified measured traffic condition.	4.1.0-5 4.1.0-3	The system needs to minimize the chance that a queue forms at a specified location. The system needs the ability to change the operational strategy (for example, from smooth flow to maximizing throughput or managing queues) based on changing traffic conditions.		X	
2.5.0-7	The ASCT shall allow flexible assignment of the coordinated phases based on a user-specified time-of-day schedule.	4.1.0-5 4.1.0-3	The system needs to minimize the chance that a queue forms at a specified location. The system needs the ability to change the operational strategy (for example, from smooth flow to maximizing throughput or managing queues) based on changing traffic conditions.		X	
2.5.0-8	The ASCT shall allow fully-actuated coordination where the coordinated phases may gap out in absence of demand.	4.1.0-5 4.1.0-3	The system needs to minimize the chance that a queue forms at a specified location. The system needs the ability to vary the number of signals in an adaptively controlled group to accommodate the prevailing traffic conditions.	X		
2.5.0-9	The ASCT shall have the ability to allow the coordinated phase (X+X) to be on recall.	4.1.0-5 4.1.0-3	The system needs to minimize the chance that a queue forms at a specified location. The system needs the ability to change the operational strategy (for example, from smooth flow to maximizing throughput or managing queues) based on changing traffic conditions.	X		
2.6	**Responsiveness**					
2.6.0-1	The ASCT shall have the ability to limit the change in consecutive cycle lengths to be less than a user-specified value.	4.8.0-1 4.8.0-2	The system needs the ability to modify the ASCT operation to closely follow changes in traffic conditions. The system needs the ability to constrain the selection of cycle lengths to those that provide acceptable operations, such as when resonant progression solutions are desired.		X	
2.6.0-2	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.)	4.8.0-1	The system needs the ability to modify the ASCT operation to closely follow changes in traffic conditions.		X	

System Requirements Reference Number	System Requirement Description	ConOps Needs	ConOps Statement	Mandatory	Desirable	Optional
2.6.0-3	The ASCT shall limit the changes in the direction of primary coordination to a user-specified frequency.	4.8.0-1 4.8.0-2	The system needs the ability to modify the ASCT operation to closely follow changes in traffic conditions. The system needs the ability to constrain the selection of cycle lengths to those that provide acceptable operations, such as when resonant progression solutions are desired.		X	
2.6.0-4	When a large change in traffic demand is detected, the ASCT shall have the ability to respond within a user-defined amount of cycles more quickly than during normal operation, subject to user-specified limits.	4.8.0-3 4.17.0-2 5.2.0-8 8.9.1-1	The system needs to respond within a user-defined amount of cycles to sudden large shift in traffic conditions. The system needs to react to traffic volume and traffic operation condition change due to special events. Within these operational objectives, the ASCT system will change its operation to accommodate the rise and fall of volumes through the peaks, and the changing patterns of flow throughout the day and week. However, there is also a stochastic element to traffic in the short term, with the number of arrivals for a phase varying from cycle to cycle, and pedestrians not being present on all phases in all cycles. It is therefore desirable for the system to have some local tactical control. While vehicle-actuated coordination typically allows phases to run longer or shorter from cycle to cycle to match the actual number of vehicles using the phase, the system will also allow the operator to decide where the unused time will be used. If a phase is to be skipped, the operator can specify that the spare time will be added to the existing phase, the following phase, or the next coordinated phase. 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. The system will then return to normal operation.		X	
2.6.0-5	The ASCT shall have the ability to automatically select cycle/period lengths from a list of user-defined cycle lengths.	4.8.0-2	The system needs the ability to constrain the selection of cycle lengths to those that provide acceptable operations, such as when resonant progression solutions are desired.	X		
2.6.0-6	The ASCT shall have the ability to respond non-reoccurring events, incidents and other unexpected events.	8.5.1.1 8.5.1.2 8.5.1.3 8.5.1.4 8.5.1.5 8.5.1.6	If there is heavily direction traffic before or after an event, the system will determine the predominate direction and coordinate accordingly, with appropriate cycle length and offset. If the event is not as heavy as peak hours, but the traffic is still highly directional, then the system will recognize this and provide the coordination predominantly in the heaviest direction, even though the cycle length may be similar to peak hour cycle lengths. The entire corridor may be set by the operator to operate as one or more coordinated groups, or the system may have the freedom to operate it as one of more groups subject to user-specified criteria, such as similar required cycle lengths in different parts of the corridor, of the volume of traffic at key locations exceeds a threshold. If downstream signals experience lighter traffic as a result of an incident blocking and restricting traffic, those signal should be coordinate as a group, with cycle length, splits and offsets that react to the measured traffic. If a detected blockage is in the peak direction, then the system may coordinate in the opposite direction if that traffic is similar to or greater than normal peak direction. The system needs to recognize the presence of an abnormal obstruction, modify the signal operation to react to the change traffic conditions in an efficient manner, and report the abnormal condition to the operator.	X		

System Requirements Reference Number	System Requirement Description	ConOps Needs	ConOps Statement	Mandatory	Desirable	Optional
3	**External/Internal Interfaces**					
3.0-1	The ASCT shall support external interfaces according to the following detailed requirements: • Information layer protocol • Application layer protocol • Lower layer protocol • Data interface • Frequency of storage • Frequency of reporting • Duration of storage)	4.3.0-1 4.3.0-2 4.3.0-4 4.11-0.5 4.17.0-3	The system needs the ability to adaptively control signals operated by NJDOT. The system needs the ability to send data to another system that would allow the other system to coordinate with the ASCT system. The system needs the ability to receive data from another system that will allow the ASCT system to coordinate its operation with the adjacent system. The system needs the ability to report performance data at least once a minute. The system needs the ability to be capable of responding to commands issued by the Traffic Management System.	X		
3.0-1.0-1	The ASCT shall send the following data to external systems including ITS Readiness Checklist in SQL: • Operational • Performance	4.3.0-2 4.11-0.5 4.17.0-1	The system needs the ability to send data to another system that would allow the other system to coordinate with the ASCT system. The system needs the ability to report performance data at least once a minute. The system needs the ability 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	X		
3.0-1.0-2	The ASCT shall have the capability to internally log the following data: • Operational • Control • Monitoring • Coordination • Performance	4.3.0-2	The system needs the ability to send data to another system that would allow the other system to coordinate with the ASCT system.	X		
3.0-1.0-3	The ASCT shall have the ability to send operational, control, monitoring, and control data to external systems in non-proprietary formats.	4.3.0-2	The system needs the ability to send data to another system that would allow the other system to coordinate with the ASCT system.	X		
3.0-1.0-4	The ASCT shall coexist with the external Traffic Management System software compatible with the local traffic signal controller.	4.11-0.1	The NJDOT needs the ability for the Traffic Management System to be able to coexist with or monitor the adaptive system.	X		
3.0-1.0-5	The ASCT shall have the ability to integrate the midblock system detector data into adaptive operation for event triggers, routines, changes to offsets, and force offs.	4.19.0-1 4.19.0-3	The system needs the ability to interface with midblock system detectors. The adaptive system needs the ability to integrate the system detection data into adaptive operation.	X		
3.1-1	The ASCT shall have an integrated user-friendly graphic user interface (GUI) to provide graphic displays, import and generation of graphic images, and automatic update of maps and graphics.	4.10.0-3	The system needs to have an integrated user-friendly graphic user interface (GUI) to provide graphic displays, import and generation of graphic images, automatic updating of maps and graphics, and update this data in real time (at least once per second).	X		
3.1-2	All graphic displays shall ensure instantaneous generation of the graphic display, including the background map and the real-time (at least once a second) feedback data.	4.10.0-3	The system needs to have an integrated user-friendly graphic user interface (GUI) to provide graphic displays, import and generation of graphic images, automatic updating of maps and graphics, and update this data in real time (at least once per second).	X		
3.1-3	At the system-wide graphic display, the GUI shall identify the following status for traffic signals with less than 2 seconds of latency:	4.10.0-3	The system needs to have an integrated user-friendly graphic user interface (GUI) to provide graphic displays, import and generation of graphic images, automatic updating of maps and graphics, and update this data in real time (at least once per second).			

System Requirements Reference Number	System Requirement Description	ConOps Needs	ConOps Statement	Mandatory	Desirable	Optional
	• Free operation • Coordinated operation • Adaptive operation • Dynamic grouping • Pattern transition • Tripped conflict monitor • Flash mode • Loss of communications • Loss of detection • Failure of adaptive software/hardware • Emergency or railroad preemption • Transit priority service	4.10.0-3	The system needs to have an integrated user-friendly graphic user interface (GUI) to provide graphic displays, import and generation of graphic images, automatic updating of maps and graphics, and update this data in real time (at least once per second).	X		
3.1-4	At a detailed intersection display, the GUI shall provide a greater level of detail information in addition to the above-listed, and including: • Street names • Current timing plan in use (cycle length and offset) • Signal displays (vehicle and pedestrian) • Current communications status • Control mode • Vehicle calls by phase • Pedestrian calls by phase • Detector status and actuation • Special functions • Timing plan parameters (actual versus programmed – only applicable when operating TOD) • Active, incrementing cycle clock • Active and progressive real-time timing bands (Time Space Diagram)	4.10.0-3 4.10.0-3	The system needs to have an integrated user-friendly graphic user interface (GUI) to provide graphic displays, import and generation of graphic images, automatic updating of maps and graphics, and update this data in real time (at least once per second). The system needs to have an integrated user-friendly graphic user interface (GUI) to provide graphic displays, import and generation of graphic images, automatic updating of maps and graphics, and update this data in real time (at least once per second).	X		
3.1-5	The GUI shall allow the user to enable/disable the desired layer displays at different zoom scale range in order to control which layers are displayed at different zoom scales.	4.10.0-3	The system needs to have an integrated user-friendly graphic user interface (GUI) to provide graphic displays, import and generation of graphic images, automatic updating of maps and graphics, and update this data in real time (at least once per second).	X		
3.1-6	The adaptive system shall have the ability to integrate the system detection data into the adaptive system GUI.	4.19.0-4	The adaptive system needs the ability to integrate the system detection data into the adaptive system GUI.		X	
3.1-7	The ASCT system operator and user interface shall be integrated with the Department's existing Arterial Management Center ASCT software.	4.10.0-3	The system needs to have an integrated user-friendly graphic user interface (GUI) to provide graphic displays, import and generation of graphic images, automatic updating of maps and graphics, and update this data in real time (at least once per second).	X		
4	**Crossing Arterials and Boundaries**					
4.0-1	The ASCT shall have the ability to conform its operation to an external system's operation data.	4.3.0-4 4.3.0-6 4.17.0-3	The system needs the ability to receive data from another system that will allow the ASCT system to coordinate its operation with the adjacent system. The system needs the ability to detect traffic approaching from a neighboring system and coordinate the ASCT operation with the adjacent system. The system needs the ability to be capable of responding to commands issued by the Traffic Management System.	X		

System Requirements Reference Number	System Requirement Description	ConOps Needs	ConOps Statement	Mandatory	Desirable	Optional
		5.4.0-3	The system will accept data from a neighboring system that allows it to stay in coordination with the adjacent system while still operating in adaptive mode.			
4.0-1.0-1	The ASCT shall adjust its operation to minimize interruption of traffic entering the system. (This may be achieved via detection, with no direct connection to the other system.)	4.3.0-4 5.4.0-2 4.3.0-6	The system needs the ability to receive data from another system that will allow the ASCT system to coordinate its operation with the adjacent system. The NJDOT needs the adaptive system to maintain coordination with another adjacent system either by sensing arriving traffic or by using constraints on cycle length. The system needs the ability to detect traffic approaching from a neighboring system and coordinate the ASCT operation with the adjacent system.	X		
4.0-1.0-2	The ASCT shall have the ability to operate a fixed cycle length to match the cycle length of any adjacent systems.	4.3.0-5	The system needs the ability to constrain the adaptive system to operate a cycle length compatible with the crossing arterial.	X		
4.0-1.0-3	The ASCT shall have the ability to alter its operation based on data received from another system.	4.3.0-4	The system needs the ability to receive data from another system that will allow the ASCT system to coordinate its operation with the adjacent system.	X		
4.0-1.0-4	The ASCT shall support adaptive coordination on crossing routes.	4.3.0-3 5.4.0-1	The system needs the ability to adaptively coordinate signals on two crossing routes simultaneously. A coordinated group will be able to include more than one coordinated route, such as two crossing arterials. The system will be able to maintain coordination along both roads.	X		
5	**Access and Security**					
5.0-1	The ASCT shall be implemented with a security policy that assigns different user privileges to the traffic engineering and maintenance staff of different authorities that have jurisdiction over a specific traffic signal. Typical user privileges include:	4.4.0-1 4.10.0-2 5.5.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies. The operator needs the ability to access to the database management, monitoring and reporting features and functions of the signal controllers and any related signal management system as per his/her defined privilege level from the access points defined for those system components. Operators, traffic engineering, and maintenance staff will be assigned different levels of authority, and access to equipment for which they are authorized, based on their roles and responsibilities. This will allow them to control, view, monitor, and analyze the operation of the system as appropriate.	X		
5.0-1.0-1	Local access to the ASCT	4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies.	X		
5.0-1.0-2	Remote access to the ASCT	4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies.	X		
5.0-1.0-3	System monitoring	4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies.	X		
5.0-1.0-4	System manual override	4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies.	X		

System Requirements Reference Number	System Requirement Description	ConOps Needs	ConOps Statement	Mandatory	Desirable	Optional
5.0-1.0-5	Signal timing plan development and implementation	4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies.	X		
5.0-1.0-6	Traffic operations	4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies.	X		
5.0-1.0-7	User login	4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies.	X		
5.0-1.0-8	User password and security	4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies.	X		
5.0-1.0-9	Administration of the system	4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies.	X		
5.0-1.0-10	Signal controller group access	4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies.	X		
5.0-1.0-11	Access to classes of equipment	4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies.	X		
5.0-1.0-12	Access to equipment by jurisdiction	4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies.	X		
5.0-1.0-13	Output activation	4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies.	X		
5.0-1.0-14	System parameters	4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies.	X		
5.0-1.0-15	Report generation	4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies.	X		
5.0-1.0-16	Configuration of system devices	4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies.			

System Requirements Reference Number	System Requirement Description	ConOps Needs	ConOps Statement	Mandatory	Desirable	Optional
		8.11.0-1	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. 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 that has a heavy U-turn volume.	X		
5.0-1.0-17	Security alerts	4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies.	X		
5.0-1.0-18	Security logging	4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies.	X		
5.0-1.0-19	Security reporting	4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies.	X		
5.0-1.0-20	Database access and configuration	4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies.	X		
5.0-1.0-21	Signal controller	4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies.	X		
1.0-2.0-1	The boundaries surrounding signal controllers that operate in a coordinated fashion shall be defined by the user.	4.1.0-2	The system needs the ability to manage the coordination in small groups of signals to link phase service at some intersections with phase service at adjacent intersections.	X		
1.0-2.0-2	The ASCT shall control a minimum of XX groups of adaptive signals.	4.2.0-2	The system needs the ability to be able to eventually adaptively control up to XX independent groups of signalized intersections.	X		
1.0-2.0-3	The size of a group shall range from 1 to XX adaptive signals.	4.2.0-3	The system needs the ability to vary the number of signals in an adaptively controlled group to accommodate the prevailing traffic conditions.	X		
1.0-2.0-4	Each group shall operate independently.	4.2.0-2	The system needs the ability to be able to eventually adaptively control up to XX independent groups of signalized intersections.	X		
1.0-2.0-5	The boundaries surrounding signal controllers that operate in a coordinated fashion shall be altered by the system according to configured parameters.	4.2.0-3	The system needs the ability to vary the number of signals in an adaptively controlled group to accommodate the prevailing traffic conditions.	X		
1.0-2.0-5.0-1	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.)	4.2.0-3	The system needs the ability to vary the number of signals in an adaptively controlled group to accommodate the prevailing traffic conditions.	X		

System Requirements Reference Number	System Requirement Description	ConOps Needs	ConOps Statement	Mandatory	Desirable	Optional
5.0-5	The ASCT shall provide a user priority assignment, configurable by the System Administrator, for resolution of command conflicts from concurrent users.	4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies.	X		
6	**Data Log**					
6.0-1	The ASCT shall log the following events for all modes of operation for each intersection:	4.11-0.6 4.11-0.6	The system needs the ability to be able to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation The system needs the ability to be able to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation	X		
6.0-1.0-1	Time-stamped emergency vehicle preemption calls	4.11-0.6	The system needs the ability to be able to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation	X		
6.0-1.0-2	Time-stamped transit priority calls	4.11-0.6	The system needs the ability to be able to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation	X		
6.0-1.0-3	Time-stamped railroad preemption calls	4.11-0.6	The system needs the ability to be able to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation	X		
6.0-1.0-6	Time-stamped start, end, and length of each phase	4.11-0.6	The system needs the ability to be able to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation	X		
6.0-1.0-7	Time-stamped controller interval changes	4.11-0.6	The system needs the ability to be able to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation	X		
6.0-1.0-8	Time-stamped start and end of each transition to a new timing plan	4.11-0.6	The system needs the ability to be able to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation	X		
6.0-2	The ASCT shall export its systems log in the following formats: • Text • CSV	4.11-0.4 4.11-0.2 4.11-0.3 4.11-0.4	The system needs the ability to store all operational data and signal timing parameters calculated by the adaptive system, and export selected data. The system needs the ability to store and report data used to calculate signal timing and have the data available for subsequent analysis. The system needs the ability to store and report data that can be used to measure traffic performance under adaptive control. The system needs the ability to store all operational data and signal timing parameters calculated by the adaptive system, and export selected data.	X		
6.0-3	The ASCT shall store the event log for a minimum of XX days.	4.11-0.4 4.11-0.6	The system needs the ability to store all operational data and signal timing parameters calculated by the adaptive system, and export selected data. The system needs the ability to be able to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation	X		
6.0-4	The ASCT shall store results of all actual signal timing parameters (cycle length, offset, phases, splits, interval times, etc.) for a minimum of XXX days.	4.11-0.2 4.11-0.3 4.11-0.6	The system needs the ability to store and report data used to calculate signal timing and have the data available for subsequent analysis. The system needs the ability to store and report data that can be used to measure traffic performance under adaptive control. The system needs the ability to be able to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation	X		
6.0-5	The ASCT shall archive all data automatically, generate historic reports with less than a XXX second(s) of lag, and provide real-time reports to support operation, maintenance and reporting of system	4.11-0.7	Have the ability to generate historic and real-time reports that effectively support operation, maintenance, and reporting of system performance and traffic conditions.			

System Requirements Reference Number	System Requirement Description	ConOps Needs	ConOps Statement	Mandatory	Desirable	Optional
	performance and traffic conditions. Such reports shall be able to be displayed graphically, in a table format, timeline, and summary report.	4.11-0.2 4.11-0.3 4.11-0.7	The system needs the ability to store and report data used to calculate signal timing and have the data available for subsequent analysis. The system needs the ability to store and report data that can be used to measure traffic performance under adaptive control. Have the ability to generate historic and real-time reports that effectively support operation, maintenance, and reporting of system performance and traffic conditions.	X		
6.0-6	The system shall store the following measured data in for a minimum of XX days: • Volume • Occupancy • Queue length • Phase utilization • Arrivals in green • Green band efficiency	4.11-0.7 4.11-0.2 4.11-0.3	Have the ability to generate historic and real-time reports that effectively support operation, maintenance, and reporting of system performance and traffic conditions. The system needs the ability to store and report data used to calculate signal timing and have the data available for subsequent analysis. The system needs the ability to store and report data that can be used to measure traffic performance under adaptive control.	X		
6.0-7	The ASCT shall summarize the volume data into a traffic volume report, which provides aggregate XX-minute volumes for any XX-day period in text and the XXX format.	4.11-0.2	The system needs the ability to store and report data used to calculate signal timing and have the data available for subsequent analysis.	X		
6.0-8	The ASCT shall provide data storage for a system size of at least XX ASCT signal controllers. The data to be stored shall include the following: • Controller state data • Reports • Log data • Security data • ASCT parameters • Detector status data	4.11-0.4	The system needs the ability to store all operational data and signal timing parameters calculated by the adaptive system, and export selected data.	X		
6.0-9	The ASCT shall calculate and report relative data quality including: • The extent data is affected by detector faults • Other applicable items	4.11-0.7	Have the ability to generate historic and real-time reports that effectively support operation, maintenance, and reporting of system performance and traffic conditions.	X		
6.0-10	The ASCT shall report comparisons of logged data when requested by the user: • 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	4.11-0.7	Have the ability to generate historic and real-time reports that effectively support operation, maintenance, and reporting of system performance and traffic conditions.	X		
6.0-11	The ASCT shall store data logs in a NJ-OIT approved database formats.	4.11-0.7	Have the ability to generate historic and real-time reports that effectively support operation, maintenance, and reporting of system performance and traffic conditions.	X		
6.0-12	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.	4.11-0.7	Have the ability to generate historic and real-time reports that effectively support operation, maintenance, and reporting of system performance and traffic conditions.	X		
6.0-13	The ASCT shall store the following data in XX minute increments from stopline detectors and midblock system detectors: • Volume • Occupancy • Queue length	4.11-0.2	The system needs the ability to store and report data used to calculate signal timing and have the data available for subsequent analysis.	X		
7	**Advanced Controller Operation**					
7.0-1	When specified by the user, the ASCT shall display a vehicle phase more than once for each time the coordinated phase is served.	4.9.0-1.0-1 5.6.0-2	• Service a phase more than once per cycle based on user-defined constraints. • The ability to repeat a phase, such as running a left turn phase before and after its opposing through movement.	X		
7.0-2	The ASCT shall provide a minimum of X phase overlaps.	4.9.0-1.0-2	• Operate at least X overlap phases.			

System Requirements Reference Number	System Requirement Description	ConOps Needs	ConOps Statement	Mandatory	Desirable	Optional
		5.6.0-7	• The NJDOT will permit phases or overlaps by time-of-day schedule or external input.	X		
7.0-3	The ASCT shall accommodate a minimum of XX phases at each signal	4.9.0-1.0-3	• Operate up to X rings, X phases and X phases per ring.	X		
7.0-4	The ASCT shall accommodate a minimum of X rings at each signal.	4.9.0-1.0-3	• Operate up to X rings, X phases and X phases per ring.	X		
7.0-5	The ASCT shall accommodate a minimum of X phases per ring	4.9.0-1.0-3 5.6.0-3	• Operate up to X rings, X phases and X phases per ring. • Provision for the required number of rings, phases, phases per ring, and overlap phases.	X		
7.0-6	The ASCT shall provide a minimum of X different user-defined phase sequences for each signal.	4.9.0-1.0-3	• Operate up to X rings, X phases and X phases per ring.	X		
7.0-6.0-1	Each permissible phase sequence shall be user-assignable to any signal timing plan.	4.9.0-1.0-3	• Operate up to X rings, X phases and X phases per ring.	X		
7.0-6.0-2	Each permissible phase sequence shall be executable by a time of day schedule.	4.9.0-1.0-3	• Operate up to X rings, X phases and X phases per ring.	X		
7.0-6.0-3	Each permissible phase sequence shall be executable based on measured traffic conditions	4.9.0-1.0-3	• Operate up to X rings, X phases and X phases per ring.	X		
7.0-7	The ASCT shall permit a phase/overlap output by time-of-day.	4.9.0-1.0-8	• Allow any phase to be designated as the coordinated phase.	X		
7.0-8	The ASCT shall permit a phase/overlap output based on an external input.	4.9.0-1.0-8 4.17.0-3	• Allow any phase to be designated as the coordinated phase. The system needs the ability to be capable of responding to commands issued by the Traffic Management System.	X		
7.0-9	The ASCT shall have the ability to provide for the following phases to be designated as coordinated phases. • Lead left turn • Lag left turn • Permissive left turn	4.9.0-1.0-3 4.9.0-1.0-8 5.6.0-8	• Operate up to X rings, X phases and X phases per ring. • Allow any phase to be designated as the coordinated phase. • The ability to designate specific phases as coordinated phases.		X	
7.0-10	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.	4.9.0-1.0-11	• Allow the coordinated phase to terminate early under prescribed traffic conditions	X		
7.0-12	The ASCT shall permit the local signal controller to perform actuated phase control using up to X extension/passage timers as assigned to user-specified vehicle detector input channels in the local controller.	4.9.0-1.0-10	• Allow the controller to respond independently to individual lanes of an approach. This may be implemented in the signal controller using up to X 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.	X		
7.0-12.0-1	The ASCT shall operate adaptively using user-specified detector channels.	4.9.0-1.0-10	• Allow the controller to respond independently to individual lanes of an approach. This may be implemented in the signal controller using up to X 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.	X		
7.0-13	When adaptive operation is used in conjunction with normal coordination, the ASCT shall permit a controller to serve a cycle length different from the cycles used at adjacent intersections.	4.9.0-1.0-14	• 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.	X		
7.0-14	The ASCT shall have the ability to operate with detector switching, dynamic max, and coordination at the end of green/yellow.	4.9.0-1.0-7 5.6.0-5	• Accommodate the custom features used by NJDOT. • Special features unique to the NJDOT such as detector switching, dynamic max, coordination beginning of yellow.	X		
7.0-15	Extension/passage timers shall be assignable to each vehicle detector input channel.	5.6.0-9	• The ability to separately monitor each lane on an approach and take different action depending on the conditions measured in each lane.	X		
7.0-16	The system shall have the ability for a coordinated phase to be released early constrained by user-constraints.	5.6.0-15	• The ability for a coordinated phase to be released early.	X		
8	**Pedestrians**					
8.0-1	The ASCT shall execute exclusive user-specified pedestrian phases before the vehicle green of the related vehicle phase.	4.6.0-1	Infrequent pedestrian actuated calls: The system needs the ability to accommodate infrequent pedestrian operation and then adaptively recover.	X		
8.0-2	When the pedestrian phase is called, the ASCT shall accommodate pedestrian crossing times during adaptive operations.	4.6.0-2	Infrequent pedestrian actuated calls: The system needs the ability to accommodate infrequent pedestrian operation while maintaining adaptive operation.	X		

System Requirements Reference Number	System Requirement Description	ConOps Needs	ConOps Statement	Mandatory	Desirable	Optional
8.0-3	The ASCT shall execute user-specified exclusive pedestrian phases during adaptive operation.	4.6.0-3 4.6.0-5 4.6.0-6	Frequent pedestrian actuated calls: The system needs the ability to incorporate frequent pedestrian operation into routine adaptive operation. The system needs the ability to accommodate custom pedestrian features. The system needs to the ability to accommodate early start of walk and exclusive pedestrian phases.	X		
8.0-4	The ASCT shall execute pedestrian recall on user-defined phases in accordance with a time of day schedule.	4.6.0-4	Pedestrian nonactuated calls: Nonactuated pedestrian phases are always on recall.		X	
8.0-5	The ASCT shall have the option for a phase to start late, when there is not a pedestrian call for that phase, provided the minimum green time is available.	4.9.0-1.0-12 5.6.0-11	• Allow flexible timing of non-coordinated phases (such as late start of a phase) while maintaining coordination. • The ability to introduce a non-coordinated phase later than its normal starting point within a cycle, if it can be served with minimum green within the remaining time available.		X	
8.0-6	For all nonactuated pedestrian phases, the ASCT shall execute pedestrian recall.	4.6.0-4	Pedestrian nonactuated calls: Nonactuated pedestrian phases are always on recall.	X		
8.0-7	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 • Sufficient time in the cycle remains to serve the minimum green times for the phase and the subsequent noncoordinated phases before the beginning of the coordinated phase • The phase is called after its normal start time • The associated pedestrian phase is not called	4.9.0-1.0-12	• Allow flexible timing of non-coordinated phases (such as late start of a phase) while maintaining coordination.	X		
9	**Special Functions**					
9.0-1	The ASCT shall set a specific state for each special function output based on the occupancy on a user-specified detector.	4.9.0-1.0-10 4.17.0-1 4.9.0-1.0-6 6.2.1.0-21	• Allow the controller to respond independently to individual lanes of an approach. This may be implemented in the signal controller using up to X 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. The system needs the ability 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 • Allow detector logic at an intersection to be varied depending on local signal states. The NJDOT's experienced operators will be able to write customized routines using the ASCT's API.		X	
9.0-2	The ASCT shall set a specific state for each special function output based on the current cycle length.	4.17.0-1	The system needs the ability 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		X	
9.0-3	The ASCT shall have the ability to set a specific state for each special function output based on a time-of-day schedule.	4.17.0-1	The system needs the ability 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		X	
9.0-4	The ASCT shall keep all intersections synchronized to a common time base. The ASCT shall also provide a means of verifying intersection controller clocks against the central time clock with an option to recalibrate the controller clock on an as needed basis.	4.1.0-8	The system needs the ability to set signal timing parameters to comply with NJDOT policies.	X		
10	**10 Detection**					
10.0-1	The ASCT stopline detectors shall have the following capabilities: • Detect a minimum of X lanes of traffic per device • Detect a minimum of X detection zone per lane	4.20.0-2.01 4.20.0-2.02	• Detect a minimum of X lanes of traffic per device • Detect a minimum of X detection zone per lane			

System Requirements Reference Number	System Requirement Description	ConOps Needs	ConOps Statement	Mandatory	Desirable	Optional
	• Utilize power/communication cables greater than XX feet in length • Utilize a CCD sensor for image detectors • Utilize an integrated processor	4.20.0-2.03 4.20.0-2.04 4.20.0-2.05 5.6.0-9	• Utilize power/communication cables greater than XX feet in length • Utilize a CCD sensor for image detectors • Utilize an integrated processor • The ability to separately monitor each lane on an approach and take different action depending on the conditions measured in each lane.	X		
10.1-1	The ASCT shall accommodate up to XX discrete detector inputs per intersection, each assignable to phase calls with delay and/or extend call timing.	4.9.0-1.0-10	• Allow the controller to respond independently to individual lanes of an approach. This may be implemented in the signal controller using up to X 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.	X		
10.1-2	The ASCT shall have the ability to operate adaptively utilizing only stop bar detection zones. (i.e., advanced detection is not required for functionality	4.9.0-1.0-10 4.15.0-1.0-2	• Allow the controller to respond independently to individual lanes of an approach. This may be implemented in the signal controller using up to X 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. • Non roadway-intrusive detectors (stopbar and system)	X		
10.1-3	The system shall continuously monitor the detector status as operational, disabled, or failed. Detector failures shall be reported to the system log and operator alarm.	4.11-0.8	Have the ability to continuously monitor and diagnose the status of stopline and system detectors.	X		
10.1-4	The system shall have user-specified thresholds that a detector must exceed to be considered failed based on a time-of-day basis.	4.11-0.8	Have the ability to continuously monitor and diagnose the status of stopline and system detectors.	X		
10.1-5	The ASCT shall provide diagnosis for the following detector failure types: • Maximum presence - if an active detector exhibits continuous detection over an operator-defined time interval • No activity - if an active detector does not exhibit any actuation during an operator-defined elapsed time interval • Erratic output - if an active detector exhibits excessive actuation (i.e., field count over an operator-defined elapsed time interval exceeds user programmed threshold) • Failed communication - failed detectors shall not be available for traffic control strategies	4.11-0.8	Have the ability to continuously monitor and diagnose the status of stopline and system detectors.	X		
10.1-6	The ASCT shall have the ability to interface and integrate with the depicted midblock system detectors.	4.19.0-1	The system needs the ability to interface with midblock system detectors.	X		
10.1-7	The midblock system detectors shall collect the following data:	4.19.0-2.04	The data collected by the system detectors is as follows:	X		
10.1-8	• Volume	4.19.0-2.05	• Volume	X		
10.1-9	• Speed	4.19.0-2.06	• Speed	X		
10.1-10	• Classification	4.19.0-2.07	• Classification		X	
10.1-11	• Travel Time	4.19.0-2.08	• Travel Time	X		
10.1-12	• Occupancy	4.19.0-2.09	• Occupancy	X		
10.1-13	The midblock system detectors shall be integrated into the applicable traffic signal cabinet back panels and the existing Department Traffic Management System.	4.19.0-1	The system needs the ability to interface with midblock system detectors.	X		
10.1-14	The adaptive system shall integrate the depicted midblock system detection data into adaptive operation for user-defined event triggers, routines, and force offs.	4.19.0-3	The adaptive system needs the ability to integrate the system detection data into adaptive operation.	X		
11	**Emergency Vehicle Pre-emption**					
11.0-1	The ASCT shall have the ability to maintain adaptive operation at non-preempted intersections during emergency vehicle or railroad preemption.	4.13.0-1 8.8.1-1	The system needs the ability to accommodate emergency vehicle preemption. When an intersection responds to preemption, other signals within the coordinate group continue to operate adaptively. The preempted signal returns to adaptive control once the preemption is released.	X		
11.0-2	The ASCT shall have the ability to allow for immediate response to the presence of a valid emergency preemption call.	4.13.0-1	The system needs the ability to accommodate emergency vehicle preemption.	X		
11.0-3	The ASCT shall have the ability to resume adaptive control of signal controllers when preemptions are released.	4.13.0-1	The system needs the ability to accommodate emergency vehicle preemption.	X		
11.0-4	The ASCT shall have the ability to provide for the immediate return to servicing of the appropriate phase combinations that would have been served at that time if preemption routine had not been initiated.	4.13.0-1	The system needs the ability to accommodate emergency vehicle preemption.	X		

System Requirements Reference Number	System Requirement Description	ConOps Needs	ConOps Statement	Mandatory	Desirable	Optional
11.0-5	The ASCT shall have the ability to 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)	4.13.0-1	The system needs the ability to accommodate emergency vehicle preemption.	X		
11.0-6	The ASCT shall have the ability to operate normally at non-preempted signal controllers when special functions are engaged by a preemption event. (An example of such a special functions is a phase omit, a phase maximum recall or a fire route.)	4.13.0-1	The system needs the ability to accommodate emergency vehicle preemption.	X		
11.0-7	The ASCT shall have the ability to release user-specified signal controllers to local control when one signal in a group is preempted.	4.13.0-1	The system needs the ability to accommodate emergency vehicle preemption.	X		
11.0-8	The ASCT shall have the ability to permit the local signal controller from operating in normally detected limited-service actuated mode during preemption.	4.13.0-1	The system needs the ability to accommodate emergency vehicle preemption.	X		
12	**Transit Priority**					
12.0-1	The ASCT shall continue adaptive operations of a group when one of its signal controllers has a transit priority call.	4.13.0-2	The system needs the ability to accommodate transit signal priority.			X
12.0-2	The ASCT shall advance the start of a user-specified green phase in response to a transit priority call.	4.13.0-2	The system needs the ability to accommodate transit signal priority.			X
12.0-2.0-1	The advance of start of green phase shall be user-defined.	4.13.0-2	The system needs the ability to accommodate transit signal priority.			X
12.0-2.0-2	Adaptive operations shall continue during the advance of the start of green phase.	4.13.0-2	The system needs the ability to accommodate transit signal priority.			X
12.0-3	The ASCT shall delay the end of a green phase, in response to a priority call.	4.13.0-2	The system needs the ability to accommodate transit signal priority.			X
12.0-3.0-1	The delay of end of green phase shall be user-defined.	4.13.0-2	The system needs the ability to accommodate transit signal priority.			X
12.0-3.0-2	Adaptive operations shall continue during the delay of the end of green phase.	4.13.0-2	The system needs the ability to accommodate transit signal priority.			X
12.0-4	The ASCT shall permit at least X exclusive transit phase.	4.13.0-2	The system needs the ability to accommodate transit signal priority.			X
12.0-4.0-1	Adaptive operations shall continue when there is an exclusive transit phase call.	4.13.0-2	The system needs the ability to accommodate transit signal priority.			X
12.0-5	The ASCT shall control vehicle phases independently of the bus only phases.	4.13.0-2	The system needs the ability to accommodate transit signal priority.			X
12.0-6	The ASCT shall accept a transit priority call from: • A signal controller/transit vehicle detector • An external system	4.13.0-2	The system needs the ability to accommodate transit signal priority.		X	
12.0-7	The ASCT shall provide a minimum of 1 transit priority sequence.	4.13.0-2	The system needs the ability to accommodate transit signal priority.			X
13	**Failure Events and Fallback**					
13.1	**Detector Failure**					
13.1.0-1	The ASCT shall take user-specified action in the absence of valid detector data from a user-specified number of vehicle detectors within a group.	5.3.0-1 5.3.0-2 5.3.0-3	The system will have a fallback state that allows coordination using a common cycle length for all signals within a coordinated group when falling back to TOD plans. The system will have a fallback state that allows individual intersections to operate in a vehicle-actuated mode constrained by coordination in the event of failures of the adaptive software or hardware, detectors or communication. The system will have a fallback state that allows one or more intersections to be unmarried from a critical intersection in the event of failures of the adaptive software or hardware, detectors or communication.			

System Requirements Reference Number	System Requirement Description	ConOps Needs	ConOps Statement	Mandatory	Desirable	Optional
		8.7.1-1	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.	X		
13.1.0-1.0-1	The ASCT shall release control to local traffic controllers to operate under its own time-of-day schedule at a user-specified threshold of failures.	5.3.0-2	The system will have a fallback state that allows individual intersections to operate in a vehicle-actuated mode constrained by coordination in the event of failures of the adaptive software or hardware, detectors or communication.	X		
13.1.0-2	The ASCT shall use the following alternate data sources for operations in the absence of the real-time data from a detector: • Data from a user-specified alternate detector • Stored historical data from the failed detector	4.14.0-1	The system needs the ability to fall back to TOD or actuated operation constrained by coordination, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications, and software failure.	X		
13.1.0-2.0-1	The ASCT shall switch to the alternate data source automatically without operator intervention during user-specified threshold of detector failures.	4.14.0-1	The system needs the ability to fall back to TOD or actuated operation constrained by coordination, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications, and software failure.	X		
13.1.0-3	In the event of a 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. The alarm shall be delivered via the following means: • Email • Text Message • Pop-up window on all workstations currently connected to the ASCT	4.12.0-1 4.11-0.8 4.12.0-1 4.12.0-2	The system needs the ability to immediately notify maintenance and operations staff of alarms and alerts. Have the ability to continuously monitor and diagnose the status of stopline and system detectors The system needs the ability to immediately notify maintenance and operations staff of alarms and alerts. The system needs the ability to immediately and automatically pass alarms and alerts.	X		
13.1.0-4	In the event of a failure, the ASCT shall log details of the failure in a permanent log.	4.12.0-3	The system needs the ability to maintain a complete log of alarms and failure events.	X		
13.1.0-5	The permanent failure log shall be searchable, archivable and exportable.	4.12.0-3	The system needs the ability to maintain a complete log of alarms and failure events.	X		
13.2	**Communications Failure**					
13.2-1	The ASCT shall execute user-specified actions when communications to one or more signal controllers fails within a group.	4.14.0-1 5.3.0-3 8.6.1-1	The system needs the ability to fall back to TOD or actuated operation constrained by coordination, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications, and software failure. The system will have a fallback state that allows one or more intersections to be unmarried from a critical intersection in the event of failures of the adaptive software or hardware, detectors or communication. 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.	X		

System Requirements Reference Number	System Requirement Description	ConOps Needs	ConOps Statement	Mandatory	Desirable	Optional
13.2-1.0-1	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.	4.14.0-1	The system needs the ability to fall back to TOD or actuated operation constrained by coordination, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications, and software failure.	X		
13.2-1.0-2	The ASCT shall switch to the alternate operation in real time without operator intervention.	4.14.0-1	The system needs the ability to fall back to TOD or actuated operation constrained by coordination, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications, and software failure.	X		
13.2-2	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. The alarm shall be delivered via the following means: • Email • Text Message • Pop-up window on all workstations currently connected to the ASCT	4.14.0-1	The system needs the ability to fall back to TOD or actuated operation constrained by coordination, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications, and software failure.	X		
13.2-3	The ASCT shall issue an alarm within a user-defined threshold (default of X (X) minutes) of detection of a communication failure.	4.12.0-1	The system needs the ability to immediately notify maintenance and operations staff of alarms and alerts.	X		
13.2-4	In the event of a communications failure, the ASCT shall log details of the failure in a permanent log.	4.12.0-3	The system needs the ability to maintain a complete log of alarms and failure events.	X		
13.2-5	The permanent failure log shall be searchable, archival and exportable.	4.12.0-3	The system needs the ability to maintain a complete log of alarms and failure events.	X		
13.3	**Adaptive Server Failure**					
13.3-1	The ASCT shall execute user-specified actions when adaptive control fails:	4.14.0-1 5.3.0-1 5.3.0-3	The system needs the ability to fall back to TOD or actuated operation constrained by coordination, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications, and software failure. The system will have a fallback state that allows coordination using a common cycle length for all signals within a coordinated group when falling back to TOD plans. The system will have a fallback state that allows one or more intersections to be unmarried from a critical intersection in the event of failures of the adaptive software or hardware, detectors or communication.	X		
13.3-1.0-1	The ASCT shall release control to user-specified local operations to operate under its own time-of-day schedule.	4.14.0-1	The system needs the ability to fall back to TOD or actuated operation constrained by coordination, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications, and software failure.	X		
13.3-2	In the event of adaptive software 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. The alarm shall be delivered via the following means: • Email • Text Message • Pop-up window on all workstations currently connected to the ASCT	4.12.0-1	The system needs the ability to immediately notify maintenance and operations staff of alarms and alerts.	X		
13.3-3	The permanent failure log shall be searchable, archival and exportable.	4.12.0-3	The system needs the ability to maintain a complete log of alarms and failure events.	X		
13.3-4	During adaptive software failure, all local detector inputs shall be provided to the local controller.	4.12.0-3	The system needs the ability to maintain a complete log of alarms and failure events.	X		
14	**Software**					
14.0-1	The vendor's adaptive software shall be fully operational within the following server platforms: • Windows Server	4.15.0-1.0-6	The system needs the ability to use equipment and software acceptable under current NJ OIT policies and procedures.	X		
14.0-2	The system shall interface with the midblock system detection as per Requirement 10.1-13.	4.19.0-1	The system needs the ability to interface with midblock system detectors.	X		
14.0-3	The ASCT server software shall be compatible with the existing Mobility Management ASCT software and the user interface and control shall be integrated as per Requirement 3.1-7.	4.10.0-1.01	The system needs the ability to monitor and control all required features of adaptive operation from the following locations: • Traffic Operation Center XXX	X		
15	**Training**					

System Requirements Reference Number	System Requirement Description	ConOps Needs	ConOps Statement	Mandatory	Desirable	Optional
15.0-1	The vendor shall provide the following training:	4.16.0-1	The NJDOT needs all staff involved in operation and maintenance to receive appropriate training.			
15.0-1.0-1	The vendor shall provide training on the operations of the adaptive system.	4.16.0-1	The NJDOT needs all staff involved in operation and maintenance to receive appropriate training.	X		
15.0-1.0-2	The vendor shall provide training on trouble-shooting the system.	4.16.0-1	The NJDOT needs all staff involved in operation and maintenance to receive appropriate training.	X		
15.0-1.0-3	The vendor shall provide training on preventive maintenance and repair of equipment.	4.16.0-1	The NJDOT needs all staff involved in operation and maintenance to receive appropriate training.	X		
15.0-1.0-4	The vendor shall provide training on system configuration.	4.16.0-1	The NJDOT needs all staff involved in operation and maintenance to receive appropriate training.	X		
15.0-1.0-5	The vendor shall provide training on administration of the system.	4.16.0-1	The NJDOT needs all staff involved in operation and maintenance to receive appropriate training.	X		
15.0-1.0-6	The vendor shall provide training on system calibration.	4.16.0-1	The NJDOT needs all staff involved in operation and maintenance to receive appropriate training.	X		
15.0-1.0-7	The vendor's training delivery shall include: printed course materials and references, electronic copies of presentations and references.	4.16.0-1	The NJDOT needs all staff involved in operation and maintenance to receive appropriate training.	X		
15.0-1.0-8	The vendor's training shall be delivered at a time and location designated by the NJDOT.	4.16.0-1	The NJDOT needs all staff involved in operation and maintenance to receive appropriate training.	X		
15.0-1.0-9	The vendor shall provide a minimum of XX hours training to a minimum of XX staff.	4.16.0-1	The NJDOT needs all staff involved in operation and maintenance to receive appropriate training.	X		
15.0-1.0-10	The vendor shall provide a minimum of X training sessions.	4.16.0-1	The NJDOT needs all staff involved in operation and maintenance to receive appropriate training.	X		
16	**Maintenance, Support and Warranty**					
16.0-1	The vendor shall provide maintenance of the following hardware for a minimum of **X** years: • Traffic Controllers • Conflict Monitors • Detector Equipment	4.16.0-2 6.2.1.0-15 4.18.0-2	The NJDOT needs the system to fulfill all requirements for the life of the system. Therefore, NJDOT needs the system to be maintained to repair faults that are not defects in materials and workmanship. The NJDOT expects maintenance of parts and field equipment for a period of X years after acceptance will be included in the purchase price. The ability for an on-going contract will be available thereafter. NJDOT needs to have spare parts for critical equipment. The initial cost of all equipment needs to include maintenance for a minimum of XX (X) years from the date of installation.	X		
16.0-2	The vendor shall provide maintenance of the following for a minimum of **X** years: • Adaptive controller software • Adaptive server and client software	6.2.1.0-16	The NJDOT expects maintenance of all adaptive system servers and software for a period of X years after acceptance will be included in the purchase price. The ability for an on-going maintenance contract will be available thereafter.	X		
16.0-3	Vendor shall provide warranty for a minimum of X years, covering parts and labor for all material supplied. Warranty is defined as correcting defects in materials and workmanship. Defect is defined as any circumstance in which the material does not perform according to its specification.	6.2.1.0-14 4.16.0-3 4.16.0-4 4.17.0-1	Replacement or repair of defective or failed field equipment will be covered for X years by the manufacturers' warranties. The labor cost of replacement during this period will be included in the purchase price. The ability for an on-going contract will be available thereafter. The NJDOT needs the system to fulfill all requirements for the life of the system. Therefore, NJDOT needs the system to remain free of defects in materials and workmanship that result in requirements no longer being fulfilled. The agency needs the system to fulfill all requirements for the life of the system. Therefore, NJDOT needs support to keep software and software environment updated as necessary to prevent requirements no longer being fulfilled. The system needs the ability 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	X		

System Requirements Reference Number	System Requirement Description	ConOps Needs	ConOps Statement	Mandatory	Desirable	Optional
16.0-4	The maintenance can be performed locally or remotely X a month.	6.2.1.0-19	Operations and maintenance staff will have the ability to log in to the system from remote locations via a secured-connection and have full functionality consistent with their access level.	X		
16.0-5	The vendor shall supply technical support for a minimum of X years.	6.2.1.0-18	The NJDOT will seek technical support from the vendor for assistance in using the adaptive software for X years after acceptance. The ability for an on-going contract will be available thereafter.	X		
16.0-6	The vendor shall respond to requests for hardware maintenance within a minimum of X years.	6.2.1.0-15	The NJDOT expects maintenance of parts and field equipment for a period of X years after acceptance will be included in the purchase price. The ability for an on-going contract will be available thereafter.	X		
16.0-7	The vendor shall respond to requests for software technical support within a minimum of X years.	6.2.1.0-18	The NJDOT will seek technical support from the vendor for assistance in using the adaptive software for X years after acceptance. The ability for an on-going contract will be available thereafter.	X		
16.0-8	Acquisition and installation of upgrades of all ASCT software to the latest version for a period of X years shall be included in the purchase price.	6.2.1.0-17	The NJDOT expects to operate this system using the latest software for a period of X years after acceptance.	X		
16.0-9	The vendor shall set up and fine tune the operation of the ASCT prior to handover to the NJDOT.	6.2.1.0-8	The vendor will setup and fine tune the adaptive system prior to handover to the NJDOT.	X		
16.0-10	The vendor shall provide a refresher training course on-site at NJDOT X months into the software support period.	6.2.1.0-22	The NJDOT needs a refresher training course on-site at NJDOT XX months into the software support period.	X		
17	**Schedule**					
17.0-1	The ASCT shall set the state of external input/output states according to a time-of-day schedule.	4.17.0-1	The system needs the ability 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		X	
17.0-2	The ASCT output states shall be settable according to a time-of-day schedule	4.17.0-1	The system needs the ability 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		X	
17.0-3	The ASCT operational parameters shall have the ability to be set according to a Time of Day schedule.	4.17.0-1	The system needs the ability 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		X	
18	**Performance Measurement, Monitoring and Reporting**					
18.0-1	The ASCT shall report measures of current traffic conditions on which it bases signal state alterations.	4.11-0.2	The system needs the ability to store and report data used to calculate signal timing and have the data available for subsequent analysis.	X		
18.0-2	The ASCT shall report all intermediate calculated values that are affected by calibration parameters.	4.11-0.2	The system needs the ability to store and report data used to calculate signal timing and have the data available for subsequent analysis.	X		
18.0-3	The ASCT shall maintain a log of all signal state alterations directed by the ASCT.	4.11-0.7 4.11-0.2	Have the ability to generate historic and real-time reports that effectively support operation, maintenance, and reporting of system performance and traffic conditions. The system needs the ability to store and report data used to calculate signal timing and have the data available for subsequent analysis.	X		
18.0-3.0-1	The ASCT log shall include all events directed by the external inputs.	4.11-0.7	Have the ability to generate historic and real-time reports that effectively support operation, maintenance, and reporting of system performance and traffic conditions.	X		
18.0-3.0-2	The ASCT log shall include all external output state changes.	4.11-0.2	The system needs the ability to store and report data used to calculate signal timing and have the data available for subsequent analysis.	X		
18.0-3.0-3	The ASCT log shall include all actual parameter values that are subject to user-specified values.	4.11-0.7	Have the ability to generate historic and real-time reports that effectively support operation, maintenance, and reporting of system performance and traffic conditions.	X		

System Requirements Reference Number	System Requirement Description	ConOps Needs	ConOps Statement	Mandatory	Desirable	Optional
		4.11-0.2	The system needs the ability to store and report data used to calculate signal timing and have the data available for subsequent analysis.	X		
18.0-3.0-4	The ASCT shall maintain the records in this ASCT log for X (X) year.	4.11-0.7	Have the ability to generate historic and real-time reports that effectively support operation, maintenance, and reporting of system performance and traffic conditions.	X		
18.0-3.0-5	The ASCT shall archive the ASCT log (hot synced).	4.11-0.7 4.19.0-5	Have the ability to generate historic and real-time reports that effectively support operation, maintenance, and reporting of system performance and traffic conditions. The historical system detection data needs to be stored locally and pushed remotely.	X		

Appendix X - Traceability Matrix

Need Statement Reference Number	Concept of Operations Need Statement	System Requirements Reference Numbers														
3.4.3.0-1.0-2	Provide the same or higher level of safety provided by the existing system to vehicles, pedestrians and transit.	2.1.3														
4.0-1	The system needs to have ability to operate under user-defined constraints to the sequence based operation.															
4.1.0-1.0-1	Maximize the throughput on coordinated routes.	2.1.1.0-7	2.1.1.0-7.0-1	2.2.0-1	2.2.0-2	2.2.0-4	2.2.0-4.0-1	2.2.0-5	2.2.0-5.0-1	2.2.0-5.0-2	2.2.0-5.0-3	2.2.0-5.0-4				
4.1.0-1.0-2	Provide smooth flow along coordinated routes.	2.1.1.0-7.0-4	2.2.0-1	2.2.0-2	2.2.0-5	2.2.0-5.0-1	2.2.0-5.0-2	2.2.0-5.0-3	2.2.0-5.0-4							
4.1.0-1.0-3	Distribute phase times in an equitable fashion.	2.1.1.0-7	2.1.1.0-7.0-3	2.1.1.0-7.0-4	2.1.1.0-8	2.1.1.0-8.0-1	2.1.1.0-8.0-2	2.1.1.0-8.0-2.0-1	2.2.0-1							
4.1.0-1.0-4	Manage the length of queues.	2.1.1.0-7.0-2	2.1.3.0-1	2.1.3.0-2	2.1.3.0-3	2.1.3.0-4	2.1.3.0-5	2.2.0-1	2.2.0-2	2.2.0-3	2.2.0-5	2.2.0-5.0-1	2.2.0-5.0-2	2.2.0-5.0-3	2.4.0-2	2.4.0-2.0-1
4.1.0-1.0-5	Manage the locations of queues within the network.	2.1.3.0-1	2.1.3.0-2	2.1.3.0-3	2.1.3.0-4	2.2.0-3										
4.1.0-1.0-6	At an isolated intersection, optimize operation with a minimum of phase failures (based on the optimization objectives).	2.1.1.0-8	2.1.1.0-8.0-1	2.1.1.0-8.0-1.0-1	2.1.1.0-8.0-2	2.1.1.0-8.0-2.0-1										
4.1.0-2	The system needs the ability to manage the coordination in small groups of signals to link phase service at some intersections with phase service at adjacent intersections.	1.0-2.0-1	2.5.0-1	2.5.0-2	2.5.0-3	2.5.0-4	2.5.0-5									
4.1.0-3	The system needs the ability to change the operational strategy (for example, from smooth flow to maximizing throughput or managing queues) based on changing traffic conditions.	2.1.1.0-7	2.1.1.0-7.0-3	2.1.1.0-7.0-2												
4.1.0-4	The system needs the ability to detect repeated phase failures and control signal timing to prevent phase failures building up queues.	2.1.1.0-9	2.1.1.0-9.0-1	2.1.3.0-1	2.2.0-3											
4.1.0-5	The system needs to minimize the chance that a queue forms at a specified location.	2.2.0-5.0-5	2.5.0-6	2.5.0-7	2.5.0-8	2.5.0-9										
4.1.0-6	The system needs the ability to fix the sequence of phases at any specified location.	2.1.2.0-11														
4.1.0-7	The system needs the ability to designate the coordinated route based on traffic conditions and the selected operational strategy	2.1.1.0-10	2.1.1.0-10.0-1	2.1.1.0-10.0-2	2.1.1.0-10.0-3	2.1.1.0-10.0-4	2.1.1.0-10.0-4.0-1	2.1.1.0-10.0-4.0-2	2.1.1.0-10.0-4.0-3							
4.1.0-8	The system needs the ability to set signal timing parameters to comply with agency policies.	2.1.1.0-11	9.0-4													
4.2.0-1	The system needs the ability to eventually adaptively control up to XX signalized intersections, up to XX miles from the Traffic Management Center (TMC) (or specified location).	1.0-1														
4.2.0-2	The system needs the ability to be able to eventually adaptively control up to XX independent groups of signalized intersections.	1.0-2	1.0-2.0-2													
4.2.0-3	The system needs the ability to vary the number of signals in an adaptively controlled group to accommodate the prevailing traffic conditions.	1.0-2	1.0-2.0-3	1.0-2.0-5	1.0-2.0-5.0-1	1.0-2.0-5.0-2	1.0-2.0-5.0-3									
4.3.0-1	The system needs the ability to adaptively control signals operated by NJDOT.	3.0-1														
4.3.0-2	The system needs the ability to send data to another system that would allow the other system to coordinate with the ASCT system.	3.0-1	3.0-1.0-1	3.0-1.0-2	3.0-1.0-3											
4.3.0-3	The system needs the ability to adaptively coordinate signals on two crossing routes simultaneously.	3.1-7														
4.3.0-4	The system needs the ability to receive data from another system that will allow the ASCT system to coordinate its operation with the adjacent system.	3.0-1	4.0-1	4.0-1.0-1	4.0-1.0-3											
4.3.0-5	The system needs the ability to constrain the adaptive system to operate a cycle length compatible with the crossing arterial.	4.0-1.0-2														
4.3.0-6	The system needs the ability to detect traffic approaching from a neighboring system and coordinate the ASCT operation with the adjacent system.	4.0-1	4.0-1.0-1													
4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies.	5.0-1 5.0-1.0-16	5.0-1.0-1 5.0-1.0-17	5.0-1.0-3 5.0-1.0-18	5.0-1.0-4 5.0-1.0-19	5.0-1.0-5 5.0-1.0-20	5.0-1.0-6 5.0-1.0-21	5.0-1.0-7 5.0-3	5.0-1.0-8 2.1.2.0-2	5.0-1.0-9	5.0-1.0-10	5.0-1.0-11	5.0-1.0-12	5.0-1.0-13	5.0-1.0-14	5.0-1.0-15
4.5.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies.	2.1.3.0-1	2.1.3.0-2	2.1.3.0-3	2.1.3.0-4											
4.5.0-2	The system needs the ability to detect queues within the system's boundaries and modify the ASCT operation to accommodate the queuing.	2.1.3.0-1	2.1.3.0-3	2.1.3.0-4												
4.5.0-3	The system needs the ability to detect queues propagating outside its boundaries from within the ASCT boundaries, and modify its operation to accommodate the queuing.	2.1.3.0-1	2.1.3.0-3	2.1.3.0-4												
4.5.0-4	The system needs the ability to store queues in locations where they can be accommodated without adversely affecting adaptive operation.	2.1.3.0-1	2.1.3.0-3	2.1.3.0-4												
4.5.0-5	The system needs the ability to prevent queues forming at user specified locations.	2.1.3.0-1	2.1.3.0-3	2.1.3.0-4												
4.6.0-1	Infrequent pedestrian actuated calls: The system needs the ability to accommodate infrequent pedestrian operation and then adaptively recover.	8.0-1	8.0-5													
4.6.0-2	Infrequent pedestrian actuated calls: The system needs the ability to accommodate infrequent pedestrian operation while maintaining adaptive operation.	8.0-2														
4.6.0-3	Frequent pedestrian actuated calls: The system needs the ability to incorporate frequent pedestrian operation into routine adaptive operation.	2.1.3.0-2	8.0-3													
4.6.0-4	Pedestrian nonactuated calls: Nonactuated pedestrian phases are always on recall.	2.1.3.0-2	8.0-4	8.0-6												
4.6.0-5	The system needs the ability to accommodate custom pedestrian features.	8.0-3														
4.6.0-6	The system needs to the ability to accommodate early start of walk and exclusive pedestrian phases.	8.0-3														
4.7.0-1	The system needs the ability to detect traffic conditions during which adaptive control is not the preferred operation, and implement some pre-defined operation while that condition is present.	2.1.1.0-1	2.1.1.0-7.0-5													
4.7.0-2	The system needs the ability to schedule pre-determined operation by time of day.	2.1.1.0-5														
4.7.0-3	The system needs the ability to over-ride adaptive operation.	2.1.1.0-3	2.1.1.0-4	2.1.1.0-5												
4.8.0-1	The system needs the ability to modify the ASCT operation to closely follow changes in traffic conditions.	2.6.0-1	2.6.0-2	2.6.0-3												
4.8.0-2	The system needs the ability to constrain the selection of cycle lengths to those that provide acceptable operations, such as when resonant progression solutions are desired.	2.6.0-1	2.6.0-3	2.6.0-5												
4.8.0-3	The system needs to respond within a user-defined amount of cycles to sudden large shift in traffic conditions.	2.6.0-4														

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Need Statement Reference Number	Concept of Operations Need Statement	System Requirements Reference Numbers														
4.9.0-1	**The system needs the ability to implement the following advanced controller features while maintaining adaptive operation:**															
4.9.0-1.0-1	• Service a phase more than once per cycle based on user-defined constraints.	2.1.2.0-1	2.1.2.0-2	7.0-1	7.0-10	7.0-11	7.0-12	7.0-12.0-1	7.0-13	8.0-7	9.0-1	10.1-1	10.1-2			
4.9.0-1.0-2	• Operate at least X overlap phases.	7.0-2														
4.9.0-1.0-3	• Operate up to Xrings, X phases and X phases per ring.	7.0-3	7.0-4	7.0-5	7.0-6	7.0-6.0-1	7.0-6.0-2	7.0-6.0-3	7.0-9							
4.9.0-1.0-4	• Allow one or more phases to be omitted (disabled) under certain traffic conditions or signal states.	2.1.2.0-6	2.1.2.0-7	2.1.2.0-8												
4.9.0-1.0-5	• Prevent one or more phases being skipped under certain traffic conditions or signal states.	2.1.2.0-3	2.1.2.0-4	2.1.2.0-5												
4.9.0-1.0-6	• Allow detector logic at an intersection to be varied depending on local signal states.	9.0-1														
4.9.0-1.0-7	• Accommodate the custom features used by NJDOT.	7.0-14														
4.9.0-1.0-8	• Allow any phase to be designated as the coordinated phase.	7.0-7	7.0-8	7.0-9												
4.9.0-1.0-9	• Allow the operator to specify which phase receives unused time from a preceding phase.	2.1.2.0-9	2.1.2.0-10													
4.9.0-1.0-10	• Allow the controller to respond independently to individual lanes of an approach. This may be implemented in the signal controller using up to X 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.	7.0-12	7.0-12.0-1	9.0-1	10.1-1	10.1-2										
4.9.0-1.0-11	• Allow the coordinated phase to terminate early under prescribed traffic conditions	7.0-10														
4.9.0-1.0-12	• Allow flexible timing of non-coordinated phases (such as late start of a phase) while maintaining coordination.	7.0-11	8.0-5	8.0-6												
4.9.0-1.0-13	• Protected/permissive phasing and alternate left turn phase sequences.	2.1.2.0-1	2.1.2.0-2													
4.9.0-1.0-14	• 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.	7.0-13														
4.10.0-1	**The system needs the ability to monitor and control all required features of adaptive operation from the following locations:**															
4.10.0-1.01	• NJDOT Traffic Operation Centers	1.0-1														
4.10.0-1.02	• Arterial Management Center (AMC)	1.0-1														
4.10.0-1.03	• Statewide Traffic Management Center (STraffic Management Center (TMC))	1.0-1														
4.10.0-1.04	• Local Controller Cabinets	1.0-1														
4.10.0-1.05	• Maintenance Vehicles	1.0-1														
4.10.0-2	The operator needs the ability to access to the database management, monitoring and reporting features and functions of the signal controllers and any related signal management system as per his/her defined privilege level from the access points defined for those system components.	5.0-1														
4.10.0-3	The system needs to have an integrated user-friendly graphic user interface (GUI) to provide graphic displays, import and generation of graphic images, automatic updating of maps and graphics, and update this data in real time (at least once per second).	3.1-3	3.1-4													
4.11-0.1	The NJDOT needs the ability for the Traffic Management System to be able to coexist with or monitor the adaptive system.	1.0-3														
4.11-0.2	The system needs the ability to store and report data used to calculate signal timing and have the data available for subsequent analysis.	6.0-2														
4.11-0.3	The system needs the ability to store and report data that can be used to measure traffic performance under adaptive control.	6.0-2														
4.11-0.4	The system needs the ability to store all operational data and signal timing parameters calculated by the adaptive system, and export selected data.	6.0-2														
4.11-0.5	The system needs the ability to report performance data at least once a minute.	6.0-1														
4.11-0.6	The system needs the ability to be able to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation	6.0-4														
4.11-0.7	Have the ability to generate historic and real-time reports that effectively support operation, maintenance, and reporting of system performance and traffic conditions.	6.0-5														
4.11-0.8	Have the ability to continuously monitor and diagnose the status of stopline and system detectors.	13.1.0-3														
4.12.0-1	The system needs the ability to immediately notify maintenance and operations staff of alarms and alerts.	13.1.0-3														
4.12.0-2	The system needs the ability to immediately and automatically pass alarms and alerts.	13.1.0-3														
4.12.0-3	The system needs the ability to maintain a complete log of alarms and failure events.	13.1.0-4	13.1.0-5	13.2-4	13.2-5	13.3-3	13.3-4									
4.13.0-1	The system needs the ability to accommodate emergency vehicle preemption.	11.0-1	11.0-2	11.0-3	11.0-4	11.0-5	11.0-6	11.0-7	11.0-8							
4.13.0-2	The system needs the ability to accommodate transit signal priority.	12.0-1	12.0-2	12.0-2.0-1	12.0-2.0-2	12.0-3										
4.14.0-1	The system needs the ability to fall back to TOD or actuated operation constrained by coordination, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications, and software failure.	2.1.1.0-2	2.1.1.0-2.0-1	2.1.1.0-2.0-2	2.1.1.0-2.0-3	12.0-3	12.0-3.0-1	12.0-3.0-2	12.0-4	12.0-4.0-1	12.0-5	12.0-6	12.0-7			
4.15.0-1	**The system is constrained to use the following equipment:**															
4.15.0-1.0-1	• Naztec 2070N controllers are utilized by not a mandatory constraints	1.0-3														
4.15.0-1.0-2	• Non roadway-intrusive detectors (stopbar and system)	10.1-2														
4.15.0-1.0-5	• Coexist with the Traffic Management System	1.0-3														
4.15.0-1.0-6	The system needs the ability to use equipment and software acceptable under current NJ OIT policies and procedures.	14.0-1														
4.16.0-1	The NJDOT needs all staff involved in operation and maintenance to receive appropriate training.	15.0-1	15.0-1.0-1	15.0-1.0-2	15.0-1.0-3	15.0-1.0-4	15.0-1.0-5	15.0-1.0-6	15.0-1.0-7	15.0-1.0-8	15.0-1.0-9	15.0-1.0-10				
4.16.0-2	The NJDOT needs the system to fulfill all requirements for the life of the system. Therefore, NJDOT needs the system to be maintained to repair faults that are not defects in materials and workmanship.	16.0-1														
4.16.0-3	The NJDOT needs the system to fulfill all requirements for the life of the system. Therefore, NJDOT needs the system to remain free of defects in materials and workmanship that result in requirements no longer being fulfilled.	16.0-3														
4.16.0-4	The agency needs the system to fulfill all requirements for the life of the system. Therefore, NJDOT needs support to keep software and software environment updated as necessary to prevent requirements no longer being fulfilled.	16.0-3														
4.17.0-1	The system needs the ability 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	3.0-1.0-1														
4.17.0-2	The system needs to react to traffic volume and traffic operation condition change due to special events.	2.5.0-4	2.6.0-4													
4.17.0-3	The system needs the ability to be capable of responding to commands issued by the Traffic Management System.	2.1.1.0-6	2.1.2.0-4	2.1.2.0-7												

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Need Statement Reference Number	Concept of Operations Need Statement	System Requirements Reference Numbers														
4.18.0-2	NJDOT needs to have spare parts for critical equipment. The initial cost of all equipment needs to include maintenance for a minimum of XX (X) years from the date of installation.	16.0-1														
4.19.0-1	The system needs the ability to interface with midblock system detectors.	3.0-1.0-5	10.1-6	10.1-13	14.0-2											
4.19.0-2.04	**The data collected by the system detectors is as follows:**															
4.19.0-2.05	• Volume	10.1-8														
4.19.0-2.06	• Speed	10.1-9														
4.19.0-2.07	• Classification	10.1-10														
4.19.0-2.08	• Travel Time	10.1-11														
4.19.0-2.09	• Occupancy	10.1-12														
4.19.0-3	The adaptive system needs the ability to integrate the system detection data into adaptive operation.	3.0-1.0-5	10.1-14													
4.19.0-4	The adaptive system needs the ability to integrate the system detection data into the adaptive system GUI.	3.1-6														
4.19.0-5	The historical system detection data needs to be stored locally and pushed remotely.	18.0-3.0-5														
4.20.0-1	**The traffic signal detection needs the following capabilities:**															
4.20.0-2.01	• Detect a minimum of X lanes of traffic per device	10.0-1														
4.20.0-2.02	• Detect a minimum of X detection zone per lane	10.0-1														
4.20.0-2.03	• Utilize power/communication cables greater than XX feet in length	10.0-1														
4.20.0-2.04	• Utilize a CCD sensor for image detectors	10.0-1														
4.20.0-2.05	• Utilize an integrated processor	10.0-1														
5.2.0-1	The objective of the coordination will be to provide for smooth flow along the arterial road, minimizing the number of stops experienced by vehicles traveling along the road. Where "natural" cycle lengths exist that permit two-way progression, the system will generally operate at one of those cycle lengths unless longer phase lengths, are required to accommodate the demand.	2.2.0-5														
5.2.0-2	The objective of the coordination will be to maximize the throughput along the coordinated route. This may involve a tradeoff that increases delay to cross streets and turning movements, in order to maximize the green time provided to coordinated traffic flows.	2.2.0-5.0-2														
5.2.0-3	The objective of the coordination will be to control traffic in a manner that equitably serves the adjacent land uses. The delays experienced by the traffic entering and leaving the coordinated route will be balanced with the delays and stops experienced by other traffic traveling along the route.	2.1.1.0-7.0-3														
5.2.0-4	The objective of the coordination will be to manage the lengths of queues stored at critical locations within the coordinated group so that long queues do not block upstream intersections or otherwise reduce the capacity available during the green phases. This will involve controlling phase lengths so that the size of platoons entering a downstream block does not exceed the storage length if the platoon will be stopped. It will also involve control of offsets and phase lengths so that queues may be stored in locations where they will not adversely affect capacity of the system.	2.1.3.0-3														
5.2.0-5	The system, or the operator, will select the appropriate coordination objective, depending on the current traffic conditions. For example, during commuter peaks the primary objective may be to maximize the throughput along the road in the peak direction. Then during the business hours the objective may be to balance delays between traffic associated with the adjacent activity and traffic simply traveling through the system.	2.2.0-4														
5.2.0-6	The operator will be able to define for each group of intersections the appropriate operational objective. For example, near a freeway interchange or in a location with heavy turning movements, the queue management strategy may be specified, while on an arterial with long signal spacing the smooth flow objective may be specified.	2.2.0-5														
5.2.0-7	During moderate to light traffic conditions, one or more phases may be omitted (e.g., a protected phase if protected/ permissive left turns are operated), in order to more efficiently serve other movements, provided it is safe to do so. This may be accomplished through a time of day schedule or based on the measured traffic conditions.	2.1.2.0-7														
5.2.0-8	Within these operational objectives, the ASCT system will change its operation to accommodate the rise and fall of volumes through the peaks, and the changing patterns of flow throughout the day and week. However, there is also a stochastic element to traffic in the short term, with the number of arrivals for a phase varying from cycle to cycle, and pedestrians not being present on all phases in all cycles. It is therefore desirable for the system to have some local tactical control. While vehicle-actuated coordination typically allows phases to run longer or shorter from cycle to cycle to match the actual number of vehicles using the phase, the system will also allow the operator to decide where the unused time will be used. If a phase is to be skipped, the operator can specify that the spare time will be added to the existing phase, the following phase, or the next coordinated phase.	2.6.0-4														
5.2.0-9	At an isolated intersection with widely varying traffic patterns and a high degree of saturation during peak times, the system will calculate the optimum cycle length, and phase times in real time to match the changing traffic conditions.	2.1.3.0-3														
5.2.0-10	At a small group of intersections, with the user defining one as being critical, while the adjacent intersections require a lower cycle length or progression must be provided for specific phases to minimize the formation of queues on the approaches to the critical intersection, the phase lengths of the critical intersection will be determined by the system based on the current traffic conditions. The operation of the adjacent intersections will then be set so that platoons departing the critical intersection are progressed through the non-critical intersections, or platoons arriving at the critical intersection do so at a time when they will have little or no delay waiting for the appropriate phase.	2.5.0-4														
5.3.0-1	The system will have a fallback state that allows coordination using a common cycle length for all signals within a coordinated group when falling back to TOD plans.	13.1.0-1	13.3-1													
5.3.0-2	The system will have a fallback state that allows individual intersections to operate in a vehicle-actuated mode constrained by coordination in the event of failures of the adaptive software or hardware, detectors or communication.	13.1.0-1	13.1.0-1.0-1													
5.3.0-3	The system will have a fallback state that allows one or more intersections to be unmarried from a critical intersection in the event of failures of the adaptive software or hardware, detectors or communication.	13.1.0-1	13.2-1	13.3-1												
5.4.0-1	A coordinated group will be able to include more than one coordinated route, such as two crossing arterials. The system will be able to maintain coordination along both roads.	4.0-1.0-4														
5.4.0-2	The NJDOT needs the adaptive system to maintain coordination with another adjacent system either by sensing arriving traffic or by using constraints on cycle length.	4.0-1.0-1														

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Need Statement Reference Number	Concept of Operations Need Statement	System Requirements Reference Numbers														
5.4.0-3	The system will accept data from a neighboring system that allows it to stay in coordination with the adjacent system while still operating in adaptive mode.	4.0-1														
5.5.0-1	Operators, traffic engineering, and maintenance staff will be assigned different levels of authority, and access to equipment for which they are authorized, based on their roles and responsibilities. This will allow them to control, view, monitor, and analyze the operation of the system as appropriate.	5.0-1														
5.5.0-3	The system will be connected to the NJDOT's Statewide Network allowing access to all authorized users.	1.0-1														
5.5.0-4	The system will allow access by authorized users outside the NJDOT (such as system vendor) utilizing OIT's VPN interface	1.0-1														
5.6.0-1	**The NJDOT will use the following complex coordination and controller features:**															
5.6.0-2	• The ability to repeat a phase, such as running a left turn phase before and after its opposing through movement.	7.0-1														
5.6.0-3	• Provision for the required number of rings, phases, phases per ring, and overlap phases.	7.0-5														
5.6.0-4	• The ability to omit a phase under some traffic conditions, or based on external input, to allow a shorter cycle length to operate, or to provide additional time to other phases.	2.1.2.0-7														
5.6.0-5	• Special features unique to the NJDOT such as detector switching, dynamic max, coordination beginning of yellow.	7.0-14														
5.6.0-6	• The ability to maintain coordination with external movements by preventing phases from being skipped, based on time-of-day, external input or when certain phase sequences are in operation.	2.1.2.0-4														
5.6.0-7	• The NJDOT will permit phases or overlaps by time-of-day schedule or external input.	7.0-2														
5.6.0-8	• The ability to designate specific phases as coordinated phases.	7.0-9														
5.6.0-9	• The ability to separately monitor each lane on an approach and take different action depending on the conditions measured in each lane.	10.0-1														
5.6.0-10	• The ability to allow the coordinated phase to terminate early if the coordinated platoon is short.	2.1.2.0-9														
5.6.0-11	• The ability to introduce a non-coordinated phase later than its normal starting point within a cycle, if it can be served with minimum green within the remaining time available.	2.1.2.0-9	8.0-5													
5.6.0-12	• Protected/permissive and permissive only phasing.	2.1.2.0-1														
5.6.0-14	• The NJDOT may operate external devices using discrete signal outputs from the ASCT including occupancy on a detector, cycle length, and time-of-day.	9.0-1														
5.6.0-15	• The ability for a coordinated phase to be released early.	7.0-16														
7.6	**7.6 Personnel**															
7.6.0-1	The system will need the ability to handle up to XX concurrent operators.	5.0-2	5.0-3	5.0-4	5.0-5											
7.6.0-2	The system will need the ability to handle up to XX user profiles.	5.0-2	5.0-3	5.0-4	5.0-5											
8	**8 Chapter 8: Operational Scenarios**															
8.2	**8.2 Peak Period. Typical heavy uncongested conditions (unsaturated)**															
8.2.1	**8.2.1 Arterial with highway interchange**															
8.2.1.1	Have the ability to monitor traffic conditions and select appropriate signal timing parameters, such as cycle length, green time, offsets, and/or double servicing specific phases where conditions permit.	2.1.1.0-7														
8.2.1.2	Have the ability to determine intersection grouping and establish timing to smooth traffic and provide progression.	2.1.1.0-7														
8.2.1.3	Have the ability to for timing parameters will vary cycle to cycle based on changing traffic conditions.	2.1.1.0-7														
8.2.1.4	Have the ability to monitor traffic volumes and adjust progression based on traffic demands.	2.1.1.0-7														
8.2.1.5	Have the ability to monitor minor approach left turns for queue spillback and automatically increase left turn green time or double service to minimize queue length, constrained by coordination.	2.1.1.0-7														
8.2.1.6	Have the flexibility to be coordinated as one group or have the freedom to operate as separate groups as set by the operators or as dictated by traffic demand.	2.1.1.0-7														
8.2.2	**8.2.2 Arterial with one critical intersection**															
8.2.2.1	Have the ability to monitor traffic conditions and select appropriate signal timing parameters, such as cycle length, green time, offsets, and/or double servicing specific phases where conditions permit.	2.1.1.0-7														
8.2.2.2	Have the ability to determine intersection grouping and establish timing to smooth traffic and provide progression.	2.1.1.0-7														
8.2.2.3	Have the ability to for timing parameters will vary cycle to cycle based on changing traffic conditions.	2.1.1.0-7														
8.2.2.4	Have the ability to monitor traffic volumes and adjust progression based on traffic demands.	2.1.1.0-7														
8.2.2.5	Have the ability to monitor minor approach left turns for queue spillback and automatically increase left turn green time or double service to minimize queue length, constrained by coordination.	2.1.1.0-7														
8.2.2.6	Have the flexibility to be coordinated as one group or have the freedom to operate as separate groups as set by the operators or as dictated by traffic demand.	2.1.1.0-7														
8.2.3	**8.2.3 Arterial with several critical intersections**															
8.2.3.1	Have the ability to monitor traffic conditions and select appropriate signal timing parameters, such as cycle length, green time, offsets, and/or double servicing specific phases where conditions permit.	2.1.1.0-7														
8.2.3.2	Have the ability to determine intersection grouping and establish timing to smooth traffic and provide progression.	2.1.1.0-7														
8.2.3.3	Have the ability to for timing parameters will vary cycle to cycle based on changing traffic conditions.	2.1.1.0-7														
8.2.3.4	Have the ability to monitor traffic volumes and adjust progression based on traffic demands.	2.1.1.0-7														
8.2.3.5	Have the ability to monitor minor approach left turns for queue spillback and automatically increase left turn green time or double service to minimize queue length, constrained by coordination.	2.1.1.0-7														
8.2.3.6	Have the flexibility to be coordinated as one group or have the freedom to operate as separate groups as set by the operators or as dictated by traffic demand.	2.1.1.0-7														
8.3	**8.3 Peak Period. Typical heavy congested conditions (oversaturated)**															
8.3.1	**8.3.1 Arterial with highway interchange**															
8.3.1.1	Have the ability to automatically change goals to provide maximum throughput.	2.1.1.0-7														
8.3.1.2	Have the ability to monitor traffic conditions and select appropriate signal timing parameters, cycle length, green time, offsets, and/or double servicing specific phases where conditions permit.	2.1.1.0-7														
8.3.1.3	Have the ability to determine intersection grouping and establish timing to maximize the movement of vehicles	2.1.1.0-7														
8.3.1.4	Have the ability for timing parameters to vary cycle to cycle based on changing traffic conditions.	2.1.1.0-7														
8.3.1.5	Have the ability to monitor traffic volumes and adjust progression based on traffic demands.	2.1.1.0-7														
8.3.1.6	Have the ability to monitor minor approach left turns for queue spillback and automatically increase left turn green time or double service to minimize queue length, constrained by coordination.	2.1.1.0-7														

Need Statement Reference Number	Concept of Operations Need Statement	System Requirements Reference Numbers														
8.3.1.7	Have the flexibility to be coordinated as one group or have the freedom to operate as separate groups as set by the operators or as dictated by traffic demand	2.1.1.0-7														
8.3.2	**8.3.2 Arterial with one critical intersection**															
8.3.2.1	Have the ability to automatically change goals to provide maximum throughput.	2.1.1.0-7														
8.3.2.2	Have the ability to monitor traffic conditions and select appropriate signal timing parameters, cycle length, green time, offsets, and/or double servicing specific phases where conditions permit.	2.1.1.0-7														
8.3.2.3	Have the ability to determine intersection grouping and establish timing to maximize the movement of vehicles	2.1.1.0-7														
8.3.2.4	Have the ability for timing parameters to vary cycle to cycle based on changing traffic conditions.	2.1.1.0-7														
8.3.2.5	Have the ability to monitor traffic volumes and adjust progression based on traffic demands.	2.1.1.0-7														
8.3.2.6	Have the ability to monitor minor approach left turns for queue spillback and automatically increase left turn green time or double service to minimize queue length, constrained by coordination.	2.1.1.0-7														
8.3.2.7	Have the flexibility to be coordinated as one group or have the freedom to operate as separate groups as set by the operators or as dictated by traffic demand	2.1.1.0-7														
8.3.3	**8.3.3 Arterial with several critical intersections**															
8.3.3.1	Have the ability to automatically change goals to provide maximum throughput.	2.1.1.0-7														
8.3.3.2	Have the ability to monitor traffic conditions and select appropriate signal timing parameters, cycle length, green time, offsets, and/or double servicing specific phases where conditions permit.	2.1.1.0-7														
8.3.3.3	Have the ability to determine intersection grouping and establish timing to maximize the movement of vehicles	2.1.1.0-7														
8.3.3.4	Have the ability for timing parameters to vary cycle to cycle based on changing traffic conditions.	2.1.1.0-7														
8.3.3.5	Have the ability to monitor traffic volumes and adjust progression based on traffic demands.	2.1.1.0-7														
8.3.3.6	Have the ability to monitor minor approach left turns for queue spillback and automatically increase left turn green time or double service to minimize queue length, constrained by coordination.	2.1.1.0-7														
8.3.3.7	Have the flexibility to be coordinated as one group or have the freedom to operate as separate groups as set by the operators or as dictated by traffic demand	2.1.1.0-7														
8.4	**8.4 Moderate balanced flows**															
8.4.1.1	Select phase times or offsets that provide smooth flow along the corridor in both directions.	2.1.1.0-7														
8.4.1.2	Provide signal timing that prevents phase failures at all intersections and serves all turning traffic.	2.1.1.0-7														
8.4.1.3	At specified intersections, select phase times that will accommodate frequent use of pedestrian phases.	2.1.1.0-7														
8.4.1.4	At other intersections, select phase times that will accommodate occasional use of pedestrian phases.	2.1.1.0-7														
8.5	**8.5 Non-reoccurring events, incidents and other unexpected events**															
8.5.1.1	If there is heavily direction traffic before or after an event, the system will determine the predominate direction and coordinate accordingly, with appropriate cycle length and offset.	2.6.0-6														
8.5.1.2	If the event is not as heavy as peak hours, but the traffic is still highly directional, then the system will recognize this and provide the coordination predominantly in the heaviest direction, even though the cycle length may be similar to peak hour cycle lengths.	2.6.0-6														
8.5.1.3	The entire corridor may be set by the operator to operate as one or more coordinated groups, or the system may have the freedom to operate it as one of more groups subject to user-specified criteria, such as similar required cycle lengths in different parts of the corridor, of the volume of traffic at key locations exceeds a threshold.	2.6.0-6														
8.5.1.4	If downstream signals experience lighter traffic as a result of an incident blocking and restricting traffic, those signal should be coordinate as a group, with cycle length, splits and offsets that react to the measured traffic.	2.6.0-6														
8.5.1.5	If a detected blockage is in the peak direction, then the system may coordinate in the opposite direction if that traffic is similar to or greater than normal peak direction.	2.6.0-6														
8.5.1.6	The system needs to recognize the presence of an abnormal obstruction, modify the signal operation to react to the change traffic conditions in an efficient manner, and report the abnormal condition to the operator.	2.6.0-6														
8.6.1-1	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.	13.2-1														
8.7.1-1	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.	13.1.0-1														
8.8.1-1	When an intersection responds to preemption, other signals within the coordinate group continue to operate adaptively. The preempted signal returns to adaptive control once the preemption is released.	11.0-1														
8.9.1-1	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. The system will then return to normal operation.	2.6.0-4														

Need Statement Reference Number	Concept of Operations Need Statement	System Requirements Reference Numbers														
8.11.0-1	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. 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 that has a heavy U-turn volume.	5.0-1.0-16														

Verification Plan
for
NJ RT XX Traffic Signal System Contract No. XX (20XX)

CITY
COUNTY, NEW JERSEY

Month 20XX

Prepared For

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Table of Contents

1.0 Purpose of Document

This document describes how the Adaptive Signal Control Technology (ASCT) Controlled Traffic Signal System (CTSS) and related subsystem components shall be verified to ensure that the system functions as specified. The Adaptive CTSS is composed of a complex, integrated blend of hardware, software, and processes performing a range of functions. These functions include data acquisition, command and control, data processing and analysis, and communications. This document plans, describes, and records the activities which verify that the systems being built meets the needs and scenarios developed in the Concept of Operations, by fulfilling the requirements described in the requirements documents.

The main purpose of providing computerized control on this corridor is to optimize the use of existing roadway capacity by providing more efficient traffic signal operation while maintaining safety. The causes of intermittent congestion and delay are varied and change throughout the various corridors in New Jersey. The general commuter traffic trend has approximately a XX/XX split with peak AM traffic heading northbound and peak PM traffic heading southbound. Abutting land uses also affect the traffic patterns on the corridor and place conflicting demands on the roadway and traffic signals.

The proposed CTSS shall be accessed and maintained from the NJDOT Arterial Management Center (AMC) located in Trenton. The proposed system shall communicate to the AMC through an existing fiber optic communications tied into the existing statewide fiber optic cable network.

The intended audience of this document typically includes the following stakeholders:

- NJDOT
- Neighboring jurisdictions that operate signals
    - XX County
    - XX Municipality
- Fire departments
- Police departments
- NJTA
- NJ Transit
- FHWA

Hence, the Verification Plan's purpose is to ensure that what was specified is what was delivered. It verifies that the system meets the functional, performance, design, and implementation requirements identified in the procurement specifications.

Verification is about managing risk for both NJDOT and the Adaptive CTSS vendor/developer/integrator. The Verification Plan shall facilitate the process of managing the programmatic and technical risks and help to assure the success of the CTSS project. The Verification Plan shall be used to identify the point at which the work has been "completed" and the Adaptive system has been fully integrated into the communication and vehicle detection systems. Once the full integration and acceptance of all systems has taken place, the system can be shifted by NJDOT into the warranty and maintenance phase of the project. Incremental testing is often tied to intermediate milestones and allows NJDOT to start using the system for the benefit of the public.

The Systems Engineering documents used to develop the Verification Plan were developed with guidance from the Federal Highway Administration (FHWA) Model Systems Engineering Documents for Adaptive Signal Control Technology (ASCT) Systems. The general work flow of the System Engineering process is shown in Exhibit X of the Concept of Operations. While Verification is shown as one stage of the life cycle, it is important to understand that Verification is also a continuous process within the life cycle. Verification begins with writing the requirements; each requirement must be written in a manner that allows it to be verified. During the design stages, Verification shall be a consideration as design options are evaluated for their ability to satisfy the requirements. New requirements may emerge from the designs as choices are made to satisfy the requirements within the project's constraints. Hardware components, software components, subsystems, and systems shall be verified during the implementation and testing stages. Final system-level tests shall be performed to accept the system and demonstrate the system's readiness for operation. . However, testing activities shall not end once the system is in operation; it shall continue as the operations and maintenance staff perform corrective and maintenance activities.

Each of the system requirements shall be traced to a Verification case, and then into appropriate steps in the Verification procedures. The Verification will be witnessed by Department personnel and the results will be audited by the Department to ensure authenticity. In some circumstances a Certificate of Compliance may be requested by the Department. The Adaptive CTSS vendor shall be required to provide the Department the appropriate documentation verifying compliance with the system requirements and conformance with the applicable Department and NJ OIT standards.

During the configuration and set-up of the Adaptive CTSS, user-specified criteria and parameters shall be inputted into the system by the contractor in accordance with the Special Provisions.

The contractor shall determine the daily volume at each traffic signal, average corridor travel time, and the average intersection delay per vehicle prior to Adaptive CTSS Turn On. These baseline conditions shall be determined for an average of two (X) typical weeks and weekends. The method for determination of baseline performance conditions shall be performed in accordance with MSE Data Collection Guidelines and coordination with the RE, and shall be reviewed and approved by the Department prior to the start of construction. Subsequent to the collection of these baseline performance datasets, the Verification activities can be performed.

The Verification activities shall include the following:

Demonstration

Demonstration is the functional Verification that a specification requirement is met by observing the qualitative results of an operation or exercise performed under specific condition without the need for external test equipment. This includes content and accuracy of displays, comparison of system outputs with independently derived test cases, and system recovery from induced failure conditions. For requirements that are intended for future capabilities or expansion of the Adaptive CTSS and cannot be demonstration based on the proposed Adaptive CTSS depicted in the Plans and Special Provisions, the contractor may utilize the demonstration of other similarly deployed Adaptive CTSS or through documentation, subject to written pre-approval of the Department prior to commencement of construction activities.

Testing

Formal testing is the Verification that a requirement has been met by measuring, recording, or evaluating qualitative and quantitative data obtained during controlled exercises under all appropriate conditions using real and/or simulated stimulus with test equipment. This includes Verification of system performance, system functionality, and correct data distribution.

Testing shall be performed, where applicable, by comparing baseline performance data, as indicated above, to post Adaptive CTSS Turn On collected data. The data shall be quantitatively verified against the performance measures of effectiveness as indicated by the contractor in documents submitting at the Kickoff/Pre-Construction Meeting (i.e. percent decrease in stopping delays, decrease in travel time, increase in throughput, etc.).

For requirements that are intended for future capabilities or expansion of the Adaptive CTSS and cannot be tested based on the proposed Adaptive CTSS depicted in the Plans and Special Provisions, the contractor may utilize the testing of other similarly deployed Adaptive CTSS, subject to written pre-approval of the Department prior to commencement of construction activities.

Analysis

Analysis is used for a requirement that is met indirectly through a logical conclusion or mathematical analysis of a result. Analysis is the Verification by evaluation or simulation using mathematical representations, charts, graphs, circuit diagrams, calculation, or data reduction. This includes analysis of algorithms independent of computer implementation, analytical conclusions drawn from test data, and extension of test-produced data to untested conditions. This is often used to extrapolate past performance (which was accurately measured) to a scaled up deployment.

Inspection

Inspection is used for a requirement that is met through visual comparison. Inspection is the Verification by physical and visual examinations of the item, reviewing descriptive documentation, and comparing the appropriate characteristics with all the referenced standards to determine compliance with the requirements. Examples include measuring cabinets sizes, matching paint color samples, observing printed circuit boards to inspect component mounting and construction techniques.

2.0 Scope of Project

An Adaptive CTSS is typically planned as part of an enhancement to an existing traffic signal system on any state corridor to provide responsive or adaptive capabilities. Enhancement projects include traffic signal equipment upgrades and the installation of interconnected communications between the intersections as well as midblock system detection. The limits of the project is shown along state corridor from a system detector site at milepost XX to a system detector site at milepost XX.

3.0 Reference Documents

This section provides a list of documents related to the CTSS Systems Engineering analysis. Related documents are not directly referenced within the narrative of this report, but all related documents have been used to develop the Concept of Operations Report. Some of these documents provide policy guidance, 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.

- *Concept of Operations for Route NJ XX Computerized Traffic Signal System Milepost XX to Milepost XX*, July XX.
- *System Requirements for Route NJ XX Computerized Traffic Signal System Milepost XX to Milepost XX*, July XX.
- *Model System Engineering Document for Adaptive Signal Control Technology (ASCT) Systems*, August 2012, Federal Highway Administration.
- *NCHRP Synthesis 403 – Adaptive Traffic Control Systems: Domestic and Foreign State of Practice*, 2010, Transportation Research Board.
- *Developing and Using a Concept of Operations in Transportation Management Systems*, December 2004, Federal Highway Administration.
- *New Jersey Statewide Intelligent Transportation Systems (ITS) Architecture*, February 18, 2005, New Jersey Department of transportation-Division of Statewide Traffic Operations
- *Institutional Coordination of Intelligent Transportation Systems in the Delaware Valley – Regional ITS Architecture,* March 2001, Delaware Valley Regional Planning Commission.
- *National Transportation Communications for ITS Protocols (NTCIP) – The NTCIP Guide*, July 2009, AASHTO, ITE, NEMA.
- *Standardization Policies and Procedures of the National Electrical Manufactures Association (NEMA)*, December 31, 2009, NEMA.
- *Manual on Uniform Traffic Control Devices (MUTCD), 2009, revised through May 2012,* Federal Highway Administration.
- *Highway Capacity Manual, 2010, Transportation Research Board.*
- *National Electrical Safety Code (NESC) and Handbook Set, 2012, Institute of Electrical and Electronics Engineers (IEEE).*
- *NFPA 70: National Electrical Code, 2014, National Fire Protection Association.*

4.0 Conducting Verification

The Verification shall be conducted by the system vendor/supplier in presence of the NJDOT. Prior to the actual Verification process, a Test Readiness Review shall be held to determine the readiness of the sub-systems for Verification. The contractor shall also prepare a systems integration plan for review by the Department for all systems and subsystems (Adaptive CTSS/Image Detection/Radar System Detection/Communications System, etc.). This systems integration plan shall verify that all components and interfaces of the systems and subsystems operate and function as per the system requirements as one composite system. The results of the integration plan tests shall be submitted to the Department for review and approval.

When the Department has determined that Verification process can proceed, the sub-systems shall be verified. Beginning with the communications system and image and system detection systems, each component system shall be tested incrementally in accordance with standard Department testing procedures until the entire system is operational. When the integration and testing are completed, the next level of sub-system is integrated and tested in the same manner. The Adaptive CTSS shall be the final system to be tested and verified.

The contractor shall conduct the Verification in two stages. The first stage is to be completed under a controlled environment (Department signal shop, vendor's facility, etc.) in accordance with Department testing procedures. The second stage is to be completed within the applicable environment that the system or subsystem is intended to operate after Initial System Deployment (in the field, server room, etc.) in accordance with Department testing procedures.

The Verification Plan Matrix included in this Attachment indicates the Verification method that shall be conducted by the contractor to verify each specific requirement has been met. During the Kickoff Meeting the contractor shall indicate the planned Verification Procedure(s) for each requirement as well as the logical grouping of the procedures (if rearranging or grouping is necessary). The Department will review and approve Verification activities, as well as the applicable verification measures of effectiveness, prior to the contractor conducting the Verification. The vendor shall coordinate with the Department to schedule the demonstration and testing time periods. At this stage, the system and subsystems shall be verified in accordance with the Verification Plan.

During initial Adaptive CTSS deployment, the Adaptive CTSS shall be integrated into its intended operational environment. This "system burn-in" shall take up to XX months to complete (or as directed by the Department) to ensure that the system operates satisfactorily in the long term.

The contractor shall complete the Verification Plan Matrix included in this Attachment to include the Verification and testing results. Any failure or lack of performance to meet the "mandatory" system requirements shall be immediately recorded and the contractor shall prepare a report stating why the system requirement was not met. The report shall include a proposed solution to resolve the deficiency and shall be submitted for Department review within seven (X) days of the discovery of a failure. If the vendor is not able to meet a "desirable" or "optional" system requirement that was included in the contractor submittal at the Kickoff Meeting, the contractor shall prepare a report and develop a plan to provide similar performance operation through alternative means, as reviewed and approved by the Department. The Department does not anticipate that any software revisions would be required to satisfy the mandatory requirements, and if any software requirements become necessary, additional payment will not be made. Upon completion of all required Verification activities and procedures, and prior to Department project acceptance, the contractor shall prepare a final Verification Report which shall contain all critical information regarding Verification conducted including both failures and successes. Resolution of the cause of failures should also be detailed. A list of all hardware, software, and special equipment utilized in the Verification shall be provided.

5.0 Verification Identification

The Verification cases shall be tested and documented by the system and subsystem vendor. Each Verification case consists of the system requirement or group of system requirements that satisfy an operational need of NJDOT. These needs are described in the Concept of Operations. The Verification plan does not include the Verification procedures. That is to be inputted by the vendor during the prior to the Construction Kickoff meeting. As a result, the Verification tests are not grouped by action procedures. The vendor is allowed to rearrange the Verification demonstrations and tests by the respective action procedures. The vendor shall provide the final action procedures for the demonstrations and tests and the logical grouping of the procedures (if re-arranged) for NJDOT's review and approval before conducting the Verification. The Verification Plan Matrix can be found in Appendix X of this document, and the Verification Plan, Attachment of the Special Provisions. The Verification Plan, Attachment of the Special Provisions shall govern over Appendix X of this document in case of discrepancy.

Appendix X – Verification Plan Matrix

System Requirements Reference Number	System Requirement Description	ConOps Needs	ConOps Statement	Verification Method	Verification Procedure	Pass/Fail**	If the verification procedure fails, explain the reason why and how the issue will be resolved**
	* *requires a verification measure of effectiveness*						
1	**1 Network Characteristics**						
1.0-1	The ASCT shall have the ability to control a minimum of XX ASCT signalized intersections concurrently.	4.2.0-1 4.10.0-1 4.10.0-1.01 4.10.0-1.02 4.10.0-1.03 4.10.0-1.04 4.10.0-1.05 5.5.0-3 5.5.0-4	The system needs the ability to eventually adaptively control up to XX signalized intersections, up to XX miles from XXX (TMC, TOC, etc.). The system needs the ability to monitor and control all required features of adaptive operation from the following locations • Traffic Operation Center XXX • Arterial Management Center (AMC) • Statewide Traffic Management Center (STMC) • Local Controller Cabinets • Maintenance Vehicles The system will be connected to the NJDOT's Statewide Network allowing access to all authorized users The system will allow access by authorized users outside the NJDOT (such as system vendor) utilizing OIT's VPN interface	Demonstration	Provide documentation of system capabilities.		
1.0-2	The ASCT shall support XX groups of signalized intersections.	4.2.0-2 4.2.0-3	The system needs the ability to be able to eventually adaptively control up to XX independent groups of signalized intersections The system needs the ability to vary the number of signals in an adaptively controlled group to accommodate the prevailing traffic conditions.	Demonstration	Provide documentation of system capabilities.		
1.0-2.0-1	The boundaries surrounding signal controllers that operate in a coordinated fashion shall be defined by the user.	4.1.0-2	The system needs the ability to manage the coordination in small groups of signals to link phase service at some intersections with phase service at adjacent intersections	Demonstration	Provide documentation of system capabilities.		
1.0-2.0-2	The ASCT shall control a minimum of XX groups of adaptive signals.	4.2.0-2	The system needs the ability to be able to eventually adaptively control up to XX independent groups of signalized intersections	Demonstration	Provide documentation of system capabilities.		
1.0-2.0-3	The size of a group shall range from 1 to XX adaptive signals.	4.2.0-3	The system needs the ability to vary the number of signals in an adaptively controlled group to accommodate the prevailing traffic conditions.	Demonstration	Provide documentation of system capabilities.		
1.0-2.0-4	Each group shall operate independently.	4.2.0-2	The system needs the ability to be able to eventually adaptively control up to XX independent groups of signalized intersections	Demonstration	Provide documentation of system capabilities.		
1.0-2.0-5	The boundaries surrounding signal controllers that operate in a coordinated fashion shall be altered by the system according to configured parameters.	4.2.0-3	The system needs the ability to vary the number of signals in an adaptively controlled group to accommodate the prevailing traffic conditions.	Demonstration	Demonstrate the functionality.		
1.0-2.0-5.0-1	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.	4.2.0-3	The system needs the ability to vary the number of signals in an adaptively controlled group to accommodate the prevailing traffic conditions.	Demonstration	Demonstrate the functionality.		
1.0-2.0-5.0-2	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.	4.2.0-3	The system needs the ability to vary the number of signals in an adaptively controlled group to accommodate the prevailing traffic conditions.	Demo/Testing	Demonstrate/ test the functionality.		
1.0-2.0-5.0-3	The boundaries surrounding signal controllers that operate in a coordinated fashion shall be altered by the system when commanded by the user.	4.2.0-3	The system needs the ability to vary the number of signals in an adaptively controlled group to accommodate the prevailing traffic conditions.	Demonstration	Provide documentation of system capabilities.		
1.0-3	The local traffic signal controller ASCT software/firmware shall have the ability to coexist with the NJDOT's existing Traffic Management System local traffic signal controller software/firmware (It is acceptable to have separate controller boot sequences).	4.15.0-1.0-5 4.11-0.1 4.15.0-1.0-1	• Coexist with the Traffic Management System The NJDOT needs the ability for the Traffic Management System to be able to coexist with or monitor the adaptive system • Naztec 2070N controllers are utilized by not a mandatory constraints	Demonstration	Demonstrate the functionality.		
2	**2 Type of Operation**						
2.1	**2.1 General**						
2.1.1	**2.1.1 Mode of Operation**						
2.1.1.0-1	The ASCT shall operate non-adaptively during the presence of a defined condition.	4.7.0-1	The system needs the ability to detect traffic conditions during which adaptive control is not the preferred operation, and implement some pre-defined operation while that condition is present.	Demo/Testing	Demonstrate/test the functionality.		
2.1.1.0-2	The ASCT shall operate non-adaptively when adaptive control equipment fails.	4.14.0-1	The system needs the ability to fall back to TOD or actuated operation constrained by coordination, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications, and software failure	Demo/Testing	Demonstrate/test the functionality.		
2.1.1.0-2.0-1	The ASCT shall be capable of operating non-adaptively when the number of failed detectors connected to a signal controller exceeds a user-defined value.	4.14.0-1	The system needs the ability to fall back to TOD or actuated operation constrained by coordination, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications, and software failure	Demo/Testing	Demonstrate/test the functionality.		
2.1.1.0-2.0-2	The ASCT shall be capable of operating non-adaptively when a user manually commands the ASCT to cease adaptively controlling a group of signals.	4.14.0-1	The system needs the ability to fall back to TOD or actuated operation constrained by coordination, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications, and software failure	Demo/Testing	Demonstrate/test the functionality.		
2.1.1.0-2.0-3	The ASCT shall be capable of operating non-adaptively when a user-defined communications link fails.	4.14.0-1	The system needs the ability to fall back to TOD or actuated operation constrained by coordination, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications, and software failure	Demo/Testing	Demonstrate/test the functionality.		
2.1.1.0-3	The ASCT shall be capable of operating non-adaptively when a user manually commands the ASCT to cease adaptively controlling a group of signals	4.7.0-3	The system needs the ability to over-ride adaptive operation.	Demo/Testing	Demonstrate/test the functionality.		
2.1.1.0-4	The ASCT shall be capable of operating non-adaptively when a user manually commands the ASCT to cease adaptive operation.	4.7.0-3	The system needs the ability to fall back to TOD or actuated operation constrained by coordination, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications, and software failure	Demo/Testing	Demonstrate/test the functionality.		
2.1.1.0-5	The ASCT shall be capable of operating non-adaptively in accordance with a user-defined time-of-day schedule such as AM/PM peaks.	4.7.0-2 4.7.0-3	The system needs the ability to schedule pre-determined operation by time of day. The system needs the ability to fall back to TOD or actuated operation constrained by coordination, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications, and software failure	Demo/Testing	Demonstrate/test the functionality.		

System Requirements Reference Number	System Requirement Description	ConOps Needs	ConOps Statement	Verification Method	Verification Procedure	Pass/Fail**	If the verification procedure fails, explain the reason why and how the issue will be resolved**
2.1.1.0-6	The ASCT shall be capable of operating non-adaptively when commanded by an external system process.	4.17.0-3	The system needs the ability to be capable of responding to commands issued by the Traffic Management System	Demo/Testing	Demonstrate/test the functionality.		
2.1.1.0-7	The ASCT be capable of altering the adaptive operation by adjusting parameters or by directly controlling the state of signal controllers.	4.1.0-1.0-1	Maximize the throughput on coordinated routes.	Demo/Testing	Demonstrate/test the functionality and verify the performance measures.		
		4.1.0-1.0-3	Distribute phase times in an equitable fashion				
		4.1.0-3	The system needs the ability to change the operational strategy (for example, from smooth flow to maximizing throughput or managing queues) based on changing traffic conditions				
		8.2.1.1	Have the ability to monitor traffic conditions and select appropriate signal timing parameters, such as cycle length, green time, offsets, and/or double servicing specific phases where conditions permit.				
		8.2.1.2	Have the ability to determine intersection grouping and establish timing to smooth traffic and provide progression.				
		8.2.1.3	Have the ability to for timing parameters will vary cycle to cycle based on changing traffic conditions.				
		8.2.1.4	Have the ability to monitor traffic volumes and adjust progression based on traffic demands.				
		8.2.1.5	Have the ability to monitor minor approach left turns for queue spillback and automatically increase left turn green time or double service to minimize queue length, constrained by coordination.				
		8.2.1.6	Have the flexibility to be coordinated as one group or have the freedom to operate as separate groups as set by the operators or as dictated by traffic demand.				
		8.2.2.1	Have the ability to monitor traffic conditions and select appropriate signal timing parameters, such as cycle length, green time, offsets, and/or double servicing specific phases where conditions permit.				
		8.2.2.2	Have the ability to determine intersection grouping and establish timing to smooth traffic and provide progression.				
		8.2.2.3	Have the ability to for timing parameters will vary cycle to cycle based on changing traffic conditions.				
		8.2.2.4	Have the ability to monitor traffic volumes and adjust progression based on traffic demands.				
		8.2.2.5	Have the ability to monitor minor approach left turns for queue spillback and automatically increase left turn green time or double service to minimize queue length, constrained by coordination				
		8.2.2.6	Have the flexibility to be coordinated as one group or have the freedom to operate as separate groups as set by the operators or as dictated by traffic demand.				
		8.2.3.1	Have the ability to monitor traffic conditions and select appropriate signal timing parameters, such as cycle length, green time, offsets, and/or double servicing specific phases where conditions permit.				
		8.2.3.2	Have the ability to determine intersection grouping and establish timing to smooth traffic and provide progression.				
		8.2.3.3	Have the ability to for timing parameters will vary cycle to cycle based on changing traffic conditions.				
		8.2.3.4	Have the ability to monitor traffic volumes and adjust progression based on traffic demands.				
		8.2.3.5	Have the ability to monitor minor approach left turns for queue spillback and automatically increase left turn green time or double service to minimize queue length, constrained by coordination.				
		8.2.3.6	Have the flexibility to be coordinated as one group or have the freedom to operate as separate groups as set by the operators or as dictated by traffic demand.				
		8.3.1.1	Have the ability to automatically change goals to provide maximum throughput.				
		8.3.1.2	Have the ability to monitor traffic conditions and select appropriate signal timing parameters, cycle length, green time, offsets, and/or double servicing specific phases where conditions permit				
		8.3.1.3	Have the ability to determine intersection grouping and establish timing to maximize the movement of vehicles				
		8.3.1.4	Have the ability for timing parameters to vary cycle to cycle based on changing traffic conditions.				
		8.3.1.5	Have the ability to monitor traffic volumes and adjust progression based on traffic demands.				
		8.3.1.6	Have the ability to monitor minor approach left turns for queue spillback and automatically increase left turn green time or double service to minimize queue length, constrained by coordination.				
		8.3.1.7	Have the flexibility to be coordinated as one group or have the freedom to operate as separate groups as set by the operators or as dictated by traffic demand				
		8.3.2.1	Have the ability to automatically change goals to provide maximum throughput.				
		8.3.2.2	Have the ability to monitor traffic conditions and select appropriate signal timing parameters, cycle length, green time, offsets, and/or double servicing specific phases where conditions permit				
		8.3.2.3	Have the ability to determine intersection grouping and establish timing to maximize the movement of vehicles				
		8.3.2.4	Have the ability for timing parameters to vary cycle to cycle based on changing traffic conditions.				
		8.3.2.5	Have the ability to monitor traffic volumes and adjust progression based on traffic demands.				
		8.3.2.6	Have the ability to monitor minor approach left turns for queue spillback and automatically increase left turn green time or double service to minimize queue length, constrained by coordination.				

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		8.3.2.7 8.3.3.1 8.3.3.2 8.3.3.3 8.3.3.4 8.3.3.5 8.3.3.6 8.3.3.7 8.4.1.1 8.4.1.2 8.4.1.3 8.4.1.4 8.5.1.1 8.5.1.2 8.5.1.3 8.5.1.4 8.5.1.5 8.5.1.6 8.6.1-1	Have the flexibility to be coordinated as one group or have the freedom to operate as separate groups as set by the operators or as dictated by traffic demand Have the ability to automatically change goals to provide maximum throughput. Have the ability to monitor traffic conditions and select appropriate signal timing parameters, cycle length, green time, offsets, and/or double servicing specific phases where conditions permit. Have the ability to determine intersection grouping and establish timing to maximize the movement of vehicles Have the ability for timing parameters to vary cycle to cycle based on changing traffic conditions. Have the ability to monitor traffic volumes and adjust progression based on traffic demands. Have the ability to monitor minor approach left turns for queue spillback and automatically increase left turn green time or double service to minimize queue length, constrained by coordination. Have the flexibility to be coordinated as one group or have the freedom to operate as separate groups as set by the operators or as dictated by traffic demand Select phase times or offsets that provide smooth flow along the corridor in both directions. Provide signal timing that prevents phase failures at all intersections and serves all turning traffic. At specified intersections, select phase times that will accommodate frequent use of pedestrian phases At other intersections, select phase times that will accommodate occasional use of pedestrian phases. If there is heavily direction traffic before or after an event, the system will determine the predominate direction and coordinate accordingly, with appropriate cycle length and offset If the event is not as heavy as peak hours, but the traffic is still highly directional, then the system will recognize this and provide the coordination predominantly in the heaviest direction, even though the cycle length may be similar to peak hour cycle lengths. The entire corridor may be set by the operator to operate as one or more coordinated groups, or the system may have the freedom to operate it as one of more groups subject to user-specified criteria, such as similar required cycle lengths in different parts of the corridor, of the volume of traffic at key locations exceeds a threshold. If downstream signals experience lighter traffic as a result of an incident blocking and restricting traffic, those signal should be coordinate as a group, with cycle length, splits and offsets that react to the measured traffic. If a detected blockage is in the peak direction, then the system may coordinate in the opposite direction if that traffic is similar to or greater than normal peak direction The system needs to recognize the presence of an abnormal obstruction, modify the signal operation to react to the change traffic conditions in an efficient manner, and report the abnormal condition to the operator. 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.				
2.1.1.0-7.0-1	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	4.1.0-1.0-1 4.1.0-3	Maximize the throughput on coordinated routes. The system needs the ability to change the operational strategy (for example, from smooth flow to maximizing throughput or managing queues) based on changing traffic conditions	Demo/Testing	Demonstrate/test the functionality.		
2.1.1.0-7.0-2	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.	4.1.0-1.0-4 4.1.0-3	Manage the length of queues. The system needs the ability to change the operational strategy (for example, from smooth flow to maximizing throughput or managing queues) based on changing traffic conditions	Demo/Testing	Demonstrate/test the functionality.		
2.1.1.0-7.0-3	When current measured traffic conditions meet user-specified criteria, the ASCT shall alter the state of signal controllers providing equitable distribution of green times.	4.1.0-1.0-3 4.1.0-3 5.2.0-3	Distribute phase times in an equitable fashion. The system needs the ability to change the operational strategy (for example, from smooth flow to maximizing throughput or managing queues) based on changing traffic conditions The objective of the coordination will be to control traffic in a manner that equitably serves the adjacent land uses. The delays experienced by the traffic entering and leaving the coordinated route will be balanced with the delays and stops experienced by other traffic traveling along the route.	Demo/Testing	Demonstrate/test the functionality and verify the performance measures.		
2.1.1.0-7.0-4	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	4.1.0-1.0-2	Provide smooth flow along coordinated routes.	Demo/Testing	Demonstrate/test the functionality.		

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		4.1.0-3	The system needs the ability to change the operational strategy (for example, from smooth flow to maximizing throughput or managing queues) based on changing traffic conditions				
2.1.1.0-7.0-5	The ASCT shall operate non-adaptively when user constraints command the ASCT to cease adaptive operation.	4.7.0-1	The system needs the ability to detect traffic conditions during which adaptive control is not the preferred operation, and implement some pre-defined operation while that condition is present.	Demo/Testing	Demonstrate/test the functionality.		
2.1.1.0-8	The ASCT shall provide maximum and minimum phase times	4.1.0-1.0-3 4.1.0-1.0-6	Distribute phase times in an equitable fashion At an isolated intersection, optimize operation with a minimum of phase failures (based on the optimization objectives)	Demo/Testing	Demonstrate/test the functionality.		
2.1.1.0-8.0-1	The ASCT shall provide a user-specified maximum value for each phase at each signal controller.	4.1.0-1.0-3 4.1.0-1.0-6	Distribute phase times in an equitable fashion. At an isolated intersection, optimize operation with a minimum of phase failures (based on the optimization objectives)	Demo/Testing	Demonstrate/test the functionality.		
2.1.1.0-8.0-1.0-1	The ASCT shall not provide a phase length longer than the maximum value.	4.1.0-1.0-3 4.1.0-1.0-6	Distribute phase times in an equitable fashion At an isolated intersection, optimize operation with a minimum of phase failures (based on the optimization objectives)	Demo/Testing	Demonstrate/test the functionality and verify the performance measures.		
2.1.1.0-8.0-2	The ASCT shall provide a user-specified minimum value for each phase at each signal controller.*	4.1.0-1.0-3 4.1.0-1.0-6	Distribute phase times in an equitable fashion. At an isolated intersection, optimize operation with a minimum of phase failures (based on the optimization objectives)	Demo/Testing	Demonstrate/test the functionality and verify the performance measures.		
2.1.1.0-8.0-2.0-1	The ASCT shall not provide a phase length shorter than the minimum value	4.1.0-1.0-3 4.1.0-1.0-6	Distribute phase times in an equitable fashion At an isolated intersection, optimize operation with a minimum of phase failures (based on the optimization objectives)	Demonstration	Demonstrate/test the functionality.		
2.1.1.0-9	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.)*	4.1.0-4	The system needs the ability to detect repeated phase failures and control signal timing to prevent phase failures building up queues.	Demo/Testing	Demonstrate/test the functionality and verify the performance measures.		
2.1.1.0-9.0-1	The ASCT shall alter operations to minimize phase failures if it detects repeated phases that do not serve all waiting vehicles.*	4.1.0-4	The system needs the ability to detect repeated phase failures and control signal timing to prevent phase failures building up queues.	Demo/Testing	Demonstrate/test the functionality and verify the performance measures.		
2.1.1.0-10	The ASCT shall provide coordination along a route.*	4.1.0-7	The system needs the ability to designate the coordinated route based on traffic conditions and the selected operational strategy	Demo/Testing	Demonstrate/test the functionality and verify the performance measures.		
2.1.1.0-10.0-1	The ASCT shall coordinate along a user-defined route.	4.1.0-7	The system needs the ability to designate the coordinated route based on traffic conditions and the selected operational strategy	Demo/Testing	Demonstrate/test the functionality.		
2.1.1.0-10.0-2	The ASCT shall determine the coordinated route based on traffic conditions.	4.1.0-7	The system needs the ability to designate the coordinated route based on traffic conditions and the selected operational strategy	Demo/Testing	Demonstrate/test the functionality.		
2.1.1.0-10.0-3	The ASCT shall determine the coordinated route based on a user-defined schedule.	4.1.0-7	The system needs the ability to designate the coordinated route based on traffic conditions and the selected operational strategy	Demo/Testing	Demonstrate/test the functionality.		
2.1.1.0-10.0-4	The ASCT shall store user-defined coordination routes.	4.1.0-7	The system needs the ability to designate the coordinated route based on traffic conditions and the selected operational strategy	Demo/Testing	Demonstrate/test the functionality.		
2.1.1.0-10.0-4.0-1	The ASCT shall implement a stored coordinated route by operator command.	4.1.0-7	The system needs the ability to designate the coordinated route based on traffic conditions and the selected operational strategy	Demo/Testing	Demonstrate/test the functionality.		
2.1.1.0-10.0-4.0-2	The ASCT shall implement a stored coordinated route based on traffic conditions.	4.1.0-7	The system needs the ability to designate the coordinated route based on traffic conditions and the selected operational strategy	Demo/Testing	Demonstrate/test the functionality.		
2.1.1.0-10.0-4.0-3	The ASCT shall implement a stored coordinated route based on a user-defined schedule.	4.1.0-7	The system needs the ability to designate the coordinated route based on traffic conditions and the selected operational strategy	Demo/Testing	Demonstrate/test the functionality.		
2.1.1.0-11	The ASCT shall not prevent the use of phase timings in the local controller set by NJDOT policy.	4.1.0-8	The system needs the ability to set signal timing parameters to comply with NJDOT policies.	Demo/Testing	Demonstrate/test the functionality.		
2.1.2	**2.1.2 Allowable Phases**						
2.1.2.0-1	The ASCT shall allow protected/permissive left turn phase operation.	4.9.0-1.0-13 5.6.0-12	• Protected/permissive phasing and alternate left turn phase sequences. • Protected/permissive and permissive only phasing	Demo/Testing	Demonstrate/test the functionality.		
2.1.2.0-2	The ASCT shall allow the protected left turn phase to lead or lag the opposing through phase based upon user-specified conditions	4.9.0-1.0-13	• Protected/permissive phasing and alternate left turn phase sequences.	Demo/Testing	Demonstrate/test the functionality.		
2.1.2.0-3	The ASCT shall prevent skipping a user-specified phase when the user-specified phase sequence is operating.	4.9.0-1.0-5	• Prevent one or more phases being skipped under certain traffic conditions or signal states.	Demo/Testing	Demonstrate/test the functionality.		
2.1.2.0-4	The ASCT shall prevent skipping a user-specified phase based on a user-specified external input.	4.9.0-1.0-5 4.17.0-3 5.6.0-7	• Prevent one or more phases being skipped under certain traffic conditions or signal states. The system needs the ability to be capable of responding to commands issued by the Traffic Management System • The NJDOT will permit phases or overlaps by time-of-day schedule or external input.	Demo/Testing	Demonstrate/test the functionality.		
2.1.2.0-5	The ASCT shall prevent skipping a user-specified phase according to a time of day schedule.	4.9.0-1.0-5	• Prevent one or more phases being skipped under certain traffic conditions or signal states.	Demo/Testing	Demonstrate/test the functionality.		
2.1.2.0-6	The ASCT shall have the ability, subject to user constraints, to omit a user-specified phase when the cycle length is below a user-specified value	4.9.0-1.0-4 5.6.0-4	• Allow one or more phases to be omitted (disabled) under certain traffic conditions or signal states • The ability to omit a phase under some traffic conditions, or based on external input, to allow a shorter cycle length to operate, or to provide additional time to other phases	Demo/Testing	Demonstrate/test the functionality.		
2.1.2.0-7	The ASCT shall have the ability to omit a user-specified phase based on measured traffic conditions.	4.9.0-1.0-4 4.17.0-3	• Allow one or more phases to be omitted (disabled) under certain traffic conditions or signal states The system needs the ability to be capable of responding to commands issued by the Traffic Management System	Demo/Testing	Demonstrate/test the functionality.		

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		5.2.0-6	The operator will be able to define for each group of intersections the appropriate operational objective. For example, near a freeway interchange or in a location with heavy turning movements, the queue management strategy may be specified, while on an arterial with long signal spacing the smooth flow objective may be specified.				
2.1.2.0-8	The ASCT shall have the ability to omit a user-specified phase according to a time of day schedule	4.9.0-1.0-4	• Allow one or more phases to be omitted (disabled) under certain traffic conditions or signal states	Demo/Testing	Demonstrate/test the functionality.		
2.1.2.0-9	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	4.9.0-1.0-9 5.6.0-10 5.6.0-11	• Allow the operator to specify which phase receives unused time from a preceding phase. • The ability to allow the coordinated phase to terminate early if the coordinated platoon is short. • The ability to introduce a non-coordinated phase later than its normal starting point within a cycle, if it can be served with minimum green within the remaining time available	Analysis	Provide data analysis to verify functionality		
2.1.2.0-10	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	4.9.0-1.0-9	• Allow the operator to specify which phase receives unused time from a preceding phase.	Analysis	Provide data analysis to verify functionality		
2.1.2.0-11	The ASCT shall have the ability to not alter the order of phases at a user-specified intersection.	4.1.0-6	The system needs the ability to fix the sequence of phases at any specified location.	Analysis	Provide data analysis to verify functionality		
2.1.2.0-12	The ASCT shall prevent, without the use of wired jumpers in the cabinet, controller phase change sequences that would create a "Yellow Trap" condition for left turn	3.4.3.0-1.0-2	• Provide the same or higher level of safety provided by the existing system to vehicles, pedestrians and transit	Analysis	Demonstrate/test the functionality.		
2.1.3	**2.1.3 Oversaturation**						
2.1.3.0-1	The ASCT shall detect the presence of queues at preconfigured locations	4.1.0-1.0-4 4.1.0-1.0-5 4.1.0-4 4.5.0-1 4.5.0-2 4.5.0-3 4.5.0-4 4.5.0-5	Manage the length of queues Manage the locations of queues within the network The system needs the ability to detect repeated phase failures and control signal timing to prevent phase failures building up queues. The system needs the ability to detect queues from outside the system and modify the ASCT operation to accommodate the queuing. The system needs the ability to detect queues within the system's boundaries and modify the ASCT operation to accommodate the queuing. The system needs the ability to detect queues propagating outside its boundaries from within the ASCT boundaries, and modify its operation to accommodate the queuing. The system needs the ability to store queues in locations where they can be accommodated without adversely affecting adaptive operation. The system needs the ability to prevent queues forming at user specified locations.	Demonstration	Demonstrate the functionality.		
2.1.3.0-2	When queues are detected at user-specified locations, the ASCT shall execute user-specified timing plan/operational mode.	4.1.0-1.0-4 4.1.0-1.0-5 4.5.0-1 4.2.0-2 4.6.0-3 4.6.0-4	Manage the length of queues. Manage the locations of queues within the network The system needs the ability to detect queues from outside the system and modify the ASCT operation to accommodate the queuing. The system needs the ability to be able to eventually adaptively control up to XX independent groups of signalized intersections Frequent pedestrian actuated calls: The system needs the ability to incorporate frequent pedestrian operation into routine adaptive operation. Pedestrian nonactuated calls: Nonactuated pedestrian phases are always on recall.	Demonstration	Demonstrate the functionality.		
2.1.3.0-3	When queues are detected at user-specified locations, the ASCT shall execute user-specified adaptive strategy.*	4.1.0-1.0-4 4.1.0-1.0-5 4.5.0-1 4.5.0-2 4.5.0-3 4.5.0-4 4.5.0-5	Manage the length of queues. Manage the locations of queues within the network The system needs the ability to detect queues from outside the system and modify the ASCT operation to accommodate the queuing. The system needs the ability to detect queues within the system's boundaries and modify the ASCT operation to accommodate the queuing. The system needs the ability to detect queues propagating outside its boundaries from within the ASCT boundaries, and modify its operation to accommodate the queuing. The system needs the ability to store queues in locations where they can be accommodated without adversely affecting adaptive operation. The system needs the ability to prevent queues forming at user specified locations.	Demonstration	Demonstrate the functionality.		

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		5.2.0-4 5.2.0-9	The objective of the coordination will be to manage the lengths of queues stored at critical locations within the coordinated group so that long queues do not block upstream intersections or otherwise reduce the capacity available during the green phases. This will involve controlling phase lengths so that the size of platoons entering a downstream block does not exceed the storage length if the platoon will be stopped. It will also involve control of offsets and phase lengths so that queues may be stored in locations where they will not adversely affect capacity of the system. At an isolated intersection with widely varying traffic patterns and a high degree of saturation during peak times, the system will calculate the optimum cycle length, and phase times in real time to match the changing traffic conditions				
2.1.3.0-4	When queues are detected at user-specified locations, the ASCT shall omit a user-specified phase at a user-specified signal controller	4.1.0-1.0-4 4.1.0-1.0-5 4.5.0-1 4.5.0-2 4.5.0-3 4.5.0-4 4.5.0-5	Manage the length of queues. Manage the locations of queues within the network The system needs the ability to detect queues from outside the system and modify the ASCT operation to accommodate the queuing. The system needs the ability to detect queues within the system's boundaries and modify the ASCT operation to accommodate the queuing. The system needs the ability to detect queues propagating outside its boundaries from within the ASCT boundaries, and modify its operation to accommodate the queuing. The system needs the ability to store queues in locations where they can be accommodated without adversely affecting adaptive operation. The system needs the ability to prevent queues forming at user specified locations.	Demonstration	Demonstrate the functionality.		
2.1.3.0-5	When queues are detected at user-specified locations, the ASCT shall limit the cycle length of the group to a user-specified value.*	4.1.0-1.0-4	Manage the length of queues.	Demonstration	Demonstrate the functionality.		
2.2	**2.2 Sequence-based Adaptive Coordination**						
2.2.0-1	The ASCT shall calculate appropriate cycle length for a signal group based on existing traffic conditions.	4.1.0-1.0-1 4.1.0-1.0-2 4.1.0-1.0-3 4.1.0-1.0-4	Maximize the throughput on coordinated routes. Provide smooth flow along coordinated routes. Distribute phase times in an equitable fashion Manage the length of queues	Demonstration	Demonstrate the functionality.		
2.2.0-2	The ASCT shall have the ability to select a cycle/period length based on a time of day schedule	4.1.0-1.0-1 4.1.0-1.0-2 4.1.0-1.0-3 4.1.0-1.0-4	Maximize the throughput on coordinated routes Provide smooth flow along coordinated routes. Distribute phase times in an equitable fashion Manage the length of queues	Demonstration	Demonstrate the functionality.		
2.2.0-3	The ASCT shall calculate phase lengths for all phases at each signal controller to suit the current coordination strategy.	4.1.0-1.0-3 4.1.0-1.0-5 4.1.0-4	Distribute phase times in an equitable fashion. Manage the locations of queues within the network The system needs the ability to detect repeated phase failures and control signal timing to prevent phase failures building up queues.	Demonstration	Demonstrate the functionality.		
2.2.0-4	The ASCT shall calculate and vary offsets to suit the current coordination strategy for the user-specified reference point for each signal controller along a coordinated route within a group	4.1.0-1.0-1 4.1.0-1.0-2 4.1.0-1.0-4 5.2.0-5	Maximize the throughput on coordinated routes. Provide smooth flow along coordinated routes. Manage the length of queues The system, or the operator, will select the appropriate coordination objective, depending on the current traffic conditions. For example, during commuter peaks the primary objective may be to maximize the throughput along the road in the peak direction. Then during the business hours the objective may be to balance delays between traffic associated with the adjacent activity and traffic simply traveling through the system.	Demonstration	Demonstrate the functionality.		
2.2.0-4.0-1	The ASCT shall apply offsets for the user-specified reference point of each signal controller along a coordinated route.	4.1.0-1.0-1	Maximize the throughput on coordinated routes.	Demonstration	Demonstrate the functionality.		
2.2.0-5	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	4.1.0-1.0-1 4.1.0-1.0-2 4.1.0-1.0-3 4.1.0-1.0-4 5.2.0-2 5.2.0-6	Maximize the throughput on coordinated routes. Provide smooth flow along coordinated routes. Distribute phase times in an equitable fashion Manage the length of queues The objective of the coordination will be to maximize the throughput along the coordinated route. This may involve a tradeoff that increases delay to cross streets and turning movements, in order to maximize the green time provided to coordinated traffic flows. The operator will be able to define for each group of intersections the appropriate operational objective. For example, near a freeway interchange or in a location with heavy turning movements, the queue management strategy may be specified, while on an arterial with long signal spacing the smooth flow objective may be specified.	Demonstration	Demonstrate the functionality.		
2.2.0-5.0-1	The ASCT shall limit cycle lengths to user-specified values	4.1.0-1.0-1 4.1.0-1.0-2 4.1.0-1.0-3 4.1.0-1.0-4	Maximize the throughput on coordinated routes Provide smooth flow along coordinated routes. Distribute phase times in an equitable fashion Manage the length of queues	Demonstration	Demonstrate the functionality.		
2.2.0-5.0-2	The ASCT shall limit cycle lengths to a user-specified range	4.1.0-1.0-1 4.1.0-1.0-2 4.1.0-1.0-3	Maximize the throughput on coordinated routes Provide smooth flow along coordinated routes. Distribute phase times in an equitable fashion	Demonstration	Demonstrate the functionality.		

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		4.1.0-1.0-4 5.2.0-2	Manage the length of queues The objective of the coordination will be to maximize the throughput along the coordinated route. This may involve a tradeoff that increases delay to cross streets and turning movements, in order to maximize the green time provided to coordinated traffic flows.				
2.2.0-5.0-3	The ASCT shall calculate optimum cycle length according to the user-specified coordination strategy.	4.1.0-1.0-1 4.1.0-1.0-2 4.1.0-1.0-3 4.1.0-1.0-4	Maximize the throughput on coordinated routes. Provide smooth flow along coordinated routes. Distribute phase times in an equitable fashion Manage the length of queues	Demonstration	Demonstrate the functionality.		
2.2.0-5.0-4	The ASCT shall limit changes in cycle length to not exceed a user-specified value for user-specified time-of-day schedule.	4.1.0-1.0-1 4.1.0-1.0-2 4.1.0-1.0-3 4.1.0-1.0-4	Maximize the throughput on coordinated routes. Provide smooth flow along coordinated routes. Distribute phase times in an equitable fashion Manage the length of queues	Demonstration	Demonstrate the functionality.		
2.2.0-5.0-5	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 signa	4.1.0-5	The system needs to minimize the chance that a queue forms at a specified location.	Demonstration	Demonstrate the functionality.		
2.3	**Non-sequence-based adaptive coordination**						
2.4	**Single intersection adaptive operation**						
2.4.0-1	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.	4.1.0-1.0-6	At an isolated intersection, optimize operation with a minimum of phase failures (based on the optimization objectives)	Demonstration	Demonstrate the functionality.		
2.4.0-2	The ASCT shall calculate optimum phase lengths of a single intersection, based on current measured traffic conditions. (The calculation is based on the optimization objectives.	4.1.0-1.0-3	Distribute phase times in an equitable fashion.	Demonstration	Demonstrate the functionality.		
2.4.0-2.0-1	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	4.1.0-1.0-3 4.1.0-1.0-6	Distribute phase times in an equitable fashion. At an isolated intersection, optimize operation with a minimum of phase failures (based on the optimization objectives)	Demonstration	Demonstrate the functionality.		
2.4.0-3	The ASCT shall calculate phase order based on current measured traffic conditions and the optimization objectives, while constrained by user-input.	4.1.0-1.0-6	At an isolated intersection, optimize operation with a minimum of phase failures (based on the optimization objectives)	Demonstration	Demonstrate the functionality.		
2.5	**Phase-based adaptive coordination**						
2.5.0-1	The ASCT shall alter the state of the signal controller for all phases at the user-specified intersection.	4.1.0-2	The system needs the ability to manage the coordination in small groups of signals to link phase service at some intersections with phase service at adjacent intersections	Demonstration	Demonstrate the functionality.		
2.5.0-2	The ASCT shall calculate the time at which a user-specified phase shall be green at an intersection.*	4.1.0-2	The system needs the ability to manage the coordination in small groups of signals to link phase service at some intersections with phase service at adjacent intersections	Demonstration	Demonstrate/test the functionality and verify the performance measures.		
2.5.0-3	When demand is present, the ASCT shall implement a user-specified maximum time between successive displays of each phase at each intersection.	4.1.0-2	The system needs the ability to manage the coordination in small groups of signals to link phase service at some intersections with phase service at adjacent intersections	Demonstration	Demonstrate the functionality.		
2.5.0-4	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.*	4.1.0-2 4.17.0-2	The system needs the ability to manage the coordination in small groups of signals to link phase service at some intersections with phase service at adjacent intersections The system needs to react to traffic volume and traffic operation condition change due to special events.	Demonstration	Demonstrate/test the functionality and verify the performance measures.		
		5.2.0-10	At a small group of intersections, with the user defining one as being critical, while the adjacent intersections require a lower cycle length or progression must be provided for specific phases to minimize the formation of queues on the approaches to the critical intersection, the phase lengths of the critical intersection will be determined by the system based on the current traffic conditions. The operation of the adjacent intersections will then be set so that platoons departing the critical intersection are progressed through the non-critical intersections, or platoons arriving at the critical intersection do so at a time when they will have little or no delay waiting for the appropriate phase.	Demonstration	Demonstrate the functionality.		
2.5.0-5	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.*	4.1.0-2	The system needs the ability to manage the coordination in small groups of signals to link phase service at some intersections with phase service at adjacent intersections	Demonstration	Demonstrate/test the functionality and verify the performance measures (% reduction in delay).		
2.5.0-6	The ASCT shall allow flexible assignment of the coordinated phases based on a user-specified measured traffic condition.	4.1.0-5 4.1.0-3	The system needs to minimize the chance that a queue forms at a specified location. The system needs the ability to change the operational strategy (for example, from smooth flow to maximizing throughput or managing queues) based on changing traffic conditions	Demonstration	Demonstrate the functionality.		
2.5.0-7	The ASCT shall allow flexible assignment of the coordinated phases based on a user-specified time-of-day schedule.	4.1.0-5 4.1.0-3	The system needs to minimize the chance that a queue forms at a specified location. The system needs the ability to change the operational strategy (for example, from smooth flow to maximizing throughput or managing queues) based on changing traffic conditions	Demonstration	Demonstrate the functionality.		
2.5.0-8	The ASCT shall allow fully-actuated coordination where the coordinated phases may gap out in absence of demand.	4.1.0-5 4.1.0-3	The system needs to minimize the chance that a queue forms at a specified location. The system needs the ability to vary the number of signals in an adaptively controlled group to accommodate the prevailing traffic conditions.	Demonstration	Demonstrate the functionality.		
2.5.0-9	The ASCT shall have the ability to allow the coordinated phase (X+X) to be on recall.	4.1.0-5 4.1.0-3	The system needs to minimize the chance that a queue forms at a specified location. The system needs the ability to change the operational strategy (for example, from smooth flow to maximizing throughput or managing queues) based on changing traffic conditions	Demonstration	Demonstrate the functionality.		
2.6	**Responsiveness**						
2.6.0-1	The ASCT shall have the ability to limit the change in consecutive cycle lengths to be less than a user-specified value.	4.8.0-1 4.8.0-2	The system needs the ability to modify the ASCT operation to closely follow changes in traffic conditions The system needs the ability to constrain the selection of cycle lengths to those that provide acceptable operations, such as when resonant progression solutions are desired	Demonstration	Demonstrate the functionality.		

System Requirements Reference Number	System Requirement Description	ConOps Needs	ConOps Statement	Verification Method	Verification Procedure	Pass/Fail**	If the verification procedure fails, explain the reason why and how the issue will be resolved**
2.6.0-2	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	4.8.0-1	The system needs the ability to modify the ASCT operation to closely follow changes in traffic conditions	Demonstration	Demonstrate the functionality.		
2.6.0-3	The ASCT shall limit the changes in the direction of primary coordination to a user-specified frequency.	4.8.0-1 4.8.0-2	The system needs the ability to modify the ASCT operation to closely follow changes in traffic conditions The system needs the ability to constrain the selection of cycle lengths to those that provide acceptable operations, such as when resonant progression solutions are desired	Demonstration	Demonstrate the functionality.		
2.6.0-4	When a large change in traffic demand is detected, the ASCT shall have the ability to respond within a user-defined amount of cycles more quickly than during normal operation, subject to user-specified limits.	4.8.0-3 4.17.0-2 5.2.0-8 8.9.1-1	The system needs to respond within a user-defined amount of cycles to sudden large shift in traffic conditions. The system needs to react to traffic volume and traffic operation condition change due to special events. Within these operational objectives, the ASCT system will change its operation to accommodate the rise and fall of volumes through the peaks, and the changing patterns of flow throughout the day and week. However, there is also a stochastic element to traffic in the short term, with the number of arrivals for a phase varying from cycle to cycle, and pedestrians not being present on all phases in all cycles. It is therefore desirable for the system to have some local tactical control. While vehicle-actuated coordination typically allows phases to run longer or shorter from cycle to cycle to match the actual number of vehicles using the phase, the system will also allow the operator to decide where the unused time will be used. If a phase is to be skipped, the operator can specify that the spare time will be added to the existing phase, the following phase, or the next coordinated phase. 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. The system will then return to normal operation	Demonstration	Demonstrate the functionality.		
2.6.0-5	The ASCT shall have the ability to automatically select cycle/period lengths from a list of user-defined cycle lengths.	4.8.0-2	The system needs the ability to constrain the selection of cycle lengths to those that provide acceptable operations, such as when resonant progression solutions are desired	Demonstration	Demonstrate the functionality.		
2.6.0-6	The ASCT shall have the ability to respond non-reoccurring events, incidents and other unexpected events.	8.5.1.1 8.5.1.2 8.5.1.3	If there is heavily direction traffic before or after an event, the system will determine the predominate direction and coordinate accordingly, with appropriate cycle length and offset If the event is not as heavy as peak hours, but the traffic is still highly directional, then the system will recognize this and provide the coordination predominantly in the heaviest direction, even though the cycle length may be similar to peak hour cycle lengths. The entire corridor may be set by the operator to operate as one or more coordinated groups, or the system may have the freedom to operate it as one of more groups subject to user-specified criteria, such as similar required cycle lengths in different parts of the corridor, of the volume of traffic at key locations exceeds a threshold.	Demonstration	Demonstrate the functionality.		
	njta	8.5.1.4 8.5.1.5 8.5.1.6	If downstream signals experience lighter traffic as a result of an incident blocking and restricting traffic, those signal should be coordinate as a group, with cycle length, splits and offsets that react to the measured traffic. If a detected blockage is in the peak direction, then the system may coordinate in the opposite direction if that traffic is similar to or greater than normal peak direction The system needs to recognize the presence of an abnormal obstruction, modify the signal operation to react to the change traffic conditions in an efficient manner, and report the abnormal condition to the operator.	Demonstration	Demonstrate the functionality.		
3	**External/Internal Interfaces**						
3.0-1	The ASCT shall support external interfaces according to the following detailed requirements • Information layer protocol • Application layer protocol • Lower layer protocol • Data interface • Frequency of storage • Frequency of reporting • Duration of storage)	4.3.0-1 4.3.0-2 4.3.0-4 4.11-0.5 4.17.0-3	The system needs the ability to adaptively control signals operated by NJDOT. The system needs the ability to send data to another system that would allow the other system to coordinate with the ASCT system. The system needs the ability to receive data from another system that will allow the ASCT system to coordinate its operation with the adjacent system. The system needs the ability to report performance data at least once a minute. The system needs the ability to be capable of responding to commands issued by the Traffic Management System	Demonstration	Demonstrate the functionality.		
3.0-1.0-1	The ASCT shall send the following data to external systems including ITS Readiness Checklist in SQL: • Operational • Performance	4.3.0-2	The system needs the ability to send data to another system that would allow the other system to coordinate with the ASCT system.	Demonstration	Demonstrate the functionality.		

System Requirements Reference Number	System Requirement Description	ConOps Needs	ConOps Statement	Verification Method	Verification Procedure	Pass/Fail**	If the verification procedure fails, explain the reason why and how the issue will be resolved**
		4.11-0.5 4.17.0-1	The system needs the ability to report performance data at least once a minute. The system needs the ability to be able to turn on signs that contro 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				
3.0-1.0-2	The ASCT shall have the capability to internally log the following data • Operational • Control • Monitoring • Coordination • Performance	4.3.0-2	The system needs the ability to send data to another system that would allow the other system to coordinate with the ASCT system.	Demonstration	Demonstrate the functionality.		
3.0-1.0-3	The ASCT shall have the ability to send operational, control, monitoring, and control data to external systems in non-proprietary formats.	4.3.0-2	The system needs the ability to send data to another system that would allow the other system to coordinate with the ASCT system.	Demonstration	Demonstrate the functionality.		
3.0-1.0-4	The ASCT shall coexist with the external Traffic Management System software compatible with the local traffic signal controller.	4.11-0.1	The NJDOT needs the ability for the Traffic Management System to be able to coexist with or monitor the adaptive system	Demonstration	Demonstrate the functionality.		
3.0-1.0-5	The ASCT shall have the ability to integrate the midblock system detector data into adaptive operation for event triggers, routines, changes to offsets, and force offs	4.19.0-1 4.19.0-3	The system needs the ability to interface with midblock system detectors. The adaptive system needs the ability to integrate the system detectior data into adaptive operation.	Demonstration	Demonstrate the functionality.		
3.1-1	The ASCT shall have an integrated user-friendly graphic user interface (GUI) to provide graphic displays, import and generation of graphic images, and automatic update of maps and graphics.	4.10.0-3	The system needs to have an integrated user-friendly graphic user interface (GUI) to provide graphic displays, import and generation of graphic images, automatic updating of maps and graphics, and update this data in real time (at least once per second).	Demonstration	Demonstrate the functionality.		
3.1-2	All graphic displays shall ensure instantaneous generation of the graphic display, including the background map and the real-time (at least once a second) feedback data.	4.10.0-3	The system needs to have an integrated user-friendly graphic user interface (GUI) to provide graphic displays, import and generation of graphic images, automatic updating of maps and graphics, and update this data in real time (at least once per second).	Demonstration	Demonstrate the functionality.		
3.1-3	At the system-wide graphic display, the GUI shall identify the following status for traffic signals with less than 2 seconds of latency: • Free operation • Coordinated operatior • Adaptive operatior • Dynamic grouping • Pattern transitior • Tripped conflict monitoı • Flash mode • Loss of communications • Loss of detectior • Failure of adaptive software/hardware • Emergency or railroad preemptior • Transit priority service	4.10.0-3 4.10.0-3	The system needs to have an integrated user-friendly graphic user interface (GUI) to provide graphic displays, import and generation of graphic images, automatic updating of maps and graphics, and update this data in real time (at least once per second). The system needs to have an integrated user-friendly graphic user interface (GUI) to provide graphic displays, import and generation of graphic images, automatic updating of maps and graphics, and update this data in real time (at least once per second).	Demonstration	Demonstrate the functionality.		
3.1-4	At a detailed intersection display, the GUI shall provide a greater level of detail information in addition to the above-listed, and including: • Street names • Current timing plan in use (cycle length and offset) • Signal displays (vehicle and pedestrian) • Current communications status • Control mode • Vehicle calls by phase • Pedestrian calls by phase • Detector status and actuation • Special functions • Timing plan parameters (actual versus programmed – only applicable when operating TOD) • Active, incrementing cycle clock • Active and progressive real-time timing bands (Time Space Diagram	4.10.0-3 4.10.0-3	The system needs to have an integrated user-friendly graphic user interface (GUI) to provide graphic displays, import and generation of graphic images, automatic updating of maps and graphics, and update this data in real time (at least once per second). The system needs to have an integrated user-friendly graphic user interface (GUI) to provide graphic displays, import and generation of graphic images, automatic updating of maps and graphics, and update this data in real time (at least once per second).	Demonstration	Demonstrate the functionality.		
3.1-5	The GUI shall allow the user to enable/disable the desired layer displays at different zoom scale range in order to control which layers are displayed at different zoom scales.	4.10.0-3	The system needs to have an integrated user-friendly graphic user interface (GUI) to provide graphic displays, import and generation of graphic images, automatic updating of maps and graphics, and update this data in real time (at least once per second).	Demonstration	Demonstrate the functionality.		
3.1-6	The adaptive system shall have the ability to integrate the system detection data into the adaptive system GUI.	4.19.0-4	The adaptive system needs the ability to integrate the system detectior data into the adaptive system GUI	Demonstration	Demonstrate the functionality.		

System Requirements Reference Number	System Requirement Description	ConOps Needs	ConOps Statement	Verification Method	Verification Procedure	Pass/Fail**	If the verification procedure fails, explain the reason why and how the issue will be resolved**
3.1-7	The ASCT system operator and user interface shall be integrated with the Department's existing Arterial Management Center ASCT software.	4.10.0-3	The system needs to have an integrated user-friendly graphic user interface (GUI) to provide graphic displays, import and generation of graphic images, automatic updating of maps and graphics, and update this data in real time (at least once per second).	Demonstration	Demonstrate the functionality.		
4	**Crossing Arterials and Boundaries**						
4.0-1	The ASCT shall have the ability to conform its operation to an external system's operation data.	4.3.0-4 4.3.0-6 4.17.0-3 5.4.0-3	The system needs the ability to receive data from another system that will allow the ASCT system to coordinate its operation with the adjacent system. The system needs the ability to detect traffic approaching from a neighboring system and coordinate the ASCT operation with the adjacent system. The system needs the ability to be capable of responding to commands issued by the Traffic Management System The system will accept data from a neighboring system that allows it to stay in coordination with the adjacent system while still operating in adaptive mode.	Demonstration	Demonstrate the functionality.		
4.0-1.0-1	The ASCT shall adjust its operation to minimize interruption of traffic entering the system. (This may be achieved via detection, with no direct connection to the other system.)	4.3.0-4 5.4.0-2 4.3.0-6	The system needs the ability to receive data from another system that will allow the ASCT system to coordinate its operation with the adjacent system. The NJDOT needs the adaptive system to maintain coordination with another adjacent system either by sensing arriving traffic or by using constraints on cycle length The system needs the ability to detect traffic approaching from a neighboring system and coordinate the ASCT operation with the adjacent system.	Demonstration	Demonstrate the functionality.		
4.0-1.0-2	The ASCT shall have the ability to operate a fixed cycle length to match the cycle length of any adjacent systems.	4.3.0-5	The system needs the ability to constrain the adaptive system to operate a cycle length compatible with the crossing arteria	Demonstration	Demonstrate the functionality.		
4.0-1.0-3	The ASCT shall have the ability to alter its operation based on data received from another system.	4.3.0-4	The system needs the ability to receive data from another system that will allow the ASCT system to coordinate its operation with the adjacent system.	Demonstration	Demonstrate the functionality.		
4.0-1.0-4	The ASCT shall support adaptive coordination on crossing routes.	4.3.0-3 5.4.0-1	The system needs the ability to adaptively coordinate signals on two crossing routes simultaneously A coordinated group will be able to include more than one coordinated route, such as two crossing arterials. The system will be able to maintain coordination along both roads	Demonstration	Demonstrate the functionality.		
5	**Access and Security**						
5.0-1	The ASCT shall be implemented with a security policy that assigns different user privileges to the traffic engineering and maintenance staff of different authorities that have jurisdiction over a specific traffic signal. Typical user privileges include:	4.4.0-1 4.10.0-2 5.5.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies The operator needs the ability to access to the database management, monitoring and reporting features and functions of the signal controllers and any related signal management system as per his/her defined privilege level from the access points defined for those system components. Operators, traffic engineering, and maintenance staff will be assigned different levels of authority, and access to equipment for which they are authorized, based on their roles and responsibilities. This will allow them to control, view, monitor, and analyze the operation of the system as appropriate.	Demonstration	Demonstrate the functionality.		
5.0-1.0-1	Local access to the ASCT	4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies	Demonstration	Demonstrate the functionality.		
5.0-1.0-2	Remote access to the ASCT	4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies	Demonstration	Demonstrate the functionality.		
5.0-1.0-3	System monitoring	4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies	Demonstration	Demonstrate the functionality.		
5.0-1.0-4	System manual override	4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies	Demonstration	Demonstrate the functionality.		
5.0-1.0-5	Signal timing plan development and implementation	4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies	Demonstration	Demonstrate the functionality.		
5.0-1.0-6	Traffic operations	4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies	Demonstration	Demonstrate the functionality.		

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5.0-1.0-7	User login	4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies	Demonstration	Demonstrate the functionality.		
5.0-1.0-8	User password and security	4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies	Demonstration	Demonstrate the functionality.		
5.0-1.0-9	Administration of the system	4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies	Demonstration	Demonstrate the functionality.		
5.0-1.0-10	Signal controller group access	4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies	Demonstration	Demonstrate the functionality.		
5.0-1.0-11	Access to classes of equipment	4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies	Demonstration	Demonstrate the functionality.		
5.0-1.0-12	Access to equipment by jurisdiction	4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies	Demonstration	Demonstrate the functionality.		
5.0-1.0-13	Output activation	4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies	Demonstration	Demonstrate the functionality.		
5.0-1.0-14	System parameters	4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies	Demonstration	Demonstrate the functionality.		
5.0-1.0-15	Report generation	4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies	Demonstration	Demonstrate the functionality.		
5.0-1.0-16	Configuration of system devices	4.4.0-1 8.11.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies During installation and fine tuning, the operator will calibrate all the use 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. 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 that has a heavy U-turn volume.	Demonstration	Demonstrate the functionality.		
5.0-1.0-17	Security alerts	4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies	Demonstration	Demonstrate the functionality.		
5.0-1.0-18	Security logging	4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies	Demonstration	Demonstrate the functionality.		
5.0-1.0-19	Security reporting	4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies	Demonstration	Demonstrate the functionality.		

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5.0-1.0-20	Database access and configuration	4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies	Demonstration	Demonstrate the functionality.		
5.0-1.0-21	Signal controller	4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies	Demonstration	Demonstrate the functionality.		
5.0-2	The ASCT shall support a minimum of XXunique user profiles.	4.10.0-1 7.6.0-2	The system needs the ability to monitor and control all required features of adaptive operation from the following locations • Traffic Operation Center XXX • Arterial Management Center (AMC) • Statewide Traffic Management Center (STMC) • Local Controller Cabinets • Maintenance Vehicles The system will need the ability to handle up to XX user profiles	Demonstration	Demonstrate the functionality.		
5.0-3	The ASCT shall support a multi-terminal, multi-user interface in compliance with NJDOT and NJ-OIT security policies.	4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies	Demonstration	Demonstrate the functionality.		
5.0-4	The ASCT shall simultaneously support a minimum of XX users (local and remote) at any time in order t accommodate high and extended usage that might occur during special events with no increase in latency	7.6.0-1	The system will need the ability to handle up to XX concurrent operators.	Demonstration	Demonstrate the functionality.		
5.0-5	The ASCT shall provide a user priority assignment, configurable by the System Administrator, for resolution of command conflicts from concurrent users.	4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies	Demonstration	Demonstrate the functionality.		
6	**Data Log**						
6.0-1	The ASCT shall log the following events for all modes of operation for each intersection:	4.11-0.6 4.11-0.6	The system needs the ability to be able to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation The system needs the ability to be able to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation	Demonstration	Demonstrate the functionality.		
6.0-1.0-1	Time-stamped emergency vehicle preemption calls	4.11-0.6	The system needs the ability to be able to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation	Demonstration	Demonstrate the functionality.		
6.0-1.0-2	Time-stamped transit priority calls	4.11-0.6	The system needs the ability to be able to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation	Demonstration	Demonstrate the functionality.		
6.0-1.0-3	Time-stamped railroad preemption calls	4.11-0.6	The system needs the ability to be able to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation	Demonstration	Demonstrate the functionality.		
6.0-1.0-6	Time-stamped start, end, and length of each phase	4.11-0.6	The system needs the ability to be able to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation	Demonstration	Demonstrate the functionality.		
6.0-1.0-7	Time-stamped controller interval changes	4.11-0.6	The system needs the ability to be able to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation	Demonstration	Demonstrate the functionality.		
6.0-1.0-8	Time-stamped start and end of each transition to a new timing plan	4.11-0.6	The system needs the ability to be able to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation	Demonstration	Demonstrate the functionality.		
6.0-2	The ASCT shall export its systems log in the following formats: • Text • CSV	4.11-0.4 4.11-0.2 4.11-0.3 4.11-0.4	The system needs the ability to store all operational data and signal timing parameters calculated by the adaptive system, and export selected data. The system needs the ability to store and report data used to calculate signal timing and have the data available for subsequent analysis. The system needs the ability to store and report data that can be used to measure traffic performance under adaptive control The system needs the ability to store all operational data and signal timing parameters calculated by the adaptive system, and export selected data.	Demonstration	Demonstrate the functionality.		
6.0-3	The ASCT shall store the event log for a minimum of XX days.	4.11-0.4 4.11-0.6	The system needs the ability to store all operational data and signal timing parameters calculated by the adaptive system, and export selected data. The system needs the ability to be able to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation	Demonstration	Demonstrate the functionality.		
6.0-4	The ASCT shall store results of all actual signal timing parameters (cycle length, offset, phases, splits, interval times, etc.) for a minimum of XXX days.	4.11-0.2 4.11-0.3 4.11-0.6	The system needs the ability to store and report data used to calculate signal timing and have the data available for subsequent analysis. The system needs the ability to store and report data that can be used to measure traffic performance under adaptive control The system needs the ability to be able to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation	Demonstration	Demonstrate the functionality.		
6.0-5	The ASCT shall archive all data automatically, generate historic reports with less than a XXX second(s) of lag, and provide real-time reports to support operation, maintenance and reporting of system	4.11-0.7	Have the ability to generate historic and real-time reports that effectively support operation, maintenance, and reporting of system performance and traffic conditions.	Demonstration	Demonstrate the functionality.		

System Requirements Reference Number	System Requirement Description	ConOps Needs	ConOps Statement	Verification Method	Verification Procedure	Pass/Fail**	If the verification procedure fails, explain the reason why and how the issue will be resolved**
	performance and traffic conditions. Such reports shall be able to be displayed graphically, in a tabl format, timeline, and summary report.	4.11-0.2 4.11-0.3 4.11-0.7	The system needs the ability to store and report data used to calculate signal timing and have the data available for subsequent analysis. The system needs the ability to store and report data that can be used to measure traffic performance under adaptive control Have the ability to generate historic and real-time reports that effectively support operation, maintenance, and reporting of system performance and traffic conditions.				
6.0-6	The system shall store the following measured data in for a minimum of XX days: • Volume • Occupancy • Queue length • Phase utilization • Arrivals in green • Green band efficiency	4.11-0.7 4.11-0.2 4.11-0.3	Have the ability to generate historic and real-time reports that effectively support operation, maintenance, and reporting of system performance and traffic conditions. The system needs the ability to store and report data used to calculate signal timing and have the data available for subsequent analysis. The system needs the ability to store and report data that can be used to measure traffic performance under adaptive control	Demonstration	Demonstrate the functionality.		
6.0-7	The ASCT shall summarize the volume data into a traffic volume report, which provides aggregate XX-minute volumes for any XX-day period in text and the XXX format.	4.11-0.2	The system needs the ability to store and report data used to calculate signal timing and have the data available for subsequent analysis.	Demonstration	Demonstrate the functionality.		
6.0-8	The ASCT shall provide data storage for a system size of at least XX ASCT signal controllers. The data to be stored shall include the following: • Controller state data • Reports • Log data • Security data • ASCT parameters • Detector status data	4.11-0.4	The system needs the ability to store all operational data and signal timing parameters calculated by the adaptive system, and export selected data.	Demonstration	Demonstrate the functionality.		
6.0-9	The ASCT shall calculate and report relative data quality including: • The extent data is affected by detector faults • Other applicable items	4.11-0.7	Have the ability to generate historic and real-time reports that effectively support operation, maintenance, and reporting of system performance and traffic conditions.	Demonstration	Demonstrate the functionality.		
6.0-10	The ASCT shall report comparisons of logged data when requested by the user: • 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	4.11-0.7	Have the ability to generate historic and real-time reports that effectively support operation, maintenance, and reporting of system performance and traffic conditions.	Demonstration	Demonstrate the functionality.		
6.0-11	The ASCT shall store data logs in a NJ-OIT approved database formats.	4.11-0.7	Have the ability to generate historic and real-time reports that effectively support operation, maintenance, and reporting of system performance and traffic conditions.	Demonstration	Demonstrate the functionality.		
6.0-12	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.	4.11-0.7	Have the ability to generate historic and real-time reports that effectively support operation, maintenance, and reporting of system performance and traffic conditions.	Demonstration	Demonstrate the functionality.		
6.0-13	The ASCT shall store the following data in XX minute increments from stopline detectors and midblock system detectors: • Volume • Occupancy • Queue length	4.11-0.2	The system needs the ability to store and report data used to calculate signal timing and have the data available for subsequent analysis.	Demonstration	Demonstrate the functionality.		
7	**Advanced Controller Operation**						
7.0-1	When specified by the user, the ASCT shall display a vehicle phase more than once for each time the coordinated phase is served.	4.9.0-1.0-1 5.6.0-2	• Service a phase more than once per cycle based on user-defined constraints. • The ability to repeat a phase, such as running a left turn phase before and after its opposing through movement	Demonstration	Demonstrate the functionality.		
7.0-2	The ASCT shall provide a minimum of X phase overlaps	4.9.0-1.0-2 5.6.0-7	• Operate at least X overlap phases • The NJDOT will permit phases or overlaps by time-of-day schedule or external input.	Demonstration	Demonstrate the functionality.		
7.0-3	The ASCT shall accommodate a minimum of XX phases at each signal	4.9.0-1.0-3	• Operate up to X rings, X phases and X phases per ring.	Demonstration	Demonstrate the functionality.		
7.0-4	The ASCT shall accommodate a minimum of X rings at each signal.	4.9.0-1.0-3	• Operate up to X rings, X phases and X phases per ring.	Demonstration	Demonstrate the functionality.		
7.0-5	The ASCT shall accommodate a minimum of X phases per ring	4.9.0-1.0-3 5.6.0-3	• Operate up to X rings, X phases and X phases per ring • Provision for the required number of rings, phases, phases per ring, and overlap phases.	Demonstration	Demonstrate the functionality.		
7.0-6	The ASCT shall provide a minimum of X different user-defined phase sequences for each signal.	4.9.0-1.0-3	• Operate up to X rings, X phases and X phases per ring.	Demonstration	Demonstrate the functionality.		
7.0-6.0-1	Each permissible phase sequence shall be user-assignable to any signal timing plan.	4.9.0-1.0-3	• Operate up to X rings, X phases and X phases per ring.	Demonstration	Demonstrate the functionality.		
7.0-6.0-2	Each permissible phase sequence shall be executable by a time of day schedule	4.9.0-1.0-3	• Operate up to X rings, X phases and X phases per ring	Demonstration	Demonstrate the functionality.		
7.0-6.0-3	Each permissible phase sequence shall be executable based on measured traffic condition	4.9.0-1.0-3	• Operate up to X rings, X phases and X phases per ring	Demonstration	Demonstrate the functionality.		
7.0-7	The ASCT shall permit a phase/overlap output by time-of-day.	4.9.0-1.0-8	• Allow any phase to be designated as the coordinated phase.	Demonstration	Demonstrate the functionality.		
7.0-8	The ASCT shall permit a phase/overlap output based on an external input	4.9.0-1.0-8 4.17.0-3	• Allow any phase to be designated as the coordinated phase The system needs the ability to be capable of responding to commands issued by the Traffic Management System	Demonstration	Demonstrate the functionality.		
7.0-9	The ASCT shall have the ability to provide for the following phases to be designated as coordinated phases. • Lead left turn • Lag left turn • Permissive left turn	4.9.0-1.0-3 4.9.0-1.0-8 5.6.0-8	• Operate up to X rings, X phases and X phases per ring. • Allow any phase to be designated as the coordinated phase • The ability to designate specific phases as coordinated phases.	Demonstration Demonstration	Demonstrate the functionality. Demonstrate the functionality.		
7.0-10	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	4.9.0-1.0-11	• Allow the coordinated phase to terminate early under prescribed traffic conditions	Demonstration	Demonstrate the functionality.		

System Requirements Reference Number	System Requirement Description	ConOps Needs	ConOps Statement	Verification Method	Verification Procedure	Pass/Fail**	If the verification procedure fails, explain the reason why and how the issue will be resolved**
7.0-12	The ASCT shall permit the local signal controller to perform actuated phase control using up to X extension/passage timers as assigned to user-specified vehicle detector input channels in the local controller.	4.9.0-1.0-10	• Allow the controller to respond independently to individual lanes of an approach. This may be implemented in the signal controller using up to X 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.				
7.0-12.0-1	The ASCT shall operate adaptively using user-specified detector channels.	4.9.0-1.0-10	• Allow the controller to respond independently to individual lanes of an approach. This may be implemented in the signal controller using up to X 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.				
7.0-13	When adaptive operation is used in conjunction with normal coordination, the ASCT shall permit a controller to serve a cycle length different from the cycles used at adjacent intersections.	4.9.0-1.0-14	• 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.				
7.0-14	The ASCT shall have the ability to operate with detector switching, dynamic max, and coordination at the end of green/yellow.	4.9.0-1.0-7 5.6.0-5	• Accommodate the custom features used by NJDOT. • Special features unique to the NJDOT such as detector switching, dynamic max, coordination beginning of yellow	Demonstration	Demonstrate the functionality.		
7.0-15	Extension/passage timers shall be assignable to each vehicle detector input channel.	5.6.0-9	• The ability to separately monitor each lane on an approach and take different action depending on the conditions measured in each lane.				
7.0-16	The system shall have the ability for a coordinated phase to be released early constrained by user-constraints.	5.6.0-15	• The ability for a coordinated phase to be released early.				
8	**Pedestrians**						
8.0-1	The ASCT shall execute exclusive user-specified pedestrian phases before the vehicle green of the related vehicle phase.	4.6.0-1	Infrequent pedestrian actuated calls: The system needs the ability to accommodate infrequent pedestrian operation and then adaptively recover.	Demonstration	Demonstrate the functionality.		
8.0-2	When the pedestrian phase is called, the ASCT shall accommodate pedestrian crossing times during adaptive operations.	4.6.0-2	Infrequent pedestrian actuated calls: The system needs the ability to accommodate infrequent pedestrian operation while maintaining adaptive operation.	Demonstration	Demonstrate the functionality.		
8.0-3	The ASCT shall execute user-specified exclusive pedestrian phases during adaptive operation.	4.6.0-3 4.6.0-5 4.6.0-6	Frequent pedestrian actuated calls: The system needs the ability to incorporate frequent pedestrian operation into routine adaptive operation. The system needs the ability to accommodate custom pedestrian features. The system needs to the ability to accommodate early start of walk and exclusive pedestrian phases.	Demonstration Demonstration	Demonstrate the functionality. Demonstrate the functionality.		
8.0-4	The ASCT shall execute pedestrian recall on user-defined phases in accordance with a time of day schedule.	4.6.0-4	Pedestrian nonactuated calls: Nonactuated pedestrian phases are always on recall.	Demonstration	Demonstrate the functionality.		
8.0-5	The ASCT shall have the option for a phase to start late, when there is not a pedestrian call for that phase, provided the minimum green time is available	4.9.0-1.0-12 5.6.0-11	• Allow flexible timing of non-coordinated phases (such as late start of a phase) while maintaining coordination • The ability to introduce a non-coordinated phase later than its normal starting point within a cycle, if it can be served with minimum green within the remaining time available	Demonstration	Demonstrate the functionality.		
8.0-6	For all nonactuated pedestrian phases, the ASCT shall execute pedestrian recall.	4.6.0-4	Pedestrian nonactuated calls: Nonactuated pedestrian phases are always on recall.	Demonstration	Demonstrate the functionality.		
8.0-7	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 • Sufficient time in the cycle remains to serve the minimum green times for the phase and the subsequent noncoordinated phases before the beginning of the coordinated phase • The phase is called after its normal start time • The associated pedestrian phase is not called	4.9.0-1.0-12	• Allow flexible timing of non-coordinated phases (such as late start of a phase) while maintaining coordination.	Demonstration	Demonstrate the functionality.		
9	**Special Functions**						
9.0-1	The ASCT shall set a specific state for each special function output based on the occupancy on a user-specified detector.	4.9.0-1.0-10 4.17.0-1 4.9.0-1.0-6 6.2.1.0-21	• Allow the controller to respond independently to individual lanes of an approach. This may be implemented in the signal controller using up to X 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. The system needs the ability 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 • Allow detector logic at an intersection to be varied depending on local signal states. The NJDOT's experienced operators will be able to write customized routines using the ASCT's API.	Demonstration Demonstration Demonstration	Demonstrate the functionality. Demonstrate the functionality. Demonstrate the functionality.		
9.0-2	The ASCT shall set a specific state for each special function output based on the current cycle length.	4.17.0-1	The system needs the ability 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	Demonstration	Demonstrate the functionality.		
9.0-3	The ASCT shall have the ability to set a specific state for each special function output based on a time-of-day schedule.	4.17.0-1	The system needs the ability 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	Demonstration	Demonstrate the functionality.		
9.0-4	The ASCT shall keep all intersections synchronized to a common time base. The ASCT shall also provide a means of verifying intersection controller clocks against the central time clock with an option to recalibrate the controller clock on an as needed basis.	4.1.0-8	The system needs the ability to set signal timing parameters to comply with NJDOT policies.				

System Requirements Reference Number	System Requirement Description	ConOps Needs	ConOps Statement	Verification Method	Verification Procedure	Pass/Fail**	If the verification procedure fails, explain the reason why and how the issue will be resolved**
10	**10 Detection**			Demonstration	Demonstrate the functionality.		
10.0-1	The ASCT stopline detectors shall have the following capabilities						
	• Detect a minimum of X lanes of traffic per device	4.20.0-2.01	• Detect a minimum of X lanes of traffic per device				
	• Detect a minimum of X detection zone per lane	4.20.0-2.02	• Detect a minimum of X detection zone per lane				
	• Utilize power/communication cables greater than XX feet in length	4.20.0-2.03	• Utilize power/communication cables greater than XX feet in length	Demonstration	Demonstrate the functionality.		
	• Utilize a CCD sensor for image detectors	4.20.0-2.04	• Utilize a CCD sensor for image detectors	Demonstration	Demonstrate the functionality		
	• Utilize an integrated processor	4.20.0-2.05	• Utilize an integrated processor	Demonstration	Demonstrate the functionality		
		5.6.0-9	• The ability to separately monitor each lane on an approach and take different action depending on the conditions measured in each lane.				
10.1-1	The ASCT shall accommodate up to XX discrete detector inputs per intersection, each assignable to phase calls with delay and/or extend call timing.	4.9.0-1.0-10	• Allow the controller to respond independently to individual lanes of an approach. This may be implemented in the signal controller using up to X 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.	Demonstration	Demonstrate the functionality.		
10.1-2	The ASCT shall have the ability to operate adaptively utilizing only stop bar detection zones. (i.e., advanced detection is not required for functionality	4.9.0-1.0-10	• Allow the controller to respond independently to individual lanes of an approach. This may be implemented in the signal controller using up to X 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.				
		4.15.0-1.0-2	• Non roadway-intrusive detectors (stopbar and system				
10.1-3	The system shall continuously monitor the detector status as operational, disabled, or failed. Detector failures shall be reported to the system log and operator alarm	4.11-0.8	Have the ability to continuously monitor and diagnose the status of stopline and system detectors.				
10.1-4	The system shall have user-specified thresholds that a detector must exceed to be considered failed based on a time-of-day basis.	4.11-0.8	Have the ability to continuously monitor and diagnose the status of stopline and system detectors.				
10.1-5	The ASCT shall provide diagnosis for the following detector failure types:	4.11-0.8	Have the ability to continuously monitor and diagnose the status of stopline and system detectors.				
	• Maximum presence - if an active detector exhibits continuous detection over an operator-defined time interval						
	• No activity - if an active detector does not exhibit any actuation during an operator-defined elapsed time interval			Demonstration	Demonstrate the functionality.		
	• Erratic output - if an active detector exhibits excessive actuation (i.e., field count over an operator-defined elapsed time interval exceeds user programmed threshold			Demonstration	Demonstrate the functionality.		
	• Failed communication - failed detectors shall not be available for traffic control strategies						
10.1-6	The ASCT shall have the ability to interface and integrate with the depicted midblock system detectors.	4.19.0-1	The system needs the ability to interface with midblock system detectors.	Testing	Provide test results of the functionality.		
10.1-7	The midblock system detectors shall collect the following data:	4.19.0-2.04	The data collected by the system detectors is as follows:	Demonstration	Demonstrate the functionality.		
10.1-8	• Volume	4.19.0-2.05	• Volume	Analysis	Provide data analysis to verify the functionality		
10.1-9	• Speed	4.19.0-2.06	• Speed				
10.1-10	• Classification	4.19.0-2.07	• Classification				
10.1-11	• Travel Time	4.19.0-2.08	• Travel Time				
10.1-12	• Occupancy	4.19.0-2.09	• Occupancy				
10.1-13	The midblock system detectors shall be integrated into the applicable traffic signal cabinet back panels and the existing Department Traffic Management System	4.19.0-1	The system needs the ability to interface with midblock system detectors.	Demonstration	Demonstrate the functionality.		
10.1-14	The adaptive system shall integrate the depicted midblock system detection data into adaptive operation for user-defined event triggers, routines, and force offs	4.19.0-3	The adaptive system needs the ability to integrate the system detection data into adaptive operation.	Demonstration	Demonstrate the functionality.		
11	**Emergency Vehicle Pre-emption**			Demonstration	Demonstrate the functionality.		
11.0-1	The ASCT shall have the ability to maintain adaptive operation at non-preempted intersections during emergency vehicle or railroad preemption	4.13.0-1	The system needs the ability to accommodate emergency vehicle preemption.	Demonstration	Demonstrate the functionality.		
		8.8.1-1	When an intersection responds to preemption, other signals within the coordinate group continue to operate adaptively. The preempted signal returns to adaptive control once the preemption is released.	Demonstration	Demonstrate the functionality.		
11.0-2	The ASCT shall have the ability to allow for immediate response to the presence of a valid emergency preemption call.	4.13.0-1	The system needs the ability to accommodate emergency vehicle preemption.	Demonstration	Demonstrate the functionality.		
11.0-3	The ASCT shall have the ability to resume adaptive control of signal controllers when preemptions are released.	4.13.0-1	The system needs the ability to accommodate emergency vehicle preemption.	Demonstration	Demonstrate the functionality.		
11.0-4	The ASCT shall have the ability to provide for the immediate return to servicing of the appropriate phase combinations that would have been served at that time if preemption routine had not been initiated.	4.13.0-1	The system needs the ability to accommodate emergency vehicle preemption.	Demonstration	Demonstrate the functionality.		
11.0-5	The ASCT shall have the ability to 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)	4.13.0-1	The system needs the ability to accommodate emergency vehicle preemption.	Demonstration	Demonstrate the functionality.		
11.0-6	The ASCT shall have the ability to operate normally at non-preempted signal controllers when special functions are engaged by a preemption event. (An example of such a special functions is a phase omit, a phase maximum recall or a fire route.)	4.13.0-1	The system needs the ability to accommodate emergency vehicle preemption.				
11.0-7	The ASCT shall have the ability to release user-specified signal controllers to local control when one signal in a group is preempted	4.13.0-1	The system needs the ability to accommodate emergency vehicle preemption.	Analysis	Provide data analysis to verify the functionality		
11.0-8	The ASCT shall have the ability to permit the local signal controller from operating in normally detected limited-service actuated mode during preemption	4.13.0-1	The system needs the ability to accommodate emergency vehicle preemption.				
12	**Transit Priority**			Analysis	Provide data analysis to verify the functionality		
12.0-1	The ASCT shall continue adaptive operations of a group when one of its signal controllers has a transit priority call.	4.13.0-2	The system needs the ability to accommodate transit signal priority.	Analysis	Provide data analysis to verify the functionality		
12.0-2	The ASCT shall advance the start of a user-specified green phase in response to a transit priority call.	4.13.0-2	The system needs the ability to accommodate transit signal priority.	Analysis	Provide data analysis to verify the functionality		
12.0-2.0-1	The advance of start of green phase shall be user-defined.	4.13.0-2	The system needs the ability to accommodate transit signal priority.	Analysis	Provide data analysis to verify the functionality		
12.0-2.0-2	Adaptive operations shall continue during the advance of the start of green phase.	4.13.0-2	The system needs the ability to accommodate transit signal priority.	Analysis	Provide data analysis to verify the functionality		
12.0-3	The ASCT shall delay the end of a green phase, in response to a priority call.	4.13.0-2	The system needs the ability to accommodate transit signal priority.	Analysis	Provide data analysis to verify the functionality		

System Requirements Reference Number	System Requirement Description	ConOps Needs	ConOps Statement	Verification Method	Verification Procedure	Pass/Fail**	If the verification procedure fails, explain the reason why and how the issue will be resolved**
12.0-3.0-1	The delay of end of green phase shall be user-defined.	4.13.0-2	The system needs the ability to accommodate transit signal priority.	Analysis	Provide data analysis to verify the functionality		
12.0-3.0-2	Adaptive operations shall continue during the delay of the end of green phase.	4.13.0-2	The system needs the ability to accommodate transit signal priority.				
12.0-4	The ASCT shall permit at least X exclusive transit phase.	4.13.0-2	The system needs the ability to accommodate transit signal priority.	Analysis	Provide data analysis to verify the functionality		
12.0-4.0-1	Adaptive operations shall continue when there is an exclusive transit phase call.	4.13.0-2	The system needs the ability to accommodate transit signal priority.	Analysis	Provide data analysis to verify the functionality		
12.0-5	The ASCT shall control vehicle phases independently of the bus only phases.	4.13.0-2	The system needs the ability to accommodate transit signal priority.	Analysis	Provide data analysis to verify the functionality		
12.0-6	The ASCT shall accept a transit priority call from:	4.13.0-2	The system needs the ability to accommodate transit signal priority.	Analysis	Provide data analysis to verify the functionality		
	• A signal controller/transit vehicle detector			Analysis	Provide data analysis to verify the functionality		
	• An external system			Analysis	Provide data analysis to verify the functionality		
12.0-7	The ASCT shall provide a minimum of 1 transit priority sequence.	4.13.0-2	The system needs the ability to accommodate transit signal priority.	Analysis	Provide data analysis to verify the functionality		
13	**Failure Events and Fallback**			Analysis	Provide data analysis to verify the functionality		
13.1	**Detector Failure**			Analysis	Provide data analysis to verify the functionality		
13.1.0-1	The ASCT shall take user-specified action in the absence of valid detector data from a user-specified number of vehicle detectors within a group.	5.3.0-1	The system will have a fallback state that allows coordination using a common cycle length for all signals within a coordinated group when falling back to TOD plans	Analysis	Provide data analysis to verify the functionality		
		5.3.0-2	The system will have a fallback state that allows individual intersections to operate in a vehicle-actuated mode constrained by coordination in the event of failures of the adaptive software or hardware, detectors or communication	Analysis	Provide data analysis to verify the functionality		
		5.3.0-3	The system will have a fallback state that allows one or more intersections to be unmarried from a critical intersection in the event of failures of the adaptive software or hardware, detectors or communication.				
		8.7.1-1	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.				
13.1.0-1.0-1	The ASCT shall release control to local traffic controllers to operate under its own time-of-day schedule at a user-specified threshold of failures.	5.3.0-2	The system will have a fallback state that allows individual intersections to operate in a vehicle-actuated mode constrained by coordination in the event of failures of the adaptive software or hardware, detectors or communication	Analysis	Provide data analysis to verify the functionality		
13.1.0-2	The ASCT shall use the following alternate data sources for operations in the absence of the real-time data from a detector:	4.14.0-1	The system needs the ability to fall back to TOD or actuated operation constrained by coordination, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications, and software failure				
	• Data from a user-specified alternate detector						
	• Stored historical data from the failed detecto			Testing	Provide test results to verify functionality.		
13.1.0-2.0-1	The ASCT shall switch to the alternate data source automatically without operator intervention during user-specified threshold of detector failures.	4.14.0-1	The system needs the ability to fall back to TOD or actuated operation constrained by coordination, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications, and software failure				
13.1.0-3	In the event of a failure, the ASCT shall issue an alarm to user-specified recipients. (This requiremen 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. The alarm shall be delivered via the following means:	4.12.0-1	The system needs the ability to immediately notify maintenance and operations staff of alarms and alerts.				
	• Email	4.11-0.8	Have the ability to continuously monitor and diagnose the status o				
	• Text Message	4.12.0-1	The system needs the ability to immediately notify maintenance and operations staff of alarms and alerts.	Testing	Provide test results to verify functionality.		
	• Pop-up window on all workstations currently connected to the ASCT	4.12.0-2	The system needs the ability to immediately and automatically pass alarms and alerts.	Testing	Provide test results to verify functionality.		
13.1.0-4	In the event of a failure, the ASCT shall log details of the failure in a permanent log.	4.12.0-3	The system needs the ability to maintain a complete log of alarms and failure events.				
13.1.0-5	The permanent failure log shall be searchable, archivable and exportable.	4.12.0-3	The system needs the ability to maintain a complete log of alarms and failure events.				
13.2	**Communications Failure**			Testing	Provide test results to verify functionality.		
13.2-1	The ASCT shall execute user-specified actions when communications to one or more signal controllers fails within a group.	4.14.0-1	The system needs the ability to fall back to TOD or actuated operation constrained by coordination, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications, and software failure	Testing	Provide test results to verify functionality.		
		5.3.0-3	The system will have a fallback state that allows one or more intersections to be unmarried from a critical intersection in the event of failures of the adaptive software or hardware, detectors or communication.				

System Requirements Reference Number	System Requirement Description	ConOps Needs	ConOps Statement	Verification Method	Verification Procedure	Pass/Fail**	If the verification procedure fails, explain the reason why and how the issue will be resolved**
		8.6.1-1	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.				
13.2-1.0-1	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.	4.14.0-1	The system needs the ability to fall back to TOD or actuated operatior constrained by coordination, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications, and software failure				
13.2-1.0-2	The ASCT shall switch to the alternate operation in real time without operator intervention.	4.14.0-1	The system needs the ability to fall back to TOD or actuated operatior constrained by coordination, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications, and software failure	Demonstration	Demonstrate the functionality.		
13.2-2	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. The alarm shall be delivered via the following means: • Email • Text Message • Pop-up window on all workstations currently connected to the ASCT	4.14.0-1	The system needs the ability to fall back to TOD or actuated operatior constrained by coordination, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications, and software failure	Demonstration Testing	Demonstrate the functionality. Provide test results to verify functionality.		
13.2-3	The ASCT shall issue an alarm within a user-defined threshold (default of X (X) minutes) of detection of a communication failure.	4.12.0-1	The system needs the ability to immediately notify maintenance and operations staff of alarms and alerts.				
13.2-4	In the event of a communications failure, the ASCT shall log details of the failure in a permanent log.	4.12.0-3	The system needs the ability to maintain a complete log of alarms and failure events.	Testing	Provide test results to verify functionality.		
13.2-5	The permanent failure log shall be searchable, archival and exportable.	4.12.0-3	The system needs the ability to maintain a complete log of alarms and failure events.	Testingion	Provide test results to verify functionality.		
13.3	**Adaptive Server Failure**			Demonstration	Demonstrate the functionality.		
13.3-1	The ASCT shall execute user-specified actions when adaptive control fails:	4.14.0-1 5.3.0-1 5.3.0-3	The system needs the ability to fall back to TOD or actuated operatior constrained by coordination, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications, and software failure The system will have a fallback state that allows coordination using a common cycle length for all signals within a coordinated group when falling back to TOD plans The system will have a fallback state that allows one or more intersections to be unmarried from a critical intersection in the event of failures of the adaptive software or hardware, detectors or communication.				
13.3-1.0-1	The ASCT shall release control to user-specified local operations to operate under its own time-of-day schedule.	4.14.0-1	The system needs the ability to fall back to TOD or actuated operatior constrained by coordination, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications, and software failure	Demonstration	Demonstrate the functionality.		
13.3-2	In the event of adaptive software 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. The alarm shall be delivered via the following means: • Email • Text Message • Pop-up window on all workstations currently connected to the ASCT	4.12.0-1	The system needs the ability to immediately notify maintenance and operations staff of alarms and alerts.	Demonstration Demonstration Demonstration	Demonstrate the functionality. Demonstrate the functionality Provide test results to verify functionality.		
13.3-3	The permanent failure log shall be searchable, archival and exportable.	4.12.0-3	The system needs the ability to maintain a complete log of alarms and failure events.				
13.3-4	During adaptive software failure, all local detector inputs shall be provided to the local controller.	4.12.0-3	The system needs the ability to maintain a complete log of alarms and failure events.				
14	**Software**			Testing	Provide test results to verify functionality.		
14.0-1	The vendor's adaptive software shall be fully operational within the following server platforms: • Windows Server	4.15.0-1.0-6	The system needs the ability to use equipment and software acceptable under current NJ OIT policies and procedures	Testing	Provide test results to verify functionality.		
14.0-2	The system shall interface with the midblock system detection as per Requirement 10.1-13.	4.19.0-1	The system needs the ability to interface with midblock system detectors.				
14.0-3	The ASCT server software shall be compatible with the existing Mobility Management ASCT software and the user interface and control shall be integrated as per Requirement 3.1-7.	4.10.0-1.01	The system needs the ability to monitor and control all required features of adaptive operation from the following locations • Traffic Operation Center XXX	Testing Testing	Provide test results to verify functionality. Provide test results to verify functionality.		
15	**Training**						
15.0-1	The vendor shall provide the following training:	4.16.0-1	The NJDOT needs all staff involved in operation and maintenance to receive appropriate training	Demonstration	Demonstrate the functionality.		
15.0-1.0-1	The vendor shall provide training on the operations of the adaptive system.	4.16.0-1	The NJDOT needs all staff involved in operation and maintenance to receive appropriate training				
15.0-1.0-2	The vendor shall provide training on trouble-shooting the system.	4.16.0-1	The NJDOT needs all staff involved in operation and maintenance to receive appropriate training	Demonstration	Demonstrate the functionality.		
15.0-1.0-3	The vendor shall provide training on preventive maintenance and repair of equipment.	4.16.0-1	The NJDOT needs all staff involved in operation and maintenance to receive appropriate training	Demonstration	Demonstrate the functionality.		
15.0-1.0-4	The vendor shall provide training on system configuration.	4.16.0-1	The NJDOT needs all staff involved in operation and maintenance to receive appropriate training				
15.0-1.0-5	The vendor shall provide training on administration of the system.	4.16.0-1	The NJDOT needs all staff involved in operation and maintenance to receive appropriate training				
15.0-1.0-6	The vendor shall provide training on system calibration.	4.16.0-1	The NJDOT needs all staff involved in operation and maintenance to receive appropriate training				
15.0-1.0-7	The vendor's training delivery shall include: printed course materials and references, electronic copies of presentations and references.	4.16.0-1	The NJDOT needs all staff involved in operation and maintenance to receive appropriate training	Demonstration	Provide documentation.		
15.0-1.0-8	The vendor's training shall be delivered at a time and location designated by the NJDOT.	4.16.0-1	The NJDOT needs all staff involved in operation and maintenance to receive appropriate training	Demonstration	Provide documentation.		

System Requirements Reference Number	System Requirement Description	ConOps Needs	ConOps Statement	Verification Method	Verification Procedure	Pass/Fail**	If the verification procedure fails, explain the reason why and how the issue will be resolved**
15.0-1.0-9	The vendor shall provide a minimum of XX hours training to a minimum of XX staff.	4.16.0-1	The NJDOT needs all staff involved in operation and maintenance to receive appropriate training	Demonstration	Provide documentation.		
15.0-1.0-10	The vendor shall provide a minimum of X training sessions.	4.16.0-1	The NJDOT needs all staff involved in operation and maintenance to receive appropriate training	Demonstration	Provide documentation.		
16	**Maintenance, Support and Warranty**			Demonstration	Provide documentation.		
16.0-1	The vendor shall provide maintenance of the following hardware for a minimum of X years:	4.16.0-2	The NJDOT needs the system to fulfill all requirements for the life of the system. Therefore, NJDOT needs the system to be maintained to repair faults that are not defects in materials and workmanship.	Demonstration	Provide documentation.		
	• Traffic Controllers	6.2.1.0-15	The NJDOT expects maintenance of parts and field equipment for a period of X years after acceptance will be included in the purchase price. The ability for an on-going contract will be available thereafter.	Demonstration	Provide documentation.		
	• Conflict Monitors	4.18.0-2	NJDOT needs to have spare parts for critical equipment. The initial cost of all equipment needs to include maintenance for a minimum of XX (X) years from the date of installation.	Demonstration	Provide documentation.		
	• Detector Equipment			Demonstration	Provide documentation.		
16.0-2	The vendor shall provide maintenance of the following for a minimum of X years:	6.2.1.0-16	The NJDOT expects maintenance of all adaptive system servers and software for a period of X years after acceptance will be included in the purchase price. The ability for an on-going maintenance contract will be available thereafter.	Demonstration	Provide documentation.		
	• Adaptive controller software • Adaptive server and client software			Demonstration	Provide documentation.		
16.0-3	Vendor shall provide warranty for a minimum of X years, covering parts and labor for all material supplied. Warranty is defined as correcting defects in materials and workmanship. Defect is defined as any circumstance in which the material does not perform according to its specification.	6.2.1.0-14	Replacement or repair of defective or failed field equipment will be covered for X years by the manufacturers' warranties. The labor cost of replacement during this period will be included in the purchase price. The ability for an on-going contract will be available thereafter.	Demonstration	Provide documentation.		
		4.16.0-3	The NJDOT needs the system to fulfill all requirements for the life of the system. Therefore, NJDOT needs the system to remain free of defects in materials and workmanship that result in requirements no longer being fulfilled				
		4.16.0-4	The agency needs the system to fulfill all requirements for the life of the system. Therefore, NJDOT needs support to keep software and software environment updated as necessary to prevent requirements no longer being fulfilled	Demonstration	Provide documentation.		
		4.17.0-1	The system needs the ability 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				
16.0-4	The maintenance can be performed locally or remotely X a month.	6.2.1.0-19	Operations and maintenance staff will have the ability to log in to the system from remote locations via a secured-connection and have full functionality consistent with their access level	Demonstration	Provide documentation.		
16.0-5	The vendor shall supply technical support for a minimum of X years.	6.2.1.0-18	The NJDOT will seek technical support from the vendor for assistance in using the adaptive software for X years after acceptance. The ability for an on-going contract will be available thereafter.				
16.0-6	The vendor shall respond to requests for hardware maintenance within a minimum of X years.	6.2.1.0-15	The NJDOT expects maintenance of parts and field equipment for a period of X years after acceptance will be included in the purchase price. The ability for an on-going contract will be available thereafter.				
16.0-7	The vendor shall respond to requests for software technical support within a minimum of X years.	6.2.1.0-18	The NJDOT will seek technical support from the vendor for assistance in using the adaptive software for X years after acceptance. The ability for an on-going contract will be available thereafter.	Demonstration	Provide documentation.		
16.0-8	Acquisition and installation of upgrades of all ASCT software to the latest version for a period of X years shall be included in the purchase price	6.2.1.0-17	The NJDOT expects to operate this system using the latest software for a period of X years after acceptance				
16.0-9	The vendor shall set up and fine tune the operation of the ASCT prior to handover to the NJDOT.	6.2.1.0-8	The vendor will setup and fine tune the adaptive system prior to handover to the NJDOT.				
16.0-10	The vendor shall provide a refresher training course on-site at NJDOT X months into the software support period.	6.2.1.0-22	The NJDOT needs a refresher training course on-site at NJDOT XX months into the software support period				
17	**Schedule**			Demonstration	Provide documentation.		
17.0-1	The ASCT shall set the state of external input/output states according to a time-of-day schedule.	4.17.0-1	The system needs the ability 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	Demonstration	Provide documentation.		
17.0-2	The ASCT output states shall be settable according to a time-of-day schedule	4.17.0-1	The system needs the ability 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	Demonstration	Provide documentation.		
17.0-3	The ASCT operational parameters shall have the ability to be set according to a Time of Day schedule.	4.17.0-1	The system needs the ability 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	Demonstration	Provide documentation.		
18	**Performance Measurement, Monitoring and Reporting**			Demonstration	Provide documentation.		
18.0-1	The ASCT shall report measures of current traffic conditions on which it bases signal state alterations.	4.11-0.2	The system needs the ability to store and report data used to calculate signal timing and have the data available for subsequent analysis.	Demonstration	Provide documentation.		
18.0-2	The ASCT shall report all intermediate calculated values that are affected by calibration parameters.	4.11-0.2	The system needs the ability to store and report data used to calculate signal timing and have the data available for subsequent analysis.	Demonstration	Provide documentation.		

System Requirements Reference Number	System Requirement Description	ConOps Needs	ConOps Statement	Verification Method	Verification Procedure	Pass/Fail**	If the verification procedure fails, explain the reason why and how the issue will be resolved**
18.0-3	The ASCT shall maintain a log of all signal state alterations directed by the ASCT.	4.11-0.7	Have the ability to generate historic and real-time reports that effectively support operation, maintenance, and reporting of system performance and traffic conditions.				
		4.11-0.2	The system needs the ability to store and report data used to calculate signal timing and have the data available for subsequent analysis.	Demonstration	Demonstrate the functionality.		
18.0-3.0-1	The ASCT log shall include all events directed by the external inputs.	4.11-0.7	Have the ability to generate historic and real-time reports that effectively support operation, maintenance, and reporting of system performance and traffic conditions.	Demonstration	Demonstrate the functionality.		
18.0-3.0-2	The ASCT log shall include all external output state changes.	4.11-0.2	The system needs the ability to store and report data used to calculate signal timing and have the data available for subsequent analysis.	Demonstration	Demonstrate the functionality.		
18.0-3.0-3	The ASCT log shall include all actual parameter values that are subject to user-specified values.	4.11-0.7	Have the ability to generate historic and real-time reports that effectively support operation, maintenance, and reporting of system performance and traffic conditions.				
		4.11-0.2	The system needs the ability to store and report data used to calculate signal timing and have the data available for subsequent analysis.	Demonstration	Demonstrate the functionality.		
18.0-3.0-4	The ASCT shall maintain the records in this ASCT log for X (X) year.	4.11-0.7	Have the ability to generate historic and real-time reports that effectively support operation, maintenance, and reporting of system performance and traffic conditions.	Demonstration	Demonstrate the functionality.		
18.0-3.0-5	The ASCT shall archive the ASCT log (hot synced).	4.11-0.7	Have the ability to generate historic and real-time reports that effectively support operation, maintenance, and reporting of system performance and traffic conditions.	Demonstration	Demonstrate the functionality.		
		4.19.0-5	The historical system detection data needs to be stored locally and pushed remotely.				

Validation Plan
for
NJ RT XX Traffic Signal System Contract No. XX (20XX)

CITY
COUNTY, NEW JERSEY

Month 20XX

Prepared For

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Table of Contents

1.0 Purpose of Document

This document describes the process and strategy of how an Adaptive Computerized/Controlled Traffic Signal System (CTSS) and related subsystem components will be measured to determine whether or not the needs expressed in the Concept of Operations have been met. Validation determines if the system meets the intended needs of the system's owner and stakeholders once completed. This document plans, describes, and records the activities to assess the system's performance against the intended needs, goals, and expectations documented in the Concept of Operations. The system validation will be performed by NJDOT and the applicable stakeholders after the system has been verified and accepted. Validation is the responsibility of the system owner, and cannot be delegated to the system supplier or vendor. As a result of validation, new needs and requirements may potentially be identified. This evaluation sets the stage for the next evolution of the system

The Systems Engineering documents used to develop the Validation Plan were developed with guidance from the Federal Highway Administration (FHWA) Model Systems Engineering Documents for Adaptive Signal Control Technology (ASCT) Systems.

The intended audience of this document typically includes the following stakeholders:

- NJDOT
- Neighboring jurisdictions that operate signals
    - XX County
    - XX Municipality
- Fire departments
- Police departments
- NJTA
- NJ Transit
- FHWA

2.0 Scope of Project

An Adaptive CTSS is typically planned as part of an enhancement to an existing traffic signal system on any state corridor to provide responsive or adaptive capabilities. Enhancement projects include traffic signal equipment upgrades and the installation of interconnected communications between the intersections as well as midblock system detection. The limits of the project is shown along state corridor from a system detector site at milepost XX to a system detector site at milepost XX.

3.0 Reference Documents

This section provides a list of documents related to the CTSS Systems Engineering analysis. Related documents are not directly referenced within the narrative of this report, but all related documents have been used to develop the Concept of Operations Report. Some of these documents provide policy guidance, 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.

- *Concept of Operations for Route NJ XX Computerized Traffic Signal System Milepost XX to Milepost XX*, August XX.
- *System Requirements for Route NJ XX Computerized Traffic Signal System Milepost XX to Milepost XX*, August XX.
- *Verification Plan for Route NJ XX Computerized Traffic Signal System Milepost 3XX to Milepost XX*, August XX.
- *Model System Engineering Document for Adaptive Signal Control Technology (ASCT) Systems*, August 2012, Federal Highway Administration.
- *NCHRP Synthesis 403 – Adaptive Traffic Control Systems: Domestic and Foreign State of Practice*, 2010, Transportation Research Board.
- *Developing and Using a Concept of Operations in Transportation Management Systems*, December 2004, Federal Highway Administration.
- *New Jersey Statewide Intelligent Transportation Systems (ITS) Architecture*, February 18, 2005, New Jersey Department of transportation-Division of Statewide Traffic Operations
- *Institutional Coordination of Intelligent Transportation Systems in the Delaware Valley – Regional ITS Architecture,* March 2001, Delaware Valley Regional Planning Commission.
- *National Transportation Communications for ITS Protocols (NTCIP) – The NTCIP Guide*, July 2009, AASHTO, ITE, NEMA.
- *Standardization Policies and Procedures of the National Electrical Manufactures Association (NEMA)*, December 31, 2009, NEMA.
- *Manual on Uniform Traffic Control Devices (MUTCD), 2009, revised through May 2012,* Federal Highway Administration.
- *Highway Capacity Manual, 2010, Transportation Research Board.*
- *National Electrical Safety Code (NESC) and Handbook Set, 2012, Institute of Electrical and Electronics Engineers (IEEE).*

- *NFPA 70: National Electrical Code, 2014, National Fire Protection Association.*

4.0 Conducting Validation

The system validation will be conducted by NJDOT's system operator. The system operator will conduct the validation tests, record the results, and prepare summary report of the results. Validation procedures for each validation test have been prepared. The validation procedures describe the equipment setup, responsible personnel and steps to be followed to conduct the validation test.

The validation tests will be conducted after the system deployment and verification have been completed. The system will be validated using the hardware and software setup for the Adaptive CTSS. The system operator will configure system software to setup the system to collect and process data for validation tests. The system operator may need to observe traffic operation in the field or via image detectors to measure test outcomes of some validation tests.

Validation of several cases, identified as operational scenarios in the Concept of Operations, will require a comparison of operations before and after implementation of the Adaptive CTSS. The procedures for the before and after data collection are set forth in the Special Provisions as well as the Verification Plan. Data to be used for validation should be collected prior to implementation of the Adaptive CTSS and/or during a brief period after implementation but before the system turn-on, specifically during the burn-in period for data collection.

5.0 Validation Identification

The validation scenarios will be tested and documented by the system operator. The validation tests will validate the user needs to evaluate the project goals and the key operational scenarios described in the Concept of Operations document. These tests can be found in Appendix X – Validation Plan Matrix.

Appendix X – Validation Plan Matrix

TEMPLATE

Need Statement Reference Number	Concept of Operations Need Statement	System Requirements Reference Numbers															Data Source / Test Procedure	Results	Pass/Fail
3.4.3.0-1.0-2	• Provide the same or higher level of safety provided by the existing system to vehicles, pedestrians and transit.	2.1.2.0-12															System Inspection/ Observation		
4.0-1	The system needs to have ability to operate under user-defined constraints to the sequence based operation.																Signal Timing Data; System Inspection/ Observation		
4.1.0-1.0-1	Maximize the throughput on coordinated routes.	2.1.1.0-7	2.1.1.0-7.0-1	2.2.0-1	2.2.0-2	2.2.0-4	2.2.0-4.0-1	2.2.0-5	2.2.0-5.0-1	2.2.0-5.0-2	2.2.0-5.0-3	2.2.0-5.0-4					Detector Data; Field Observations		
4.1.0-1.0-2	Provide smooth flow along coordinated routes.	2.1.1.0-7.0-4	2.2.0-1	2.2.0-2	2.2.0-5	2.2.0-5.0-1	2.2.0-5.0-2	2.2.0-5.0-3	2.2.0-5.0-4								Signal Timing and Detector Data; Percent Arrival on Green; Field Observations		
4.1.0-1.0-3	Distribute phase times in an equitable fashion.	2.1.1.0-7	2.1.1.0-7.0-3	2.1.1.0-7.0-4	2.1.1.0-8	2.1.1.0-8.0-1	2.1.1.0-8.0-2	2.1.1.0-8.0-2.0-1	2.2.0-1								Signal Timing and Detector Data; Percent Arrival on Green; Field Observations		
4.1.0-1.0-4	Manage the length of queues.	2.1.1.0-7.0-2	2.1.3.0-1	2.1.3.0-2	2.1.3.0-3	2.1.3.0-4	2.1.3.0-5	2.2.0-1	2.2.0-2	2.2.0-3	2.2.0-5	2.2.0-5.0-1	2.2.0-5.0-2	2.2.0-5.0-3	2.4.0-2	2.4.0-2.0-1	Detector Data; Field Observations		
4.1.0-1.0-5	Manage the locations of queues within the network.	2.1.3.0-1	2.1.3.0-2	2.1.3.0-3	2.1.3.0-4	2.2.0-3											Detector Data; Field Observations		
4.1.0-1.0-6	At an isolated intersection, optimize operation with a minimum of phase failures (based on the optimization objectives).	2.1.1.0-8	2.1.1.0-8.0-1	2.1.1.0-8.0-1.0-1	2.1.1.0-8.0-2	2.1.1.0-8.0-2.0-1											Signal Timing and Detector Data; Field Observations		
4.1.0-2	The system needs the ability to manage the coordination in small groups of signals to link phase service at some intersections with phase service at adjacent intersections.	1.0-2.0-1	2.5.0-1	2.5.0-2	2.5.0-3	2.5.0-4	2.5.0-5										System Inspection; Signal Timing Data		
4.1.0-3	The system needs the ability to change the operational strategy (for example, from smooth flow to maximizing throughput or managing queues) based on changing traffic conditions.	2.1.1.0-7	2.1.1.0-7.0-3	2.1.1.0-7.0-2													Signal Timing and Detector Data; Field Observations		
4.1.0-4	The system needs the ability to detect repeated phase failures and control signal timing to prevent phase failures building up queues.	2.1.1.0-9	2.1.1.0-9.0-1	2.1.3.0-1	2.2.0-3												Signal Timing and Detector Data; Field Observations		
4.1.0-5	The system needs to minimize the chance that a queue forms at a specified location.	2.2.0-5.0-5	2.5.0-6	2.5.0-7	2.5.0-8	2.5.0-9											Field Observations; Detector Data		
4.1.0-6	The system needs the ability to fix the sequence of phases at any specified location.	2.1.2.0-11															Signal Timing Data		
4.1.0-7	The system needs the ability to designate the coordinated route based on traffic conditions and the selected operational strategy	2.1.1.0-10	2.1.1.0-10.0-1	2.1.1.0-10.0-2	2.1.1.0-10.0-3	2.1.1.0-10.0-4	2.1.1.0-10.0-4.0-1	2.1.1.0-10.0-4.0-2	2.1.1.0-10.0-4.0-3								Performance Data Analysis		
4.1.0-8	The system needs the ability to set signal timing parameters to comply with NJDOT policies.	2.1.1.0-11	9.0-4														Performance Data Analysis		
4.2.0-1	The system needs the ability to eventually adaptively control up to XX signalized intersections, up to XX miles from XXX (TMC, TOC, etc.).	1.0-1															Performance Data Analysis		
4.2.0-2	The system needs the ability to be able to eventually adaptively control up to XX independent groups of signalized intersections.	1.0-2	1.0-2.0-2														System Documentation		
4.2.0-3	The system needs the ability to vary the number of signals in an adaptively controlled group to accommodate the prevailing traffic conditions.	1.0-2	1.0-2.0-3	1.0-2.0-5	1.0-2.0-5.0-1	1.0-2.0-5.0-2	1.0-2.0-5.0-3										System Documentation		
4.3.0-1	The system needs the ability to adaptively control signals operated by NJDOT.	3.0-1															System Inspection; Field Observations		
4.3.0-2	The system needs the ability to send data to another system that would allow the other system to coordinate with the ASCT system.	3.0-1	3.0-1.0-1	3.0-1.0-2	3.0-1.0-3												Signal Timing and Detector Data; Percent Arrival on Green; Field Observations		
4.3.0-3	The system needs the ability to adaptively coordinate signals on two crossing routes simultaneously.	3.1-7															System Documentation		
4.3.0-4	The system needs the ability to receive data from another system that will allow the ASCT system to coordinate its operation with the adjacent system.	3.0-1	4.0-1	4.0-1.0-1	4.0-1.0-3												System Documentation		
4.3.0-5	The system needs the ability to constrain the adaptive system to operate a cycle length compatible with the crossing arterial.	4.0-1.0-2															System Documentation		
4.3.0-6	The system needs the ability to detect traffic approaching from a neighboring system and coordinate the ASCT operation with the adjacent system.	4.0-1	4.0-1.0-1														System Documentation		
4.4.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies.	5.0-1 5.0-1.0-16	5.0-1.0-1 5.0-1.0-17	5.0-1.0-3 5.0-1.0-18	5.0-1.0-4 5.0-1.0-19	5.0-1.0-5 5.0-1.0-20	5.0-1.0-6 5.0-1.0-21	5.0-1.0-7 5.0-3	5.0-1.0-8 2.1.2.0-2	5.0-1.0-9	5.0-1.0-10	5.0-1.0-11	5.0-1.0-12	5.0-1.0-13	5.0-1.0-14	5.0-1.0-15	System Documentation		
4.5.0-1	The system needs the ability to have a security management and administrative system that allows access and operational privileges to be assigned, monitored, and controlled by an administrator, and conform to the NJ-OIT's and NJDOT's access and network infrastructure security policies.	2.1.3.0-1	2.1.3.0-2	2.1.3.0-3	2.1.3.0-4												Field Observations; Detector Data		
4.5.0-2	The system needs the ability to detect queues within the system's boundaries and modify the ASCT operation to accommodate the queuing.	2.1.3.0-1	2.1.3.0-3	2.1.3.0-4													Field Observations; Detector Data		
4.5.0-3	The system needs the ability to detect queues propagating outside its boundaries from within the ASCT boundaries, and modify its operation to accommodate the queuing.	2.1.3.0-1	2.1.3.0-3	2.1.3.0-4													Field Observations; Detector Data		
4.5.0-4	The system needs the ability to store queues in locations where they can be accommodated without adversely affecting adaptive operation.	2.1.3.0-1	2.1.3.0-3	2.1.3.0-4													Field Observations; Detector Data		
4.5.0-5	The system needs the ability to prevent queues forming at user specified locations.	2.1.3.0-1	2.1.3.0-3	2.1.3.0-4													Field Observations; Detector Data		
4.6.0-1	Infrequent pedestrian actuated calls: The system needs the ability to accommodate infrequent pedestrian operation and then adaptively recover.	8.0-1	8.0-5														Signal Timing Data		
4.6.0-2	Infrequent pedestrian actuated calls: The system needs the ability to accommodate infrequent pedestrian operation while maintaining adaptive operation.	8.0-2															Signal Timing Data, Observation		
4.6.0-3	Frequent pedestrian actuated calls: The system needs the ability to incorporate frequent pedestrian operation into routine adaptive operation.	2.1.3.0-2	8.0-3														Signal Timing Data, Observation		
4.6.0-4	Pedestrian nonactuated calls: Nonactuated pedestrian phases are always on recall.	2.1.3.0-2	8.0-4	8.0-6													Signal Timing Data, Observation		
4.6.0-5	The system needs the ability to accommodate custom pedestrian features.	8.0-3															Signal Timing Data, Observation		
4.6.0-6	The system needs to the ability to accommodate early start of walk and exclusive pedestrian phases.	8.0-3															Signal Timing Data, Observation		
4.7.0-1	The system needs the ability to detect traffic conditions during which adaptive control is not the preferred operation, and implement some pre-defined operation while that condition is present.	2.1.1.0-1	2.1.1.0-7.0-5														System Inspection; Detector Data; Signal Timing Data		
4.7.0-2	The system needs the ability to schedule pre-determined operation by time of day.	2.1.1.0-5															Observation		
4.7.0-3	The system needs the ability to over-ride adaptive operation.	2.1.1.0-3	2.1.1.0-4	2.1.1.0-5													Observation		
4.8.0-1	The system needs the ability to modify the ASCT operation to closely follow changes in traffic conditions.	2.6.0-1	2.6.0-2	2.6.0-3													System Inspection; Detector Data; Signal Timing Data		
4.8.0-2	The system needs the ability to constrain the selection of cycle lengths to those that provide acceptable operations, such as when resonant progression solutions are desired.	2.6.0-1	2.6.0-3	2.6.0-5													Observation		
4.8.0-3	The system needs to respond within a user-defined amount of cycles to sudden large shift in traffic conditions.	2.6.0-4															Signal Timing Data		
4.9.0-1	**The system needs the ability to implement the following advanced controller features while maintaining adaptive operation:**																		
4.9.0-1.0-1	• Service a phase more than once per cycle based on user-defined constraints.	2.1.2.0-1	2.1.2.0-2	7.0-1	7.0-10	7.0-11	7.0-12	7.0-12.0-1	7.0-13	8.0-7	9.0-1	10.1-1	10.1-2				Signal Timing Data, Observation		

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Need Statement Reference Number	Concept of Operations Need Statement	System Requirements Reference Numbers															Data Source / Test Procedure	Results	Pass/Fail
4.9.0-1.0-2	• Operate at least X overlap phases.	7.0-2															Signal Timing Data, Observation		
4.9.0-1.0-3	• Operate up to X rings, X phases and X phases per ring.	7.0-3	7.0-4	7.0-5	7.0-6	7.0-6.0-1	7.0-6.0-2	7.0-6.0-3	7.0-9								Signal Timing Data, Observation		
4.9.0-1.0-4	• Allow one or more phases to be omitted (disabled) under certain traffic conditions or signal states.	2.1.2.0-6	2.1.2.0-7	2.1.2.0-8													Signal Timing Data, Observation		
4.9.0-1.0-5	• Prevent one or more phases being skipped under certain traffic conditions or signal states.	2.1.2.0-3	2.1.2.0-4	2.1.2.0-5													Signal Timing Data, Observation		
4.9.0-1.0-6	• Allow detector logic at an intersection to be varied depending on local signal states.	9.0-1															Signal Timing Data, Observation		
4.9.0-1.0-7	• Accommodate the custom features used by NJDOT.	7.0-14															Signal Timing Data, Observation		
4.9.0-1.0-8	• Allow any phase to be designated as the coordinated phase.	7.0-7	7.0-8	7.0-9													Signal Timing Data, Observation		
4.9.0-1.0-9	• Allow the operator to specify which phase receives unused time from a preceding phase.	2.1.2.0-9	2.1.2.0-10														Signal Timing Data, Observation		
4.9.0-1.0-10	• Allow the controller to respond independently to individual lanes of an approach. This may be implemented in the signal controller using up to X 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.	7.0-12	7.0-12.0-1	9.0-1	10.1-1	10.1-2											Signal Timing Data, Observation		
4.9.0-1.0-11	• Allow the coordinated phase to terminate early under prescribed traffic conditions	7.0-10															Signal Timing Data, Observation		
4.9.0-1.0-12	• Allow flexible timing of non-coordinated phases (such as late start of a phase) while maintaining coordination.	7.0-11	8.0-5	8.0-6													Signal Timing Data, Observation		
4.9.0-1.0-13	• Protected/permissive phasing and alternate left turn phase sequences.	2.1.2.0-1	2.1.2.0-2														Signal Timing Data, Observation		
4.9.0-1.0-14	• 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.	7.0-13															Signal Timing Data, Observation, Field Observations		
4.10.0-1	**The system needs the ability to monitor and control all required features of adaptive operation from the following locations:**																		
4.10.0-1.01	• Traffic Operation Center XXX	1.0-1															System Inspection		
4.10.0-1.02	• Arterial Management Center (AMC)	1.0-1															System Inspection		
4.10.0-1.03	• Statewide Traffic Management Center (STMC)	1.0-1															System Inspection		
4.10.0-1.04	• Local Controller Cabinets	1.0-1															System Inspection		
4.10.0-1.05	• Maintenance Vehicles	1.0-1															System Inspection		
4.10.0-2	The operator needs the ability to access to the database management, monitoring and reporting features and functions of the signal controllers and any related signal management system as per his/her defined privilege level from the access points defined for those system components.	5.0-1															System Inspection		
4.10.0-3	The system needs to have an integrated user-friendly graphic user interface (GUI) to provide graphic displays, import and generation of graphic images, automatic updating of maps and graphics, and update this data in real time (at least once per second).	3.1-3	3.1-4														System Inspection		
4.11-0.1	The NJDOT needs the ability for the Traffic Management System to be able to coexist with or monitor the adaptive system.	1.0-3															System Inspection		
4.11-0.2	The system needs the ability to store and report data used to calculate signal timing and have the data available for subsequent analysis.	6.0-2															System Inspection		
4.11-0.3	The system needs the ability to store and report data that can be used to measure traffic performance under adaptive control.	6.0-2															System Inspection		
4.11-0.4	The system needs the ability to store all operational data and signal timing parameters calculated by the adaptive system, and export selected data.	6.0-2															System Inspection		
4.11-0.5	The system needs the ability to report performance data at least once a minute.	6.0-1															System Inspection		
4.11-0.6	The system needs the ability to be able to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation	6.0-4															System Inspection		
4.11-0.7	Have the ability to generate historic and real-time reports that effectively support operation, maintenance, and reporting of system performance and traffic conditions.	6.0-5															System Inspection		
4.11-0.8	Have the ability to continuously monitor and diagnose the status of stopline and system detectors.	13.1.0-3															System Inspection		
4.12.0-1	The system needs the ability to immediately notify maintenance and operations staff of alarms and alerts.	13.1.0-3															System Inspection		
4.12.0-2	The system needs the ability to immediately and automatically pass alarms and alerts.	13.1.0-3															System Inspection		
4.12.0-3	The system needs the ability to maintain a complete log of alarms and failure events.	13.1.0-4	13.1.0-5	13.2-4	13.2-5	13.3-3	13.3-4										System Inspection		
4.13.0-1	The system needs the ability to accommodate emergency vehicle preemption.	11.0-1	11.0-2	11.0-3	11.0-4	11.0-5	11.0-6	11.0-7	11.0-8								Documentation, Observation		
4.13.0-2	The system needs the ability to accommodate transit signal priority.	12.0-1	12.0-2	12.0-2.0-1	12.0-2.0-2	12.0-3											Documentation, Observation		
4.14.0-1	The system needs the ability to fall back to TOD or actuated operation constrained by coordination, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications, and software failure.	2.1.1.0-2	2.1.1.0-2.0-1	2.1.1.0-2.0-2	2.1.1.0-2.0-3	12.0-3	12.0-3.0-1	12.0-3.0-2	12.0-4	12.0-4.0-1	12.0-5	12.0-6	12.0-7				System Inspection		
4.15.0-1	**The system is constrained to use the following equipment:**																		
4.15.0-1.0-1	• Naztec 2070N controllers are utilized by not a mandatory constraints	1.0-3															System Inspection		
4.15.0-1.0-2	• Non roadway-intrusive detectors (stopbar and system)	10.1-2															System Inspection		
4.15.0-1.0-5	• Coexist with the Traffic Management System	1.0-3															System Inspection		
4.15.0-1.0-6	The system needs the ability to use equipment and software acceptable under current NJ OIT policies and procedures.	14.0-1															System Inspection		
4.16.0-1	The NJDOT needs all staff involved in operation and maintenance to receive appropriate training.	15.0-1	15.0-1.0-1	15.0-1.0-2	15.0-1.0-3	15.0-1.0-4	15.0-1.0-5	15.0-1.0-6	15.0-1.0-7	15.0-1.0-8	15.0-1.0-9	15.0-1.0-10					System Inspection		
4.16.0-2	The NJDOT needs the system to fulfill all requirements for the life of the system. Therefore, NJDOT needs the system to be maintained to repair faults that are not defects in materials and workmanship.	16.0-1															System Inspection		
4.16.0-3	The NJDOT needs the system to fulfill all requirements for the life of the system. Therefore, NJDOT needs the system to remain free of defects in materials and workmanship that result in requirements no longer being fulfilled.	16.0-3															System Inspection		
4.16.0-4	The agency needs the system to fulfill all requirements for the life of the system. Therefore, NJDOT needs support to keep software and software environment updated as necessary to prevent requirements no longer being fulfilled.	16.0-3															System Inspection		
4.17.0-1	The system needs the ability 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	3.0-1.0-1															System Inspection/ Observation		
4.17.0-2	The system needs to react to traffic volume and traffic operation condition change due to special events.	2.5.0-4	2.6.0-4														System Inspection/ Observation		
4.17.0-3	The system needs the ability to be capable of responding to commands issued by the Traffic Management System.	2.1.1.0-6	2.1.2.0-4	2.1.2.0-7													System Inspection/ Observation		
4.18.0-2	NJDOT needs to have spare parts for critical equipment. The initial cost of all equipment needs to include maintenance for a minimum of XX (X) years from the date of installation.	16.0-1															System Inspection/ Observation		

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4.19.0-1	The system needs the ability to interface with midblock system detectors.	3.0-1.0-5	10.1-6	10.1-13	14.0-2												System Inspection/ Observation		
4.19.0-2.04	**The data collected by the system detectors is as follows:**																		
4.19.0-2.05	• Volume	10.1-8															System Inspection/ Observation		
4.19.0-2.06	• Speed	10.1-9															System Inspection/ Observation		
4.19.0-2.07	• Classification	10.1-10															System Inspection/ Observation		
4.19.0-2.08	• Travel Time	10.1-11															System Inspection/ Observation		
4.19.0-2.09	• Occupancy	10.1-12															System Inspection/ Observation		
4.19.0-3	The adaptive system needs the ability to integrate the system detection data into adaptive operation.	3.0-1.0-5	10.1-14														System Inspection/ Observation		
4.19.0-4	The adaptive system needs the ability to integrate the system detection data into the adaptive system GUI.	3.1-6															System Inspection/ Observation		
4.19.0-5	The historical system detection data needs to be stored locally and pushed remotely.	18.0-3.0-5															System Inspection/ Observation		
4.20.0-1	**The traffic signal detection needs the following capabilities:**																		
4.20.0-2.01	• Detect a minimum of X lanes of traffic per device	10.0-1															System Inspection/ Observation		
4.20.0-2.02	• Detect a minimum of X detection zone per lane	10.0-1															System Inspection/ Observation		
4.20.0-2.03	• Utilize power/communication cables greater than XX feet in length	10.0-1															System Inspection/ Observation		
4.20.0-2.04	• Utilize a CCD sensor for image detectors	10.0-1															System Inspection/ Observation		
4.20.0-2.05	• Utilize an integrated processor	10.0-1															System Inspection/ Observation		
5.2.0-1	The objective of the coordination will be to provide for smooth flow along the arterial road, minimizing the number of stops experienced by vehicles traveling along the road. Where "natural" cycle lengths exist that permit two-way progression, the system will generally operate at one of those cycle lengths unless longer phase lengths, are required to accommodate the demand.	2.2.0-5															System Inspection		
5.2.0-2	The objective of the coordination will be to maximize the throughput along the coordinated route. This may involve a tradeoff that increases delay to cross streets and turning movements, in order to maximize the green time provided to coordinated traffic flows.	2.2.0-5.0-2															System Inspection		
5.2.0-3	The objective of the coordination will be to control traffic in a manner that equitably serves the adjacent land uses. The delays experienced by the traffic entering and leaving the coordinated route will be balanced with the delays and stops experienced by other traffic traveling along the route.	2.1.1.0-7.0-3															System Inspection		
5.2.0-4	The objective of the coordination will be to manage the lengths of queues stored at critical locations within the coordinated group so that long queues do not block upstream intersections or otherwise reduce the capacity available during the green phases. This will involve controlling phase lengths so that the size of platoons entering a downstream block does not exceed the storage length if the platoon will be stopped. It will also involve control of offsets and phase lengths so that queues may be stored in locations where they will not adversely affect capacity of the system.	2.1.3.0-3															System Inspection		
5.2.0-5	The system, or the operator, will select the appropriate coordination objective, depending on the current traffic conditions. For example, during commuter peaks the primary objective may be to maximize the throughput along the road in the peak direction. Then during the business hours the objective may be to balance delays between traffic associated with the adjacent activity and traffic simply traveling through the system.	2.2.0-4															System Inspection		
5.2.0-6	The operator will be able to define for each group of intersections the appropriate operational objective. For example, near a freeway interchange or in a location with heavy turning movements, the queue management strategy may be specified, while on an arterial with long signal spacing the smooth flow objective may be specified.	2.2.0-5															System Inspection		
5.2.0-7	During moderate to light traffic conditions, one or more phases may be omitted (e.g., a protected phase if protected/ permissive left turns are operated), in order to more efficiently serve other movements, provided it is safe to do so. This may be accomplished through a time of day schedule or based on the measured traffic conditions.	2.1.2.0-7															System Inspection		
5.2.0-8	Within these operational objectives, the ASCT system will change its operation to accommodate the rise and fall of volumes through the peaks, and the changing patterns of flow throughout the day and week. However, there is also a stochastic element to traffic in the short term, with the number of arrivals for a phase varying from cycle to cycle, and pedestrians not being present on all phases in all cycles. It is therefore desirable for the system to have some local tactical control. While vehicle-actuated coordination typically allows phases to run longer or shorter from cycle to cycle to match the actual number of vehicles using the phase, the system will also allow the operator to decide where the unused time will be used. If a phase is to be skipped, the operator can specify that the spare time will be added to the existing phase, the following phase, or the next coordinated phase.	2.6.0-4															System Inspection		
5.2.0-9	At an isolated intersection with widely varying traffic patterns and a high degree of saturation during peak times, the system will calculate the optimum cycle length, and phase times in real time to match the changing traffic conditions.	2.1.3.0-3															System Inspection		
5.2.0-10	At a small group of intersections, with the user defining one as being critical, while the adjacent intersections require a lower cycle length or progression must be provided for specific phases to minimize the formation of queues on the approaches to the critical intersection, the phase lengths of the critical intersection will be determined by the system based on the current traffic conditions. The operation of the adjacent intersections will then be set so that platoons departing the critical intersection are progressed through the non-critical intersections, or platoons arriving at the critical intersection do so at a time when they will have little or no delay waiting for the appropriate phase.	2.5.0-4															System Inspection		
5.3.0-1	The system will have a fallback state that allows coordination using a common cycle length for all signals within a coordinated group when falling back to TOD plans.	13.1.0-1	13.3-1														System Inspection		
5.3.0-2	The system will have a fallback state that allows individual intersections to operate in a vehicle-actuated mode constrained by coordination in the event of failures of the adaptive software or hardware, detectors or communication.	13.1.0-1	13.1.0-1.0-1														System Inspection		
5.3.0-3	The system will have a fallback state that allows one or more intersections to be unmarried from a critical intersection in the event of failures of the adaptive software or hardware, detectors or communication.	13.1.0-1	13.2-1	13.3-1													System Inspection		
5.4.0-1	A coordinated group will be able to include more than one coordinated route, such as two crossing arterials. The system will be able to maintain coordination along both roads.	4.0-1.0-4															System Inspection		
5.4.0-2	The NJDOT needs the adaptive system to maintain coordination with another adjacent system either by sensing arriving traffic or by using constraints on cycle length.	4.0-1.0-1															Documentation		
5.4.0-3	The system will accept data from a neighboring system that allows it to stay in coordination with the adjacent system while still operating in adaptive mode.	4.0-1															Documentation		

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5.5.0-1	Operators, traffic engineering, and maintenance staff will be assigned different levels of authority, and access to equipment for which they are authorized, based on their roles and responsibilities. This will allow them to control, view, monitor, and analyze the operation of the system as appropriate.	5.0-1															System Inspection		
5.5.0-3	The system will be connected to the NJDOT's Statewide Network allowing access to all authorized users.	1.0-1															System Inspection		
5.5.0-4	The system will allow access by authorized users outside the NJDOT (such as system vendor) utilizing OIT's VPN interface	1.0-1															System Inspection		
5.6.0-1	**The NJDOT will use the following complex coordination and controller features:**																		
5.6.0-2	• The ability to repeat a phase, such as running a left turn phase before and after its opposing through movement.	7.0-1															System Inspection		
5.6.0-3	• Provision for the required number of rings, phases, phases per ring, and overlap phases.	7.0-5															System Inspection		
5.6.0-4	• The ability to omit a phase under some traffic conditions, or based on external input, to allow a shorter cycle length to operate, or to provide additional time to other phases.	2.1.2.0-7															System Inspection		
5.6.0-5	• Special features unique to the NJDOT such as detector switching, dynamic max, coordination beginning of yellow.	7.0-14															System Inspection		
5.6.0-6	• The ability to maintain coordination with external movements by preventing phases from being skipped, based on time-of-day, external input or when certain phase sequences are in operation.	2.1.2.0-4															System Inspection		
5.6.0-7	• The NJDOT will permit phases or overlaps by time-of-day schedule or external input.	7.0-2															System Inspection		
5.6.0-8	• The ability to designate specific phases as coordinated phases.	7.0-9															System Inspection		
5.6.0-9	• The ability to separately monitor each lane on an approach and take different action depending on the conditions measured in each lane.	10.0-1															System Inspection		
5.6.0-10	• The ability to allow the coordinated phase to terminate early if the coordinated platoon is short.	2.1.2.0-9															System Inspection		
5.6.0-11	• The ability to introduce a non-coordinated phase later than its normal starting point within a cycle, if it can be served with minimum green within the remaining time available.	2.1.2.0-9	8.0-5														System Inspection		
5.6.0-12	• Protected/permissive and permissive only phasing.	2.1.2.0-1															System Inspection		
5.6.0-14	• The NJDOT may operate external devices using discrete signal outputs from the ASCT including occupancy on a detector, cycle length, and time-of-day.	9.0-1															System Inspection		
5.6.0-15	• The ability for a coordinated phase to be released early.	7.0-16															System Inspection		
8	**8 Chapter 8: Operational Scenarios**																		
8.2	**8.2 Peak Period. Typical heavy uncongested conditions (unsaturated)**																		
8.2.1	**8.2.1 Arterial with highway interchange**																		
8.2.1.1	Have the ability to monitor traffic conditions and select appropriate signal timing parameters, such as cycle length, green time, offsets, and/or double servicing specific phases where conditions permit.	2.1.1.0-7															System Inspection, Field Observations		
8.2.1.2	Have the ability to determine intersection grouping and establish timing to smooth traffic and provide progression.	2.1.1.0-7															System Inspection, Field Observations		
8.2.1.3	Have the ability to for timing parameters will vary cycle to cycle based on changing traffic conditions.	2.1.1.0-7															System Inspection, Field Observations		
8.2.1.4	Have the ability to monitor traffic volumes and adjust progression based on traffic demands.	2.1.1.0-7															System Inspection, Field Observations		
8.2.1.5	Have the ability to monitor minor approach left turns for queue spillback and automatically increase left turn green time or double service to minimize queue length, constrained by coordination.	2.1.1.0-7															System Inspection, Field Observations		
8.2.1.6	Have the flexibility to be coordinated as one group or have the freedom to operate as separate groups as set by the operators or as dictated by traffic demand.	2.1.1.0-7															System Inspection, Field Observations		
8.2.2	**8.2.2 Arterial with one critical intersection**																		
8.2.2.1	Have the ability to monitor traffic conditions and select appropriate signal timing parameters, such as cycle length, green time, offsets, and/or double servicing specific phases where conditions permit.	2.1.1.0-7															System Inspection, Field Observations		
8.2.2.2	Have the ability to determine intersection grouping and establish timing to smooth traffic and provide progression.	2.1.1.0-7															System Inspection, Field Observations		
8.2.2.3	Have the ability to for timing parameters will vary cycle to cycle based on changing traffic conditions.	2.1.1.0-7															System Inspection, Field Observations		
8.2.2.4	Have the ability to monitor traffic volumes and adjust progression based on traffic demands.	2.1.1.0-7															System Inspection, Field Observations		
8.2.2.5	Have the ability to monitor minor approach left turns for queue spillback and automatically increase left turn green time or double service to minimize queue length, constrained by coordination.	2.1.1.0-7															System Inspection, Field Observations		
8.2.2.6	Have the flexibility to be coordinated as one group or have the freedom to operate as separate groups as set by the operators or as dictated by traffic demand.	2.1.1.0-7															System Inspection, Field Observations		
8.2.3	**8.2.3 Arterial with several critical intersections**																		
8.2.3.1	Have the ability to monitor traffic conditions and select appropriate signal timing parameters, such as cycle length, green time, offsets, and/or double servicing specific phases where conditions permit.	2.1.1.0-7															System Inspection, Field Observations		
8.2.3.2	Have the ability to determine intersection grouping and establish timing to smooth traffic and provide progression.	2.1.1.0-7															System Inspection, Field Observations		
8.2.3.3	Have the ability to for timing parameters will vary cycle to cycle based on changing traffic conditions.	2.1.1.0-7															System Inspection, Field Observations		
8.2.3.4	Have the ability to monitor traffic volumes and adjust progression based on traffic demands.	2.1.1.0-7															System Inspection, Field Observations		
8.2.3.5	Have the ability to monitor minor approach left turns for queue spillback and automatically increase left turn green time or double service to minimize queue length, constrained by coordination.	2.1.1.0-7															System Inspection, Field Observations		
8.2.3.6	Have the flexibility to be coordinated as one group or have the freedom to operate as separate groups as set by the operators or as dictated by traffic demand.	2.1.1.0-7															System Inspection, Field Observations		
8.3	**8.3 Peak Period. Typical heavy congested conditions (oversaturated)**																		
8.3.1	**8.3.1 Arterial with highway interchange**																		
8.3.1.1	Have the ability to automatically change goals to provide maximum throughput.	2.1.1.0-7															System Inspection, Field Observations		
8.3.1.2	Have the ability to monitor traffic conditions and select appropriate signal timing parameters, cycle length, green time, offsets, and/or double servicing specific phases where conditions permit.	2.1.1.0-7															System Inspection, Field Observations		
8.3.1.3	Have the ability to determine intersection grouping and establish timing to maximize the movement of vehicles	2.1.1.0-7															System Inspection, Field Observations		
8.3.1.4	Have the ability for timing parameters to vary cycle to cycle based on changing traffic conditions.	2.1.1.0-7															System Inspection, Field Observations		
8.3.1.5	Have the ability to monitor traffic volumes and adjust progression based on traffic demands.	2.1.1.0-7															System Inspection, Field Observations		
8.3.1.6	Have the ability to monitor minor approach left turns for queue spillback and automatically increase left turn green time or double service to minimize queue length, constrained by coordination.	2.1.1.0-7															System Inspection, Field Observations		
8.3.1.7	Have the flexibility to be coordinated as one group or have the freedom to operate as separate groups as set by the operators or as dictated by traffic demand	2.1.1.0-7															System Inspection, Field Observations		
8.3.2	**8.3.2 Arterial with one critical intersection**																		
8.3.2.1	Have the ability to automatically change goals to provide maximum throughput.	2.1.1.0-7															System Inspection, Field Observations		
8.3.2.2	Have the ability to monitor traffic conditions and select appropriate signal timing parameters, cycle length, green time, offsets, and/or double servicing specific phases where conditions permit.	2.1.1.0-7															System Inspection, Field Observations		

Need Statement Reference Number	Concept of Operations Need Statement	System Requirements Reference Numbers	Data Source / Test Procedure	Results	Pass/Fail
8.3.2.3	Have the ability to determine intersection grouping and establish timing to maximize the movement of vehicles	2.1.1.0-7	System Inspection, Field Observations		
8.3.2.4	Have the ability for timing parameters to vary cycle to cycle based on changing traffic conditions.	2.1.1.0-7	System Inspection, Field Observations		
8.3.2.5	Have the ability to monitor traffic volumes and adjust progression based on traffic demands.	2.1.1.0-7	System Inspection, Field Observations		
8.3.2.6	Have the ability to monitor minor approach left turns for queue spillback and automatically increase left turn green time or double service to minimize queue length, constrained by coordination.	2.1.1.0-7	System Inspection, Field Observations		
8.3.2.7	Have the flexibility to be coordinated as one group or have the freedom to operate as separate groups as set by the operators or as dictated by traffic demand	2.1.1.0-7	System Inspection, Field Observations		
8.3.3	**8.3.3 Arterial with several critical intersections**				
8.3.3.1	Have the ability to automatically change goals to provide maximum throughput.	2.1.1.0-7	System Inspection, Field Observations		
8.3.3.2	Have the ability to monitor traffic conditions and select appropriate signal timing parameters, cycle length, green time, offsets, and/or double servicing specific phases where conditions permit.	2.1.1.0-7	System Inspection, Field Observations		
8.3.3.3	Have the ability to determine intersection grouping and establish timing to maximize the movement of vehicles	2.1.1.0-7	System Inspection, Field Observations		
8.3.3.4	Have the ability for timing parameters to vary cycle to cycle based on changing traffic conditions.	2.1.1.0-7	System Inspection, Field Observations		
8.3.3.5	Have the ability to monitor traffic volumes and adjust progression based on traffic demands.	2.1.1.0-7	System Inspection, Field Observations		
8.3.3.6	Have the ability to monitor minor approach left turns for queue spillback and automatically increase left turn green time or double service to minimize queue length, constrained by coordination.	2.1.1.0-7	System Inspection, Field Observations		
8.3.3.7	Have the flexibility to be coordinated as one group or have the freedom to operate as separate groups as set by the operators or as dictated by traffic demand	2.1.1.0-7	System Inspection, Field Observations		
8.4	**8.4 Moderate balanced flows**				
8.4.1.1	Select phase times or offsets that provide smooth flow along the corridor in both directions.	2.1.1.0-7	System Inspection, Field Observations		
8.4.1.2	Provide signal timing that prevents phase failures at all intersections and serves all turning traffic.	2.1.1.0-7	System Inspection, Field Observations		
8.4.1.3	At specified intersections, select phase times that will accommodate frequent use of pedestrian phases.	2.1.1.0-7	System Inspection, Field Observations		
8.4.1.4	At other intersections, select phase times that will accommodate occasional use of pedestrian phases.	2.1.1.0-7	System Inspection, Field Observations		
8.5	**8.5 Non-reoccurring events, incidents and other unexpected events**				
8.5.1.1	If there is heavily direction traffic before or after an event, the system will determine the predominate direction and coordinate accordingly, with appropriate cycle length and offset.	2.6.0-6	System Inspection, Field Observations		
8.5.1.2	If the event is not as heavy as peak hours, but the traffic is still highly directional, then the system will recognize this and provide the coordination predominantly in the heaviest direction, even though the cycle length may be similar to peak hour cycle lengths.	2.6.0-6	System Inspection, Field Observations		
8.5.1.3	The entire corridor may be set by the operator to operate as one or more coordinated groups, or the system may have the freedom to operate it as one of more groups subject to user-specified criteria, such as similar required cycle lengths in different parts of the corridor, of the volume of traffic at key locations exceeds a threshold.	2.6.0-6	System Inspection, Field Observations		
8.5.1.4	If downstream signals experience lighter traffic as a result of an incident blocking and restricting traffic, those signal should be coordinate as a group, with cycle length, splits and offsets that react to the measured traffic.	2.6.0-6	System Inspection, Field Observations		
8.5.1.5	If a detected blockage is in the peak direction, then the system may coordinate in the opposite direction if that traffic is similar to or greater than normal peak direction.	2.6.0-6	System Inspection, Field Observations		
8.5.1.6	The system needs to recognize the presence of an abnormal obstruction, modify the signal operation to react to the change traffic conditions in an efficient manner, and report the abnormal condition to the operator.	2.6.0-6	System Inspection, Field Observations		
8.6.1-1	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.	13.2-1	System Inspection, Field Observations		
8.7.1-1	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.	13.1.0-1	System Inspection, Field Observations		
8.8.1-1	When an intersection responds to preemption, other signals within the coordinate group continue to operate adaptively. The preempted signal returns to adaptive control once the preemption is released.	11.0-1	System Inspection, Field Observations		
8.9.1-1	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. The system will then return to normal operation.	2.6.0-4	System Inspection, Field Observations		
8.11.0-1	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. 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 that has a heavy U-turn volume.	5.0-1.0-16	System Inspection, Field Observations		