Zoo Interchange Reconstruction

Integrated Corridor Management



Adaptive Signal Control Concept of Operations and Requirements Statements FINAL

*Prepared For:*

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*Prepared By:*

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| Concept of Operations Reference Number | Concept of Operations Statements | Requirements (Section 4 Only) |
| 1 | Chapter 1: Scope |  |
| 1.1 | **Document Purpose and Scope** |  |
| 1.1.1 | The scope of this document covers the consideration of adaptive signal control technology (ASCT) planned for the arterial street network adjacent to the I-894 and I-94 interchange located west of the City of Milwaukee. |  |
| 1.1.2 | The ASCT system will be implemented and completely operational in advance of the reconstruction of the core of the I-894/I-94 interchange. |  |
| 1.1.3 | This document describes and provides a rationale for the expected operations of the proposed ASCT system. |  |
| 1.1.4 | It documents the outcome of stakeholder discussions and consensus building undertaken to ensure the ASCT system that is implemented is operationally feasible and has the support of stakeholders. |  |
| 1.1.5 | The intended audience of this document includes: system operators, administrators, decision-makers, elected officials, non-technical readers and other stakeholders who will share the operation of the system or be directly impacted by it. |  |
| 1.2 | **Project Purpose and Scope** |  |
| 1.2.1 | An ASCT system is one in which some or all of the signal timing parameters are modified in response to changes in traffic conditions, in real-time. |  |
| 1.2.2 | The purpose of providing adaptive traffic signal control in this area is to overcome traffic signal and intersection deficiencies/limitations in response to increased, dynamic fluctuations in traffic demand. |  |
| 1.2.3 | This project will add adaptive capabilities to the existing traffic signal system. |  |
| 1.2.4 | All capabilities of the existing traffic signal system will be maintained. |  |
| 1.2.5 | The adaptive capability will be added to select signalized intersections within the project area, with the possibility of expanding the system to include new intersections as needed and as funding becomes available in the future. |  |
| 1.2.6 | The adaptive capability will span multiple jurisdictions with various levels of maintenance responsibilities, including: |  |
| 1.2.6.1 | City of Brookfield |  |
| 1.2.6.2 | City of Milwaukee |  |
| 1.2.6.3 | City of New Berlin |  |
| 1.2.6.4 | City of Wauwatosa |  |
| 1.2.6.5 | City of West Allis |  |
| 1.2.6.6 | Waukesha County |  |
| 1.2.6.7 | Town of Brookfield |  |
| 1.2.6.8 | Village of Elm Grove |  |
| 1.3 | **Procurement** |  |
| 1.3.1 | The ASCT system will be procured using a competitive, best value procurement process based on responses to a request for proposals issued by the WisDOT Bureau of Traffic Operations (BTO). |  |
| 1.3.2 | Award will be issued to multiple vendors which will then be individually selected on an on-call basis for ASCT projects throughout the state. |  |
| 1.3.3 | For the Zoo corridor, the selected system will be the one that provides the best value (i.e., one that meets the operational needs of the corridors at the lowest possible cost), subject to financial and schedule constraints, and requirements documented herein. |  |
| 2 | Chapter 2: Referenced Documents |  |
| 2.1 | The following documents have been used in the preparation of this Concept of Operations. |  |
| 2.1.1 | SEWRPC Regional Transportation System Plan for Southeastern WI: 2035. <http://www.sewrpc.org/SEWRPC/Transportation/2035RegionalTransportationPlan.htm> |  |
| 2.1.2 | The Zoo Interchange FEIS. <http://www.dot.wisconsin.gov/projects/sefreeways/zooenviron.htm#feis> |  |
| 2.1.3 | 2003 SEWRPC regional freeway system plan. <http://www.sewrpc.org/SEWRPCFiles/Publications/pr/pr-047_regional_freeway_system_reconstruction.pdf> |  |
| 2.1.4 | Model Systems Engineering Documents for Adaptive Signal Control Technology (ASCT) Systems. <http://ops.fhwa.dot.gov/publications/fhwahop11027/index.htm> |  |
| 2.1.5 | "Building Quality Intelligent Transportation Systems Through Systems Engineering," Mitretek Systems, April 2002. <http://ntl.bts.gov/lib/jpodocs/repts_te/13620.html> |  |
| 2.1.6 | "Developing Functional Requirements for ITS Projects," Mitretek Systems, April 2002. <http://ntl.bts.gov/lib/jpodocs/repts_te/13621.html> |  |
| 2.1.7 | "Systems Engineering Guidebook for ITS," California Department of Transportation, Division of Research & Innovation, Version 1.1, February 14, 2005. <http://www.fhwa.dot.gov/cadiv/segb/> |  |
| 2.1.8 | Wisconsin Statewide ITS Architecture website. <http://www.topslab.wisc.edu/its/architecture/scope.html> |  |
| 2.1.9 | NCHRP Synthesis 403, Adaptive Traffic Control Systems: Domestic and Foreign State of Practice. <http://www.trb.org/Main/Blurbs/163323.aspx> |  |
| 2.1.10 | Every Day Counts: Validate Traffic Signal Operational Objectives – Draft MOE and Evaluation Approach Plan |  |
| 2.1.11 | Concept of Operations Sample Statements, City of Spokane, North Division Adaptive Control System, Project 2011075. |  |
| 2.1.12 | Systems Engineering Analysis, Adaptive Signal Control, Aptakisic Road – Brandywyn Lane to Parkway Drive, Prepared by Lake County Division of Transportation, October 15, 2012. |  |
| 2.1.13 | Project-Level ITS Architecture & Systems Engineering Analysis - DRAFT |  |
| 2.1.14 | FHWA Rule on ITS Architecture and Standards Conformity. <http://www.ops.fhwa.dot.gov/its_arch_imp/policy.htm> |  |
| 3 | Chapter 3: User-Oriented Operational Description |  |
| 3.1 | **The Existing Situation** |  |
| 3.1.1 | **Network Characteristics** |  |
| 3.1.1.1 | **Freeway and Interchange** |  |
| 3.1.1.1.1 | The Zoo interchange consists of the connection of IH 94 and USH 45/IH 894 in Milwaukee County. |  |
| 3.1.1.1.1.1 | IH 94 is an east-west commuter corridor used for travel between the City of Milwaukee central business district and suburban residential areas. |  |
| 3.1.1.1.1.2 | IH 894 is an “L” shaped bypass around the City of Milwaukee that connects to IH 94 in the Zoo Interchange to the west and the Mitchell interchange to the south. |  |
| 3.1.1.1.1.3 | Regional travelers typically use the IH 894 bypass to travel through Milwaukee County without having to travel into downtown Milwaukee. |  |
| 3.1.1.1.1.4 | Within the project area IH 894 is a north-south corridor and serves a mix of regional travelers, commuters and commercial vehicles. |  |
| 3.1.1.1.2 | The Zoo interchange is the most heavily traveled system interchange in the state of Wisconsin. |  |
| 3.1.1.1.3 | The Zoo Interchange serves over 300,000 motorists every day. |  |
| 3.1.1.1.4 | The interchange serves long-distance travelers, including regional and national freight. |  |
| 3.1.1.1.5 | The Zoo interchange is plagued by the following geometric deficiencies. |  |
| 3.1.1.1.5.1 | Combinations of left- and right-hand system ramps. |  |
| 3.1.1.1.5.2 | Service interchanges that exist within a mile of the core on all four legs of the interchange. This close proximity between the left –hand system ramps and adjacent service interchanges causes traffic to weave between lanes as it approaches and exits the interchange. |  |
| 3.1.1.1.6 | The Zoo interchange has volumes that exceed capacity during many hours of the day which contribute to the traffic operational problems on the freeway. |  |
| 3.1.1.1.6.1 | On a typical day, at least one leg of the interchange is at capacity from about 6am to 6pm. |  |
| 3.1.1.1.7 | About 50% of the daily traffic using the interchange changes their direction of travel, which puts a heavy demand on the system ramps. |  |
| 3.1.1.1.8 | During peak hours, freeway traffic incidents, and planned special events the freeway system becomes severely congested and travelers look for alternate arterial routes. |  |
| 3.1.1.1.9 | Many of the alternate arterial routes also operate below an acceptable level of service (LOS) during the peak periods. Any additional demand will have a significant impact on arterial operations and in some cases may result in traffic backing up onto the freeway exit onto the mainline, or into adjacent intersections. |  |
| 3.1.1.2 | **Arterial** |  |
| 3.1.1.2.1 | A combination of WisDOT and the respective municipal departments of public works operate and maintain the arterials in the project area. |  |
| 3.1.1.2.2 | The project area is shown in the figure below. | |
| 3.1.1.2.3 | WisDOT and the respective local municipalities currently operate one hundred and fifty six (156) traffic signals along the priority arterials, which have been categorized as critical, very important, and important . |  |
| 3.1.1.2.3.1 | Traffic signals represent a mix of available technologies and vary in level of sophistication (i.e., pre-timed, actuated, traffic responsive). |  |
| 3.1.1.2.3.2 | Coordination between traffic signals vary along corridors, and between intersections along corridors. The following coordination schemes are used: |  |
| 3.1.1.2.3.2.1 | Full coordination |  |
| 3.1.1.2.3.2.2 | Time-based coordination |  |
| 3.1.1.2.3.2.3 | Limited time-based coordination |  |
| 3.1.1.2.4 | The arterial network for which ASCT is being considered generally follows a grid type network, with several of the arterials crossing others. |  |
| 3.1.1.2.5 | The arterial network for which ASCT is being considered has several freeway interchanges. |  |
| 3.1.1.2.6 | The arterial network for which ASCT is being considered experience volumes between 1,000 and 4,500 vehicles per hour between the hours of 6 am and 6 pm. The arterial network capacity is between 1,260 and 4,100 vehicles per hour. |  |
| 3.1.1.2.6.1 | Major arterials and several intersections operate at LOS D or worse during both peak hours. |  |
| 3.1.1.2.6.2 | Operations and congestion on arterials worsen due to freeway or arterial incidents and planned special events. |  |
| 3.1.1.2.7 | Based on Southeastern Wisconsin Regional Planning Commission forecasts, traffic volumes around the Zoo interchange should increase an average of 18% by 2035. |  |
| 3.1.1.2.8 | The freeways and major arterials around the Zoo Interchange exhibit high crash rates partly due to congestion, especially during the peak hours. |  |
| 3.1.1.2.9 | The arterial road network is subject to unpredictable fluctuations in traffic demand. This will be especially true during the multi-year reconstruction of the Zoo Interchange. |  |
| 3.1.1.2.10 | The arterial network for which ASCT is being considered generally has regularly spaced intersections. |  |
| 3.1.1.2.10.1 | The spacing between major intersections is generally ½ to 1 miles apart, with 1/8 to ½ mile spacing between minor intersections. |  |
| 3.1.1.2.10.2 | The free-flow travel time between major intersections is approximately 60 to 180 seconds. |  |
| 3.1.2 | **Traffic Characteristics** |  |
| 3.1.2.1 | **Overview** |  |
| 3.1.2.2 | **Freeway** |  |
| 3.1.2.2.1 | As shown in the figures below, the freeway corridors operate poorly in all directions during the morning (AM) and evening (PM) peak hours. |  |
| 3.1.2.2.2 | The majority of the freeway system operates at level of service (LOS) D or worse during the AM peak period (see figure). |  |
| 3.1.2.2.3 | **The majority of the freeway system operates at level of service (LOS) D or worse during the PM peak period (see figure).** |  |
|  | Existing freeway volumes throughout a typical day are shown in the following figure. | |
| 3.1.2.3 | **Arterial** |  |
| 3.1.2.3.1 | The traffic characteristics are highly directional during peak periods. |  |
| 3.1.2.3.2 | Existing local arterial volumes throughout a typical day are shown in the figure below: | |
| 3.1.2.3.3 | Congestion on the Zoo arterial corridors is shown in the figure below (2011) | |
| 3.1.2.4 | **Peak Periods** |  |
| 3.1.2.4.1 | The major local arterials operate poorly during the AM and PM peak hours, with several intersections operating at LOS D or worse during both peaks. |  |
| 3.1.2.4.2 | The freeway and major arterials around the Zoo Interchange exhibit high crash rates partly due to congestion, especially during the peak hours. |  |
| 3.1.2.4.3 | During special events and incidents, building traffic volumes on arterials often result in cycle failures where queues cannot be serviced within 1 cycle. |  |
| 3.1.2.5 | **Business Hours** |  |
| 3.1.2.5.1 | Between the AM and PM peak periods traffic demand remains at elevated levels. |  |
| 3.1.2.5.2 | Between the AM and PM peak periods traffic demand is unpredictable due to local traffic generators. |  |
| 3.1.2.6 | **Evenings** |  |
| 3.1.2.6.1 | During the evenings after the PM peak, arterial traffic demand is generally lighter than the daytime periods but is subject to fluctuations as a result of special events (e.g., Brewers games), seasonal events such as the state fair and holiday shopping activities. |  |
| 3.1.2.6.2 | Generally speaking traffic volumes are balanced along the arterial road network. |  |
| 3.1.2.6.3 | During the reconstruction of the Zoo Interchange, traffic volumes during the evening are expected to fluctuate and will be heavier along select arterials based on on-going construction activity. |  |
| 3.1.2.7 | **Weekends** |  |
| 3.1.2.7.1 | During the weekends, arterial traffic demand is generally lighter than the weekdays, but remains at elevated levels. This is due in part to special event traffic and traffic generators within the project area (e.g., Brewers games). |  |
| 3.1.2.7.2 | During the reconstruction of the Zoo Interchange, traffic volumes during the weekends are expected to be heavy. |  |
| 3.1.2.8 | **Events and Incidents** |  |
| 3.1.2.8.1 | During the reconstruction of the Zoo Interchange, arterials will be subject to heavy directional traffic such as when traffic exits the freeway in search of an alternate arterial route. |  |
| 3.1.2.9 | **Future Traffic Conditions** |  |
| 3.1.2.9.1 | Traffic conditions along the Zoo Corridor Arterials are expected to worsen significantly when construction begins. |  |
| 3.1.2.9.1.1 | Depending on freeway construction activity and staging, all or a percentage of traffic is expected to divert from the freeway onto the local arterial network. |  |
| 3.1.2.9.1.2 | Depending on freeway construction activity and staging, all or a percentage of arterial traffic that normally uses the freeway may seek to instead stay within the local arterial network. |  |
| 3.1.2.9.2 | Traffic conditions are expected to remain poor throughout the 3 year duration of construction. |  |
| 3.1.2.9.3 | Traffic conditions are expected to deteriorate as traffic volumes continue to grow. 15% growth in traffic volumes is anticipated on local street network by 2035. |  |
| 3.1.3 | **Signal Grouping** |  |
| 3.1.3.1 | All signals are relatively close and are expected to be operated and coordinated as a group of signal groupings. |  |
| 3.1.3.1.1 | Traffic signals will be grouped by corridor. |  |
| 3.1.3.1.2 | Traffic signals will be grouped by diversion route. |  |
| 3.1.4 | **Land Use** |  |
| 3.1.4.1 | The Zoo Corridors arterials serve a mixture of land uses, including residential, office, industrial commercial, retail, and medical. |  |
| 3.1.4.2 | The Zoo Corridors arterials services the following notable regional traffic generators: |  |
| 3.1.4.2.1 | Milwaukee Regional Medical Center (of critical importance) |  |
| 3.1.4.2.2 | Milwaukee County Research Park |  |
| 3.1.4.2.3 | Milwaukee County Grounds (future UWM expansion) |  |
| 3.1.4.2.4 | Mayfair Mall |  |
| 3.1.4.2.5 | Milwaukee County Zoo |  |
| 3.1.4.2.6 | Burleigh Triangle Redevelopment |  |
| 3.1.4.2.7 | State Fair Park |  |
| 3.1.4.2.8 | Miller Park |  |
| 3.1.4.2.9 | Brookfield Square Shopping Center |  |
| 3.1.4.3 | The following zoo corridors serve as a parallel route to a freeway: |  |
| 3.1.4.3.1 | Bluemound Road |  |
| 3.1.4.3.2 | Greenfield Avenue |  |
| 3.1.4.3.3 | Highway 100 |  |
| 3.1.4.3.4 | 84th Street /Glenview Avenue |  |
| 3.1.4.4 | The following zoo corridors provide access to a freeway interchange: |  |
| 3.1.4.4.1 | Barker Road |  |
| 3.1.4.4.2 | Moorland Road |  |
| 3.1.4.4.3 | Watertown Plank Road |  |
| 3.1.4.4.4 | Capitol Drive |  |
| 3.1.4.4.5 | North Avenue |  |
| 3.1.4.4.6 | Bluemound Road |  |
| 3.1.4.4.7 | 84th Street/Glenview Avenue |  |
| 3.1.4.4.8 | Highway 100 |  |
| 3.1.4.4.9 | Greenfield Avenue |  |
| 3.1.4.5 | **Pedestrians** |  |
| 3.1.4.5.1 | Pedestrian delays are a factor in choosing phasing and timing parameters. |  |
| 3.1.4.5.2 | Pedestrian movements are present at most cycles at intersections near the Mall and at those adjacent to special event venues immediately before, during and after events. |  |
| 3.1.5 | **Operating Agencies** |  |
| 3.1.5.1 | The existing traffic signal system is operated by the following agencies. |  |
| 3.1.5.1.1 | Wisconsin Department of Transportation |  |
| 3.1.5.1.2 | City of Milwaukee |  |
| 3.1.5.1.3 | City of West Allis |  |
| 3.1.5.1.4 | City of Wauwatosa |  |
| 3.1.5.1.5 | City of Brookfield |  |
| 3.1.5.1.6 | Village of Elm Grove |  |
| 3.1.5.1.7 | Waukesha County |  |
| 3.1.6 | **Existing Architecture (Provided as Separate Document)** |  |
| 3.2 | **Limitations of the Existing System** |  |
| 3.2.1 | The following statements summarize the limitations of the existing system that prevent it from satisfactorily accommodating the traffic situations previously described. |  |
| 3.2.1.1 | The existing traffic signals along the Zoo Interchange corridors vary in level of sophistication ranging from pre-timed signals to fully actuated signals. |  |
| 3.2.1.2 | Many intersections lack detection at and upstream of the intersection. |  |
| 3.2.1.3 | The existing system cannot adequately clear queues that result from anticipated changing traffic patterns and higher volumes (i.e., cycle failure). |  |
| 3.2.1.4 | The existing signal system is inefficient in the manner in which it provides green time to movements. |  |
| 3.2.1.5 | The existing system cannot detect unexpected changes in traffic demand as a result of incidents on the adjacent freeway. As a result, the congestion/delay 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. |  |
| 3.2.1.6 | The existing system cannot detect changes in traffic conditions that result from special events. An adaptive system is expected to reduce this inefficiency and match signal timing more closely to the actual traffic patterns. |  |
| 3.2.1.7 | The existing system uses a variety of traffic signal controllers which may limit the compatibility to available ASTC systems, without the additional costs to upgrade/replace controllers. Controllers in use include: |  |
| 3.2.1.7.1 | TCT LC8000 |  |
| 3.2.1.7.2 | EPIC |  |
| 3.2.1.7.3 | EF 140 |  |
| 3.2.1.7.4 | EPAC |  |
| 3.2.1.7.5 | 170 and 170 w/ Wapiti Firmware |  |
| 3.2.1.7.6 | EPIC 140 |  |
| 3.2.1.8 | Many of the agencies that own and maintain traffic signals do not have on-going signal re-timing programs due to limited resources. |  |
| 3.2.1.9 | Many of the agencies that own and maintain traffic signals do not have traffic signal timing plans specifically designed to accommodate large volumes of traffic exiting the freeway at specific points along the arterial road network nor do they possess the resources needed to perform such activities. |  |
| 3.3 | **Proposed Improvements to the System** |  |
| 3.3.1 | 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: |  |
| 3.3.1.1 | Recognize changes in traffic conditions and react quickly and automatically to accommodate those changes. |  |
| 3.3.1.2 | Overcome the institutional boundaries that currently prevent the signals under the control of the different jurisdictions from operating in a coordinated fashion. |  |
| 3.3.1.3 | In the presence of higher volumes, more efficiently accommodate emergency vehicles to speed incident and emergency response. |  |
| 3.3.1.4 | Manage queues within the network by preventing queues from spilling back into adjacent intersections and facilities. |  |
| 3.3.1.5 | Recognize the existence of differing traffic conditions in various parts of the network and set in place signal timing plans that appropriately respond to them. |  |
| 3.3.1.6 | Quickly recover from traffic signal preemption. |  |
| 3.3.1.7 | Keep traffic signal timing current rather than letting its efficiency deteriorate between periodic signal re-timing efforts. |  |
| 3.4 | **Vision, Goals and Objectives for the Proposed System** |  |
| 3.4.1 | Vision |  |
| 3.4.1.1 | The vision of the ASCT system is to provide an advanced traffic signal system that will continuously adjust traffic signal parameters (i.e., green time, coordination settings) based on changing conditions in real-time in an overall effort to mitigate the impacts (e.g., congestion, delay, incidents) associated with greater volumes of traffic expected to use the arterial network throughout freeway construction activity. |  |
| 3.4.2 | Goals: |  |
| 3.4.2.1 | Support vehicle and pedestrian mobility along arterials under normal/construction activity. |  |
| 3.4.2.2 | Support vehicle and pedestrian mobility along arterials during incidents, special events, and other non-recurring event. |  |
| 3.4.2.3 | Support the freeway system when operations are adversely impacted. |  |
| 3.4.2.4 | Support freeway construction. |  |
| 3.4.2.5 | Support regional planning efforts. |  |
| 3.4.2.6 | Support the Zoo interchange reconstruction schedule. |  |
| 3.4.2.7 | Support interoperability between agencies. |  |
| 3.4.3 | User Objectives: |  |
| 3.4.3.1 | To improve safety by reducing number of vehicle stops along coordinated routes |  |
| 3.4.3.2 | To proactively support vehicle mobility during freeway construction at all times: |  |
| 3.4.3.2.1 | Adjust operations to changing traffic conditions on a continuous, real-time basis |  |
| 3.4.3.2.2 | Reduce delays |  |
| 3.4.3.2.3 | Reduce travel times |  |
| 3.4.3.2.4 | Minimize adverse effects caused by preemption and unexpected events |  |
| 3.4.3.3 | To integrate arterial operations with the freeway system |  |
| 3.4.3.4 | To support freeway construction stage changes |  |
| 3.4.3.5 | To support regional planning efforts: |  |
| 3.4.3.5.1 | Be compliant with the Statewide ITS Architecture |  |
| 3.4.3.6 | To support a timely schedule implementation: |  |
| 3.4.3.6.1 | Be sufficiently mature and robust so that risk can be minimized and little or no development time will be required. |  |
| 3.4.3.6.2 | Be ready for full operation by the start of freeway core construction (estimated January 1, 2015). |  |
| 3.4.4 | Operational Objectives: |  |
| 3.4.4.1 | Provide smooth traffic flow along arterials. |  |
| 3.4.4.2 | Effectively manage traffic along priority corridors in real-time, in response to a variety of situations and events. |  |
| 3.4.4.3 | Maximize the throughput of traffic along designated arterial routes. |  |
| 3.4.4.4 | Manage queues at signalized intersections, to prevent excessive queuing and spillover into adjacent intersections, driveways, and freeway exit ramps. |  |
| 3.4.4.4.1 | At arterial/freeway intersections, queues should be flushed to prevent queues from entering onto the freeway mainline. |  |
| 3.4.4.5 | Respond to, and recover from, emergency vehicle priority requests in the corridor with a minimum reduction in corridor performance. |  |
| 3.4.4.6 | Reduce the number of stops and delay on arterials. |  |
| 3.4.4.7 | Effectively use available arterial capacity to better serve increases in demand. |  |
| 3.4.4.8 | Provide effective traffic progression on detour routes or to and from large traffic generators including cross streets. |  |
| 3.4.4.9 | Minimize side street delay while maintaining progression on the mainline routes |  |
| 3.4.4.10 | Provide the ability to adjust the coordinated routes in a real-time basis. |  |
| 3.4.4.11 | Provide real-time operational performance measures of the system. |  |
| 3.5 | **Strategies to be Applied by the Improved System** |  |
| 3.5.1 | Provide a pipeline along coordinated alternate arterial routes to maximize throughput and reduce stops. |  |
| 3.5.2 | Manage queues so they do not exceed the available storage capacity and are located so they do not affect the capacity of other movements. |  |
| 3.6 | **Alternative Non-Adaptive Strategies Considered** |  |
| 3.6.1 | The following non-adaptive strategies were considered: |  |
| 3.6.1.1 | Free operation |  |
| 3.6.1.2 | Pre-timed coordinated |  |
| 3.6.1.3 | Semi-actuated coordinated |  |
| 3.6.1.4 | Fully-actuated coordinated |  |
| 3.6.1.5 | Traffic Responsive |  |
| 3.6.2 | Note that some or all of these operations may be used at individual intersections or groups of intersections depending on the needs of the system at the time. Flexibility to revert to non-adaptive during certain circumstances is important. |  |
| 4 | Chapter 4: Operational Needs |  |
| 4.0 | This chapter describes the operational needs of the user that should be satisfied by the proposed ASCT system. Each of these statements describes something that the system operator (i.e., operating agency and its associated users) needs to be able to achieve. Each of these needs will be satisfied by compliance with one or more system requirements. In the attached list of requirements, each one is linked to one or more of these needs statements. |  |
| 4.1 | **Adaptive Strategies** |  |
| 4.1.1 | The system operator needs the ability to implement different strategies individually or in combination to suit prevailing traffic conditions. These strategies include: |  |
| 4.1.1.1 | Maximize the throughput on coordinated routes. | * The ASCT shall calculate the appropriate state of the signal at the critical signal controller. (A critical signal controller is defined by the user). * At non-critical intersections within a group, the system shall calculate the time at which a user-specified phase shall be green, relative to a reference point at the critical intersection. * When demand is present, the ASCT system shall implement a user-specified maximum time between successive displays of each phase at each intersection. |
| 4.1.1.2 | Provide smooth flow along key arterial routes. | * The ASCT shall determine the order of phases at a user-specified intersection. |
| 4.1.1.3 | Manage the length of queues. | * When queues are detected at user-specified locations, the ASCT shall execute user-specified timing plan/operational mode. * The ASCT shall detect the presence of queues at pre-configured locations. * When queues are detected at user-specified locations, the ASCT shall omit a user-specified phase at a user-specified signal controller. |
| 4.1.2 | The system operator needs to change the operational strategy based on changing traffic conditions. | * 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. * 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. * 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. |
| 4.1.3 | The system operator needs to detect repeated phase failures and control signal timing to prevent phase failures building up queues. The operator in this case is trying to prevent a routine queue from forming where it will block another movement in the cycle unnecessarily. | * The ASCT shall detect repeated phases that do not serve all waiting vehicles. (These phase failures may be inferred, such as detecting repeated max-out). * The ASCT shall alter operations, to minimize repeated phase failures. |
| 4.1.4 | The system operator needs to modify the sequence of phases to support the various operational strategies. | * Each permissible phase sequence shall be executable based on measured traffic conditions. |
| 4.2 | **Network Characteristics** |  |
| 4.2.1 | The system operator may need to eventually adaptively control 175 signals, up to 10 miles in all directions from the Zoo interchange. | * The ASCT shall be capable of controlling a minimum of 175 signals concurrently. |
| 4.2.2 | For the Zoo Corridor project the system operator desires to control the adaptive signals within the project limits as groups to provide the best coordination along selected corridors; however, the system operator may eventually seek to adaptively control traffic signals outside, but adjacent to signals within the project limits and these signals should constitute additional groups of signals with which the entire group of signals must interact. | * The ASCT shall support groups of signals. * The size of a group of signals shall range from 1 to 30. * The ASCT shall be capable of controlling groups of signals organized by corridor. * The ASCT shall be capable of managing all groups of signals at the same time within a single interface. * The boundaries surrounding signal controllers that operate in a coordinated fashion shall be capable of being altered by the user. |
| 4.3 | **Coordination Across Boundaries** |  |
| 4.3.1 | The system operator needs to adaptively control signals owned by multiple agencies. | * The ASCT system shall be capable of integrating all types of traffic signal systems and should do so regardless of their make, model, or age. |
| 4.3.2 | The system operator needs to adaptively coordinate signals on two crossing routes simultaneously. | * The ASCT system shall support coordination on crossing routes, although it is recognized that there may be some limitations imposed by coordinating two crossing routes. |
| 4.3.3 | The system operator needs to receive data from another system (i.e., signal pre-emption system) that will allow the ASCT system to coordinate its operation with the adjacent system. | * The ASCT shall be able to receive data from the traffic signal pre-emption systems and shall alter its operation when the signal is pre-empted. |
| 4.3.4 | The system operator needs to detect traffic approaching from a neighboring system and coordinate the ASCT operation with the adjacent system. | * The ASCT shall alter its operation to minimize interruption of traffic entering the system. |
| 4.4 | **Security** |  |
| 4.4.1 | 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 agency’s access and network infrastructure security policies. | * The system shall provide and maintain a security system to prevent unauthorized access to the system. * The system shall provide secure access for all approved users. * Each user shall have a unique, user-definable login name and password to gain access to the system. * The system shall allow users to modify their own passwords. * The system shall provide various tiers of security similar to the following: No access, view only, and full access. * The level of security for each user shall be assignable by the system administrator. * The system shall permit the system administrator to have full access to the system as well as the responsibility for establishing, maintaining, and resetting account passwords and security tiers for each user. * The system shall permit the system administrator to modify user account passwords. * The system shall allow the system administrator to set the life span of user passwords. * The system shall log each access (log in and log out) to the system by each user by time of day and day of week. * The system shall log unsuccessful login attempts. |
| 4.4.2 | The system operator needs the ASCT system to be compatible with the agency’s security policies. | * The ASCT shall comply with the agency’s security policy as described by WisDOT Enterprise IT Support. |
| 4.5 | **Queuing Interactions** |  |
| 4.5.1 | The system operator needs to detect queues within the intersection and modify the ASCT operation to accommodate the queuing. | * The ASCT shall detect the presence of queues at pre-configured locations. * When queues are detected at user-specified locations, the ASCT shall execute strategies that reduce queue lengths. * When queues are detected at user-specified locations, the ASCT shall execute user specified timing plan/operational mode. |
| 4.5.2 | The system operator needs to prevent queues from forming at user-specified/pre-configured locations. | * The ASCT shall detect the presence of queues at pre-configured locations. * When queues are detected at user-specified locations, the ASCT shall execute strategies that reduce queue lengths. * When queues are detected at user-specified locations, the ASCT shall execute user specified timing plan/operational mode. |
| 4.5.3 | The system operator needs to limit intersection queue delay. | * The ASCT shall detect the presence of queues at pre-configured locations. * When queues are detected at user-specified locations, the ASCT shall execute strategies that reduce queue lengths. * When queues are detected at user-specified locations, the ASCT shall execute user specified timing plan/operational mode. |
| 4.6 | **Pedestrians** |  |
| 4.6.1 | The system operator needs to accommodate infrequent pedestrian operation while maintaining adaptive operation. | * When a pedestrian phase is called, the system shall accommodate pedestrian crossing during adaptive operation. |
| 4.6.2 | The system operator needs to incorporate frequent pedestrian operation into non-routine adaptive operation (for example, during special or seasonal events for large groups of pedestrians when to and from these events). | * When a pedestrian phase is called, the ASCT shall accommodate pedestrian crossing times during adaptive operations. * When specified by the user, the AST shall execute pedestrian recall on pedestrian phase adjacent to coordinated phase. * When the pedestrian phases are on recall, the ASCT shall accommodate pedestrian timing during adaptive operation. |
| 4.7 | **Non-adaptive Situations** |  |
| 4.7.1 | The system operator needs to detect traffic conditions during which adaptive control is not the preferred operation, and implement some pre-defined operation while that condition is present. | * The ASCT shall operate non-adaptively during the presence of a defined condition. |
| 4.7.2 | The system operator needs the ability to manually over-ride adaptive operation. | * The system shall operate non-adaptively when a user manually commands the system to cease adaptive operation. |
| 4.7.3 | The system operator needs to operate non-adaptively when the number of failed detectors exceeds a user defined threshold. | * The ASCT shall operate non-adaptively when the number of failed detectors connected to a signal controller exceeds a user-defined value. |
| 4.7.4 | The system operator needs to schedule pre-determined operation by time of day. | * The ASCT shall operate non-adaptively in accordance with a user-defined time-of-day schedule. |
| 4.7.5 | When in non-adaptive mode, the system operator needs to use collected data to operate the traffic signal system. | * The ASCT shall operate on the data collected by the ASCT for a period of time immediately preceding the initiation of non-adaptive control. |
| 4.8 | **System Responsiveness** |  |
| 4.8.1 | The system operator needs to modify adaptive operation to address changes in traffic conditions using collected data. | * The ASCT shall limit the change in consecutive cycle lengths to be less than a user-specified value. * The ASCT shall limit the change in phase times between consecutive cycles to be less than a user-specified value. |
| 4.8.2 | The system operator needs to respond in real-time to sudden large shifts in traffic volumes or conditions. | * When a large change in traffic demand is detected, the system shall respond more quickly than normal operation, subject to user-specified limits. |
| 4.8.3 | The system operator needs to be able respond to changes in travel patterns due to incidents, special events, and increases/decreases in traffic volumes. | * The ASCT system shall have the ability to change the priority of movements. |
| 4.9 | **Complex Coordination and Controller Features** |  |
| 4.9.1 | The system operator needs to implement the following advanced controller features while maintaining adaptive operation: |  |
| 4.9.1.1 | Service a phase more than once per cycle. | * The ASCT shall have the ability to serve a vehicle phase more than once for each time the coordinated phase is served. |
| 4.9.1.2 | Change the sequence of operations to the most efficient operation based on real-time data. | * Choose an appropriate phase pair based on real-time data. * Service a phase more than once per cycle * Skip a phase |
| 4.9.1.3 | Adjust the allocated green time to the most efficient operation based on real-time data. | * The ASCT shall effectively allocate green time based on measured traffic conditions, in real-time. |
| 4.9.1.4 | Permit different phase sequences under different traffic conditions. | * The ASCT shall dynamically choose the best phase to serve based on measured traffic conditions, in real-time. |
| 4.9.1.5 | Allow one or more phases to be omitted (disabled) under certain traffic conditions or signal states. | * The ASCT shall omit a user-specified phase based on measured traffic conditions. |
| 4.9.1.6 | Protected/permissive phasing and alternate left turn sequences | * The ASCT shall allow protected/permissive left turn phase operation. * The ASCT shall allow the protected left turn phase to lead or lag the opposing through phase based upon user-specified conditions. |
| 4.10 | **Monitoring and Control** |  |
| 4.10.1 | The system operator needs to monitor and control the adaptive system from a remote location including but not limited to: | * The system shall continuously monitor feedback from the field for proper operation. * The system shall display the status of all controllers, detectors (all types) and all other equipment associated with the adaptive operation. * The system shall monitor intersection controllers on a second-by-second basis or at the most frequent rate possible, whichever is fastest. * The system shall monitor detectors for failures, and when failures are detected an alert shall be issued and the event logged. * The system shall be capable of storing vehicle count data in 5 minute increments for up to 500 local detectors continuously for a minimum of 30 days before overwriting the oldest data first. |
| 4.10.1.1 | Statewide Traffic Operations Center | * The system shall allow an operator to configure, monitor and control the system from the Wisconsin Statewide Traffic Operations Center. |
| 4.10.1.2 | Remote workstations (i.e., laptop from the field, or web access) | * The system shall allow an operator to configure, monitor and control the system from a fixed remote workstation (e.g., computer located at another agency or personal computer located at a personal residence). * The system shall allow an operator to configure, monitor, and control the system from a mobile device including laptop, smart phone, tablet, or similar wireless enabled device. |
| 4.10.1.3 | Local controller cabinets | * The system shall allow an operator to configure, monitor, and control the system from the local controller cabinet. |
| 4.10.2 | The system operator needs to be able to configure, monitor and control the ASCT system using a web-based application. | * The system shall allow an operator to monitor and control the system using a standard web browser (e.g., Microsoft Internet Explorer, Firefox, or Chrome). * The system shall not require the purchase of additional third party software to configure, monitor, and control the ASCT system. |
| 4.10.3 | The operator needs access to the database management, monitoring, and reporting features and functions of the signal controllers and any related signal management system from access points defined for those components. |  |
| 4.11 | **Performance Reporting** |  |
| 4.11.1 | The system operator needs to store and report data used to calculate signal timing and have the data available for subsequent analysis. | * The ASCT shall report measures of current traffic conditions on which it bases signal state alterations. * The ASCT shall have the ability to store results of all signal timing parameter calculations. * The ASCT shall have the ability to store the following measured data in the form used as input to the adaptive algorithm for a minimum of 3 continuous months Volume, Occupancy, Queue length, Phase utilization, arrivals on green, and green band efficiency. * The ASCT shall store the following data in 15 minute increments; volume, delay, occupancy, queue length, and percent arrivals on green. |
| 4.11.2 | The system operator needs to store and report data that can be used to measure traffic performance under adaptive control. | * The ASCT shall have the ability to store results of all signal timing parameter calculations. * The ASCT shall have the ability to store the following measured data in the form used as input to the adaptive algorithm for a minimum of 3 continuous months: volume, occupancy, queue length, phase utilization, arrivals on green, and green band efficiency. * The ASCT shall store the following data in 15 minute increments; volume, delay, occupancy, queue length, and percent arrivals on green. |
| 4.11.3 | The system operator needs to store all operational data and signal timing parameters calculated by the adaptive system, and export selected data to external systems. | * The ASCT shall export its system log in a usable format. * The ASCT shall archive all data automatically after a user-specified period. |
| 4.11.4 | Have the ability to generate reports that effectively support operation, maintenance and reporting of system performance and traffic conditions. | * The system shall include a tool capable of generating automated and manual reports. * The system shall support recurring, automated report runs at user-scheduled intervals. * The system shall be capable of generating reports using any combination of collected data within user-defined criteria. * The system shall run reports and then display the results on screen or printed, at the user’s option. * The system shall be able to save the search parameters users to run reports. |
| 4.12 | **Failure Notification** |  |
| 4.12.1 | The system operator needs to immediately notify user defined recipients of alarms and alerts. | * The system shall quickly and automatically alert operators of alarms and system failures. * The system shall display all alarm notifications on the operator’s workstation. * The system shall present alarm messages via a designated method to designated operators upon detection of an event. * The system shall have the capability to automatically send after hour notifications. |
| 4.12.2 | The system operator needs to immediately and automatically pass alarms and alerts to selected individuals and agencies. | * The system shall have the capability to automatically send alphanumeric (i.e., text and SMS) messages to e-mail accounts, mobile phones, smart devices upon detecting problems with or within the system. |
| 4.13 | **Pre-emption and Priority** |  |
| 4.13.1 | The system operator needs to accommodate emergency vehicle preemption. | * The system shall monitor all forms of traffic signal pre-emption and priority that will occur at the signalized intersection through the local traffic signal controller. * The system shall not delay signal pre-emption calls. |
| 4.13.2 | The system operator needs to resume adaptive control of signal controllers immediately following the release of signal preemption. | * The ASCT shall resume adaptive control of signal controllers immediately when pre-emptions are released. |
| 4.14 | **System Failure and Fallback Modes** |  |
| 4.14.1 | The system operator needs to fall back to TOD or isolated free operation, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications and software failure. | * The ASCT system shall revert to TOD or isolated free operation upon equipment, communications, and/or software failure. |
| 4.14.2 | The system operator needs to use collected data in the event the system is working but does not have enough real-time data to make effective decisions. | * The ASCT system shall use historical data in the event real-time data is not available to serve as input into the decision making process. |
| 4.15 | **Constraints** |  |
| 4.15.1 | The system operator is constrained to use the following type of equipment: |  |
| 4.15.1.1 | Controller type | * The ASCT system shall be compatible with any modern controller type including but not limited to the following existing types; NEMA TS1 and TS2, Type 170 and 2070 controllers used by WisDOT and partner agencies. |
| 4.15.1.2 | Detector type | * The ASCT shall be compatible with any detection technology that can be input into the controller (e.g., in-pavement loops, video detection, microwave detection, Sensys detection). |
| 4.15.1.3 | Communications system | * The ASCT system shall work with the existing communications system. Existing communications include: Fiber, radio, and wireless. |
| 4.15.1.4 | Cabinet type and size | * The ASCT system shall be able to fit within all existing cabinets including but not limited to the following existing types: TS-1, 303/330. |
| 4.16 | **Training and Support** |  |
| 4.16.1 | The system operator requires formal classroom training for staff involved in the operation and maintenance of the system to receive appropriate training. | * The ASCT system vendor shall provide on-site training to staff designated by the system operator. * Training shall be provided by experienced instructors. * The ASCT system vendor shall provide training on the operation of the adaptive system. * The ASCT system vendor shall provide training on troubleshooting the system. * The ASCT system vendor shall provide training on preventive maintenance and repair of all vendor provided equipment. * The ASCT system vendor shall provide training on system configuration. * The ASCT system vendor shall provide training on system calibration. * The ASCT system vendor shall provide printed course materials, references, and presentations (in electronic and hardcopy), at least one week prior to delivery of related training. These materials will be retained by the system operator. |
| 4.16.2 | The system operator requires documentation for all components of the system. | * The ASCT system vendor shall provide user manuals (in electronic and bound hardcopy) for all purchased and supplied equipment and components. |
| 4.17 | **External/Internal Interfaces** |  |
| 4.17.1 | The system operator requires that the ASCT support interfaces to the following systems: |  |
| 4.17.1.1 | Conflict monitor unit | * The ASCT system shall be capable of interfacing with a conflict monitor unit. * The ASCT system shall not affect the operation of the conflict monitor. |
| 4.17.1.2 | Vehicle detection | * The ASCT shall be compatible with the following technologies: In-pavement loops, video detection, microwave detection, Sensys detection. |
| 4.17.1.3 | Malfunction management unit | * The ASCT system shall support an interface with a malfunction management unit. |
| 4.17.1.4 | Emergency vehicle preemption | * The ASCT system shall be capable of modifying operations based on received pre-emption calls. * The ASCT system shall resume adaptive control automatically when the pre-emption call ends. |
| 4.17.1.5 | Pedestrian push buttons | * The ASCT system shall support an interface with pedestrian push buttons. |
| 4.18 | **Maintenance, Support and Warranty** |  |
| 4.18.1 | The system operator needs the system to fulfill all requirements for the life of the system. The system operator therefore needs the system to be maintained to repair faults that are not defects in materials and workmanship. | * The ASCT system vendor shall provide maintenance according to a separate maintenance contract. That contract shall identify repairs necessary to preserve requirements fulfillment, responsiveness in making these repairs, and all requirements on the vendor while performing repairs. |
| 4.18.2 | The system operator needs the system to fulfill all requirements for the life of the system. The system operator therefore needs the system to remain free of defects in materials and workmanship that result in requirements no longer being fulfilled. | * The ASCT vendor shall warranty the system to be free of defects in materials and workmanship for a period of 3 years, upon system acceptance. * The ASCT vendor shall offer add-on warranty coverage in multiple one (1) year increments to extend the period of warranty coverage. |
| 4.18.3 | The system operator needs the system to fulfill all requirements for the life of the system. The system operator therefore needs support to keep software and software environment updated as necessary to prevent requirements no longer being fulfilled. | * The ASCT vendor shall provide routine updates to the software and software environment necessary to preserve the fulfillment of requirements for a period of 5 years. The vendor shall note any costs above that of the base product cost to fulfill this requirement. * The ASCT vendor shall provide a help desk (or appropriate staff contract) that the system operator can call during the warranty period to get system support. * The ASCT vendor’s help desk shall be available 24 hours a day, 7 days a week, 365 days a year to the system operator during the warranty period. |
| 5 | Chapter 5: Envisioned Adaptive System Overview |  |
| 5.1 | **Size and Grouping** |  |
| 5.1.1 | The system operator has plans to adaptively control a minimum of 60 and maximum of 100 intersections. To plan for growth, the system operator may need to eventually adaptively control up to 175 intersections in the future. |  |
| 5.1.2 | The system operator will control intersections as unique groups of intersections arranged by corridors. |  |
| 5.2 | **Operational Objectives** |  |
| 5.2.1 | The objective of the coordination will be to maximize the throughput along alternate arterial routes. 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. |  |
| 5.2.2 | 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 intersection or otherwise reduce the capacity available during green phases. |  |
| 5.3 | **Fallback Operation** |  |
| 5.3.1 | The system will have a fallback state that allows individual intersections to operate in a vehicle-actuated, isolated mode in the event of failures of the adaptive processor software or hardware, detectors or communication. |  |
| 5.3.2 | The system will have a fallback state that allows coordination using historical parameters in the event of a loss of real-time data. |  |
| 5.4 | **Operator Access** |  |
| 5.4.1 | Operators, traffic engineering and maintenance staff will be assigned different level 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. |  |
| 5.4.2 | The system will allow access by authorized users outside the operating agency (i.e., view only and no control). |  |
| 6 | Chapter 6: Adaptive Operational Environment |  |
| 6.1 | The system will be operated and monitored from either the Wisconsin Department of Transportation’s SE Region Headquarters office located in the City of Waukesha, WI or WisDOT’s STOC building in Milwaukee, WI. Current thinking is that operations will be from the SE Region Headquarters office; however, DOT may decide to operate the system from their STOC. |  |
| 6.2 | The system operator will be able to have full access to the system from each local controller. |  |
| 6.3 | The system operator will be able to have full access to the system by remote desktop. |  |
| 6.4 | The system operator will have full access to the system by a secure, web-based application/interface. |  |
| 6.5 | The central server equipment (if needed) will be housed at the STOC. |  |
| 6.6 | The agency selection of controller will not be constrained by the adaptive software. |  |
| 6.7 | The ASTC system will work with all types of controllers including those that are not NTCIP compliant. |  |
| 6.8 | The operators will already be experienced in setting up and fine tuning traditional coordinated traffic signal systems. They will require additional training specific to the ASCT system, sufficient to allow them to set up, adjust and fine tune all aspects of the system. |  |
| 6.9 | Replacement or repair of defective or failed equipment will be covered for five (5) years by the manufactures’ equipment warranties. The labor cost of replacement during this period will be included in the purchase price. |  |
| 6.10 | The system operator requires maintenance of parts and equipment for a period of five (5) years. |  |
| 6.11 | The system operator requires maintenance of all adaptive system software for a period of five (5) years. |  |
| 6.12 | The system operator requires technical support from the vendor for assistance in using the adaptive software for five (5) years. |  |
| 6.13 | Operations and maintenance staff will have the ability to log into the system from remote locations via internet, and have full functionality consistent with their access level. |  |
| 7 | Chapter 7: Adaptive Support Environment |  |
| 7.1 | **Stakeholders who will be affected by or have a direct interest in the adaptive system are:** |  |
| 7.1.1 | Sponsoring agency: |  |
| 7.1.1.1 | Wisconsin Department of Transportation |  |
| 7.1.2 | Neighboring agencies that operate signals: |  |
| 7.1.2.1 | Milwaukee County Department of Transportation |  |
| 7.1.2.2 | Waukesha County Department of Public Works |  |
| 7.1.2.3 | City of Milwaukee Department of Public Works |  |
| 7.1.2.4 | City of Wauwatosa Department of Public Works |  |
| 7.1.2.5 | City of West Allis Department of Public Works |  |
| 7.1.2.6 | City of Brookfield Department of Public Works |  |
| 7.1.2.7 | City of New Berlin Department of Public Works |  |
| 7.1.2.8 | Town of Brookfield Department of Public Works |  |
| 7.1.2.9 | Village of Elm Grove Department of Public Works |  |
| 7.1.2.10 | Village of West Milwaukee Department of Public Works |  |
| 7.1.3 | Fire Departments: |  |
| 7.1.3.1 | City of Milwaukee Fire |  |
| 7.1.3.2 | City of West Allis Fire |  |
| 7.1.3.3 | City of Wauwatosa Fire |  |
| 7.1.3.4 | City of Brookfield Fire |  |
| 7.1.3.5 | Town of Brookfield Fire |  |
| 7.1.3.6 | City of New Berlin Fire |  |
| 7.1.4 | Law Enforcement Agencies: |  |
| 7.1.4.1 | Wisconsin State Patrol |  |
| 7.1.4.2 | Capitol Police (law enforcement for State Fair) |  |
| 7.1.4.3 | Milwaukee County Sheriff’s Office |  |
| 7.1.4.4 | Waukesha County Sheriff’s Office |  |
| 7.1.4.5 | City of Milwaukee Police |  |
| 7.1.4.6 | City of West Allis Police |  |
| 7.1.4.7 | City of Wauwatosa Police |  |
| 7.1.4.8 | City of Brookfield Police |  |
| 7.1.4.9 | Town of Brookfield Police |  |
| 7.1.4.10 | Village of West Milwaukee Police |  |
| 7.1.4.11 | Village of Elm Grove Police |  |
| 7.1.4.12 | City of New Berlin Police |  |
| 7.1.5 | Transit Agencies: |  |
| 7.1.5.1 | Milwaukee County Transit System |  |
| 7.1.5.2 | Waukesha County Transit |  |
| 7.1.6 | Railroad operators (freight only): |  |
| 7.1.6.1 | Union Pacific Railroad |  |
| 7.1.6.2 | Canadian Pacific Railroad |  |
| 7.1.6.3 | Wisconsin and Southern Railroad |  |
| 7.1.7 | Other Agencies: |  |
| 7.1.7.1 | WisDOT Bureau of Transportation Operations (BTO) Statewide Traffic Operations Center (STOC) |  |
| 7.1.7.2 | Milwaukee County Highway Maintenance Division  Milwaukee County Sheriff Station |  |
| 7.1.8 | Federal: |  |
| 7.1.8.1 | Federal Highway Administration |  |
| 7.2 | **Facilities** |  |
| 7.2.1 | Control of the ASCT will be from either the WisDOT SE Headquarters office in Waukesha or WisDOT’s STOC facility located in Milwaukee. |  |
| 7.3 | **Utilities** |  |
| 7.3.1 | Fiber optic cable either currently exists or will be installed to accommodate the installation of ASCT. |  |
| 7.3.2 | Other available communications include: Radio and wireless. |  |
| 7.4 | **Equipment** |  |
| 7.4.1 | Outside of equipment to be provided as part of the ASCT system delivery, no other computer hardware is needed. |  |
| 7.4.2 | A newer PC, typical of that which can be purchased off the self today will be required for each user that desires to remotely access the ASTC system. Components of such a PC include: |  |
| 7.4.2.1 | Computer CPU with sufficient processing power and system memory to run any required ASTC. |  |
| 7.5 | **Computing Hardware** |  |
| 7.5.1 | Other than the computing hardware that is associated with the ASTC system so new computing hardware will be required. |  |
| 7.5.2 | WisDOT anticipates that it will have in its possession or will be easily be able to procure the following equipment which will be needed to interface with the system from a remote location and print reports: |  |
| 7.5.2.1 | Computer CPU |  |
| 7.5.2.2 | Computer monitor |  |
| 7.5.2.3 | Mouse or track ball |  |
| 7.5.2.4 | Keyboard |  |
| 7.5.2.5 | Printer |  |
| 7.5.2.6 | Power, printer, and other associated cables. |  |
| 7.6 | **Software** |  |
| 7.6.1 | WisDOT will be responsible for coordinating with the vendor to implement software updates. |  |
| 7.6.2 | The vendor shall update any equipment added to WisDOT’s network and shall do so only with adequate advanced notification and approval from WisDOT. |  |
| 7.6.3 | The vendor shall be required to update the all equipment and software with each product update and shall do so each and every time the vendor issues the update to any other outside agency or client. |  |
| 7.7 | **Personnel** |  |
| 7.7.1 | WisDOT traffic signal operators will be responsible for monitoring and routine operations associated with the ASCT system. |  |
| 7.7.2 | WisDOT staff will require sufficiently thorough training to allow them to install, configure, monitor, operate and maintain all components of the ASCT system. |  |
| 7.7.3 | WisDOT operators are already experienced in setting up and fine tuning traditional traffic signal systems. |  |
| 7.7.4 | The vendor will be required to assist with the initial set-up, configuration and operation of the ASCT system until WisDOT operators have been trained and are comfortable operating the system. |  |
| 7.7.5 | Additional staff will be required during initial installation, set up, and operation of the ASCT system to fill in for staff that are being trained on the ASCT system. |  |
| 8 | Chapter 8: Proposed Operational Scenarios Using Adaptive System |  |
| 8.0 | The following operational scenarios describe how the system is expected to operate under various conditions. The proposed ASCT system is expected to be able to manage the following operational scenarios and issues envisioned for both the current and future project locations. Scenarios are described for the following operational conditions: |  |
| 8.1 | **Typical heavy congested conditions** |  |
| 8.1.1 | **Road network** |  |
| 8.1.1.1 | The Zoo Interchange is the intersection of an east-west freeway (IH-94) and a north-south freeway (IH-894/USH 45). The integrated corridor arterials surrounding the Zoo Interchange where adaptive signals are proposed are also both north south and east west. They are the only existing arterials surrounding the Zoo Interchange and therefore have heavy daily traffic volumes that peak during the AM and PM commute time periods.  Highway 100 is a north-south alternate arterial route that parallels IH 894/US 45 to the west and is bisected by IH-94. 84th Street/ Glenview Ave is also a north-south alternate route east of the interchange from Watertown Plank Road to the north to National Avenue to the south.  Bluemound Road and Greenfield Avenue are east-west alternate routes that parallel IH-94 to the north (Bluemound Road), and the south (Greenfield Avenue). Watertown Plank Road is also an east-west arterial north of Bluemound Road between Hwy 100 and 84th Street. |  |
| 8.1.2 | **Traffic conditions** |  |
|  | During the morning peak, traffic is heavy approaching the freeway from the residential areas. Traffic exiting the freeway is also heavy because of the commuter destinations on the arterials. The arterials are both a means to access the freeway and a means to access commuter destinations, such as the Milwaukee Regional Medical Complex (MRMC). Motorists also sometimes use the arterials instead of the freeway when freeway delay is excessive, causing traffic to be somewhat directional; however, there are heavy volumes in all directions. The intersections of the integrated corridor arterials are large intersections with many movements that are at capacity.  The afternoon commuter peak is similar to the morning where motorists use the arterials to access residential areas after exiting the freeway and to access the freeway from a workplace or shopping destination. Some locations experience more turning movements from the arterials – such as Bluemound Road and Elm Grove Road and some intersections experience more traffic turning from the side street onto the arterial – such as Watertown Plank Road and 92nd Street. |  |
| 8.1.3 | **Operational Objectives** |  |
| 8.1.3.1 | During typical heavy congested conditions, the operational objectives will be to: |  |
| 8.1.3.1.1 | Provide smooth traffic flow along arterials. |  |
| 8.1.3.1.2 | Maximize the throughput of traffic along designated arterials while minimizing delay time on side streets. |  |
| 8.1.3.1.3 | Reduce the number of stops and delays on arterials. |  |
| 8.1.3.1.4 | Efficiently use available capacity to serve the peak period demand entering the arterial network. |  |
| 8.1.3.1.5 | At the large intersections of integrated corridors, minimize the number of phase failures. Because it may not be possible to eliminate phase failures completely at these intersections, the adaptive response must be immediate to reduce their duration and impact. |  |
| 8.1.3.1.6 | At the large intersections of integrated corridors, maintain coordination as much as possible. |  |
| 8.1.4 | **Coordination and timing strategies** |  |
| 8.1.4.1 | * At critical intersections, select phase times that minimize phase failures to no more than two consecutive cycles; * At intersections where left turn queue overflow has been identified, select phase sequence that eliminates queue overflow; * Provide smooth flow along the arterial between critical intersections; * At non-critical intersections, provide sufficient time to serve all turning and side street traffic to minimize phase failures to no more than two consecutive cycles; * Eliminate spillback onto the freeway; * The adaptive system will seek to balance green time utilization at critical intersections when side-street demand is higher, but will minimize impact to the coordinated phase; * The system will manage residual queue buildup at locations where spillback and/or blocking has been observed; * At Watertown Plank Road and 87th Street, select phase timing and functions that mitigate pedestrian/turning vehicle conflicts; * At other intersections, select phase times that will accommodate occasional use of pedestrian phases; |  |
| 8.1.5 | **Summary of operations** |  |
| 8.1.5.1 | The system will detect the balanced flows and select offsets and phase sequence that provides a reasonable compromise between the two directions of travel. At the non-critical intersections where left-turn spillback is not an issue, allocate all spare time to the coordinated phases to maximize the bandwidth for progression bands along the arterial. Where spill back is an issue in left turn lanes, allocate additional time to the turn lane or coordinated phase based on a user specified number of consecutive phase max-outs.  At integrated corridor intersections, the system will detect the balanced flows and select offsets and phase sequence that provides a reasonable compromise between all four directions of travel based on the user-determined priority. |  |
| 8.2 | **Moderate to heavy balanced flows (Construction)** |  |
| 8.2.1 | **Road Network** |  |
| 8.2.1.1 | The integrated corridor arterials in the project area will provide alternate routes during construction. These routes represent a grid network that overlays the Zoo Interchange. On the freeway, fifty percent of traffic turns within the interchange. Therefore, during various construction stages a high volume of traffic will turn on the arterials. |  |
| 8.2.2 | **Traffic Conditions** |  |
| 8.2.2.1 | In general, construction activity will affect operations on the freeway resulting in a portion of traffic electing to exit the freeway in search of an arterial route that offers a reduced overall travel time. Some motorists will elect not to enter the freeway at all, resulting in increased thru traffic volumes on the arterials.  During construction activities, traffic volumes will increase on exit ramps approaching the Zoo Interchange from all directions. Conversely, traffic volumes will increase on entrance ramps departing the Zoo Interchange from all directions.  Construction will require frequent full closures during off-peak travel times (specified by the STOC). These full closures will cause a large increase on a specific path.  Construction will also require long-term full closures of lanes, system interchange ramps, and service interchange ramps. These full closures will also cause a large increase on a specific path, but since they are long-term the arterials must balance all other competing traffic demand needs with the construction increase. |  |
| 8.2.3 | **Operational Objectives** |  |
| 8.2.3.1 | Typical construction activity operational objectives are similar to daily congestion: |  |
| 8.2.3.1.1 | Provide smooth traffic flow along arterials. |  |
| 8.2.3.1.2 | Maximize the throughput of traffic along designated arterials. |  |
| 8.2.3.1.3 | Reduce the number of stops and delays on arterials. |  |
| 8.2.3.1.4 | Efficiently use available capacity to serve the peak period demand entering the arterial network. |  |
| 8.2.3.1.5 | At the large intersections of integrated corridors, minimize the number of phase failures. Because it may not be possible to eliminate phase failures completely at these intersections, the adaptive response must be immediate to reduce their duration and impact. |  |
| 8.2.3.1.6 | At the large intersections of integrated corridors, maintain coordination as much as possible. |  |
| 8.2.3.1.7 | During off-peak full closures, provide smooth traffic flow on the alternate route. |  |
| 8.2.4 | **Coordination and timing strategies** |  |
| 8.2.4.1 | * Eliminate spillback onto the freeway; * Manage demand entering the freeway ramp if the ramp meter cannot accommodate the storage needs; * At critical intersections, select phase times that minimize phase failures to no more than two consecutive cycles; * At intersections where left turn queue overflow has been identified, select phase sequence that eliminates queue overflow; * Provide smooth flow along the arterial between critical intersections; * At non-critical intersections, provide sufficient time to serve all turning and side street traffic to minimize phase failures to no more than two consecutive cycles; * The adaptive system will seek to balance green time utilization at critical intersections when side-street demand is higher, but will minimize impact to the coordinated phase; * The system will manage residual queue buildup at locations where spillback and/or blocking has been observed; * At Watertown Plank Road and 87th Street, select phase timing and functions that mitigate pedestrian/turning vehicle conflicts; * At other intersections, select phase times that will accommodate occasional use of pedestrian phases.   Off-peak full closures   * Modify coordinated phases to prioritize the alternate route. |  |
| 8.2.5 | **Summary of operations** |  |
| 8.2.5.1 | Daily operational goals are similar to typical heavy congestion; except volumes are expected to be higher and more frequent phase failure is expected.  During off-peak full closures the coordinated phases may change to optimize operations on the alternate route path. |  |
| 8.3 | **Demand Effecting Event (Scheduled Special Event)** |  |
| 8.3.1 | **Road Network** |  |
| 8.3.1.1 | The integrated corridor arterials are alternate routes for events at State Fair Park, baseball games played at Miller Park, holiday shopping at Mayfair and Brookfield Square Malls, and the Milwaukee County Zoo. Adaptive signals will provide better progression to and from these venues and freeway interchanges.  The Wisconsin State Fair Park is located north of Greenfield Avenue (STH 59) between 84th Street (STH 181) and 76th Street in the City of Milwaukee. The park hosts year-round events, in addition to its main attraction, the Wisconsin State Fair during the summer. The Wisconsin State Fair attracts nearly 900,000 people to the fairgrounds over 11 days in August. The main access to State Fair Park is from either Greenfield Avenue or 84th Street, both having freeway access. The additional traffic traveling to or from the State Fair results in heavy queuing, delays, and congestion on both arterials, and at times backs up onto the freeway.  Miller Park is the home of the Milwaukee Brewers and is located south of IH 94 and west of US 41 in the City of Milwaukee. It is a major sports and entertainment attraction in southeastern Wisconsin, as it has attracted more than 2.5 million fans during every baseball season since 2007. Bluemound Road is the major arterial north of Miller Park, and Greenfield Avenue and National Avenue are the major arterials to the south. Access to the numerous surface parking lots surrounding Miller Park heavily utilizes these three arterials and the freeway.  Mayfair Mall is a major shopping center located east of HWY 100 between North Avenue and Center Street in the City of Wauwatosa. Mayfair Mall employs a significant number of workers and attracts many more travelers, especially during the holiday season. Freeway traffic on US 45 can use the split interchange with US 45 at North Avenue, which provides access to Mayfair Mall from northbound and southbound US 45. However, a majority of users choose HWY 100 to access the mall. Therefore, the intersection of North Avenue and HWY 100 experiences high levels of congestion and delays from traffic on both streets. |  |
| 8.3.2 | **Traffic Conditions** |  |
| 8.3.2.1 | Wisconsin State Fair   * Eastbound I-94 traffic exiting at 84th Street commonly backs up on the freeway ramp while people are going to the fair. * IH-894 interchange with Greenfield Ave is congested. * As people begin to leave the fair W O’Connor Street and 84th Street is congested. * 76th St, Greenfield Ave and National Ave also experience congestion during the Fair.   Miller Park   * For evening games at Miller Park, fans are going to the park during the PM peak period. * For day games at Miller Park, fans are leaving the park during the PM peak period. * Both scenarios cause a large increase in traffic on all the arterials. * Because Miller Park is located near the downtown area, day games cause an increase in directional flow. Whereas for evening games fans are typically driving towards the downtown area during the evening peak period when commuter traffic is leaving the downtown area.   Mayfair Mall   * Holiday shopping traffic exiting US 45 at Mayfair Road commonly backs up onto the freeway from the intersection of North Avenue and HWY 100. * Intersections along HWY 100 operate poorly because of the unusual traffic patterns |  |
| 8.3.3 | **Operational Objectives** |  |
| 8.3.3.1 | During demand affecting events, the operational objectives will be to: |  |
| 8.3.3.1.1 | Maximize the throughput of traffic along designated arterials. |  |
| 8.3.3.1.2 | Effectively manage traffic along critical corridors in real-time, in response to the special event. |  |
| 8.3.3.1.3 | Manage queues at signalized intersections, to prevent excessive queuing and spillover into adjacent intersection, driveways, and freeway exit ramps. |  |
| 8.3.3.1.4 | Provide effective traffic progression on routes to and from the special event venue. |  |
| 8.3.4 | **Coordination and timing strategies** |  |
| 8.3.4.1 | All Events:   * Provide smooth flow along the arterial between critical intersections; * At intersections where left turn queue overflow has been identified, select a phase sequence that eliminates queue overflow; * The adaptive system will seek to balance green time utilization at critical intersections when side-street demand is higher, but will minimize impact to the coordinated phase.   Wisconsin State Fair:   * Eliminate spillback onto the freeway from the Greenfield Avenue and 84th Street interchanges; * When the park closes, modify coordinated phases to prioritize W O’Connor Street. * At critical intersections on Greenfield Avenue and 84th Street, select phase times that minimize phase failures to no more than two consecutive cycles; * At the Greenfield Avenue and 84th Street intersection, select phase timing and functions that mitigate pedestrian/turning vehicle conflicts; * At other intersections, select phase times that will accommodate occasional use of pedestrian phases.   Miller Park   * At critical intersections on Bluemound Road and Greenfield Avenue select phase times that minimize phase failures to no more than two consecutive cycles.   Mayfair Mall   * At HWY 100 and North Avenue select phase times that minimize phase failures to no more than one consecutive cycle on the west and south leg of the intersection; * At HWY 100 and North Avenue select phase times that minimize phase failures to no more than two consecutive cycles on the north and east leg of the intersection. |  |
| 8.3.5 | **Summary of Operations** |  |
| 8.3.5.1 | The selected ASCT system will recognize increases in traffic leading up to the start of the event and adopt an appropriate mode of operation. The system will minimize the impacts by efficiently assigning green time. The system will prevent traffic from backing up onto the freeway.  During the event, when there is little associated traffic, the system will recognize the traffic conditions and operate normally until traffic departs the special event. When traffic levels return to normal the system will then return to normal operation. |  |
| 8.4 | **Emergency signal preemption (Access to Medical Center)** |  |
| 8.4.1 | **Road Network** |  |
| 8.4.1.1 | The Milwaukee Regional Medical Center (MRMC) is located east of US 45 between Wisconsin Avenue and Watertown Plank Road in the City of Wauwatosa. It is a medical campus consisting of six health care organizations. Because of its relative size and number of employees, the MRMC is one of the most significant traffic generators within the corridor and is poised to expand significantly by 2035.  Primary motorist access to the MRMC is from Watertown Plank Road, the Watertown/Swan Boulevard Interchange, 92nd Street and 87th Street. However, the residential nature, lower capacity, and lack of direct freeway access currently minimizes the amount of traffic that can use these roadways. |  |
| 8.4.1.2 | The Zoo Interchange reconstruction will reconfigure the Watertown Plank Road interchange to be a free-flow interchange in all directions. This design will draw traffic and motorists will continue to use Watertown Plank Road as the primary access point to the MRMC. |  |
| 8.4.1.3 | Reconstruction will change the existing Bluemound Road /Wisconsin Avenue interchange to a diamond interchange at Bluemound Road. Overall, this will reduce traffic volumes on Wisconsin Avenue. However, motorists will still have access to the MRMC from the Bluemound Road interchange. |  |
| 8.4.1.4 | During construction of the Zoo interchange, it is critical to provide access to and from the MRMC. |  |
| 8.4.1.5 | In addition to the freeway, a number of arterials including Highway 100, Bluemound Road, Wisconsin Avenue, Glenview Avenue, Swan Boulevard and Watertown Plank Road in the project area are critical corridors for emergency responders to gain ingress and egress from the MRMC. |  |
| 8.4.2 | **Traffic conditions** |  |
| 8.4.2.1 | Traffic around the MRMC is directional during the peak hours and shift changes, with a high volume going to the area in the morning and coming from the area in the evening. During these periods, EVP calls are disruptive to traffic flow because interruptions to signal operations quickly cause queue overflow. |  |
| 8.4.3 | **Operational objectives** |  |
| 8.4.3.1 | When an intersection responds to EVP, the operational objectives will be to: |  |
| 8.4.3.1.1 | Effectively manage traffic along EVP equipped corridors in real-time, in response to pre-emption events. |  |
| 8.4.3.1.2 | Respond to and recover from EVP requests in the corridors with a minimum reduction in corridor performance. |  |
| 8.4.3.1.3 | Manage queues at signalized intersections, to prevent excessive queuing and spillover into adjacent intersections, driveways, and freeway exit ramps. |  |
| 8.4.3.1.4 | Manage queues downstream of the EVP call, to prevent excessive queuing from restricting the emergency vehicle after it clears the intersection. |  |
| 8.4.4 | **Coordination and timing strategies** |  |
| 8.4.4.1 | During EVP:   * At the EVP location, clear the intersection to the direction of the EVP call (including yellow and all red time for the conflicting phase but not complete pedestrian clearances) and then clear the queue in the direction of the call to provide passage for the emergency vehicle.   After EVP:   * The system will manage residual queue buildup at locations where spillback and/or blocking has been observed; * Eliminate spillback onto the freeway; * At critical intersections, select phase times that minimize phase failures to no more than two consecutive cycles; * At Watertown Plank Road and 87th Street, select phase timing and functions that mitigate pedestrian/turning vehicle conflicts. |  |
| 8.4.5 | **Summary of operations** |  |
| 8.4.5.1 | When an intersection responds to EVP, other traffic signals within the network will continue to operate adaptively. The preempted traffic signal will return to adaptive control immediately upon the release of the pre-emption. |  |
| 8.4.5.2 | After EVP is released, the system will be able to determine which phase to service by demand present within the system. Settings will be available for the system user to change options depending on time of day, vehicle demand threshold, and pedestrian calls. The system will adaptively determine, based on these preset settings, how to return to adaptive control. |  |
| 8.5 | **Fault conditions (communications, detection, adaptive processor)** |  |
| 8.5.1 | **Communications Fault Condition** |  |
| 8.5.1.1 | If communication is lost to an adaptively controlled intersection, the intersection will operate using observed, historical parameters. |  |
| 8.5.1.2 | If a communication failure occurs, and there is insufficient historical parameters the impacted signal will run in either time-of-day or free mode. |  |
| 8.5.1.2.1 | The fallback mode will be specified by the user based on location and time of day. |  |
| 8.5.1.3 | All communication failures will be automatically transmitted to designated staff for appropriate action. |  |
| 8.5.1.4 | All other non-affected signals will continue to run in adaptive mode. |  |
| 8.5.2 | **Detection Fault Condition** |  |
| 8.5.2.1 | The system will recognize a detector failure and will use historical data to accommodate missing data. |  |
| 8.5.2.2 | If more than a user-defined number of detectors fail at a single intersection or group of intersections, the system will cease operation at that intersection(s) and go to a fallback operation specified by the user. |  |
| 8.5.2.3 | All detection failures will be automatically transmitted to designated staff for appropriate action. |  |
| 8.5.3 | **Adaptive Processor Fault Condition** |  |
| 8.5.3.1 | If an adaptive processor malfunctions or fails, adaptive operation at the effected signal will cease operation and go to a fallback operation specified by the user. |  |
| 8.5.3.2 | All adaptive processor failures will be automatically transmitted to designated staff for appropriate action. |  |
| 8.5.3.3 | To speed responsive maintenance, additional adaptive processors in and above those initially deployed will be purchased and housed to replace processors as they fail. |  |