Zoo Interchange Reconstruction
Integrated Corridor Management

Project-Level ITS Architecture & Systems Engineering Analysis – Final

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List of Acronyms

AASHTO	American Association of State Highway and Transportation Officials
ACS Lite	Adaptive Control System Lite
ASC	Adaptive Signal Control
ASCT	Adaptive Signal Control Technology
ASTM	American Society for Testing and Materials
ATMS	Advanced Traffic Management System
BTO	Bureau of Traffic Operations
C2C	Center-to-Center
C2F	Center-to-Field
CAD	Computer Aided Dispatch
CCTV	Closed Circuit Television
CFR	Code of Federal Regulations
DOT	Department of Transportation
DTSD	Division of Transportation System Development
DMS	Dynamic Message Sign
FHWA	Federal Highway Administration
FMS	Field Management Station
FTA	Federal Transit Authority
HAR	Highway Advisory Radio

I	Interstate
ICM	Integrated Corridor Management
IEEE	Institute of Electrical and Electronics Engineers
IH	Interstate Highway
IP	Internet Protocol
IRU	Indefensible Right of Use
ITE	Institute of Transportation Engineers
ITS	Intelligent Transportation System
LA ACTS	Los Angeles Adaptive Control Traffic System
MOE	Measure of Effectiveness
MOTION	Method for the Optimization of Traffic signal control In Online-controlled Networks
MOU	Memorandum of Understanding
NEMA	National Electrical Manufactures Association
NTCIP	National Transportation Communications for ITS Protocol
OPAC	Optimization Policies for Adaptive Control
PITSA	Project Intelligent Transportation System Architecture
RFP	Request for Proposal
RHODES	Real-time Hierarchical Optimized Distributed and Effective System
RSC	Responsive Signal Control
SAE	Society of Automotive Engineers
SCATS	Sydney Coordinated Adaptive Traffic System
SCOOT	Split Cycle Offset Optimization Technique

SCP	Signal Control and Prioritization
SDO	Standards Development Organization
SE	Systems Engineering
STH	State Highway
STOC	State Traffic Operations Center
TIM	Traffic Incident Management
TOD	Time of Day
TSS	Transportation Sensor System
UK	United Kingdom
USDOT	United States Department of Transportation
USH	United States Highway
WisDOT	Wisconsin Department of Transportation

SECTION 1

Introduction

In early 2001, the United States Department of Transportation (USDOT) announced the release of the Federal Highway Administration's (FHWA) final rule and Federal Transit Authority's (FTA) policy for applying the National Intelligent Transportation System (ITS) Architecture at the regional level. The FHWA rule/FTA policy on ITS Architecture and Standards (23 CFR Part 940) requires that all federally funded ITS projects conform to a Regional ITS Architecture and undergo a systems engineering (SE) analysis to qualify for, or remain eligible to receive financial assistance. The definition of projects includes both standalone ITS projects and those that include ITS elements. Section 23 CFR 904.11 specifically states that a SE analysis should be developed to an extent similar to the project scope and meet the seven requirements/activities identified in **Table 1**.

This project ITS architecture (PITSA) has been prepared for the ITS elements corresponding to the Integrated Corridor Management (ICM) system to be deployed as part of the Zoo Interchange Reconstruction project. The ICM project is not federally funded and is consequently not subject to the 23 CFR Part 940 requirements. However, in the absence of federal funding it is still good practice to follow a structured approach for designing ITS systems so that risk is minimized and that quality can be built into the system. This will work toward developing systems in a structured fashion where their associated benefits are maximized and allocated funding used effectively and efficiently. To this extent, this document demonstrates compliance to FHWA's final rule and its stipulated SE requirements as if it were federally funded, but more importantly to provide the needed understanding to advance the ICM project in a cost effective, and controlled manner.

Besides identifying the SE requirements, **Table 1** also provides the applicable section within this document where those requirements are addressed. Requirement 7 (procedures and resources needed for operations and maintenance) will be addressed in the Operations Plan to be developed in Mid-2013. It should also be noted that this document is a companion document to this Operations Plan as well as the Concept of Operations.

Table 1: Systems Engineering Requirements and Document Mapping

Systems Engineering Requirement	Document Location
1) Identify portions of the regional architecture being implemented	Section 3
2) Identify participating agency roles and responsibilities	Section 4
3) Identify requirements definitions	Section 5 (Detailed ASCT requirements provided in separate document).
4) Analyze alternative system configurations and technology options to meet requirements	Section 6
5) Identify procurement options	Section 7
6) Identify applicable ITS standards and testing procedures	Section 8
7) Outline procedures and resources necessary for operations and maintenance	Operations Plan

SECTION 2

Background

Beginning in 2015, the Wisconsin Department of Transportation (WisDOT) will reconstruct the Interchange of I-894 and I-94 west of the City of Milwaukee. The interchange, also known as the Zoo Interchange, is the oldest and busiest in the State of Wisconsin. The interchange first opened to traffic in 1963 and today serves as the hub of freeway travel in the metropolitan Milwaukee area. The interchange and surrounding arterials are operating at or near capacity and cannot adequately service the growing public demand. Additionally, the facility is operating beyond its design life span and is rapidly deteriorating. The reconstruction project will address the geometric and capacity deficiency of the existing interchange and segments of adjacent arterials. Construction will last roughly 3 years and is expected to have significant impact on the freeway and adjacent local road network.

In advance of construction, WisDOT is taking proactive steps to minimize the associated impacts of construction activity on the local road network. During construction, it is expected that traffic incidents, special events, and recurring congestion will cause freeway traffic to seek alternate routes via the adjacent local road network. In anticipation of increased arterial demand, WisDOT has started to make improvements to turn lanes, bus stops, parking, and pavement. ITS roadside equipment and communications infrastructure will be deployed with these roadway projects to cost effectively integrate traffic management functions along the Zoo Corridors, which will improve safety, reliability and efficiency of the transportation network at reduced construction costs. ITS projects planned for the Zoo Corridors include:

- Adaptive traffic control system (for traffic control). This includes roadside field equipment such as processors, detection and integration with existing roadside equipment. It is also expected that there will be integration with a new or existing central control/monitoring software platform.

- Arterial dynamic message sign (DMS) and travel time system (for traveler information and way finding). This includes integration with WisDOT's existing advanced traffic management system central software.
- Arterial closed circuit television (CCTV) cameras (for general surveillance, incident management, special event traffic monitoring, and video feeds to the public). This includes integration with WisDOT's existing advanced traffic management system central software.

Collectively, these ITS improvements are referred to as the Zoo Corridors Integrated Corridors Management (ICM) system. The ICM system will provide the ability to effectively manage the unexpected volumes of traffic that are likely to divert off the freeway for the local road network during reconstruction. This improved traffic management will, in turn, provide several benefits:

- Reduced travel times, delays, fuel consumption, emissions, and incidents
- Improved reliability and predictability of travel
- Effective movement of people and goods

2.1 System Purpose

The purpose of the Zoo Corridor ICM system is to implement and operate technologies that enable the safe, effective, movement of vehicles along arterials surrounding the Zoo interchange during its reconstruction. The basic premise behind the ICM system is to operate individual transportation management systems in a more coordinated and integrated manner, thereby increasing overall corridor throughput and enhancing the safety and mobility of corridor users. The following are elements of the project's vision:

- Operate corridors in a more integrated manner between the freeway and arterial networks
- Provide access to timely, accurate and useful traveler information
- Share information and data seamlessly among all agencies to improve efficiency and management of traffic incidents
- Better align operations, technology, and institutions to address deficiencies and improve corridor performance

Traveler information systems, including full matrix DMS and hybrid travel time DMS, will be implemented along priority arterials to guide motorists along arterial networks, and provide traveler information in advance of key decision points so travelers can make informed travel decisions en-route and in response to changing conditions. Additionally, CCTV cameras will be deployed at strategic locations to remotely monitor arterial operations and make adjustments to traffic management strategies. CCTV cameras will also be used to monitor the status of traffic signals and DMS to ensure proper operation and to implement corrective actions if needed. Last, an adaptive traffic signal system will be implemented along the local road network to help manage the higher level of traffic that is expected when reconstruction begins. The adaptive traffic signal system will adjust to traffic demand in real-time and will improve existing capacity through more efficient allocation of green time at signalized intersections. The adaptive traffic signal system will be deployed at 60 intersections along key arterials within the project area, beginning with a pilot program covering 6 of these sixty intersections. The pilot program will be used to test and evaluate the effectiveness of a selected adaptive traffic system product. Although the initial target is 60 intersections, there is potential to expand the adaptive system to upwards of a 100 signalized intersections.

New CCTV cameras and DMS will supplement existing devices installed along arterials within the project limits. Components of the system will remain operational upon the completion of the Zoo Interchange reconstruction and will continue to provide operational benefits to the corridor.

2.2 Goals

The goal of the Zoo Corridors ICM project is to provide safe and effective movement of vehicles along arterials adjacent to the Zoo Interchange during its reconstruction. To the extent possible, the ICM system shall be operational before construction begins to maximize the benefits of the system and to reduce any adverse impacts that may be associated with construction. Additional goals include:

Local Arterial Operations

- Enhance monitoring of traffic along key arterial corridors
- Enhance the provision of en-route traveler information to users of the local road network
- Enhance arterial traffic signal operations to effectively manage increased traffic flows that result from incidents and activities along freeways during reconstruction and thereafter

Freeway/Arterial Operations

- Operate the freeways and arterials in an integrated manner
- Effectively manage the demand exiting the freeway so that vehicles do not backup onto the freeway resulting in additional traffic or safety problems along the freeway

In addition to these goals, it is expected that the ICM project will bring municipal agencies together to more proactively address traffic related issues prior to construction. The associated ICM project serves as a catalyst to bring together all agencies that will be impacted by construction so as to achieve cohesiveness in an approach to better manage traffic within the ICM corridors.

SECTION 3

Identification of Portions of Regional ITS Architecture Being Implemented

This section identifies the applicable ITS elements of Wisconsin's Statewide ITS Architecture that the project will build. It does this through what is known as a project-level ITS architecture (PITSA). The intent of the PITSA is to illustrate and document the manner in which ITS elements that are part of the project will come together to exchange information and data so that user needs are met and desired transportation services are provided.

3.1 ITS Architecture Overview and Understanding

An ITS Architecture is a high-level framework that describes and illustrates how existing and planned ITS elements interconnect to exchange information to collectively deliver a service or function. To this extent, an ITS Architecture can be viewed as a blueprint that shows the existing and future state of ITS integration within a particular area (e.g., state, metropolitan region or project). The Architecture identifies the individual pieces or ITS elements, the functions these pieces perform, and the information and data that are exchanged. An ITS architecture is developed at a high-level and is not intended to serve as the detailed design of the system, but rather provides sufficient detail to develop consensus between the various agencies that have a stake in ITS activities. It achieves this by providing these stakeholders the ability to visualize where in the regional context their ITS elements fit, and with what other elements they communicate.

An ITS Architecture is illustrated through a series of diagrams that show how individual elements connect. Diagrams can be oriented in 2 ways. First, diagrams can be developed to show the various interfaces a single ITS element has with respect to other ITS elements. This view allows agencies to easily understand how their respective ITS elements interconnect with other ITS elements and between what other agencies the information is shared. Conversely, diagrams can be developed to show how various ITS elements work together to deliver a specific transportation service (e.g., network surveillance). In this view, only the ITS elements and the applicable information flows that are required to deliver the specified transportation service are shown. Both views of the architecture ease the understanding of ITS integration and serve as a guide to effectively implement systems in coordination with other regional ITS activities and deliver a greater return on investment.

Besides these benefits, an ITS architecture also provides high level details needed to understand what must be built. To this extent the architecture helps to support RFP development and design process. Furthermore, the architecture can serve as an additional resource to bidders and system designers giving them clear understanding of the scope of the project and the various system-to-system interfaces that need to be developed. There are several types of architectures that can provide guidance and additional details that may be helpful in the systems planning and design process. These are outlined in the following sections.

3.1.1 National ITS Architecture

ITS Architecture development is guided by the National ITS Architecture. The National ITS Architecture, developed and maintained by FHWA, is a common, mature framework for planning, defining, and integrating ITS elements. The National ITS Architecture reflects the contributions of a broad cross-section of the ITS community and specifically defines:

- The functions that are required of ITS to perform transportation services,
- The physical entities or subsystems where these functions reside, and
- The information and data flows that connect these functions and physical subsystems together into an integrated system.

The listing of functions, subsystems and flows contained in the National Architecture is comprehensive and is intended to serve as the underlying standardized framework from which ITS projects and their corresponding project architectures are to be developed. For this reason, any locally developed architecture, including the Zoo Corridors ICM project architecture, will reflect only a sub-set of all the possible functions, subsystems, and information flows brought forward by the National ITS Architecture.

3.1.2 Regional/Statewide ITS Architecture

A regional/statewide ITS architecture is a subset of the National ITS Architecture, containing attributes specific to the ITS systems and projects within the state or region. In 2010, the Wisconsin Statewide ITS Architecture was consolidated and updated using previously developed Regional ITS Architectures. Subsequently, the regional ITS Architectures were eliminated leaving only the Wisconsin Statewide ITS Architecture as the only architecture being maintained within the state. As a result, the Statewide ITS Architecture represents the corresponding parent architecture for this project. The Statewide ITS Architecture is maintained, updated and hosted by the Wisconsin TOPS Lab.

3.1.3 Project-Level ITS Architecture

The PITSA identifies the subsystems included as part of the project and illustrates how they come together to address user needs and enable desired transportation services. It accomplishes this by mapping project ITS elements with those reflected in Wisconsin's ITS Architecture, using the National ITS Architecture as the underlying framework. If the project introduces new ITS elements that are not reflected in the statewide ITS architecture the project architecture preserves these for inclusion within the regional ITS architecture at a later date.

The Zoo Corridors ITS Project Architecture was developed to align as closely as possible with the Wisconsin Statewide ITS Architecture. Developers of this project ITS architecture collaborated with the owner/maintainer of the Wisconsin Statewide ITS Architecture to obtain the most recent files that pertain to the Statewide ITS Architecture and to ensure that project architecture was developed using desired naming conventions. In doing this, the PITSA identifies the portions of the Statewide Architecture that relate to the project being implemented.

3.1.4 Turbo Architecture Software Tool

This PITSA was developed using FHWA's Turbo Architecture (Version 7.0.5.1) software (hereafter referred to as Turbo) and is consistent with the National ITS Architecture v.7. Turbo is a software application that supports development of ITS architectures using the most recent version of the National ITS Architecture as an underlying, standardized framework. Turbo is a database that retains attributes of an architecture including stakeholders, existing and planned ITS elements, high-level system requirements, information flows, and standards.

The PITSA was developed within the most recent Statewide ITS Architecture Turbo database file, but it has yet to be merged with the Statewide Architecture database. Until the PITSA is merged with the Statewide ITS architecture, the complete extent of integration will not be shown. Since the TOPS Lab maintains the regional ITS architecture, the merging of the PITSA with the Statewide ITS Architecture is best left to the maintaining agency. This document provides the necessary information needed to easily merge the PITSA with the Statewide ITS Architecture. Upon review and acceptance of the PITSA database, the owner/maintainer of the Statewide ITS Architecture can perform this task with one single click of a mouse with in the Turbo program.

3.2 Physical ITS Architecture

The physical ITS architecture identifies the various entities that comprise the physical world in which ITS activities take place, and which are required to deliver desired transportation functions or services. Entities are classified by the National ITS Architecture as either a subsystem or a terminator. Subsystems and terminators that are applicable to the Zoo Corridors ICM project are identified in the following sections.

3.2.1 Subsystems

As its name implies, a subsystem is a standalone, independent component of a larger system – in this case the Zoo Corridors ICM system. Subsystems are critical components of the larger system and in some regards can be viewed as systems themselves. Subsystems are composed of related, yet smaller groups of technologies referred to in the National Architecture as Equipment Packages that together can be bundled to deliver specific transportation services. Subsystems represent the primary building blocks of a system's architecture. The National ITS Architecture v 7.0 identifies 22 possible subsystems grouped into four classes: Travelers, Centers, Vehicles, and Field. Project related subsystems are grouped by their applicable class in **Figure 1**; in what is known as the National Architecture Sausage Diagram. The various ITS elements that comprise the ICM and their interfaces fall under one or more of the following non-shaded subsystems in this figure:

- Personal Information Access (Travelers Class)
- Traffic Management (Centers Class)
- Maintenance and Construction Management (Centers Class)
- Information Service Provider (Centers Class)
- Archived Data Management (Centers Class)
- Emergency Vehicle (Vehicles Class)
- Roadway (Field Class)

The mapping of project-related ITS elements to their applicable National ITS Architecture subsystem(s) is provided in **Table 2**. In some cases an individual ITS element may be mapped to more than one subsystem (e.g., WisDOT_DTSD_BTO_STOC_ATMS). In these cases an element may contain more than one subsystem. A description of each ITS element is provided later in the document.

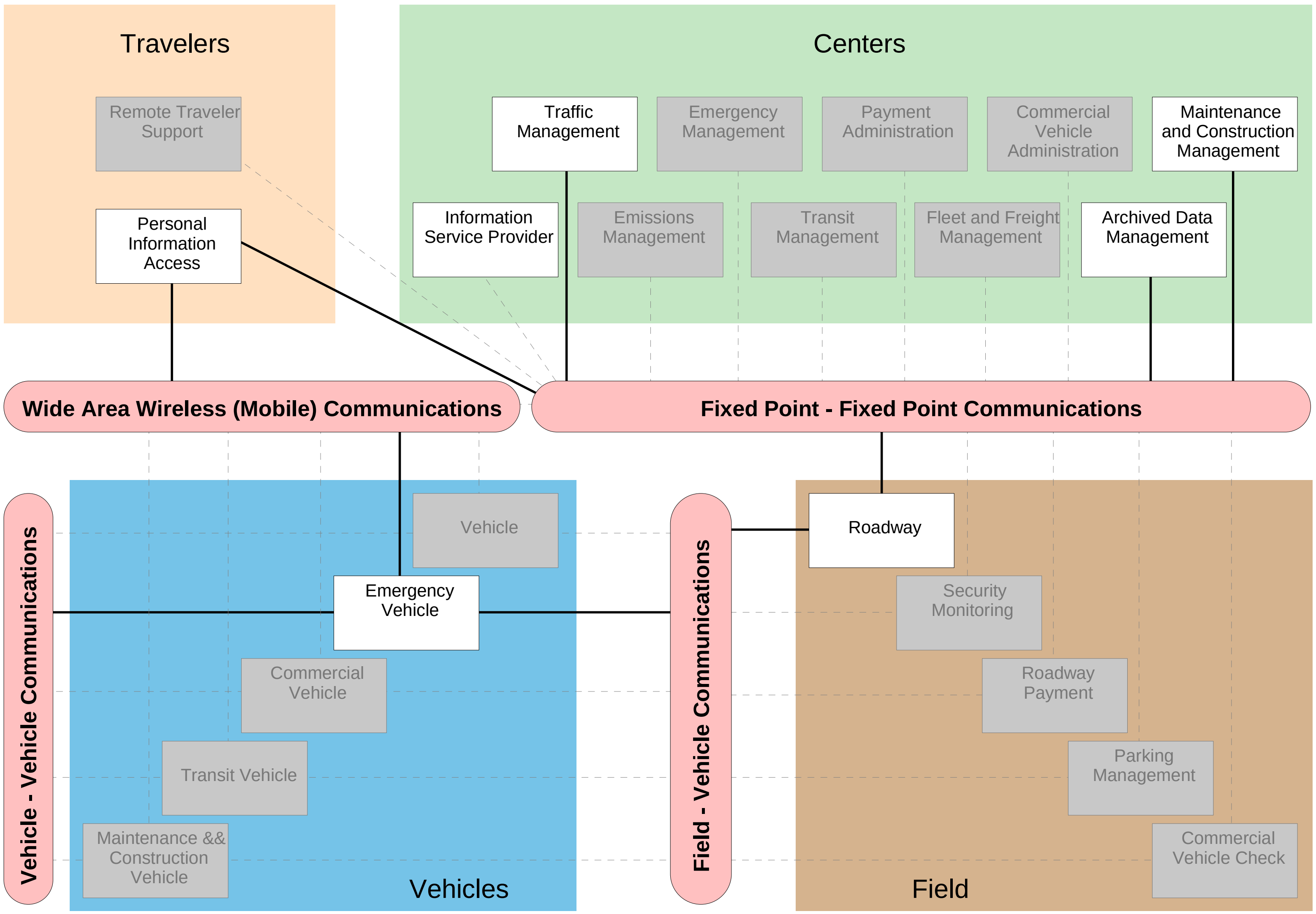


Figure 1: Project ITS Architecture Sausage Diagram

Table 2: Mapping of ICM ITS Elements to National ITS Architecture Subsystems

National ITS Architecture Subsystem	Corresponding Project ITS Element(s) Mapping
Archived Data Management	WisDOT_DTSD_BTO_STOC_ATMS WisDOT_Signal Ops Group_ATMS
Emergency Vehicle	x-Emergency Vehicles
Information Service Provider	WisDOT_DTSD_BTO_STOC_511 System WisDOT_DTSD_BTO_STOC_511 Telephony WisDOT_DTSD_BTO_STOC_511 Website WisDOT_DTSD_BTO_STOC_ATMS
Maintenance and Construction Management	WisDOT_DTSD_BTO_STOC_ATMS
Personal Information Access	User Personal Computing Devices
Roadway	Local Municipalities_Traffic Signal Equipment WisDOT_DTSD_BTO_STOC_Roadway Equip_CCTV WisDOT_Signal Ops Group_Roadway Equip_DMS WISDOT_Signal Ops Groups_ASCT Roadside Equipment WisDOT_Signal Ops Group_Roadway Equip
Traffic Management	WisDOT_DTSD_BTO_STOC_ATMS WisDOT_Signal Ops Group_ASCT Center Equipment WisDOT_Signal Ops Group_ATMS

3.2.1 Terminators

Terminators are similar to Subsystems in that they also comprise the physical world in which ITS services take place. However, unlike subsystems, terminators are not key to delivering desired transportation services, but are still important in that they are involved in these services albeit to a much lesser degree. Terminators are generally defined as the people, systems and general environment that lie outside the boundary of ITS but still impact ITS systems. The National ITS Architecture includes interfaces between terminators and subsystems and processes, but does not allocate functional requirements to terminators. To this extent understanding the role of terminators is less critical than subsystems; however, where possible it is still important to illustrate the connections with terminators to complete the picture of ITS activity and information flow. The mapping of project-related ITS elements to their applicable National ITS Architecture terminator classification is provided in Table 3.

Table 3: Mapping of ICM ITS Elements to National ITS Architecture Terminators

National ITS Architecture Terminator	Corresponding ICM ITS Element(s) Mapping
Event Promoters	Special Event Promoters
Other ISP	WisDOT_DTSD_BTO_STOC_511 Website
Other Roadway	Local Municipalities_Traffic Signal Equipment WisDOT_Signal Ops Group_ASCT Roadside Equipment WisDOT_Signal Ops Group_Roadway Equip
Other Traffic Management	WISDOT_DTSD_BTO_STOC_ATMS
Telecommunications System for Traveler Information	WisDOT_DTSD_BTO_STOC_511 Telephony
Traffic	Roadway Traffic
Traffic Operations Personnel	WisDOT_DTSD_BTO_STOC_Personnel
	WisDOT_Signal Ops Group_Personnel

3.2.2 ITS Element Inventory

An ITS element inventory is a collection of existing and planned ITS technologies that comprise the building blocks of an ITS architecture. It consists of only the elements that show potential for being integrated with other ITS elements, and are in themselves part of the larger system. ITS elements that are stand alone and cannot be integrated are not reflected in the ITS element inventory. For example, integrated traffic signals that can be remotely controlled or that communicate with other adjacent traffic signals would be included. However, an isolated traffic signal that must be controlled from the field and is not integrated with other traffic signals would not.

Table 4 provides a listing and description of ITS elements applicable to the Zoo Corridor ICM project as well as their status (existing or planned). If an element's status is shown as existing it means that the element current exists within project area; however, additional devices may be planned. If the element's status is shown as planned than that element does not current exist within the Zoo corridors. The ITS inventory was derived in part using the WisDOT Statewide ITS architecture. The Statewide ITS architecture provides a comprehensive listing of ITS elements in the state including SE Wisconsin. These elements were reviewed and those that mapped to the project were pulled out as being applicable to the PITSA.

Table 4: Inventory of Project Related ITS Elements.

ITS Element	ITS Element Description	Status
Local Municipalities_Traffic Signal Equipment	This element represents the equipment distributed on and along the roadway that monitors and controls traffic. This equipment includes traffic signal equipment (e.g., signal heads, controllers, signal pre-emption and detection) that is operated and maintained by any local municipality.	Existing
Public_Drivers	This element represents the human entity that operates a licensed vehicle on the roadway. Included are operators of private, Transit, Commercial, and Emergency vehicles where the data being sent or received is not particular to the type of vehicle. Thus this terminator originates driver requests and receives driver information that reflects the interactions which might be useful to all drivers, regardless of vehicle classification.	Existing
Roadway Traffic	This terminator represents the collective body of vehicles that travel on any type of roadway. It represents the vehicle population from which traffic flow surveillance information is collected (average occupancy, average speed, total volume, average delay, etc.), and to which traffic control indicators are applied (intersection signals, stop signs, ramp meters, lane control barriers, variable speed limit indicators, etc.).	Existing
Special Event Promoters	This terminator represents Special Event Sponsors that have knowledge of events that may impact travel on roadways. Examples of special event promoters include Miller Park, the Milwaukee County Zoo, and the State Fairgrounds. These promoters interface to the ITS to provide event information such as date, time, estimated duration, location, and any other information pertinent to traffic movement in the surrounding area.	Existing
User Personal Computing Devices	User Personal Computing Devices refers to equipment an individual owns and can personalize with their choices for information about transportation networks. Computers used to access traveler information websites are included in this element	Existing

ITS Element	ITS Element Description	Status
	as well as personal smart phones and tablets.	
WisDOT_DTSD_BTO_STOC_511 System	This element represents the 511 Traveler Information System that provides information to the 511 telephony system and to the 511 website for information dissemination.	Existing
WisDOT_DTSD_BTO_STOC_511 Telephony	This element represents the Phone based 511 information system that can be accessed by any land-line phone or cellular phone by dialing 5-1-1.	Existing
WisDOT_DTSD_BTO_STOC_511 Website	This element represents the website interface for 511 that disseminates information to the public via internet enabled devices	Existing
WisDOT_DTSD_BTO_STOC_ATMS	WisDOT STOC Advanced Traffic Management System (ATMS). WisDOT State Traffic Operations Center (STOC) handles traffic management for the state of Wisconsin. The Operations Center is located in Southeastern Wisconsin in the City of Milwaukee. The STOC is staffed 24 hours per day, 7 days per week and communicates regularly with sheriff, fire, police, and Wisconsin State Patrol, as well as media outlets and construction project managers. From the STOC, it is possible to use various traffic management tools, such as: closed circuit television units, ramp meters, variable message signs (VMS), highway advisory radio (HAR), roadway sensors and other tools. It is designed to improve the safety and efficiency of the Milwaukee freeway system by reducing incidents and relieving traffic congestion.	Existing
WisDOT_DTSD_BTO_STOC_Personnel	This element represents the personnel working for the STOC who can manage and control roadway equipment both from the STOC and remotely via a portable personal computer.	Existing
WisDOT_DTSD_BTO_STOC_Roadway Equip_CCTV	This element represents the WisDOT STOC's closed circuit television (CCTV) camera network. CCTV cameras will be deployed along freeways and key arterials to monitor traffic operations and to detect/verify incidents in a timely, proactive manner. WisDOT's STOC will be responsible for monitoring CCTV images and operating them to obtain additional details specific to an accident. Each CCTV camera will have pan-tilt-zoom capability. This element does not represent cameras	Existing

ITS Element	ITS Element Description	Status
	that are used for detection.	
WisDOT_DTSD_BTO_STOC_Roadway Equip_DMS	The element represents any type of dynamic message sign (DMS) that is deployed over or along a roadway for the purpose of disseminating en-route traffic and travel information to drivers. Both full matrix and hybrid static/dynamic DMS are represented by this element.	Existing
WisDOT_Signal Ops Group_ASCT Center Equipment	This element represents the center-based subsystem that would be either integrated into an existing ATMS or implemented as a stand-alone system to allow operators to monitor and input parameters into the ASCT system. This element would allow operators to easily and quickly create, modify and deploy traffic management variables and strategies using a map-based interface.	Planned
WisDOT_Signal Ops Group_ASCT Roadside Equipment	This element represents the hardened computer, installed in the traffic cabinet at each local intersection that holds all the artificial intelligence of an adaptive signal control technology. This element would gather and calculate detection information from sources such as video detection, loops and pedestrian intercepts and then determine the service priority for each approach. This element would communicate with the existing traffic controller to adjust to changes in demand on a real-time, proactive basis.	Planned
WisDOT_Signal Ops Group_ATMS	The Wisconsin Department of Transportation Signal Operations group is responsible for state highway traffic signal operation in Southeastern Wisconsin. However, not all signals on state highways in southeastern Wisconsin are maintained and operated by the signal ops group. The Signal Ops group is the chief operator of the ICOP signal system in SE Wisconsin. The system links traffic sensors and detectors from state, county, and city signals for coordinated traffic control. The only roadway where ICOP has been deployed is Layton Ave. on Milwaukee's south side.	Existing
WisDOT_Signal Ops Group_Personnel	This element represents the human operator working at WisDOT's SE Region Headquarters facility who manages and controls roadway equipment both from the Headquarters facility and remotely via a portable personal computer.	Existing

ITS Element	ITS Element Description	Status
WisDOT_Signal Ops Group_Roadway Equip	This element represents the equipment distributed on and along the roadway that monitors and controls traffic. This equipment includes traffic signal equipment (e.g., signal heads, controllers, signal pre-emption and detection) that is operated and maintained by WisDOT's Signal Operations Group.	Existing
x-Emergency Vehicles	This element represents a range of vehicles including those operated by police, fire, and emergency medical services. It includes ITS equipment that provides the sensory, processing, storage, and communications functions necessary to support safe and efficient emergency response.	Existing

3.2.3 ITS Functions and Service Areas

Service Packages (i.e., service areas) are tailored groupings of subsystems, terminators, and information flows that are needed to deliver a desired transportation service (e.g., Network Surveillance). Service Packages work separately, or in combination to address real-world transportation needs and desires.

The National ITS Architecture identifies 97 service packages that are categorized into the following eight general services areas:

- Archived Data Management
- Public Transportation
- Traveler Information
- Traffic Management
- Vehicle Safety
- Commercial Vehicle Operations
- Emergency Management
- Maintenance and Control Management

Table 5 shows all 97 service packages defined by the National ITS Architecture. This represents all possible service areas that ITS technologies could potentially support at present time. The Statewide ITS Architecture and the Zoo corridor PITSA can be viewed as subsets of the National ITS architecture. The (●) in Table 5 indicates that the service package is applicable to the Statewide ITS Architecture. The Zoo corridor ICM is a sub set of the Statewide ITS Architecture. The (●) indicates the service packages that are applicable to the Zoo Corridor ICM Project. Service packages that are applicable to the ICM project are described below.

Table 5: National ITS Architecture Service Areas and Service Packages Applicable to the Zoo Corridors ICM Project

Archived Data Management Service Area			Traffic Management		
	●	ITS Data Mart	●	●	Network Surveillance
●		ITS Data Warehouse	●		Traffic Probe Surveillance
●		ITS Virtual Data Warehouse	●	●	Traffic Signal Control
Public Transportation Service Area			●		Traffic Metering
●		Transit Vehicle Tracking	●		HOV Lane Management
●		Transit Fixed-Route Operations	●	●	Traffic Information Dissemination
●		Demand Response Transit Operations	●	●	Regional Traffic Management
●		Transit Fare Collection Management	●	●	Traffic Incident Management System
●		Transit Security	●		Transportation Decision Support and Demand Mngt.
●		Transit Fleet Management			Electronic Toll Collection
●		Multi-modal Coordination	●		Emissions Monitoring and Management
●		Transit Traveler Information			Roadside Lighting System Control
		Transit Signal Priority	●		Standard Railroad Grade Crossing
		Transit Passenger Counting	●		Advanced Railroad Grade Crossing
		Multimodal Connection Protection			Railroad Operations Coordination
Traveler Information			●		Parking Facility Management
●		Broadcast Traveler Information	●		Regional Parking Management
●	●	Interactive Traveler Information	●		Reversible Lane Management
		Autonomous Route Guidance	●		Speed Warning and Enforcement
		Dynamic Route Guidance	●		Drawbridge Management
●		ISP Based Trip Planning and Route Guidance	●		Roadway Closure Management
		Transportation Operations Data Sharing			Variable Speed Limits
●		Traveler Services Information and Reservation			Dynamic Lane Management and Shoulder Use
●		Dynamic Ridesharing			Dynamic Roadway Warning
		In Vehicle Signing			VMT Road User Payment
		Short Range Communications Traveler Information			Mixed Use Warning Systems
Vehicle Safety			Commercial Vehicle Operations		
		Vehicle Safety Monitoring			Carrier Operations and Fleet Management

		Driver Safety Monitoring			Freight Administration
		Longitudinal Safety Warning	●		Electronic Clearance
		Lateral Safety Warning	●		CV Administration Processes
●		Intersection Safety Warning			International Border electronic Clearance
		Pre-crash Restraint Deployment	●		Weigh-In-Motion
		Driver Visibility Improvement	●		Roadside CVO Safety
		Advanced Vehicle Longitudinal Control			On-board CVO Safety
		Advanced Vehicle Lateral Control			CVO Fleet Maintenance
		Intersection Collision Avoidance	●		HAZMAT Management
		Automated Vehicle Operations			Roadside HAZMAT Security Detection and Mitigation
		Cooperative Vehicle Safety Systems			CV Driver Security Authentication
Maintenance & Construction Management					Freight Assignment Tracking
●		Maint. & Constr. Vehicle and Equipment Tracking	**Emergency Management**		
●		Maint. & Constr. Vehicle Maintenance	●		Emergency Call-Taking and Dispatch
●		Road Weather Data Collection	●	●	Emergency Routing
●		Weather Information Processing and Distribution	●		Mayday and Alarms Support
●		Roadway Automated Treatment	●		Roadway Service Patrols
●		Winter Maintenance	●		Transportation Infrastructure Protection
●		Roadway Maintenance and Construction	●		Wide-Area Alert
●		Work Zone Management	●		Early Warning System
		Work Zone Safety Monitoring	●		Disaster Response and Recovery
●		Maintenance and Construction Activity Coordination	●		Evacuation and Reentry Management
		Environmental Probe Surveillance	●		Disaster Traveler Information
		Infrastructure Monitoring			
●	Currently Reflected within the Regional ITS Architecture				
● (green)	Applicable to Project				

ITS Data Mart

This service package provides a focused archive that houses data collected and owned by a single agency (e.g., WisDOT). This focused archive typically includes data covering a single transportation mode and one jurisdiction that is collected from an operational data store and archived for future use. It provides the basic data quality, data privacy, and meta data management common to all ITS archives and provides general query and report access to archive data users. This service package will archive the data collected by traffic signal controllers that are part of the ICM system (at least initially) for later use in performance measurement. The number of traffic signal controllers included in the service package may be expanded over time.

Interactive Traveler Information

This service package provides tailored information in response to a traveler request. Both real-time interactive request/response systems and information systems that "push" a tailored stream of information to the traveler based on a submitted profile are supported. The traveler can obtain current information regarding traffic conditions, roadway maintenance and construction, and detours. Although the Internet is the predominate network used for traveler information dissemination, a range of two-way wide-area wireless and fixed-point to fixed-point communications systems may be used to support the required data communications between the traveler and Information Service Provider. A variety of interactive devices may be used by the traveler to access information prior to a trip or en route including phones via a 511-like portal and web pages via kiosk, personal smart phones, personal computers, and a variety of in-vehicle devices. Successful deployment of this service package relies on availability of real-time transportation data from roadway instrumentation or other means. A traveler may also input personal preferences and identification information via a "traveler card" that can convey information to the system about the traveler as well as receive updates from the system so the card can be updated over time.

Network Surveillance

This service package includes traffic detectors, other surveillance equipment, the supporting field equipment, and fixed-point to fixed-point communications to transmit collected data back to the STOC. The derived data can be used locally such as when traffic detectors are connected directly to a signal control system or remotely (e.g., when a CCTV camera system transmits video to the STOC). The data generated by this service package enables traffic managers to monitor traffic and road conditions, identify and verify incidents, detect faults in indicator operations, and collect needed data for traffic strategy development and long range planning. The collected data can also be analyzed and made available to users and provided to information service providers.

Traffic Signal Control

This service package provides the central control and monitoring equipment, detectors, communication links, and the signal control equipment that support traffic control at signalized intersections. A range of traffic signal control systems are represented by this service package ranging from fixed-schedule control systems to fully traffic responsive systems that dynamically adjust control plans and strategies based on current traffic conditions and priority requests. This service package is generally an intra-jurisdictional package. Systems that achieve coordination across jurisdictions by using a common time base or other strategies that do not require real time coordination would also be represented by this package. Coordination of traffic signal systems using real-time communications is covered in the Regional Traffic Management service package. This service package is consistent with typical traffic signal control systems.

Traffic Information Dissemination

This service package provides driver information using roadway equipment such as dynamic message signs deployed along the ICM arterial roadways. A wide range of information can be disseminated including traffic and road conditions, closure and detour information, travel restrictions, incident information, and emergency alerts and driver advisories. This package provides information to drivers at specific equipped locations on the road network. Careful placement of the roadway equipment provides the information at points in the network where the drivers have recourse and can tailor their routes to account for the new information.

Regional Traffic Management

This service package provides for the sharing of traffic information and control among traffic management centers to support regional traffic management strategies. Regional traffic management strategies that are supported include inter-jurisdictional, real-time coordinated traffic signal control systems and coordination between freeway operations and traffic signal control within a corridor. This service package provides the communications links and integrated control strategies that enable integrated, inter-jurisdictional traffic management. The nature of optimization and extent of information and control sharing is determined through working arrangements between jurisdictions. Several levels of coordination are supported from sharing of information through sharing of control between traffic management centers.

Traffic Incident Management System

This service package manages both unexpected incidents and planned events so that the impact to the transportation network and traveler safety is minimized. The service package includes incident detection capabilities through roadside surveillance devices (e.g., CCTV cameras) and through regional coordination with other traffic and incident management agencies. Information from these agencies are collected and correlated by this service package to detect and verify incidents and implement an appropriate response. This service package supports traffic operations personnel in developing an appropriate response in coordination with emergency management, maintenance and construction management, and other incident response personnel to confirmed incidents. The response may include traffic control strategy modifications or resource coordination between center subsystems. Incident response also includes presentation of information to affected travelers using the Traffic Information Dissemination service package and dissemination of incident information to travelers through the Broadcast Traveler Information or Interactive Traveler Information service packages. The roadside equipment used to detect and verify incidents also allows the operator to monitor incident status as the response unfolds. The coordination with emergency management might be through a computer aided dispatch (CAD) system or through other communication with emergency field personnel. The coordination can also extend to tow trucks and other allied response agencies and field service personnel.

Emergency Routing

This service package supports automated vehicle location and dynamic routing of emergency vehicles. Special priority or other specific emergency traffic control strategies can be coordinated to improve the safety and time-efficiency of responding vehicle travel on the selected route(s). The Emergency Vehicle may also be equipped with dedicated short range communications for local signal preemption and the transmission of alerts to surrounding vehicles. The project includes local emergency vehicle preemption along a number of ICM arterials.

3.2.4 System Interfaces

System interfaces are the communications paths that carry information between subsystems and terminators. A system-to-system interface may consist of one or many information flows, and communication may occur via one or more of the following methods:

- Wide area wireless communications
- Fixed-point to fixed-point communications
- Dedicated short range communications
- Vehicle-to-vehicle communications

Table 6 provides the system-to-system interfaces that will be required of the ICM project. **Figure 2** illustrates this information and shows how each subsystem or terminator interfaces with other ICM-related elements. Since the project ITS architecture is a high-level planning document, it does not specify a design for the system or how communication will occur.

3.2.5 System Information Flows

System information flows are the information or data that are exchanged between ITS subsystems or between ITS subsystems and terminators (i.e., the data that flow across a system interface). In providing this data, information flows help to satisfy, in part or wholly a transportation service. Interfaces and information flows applicable to the ICM project are illustrated in **Figure 3**. Due to the complexity of **Figure 3**, information flows are broken down by individual ITS element and by project-applicable service package and illustrated in the figures in Appendix A and Appendix B, respectively. **Figure 3** is for illustrative purposes only and should be printed out within the Turbo Architecture software program to be legible. All system information flows are summarized in Table 7. Flows already included within the Statewide ITS Architecture are labeled as "true" in the column labeled "Flow in State Arch.". Flows labeled "false" are not currently reflected in the Statewide ITS Architecture and will be added to the Statewide Architecture when the PITSA is merged with it. Information flow definitions are provided in Appendix C.

Table 6: System-to-System Interfaces

Element 1	Element 2
Local Municipalities_Traffic Signal Equipment	Public_Drivers
Local Municipalities_Traffic Signal Equipment	Roadway Traffic
Local Municipalities_Traffic Signal Equipment	WisDOT_DTSD_BTO_STOC_ATMS
Local Municipalities_Traffic Signal Equipment	WisDOT_Signal Ops Group_ASCT Roadside Equipment
Local Municipalities_Traffic Signal Equipment	WisDOT_Signal Ops Group_ATMS
Local Municipalities_Traffic Signal Equipment	WisDOT_Signal Ops Group_Roadway Equip
Local Municipalities_Traffic Signal Equipment	x-Emergency Vehicles
Public_Drivers	WisDOT_DTSD_BTO_STOC_Roadway Equip
Public_Drivers	WisDOT_DTSD_BTO_STOC_Roadway Equip_DMS
Public_Drivers	WisDOT_Signal Ops Group_Roadway Equip
Roadway Traffic	WisDOT_Signal Ops Group_ASCT Roadside Equipment
Roadway Traffic	WisDOT_Signal Ops Group_Roadway Equip
Special Event Promoters	WisDOT_DTSD_BTO_STOC_ATMS
User Personal Computing Devices	WisDOT_DTSD_BTO_STOC_511 Telephony
User Personal Computing Devices	WisDOT_DTSD_BTO_STOC_511 Website
WisDOT_DTSD_BTO_STOC_511 System	WisDOT_DTSD_BTO_STOC_511 Telephony
WisDOT_DTSD_BTO_STOC_511 System	WisDOT_DTSD_BTO_STOC_511 Website
WisDOT_DTSD_BTO_STOC_511 System	WisDOT_DTSD_BTO_STOC_ATMS
WisDOT_DTSD_BTO_STOC_ATMS	WisDOT_DTSD_BTO_STOC_Personnel
WisDOT_DTSD_BTO_STOC_ATMS	WisDOT_DTSD_BTO_STOC_Roadway Equip
WisDOT_DTSD_BTO_STOC_ATMS	WisDOT_DTSD_BTO_STOC_Roadway Equip_CCTV
WisDOT_DTSD_BTO_STOC_ATMS	WisDOT_DTSD_BTO_STOC_Roadway Equip_DMS

Element 1	Element 2
WisDOT_DTSD_BTO_STOC_ATMS	WisDOT_Signal Ops Group_ASCT Roadside Equipment
WisDOT_DTSD_BTO_STOC_ATMS	WisDOT_Signal Ops Group_Roadway Equip
WisDOT_Signal Ops Group_ASCT Center Equipment	WisDOT_Signal Ops Group_ASCT Roadside Equipment
WisDOT_Signal Ops Group_ASCT Center Equipment	WisDOT_Signal Ops Group_Personnel
WisDOT_Signal Ops Group_ASCT Roadside Equipment	WisDOT_Signal Ops Group_ATMS
WisDOT_Signal Ops Group_ASCT Roadside Equipment	WisDOT_Signal Ops Group_Roadway Equip
WisDOT_Signal Ops Group_ATMS	WisDOT_Signal Ops Group_Personnel
WisDOT_Signal Ops Group_ATMS	WisDOT_Signal Ops Group_Roadway Equip
WisDOT_Signal Ops Group_Roadway Equip	x-Emergency Vehicles

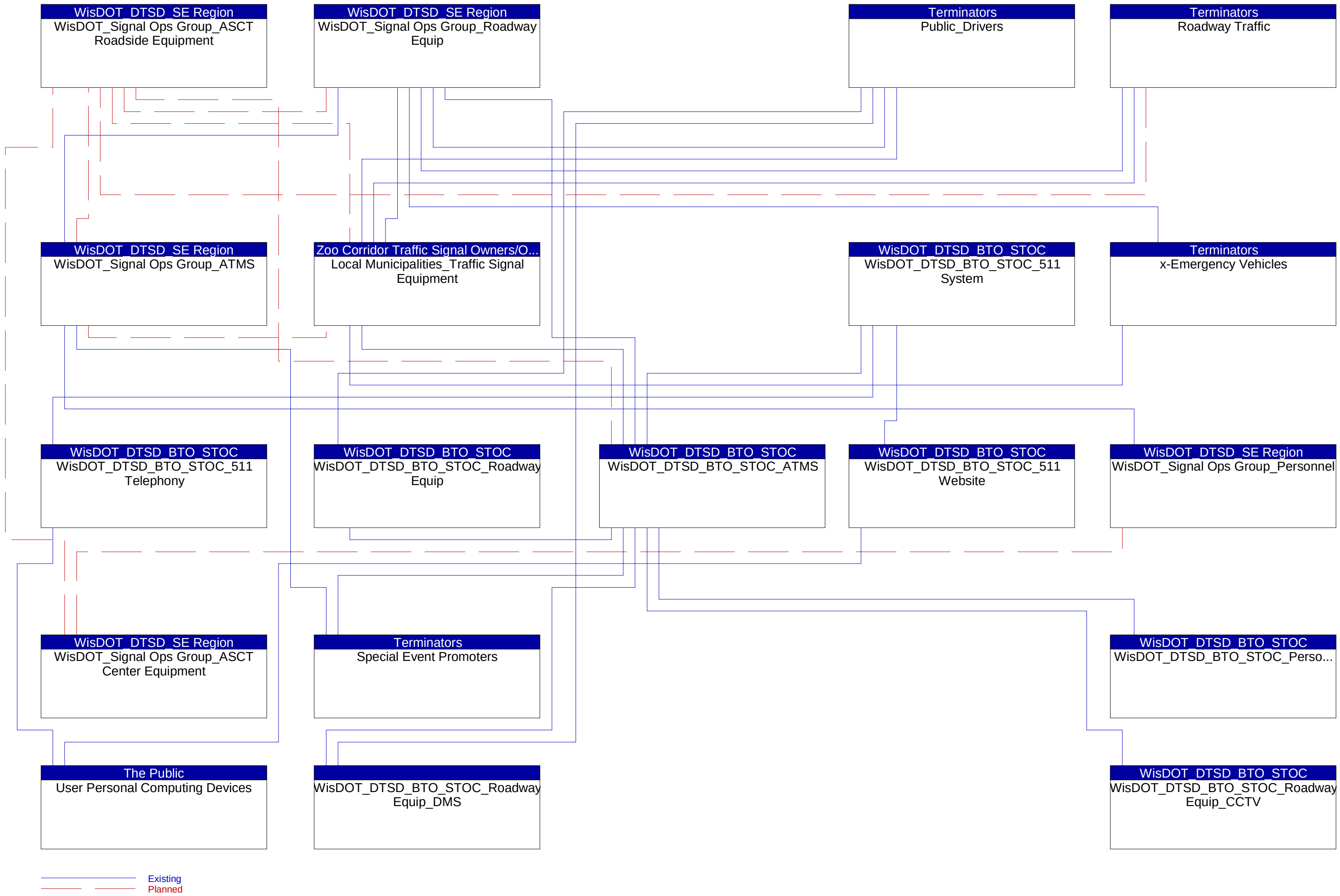


Figure 2: System Interconnect Diagram

Figure 3: Project Architecture Information Flow Diagram

Table 7: System Information Flows

Source Element	Information Flow Name	Destination Element	Flow In State Arch.?
Local Municipalities_Traffic Signal Equipment	driver information	Public_Drivers	FALSE
	signal control data	WisDOT_DTSD_BTO_STOC_ATMS	FALSE
	roadway equipment coordination	WisDOT_Signal Ops Group_ASCT Roadside Equipment	FALSE
	signal control data		FALSE
	right-of-way request notification	WisDOT_Signal Ops Group_ATMS	FALSE
	signal control status		FALSE
	signal fault data		FALSE
	traffic flow		FALSE
	traffic images		FALSE
	roadway equipment coordination	WisDOT_Signal Ops Group_Roadway Equip	FALSE
	signal control data		FALSE
Roadway Traffic	traffic characteristics	Local Municipalities_Traffic Signal Equipment	FALSE
	traffic characteristics	WisDOT_Signal Ops Group_ASCT Roadside Equipment	FALSE
	traffic characteristics	WisDOT_Signal Ops Group_Roadway Equip	FALSE
Special Event Promoters	event plans	WisDOT_DTSD_BTO_STOC_ATMS	FALSE
	event plans	WisDOT_Signal Ops Group_ATMS	FALSE
User Personal Computing Devices	traveler profile	WisDOT_DTSD_BTO_STOC_511 Telephony	FALSE
	traveler request		FALSE
	traveler profile	WisDOT_DTSD_BTO_STOC_511 Website	FALSE
	traveler request		FALSE

Source Element	Information Flow Name	Destination Element	Flow In State Arch.?
WisDOT_DTSD_BTO_STOC_511 System	voice-based traveler information		TRUE
	incident information		TRUE
	road network conditions		FALSE
	traffic images		FALSE
WisDOT_DTSD_BTO_STOC_511 Telephony	interactive traveler information	User Personal Computing Devices	FALSE
	traveler alerts		FALSE
	voice-based traveler request	WisDOT_DTSD_BTO_STOC_511 System	FALSE
WisDOT_DTSD_BTO_STOC_511 Website	interactive traveler information	User Personal Computing Devices	FALSE
	traveler alerts		FALSE
WisDOT_DTSD_BTO_STOC_ATMS	signal control data	Local Municipalities_Traffic Signal Equipment	FALSE
	incident information	WisDOT_DTSD_BTO_STOC_511 System	TRUE
	road network conditions		TRUE
	traffic images		TRUE
	transportation information for operations		TRUE
	traffic operator data	WisDOT_DTSD_BTO_STOC_Personnel	TRUE
	video surveillance control	WisDOT_DTSD_BTO_STOC_Roadway Equip_CCTV	FALSE
	roadway information system data	WisDOT_DTSD_BTO_STOC_Roadway Equip_DMS	FALSE
	signal control commands	WisDOT_Signal Ops Group_ASCT Roadside Equipment	FALSE
	signal control data		FALSE
	signal control data	WisDOT_Signal Ops Group_Roadway Equip	FALSE

Source Element	Information Flow Name	Destination Element	Flow In State Arch.?
WisDOT_DTSD_BTO_STOC_Personnel	traffic operator inputs	WisDOT_DTSD_BTO_STOC_ATMS	TRUE
WisDOT_DTSD_BTO_STOC_Roadway Equip_CCTV	traffic images	WisDOT_DTSD_BTO_STOC_ATMS	FALSE
WisDOT_DTSD_BTO_STOC_Roadway Equip_DMS	driver information	Public_Drivers	FALSE
	roadway information system status	WisDOT_DTSD_BTO_STOC_ATMS	FALSE
WisDOT_Signal Ops Group_ASCT Center Equipment	signal control commands	WisDOT_Signal Ops Group_ASCT Roadside Equipment	FALSE
	signal control device configuration		FALSE
	signal system configuration		FALSE
	traffic sensor control		FALSE
	video surveillance control		FALSE
	traffic operator data	WisDOT_Signal Ops Group_Personnel	FALSE
WisDOT_Signal Ops Group_ASCT Roadside Equipment	roadway equipment coordination	Local Municipalities_Traffic Signal Equipment	FALSE
	signal control data		FALSE
	signal control data	WisDOT_DTSD_BTO_STOC_ATMS	FALSE
	right-of-way request notification	WisDOT_Signal Ops Group_ASCT Center Equipment	FALSE
	signal control status		FALSE
	signal fault data		FALSE
	traffic flow		FALSE
	traffic images		FALSE
	roadside archive data	WisDOT_Signal Ops Group_ATMS	FALSE
	roadway equipment coordination	WisDOT_Signal Ops Group_Roadway Equip	FALSE

Source Element	Information Flow Name	Destination Element	Flow In State Arch.?
	signal control data		FALSE
WisDOT_Signal Ops Group_ATMS	signal control commands	Local Municipalities_Traffic Signal Equipment	FALSE
	signal control device configuration		FALSE
	signal control plans		FALSE
	signal system configuration		FALSE
	traffic sensor control		FALSE
	video surveillance control		FALSE
	data collection and monitoring control	WisDOT_Signal Ops Group_ASCT Roadside Equipment	FALSE
	signal control commands		FALSE
	traffic operator data	WisDOT_Signal Ops Group_Personnel	FALSE
	data collection and monitoring control	WisDOT_Signal Ops Group_Roadway Equip	FALSE
	signal control commands		TRUE
	signal control device configuration		TRUE
	signal control plans		TRUE
	signal system configuration		TRUE
	traffic sensor control		TRUE
	video surveillance control		TRUE
WisDOT_Signal Ops Group_Personnel	traffic operator inputs	WisDOT_Signal Ops Group_ASCT Center Equipment	FALSE
	traffic operator inputs	WisDOT_Signal Ops Group_ATMS	FALSE
WisDOT_Signal Ops Group_Roadway Equip	roadway equipment coordination	Local Municipalities_Traffic Signal Equipment	FALSE

Source Element	Information Flow Name	Destination Element	Flow In State Arch.?
	signal control data		FALSE
	driver information	Public_Drivers	FALSE
	signal control data	WisDOT_DTSD_BTO_STOC_ATMS	FALSE
	roadway equipment coordination	WisDOT_Signal Ops Group_ASCT Roadside Equipment	FALSE
	signal control data		FALSE
	right-of-way request notification	WisDOT_Signal Ops Group_ATMS	TRUE
	roadside archive data		FALSE
	signal control status		TRUE
	signal fault data		TRUE
	traffic flow		TRUE
	traffic images		TRUE
x-Emergency Vehicles	local signal preemption request	Local Municipalities_Traffic Signal Equipment	FALSE
	local signal preemption request	WisDOT_Signal Ops Group_Roadway Equip	FALSE

Existing Flow
Planned Flow

SECTION 4

Participating Agencies Roles and Responsibilities

In terms of project ITS architecture development, the term “stakeholder” includes only those agencies that have a role in the installation, operation or maintenance of ITS elements. This includes any agency that may collect, contribute, convey, process, or distribute information associated with the system. The key stakeholders of this project include:

- WisDOT’s Division of Transportation System Development, Bureau of Traffic Operations, Statewide Traffic Operations Center,
- WisDOT’s Division of Transportation System Development, SE Region
- Cities, Towns, and Villages located within the project limits.

Because there are many local entities that own, operate and maintain traffic signals within the project limits, a many-to-one relationship was defined within the project ITS architecture. Local cities, villages and counties were grouped together and mapped to a singular new stakeholder named “Zoo Corridor Traffic Signal Owners/Operators”. Defining this many-to-one relationship reduces complexity and simplifies understanding and maintainability of the architecture. All project stakeholders and their associated mapping to ITS elements are identified in **Table 8**. Where feasible, existing naming conventions used in the Statewide ITS Architecture were carried forth to this project to name stakeholders and their associated ITS elements.

Table 8: Project Stakeholders and Project Architecture Mapping

Stakeholder Name	Stakeholder Description	Associated ITS Element Mapping(s)
Terminators	No specific stakeholder. These represent the boundaries of the regional ITS architecture and may not have an associated stakeholder.	• Public_Drivers • Roadway Traffic • Special Event Promoters • x-Emergency Vehicles
The Public	This stakeholder represents the general population of individuals that use the transportation system.	• User Personal Computing Devices
WisDOT_DTSD_BTO_STOC	Wisconsin Department of Transportation – Division of Transportation System Development: Bureau of Traffic Operations, Statewide Traffic Operations Center. Statewide Traffic Operations Center Milwaukee-Area Traffic Operations Center 633 W. Wisconsin Avenue, Suite 1200 Milwaukee, Wisconsin 53203 Phone: (414) 227-2166	• WisDOT_DTSD_BTO_STOC_511 System • WisDOT_DTSD_BTO_STOC_511 Telephony • WisDOT_DTSD_BTO_STOC_511 Website • WisDOT_DTSD_BTO_STOC_ATMS • WisDOT_DTSD_BTO_STOC_Personnel • WisDOT_DTSD_BTO_STOC_Roadway Equip_CCTV • WisDOT_DTSD_BTO_STOC_Roadway Equip_DMS
WisDOT_DTSD_SE Region	WisDOT Southeast Region Office (formerly District 2). 2000 Pewaukee Road, Waukesha, WI 53187-0798.	• WisDOT_Signal Ops Group_ASCT Center Equipment • WisDOT_Signal Ops Group_ASCT Roadside Equipment • WisDOT_Signal Ops Group_ATMS • WisDOT_Signal Ops Group_Personnel • WisDOT_Signal Ops Group_Roadway Equip
Zoo Corridor Traffic Signal Owners/Operators	This stakeholder group consists of all local municipalities, villages, towns and counties that own and operate traffic signals within the Zoo Corridors project limits. Includes the following individual stakeholders: • City of Brookfield • City of New Berlin • City of Wauwatosa	• Local Municipalities_Traffic Signal Equipment

Stakeholder Name	Stakeholder Description	Associated ITS Element Mapping(s)
	• City of West Allis • City of Milwaukee • Waukesha County • Town of Brookfield • Village of Elm Grove	

4.1 High-level Stakeholder Roles and Responsibilities

Table 9 lists project stakeholders, the associated ITS equipment they own and operate and their high-level responsibilities pertaining to that equipment. The Operations Plan will describe stakeholder roles and responsibilities in greater detail.

Table 9: High-level Stakeholder Roles and Responsibilities

Stakeholder	Associated ITS Element	Roles and Responsibilities
WisDOT_Signal Ops Group	ASCT Roadside Equipment	• Install, configure, operate and maintain • Monitor for system errors and failures • Purchase and retain spare parts • Perform preventative and responsive maintenance • Work with system vendor to expedite initial system deployment and subsequent system fixes (under warranty period) • Coordinate installation and maintenance activities with traffic signal owners/operators • Configure and tweak video detectors to ensure most effective operation • Work with vendor to be trained on effective system operation and set up • Work with vendor during on maintenance issues as they occur during

Stakeholder	Associated ITS Element	Roles and Responsibilities
		maintenance period.
WisDOT_DTSD_BTO_STOC	ATMS	• Operate and maintain • Integrate new ICM equipment (arterial CCTV/DMS and sensors) into the existing ATMS • Use ATMS to monitor and operate new ICM equipment • Coordinate with 911, law enforcement, and emergency centers for incident management • Distribute travel time and advisory information using available outlets (web, media, hybrid DMS, etc.) • Coordinate and distribute special event information and alerts • Enter incident and alternate route information
WisDOT_Signal Ops Group	ATMS	• Install, operate and maintain • Use ATMS to monitor and operate State's traffic signal assets
WisDOT_Signal Ops Group	ASCT Center Equipment	• Install, operate, monitor and maintain • Monitor for system errors and failures • Integrate new in-field traffic signal equipment • Work with system vendor to expedite initial software installation and subsequent fixes (under warranty period) • Work with software vendor to ensure proper configuration management prior to end of warranty period. • Work with vendor to be trained on effective system operation and set up
Zoo Corridor Traffic Signal Owners/Operators	Traffic Signal Equipment	• Install and operate existing traffic signal equipment (controllers and signals) • Monitor the operational status of traffic signal controllers • Perform preventative and responsive maintenance of traffic signal controllers (excluding adaptive traffic signal system components).

Stakeholder	Associated ITS Element	Roles and Responsibilities
		• Collect and store traffic detector data (existing detection) • Share detector data with other agencies for regional traffic incident management planning • Oversee the installation of InSync Video Detection and InSync processors • Local traffic signal owners will have a license for the adaptive central software that can be used to monitor adaptive signal operations. • Coordinate with partner agencies on issues affecting traffic signal controllers.
WisDOT_DTSD_BTO_STOC	Roadway Equip_DMS	• Install, operate, monitor and maintain arterial DMS (full matrix and Hybrid) • Monitor the operational status of signs • Compose and post messages to DMS • Remove messages per STOC guidelines • Perform preventative and responsive maintenance • Install and operate state owned traffic signals • Control state-owned traffic signal system • Monitor operational status of state owned traffic signal equipment • Coordinate traffic signal operations with local jurisdictions and other State DOT agencies • Exchange traffic signal data and information with local jurisdictions and other State DOT agencies • Perform preventative and responsive maintenance
WisDOT_DTSD_BTO_STOC	Roadway Equip_CCTV	• Install, operate, monitor and maintain • Monitor operational status and respond to detected errors • Monitor video images to detect traffic incidents • Monitor video images to detect changes in road surface conditions or

Stakeholder	Associated ITS Element	Roles and Responsibilities
		other conditions that may impact the flow of traffic. • From CCTV video and images, provide incident details to partner agencies • Respond to partner agency requests for information as needed and available • Collect and store camera images and video • Perform preventative and responsive maintenance • Monitor images to improve traffic signal operations and fine tune adaptive traffic signal control operations.

SECTION 5
System Requirements

ITS functional requirements drive development of ITS elements by specifically stating what ITS elements must do to deliver transportation services and satisfy user needs and issues.

5.1 High-level Requirements

The overall Zoo ICM project has several high-level requirements that are applicable to the adaptive traffic signal system. They are:

1. The system must be implemented no later than 2014 and be operational in 2015,
2. The system must be affordable and must not require additional funding outside of the total ICM budget of $10 million,
3. The system must have proven deployments in the U.S,
4. The system must be compatible with existing signal equipment, and
5. The system must be cost effective – providing the most benefit with the lowest cost.

Requirements are organized by their respective functional area. **Table 10** provides a listing of applicable ITS functional areas from the National ITS architecture that apply to the project and a mapping of the project ITS elements that apply to each functional area. **Table 11** provides the applicable functional requirements for each ITS element. These requirements provide a starting point for defining projects and developing detailed functional requirements. Requirements are also used to verify that ITS elements are designed and built correctly.

Table 10: Mapping of ITS Elements to ITS Functional Areas

Functional Area	Functional Area Description	Element Mapping
Collect Traffic Surveillance	Management of traffic sensors and surveillance (CCTV) equipment, collection of current traffic conditions, and distribution of the collected information to other centers and operators.	WisDOT_DTSD_BTO_STOC_ATMS WisDOT_Signal Ops Group_ASCT Center Equipment
Field Management Stations Operation	Supports direct communications between field management stations and the local field equipment under their control.	Local Municipalities_Traffic Signal Equipment WisDOT_Signal Ops Group_ASCT Roadside Equipment WisDOT_Signal Ops Group_Roadway Equip
Interactive Infrastructure Information	Personalized dissemination of traffic, transit, maintenance and construction, multimodal, event, and weather information to traveler interface systems and vehicles, upon request.	WisDOT_DTSD_BTO_STOC_511 System WisDOT_DTSD_BTO_STOC_511 Telephony WisDOT_DTSD_BTO_STOC_511 Website
ISP Traveler Data Collection	Collects traveler information from other centers, consolidates and refines the collected data, and makes this data available to traveler information applications.	WisDOT_DTSD_BTO_STOC_511 System WisDOT_DTSD_BTO_STOC_ATMS
ISP Traveler Information Alerts	Provides personalized traveler information alerts, notifying travelers of relevant congestion, incidents, transit schedule delays, and other actionable information that may impact a trip. Relevant alerts are selected based on user-configurable parameters and thresholds.	WisDOT_DTSD_BTO_STOC_511 System WisDOT_DTSD_BTO_STOC_511 Telephony WisDOT_DTSD_BTO_STOC_511 Website
On-board EV En Route Support	On-board systems for gathering of dispatch and routing information for emergency vehicle personnel, vehicle tracking, communications with care facilities, and signal preemption via short range communication directly with traffic control	x-Emergency Vehicles

Functional Area	Functional Area Description	Element Mapping
	equipment at the roadside.	
Personal Interactive Information Reception	Personal traveler interface that provides traffic, transit, yellow pages, event, and trip planning information, and other personalized traveler information services upon request. Devices include personal computers and personal portable devices such as PDAs.	User Personal Computing Devices
Roadway Basic Surveillance	Field elements that monitor traffic conditions using loop detectors and CCTV cameras.	Local Municipalities_Traffic Signal Equipment WisDOT_DTSD_BTO_STOC_Roadway Equip_CCTV WisDOT_Signal Ops Group_ASCT Roadside Equipment WisDOT_Signal Ops Group_Roadway Equip
Roadway Data Collection	Field elements to collect traffic, road, and environmental conditions information for use in transportation planning, research, and other off-line applications. Includes the sensors, supporting roadside infrastructure, and communications equipment.	Local Municipalities_Traffic Signal Equipment WisDOT_Signal Ops Group_ASCT Roadside Equipment WisDOT_Signal Ops Group_Roadway Equip
Roadway Equipment Coordination	Field elements that control and send data to other field elements (such as environmental sensors that send data to a DMS or coordination between traffic controllers on adjacent intersections), without center control.	Local Municipalities_Traffic Signal Equipment WisDOT_Signal Ops Group_ASCT Roadside Equipment WisDOT_Signal Ops Group_Roadway Equip
Roadway Field Device Monitoring	Monitors field equipment operational status and detects and reports fault conditions. Device status, configuration, and fault information are provided to a remote center and a user interface provides information locally to field personnel.	Local Municipalities_Traffic Signal Equipment WisDOT_Signal Ops Group_ASCT Roadside Equipment WisDOT_Signal Ops Group_Roadway Equip WisDOT_DTSD_BTO_STOC_Roadway Equip_CCTV WisDOT_DTSD_BTO_STOC_Roadway Equip_DMS

Functional Area	Functional Area Description	Element Mapping
Roadway Incident Detection	Field elements that monitor traffic conditions to identify incidents. It includes traffic detectors that collect traffic flow information and identify unusual traffic conditions and advanced CCTV cameras with built-in incident detection algorithms.	WisDOT_DTSD_BTO_STOC_Roadway Equip_CCTV WisDOT_Signal Ops Group_ASCT Roadside Equipment
Roadway Signal Controls	Field elements including traffic signal controllers for use at signalized intersections; also supports pedestrian crossings.	Local Municipalities_Traffic Signal Equipment WisDOT_Signal Ops Group_ASCT Roadside Equipment WisDOT_Signal Ops Group_Roadway Equip
Roadway Traffic Signal Preemption	Field elements that receive signal preemption requests from approaching emergency vehicles and overrides the current operation of the traffic signals	Local Municipalities_Traffic Signal Equipment WisDOT_Signal Ops Group_Roadway Equip
Roadway Traffic Information Dissemination	Driver information systems, such as dynamic message signs and HAR).	WisDOT_DTSD_BTO_STOC_Roadway Equip_DMS
TMC Incident Detection	Remotely monitors traffic sensor and surveillance systems to detect and verify incidents. Also monitors external advisory and incident reporting systems, intermodal freight depots, and border crossings for additional incident information. Identified incidents are reported to operations personnel and other centers.	WisDOT_DTSD_BTO_STOC_ATMS WisDOT_Signal Ops Group_ASCT Center Equipment WisDOT_Signal Ops Group_ATMS
TMC Signal Control	Remotely controls traffic signal controllers to implement traffic management strategies at signalized intersections based on traffic conditions, incidents, emergency vehicle preemptions, pedestrian crossings, etc.	WisDOT_Signal Ops Group_ASCT Center Equipment WisDOT_Signal Ops Group_ATMS

Functional Area	Functional Area Description	Element Mapping
TMC Traffic Information Dissemination	Controls dissemination of traffic-related data to other centers, the media, and travelers via the driver information systems (DMS, HAR) that it operates.	WisDOT_DTSD_BTO_STOC_ATMS
Traffic and Roadside Data Archival	Collects and archives traffic and environmental information directly from the roadside for use in off-line planning, research, and analysis.	WisDOT_DTSD_BTO_STOC_ATMS WisDOT_Signal Ops Group_ATMS
Traffic Equipment Maintenance	Monitoring and remote diagnostics of field equipment - detect failures, issue problem reports, and track the repair or replacement of the failed equipment.	WisDOT_DTSD_BTO_STOC_ATMS WisDOT_Signal Ops Group_ASCT Center Equipment WisDOT_Signal Ops Group_ATMS
Traveler Telephone Information	Distribution of traveler information and wide-area alerts to traveler telephone information systems such as 511, based on voice-based traveler requests.	WisDOT_DTSD_BTO_STOC_511 System

Table 11: Mapping of ITS Elements to Functional Areas and High-level Requirements

ITS Element	Functional Area Mapping	ID	Requirement
Local Municipalities_Traffic Signal Equipment	Roadway Basic Surveillance	1	The field element shall collect, process, digitize, and send traffic sensor data (speed, volume, and occupancy) to the center for further analysis and storage, under center control.
		4	The field element shall return sensor and CCTV system operational status to the controlling center.
		5	The field element shall return sensor and CCTV system fault data to the controlling center for repair.
	Roadway Signal Controls	1	The field element shall control traffic signals under center

ITS Element	Functional Area Mapping	ID	Requirement
			control.
		2	The field element shall respond to pedestrian crossing requests by accommodating the pedestrian crossing.
		3	The field element shall provide the capability to notify the traffic management center of pedestrian calls and pedestrian accommodations.
		4	The field element shall report the current signal control information to the center.
		5	The field element shall report current preemption status to the center.
		6	The field element shall return traffic signal controller operational status to the center.
		7	The field element shall return traffic signal controller fault data to the center.
		8	The field element shall report current transit priority status to the center.
	Field Management Stations Operation	1	The field management station shall accept configuration information from the center.
		2	The filed management station shall pass data provided by the center to local field devices and report data from the field devices back to the center.
	Roadway Signal Preemption	1	The field element shall respond to signal preemption requests from emergency vehicles.
	Roadway Equipment Coordination	3	The field element shall include devices that provide data and status information to other field element devices without center control.
		4	The field element shall include devices that receive configuration data from other field element devices, without center control.
	Roadway Field Device Monitoring	1	The field element shall monitor the operational status (state of

ITS Element	Functional Area Mapping	ID	Requirement
			the device, configuration, and fault data) of connected sensors (such as traffic, infrastructure, environmental, security, speed) and devices (such as highway advisory radio, dynamic message signs, automated roadway treatment systems, barrier and safeguard systems, cameras, traffic signals, ramp meters, short range communications equipment, security surveillance equipment).
		4	The field element shall include a local interface that provides operational status and fault data for connected field equipment to field personnel.
		5	The field element shall include a local interface that allows field personnel to command diagnostic tests on connected field equipment.
	Roadway Data Collection	1	The field element shall collect traffic, road, and environmental conditions information.
		2	The field element shall include the sensors and supporting roadside devices that sense, collect, and send traffic, road, and environmental conditions information to a center for archival.
		3	The field element shall collect sensor status and sensor faults from roadside equipment and send it along with the recorded data to a center for archival.
User Personal Computing Devices	Personal Interactive Information Reception	1	The personal traveler interface shall receive traffic information from a center and present it to the traveler upon request.
		4	The personal traveler interface shall receive event information from a center and present it to the traveler upon request.
		11	The personal traveler interface shall provide digitized map data to act as the background to the information presented to the traveler.
		12	The personal traveler interface shall support traveler input in audio or manual form.
		13	The personal traveler interface shall present information to the

ITS Element	Functional Area Mapping	ID	Requirement
			traveler in audible or visual forms consistent with a personal device, and suitable for travelers with hearing and vision physical disabilities.
		15	The personal traveler interface shall receive travel alerts and present them to the traveler. Relevant alerts are provided based on pre-supplied trip characteristics and preferences.
		16	The personal traveler interface shall accept personal preferences, recurring trip characteristics, and traveler alert subscription information from the traveler and send this information to a center to support customized traveler information services.
WisDOT_DTSD_BTO_STOC_511 System	ISP Traveler Data Collection	1	The center shall collect, process, and store traffic and highway condition information, including incident information, detours and road closures, event information, recommended routes, and current speeds on specific routes.
		7	The center shall collect, process, and store event information.
	ISP Traveler Information Alerts	1	The center shall accept traveler profiles that establish recurring trip characteristics including route, mode, and timeframe information.
		3	The center shall disseminate personalized traffic alerts reporting congestion, incidents, delays, detours and road closures that may impact a current or planned trip.
	Interactive Infrastructure Information	1	The center shall disseminate customized traffic and highway condition information to travelers, including incident information, detours and road closures, recommended routes, and current speeds on specific routes upon request.
		8	The center shall disseminate customized event information to travelers upon request.
		11	The center shall accept traveler profiles for determining the type of personalized data to send to the traveler.
	Traveler Telephone Information	1	The center shall provide the capability to process voice-

ITS Element	Functional Area Mapping	ID	Requirement
			formatted requests for traveler information from a traveler telephone information system, and return the information in the requested format.
		2	The center shall provide the capability to process dual-tone multifrequency (DTMF)-based requests (touch-tone) for traveler information from a traveler telephone information system.
		3	The center shall provide the capability to process traveler information requests from a traveler telephone information system.
		4	The center shall provide information on traffic conditions in the requested voice format and for the requested location.
		7	The center shall provide weather and event information in the requested voice format and for the requested location.
WisDOT_DTSD_BTO_STOC_511 Telephony	ISP Traveler Information Alerts	1	The center shall accept traveler profiles that establish recurring trip characteristics including route, mode, and timeframe information.
		3	The center shall disseminate personalized traffic alerts reporting congestion, incidents, delays, detours and road closures that may impact a current or planned trip.
	Interactive Infrastructure Information	1	The center shall disseminate customized traffic and highway condition information to travelers, including incident information, detours and road closures, recommended routes, and current speeds on specific routes upon request.
		8	The center shall disseminate customized event information to travelers upon request.
		11	The center shall accept traveler profiles for determining the type of personalized data to send to the traveler.
WisDOT_DTSD_BTO_STOC_511 Website	ISP Traveler Information Alerts	1	The center shall accept traveler profiles that establish recurring trip characteristics including route, mode, and timeframe information.
		3	The center shall disseminate personalized traffic alerts reporting

ITS Element	Functional Area Mapping	ID	Requirement
			congestion, incidents, delays, detours and road closures that may impact a current or planned trip.
	Interactive Infrastructure Information	1	The center shall disseminate customized traffic and highway condition information to travelers, including incident information, detours and road closures, recommended routes, and current speeds on specific routes upon request.
		8	The center shall disseminate customized event information to travelers upon request.
		11	The center shall accept traveler profiles for determining the type of personalized data to send to the traveler.
WisDOT_DTSD_BTO_STOC_ATMS	Traffic and Roadside Data Archival	1	The center shall manage the collection of archive data directly from collection equipment located at the roadside.
		2	The center shall collect traffic sensor information from roadside devices.
		5	The center shall send the request for data and control parameters to the field equipment where the information is collected and returned.
	ISP Traveler Data Collection	1	The center shall collect, process, and store traffic and highway condition information, including incident information, detours and road closures, event information, recommended routes, and current speeds on specific routes.
		2	The center shall collect, process, and store maintenance and construction information, including scheduled maintenance and construction work activities and work zone activities.
		6	The center shall collect, process, and store current and forecast road conditions and surface weather conditions.
		7	The center shall collect, process, and store event information.
	Collect Traffic Surveillance	2	The center shall monitor, analyze, and distribute traffic images from CCTV systems under remote control of the center.
		5	The center shall respond to control data from center personnel

ITS Element	Functional Area Mapping	ID	Requirement
			regarding sensor and surveillance data collection, analysis, storage, and distribution.
		6	The center shall maintain a database of surveillance equipment and sensors and associated data (including the roadway on which they are located, the type of data collected, and the ownership of each)
	TMC Traffic Information Dissemination	1	The center shall remotely control dynamic messages signs for dissemination of traffic and other information to drivers.
		3	The center shall collect operational status for the driver information systems equipment (DMS, HAR, etc.).
	TMC Incident Detection	2	The center shall collect and store traffic flow and image data from the field equipment to detect and verify incidents.
		3	The center shall receive inputs concerning upcoming events that would effect the traffic network from event promoters and traveler information service providers.
		6	The center shall provide road network conditions and traffic images to emergency management centers to support the detection, verification, and classification of incidents.
		7	The center shall provide video and traffic sensor control commands to the field equipment to detect and verify incidents.
	Traffic Equipment Maintenance	1	The center shall collect and store sensor (traffic, pedestrian, multimodal crossing) operational status.
		2	The center shall collect and store CCTV surveillance system (traffic, pedestrian) operational status.
WisDOT_DTSD_BTO_STOC_Roadway Equip_CCTV	Roadway Basic Surveillance	2	The field element shall collect, process, and send traffic images to the center for further analysis and distribution.
		4	The field element shall return sensor and CCTV system operational status to the controlling center.
		5	The field element shall return sensor and CCTV system fault data to the controlling center for repair.

ITS Element	Functional Area Mapping	ID	Requirement
	Roadway Incident Detection	1	The field element shall collect, process, and send traffic images to the center for further analysis and distribution.
		2	The field element shall remotely process video data and provide an indication of potential incidents to the traffic management center.
		3	The field element's video devices shall be remotely controlled by a traffic management center.
		4	The field element shall provide operational status and fault data for the incident detection devices to the traffic management center.
	Roadway Field Device Monitoring	1	The field element shall monitor the operational status (state of the device, configuration, and fault data) of connected sensors (such as traffic, infrastructure, environmental, security, speed) and devices (such as highway advisory radio, dynamic message signs, automated roadway treatment systems, barrier and safeguard systems, cameras, traffic signals, ramp meters, short range communications equipment, security surveillance equipment).
		4	The field element shall include a local interface that provides operational status and fault data for connected field equipment to field personnel.
		5	The field element shall include a local interface that allows field personnel to command diagnostic tests on connected field equipment.
WisDOT_DTSD_BTO_STOC_Roadway Equip_DMS	Roadway Traffic Information Dissemination	1	The field element shall include dynamic messages signs for dissemination of traffic and other information to drivers, under center control; the DMS may be either those that display variable text messages, or those that have fixed format display(s) (e.g. vehicle restrictions, or lane open/close).
		4	The field element shall provide operational status for the driver information systems equipment (DMS, HAR, etc.) to the center.

ITS Element	Functional Area Mapping	ID	Requirement
		5	The field element shall provide fault data for the driver information systems equipment (DMS, HAR, etc.) to the center for repair.
	Roadway Field Device Monitoring	1	The field element shall monitor the operational status (state of the device, configuration, and fault data) of connected sensors (such as traffic, infrastructure, environmental, security, speed) and devices (such as highway advisory radio, dynamic message signs, automated roadway treatment systems, barrier and safeguard systems, cameras, traffic signals, ramp meters, short range communications equipment, security surveillance equipment).
		4	The field element shall include a local interface that provides operational status and fault data for connected field equipment to field personnel.
		5	The field element shall include a local interface that allows field personnel to command diagnostic tests on connected field equipment.
WisDOT_Signal Ops Group_ASCT Center Equipment	Collect Traffic Surveillance	1	The center shall monitor, analyze, and store traffic sensor data (speed, volume, occupancy) collected from field elements under remote control of the center.
		2	The center shall monitor, analyze, and distribute traffic images from CCTV systems under remote control of the center.
		5	The center shall respond to control data from center personnel regarding sensor and surveillance data collection, analysis, storage, and distribution.
		7	The center shall support an interface with a map update provider, or other appropriate data sources, through which updates of digitized map data can be obtained and used as a background for traffic data.
	TMC Signal Control	1	The center shall remotely control traffic signal controllers.
		2	The center shall accept notifications of pedestrian calls.

ITS Element	Functional Area Mapping	ID	Requirement
		3	The center shall collect traffic signal controller operational status and compare against the control information sent by the center.
		4	The center shall collect traffic signal controller fault data from the field.
		5	The center shall manage (define, store and modify) control plans to coordinate signalized intersections, to be engaged at the direction of center personnel or according to a daily schedule.
		6	The center shall implement control plans to coordinate signalized intersections based on data from sensors.
		7	The center shall manage boundaries of the control sections used within the signal system.
		8	The center shall maintain traffic signal coordination including synchronizing clocks throughout the system.
	TMC Incident Detection	2	The center shall collect and store traffic flow and image data from the field equipment to detect and verify incidents.
		7	The center shall provide video and traffic sensor control commands to the field equipment to detect and verify incidents.
WisDOT_Signal Ops Group_ASCT Roadside Equipment	Roadway Basic Surveillance	1	The field element shall collect, process, digitize, and send traffic sensor data (speed, volume, and occupancy) to the center for further analysis and storage, under center control.
		2	The field element shall collect, process, and send traffic images to the center for further analysis and distribution.
		4	The field element shall return sensor and CCTV system operational status to the controlling center.
		5	The field element shall return sensor and CCTV system fault data to the controlling center for repair.
	Roadway Signal Controls	1	The field element shall control traffic signals under center control.

ITS Element	Functional Area Mapping	ID	Requirement
		2	The field element shall respond to pedestrian crossing requests by accommodating the pedestrian crossing.
		3	The field element shall provide the capability to notify the traffic management center of pedestrian calls and pedestrian accommodations.
		4	The field element shall report the current signal control information to the center.
		5	The field element shall report current preemption status to the center.
		6	The field element shall return traffic signal controller operational status to the center.
		7	The field element shall return traffic signal controller fault data to the center.
	Field Management Stations Operation	1	The field management station shall accept configuration information from the center.
		2	The filed management station shall pass data provided by the center to local field devices and report data from the field devices back to the center.
	Roadway Incident Detection	1	The field element shall collect, process, and send traffic images to the center for further analysis and distribution.
		4	The field element shall provide operational status and fault data for the incident detection devices to the traffic management center.
	Roadway Equipment Coordination	1	The field element shall include sensors that provide data and status information to other field element devices, without center control.
		3	The field element shall include devices that provide data and status information to other field element devices without center control.
		4	The field element shall include devices that receive configuration data from other field element devices, without

ITS Element	Functional Area Mapping	ID	Requirement
			center control.
	Roadway Field Device Monitoring	1	The field element shall monitor the operational status (state of the device, configuration, and fault data) of connected sensors (such as traffic, infrastructure, environmental, security, speed) and devices (such as highway advisory radio, dynamic message signs, automated roadway treatment systems, barrier and safeguard systems, cameras, traffic signals, ramp meters, short range communications equipment, security surveillance equipment).
		4	The field element shall include a local interface that provides operational status and fault data for connected field equipment to field personnel.
		5	The field element shall include a local interface that allows field personnel to command diagnostic tests on connected field equipment.
	Roadway Data Collection	1	The field element shall collect traffic, road, and environmental conditions information.
		2	The field element shall include the sensors and supporting roadside devices that sense, collect, and send traffic, road, and environmental conditions information to a center for archival.
		3	The field element shall collect sensor status and sensor faults from roadside equipment and send it along with the recorded data to a center for archival.
WisDOT_Signal Ops Group_ATMS	Traffic and Roadside Data Archival	1	The center shall manage the collection of archive data directly from collection equipment located at the roadside.
		2	The center shall collect traffic sensor information from roadside devices.
		5	The center shall send the request for data and control parameters to the field equipment where the information is collected and returned.
	Collect Traffic Surveillance	1	The center shall monitor, analyze, and store traffic sensor data

ITS Element	Functional Area Mapping	ID	Requirement
			(speed, volume, occupancy) collected from field elements under remote control of the center.
		2	The center shall monitor, analyze, and distribute traffic images from CCTV systems under remote control of the center.
		5	The center shall respond to control data from center personnel regarding sensor and surveillance data collection, analysis, storage, and distribution.
		6	The center shall maintain a database of surveillance equipment and sensors and associated data (including the roadway on which they are located, the type of data collected, and the ownership of each)
	TMC Signal Control	1	The center shall remotely control traffic signal controllers.
		2	The center shall accept notifications of pedestrian calls.
		3	The center shall collect traffic signal controller operational status and compare against the control information sent by the center.
		4	The center shall collect traffic signal controller fault data from the field.
		5	The center shall manage (define, store and modify) control plans to coordinate signalized intersections, to be engaged at the direction of center personnel or according to a daily schedule.
		6	The center shall implement control plans to coordinate signalized intersections based on data from sensors.
		7	The center shall manage boundaries of the control sections used within the signal system.
	TMC Incident Detection	2	The center shall collect and store traffic flow and image data from the field equipment to detect and verify incidents.
		3	The center shall receive inputs concerning upcoming events that would effect the traffic network from event promoters and

ITS Element	Functional Area Mapping	ID	Requirement
			traveler information service providers.
		6	The center shall provide road network conditions and traffic images to emergency management centers to support the detection, verification, and classification of incidents.
		7	The center shall provide video and traffic sensor control commands to the field equipment to detect and verify incidents.
	Traffic Equipment Maintenance	1	The center shall collect and store sensor (traffic, pedestrian, multimodal crossing) operational status.
		2	The center shall collect and store CCTV surveillance system (traffic, pedestrian) operational status.
WisDOT_Signal Ops Group_Roadway Equip	Roadway Basic Surveillance	1	The field element shall collect, process, digitize, and send traffic sensor data (speed, volume, and occupancy) to the center for further analysis and storage, under center control.
		4	The field element shall return sensor and CCTV system operational status to the controlling center.
		5	The field element shall return sensor and CCTV system fault data to the controlling center for repair.
	Roadway Signal Controls	1	The field element shall control traffic signals under center control.
		2	The field element shall respond to pedestrian crossing requests by accommodating the pedestrian crossing.
		3	The field element shall provide the capability to notify the traffic management center of pedestrian calls and pedestrian accommodations.
		4	The field element shall report the current signal control information to the center.
		5	The field element shall report current preemption status to the center.
		6	The field element shall return traffic signal controller operational status to the center.

ITS Element	Functional Area Mapping	ID	Requirement
		7	The field element shall return traffic signal controller fault data to the center.
		8	The field element shall report current transit priority status to the center.
	Field Management Stations Operation	1	The field management station shall accept configuration information from the center.
		2	The filed management station shall pass data provided by the center to local field devices and report data from the field devices back to the center.
	Roadway Signal Preemption	1	The field element shall respond to signal preemption requests from emergency vehicles.
	Roadway Equipment Coordination	3	The field element shall include devices that provide data and status information to other field element devices without center control.
		4	The field element shall include devices that receive configuration data from other field element devices, without center control.
	Roadway Field Device Monitoring	1	The field element shall monitor the operational status (state of the device, configuration, and fault data) of connected sensors (such as traffic, infrastructure, environmental, security, speed) and devices (such as highway advisory radio, dynamic message signs, automated roadway treatment systems, barrier and safeguard systems, cameras, traffic signals, ramp meters, short range communications equipment, security surveillance equipment).
		4	The field element shall include a local interface that provides operational status and fault data for connected field equipment to field personnel.
		5	The field element shall include a local interface that allows field personnel to command diagnostic tests on connected field equipment.

ITS Element	Functional Area Mapping	ID	Requirement
	Roadway Data Collection	1	The field element shall collect traffic, road, and environmental conditions information.
		2	The field element shall include the sensors and supporting roadside devices that sense, collect, and send traffic, road, and environmental conditions information to a center for archival.
		3	The field element shall collect sensor status and sensor faults from roadside equipment and send it along with the recorded data to a center for archival.
x-Emergency Vehicles	On-board EV En Route Support	5	The emergency vehicle shall send requests to traffic signal control equipment at the roadside to preempt the signal.

5.2 Detailed Requirements

Detailed requirements for the adaptive signal control technology are provided as a separate document.

SECTION 6

Analysis of Alternative System Configurations

There are a number of options or configurations for controlling signalized intersections. The existing traffic signal system configurations in place along the Zoo Corridors are limited in their functionality and cannot adequately service the greater volumes and fluctuations in arterial traffic that are expected to occur when construction begins. To this extent, an analysis was undertaken of known traffic signal system configurations to determine the configuration that best meets the needs and operational objectives of the project. The following section summarizes the results of this analysis.

Available traffic signal configurations range from relatively simple pre-timed systems to highly sophisticated fully adaptive traffic signal systems. Pre-timed traffic signal systems are the oldest most proven system configuration, while adaptive is the newest, least proven configuration. In between these two are actuated and full responsive traffic signal systems. **Table 12** provides a summary of the more advanced system configurations that are believed to be most applicable for the Zoo corridors.

Existing traffic signal configurations along the Zoo corridors vary in level of sophistication from pre-timed signals to fully actuated signal systems with radio and fiber optic communications – neither of which will satisfy high-level requirements of the project. Pre-timed signal timing can be efficient during saturated traffic conditions; however, this configuration does not have the ability to respond to dynamic fluctuations in traffic demand. This would likely result in the inefficient allocation of green time to motorists, resulting in lengthy delays when fluctuations in traffic occur. For this reason alone, pre-timed traffic signal configurations were ruled out for this project.

Table 12: Comparison of Alternate System Configurations

Fully Actuated Signal Control Systems	Responsive Signal Control (RSC) Systems	Adaptive Signal Control (ACS) Systems
	General Operations	
• Fully actuated systems modify phases based on detector information, within a pre-determined range of a pre-programmed timing plan.	• RSC systems gather real-time information to select the best timing plan from a library of pre-programmed timing plans.	• ASC systems gather real-time information to optimize timing plans by changing the cycle length, sequence of phases, and offsets between signalized intersections.
	General Information	
• Green time for each phase is determined by traffic volume on the particular approach (min green is given in plans if phase is called) • Maximum green time is predetermined in the signal plans • Vehicles actuate detectors as they approach the intersection and the green phase for that approach is extended up to the max green time (passage time)	• The "library" of timing plans must be developed to consider all scenarios the signal system may have to respond to within any given day throughout the year • The best timing plan is primarily based on traffic volumes, directional distribution, and average vehicle speed information as gathered by the detectors	• Most ASC systems have a min and max boundary for green time • Max boundary is usually defined by software logic for each cycle
	Detectors	

• Fully actuated systems typically use traditional in-pavement loop detectors or video detection
• Detectors are located on both major and minor intersection approaches to detect traffic volumes
• Detectors are typically placed at the stop bar (presence detection) and an upstream location (passage detection)
  • Presence detection - determines if there are vehicle calls for a phase
  • Passage detection - determines if passage time is needed for a phase
	• Mid-block detection is ideal for an RSC system
	• Video or in-pavement loop detection can be used
	• Existing detection infrastructure can be utilized if the system is properly calibrated.
		• ASC systems can use traditional in-pavement loop detection, video detection, or microwave detection based on the system used
		• The placement of detectors within the system can vary from traditional stop bar locations to far upstream locations
		• Depending on the placement, the system can be considered either "reactive" (stop bar) or "proactive" (upstream) in its timing modifications based on the information received.

	Controllers	

• Fully actuated systems can use any one of a number of industry-standard controllers depending on location of the signal and jurisdictional preferences/requirements:
• NEMA
• 2070 ATC
	• RSC systems can use any traditional controller at an intersection
	• A "master" controller is used to select the best timing plan and send it to each individual intersection controller within the system
		• Different ASC systems require different types of controllers
		• Popular controller types (with system) include:
		  • Any existing controllers, supplemented with InSync processor
		  • NEMA (ACS Lite, SCOOT, SCATS)
		  • 2070 ATC (LA ACTS, OPAC, RHODES)
		  • Model 170 (LA ACTS, OPAC, SCATS)

	Pros	
• Fully actuated systems aim to minimize the amount of total delay at an intersection by minimizing the number of stops	• Stop delay at an intersection can be reduced by cycle length selection and split control based on the best timing plan	• ASC systems can adjust signal timings more rapidly and precisely to unanticipated changes in traffic (e.g., accidents,

Fully Actuated Signal Control Systems	Responsive Signal Control (RSC) Systems	Adaptive Signal Control (ACS) Systems
on all phases • Major street avoids unnecessary delays/stops if minor street is not called (i.e., a phase can be skipped if there are no vehicle calls or recall for that particular phase)	selected • Special event timing plans can be utilized by the "master" controller without maintenance having to program it manually. • Can reduce overall travel times and delay • "Master" controller "library" can usually hold upwards of 100+ plans and continue operating during loss of communications to the center	construction, freeway diversion, etc.) than choosing from a traditional library of timing plans • Can reduce overall travel times and delay • Reduces the need for labor-intensive maintenance and updates of traffic signal plans in cabinets • Most ASC systems can or do provide some type of transit priority at intersection controllers.
Cons		
• Timing plans need to be periodically updated to account for changing traffic patterns • Timing plans are generally programmed to be selected based on the time of day and therefore, the selected timing plan may not fit all hours within the timing plan • Fully actuated systems cannot respond to unanticipated situations that may occur (accidents, freeway diversion, etc.), which would change expected traffic patterns.	• Timing plans need to be periodically updated (as with traditional intersection timing plans) to account for changes • RSC systems are, "reactive" to traffic demand and therefore, the "best" timing plans may not fit a given situation optimally	• Requires extensive surveillance (typically video) to make sure system performance is operating acceptably and there are no failures • Synchronized (main) phases sometimes get more green time than necessary, causing unnecessary delay for minor movements. • Lack of universally acceptable computer simulation tools to accurately model operations and effects of an ASC system
Cost		
• Typically cost from $80,000 to $100,000/intersection (including installation).	• Based primarily on "master" controller cost and related infrastructure • Assumed to be less overall then ASC, no cost data found	• Reportedly costs $65,000 per intersection (on average of all ASC systems), in addition to standard equipment costs. • InSync costs the least (on average) at $25,000 per intersection.
Other		

• Fully actuated systems allow phases to terminate early if the phase is not called before the "gap time" expires (aka gapping out).	• RSC systems are a type of "closed loop" system	• Acronyms of ASC systems listed under "Controllers"
		  • InSync – InSync (Rhythm Engineering)
		  • SCATS – Sydney Coordinated Adaptive Traffic System
		  • SCOOT – Split Cycle Offset Optimization Technique
		  • OPAC – Optimization Polices for Adaptive Control
		  • ACS Lite – Adaptive Control System Lite (FHWA)
		  • LA ACTS – Los Angeles Adaptive Control Traffic System
		  • RHODES – Real-time Hierarchical Optimized Distributed and Effective System.

Source: "Adaptive Traffic Control Systems in the United States: Updated Summary and Comparison"

Actuated traffic signals use traffic detectors along with programmed minimum and maximum green times to provide flexibility when assigning green time. During unsaturated conditions, actuated traffic signals provide more efficient operations than pre-timed signals; however, actuated traffic signals are only desirable and efficient if programmed correctly and if expected traffic volumes are predictable.

Over the three-year course of construction, there is expected to be dozens of construction phases. Depending on each phase, and subsequent resulting impacts of construction, traffic may seek a number of available alternate routes. As construction moves from one phase to another traffic patterns will shift and result in traffic problems moving from one location to another – the timing of which will be largely unknown. With that said, traffic volumes and patterns will largely be unpredictable making it difficult to configure per operational objectives.   Actuated configurations would require that traffic signal timing plans be developed for each phase of construction. Same would be the case for responsive system configurations, which are similar to actuated systems but advance this concept by responding better to changing traffic volumes. This would come at great expense and would require significant effort of local staff to develop, analyze and implement a robust library of signal timing plans to cover the wide variety of traffic conditions. Municipal stakeholders do not have the staff or resources necessary to develop these needed traffic signal timing plans. Several stakeholders have supported this project only upon the understanding that they will not be responsible for making changes to their existing traffic signal timing plans nor would they have to absorb any additional operations and maintenance costs.

Actuated and responsive system configurations would also require municipal agencies to implement hundreds of new detectors to upgrade their existing system configurations.   Currently, WisDOT does not place stop bar detection on the mainline through phases. Instead, stop bar detection is used primarily for side roads and mainline left-turn lanes. Furthermore, many of the other municipal agencies also lack the needed detection for actuated signal control. The associated life cycle costs associated with the purchase, installation, and maintenance of detection are costs that municipal stakeholders cannot justify at this time – nor are the costs of additional staff to configure and develop new timing plans required of these signal configurations. Selection of an actuated or responsive system configuration would risk the support of stakeholders, which in turn may narrow the geographic scope of the project and its resulting benefits.

Another contributing factor working against the selection of a traffic responsive signal system was the difficulty of implementing such a system for the Mitchell interchange.   Due to the number of institutional players involved in the project, there was difficulty getting stakeholders to agree on how to operate it. The project lasted over a decade and resulted in the system being inoperable for many years.

For these reasons an actuated or traffic responsive signal system configuration is not desired.

Ruling out pre-timed, fully actuated and responsive signal control systems, leaves only one other configuration - adaptive signal control. Because this is a relatively new approach for controlling traffic a brief literature review was undertaken and the following adaptive systems were analyzed.

ACS Lite – Adaptive Control Software Lite (ACS Lite) is designed to operate as a closed-loop type system using local ACS Lite master controllers. Several signal control manufactures, including Econolite and Siemens, have integrated ACS Lite into their central control platforms. ACS Lite adapts splits and offsets of signal control patterns and plans with optimization steps occurring every 5 to 10 minutes. Using the currently running traffic plan, ACS Lite creates and analyzes a statistical profile of intersection efficiencies along an arterial. In the event communication interruptions occur between the ACS Lite application and the local controllers, the local controller still maintains full coordinated operation of the intersection using the preexisting plans stored in the controller.

Balance - An adaptive control strategy developed by the University of Munich in Germany. This algorithm is relatively new and still in the field trial stages of development. The algorithm is designed to use traffic modeling which allows for minimal use of traffic detectors. BALANCE develops optimal signal timings for the existing detection in the field and does not require that every intersection be equipped with detectors.

InSync - An adaptive control strategy developed by Rhythm Engineering builds on a distributed architecture that balances measures of effectiveness (MOEs) for phase splits and green band optimization. Green bands (or "tunnels" as Rhythm Engineering refers to them as) are guaranteed by successively turning each light green at the expected vehicle arrival time from upstream intersections. The solution is generally deployed with video detection and has an install base of approximately 400 intersections.

LA ATCS - Los Angeles County has developed its own version of adaptive control. The algorithm optimizes cycle length, phase split, and offset on a cycle-by-cycle basis. The algorithm requires specific detection at each intersection running on a 2070 controller platform. The algorithm and decision making functions reside with the central software. The software is available to agencies for purchase.

MOTION - MOTION is an acronym for Method for the Optimization of Traffic signal control In Online-controlled Networks. The algorithm has been developed by Siemens. MOTION has been primarily deployed in Germany. It is in the research phase of development and is not ready for deployment.

OPAC - OPAC is an acronym for Optimization Policies for Adaptive Control. OPAC is a predictive, distributed control strategy featuring an optimization algorithm that calculates signal timing to minimize the performance function of total intersection delay and stops. It evaluates specific optimization parameters every cycle. OPAC was originally developed as part of an FHWA research effort in the 1990's. OPAC is commercially available from Telvent.

RHODES - An adaptive control strategy developed by the University of Arizona in conjunction with FHWA. The algorithm is predictive and does not follow a traditional "signal timing plan" approach instead provides green time to traffic approaches as demanded. The software algorithm continues to evolve through the efforts of the University of Arizona. The solution is commercially available from the University of Arizona.

SCATS - An adaptive control strategy developed in Australia. SCATS is an acronym for Sydney Coordinated Adaptive Traffic System (SCATS). The algorithm manages "groups" of intersections from the central system using one intersection in the group as the master or critical intersection that drives the algorithm for that group by managing platoons of traffic. SCATS is distributed in the US through TransCore.

SCOOT - An adaptive control strategy developed in the UK. SCOOT is an algorithm run from a central computer that polls detectors every second and makes small adjustments to timing parameters to avoid disturbances in traffic flow. SCOOT is distributed in the US through Siemens.

Of the above potential solutions, the majority have a reasonable installation base within the U.S. Balance and Motion are two exceptions. Both are in early stages of development and are relatively unproven in the U.S. Due to the regional significance of the Interchange reconstruction and the role that the adaptive system plays in meeting high-level requirements, these adaptive platforms were considered too risky to deploy and were screened away.

Of the remaining adaptive platforms several others were quickly screened away based on their requirements. LA ATCS , OPAC and RHODES require controllers that are not generally used along the Zoo corridors. Selecting these platforms would require that a majority of traffic controllers within the Zoo corridors be replaced with compatible controller types (e.g., 2070 and Econolite ASC2, ASC3 or other NTCIP controllers). Many of the existing controllers within the Zoo corridors are not NTCIP compliant. Although upgrading to NTCIP compliant systems would be a desirable upgrade, the cost and time needed to replace controllers was considered undesirable based on requirements 1 and 3 above. Additionally, OPAC and RHODES require additional upstream detection which would add costs in and above that of the controller replacement.

Another disadvantage of OPAC and RHODES was their corresponding compatible central software platforms. Currently, WisDOT's STOC uses Transcore's TranSuite advanced traffic management software. This is compatible with the SCATS platform. However, the ability to use the TranSuite central control platform would be dependent on the type of controller and whether there is communication to the traffic signal. Along the zoo corridors many traffic signals have older, incompatible controllers. In most instances, traffic signal timings are stored within Siemens MarcNX software. This issue was considered relatively minor because traffic signal operations are currently performed from WisDOT's SE Region Headquarters and not the STOC. This was a consideration if control was ever to be integrated within the STOC.

Screening away LA ATCS, OPAC and RHODES left the four platforms analyzed in **Table 13**. These include ACS Lite, InSync, SCATS and SCOOT.

Based on the analysis of the four adaptive platforms identified in **Table 13** it is clear that SCATS is the highest cost solution, with a cost more than twice that of the least expensive solution - InSync. SCATS also requires the greatest amount of maintenance and requires the installation of new detection. SCOOT on the other hand had the second greatest cost, and would require a controller firmware upgrade. For these reasons both SCATS and SCOOT were eliminated from further consideration leaving only ACS Lite and InSync.

ACS Lite has a greater relative cost to InSync and had the lowest amount of improvement or benefit of the four platforms analyzed in **Table 13**. Perhaps the most important disadvantage of ACS Lite is the size of the network it can accommodate. ACS can only accommodate up to 16 intersections whereas the project requires a minimum of 50 intersections. ACS Lite also adapts the splits and offsets, but not the cycle length. With the large range of traffic volumes expected during construction, this capability was desired. Based on this information, ACS Lite was screened away leaving only InSync.

Table 13: Adaptive Traffic Signal Systems Comparison

ACS Lite	InSync	SCATS	SCOOT
Developer/Vendors			
Siemens Econolite	Rhythm Engineering	Transcore	Siemens
General Information			
• Works on arterial networks only • Designed to operate 8 to 10 intersections optimally, can handle up to 16 intersections • Central management of master field processor attained through Centracs or TACTICS	• Works on arterial and grid networks • Designed to operate with an infinite (in theory) number of intersection with distributed networking • Central management of system provided through a web-based interface for remote access.	• Works on arterial and grid networks • Designed to operate up to 250 intersections • Grouped into "sub-systems" of 1 to 10 intersection with one intersection labeled as "critical" • Central management of system attained through central computer tied to regional computers	• Works on arterial and grid networks • Has been installed in systems of up to 70 intersections • Central management of system attained through TACTICS
General Operations			
• Uses coordinated timing plans and makes adjustments to splits and offsets only • Cycle length is chosen by the "baseline" timing plan, which is selected according to TOD • Splits are adjusted between a minimum and maximum time for each phase every 5-10 min.	• Determines optimal sequence of phases when a phase pair should be initiated, and the duration of the phase • Does not operate with traditional intersection cycle lengths, splits, or offsets • Timings are only limited by minimum green, maximum green, and passage time considerations • Phase order and duration is adjusted continuously in real-time.	• Regional computer calculates a "degree of saturation" (DS) for movements at each intersection within a sub-system • DS = used green time/total green time • Each sub-system shares a common cycle length and related phase splits, and offsets based on the "critical" intersection • Regional computer adjusts the cycle length, splits, and offsets to maintain a user-defined DS (usually 90%).	• Central computer receives detector volume and occupancy data every second and converts this to a hybrid unit of measure. • An internal traffic model is developed based on hybrid measurement to determine "real-time" traffic conditions • Similar to TRANSYT-7F or CORSIM • 3 optimization procedures (cycle, split, and offset) are used in the internal model to determine optimal timings.
System Requirements/Communications			
• ACS Lite field processor • Traditional protocols used • Existing, twisted pair, and fiber optics tested in development.	• InSync processor at each intersection • InSync detector cards for local intersection controllers • Digital internet-protocol (IP) cameras • Uses ethernet-based communication between processors located at each intersection	• A central management computer and regional computers to control local controllers • Can work with different types of communication from regional computers to local intersections. • TCP/IP, fiber optic, etc.	• Central computer to provide timings to local intersection controllers. • Can use different types of traditional communication from central computer to local intersections • Leased line, copper cable, fiber optic, or combination

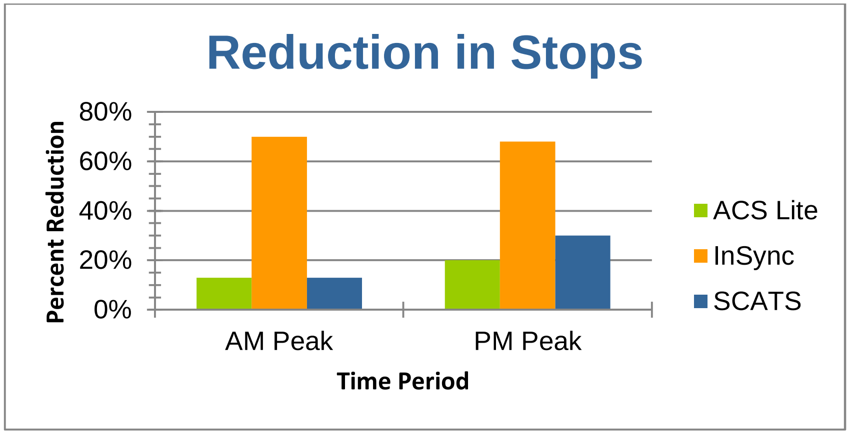
ACS Lite	InSync	SCATS	SCOOT
Master/Intersection Controllers			
• Compatible with lower cost intersection controller models (170, NEMA, etc.) • May require controller software (firmware) upgrade/update for compatibility • Local controllers allowed to execute typical, actuated gap-out of phases	• Does not use a single, central controller to optimize signals as a system • InSync processor at each intersection determines green time and coordinates with adjacent intersection to determine "green tunnels" • InSync processor is compatible with most common intersection controller models	• Regional computers calculate and send cycle lengths, splits, and offsets to each intersection in their subsystem • Requires SCATS conversion kits on 170 controllers and compatible with NEMA controllers	• Central computer software is compatible with standard Siemens SEPAC controller firmware • Older EPAC controllers require a firmware upgrade • Newer EPAC and 2070 controllers can use pre-programmed SCOOT logic
Detection			
• Flexible to existing/conventional in-pavement loop detector architecture • Needs upstream (advanced) detection on progression-desired approaches for offset optimization and adjustment	• Digital IP cameras take the place of traditional detection methods and are connected directly to the processor • Advanced detection (using traditional pavement loops, etc.) is not required for optimal performance, but can be incorporated into the system/processor • Processor reverts to fog/emergency mode automatically if camera detection is abnormal/faulty • Will use collected, historic data to determine phase sequence/duration when in fog/emergency mode	• Requires both "tactical" and "strategic" in-pavement loop detector placement • Tactical detectors are placed at stop bars for each movement (left, thru, right) to determine lane usage and speed differential • Strategic detectors are places upstream of the stop bar to determine green time usage of traffic movements	• Uses upstream in-pavement loop detection • Requires detectors in the vicinity of the previous upstream intersection • Central computer uses upstream detector information to determine a flow-profile and act more pro-actively to changes in traffic demand at downstream intersections
Strengths			
• Second lowest cost per intersection • Ease of use and configuration • Developed in conjunction with FHWA	• Lowest cost per intersection • Lowest amount of maintenance required • Most improvement in operations	• Can handle a significant number of intersections within a single system • Second best operational improvement	• Less training required compared to SCATS
Weaknesses			
• Does not adjust cycle lengths • Lowest amount of improvement in operations	• Reliance of system on camera detection. The InSync Tesla solution does not require video detection and instead can use existing detection reducing this potential weakness. • Potential communications concerns	• Highest cost per intersection • Highest amount of maintenance required per intersection	• Less training required compared to SCATS
Cost per Intersection			
• $39, 500 per intersection	• $28,500 per intersection	• $60,000 per intersection	• $49,000 per intersection

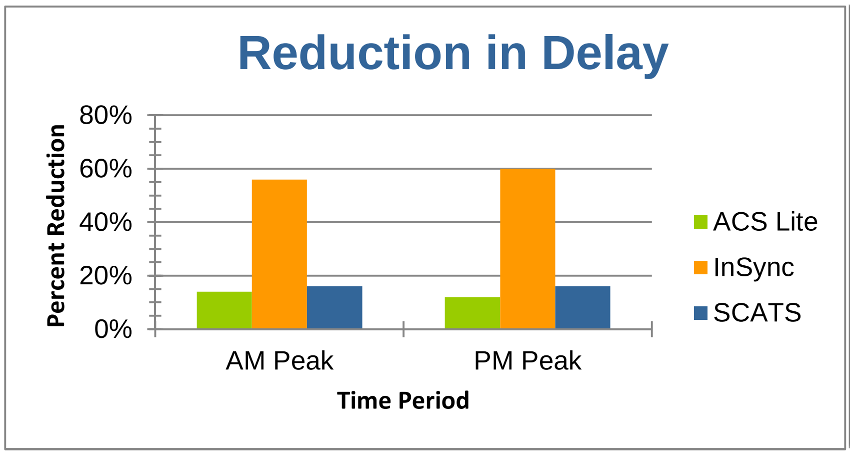
The InSync solution best addresses the high-level requirements and separates itself from the other adaptive signal platforms in several ways. First, it plugs into all existing signal hardware. In general, new cabinets, controllers, and other equipment are not needed. The system requires only camera detection at the intersection; no upstream or in-pavement detection is required. Its utilization of non-intrusive detection reduces time and resources needed for installation and has no associated pavement or restoration impacts. The system converts analog signal controller operation to digital controller operation. The system sees each allowable pair of phases as a state, and can choose any allowable state (phase pair) at any time, within defined constraints. This eliminates the concept of cycle lengths and phase sequences, as well as the transition time that signal systems experience as they shift from one timing plan to another. This capability results in the fastest response to traffic conditions among all the different adaptive systems. An immediate response to traffic conditions is critical in order to meet the operational objectives. As an example during a traffic incident, the ramp terminal traffic signal must respond immediately to prevent traffic back-ups onto the freeway.

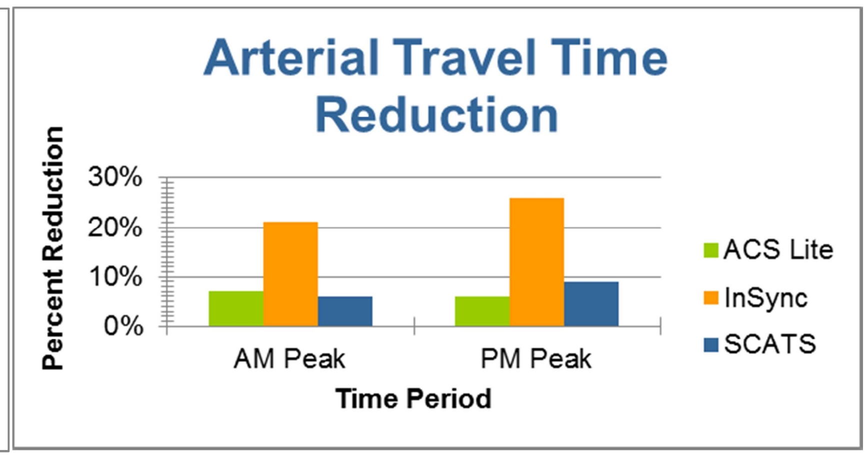
Another aspect that factored into the recommendation was concern from stakeholders of the impacts that the selected solution would place on the individual stakeholder. Some stakeholders were concerned that the selected adaptive system would require significant change be made to the manner in which their existing controllers were operated. Stakeholders desired a solution that did not require significant changes be made to how their existing controllers are operated. A more "hands off" solution was preferred over one that required each agency to make manual changes. Stakeholders made the commitment to an adaptive solution contingent upon minimal associated maintenance responsibilities of making the changes, as well as reverting back to prior control plans if the system shouldn't function as desired. In general, the reasoning behind the recommendation is bulleted below:

- Works with existing controllers and detection
- Compatible with Ethernet communications
- Lowest average cost
- Lowest overall weekly maintenance
- Lowest percent of downtime
- Highest operational benefits
- All respondents surveyed would deploy the same system again

Details of the operational performance benefits of the InSync solution are illustrated in the following figures.







Source: "Adaptive Traffic Control Systems in the United States: Updated Summary and Comparison"

SECTION 7

Procurement Approach

A competitive, requirements based procurement will be used to procure the ASCT system, while other ICM components will be procured using the statewide contract, which itself underwent a prequalification process.

SECTION 8

Applicable ITS Standards and Testing Procedures

The ITS systems selected for this project should be developed using USDOT approved standards. Standards must be identified prior to implementing projects funded by the National Highway Trust Fund. The FHWA Rule and FTA Policy on Regional ITS Architectures states that "…federally funded projects use, where appropriate, USDOT adopted ITS standards". Standards define how ITS elements will interconnect and interact with each other. The underlying principal behind standards is that they enable subsystems to be designed using "open" platforms. In other words, standards allow subsystems to be designed or easily replaced when they fail, or otherwise become interoperable. Before the introduction of standards, subsystems were often developed using proprietary software and equipment, that could not be replaced with a similar subsystem or product other than those made by the same manufacturer. This led to higher project costs and resulted in less innovative systems.

To find more information on ITS-related standards, visit: www.standards.its.dot.gov/

ITS standards applicable to the Zoo Corridor ICM project are identified in **Table 14**.

Testing procedures will involve making sure that procured systems (off-the shelf adaptive traffic control system, CCTV and DMS) are installed properly in the field and that deployed systems can communicate effectively prior to the system go live date.

Table 14: ITS Standards Applicable to the Zoo Corridor ICM Project

SDO	Standard Title	Standard Doc ID	Standard Type
SAE	Advanced Traveler Information System (ATIS) General Use Standards Group	ATIS General Use	Group
ASTM	Dedicated Short Range Communication at 915 MHz Standards Group	DSRC 915MHz	Group
IEEE	Incident Management Standards Group	IEEE IM	Group
AASHTO/ITE/NEMA	NTCIP Center-to-Center Standards Group	NTCIP C2C	Group
AASHTO/ITE/NEMA	NTCIP Center-to-Field Standards Group	NTCIP C2F	Group
AASHTO/ITE	Traffic Management Data Dictionary (TMDD) and Message Sets for External Traffic Management Center Communications (MS/ETMCC)	ITE TMDD	Message/Data
AASHTO/ITE/NEMA	Global Object Definitions	NTCIP 1201	Message/Data
AASHTO/ITE/NEMA	Object Definitions for Actuated Traffic Signal Controller (ASC) Units	NTCIP 1202	Message/Data
AASHTO/ITE/NEMA	Object Definitions for DMS	NTCIP 1203	Message/Data
AASHTO/ITE/NEMA	Object Definitions for CCTV Camera Control	NTCIP 1205	Message/Data
AASHTO/ITE/NEMA	Object Definitions for CCTV Switching	NTCIP 1208	Message/Data
AASHTO/ITE/NEMA	Data Element Definitions for	NTCIP 1209	Message/Data

SDO	Standard Title	Standard Doc ID	Standard Type
	Transportation Sensor Systems (TSS)		
AASHTO/ITE/NEMA	Field Management Stations (FMS) - Part 1: Object Definitions for Signal System Masters	NTCIP 1210	Message/Data
AASHTO/ITE/NEMA	Object Definitions for Signal Control and Prioritization (SCP)	NTCIP 1211	Message/Data
AASHTO/ITE/NEMA	Object Definitions for Conflict Monitor Units	NTCIP 1214	Message/Data

Because an off the shelf solution will likely be procured, extensive effort will be spent identifying the level of support that could be reasonability be expected from the vendor of the procured solution. The project team will talk with users of the desired solution to gage their perceptions and experience dealing with the vendor prior to the solution being procured. Additionally, a small scale deployment of adaptive signal control will be deployed and lessons learned will be applied to a larger deployment. Despite these assurances individual ICM components will still be tested prior to their activation to ensure proper and safe operation.

The project will require that CCTV cameras, DMS, traffic detectors and adaptive traffic control system be tested in their operational environment. This includes all related parts and components of these systems. The equipment vendor’s recommendations for testing shall be used and be a requirement of the contractor responsible for system installation. Additionally, the contractors shall be required to provide WisDOT with their proposed testing procedures as part of their contract and WisDOT must approve these procedures before testing begins.

Once equipment is tested and accepted by WisDOT, the contractor shall be responsible for testing the ICM components to ensure that they meet stated functional requirements. ICM components shall be operated continuously for a period of 30 days of typical operation with all systems in place. Any major errors that occur within this 30 day window shall be documented, fixed and the operational 30-day window reset to day 1. This process shall continue until no major errors occur within the 30-day window. This shall constitute successful acceptance of testing.

SECTION 9

Agreements

Each interconnect shared between ITS elements, as illustrated in **Figure 2**, represents a potential need for an agreement to support the effective exchange of information between elements. While it may not be imperative that Interconnects between ITS elements owned and operated by the same agency be defined, the opposite is true for interconnects shared by elements owned and operated by different agencies. In these instances agreements are needed to define agency roles and responsibilities for funding, implementing, operating, maintaining or other associated cooperative activity linked to the project. This includes expectations of each agency and any required resource sharing needed. Agreements can be informal handshake agreements or more formal Memorandum of Understanding or interagency or intergovernmental agreements.

This project will require agreements between the WisDOT and the various municipalities within the Zoo Corridor project limits to coordinate traffic signal operations over jurisdictional boundaries. WisDOT has handshake agreements with the various Zoo Corridor Municipalities to assume ownership of municipality owned traffic signals to improve traffic flow and operations on zoo corridor arterials.

The agreements added as part of this project supplement the following existing agreements already reflected in Wisconsin's Statewide ITS Architecture. Specific agreements identified as part of the project or that have been defined through Statewide ITS architecture development are noted below.

- **City of Milwaukee Fiber Sharing** – The City of Milwaukee and the Wisconsin Department of Transportation have an existing agreement to share fiber optic infrastructure and resources to provide each agency with a more efficient and reliable communications network.

The shared resources are in multiple areas in and around the City of Milwaukee. Local fire stations and police stations are connected to the State's fiber system through this MOU with the State.

- **City of Waukesha Fiber Sharing** – Agreement between the City of Waukesha and the State of Wisconsin Department of Transportation giving the State a revocable exclusive twenty (20) year indefensible right of use (IRU) agreement providing twelve (12) strands of single mode fiber optics located in the City's conduit/aerial system.

Additional agreements are being formalized between WisDOT and the various traffic signal owners/maintainers within the Zoo corridors. To date WisDOT has agreed to assume ownership and operational responsibility for the following traffic signals within the City of Milwaukee:

- IH 94 EB Ramps & STH 181
- IH 94 WB Ramps & STH 181
- STH 181 & Dana Street
- USH 18 & STH 181
- USH 18 & 92nd Street
- USH 18 & 95th Street
- USH 41 & 107th Street/Florist Ave.
- USH 41 & Carmen Ave
- USH 41 & 91st Street
- USH 41 & Grantosa Dr.
- USH 41 & Hampton Ave
- USH 41 & Congress St.
- STH 181 & Schlinger Ave.
- STH 181 & State Fair Entrance
- STH 59 & 84th Street
- STH 59 & 92nd Street

Signed agreements between the WisDOT and the cities of West Allis and Wauwatosa can be found in Appendix D.

SECTION 10

Appendix A: Information Flows by Element

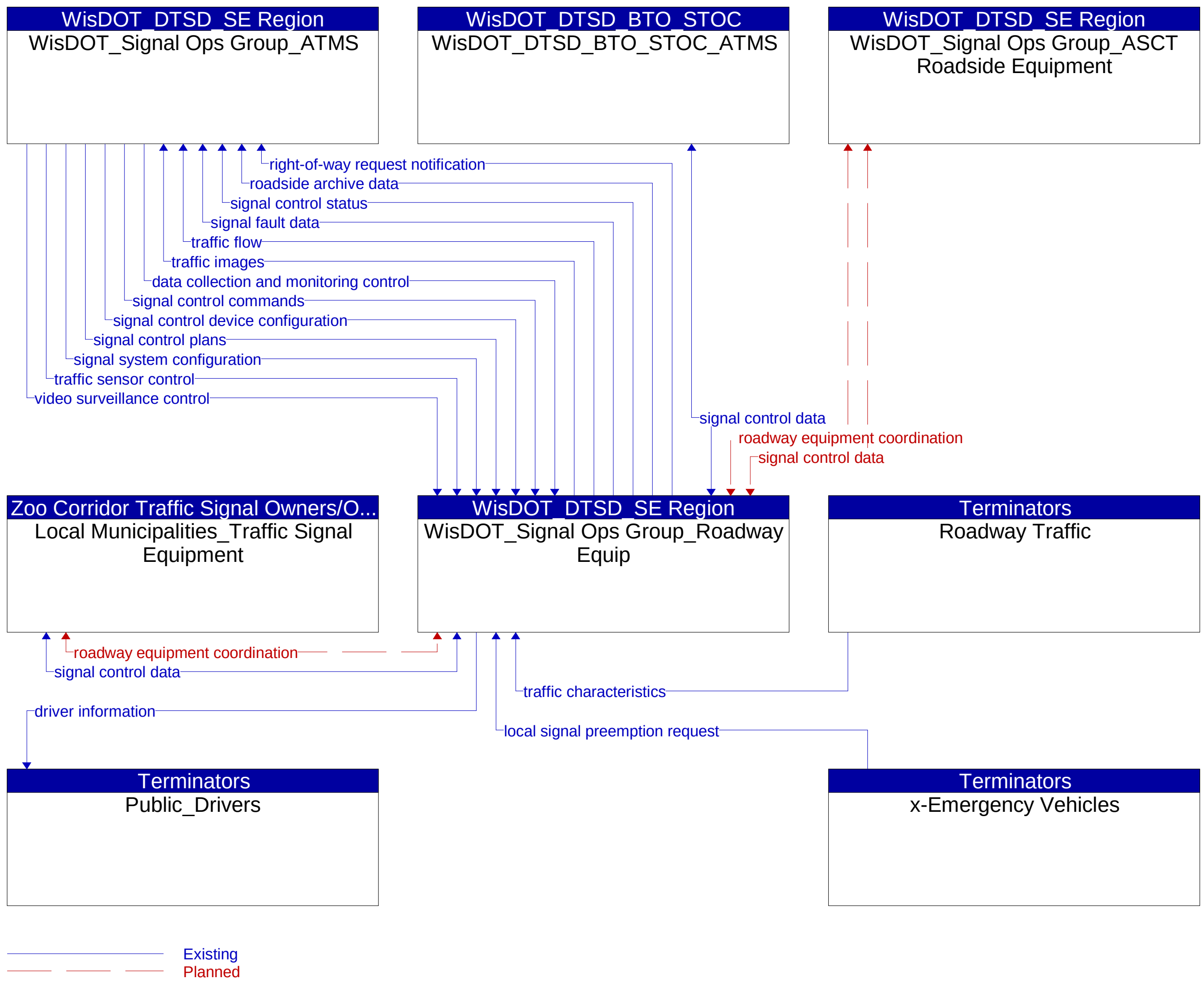


Figure 4: Information Flows Corresponding to the Element "WisDOT_Signal Ops Group_Roadway Equip"

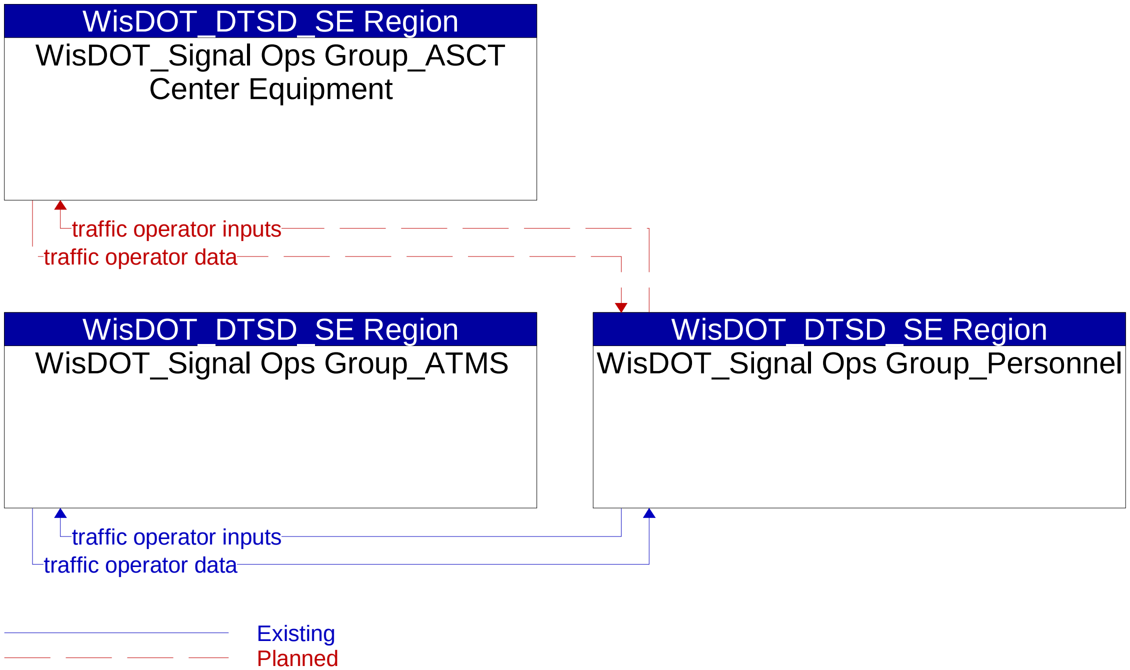


Figure 5: Information Flows Corresponding to the Element "WisDOT_Signal Ops Group_Personnel"

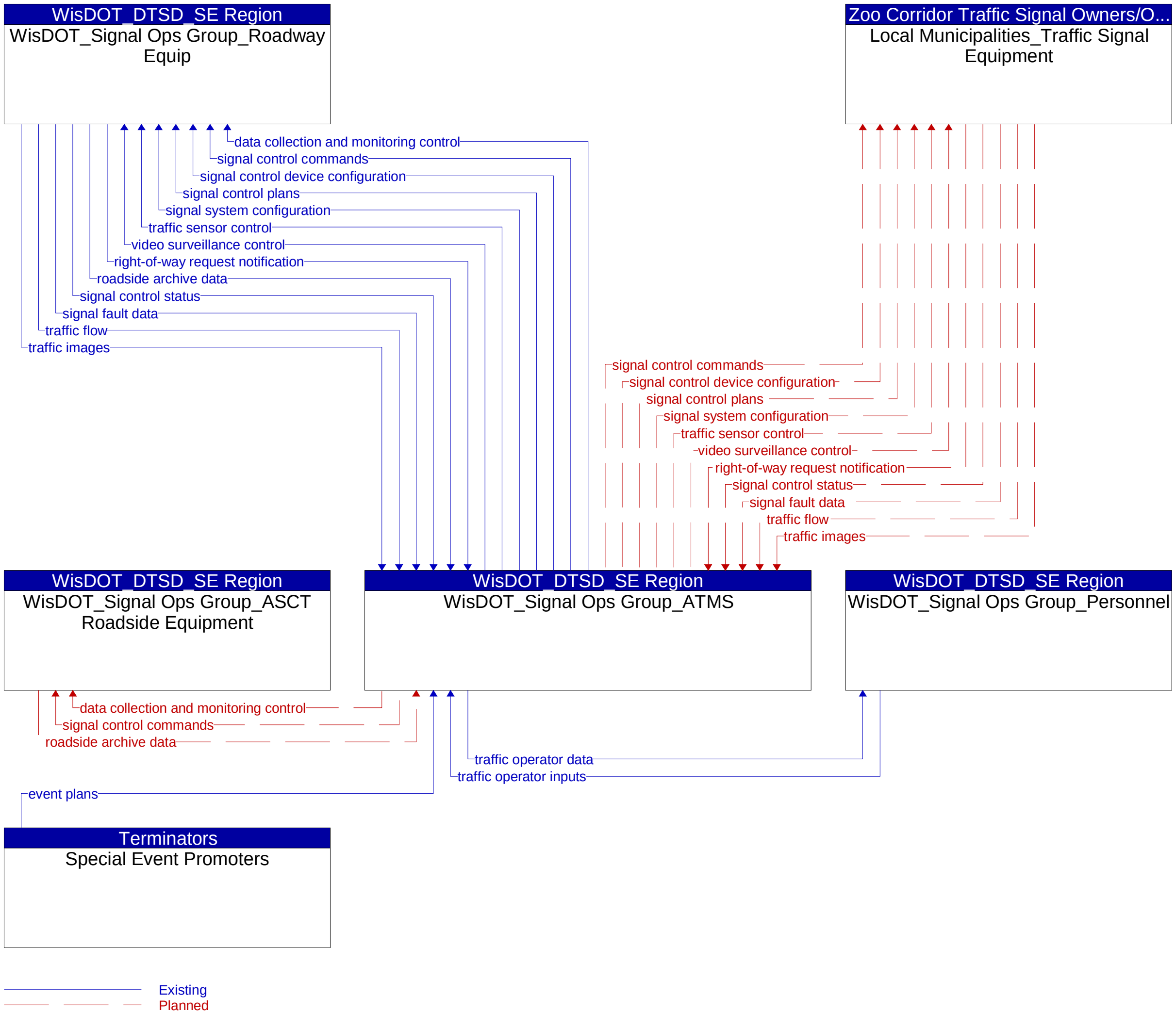


Figure 6: Information Flows Corresponding to the Element "WisDOT_Signal Ops Group_ATMS"

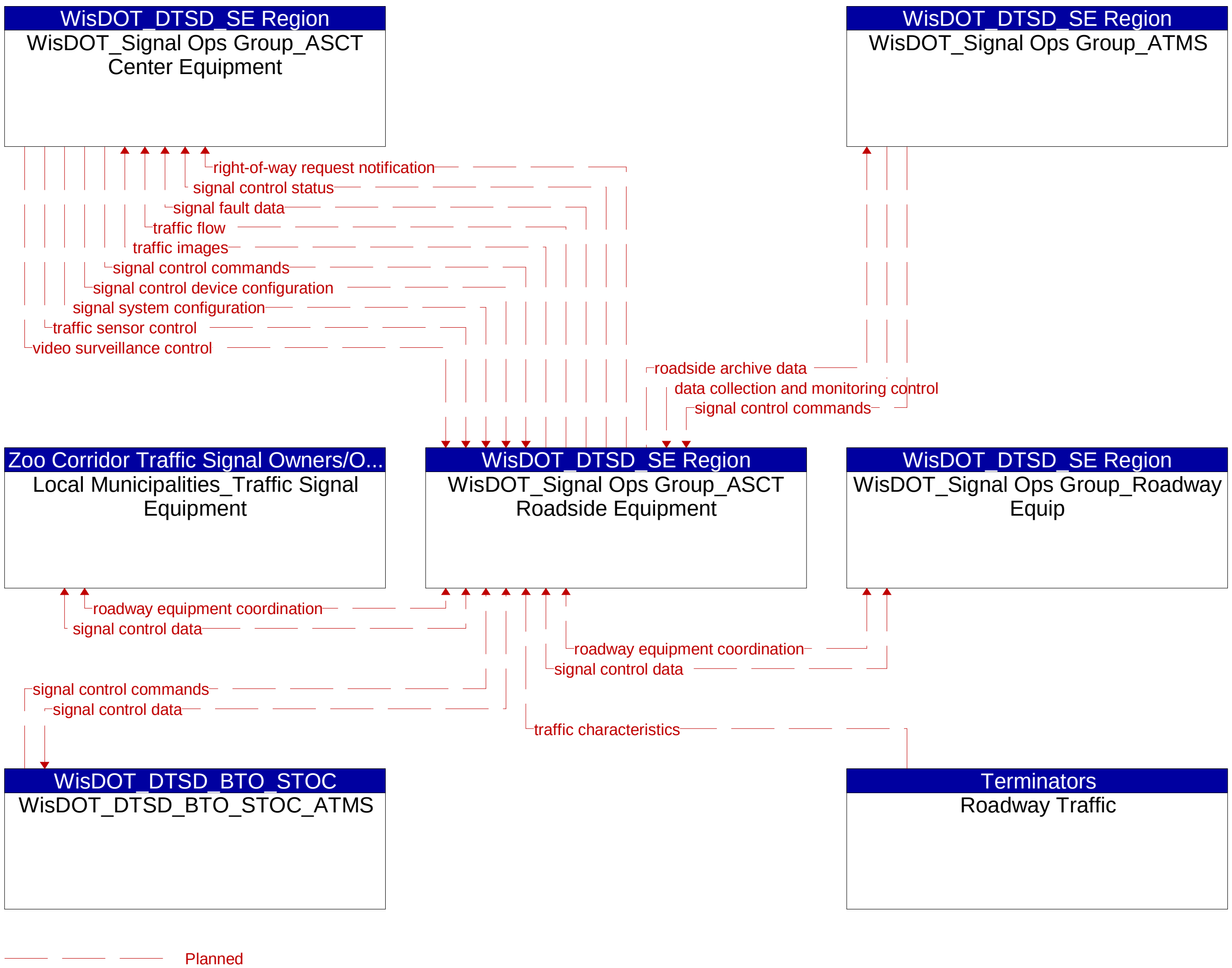


Figure 7: Information Flows Corresponding to the Element "WisDOT_Signal Ops Group_AST Roadside Equipment"

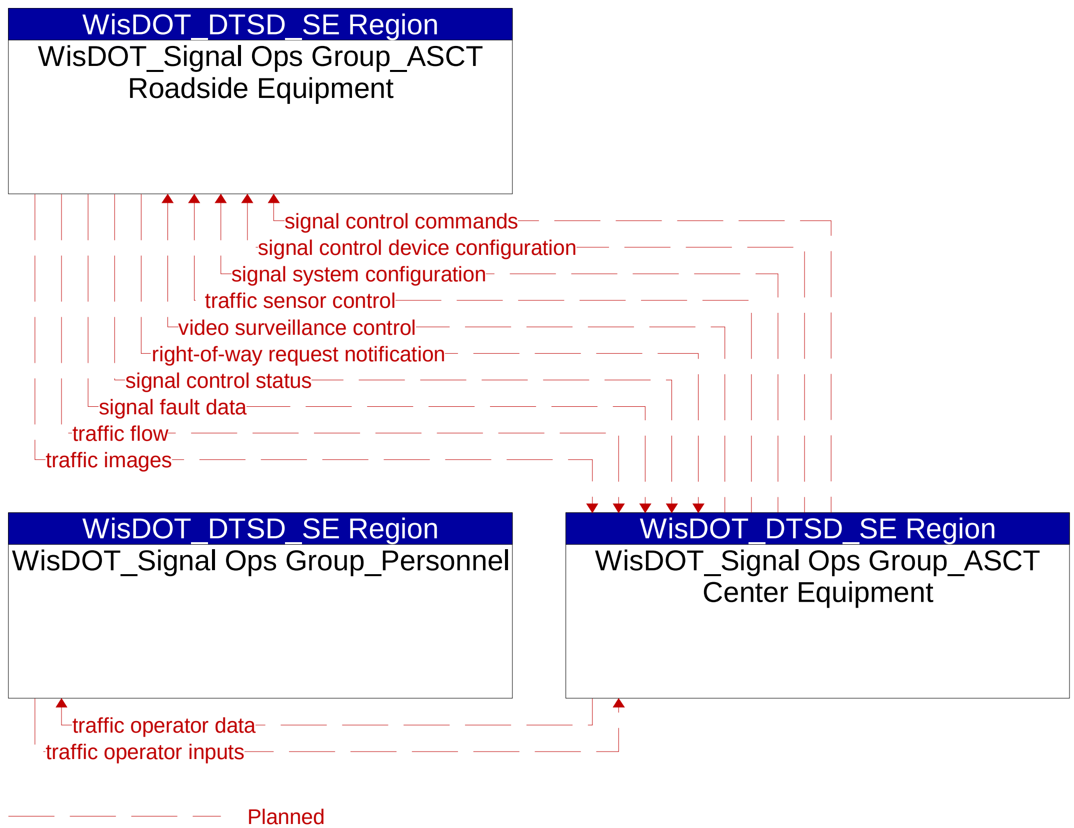


Figure 8: Information Flows Corresponding to the Element "WisDOT_Signal Ops Group_ASCT Center Equipment"

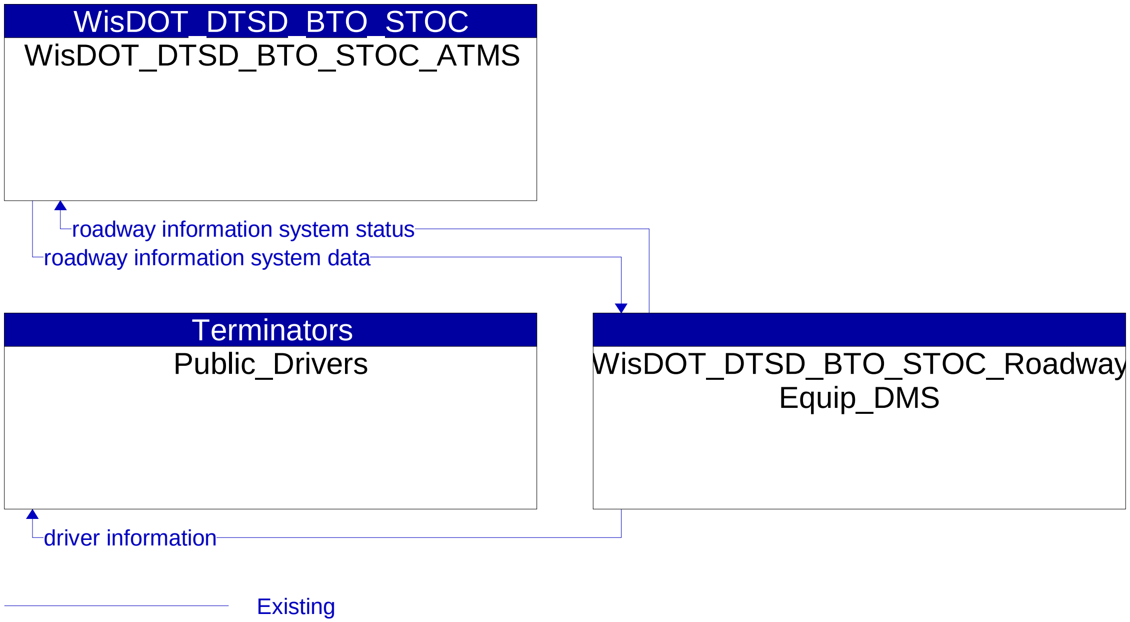


Figure 9: Information Flows Corresponding to the Element "WisDOT_DTSD_BTO_STOC_Roadway Equip_DMS"

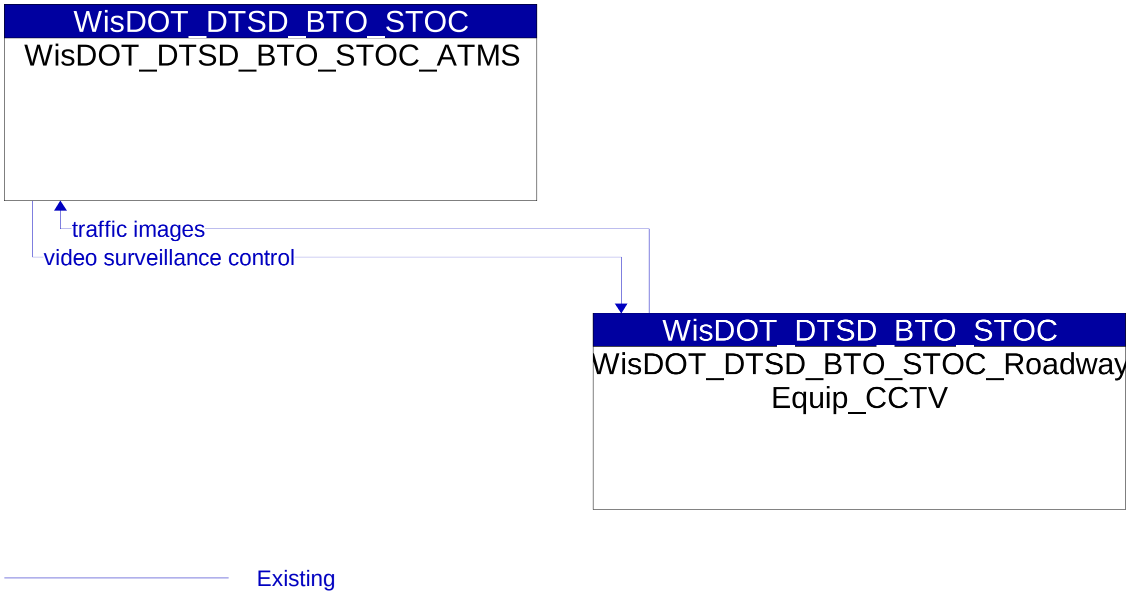


Figure 10: Information Flows Corresponding to the Element "WisDOT_DTSD_BTO_STOC_Roadway Equip_CCTV"

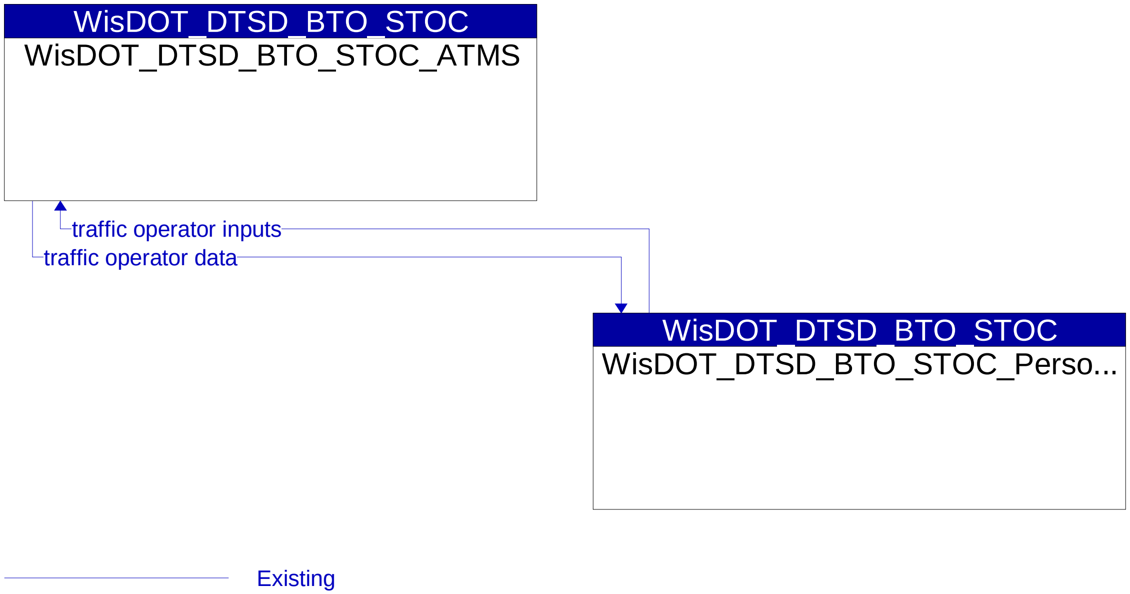


Figure 11: Information Flows Corresponding to the Element "WisDOT_DTSD_BTO_STOC_Personnel"

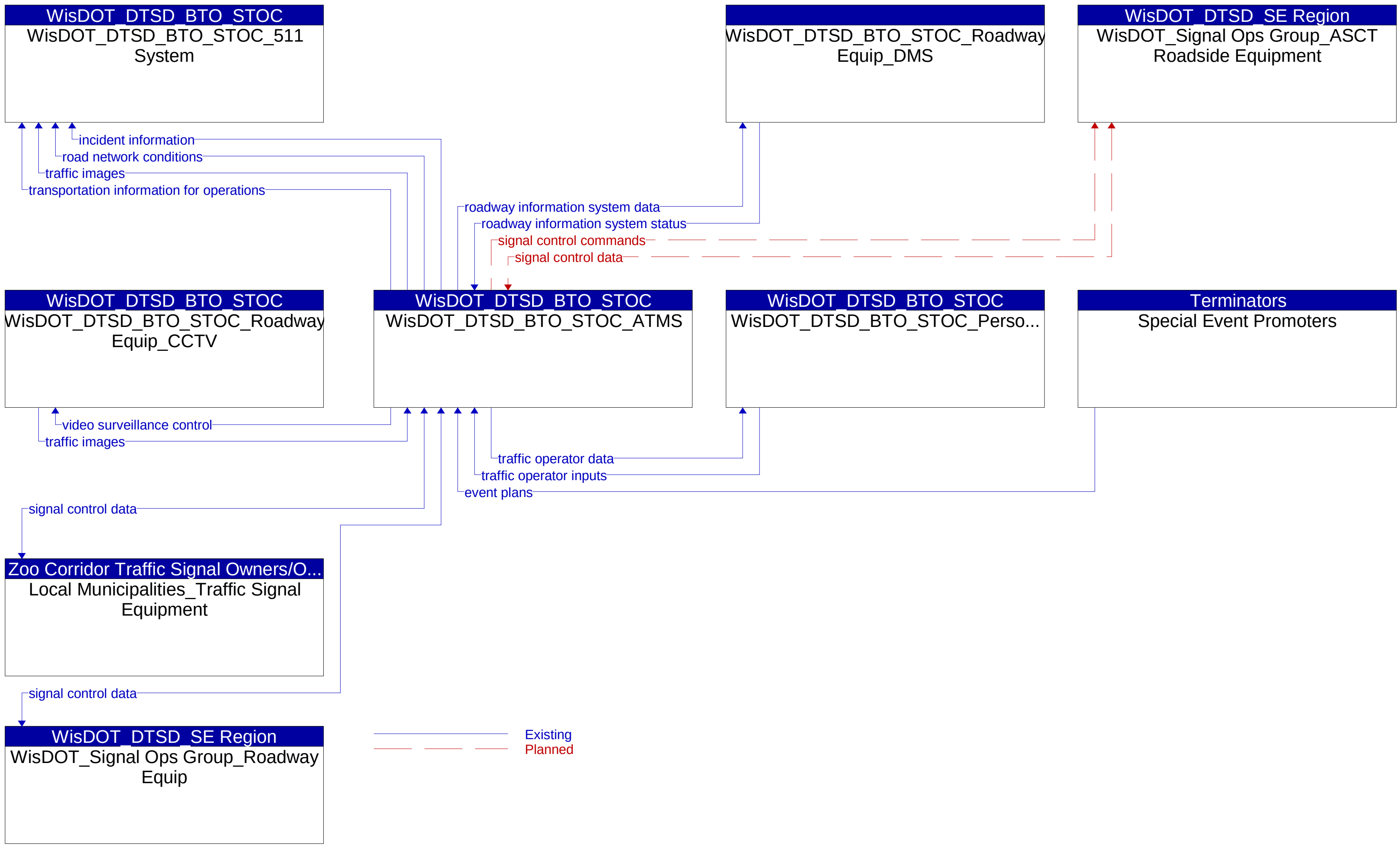


Figure 12: Information Flows Corresponding to the Element "WisDOT_DTSD_BTO_STOC_ATMS"

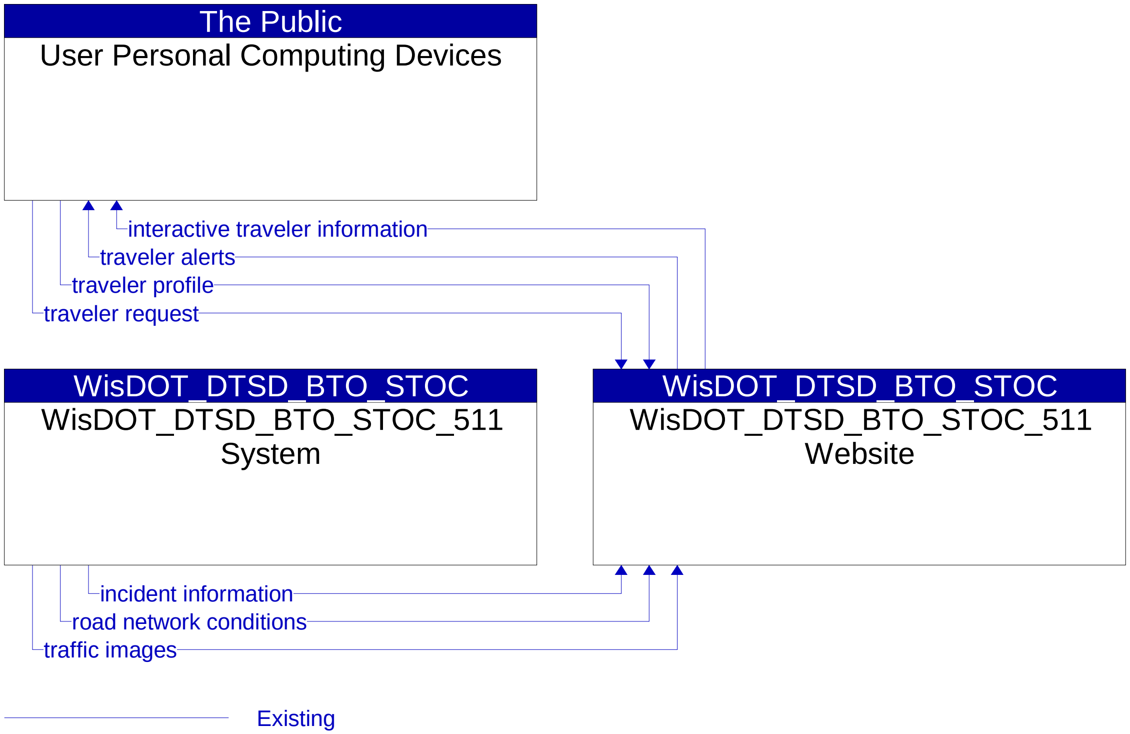


Figure 13: Information Flows Corresponding to the Element "WisDOT_DTSD_BTO_STOC_511 Website"

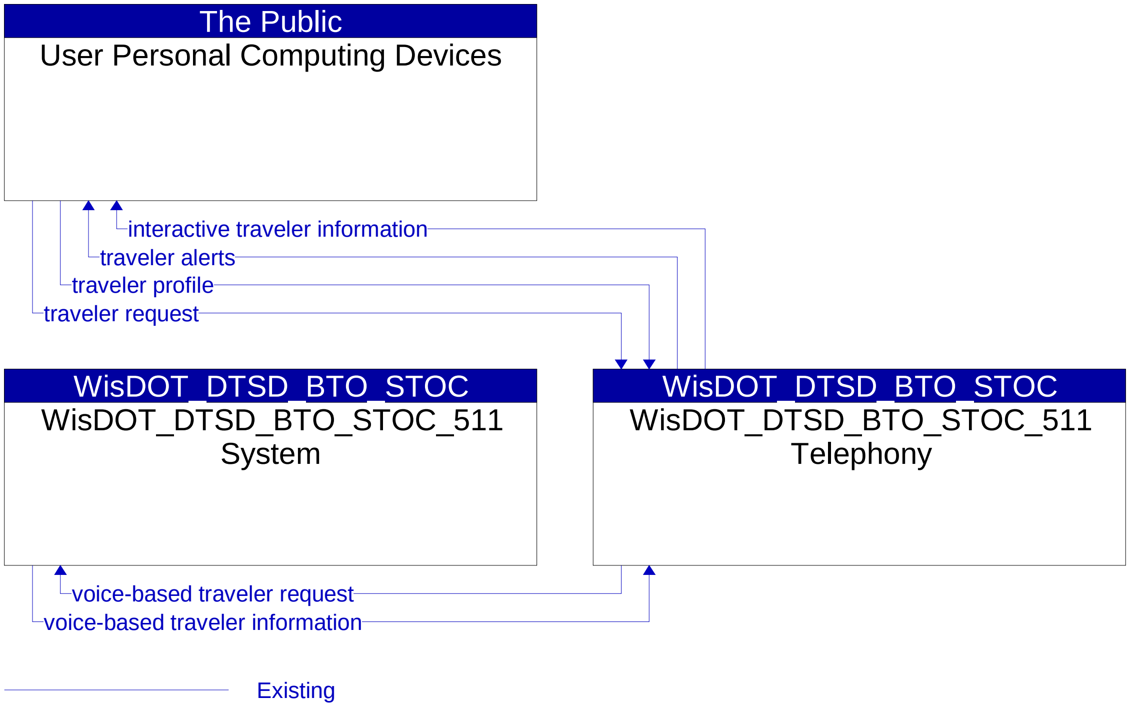


Figure 14: Information Flows Corresponding to the Element "WisDOT_DTSD_BTO_STOC_511 Telephony"

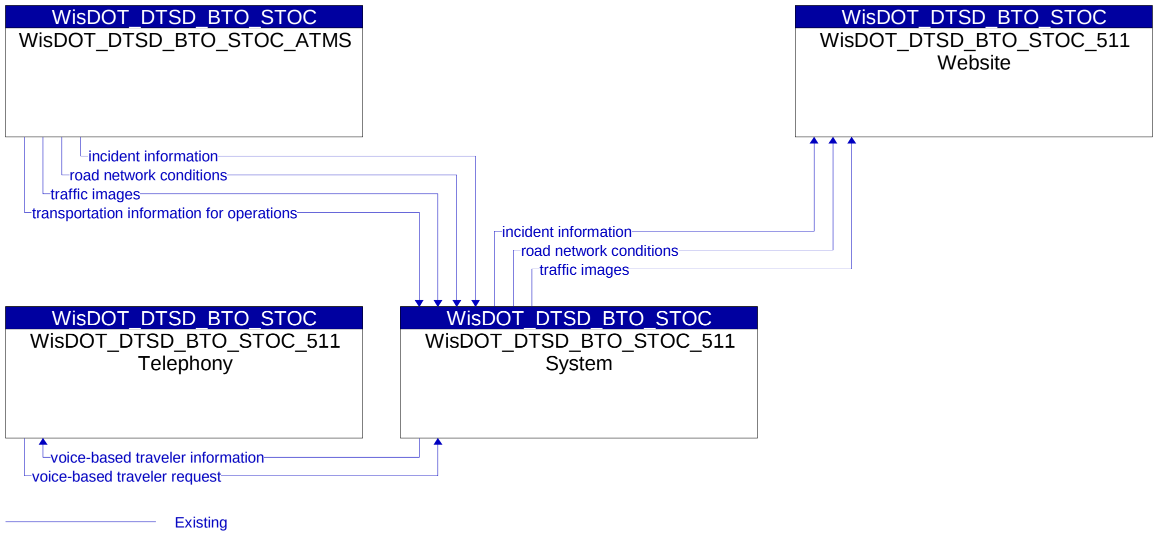


Figure 15: Information Flows Corresponding to the Element “WisDOT_DTSD_BTO_STOC_511 System”

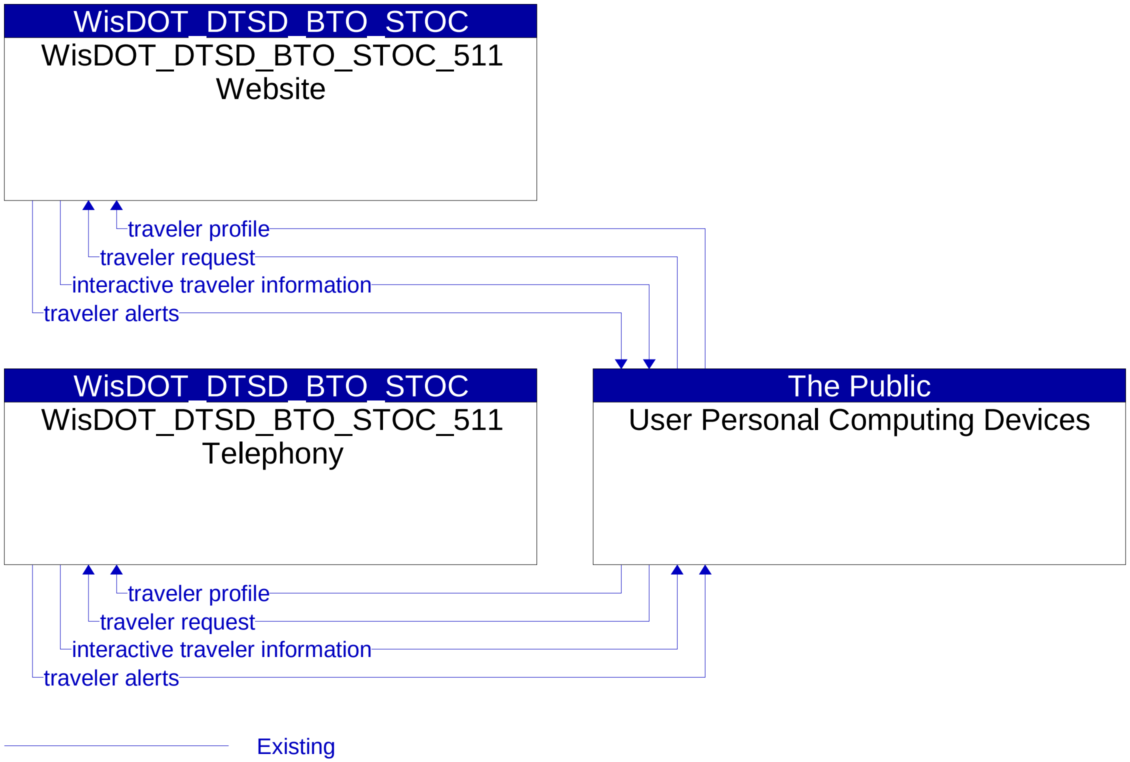


Figure 16: Information Flows Corresponding to the Element "User Personal Computing Devices"

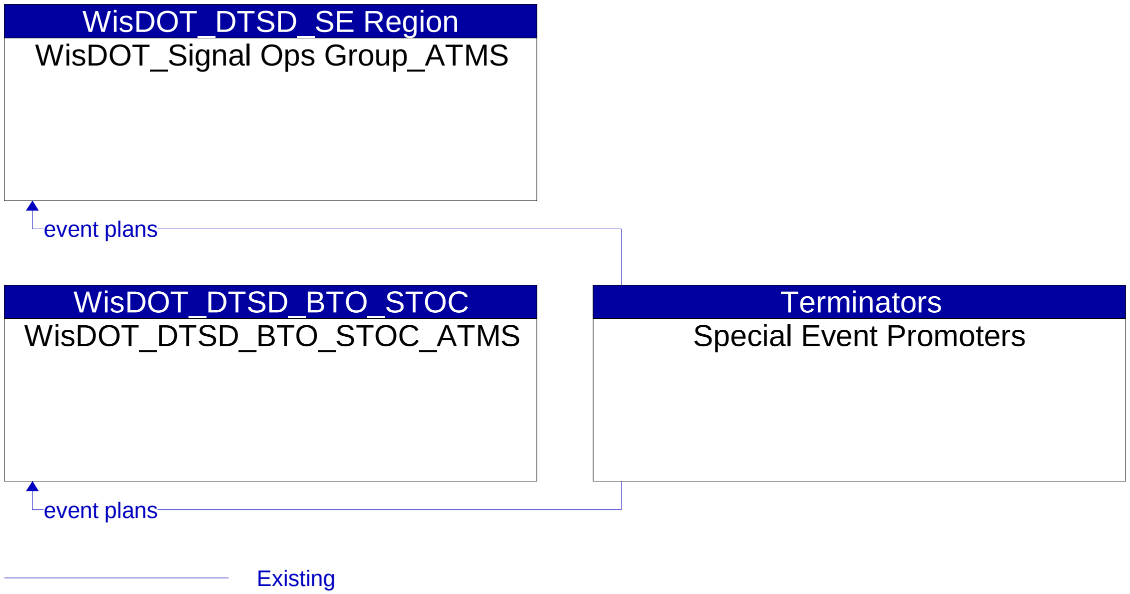


Figure 17: Information Flows Corresponding to the Element "Special Event Promoters"

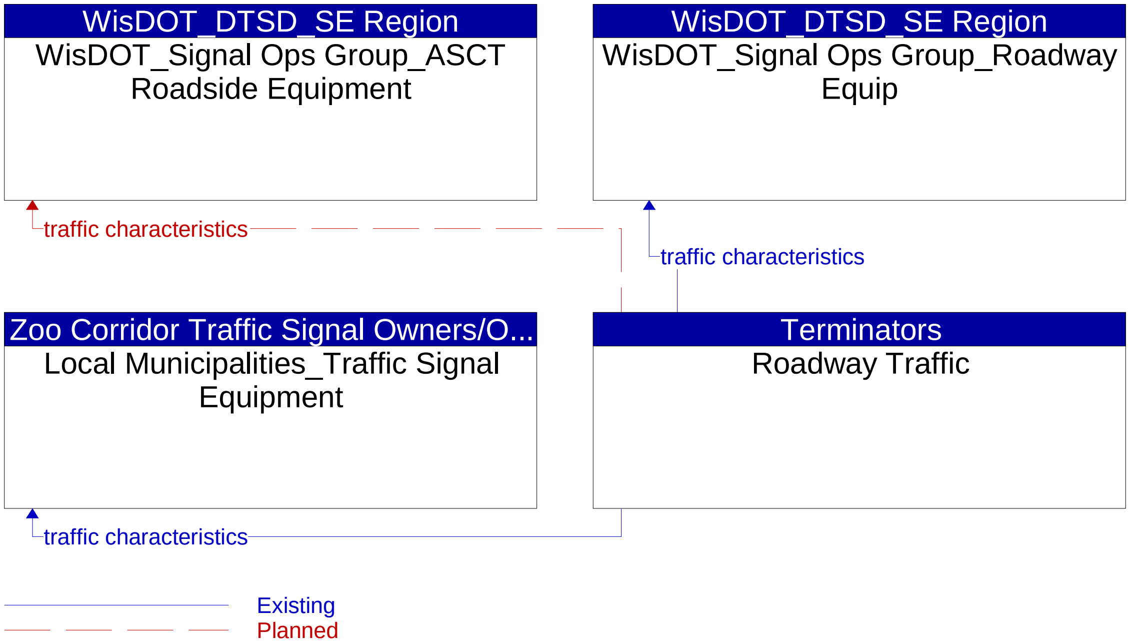


Figure 18: Information Flows Corresponding to the Element "Roadway Traffic"

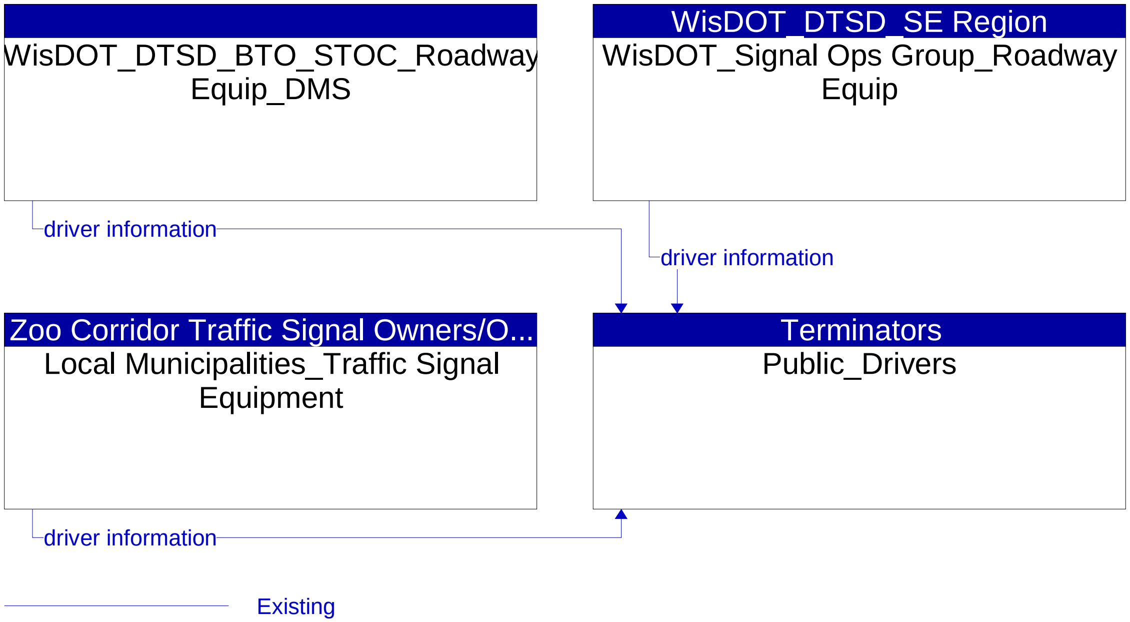


Figure 19: Information Flows Corresponding to the Element "Public_Drivers"

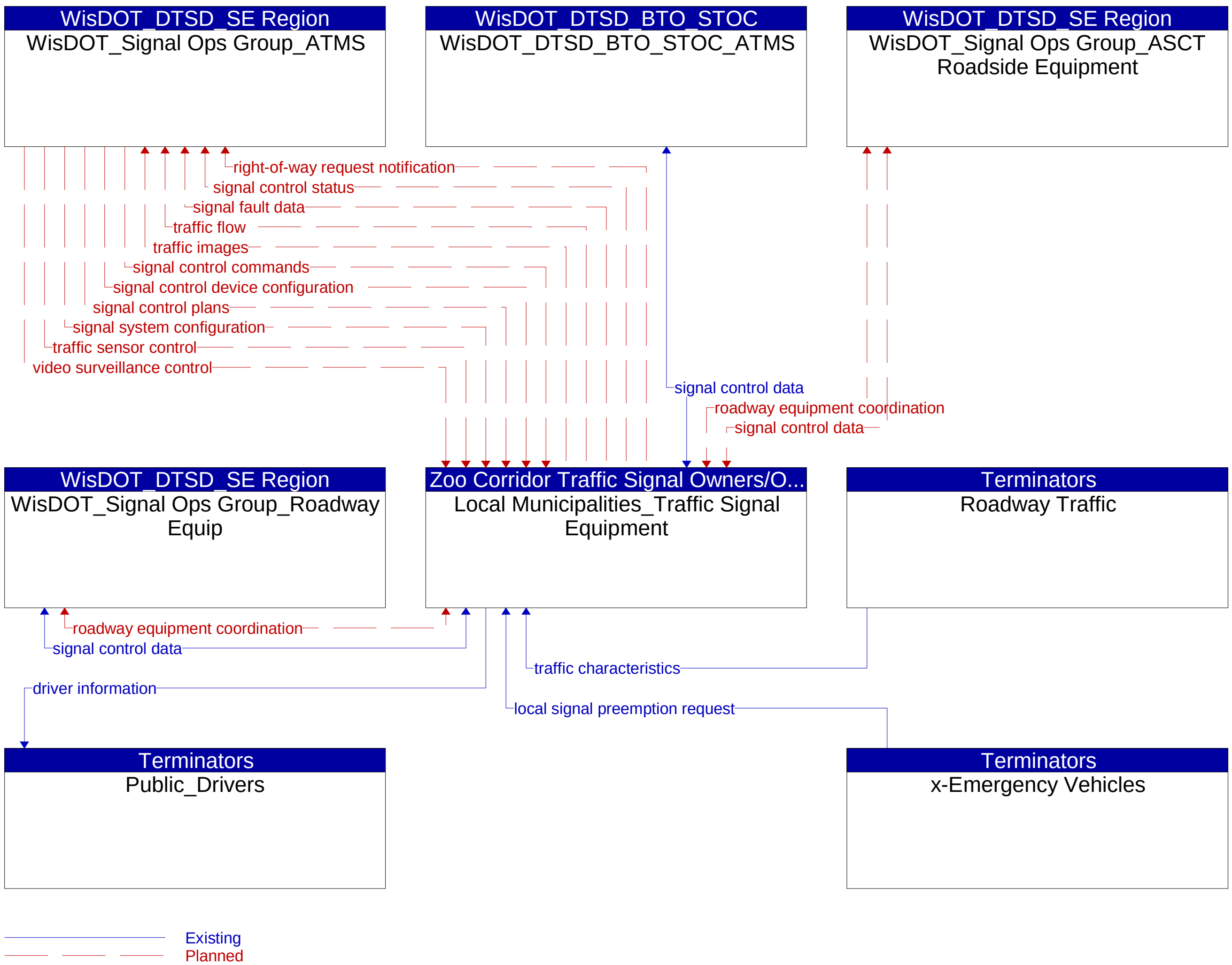


Figure 20: Information Flows Corresponding to the Element "Local Municipalities_Traffic Signal Equipment"

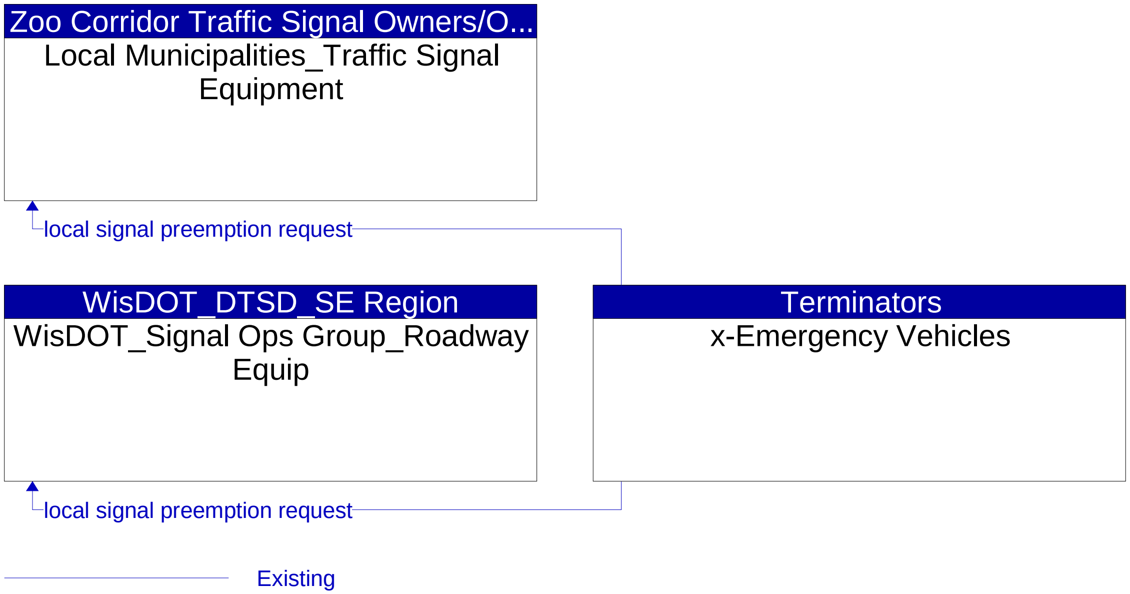


Figure 21: Information Flows Corresponding to the Element "x-Emergency Vehicles"

SECTION 11

Appendix B: Information Flows by Service Package

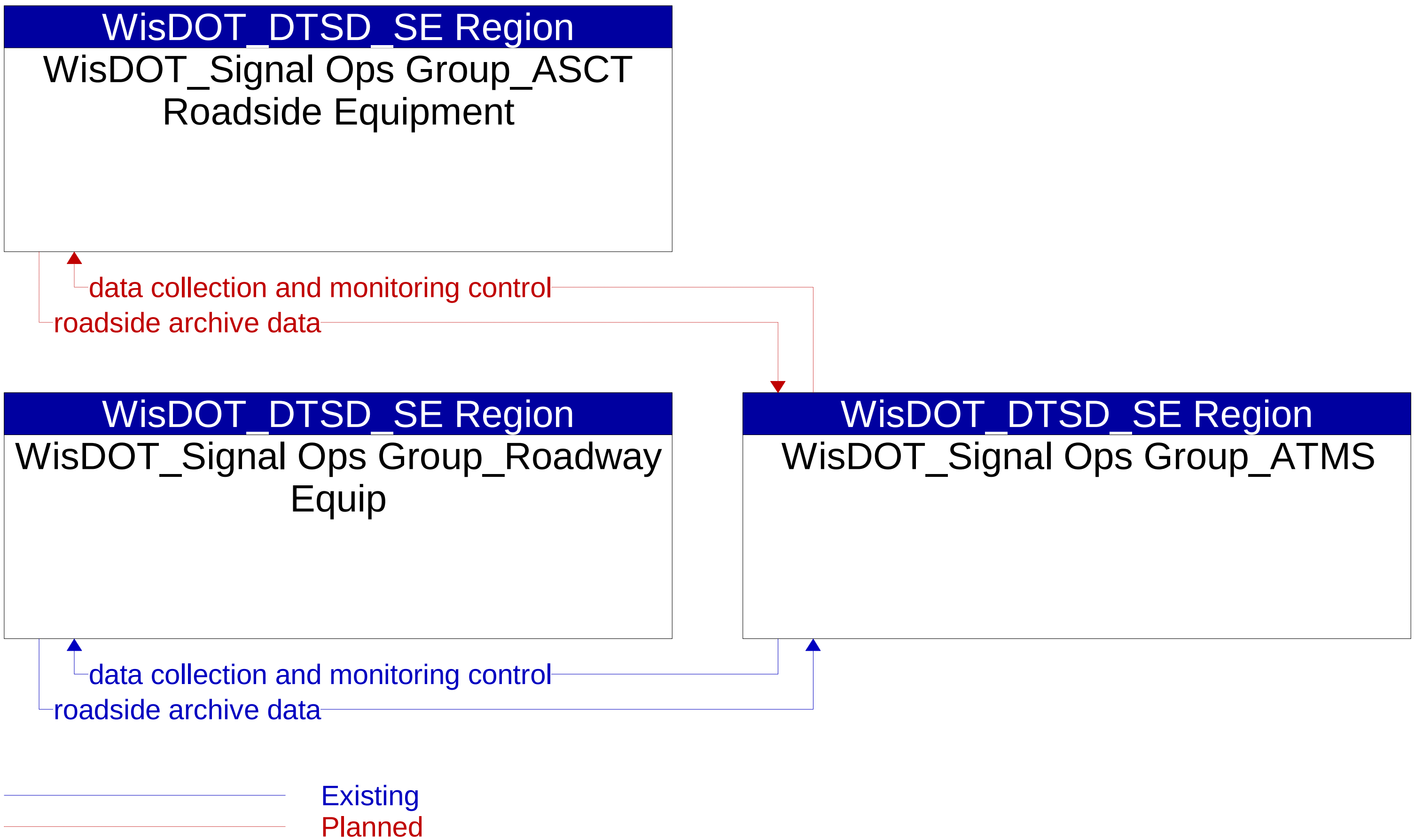


Figure 22: Information Flows Corresponding to the Service Package "ITS Data Mart"

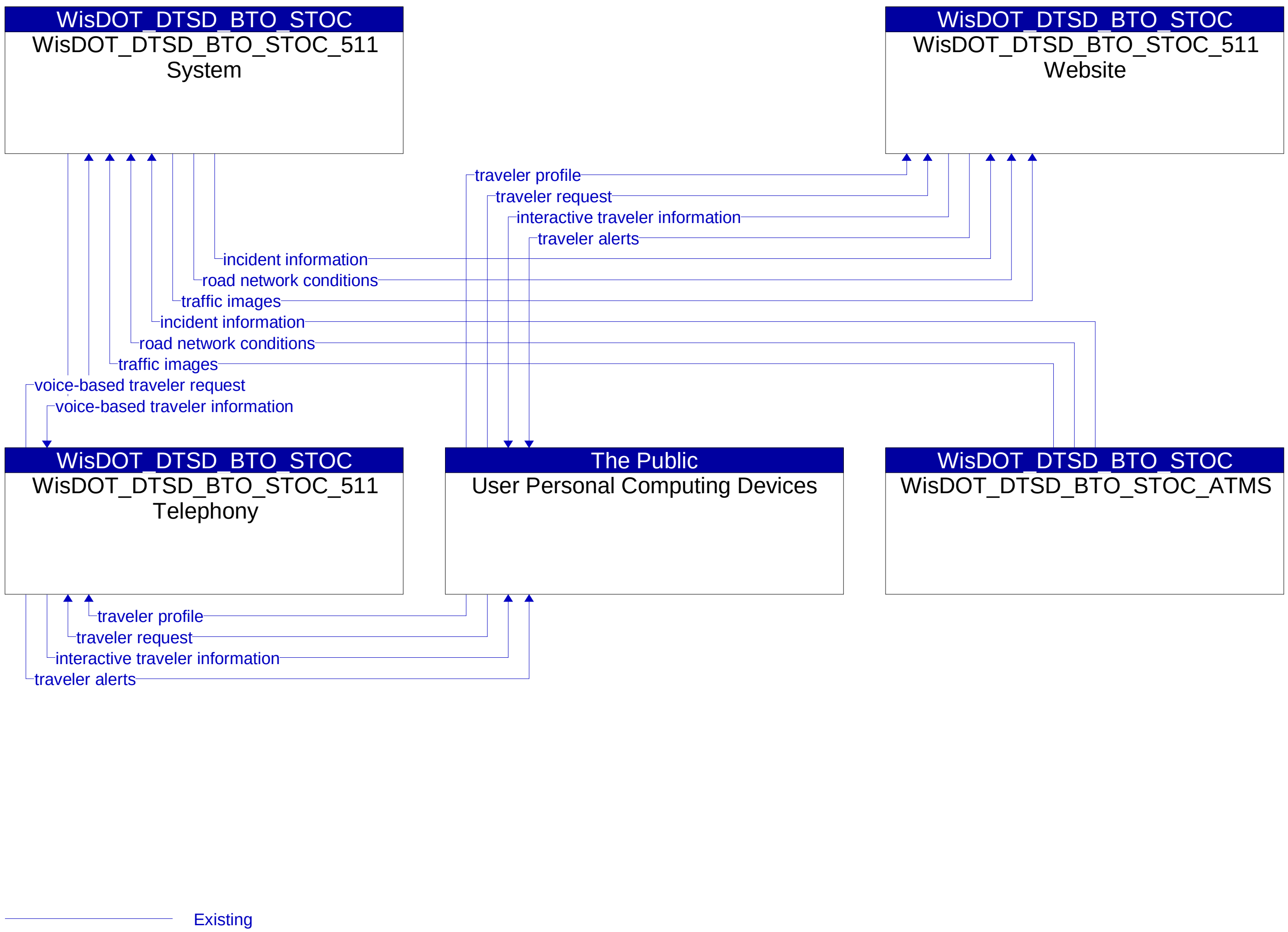


Figure 23: Information Flows Corresponding to the Service Package "Interactive Traveler Information"

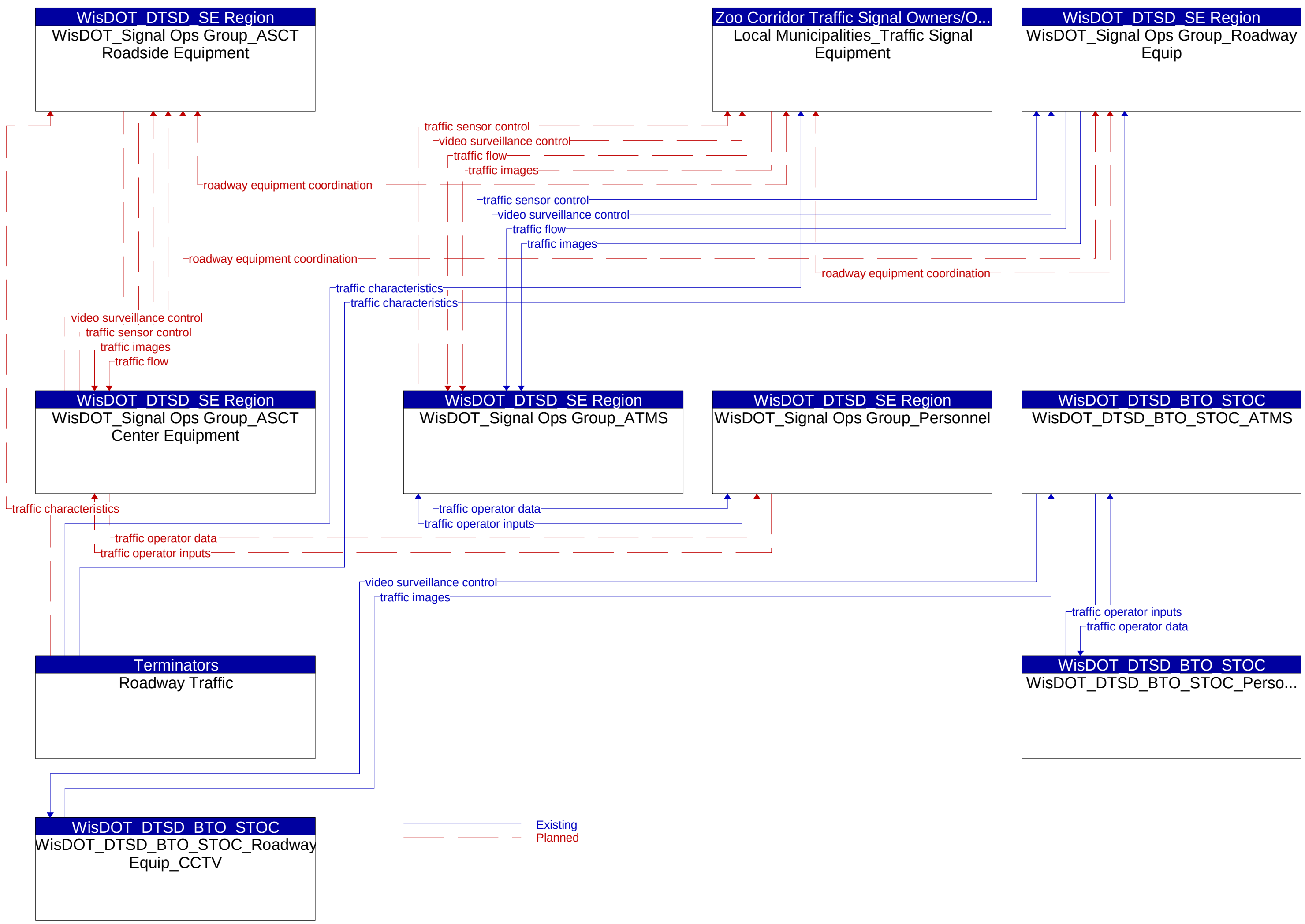


Figure 24: Information Flows Corresponding to the Service Package "Network Surveillance"

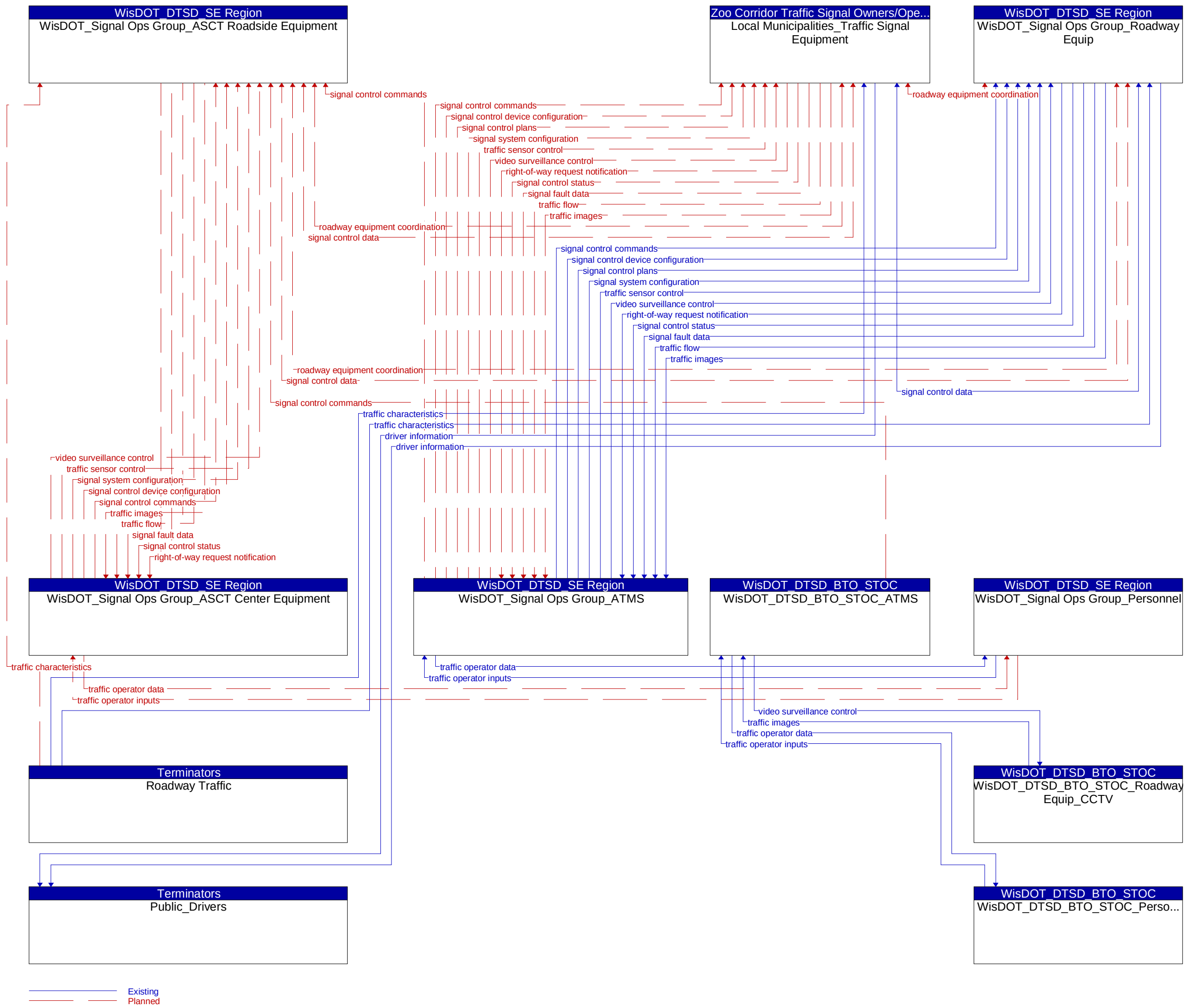


Figure 25: Information Flows Corresponding to the Service Package "Traffic Signal Control"

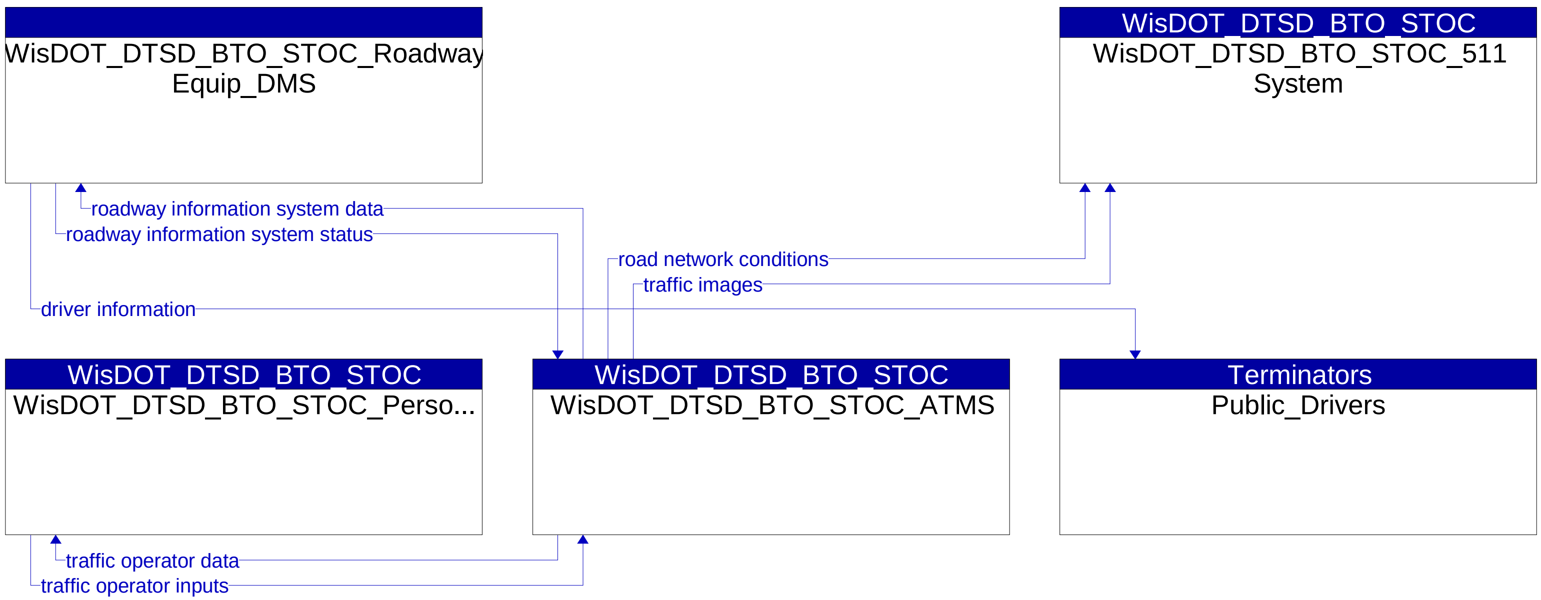


Figure 26: Information Flows Corresponding to the Service Package "Traffic Information Dissemination"

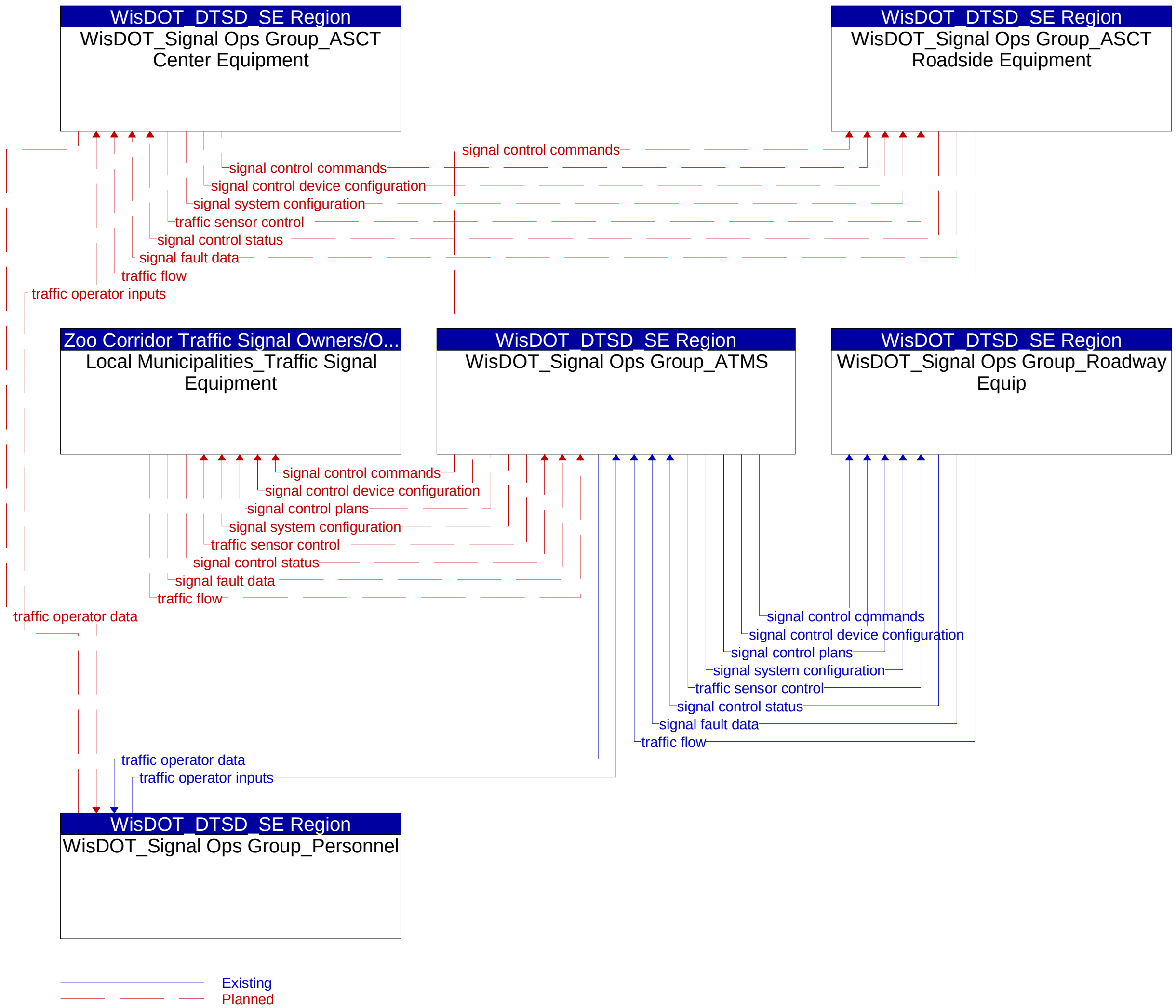


Figure 27: Information Flows Corresponding to the Service Package "Regional Traffic Management"

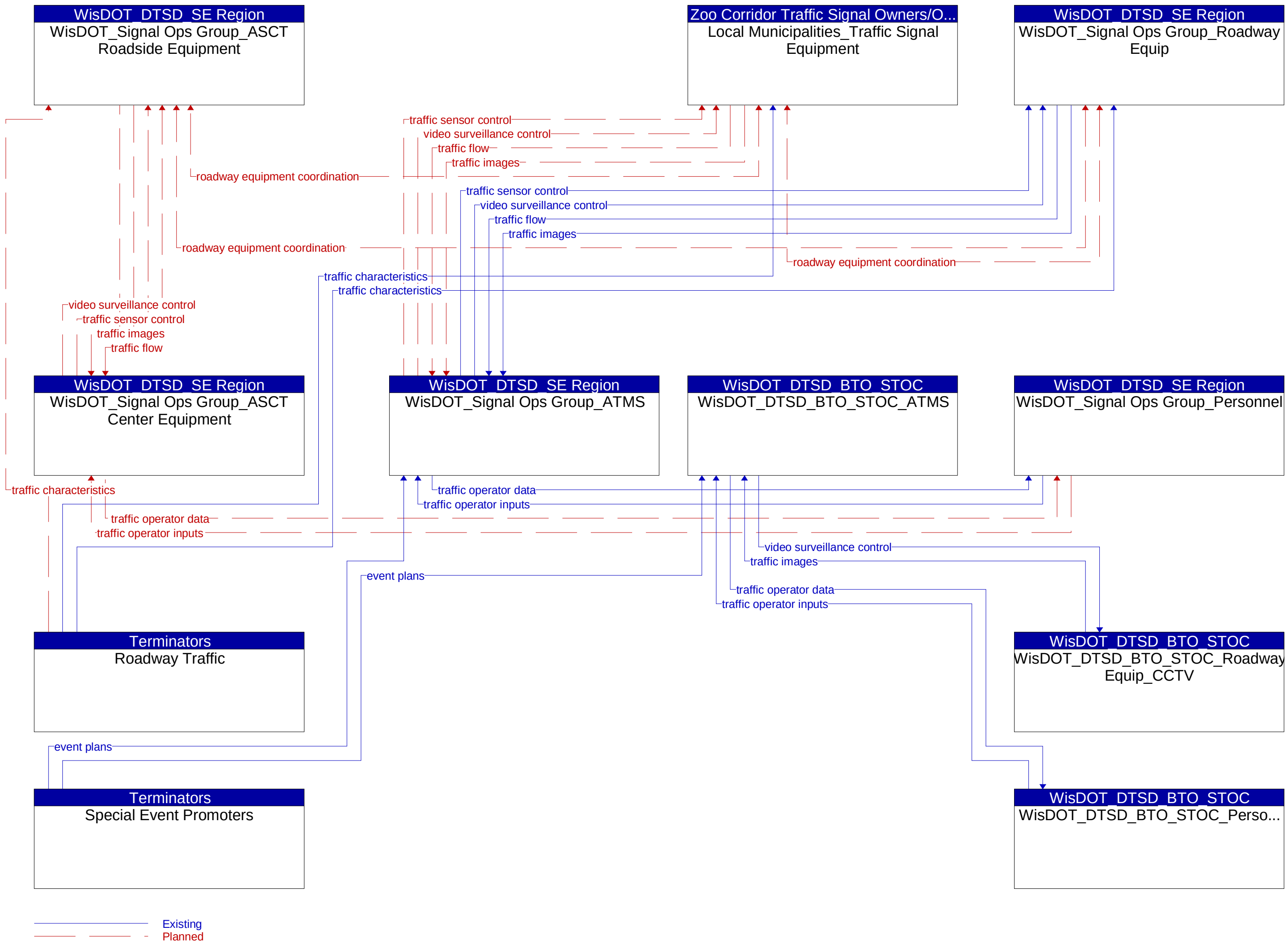


Figure 28: Information Flows Corresponding to the Service Package "Traffic Incident Management System"

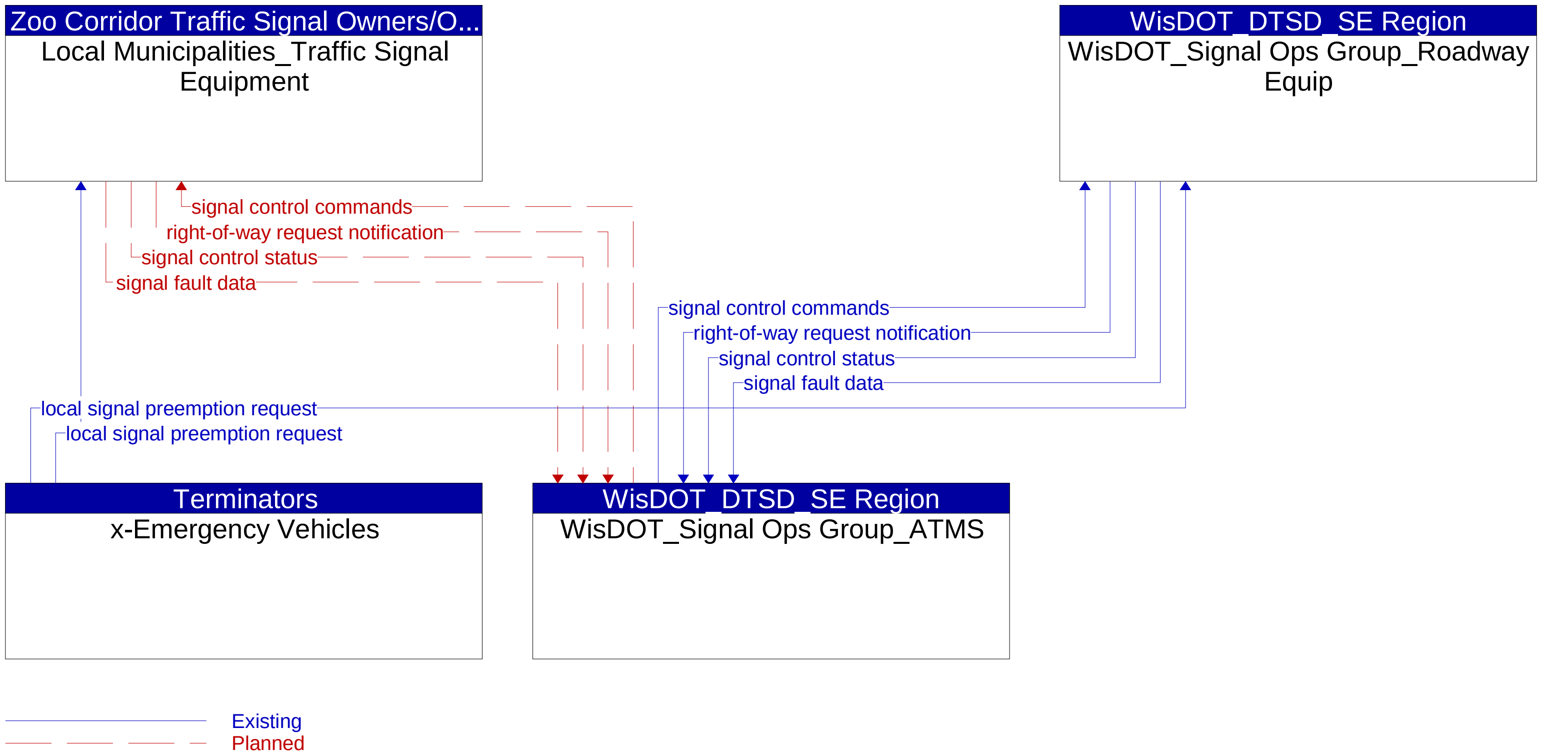


Figure 29: Information Flows Corresponding to the Service Package "Emergency Routing"

SECTION 12

Appendix C: Information Flows and Definitions

The National ITS Architecture provides a comprehensive listing of high-level information flows that are commonly exchanged between various types of ITS technologies. This listing is not intended to represent all the possible types of data/information that can be exchanged, but rather it is intended to provide a high-level representation of the types of data in which specific information may fall. Therefore, information flows from the National ITS architecture help further define the framework in which system development and integration will occur. This helps identify specific standards that may be used to ensure that systems can be easily integrated and remain interoperable well into the future. National ITS architecture information flows applicable to the Zoo Corridors ICM project are listed and defined in **Table 15**.

Table 15: Applicable Project Architecture Information Flows and Definitions

Information Flow Name	Definition
Data collection and monitoring control	Information used to configure and control data collection and monitoring systems.
Driver information	Regulatory, warning, and guidance information provided to the driver while en route to support safe and efficient vehicle operation.
Event plans	Plans for major events possibly impacting traffic.
Incident information	Notification of existence of incident and expected severity, location, time and nature of incident. As additional information is gathered and the incident evolves, updated incident information is provided. Incidents include any event that impacts transportation system operation ranging from

Information Flow Name	Definition
	routine incidents (e.g., disabled vehicle at the side of the road) through large-scale natural or human-caused disasters that involve loss of life, injuries, extensive property damage, and multi-jurisdictional response. This also includes special events, closures, and other planned events that may impact the transportation system.
Interactive traveler information	Traveler information provided in response to a traveler request. The provided information includes traffic and road conditions, advisories, incidents, payment information, transit services, parking information, weather information, and other travel-related data updates and confirmations.
Local signal preemption request	Direct control signal or message to a signalized intersection that results in preemption of the current control plan and grants right-of-way to the requesting vehicle.
Right-of-way request notification	Notice that a request has occurred for signal prioritization, signal preemption, pedestrian call, multi-modal crossing activation, or other source for right-of-way.
Road network conditions	Current and forecasted traffic information, road and weather conditions, and other road network status. Either raw data, processed data, or some combination of both may be provided by this architecture flow. Information on diversions and alternate routes, closures, and special traffic restrictions (lane/shoulder use, weight restrictions, width restrictions, HOV requirements) in effect is included along with a definition of the links, nodes, and routes that make up the road network.
Roadside archive data	A broad set of data derived from roadside sensors that includes current traffic conditions, environmental conditions, and any other data that can be directly collected by roadside sensors. This data also indicates the status of the sensors and reports of any identified sensor faults.
Roadway equipment coordination	The direct flow of information between field equipment. This includes transfer of information between sensors and driver information systems (e.g., DMS, HAR, variable speed limit signs, dynamic lane signs) or control devices (e.g., traffic signals, ramp meters), direct coordination between adjacent control devices, interfaces between detection and warning or alarm systems, and any other direct communications between field equipment.
Roadway information system data	Information used to initialize, configure, and control roadside systems that provide driver information (e.g., dynamic message signs, highway advisory radio, beacon systems). This flow can provide message content and delivery attributes, local message store maintenance requests, control mode commands, status queries, and all other commands and associated parameters that support

Information Flow Name	Definition
	remote management of these systems.
Roadway information system status	Current operating status of dynamic message signs, highway advisory radios, beacon systems, or other configurable field equipment that provides dynamic information to the driver.
Signal control commands	Control of traffic signal controllers or field masters including clock synchronization.
Signal control data	Information used to configure local traffic signal controllers.
Signal control device configuration	Data used to configure traffic signal control equipment including local controllers and system masters.
Signal control plans	Traffic signal timing parameters including minimum green time and interval durations for basic operation and cycle length, splits, offset, phase sequence, etc. for coordinated systems.
Signal control status	Operational and status data of traffic signal control equipment including operating condition and current indications.
Signal fault data	Faults from traffic signal control equipment.
Signal system configuration	Data used to configure traffic signal systems including configuring control sections and mode of operation (time based or traffic responsive).
Traffic characteristics	Physical traffic characteristics which are monitored and translated into macroscopic measures like occupancy, volume, density, and average speed. Point measures support presence detection and individual vehicle measures like speed.
Traffic flow	Raw and/or processed traffic detector data which allows derivation of traffic flow variables (e.g., speed, volume, and density measures) and associated information (e.g., congestion, potential incidents). This flow includes the traffic data and the operational status of the traffic detectors.
Traffic images	High fidelity, real-time traffic images suitable for surveillance monitoring by the operator or for use in machine vision applications.
Traffic operator data	Presentation of traffic operations data to the operator including traffic conditions, current operating status of field equipment, maintenance activity status, incident status, video images, security alerts, emergency response plan updates and other information. This data keeps the operator apprised of current road network status, provides feedback to the operator as traffic control actions are implemented, provides transportation security inputs, and supports review of historical data and

Information Flow Name	Definition
	preparation for future traffic operations activities.
Traffic operator inputs	User input from traffic operations personnel including requests for information, configuration changes, commands to adjust current traffic control strategies (e.g., adjust signal timing plans, change DMS messages), and other traffic operations data entry.
Traffic sensor control	Information used to configure and control traffic sensor systems.
Transportation information for operations	Information on the state of transportation system operations including traffic and road conditions, advisories, incidents, transit service information, weather information, parking information, and other related data.
Traveler alerts	Traveler information alerts reporting congestion, incidents, adverse road or weather conditions, parking availability, transit service delays or interruptions, and other information that may impact the traveler. Relevant alerts are provided based on traveler-supplied profile information including trip characteristics and preferences.
Traveler profile	Information about a traveler including equipment capabilities, personal preferences, and traveler alert subscriptions.
Traveler request	A request for traveler information including traffic, transit, toll, parking, road weather conditions, event, and passenger rail information. The request identifies the type of information, the area of interest, parameters that are used to prioritize or filter the returned information, and sorting preferences.
Video surveillance control	Information used to configure and control video surveillance systems.
Voice-based traveler information	Traveler information sent to the telecommunications systems for traveler information terminator. This flow may represent the bulk transfer of traveler information, including traffic conditions, incident information, transit information and weather and road condition information. It may be specially formatted for voice-based traveler information.
Voice-based traveler request	The electronic traveler information request from the telecommunications systems for traveler information terminator. It may be specifically formatted for voice-based traveler requests. The request can be a general subscription intended to initiate a continuous or regular data stream or a specific request intended to initiate a one-time response from the recipient.

SECTION 13

Appendix D: Signed Agreements

TRAFFIC CONTROL SIGNAL OPERATION AND MAINTENANCE AGREEMENT

The Wisconsin Department of Transportation agrees to assume ownership and operational responsibility for the traffic control signals at the intersections of: IH 94 EB Ramps & STH 181, IH 94 WB Ramps & STH 181, STH 181 & Dana St., USH 18 & STH 181, USH 18 & 92nd St., USH 18 & 95th St. for the purpose of controlling the flow of traffic.

The following conditions are acknowledged and accepted by the City of Milwaukee and The Wisconsin Department of Transportation:

1. The operation of the signals will comply with the Wisconsin Manual on Uniform Traffic Control Devices.
2. The reconstructed signal shall be constructed to Wisconsin Department of Transportation standards.
3. On the same day the inspection is complete and the reconstructed signal is turned on and approved for operation by the Wisconsin Department of Transportation, the Wisconsin Department of Transportation shall be responsible for ownership, operation and maintenance of the signal regardless of the completion of the remaining project work.
4. The City of Milwaukee shall be responsible for all timing requests up until the reconstructed signal is turned on and approved for operation by the Wisconsin Department of Transportation.
5. All equipment that is currently owned by the City of Milwaukee shall be returned to the City of Milwaukee.
6. Parking will be restricted by the municipality at locations on the identified intersecting streets in accordance with the need to provide adequate capacity and normal flow of traffic

Agreed on behalf of the City of Milwaukee

(Date)

Ghassan Korban
Commissioner of Public Works

Agreed on behalf of the Department

1-2-13

(Office of Traffic) (Date)

TRAFFIC CONTROL SIGNAL APPROVAL REQUEST

DT1199 8/2012 s.86.32(1) Wis. Stats.

Wisconsin Department of Transportation

Municipality City of Milwaukee	County Milwaukee
State Trunk Highway USH 41	Intersecting Road 107th Street/Florist Ave

☐ Check if connecting highway – Requires authorized municipal and departmental approval below. Approval of installation on the connecting highway system is required under s.86.32(1) Wis. Stats.

The Region requests approval of a traffic control signal at the location indicated above. Traffic volumes, crash experience and physical conditions at the described intersection have been reviewed. A traffic control signal is justified.

Approval Recommended [signature] (Regional Traffic Engineer) 9-18-12 (Date)

Approval Granted Joanna L. Bush (Bureau of Traffic Operations) 9-26-12 (Date)

TRAFFIC CONTROL SIGNAL INSTALLATION, OPERATION AND MAINTENANCE AGREEMENT

The municipality identified above agrees to install, operate and maintain a traffic control signal at the specified intersection for the purpose of controlling the flow of traffic.

The following conditions precedent to approval of the signal are acknowledged and accepted by the municipality:

1. The design, installation and operation of the signal will comply with the Wisconsin Manual on Uniform Traffic Control Devices.
2. The cost of maintenance and operation of the signal will be the responsibility of the municipality or in any case will not be an obligation of the Wisconsin Department of Transportation.
3. Parking will be restricted by the municipality at locations on the identified intersecting streets in accordance with the need to provide adequate capacity and normal flow of traffic. Specific restrictions, if needed, are as follows:
4. The municipality, with the approval or at the request of the Department of Transportation, and at the municipality's expense, shall make such adjustments in the equipment and manner of operation of these signals as are deemed necessary for public safety and facilitation of traffic movement.

☒ Yes ☐ No Further provisions are stated on the back of this document.
☐ Yes ☒ No Attachments

Agreed on behalf of the Municipality

X [signature] (Signature of Authorized Representative for Municipality) (Date)

Agreed on behalf of the Department

X Joanna L. Bush (Signature of Bureau of Traffic Operations) 9-26-12 (Date)

TRAFFIC CONTROL SIGNAL OPERATION AND MAINTENANCE AGREEMENT

1. The reconstructed signal shall be constructed to City of Milwaukee standards.
2. On the same day the inspection is complete and the reconstructed signal is turned on and approved for operation by the City of Milwaukee, the City of Milwaukee shall be responsible for ownership, operation and maintenance of the signal regardless of the completion of the remaining project work.
3. The connecting highway portion of this agreement does not apply to this agreement.
4. Item 4, which states, "The municipality, with the approval or at the request of the Department of Transportation, and at the municipality's expense, shall make such adjustments in the equipment and manner of operation of these signals as are deemed necessary for public safety and facilitation of traffic movement", does not apply.
5. The City of Milwaukee shall contact WE Energies and transfer the billing account number ~~8449-323-7~~17 from WisDOT to the City of Milwaukee.
   6444-410-884

TRAFFIC CONTROL SIGNAL APPROVAL REQUEST

DT1199 8/2012 s.86.32(1) Wis. Stats.

Wisconsin Department of Transportation

Municipality City of Milwaukee	County Milwaukee
State Trunk Highway USH 41	Intersecting Road Carmen Ave

☐ Check if connecting highway – Requires authorized municipal and departmental approval below. Approval of installation on the connecting highway system is required under s.86.32(1) Wis. Stats.

The Region requests approval of a traffic control signal at the location indicated above. Traffic volumes, crash experience and physical conditions at the described intersection have been reviewed. A traffic control signal is justified.

Approval Recommended [signature] (Regional Traffic Engineer) 9-18-12 (Date)

Approval Granted Joanne L. Bush (Bureau of Traffic Operations) 9-26-12 (Date)

TRAFFIC CONTROL SIGNAL INSTALLATION, OPERATION AND MAINTENANCE AGREEMENT

The municipality identified above agrees to install, operate and maintain a traffic control signal at the specified intersection for the purpose of controlling the flow of traffic.

The following conditions precedent to approval of the signal are acknowledged and accepted by the municipality:

1. The design, installation and operation of the signal will comply with the Wisconsin Manual on Uniform Traffic Control Devices.
2. The cost of maintenance and operation of the signal will be the responsibility of the municipality or in any case will not be an obligation of the Wisconsin Department of Transportation.
3. Parking will be restricted by the municipality at locations on the identified intersecting streets in accordance with the need to provide adequate capacity and normal flow of traffic. Specific restrictions, if needed, are as follows:
4. The municipality, with the approval or at the request of the Department of Transportation, and at the municipality's expense, shall make such adjustments in the equipment and manner of operation of these signals as are deemed necessary for public safety and facilitation of traffic movement.

☒ Yes ☐ No Further provisions are stated on the back of this document.

☐ Yes ☒ No Attachments

Agreed on behalf of the Municipality

X [signature] (Signature of Authorized Representative for Municipality) (Date)

Agreed on behalf of the Department

X Joanne L. Bush (Signature of Bureau of Traffic Operations) 9-26-12 (Date)

TRAFFIC CONTROL SIGNAL OPERATION AND MAINTENANCE AGREEMENT

1. The reconstructed signal shall be constructed to City of Milwaukee standards.
2. On the same day the inspection is complete and the reconstructed signal is turned on and approved for operation by the City of Milwaukee, the City of Milwaukee shall be responsible for ownership, operation and maintenance of the signal regardless of the completion of the remaining project work.
3. The connecting highway portion of this agreement does not apply to this agreement.
4. Item 4, which states, "The municipality, with the approval or at the request of the Department of Transportation, and at the municipality's expense, shall make such adjustments in the equipment and manner of operation of these signals as are deemed necessary for public safety and facilitation of traffic movement", does not apply.
5. The City of Milwaukee shall contact WE Energies and transfer the billing account number 8449-323-717 from WisDOT to the City of Milwaukee.

3078-984-294

TRAFFIC CONTROL SIGNAL OPERATION AND MAINTENANCE AGREEMENT

1. The reconstructed signal shall be constructed to City of Milwaukee standards.
2. On the same day the inspection is complete and the reconstructed signal is turned on and approved for operation by the City of Milwaukee, the City of Milwaukee shall be responsible for ownership, operation and maintenance of the signal regardless of the completion of the remaining project work.
3. The connecting highway portion of this agreement does not apply to this agreement.
4. Item 4, which states, "The municipality, with the approval or at the request of the Department of Transportation, and at the municipality's expense, shall make such adjustments in the equipment and manner of operation of these signals as are deemed necessary for public safety and facilitation of traffic movement", does not apply.
5. The City of Milwaukee shall contact WE Energies and transfer the billing account number 8449-323-717 from WisDOT to the City of Milwaukee.

3078-984-284

TRAFFIC CONTROL SIGNAL APPROVAL REQUEST — Wisconsin Department of Transportation

DT1199 8/2012 s.86.32(1) Wis. Stats.

Municipality	County
City of Milwaukee	Milwaukee
State Trunk Highway	**Intersecting Road**
USH 41	91st Street

☐ Check if connecting highway – Requires authorized municipal and departmental approval below. Approval of installation on the connecting highway system is required under s.86.32(1) Wis. Stats.

The Region requests approval of a traffic control signal at the location indicated above. Traffic volumes, crash experience and physical conditions at the described intersection have been reviewed. A traffic control signal is justified.

Approval Recommended [signature] (Regional Traffic Engineer) 9-18-12 (Date)

Approval Granted Joanna L. Bush (Bureau of Traffic Operations) 9-26-12 (Date)

TRAFFIC CONTROL SIGNAL INSTALLATION, OPERATION AND MAINTENANCE AGREEMENT

The municipality identified above agrees to install, operate and maintain a traffic control signal at the specified intersection for the purpose of controlling the flow of traffic.

The following conditions precedent to approval of the signal are acknowledged and accepted by the municipality:

1. The design, installation and operation of the signal will comply with the Wisconsin Manual on Uniform Traffic Control Devices.
2. The cost of maintenance and operation of the signal will be the responsibility of the municipality or in any case will not be an obligation of the Wisconsin Department of Transportation.
3. Parking will be restricted by the municipality at locations on the identified intersecting streets in accordance with the need to provide adequate capacity and normal flow of traffic. Specific restrictions, if needed, are as follows:
4. The municipality, with the approval or at the request of the Department of Transportation, and at the municipality's expense, shall make such adjustments in the equipment and manner of operation of these signals as are deemed necessary for public safety and facilitation of traffic movement.

☒ Yes ☐ No Further provisions are stated on the back of this document.
☐ Yes ☒ No Attachments

Agreed on behalf of the Municipality
X [signature]
(Signature of Authorized Representative for Municipality) (Date)

Agreed on behalf of the Department
X Joanna L. Bush 9-26-12
(Signature of Bureau of Traffic Operations) (Date)

TRAFFIC CONTROL SIGNAL OPERATION AND MAINTENANCE AGREEMENT

1. The reconstructed signal shall be constructed to City of Milwaukee standards.
2. On the same day the inspection is complete and the reconstructed signal is turned on and approved for operation by the City of Milwaukee, the City of Milwaukee shall be responsible for ownership, operation and maintenance of the signal regardless of the completion of the remaining project work.
3. The connecting highway portion of this agreement does not apply to this agreement.
4. Item 4, which states, "The municipality, with the approval or at the request of the Department of Transportation, and at the municipality's expense, shall make such adjustments in the equipment and manner of operation of these signals as are deemed necessary for public safety and facilitation of traffic movement", does not apply.
5. The City of Milwaukee shall contact WE Energies and transfer the billing account number 8449-323-717 from WisDOT to the City of Milwaukee.

TRAFFIC CONTROL SIGNAL APPROVAL REQUEST

DT1199 8/2012 s.86.32(1) Wis. Stats.

Wisconsin Department of Transportation

Municipality	County
City of Milwaukee	Milwaukee
State Trunk Highway	**Intersecting Road**
USH 41	Grantosa Dr

☐ Check if connecting highway – Requires authorized municipal and departmental approval below. Approval of installation on the connecting highway system is required under s.86.32(1) Wis. Stats.

The Region requests approval of a traffic control signal at the location indicated above. Traffic volumes, crash experience and physical conditions at the described intersection have been reviewed. A traffic control signal is justified.

Approval Recommended [signature] (Regional Traffic Engineer) 9-18-12 (Date)

Approval Granted Joanna L. Bush (Bureau of Traffic Operations) 9-26-12 (Date)

TRAFFIC CONTROL SIGNAL INSTALLATION, OPERATION AND MAINTENANCE AGREEMENT

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4. The municipality, with the approval or at the request of the Department of Transportation, and at the municipality's expense, shall make such adjustments in the equipment and manner of operation of these signals as are deemed necessary for public safety and facilitation of traffic movement.

☒ Yes ☐ No Further provisions are stated on the back of this document.

☐ Yes ☒ No Attachments

Agreed on behalf of the Municipality

X [signature] (Signature of Authorized Representative for Municipality) (Date)

Agreed on behalf of the Department

X Joanna L. Bush (Signature of Bureau of Traffic Operations) 9-26-12 (Date)

TRAFFIC CONTROL SIGNAL OPERATION AND MAINTENANCE AGREEMENT

1. The reconstructed signal shall be constructed to City of Milwaukee standards.
2. On the same day the inspection is complete and the reconstructed signal is turned on and approved for operation by the City of Milwaukee, the City of Milwaukee shall be responsible for ownership, operation and maintenance of the signal regardless of the completion of the remaining project work.
3. The connecting highway portion of this agreement does not apply to this agreement.
4. Item 4, which states, "The municipality, with the approval or at the request of the Department of Transportation, and at the municipality's expense, shall make such adjustments in the equipment and manner of operation of these signals as are deemed necessary for public safety and facilitation of traffic movement", does not apply.
5. The City of Milwaukee shall contact WE Energies and transfer the billing account number 8449-323-717 from WisDOT to the City of Milwaukee.

9402-226-027

TRAFFIC CONTROL SIGNAL APPROVAL REQUEST

DT1199 8/2012 s.86.32(1) Wis. Stats.

Wisconsin Department of Transportation

Municipality	County
City of Milwaukee	Milwaukee
State Trunk Highway	**Intersecting Road**
USH 41	Hampton Ave

☐ Check if connecting highway – Requires authorized municipal and departmental approval below. Approval of installation on the connecting highway system is required under s.86.32(1) Wis. Stats.

The Region requests approval of a traffic control signal at the location indicated above. Traffic volumes, crash experience and physical conditions at the described intersection have been reviewed. A traffic control signal is justified.

Approval Recommended [signature] (Regional Traffic Engineer) 9-18-12 (Date)

Approval Granted Joanna L. Bush (Bureau of Traffic Operations) 9-26-12 (Date)

TRAFFIC CONTROL SIGNAL INSTALLATION, OPERATION AND MAINTENANCE AGREEMENT

The municipality identified above agrees to install, operate and maintain a traffic control signal at the specified intersection for the purpose of controlling the flow of traffic.

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☒ Yes ☐ No Further provisions are stated on the back of this document.

☐ Yes ☒ No Attachments

Agreed on behalf of the Municipality

X [signature] (Signature of Authorized Representative for Municipality) (Date)

Agreed on behalf of the Department

X Joanna L. Bush (Signature of Bureau of Traffic Operations) 9-26-12 (Date)

TRAFFIC CONTROL SIGNAL OPERATION AND MAINTENANCE AGREEMENT

1. The reconstructed signal shall be constructed to City of Milwaukee standards.
2. On the same day the inspection is complete and the reconstructed signal is turned on and approved for operation by the City of Milwaukee, the City of Milwaukee shall be responsible for ownership, operation and maintenance of the signal regardless of the completion of the remaining project work.
3. The connecting highway portion of this agreement does not apply to this agreement.
4. Item 4, which states, "The municipality, with the approval or at the request of the Department of Transportation, and at the municipality's expense, shall make such adjustments in the equipment and manner of operation of these signals as are deemed necessary for public safety and facilitation of traffic movement", does not apply.
5. The City of Milwaukee shall contact WE Energies and transfer the billing account number 8449-323-717 from WisDOT to the City of Milwaukee.

0206-726-052

TRAFFIC CONTROL SIGNAL APPROVAL REQUEST

DT1199 8/2012 s.86.32(1) Wis. Stats.

Wisconsin Department of Transportation

Municipality	County
City of Milwaukee	Milwaukee
State Trunk Highway	**Intersecting Road**
USH 41	Congress St

☐ Check if connecting highway – Requires authorized municipal and departmental approval below. Approval of installation on the connecting highway system is required under s.86.32(1) Wis. Stats.

The Region requests approval of a traffic control signal at the location indicated above. Traffic volumes, crash experience and physical conditions at the described intersection have been reviewed. A traffic control signal is justified.

Approval Recommended [signature] (Regional Traffic Engineer) 9-18-12 (Date)

Approval Granted Joanna L. Bush (Bureau of Traffic Operations) 9-26-12 (Date)

TRAFFIC CONTROL SIGNAL INSTALLATION, OPERATION AND MAINTENANCE AGREEMENT

The municipality identified above agrees to install, operate and maintain a traffic control signal at the specified intersection for the purpose of controlling the flow of traffic.

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1. The design, installation and operation of the signal will comply with the Wisconsin Manual on Uniform Traffic Control Devices.
2. The cost of maintenance and operation of the signal will be the responsibility of the municipality or in any case will not be an obligation of the Wisconsin Department of Transportation.
3. Parking will be restricted by the municipality at locations on the identified intersecting streets in accordance with the need to provide adequate capacity and normal flow of traffic. Specific restrictions, if needed, are as follows:
4. The municipality, with the approval or at the request of the Department of Transportation, and at the municipality's expense, shall make such adjustments in the equipment and manner of operation of these signals as are deemed necessary for public safety and facilitation of traffic movement.

☒ Yes ☐ No Further provisions are stated on the back of this document.
☐ Yes ☒ No Attachments

Agreed on behalf of the Municipality

X [signature] (Signature of Authorized Representative for Municipality) (Date)

Agreed on behalf of the Department

X Joanna L. Bush (Signature of Bureau of Traffic Operations) 9-26-12 (Date)

TRAFFIC CONTROL SIGNAL OPERATION AND MAINTENANCE AGREEMENT

1. The reconstructed signal shall be constructed to City of Milwaukee standards.
2. On the same day the inspection is complete and the reconstructed signal is turned on and approved for operation by the City of Milwaukee, the City of Milwaukee shall be responsible for ownership, operation and maintenance of the signal regardless of the completion of the remaining project work.
3. The connecting highway portion of this agreement does not apply to this agreement.
4. Item 4, which states, "The municipality, with the approval or at the request of the Department of Transportation, and at the municipality's expense, shall make such adjustments in the equipment and manner of operation of these signals as are deemed necessary for public safety and facilitation of traffic movement", does not apply.
5. The City of Milwaukee shall contact WE Energies and transfer the billing account number 8449-323-717 from WisDOT to the City of Milwaukee.

5019-525-622

S1390

TRAFFIC CONTROL SIGNAL APPROVAL REQUEST

DT1199 8/2012 s.86.32(1) Wis. Stats.

Wisconsin Department of Transportation

Municipality City of West Allis	County Milwaukee
State Trunk Highway STH 181	Intersecting Road Schlinger Ave

☐ Check if connecting highway – Requires authorized municipal and departmental approval below. Approval of installation on the connecting highway system is required under s.86.32(1) Wis. Stats.

The Region requests approval of a traffic control signal at the location indicated above. Traffic volumes, crash experience and physical conditions at the described intersection have been reviewed. A traffic control signal is justified.

Approval Recommended [signature] (Regional Traffic Engineer) 9-18-12 (Date)

Approval Granted Joanna L. Bush (Bureau of Traffic Operations) 9-26-12 (Date)

TRAFFIC CONTROL SIGNAL INSTALLATION, OPERATION AND MAINTENANCE AGREEMENT

The municipality identified above agrees to install, operate and maintain a traffic control signal at the specified intersection for the purpose of controlling the flow of traffic.

The following conditions precedent to approval of the signal are acknowledged and accepted by the municipality:

1. The design, installation and operation of the signal will comply with the Wisconsin Manual on Uniform Traffic Control Devices.
2. The cost of maintenance and operation of the signal will be the responsibility of the municipality or in any case will not be an obligation of the Wisconsin Department of Transportation.
3. Parking will be restricted by the municipality at locations on the identified intersecting streets in accordance with the need to provide adequate capacity and normal flow of traffic. Specific restrictions, if needed, are as follows:
4. The municipality, with the approval or at the request of the Department of Transportation, and at the municipality's expense, shall make such adjustments in the equipment and manner of operation of these signals as are deemed necessary for public safety and facilitation of traffic movement.

☐ Yes ☐ No Further provisions are stated on the back of this document.
☐ Yes ☐ No Attachments

Agreed on behalf of the Municipality

X
(Signature of Authorized Representative for Municipality) (Date)

Agreed on behalf of the Department

X
(Signature of Bureau of Traffic Operations) (Date)

S1389

TRAFFIC CONTROL SIGNAL APPROVAL REQUEST

Wisconsin Department of Transportation

DT1199 8/2012 s.86.32(1) Wis. Stats.

Municipality	County
City of West Allis	Milwaukee
State Trunk Highway	**Intersecting Road**
STH 181	State Fair Entrance

☐ Check if connecting highway – Requires authorized municipal and departmental approval below. Approval of installation on the connecting highway system is required under s.86.32(1) Wis. Stats.

The Region requests approval of a traffic control signal at the location indicated above. Traffic volumes, crash experience and physical conditions at the described intersection have been reviewed. A traffic control signal is justified.

Approval Recommended [signature] (Regional Traffic Engineer) 9-18-12 (Date)

Approval Granted Joanna L. Bush (Bureau of Traffic Operations) 9-26-12 (Date)

TRAFFIC CONTROL SIGNAL INSTALLATION, OPERATION AND MAINTENANCE AGREEMENT

The municipality identified above agrees to install, operate and maintain a traffic control signal at the specified intersection for the purpose of controlling the flow of traffic.

The following conditions precedent to approval of the signal are acknowledged and accepted by the municipality:

1. The design, installation and operation of the signal will comply with the Wisconsin Manual on Uniform Traffic Control Devices.
2. The cost of maintenance and operation of the signal will be the responsibility of the municipality or in any case will not be an obligation of the Wisconsin Department of Transportation.
3. Parking will be restricted by the municipality at locations on the identified intersecting streets in accordance with the need to provide adequate capacity and normal flow of traffic. Specific restrictions, if needed, are as follows:
4. The municipality, with the approval or at the request of the Department of Transportation, and at the municipality's expense, shall make such adjustments in the equipment and manner of operation of these signals as are deemed necessary for public safety and facilitation of traffic movement.

☐ Yes ☐ No Further provisions are stated on the back of this document.
☐ Yes ☐ No Attachments

Agreed on behalf of the Municipality

X ______________________
(Signature of Authorized Representative for Municipality) (Date)

Agreed on behalf of the Department

X ______________________
(Signature of Bureau of Traffic Operations) (Date)

S1388

TRAFFIC CONTROL SIGNAL APPROVAL REQUEST

DT1199 8/2012 s.86.32(1) Wis. Stats.

Wisconsin Department of Transportation

Municipality City of West Allis	County Milwaukee
State Trunk Highway STH 59	Intersecting Road 84th Street

☐ Check if connecting highway – Requires authorized municipal and departmental approval below. Approval of installation on the connecting highway system is required under s.86.32(1) Wis. Stats.

The Region requests approval of a traffic control signal at the location indicated above. Traffic volumes, crash experience and physical conditions at the described intersection have been reviewed. A traffic control signal is justified.

Approval Recommended [signature] (Regional Traffic Engineer) 9-18-12 (Date)

Approval Granted Joanna L. Bush (Bureau of Traffic Operations) 9-26-12 (Date)

TRAFFIC CONTROL SIGNAL INSTALLATION, OPERATION AND MAINTENANCE AGREEMENT

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☐ Yes ☐ No Further provisions are stated on the back of this document.
☐ Yes ☐ No Attachments

Agreed on behalf of the Municipality

X
(Signature of Authorized Representative for Municipality) (Date)

Agreed on behalf of the Department

X
(Signature of Bureau of Traffic Operations) (Date)

S1387

TRAFFIC CONTROL SIGNAL APPROVAL REQUEST

DT1199 8/2012 s.86.32(1) Wis. Stats.

Wisconsin Department of Transportation

Municipality City of West Allis	County Milwaukee
State Trunk Highway STH 59	Intersecting Road 92nd Street

☐ Check if connecting highway – Requires authorized municipal and departmental approval below. Approval of installation on the connecting highway system is required under s.86.32(1) Wis. Stats.

The Region requests approval of a traffic control signal at the location indicated above. Traffic volumes, crash experience and physical conditions at the described intersection have been reviewed. A traffic control signal is justified.

Approval Recommended [signature] (Regional Traffic Engineer) 9-18-12 (Date)

Approval Granted Joanna L. Bush (Bureau of Traffic Operations) 9-26-12 (Date)

TRAFFIC CONTROL SIGNAL INSTALLATION, OPERATION AND MAINTENANCE AGREEMENT

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☐ Yes ☐ No Further provisions are stated on the back of this document.
☐ Yes ☐ No Attachments

Agreed on behalf of the Municipality

X ______ (Signature of Authorized Representative for Municipality) (Date)

Agreed on behalf of the Department

X ______ (Signature of Bureau of Traffic Operations) (Date)

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