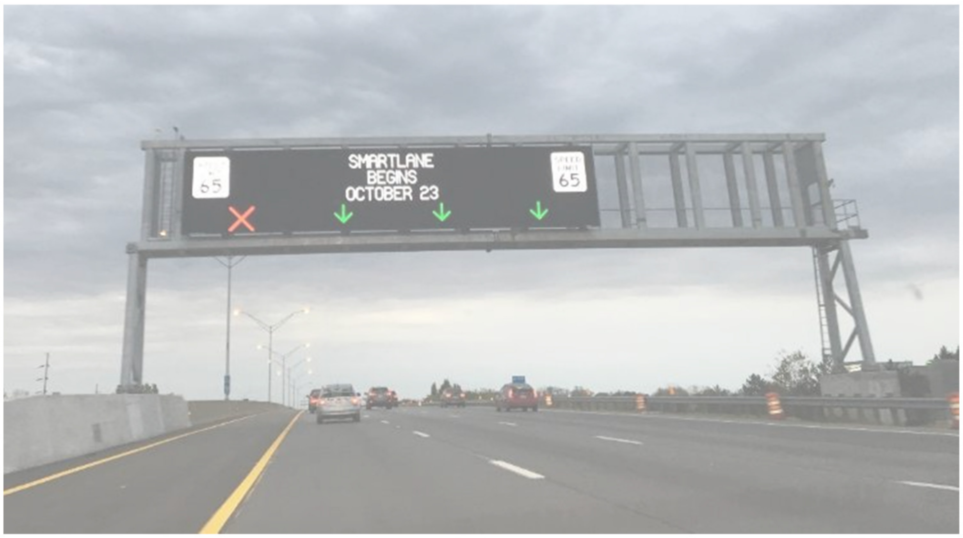
Statewide
Systems Engineering Analysis (SEA) for
Active Transportation and Demand Management
(ATDM) Projects



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Document Control

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1.1	Szymkowski	Campbell	10/20/17	Integrated ODOT and FHWA Comments
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1 General Information

1.1 Statewide ATDM Background and Scope

1.1.1 Document Purpose and Organization

The purpose of this document is to identify and document the system needs from a broad perspective that can be integrated comprehensively into future preliminary and final design activities for various Active Transportation and Demand Management (ATDM) projects throughout Ohio. It has been designed to provide a framework that enables similar projects across the state to be added by building on previously completed systems engineering analysis.

The document is intended to be updated as new projects are planned, built, and operated. It is also intended to be a location for documenting post deployment lessons learned.

The information detailed within the document is based on:

- 2016 ODOT Final Report for Determining Candidate Active Traffic and Demand Management Strategies
- 2017 Statewide Active Traffic Management Study Concept of Operations
- Input and feedback from various ODOT personnel
- Input and feedback from project stakeholders (e.g., emergency responders)
- Existing plans, policies, and technical reports provided by ODOT

The document includes discussion on many topics, consistent with requirements of CFR 940, Section 11 and other ODOT requirements related to project implementation and required systems engineering analysis (SEA):

1. Identification of participating agencies roles and responsibilities
2. Identification of portions of the regional intelligent transportation systems (ITS) architecture being implemented
3. Requirements definitions
4. Analysis of alternative system configurations and technology options to meet requirements
5. Procurement options
6. Identification of applicable ITS standards and testing procedures
7. Procedures and resources necessary for operations and management of the system

The report recommendations form the basis for future preliminary and detailed design development and follow the Vee Diagram for Systems Engineering shown in **Figure 1-1**. The ATDM project types identified in this report follow the systems engineering development process from architecture and feasibility through the concept of operations and high-level functional requirements.

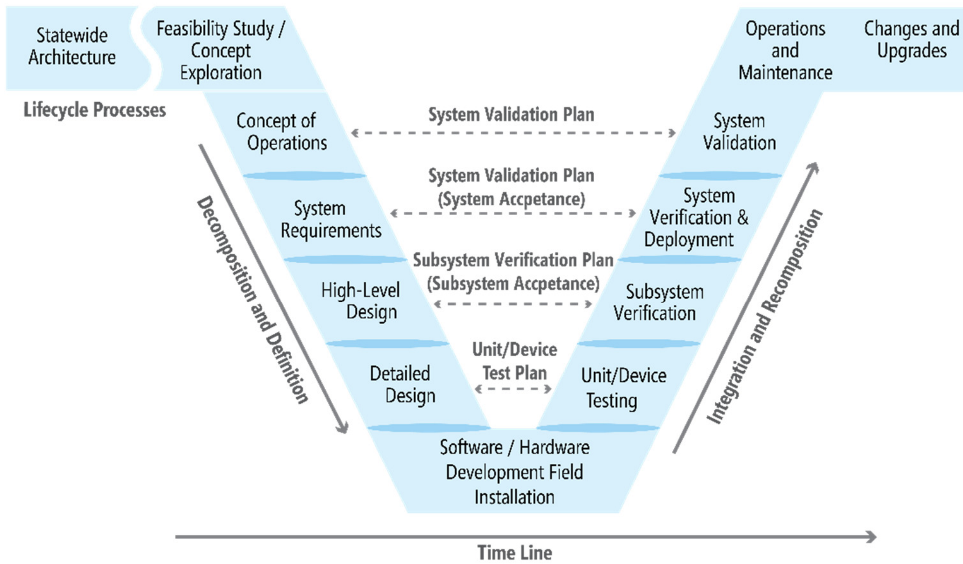

Figure 1-1. Statewide ATDM V Diagram.

Figure 1-2 shows the overall organization of the report and its relationship to previously completed ATDM planning and systems engineering studies. Some of the sections cover all of the ATDM projects, while others are more specific (e.g., alternatives systems and procurement options).

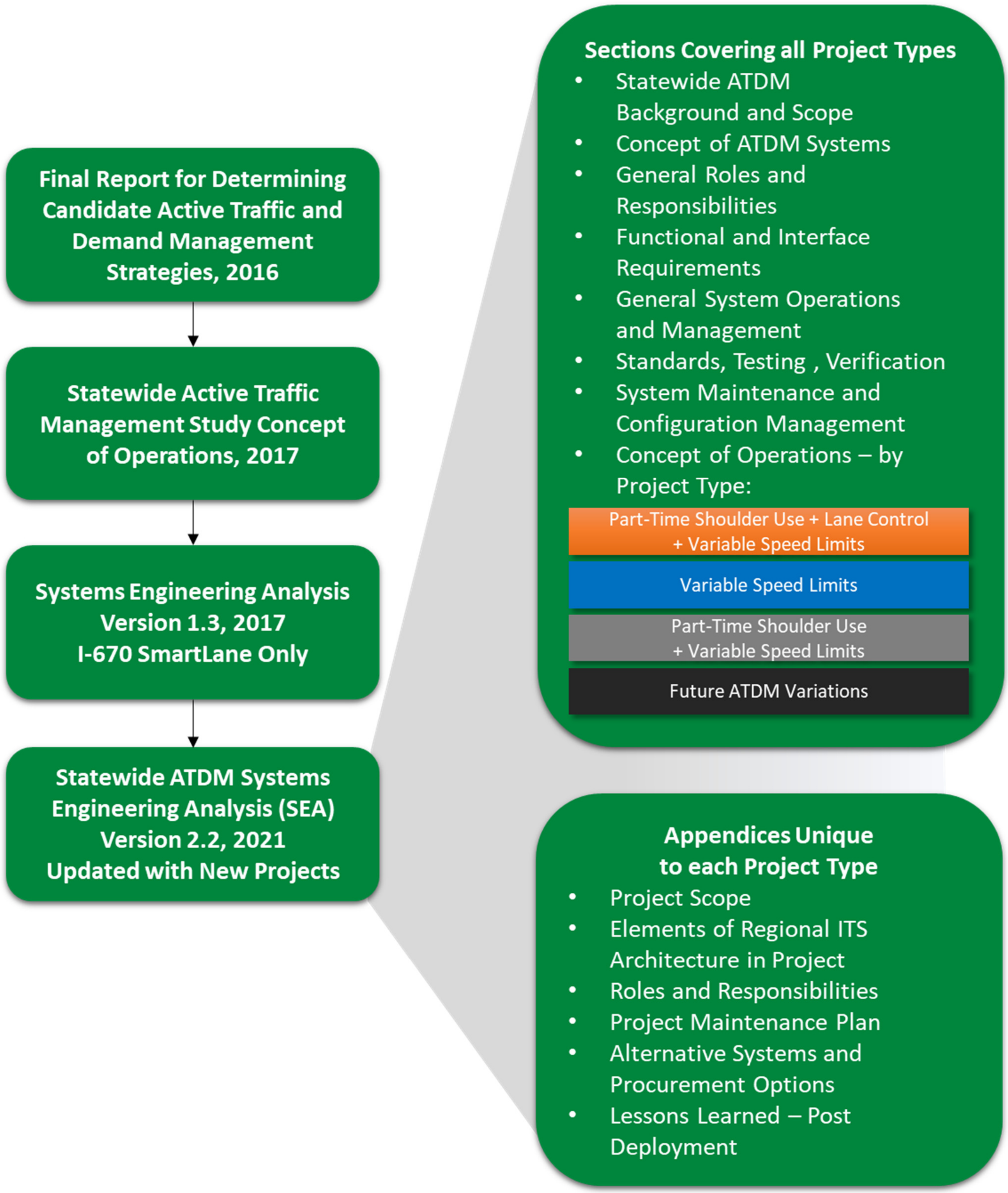

Figure 1-2. Statewide ATDM Systems Engineering Report Organization

1.1.2 Project Site Selection Background and Project Need

ODOT completed a *Final Report for Determining Candidate Active Traffic and Demand Management Strategies* in 2016 to determine what corridors should be further considered for ATDM strategies based on the goals outlined in **Table 1-1**.

Table 1-1. ATDM Goals for Urban Corridors

GOAL	DESCRIPTION
1	Improve travel time reliability
2	Preserve reliable capacity in the future
3	Improve freight travel
4	Improve transit reliability
5	Reduce vehicle delay
6	Financial Feasibility
7	Reduce overall vehicle hours of travel
8	Improve person throughput
9	Reduce personal travel time
10	Reduce overall vehicle-miles traveled

Recommended candidate ATDM corridors were selected based on the outcomes of a three-tiered screening methodology.

- Tier 1 - Primary level of screening was the broadest and considered all freeway facilities in the state to identify the locations where congestion is present.
- Tier 2 - Secondary level considered the severity of congestion, its limits and duration, corridor characteristics associated with travel demand and physical attributes, and constraints of the built environment in each region.
- Tier 3 - The tertiary level attempted to monetize the benefits and compares them with cost estimates so that a benefit/cost analysis can be performed.

Part-time shoulder use or hard shoulder running (HSR) corridors were identified using screening techniques that took into consideration existing roadway geometric factors, congestion levels during peak periods, and existing pavement conditions. Additional detail is available in Section 5.4 of the 2016 ATDM Report. After the completion of the study, ODOT selected four candidate routes to move forward with additional investigation:

- I-70 (Columbus)
- I-270 (Columbus)
- I-275 (Cincinnati)
- I-670 (Columbus)

I-670 and I-275 rose to the top of the evaluation because the anticipated user benefits of the SmartLane, existing physical characteristics, and anticipated difficulties inherent in roadway widening relative to the other candidates. The I-670 SmartLane project was constructed in 2018 and became operational in 2019.

Outside the 2016 ATDM Report, ODOT deployed a Variable Speed Limit (VSL) pilot along the I-90 corridor in Lake County (east of Cleveland) during the winter of 2017/2018. The VSL system is primarily focused on reducing speeds when visibility, precipitation, or pavement conditions warrant a speed reduction. The VSL signs are placed approximately every 1.5 - 2 miles, and weather sensors are spaced approximately every 4 miles along the roadway. VSL signs will be adjusted on the section of roadway where weather conditions or traffic crashes warrant a speed reduction.

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1.1.3 Concurrent and Related Projects and Programs

There are a number of projects and programs that have a direct or indirect relationship to the I-670, I-90, and I-275 Projects:

- *Statewide Advanced Traffic Management System* – ODOT went through a comprehensive systems engineering development that led to contracting for a new ATMS software platform in 2019. The initial roll-out of the ATMS software was in Fall of 2020 and includes operations of ITS devices throughout the state including the decision support capabilities required to operate SmartLane and VSL devices.
- *ODOT Transportation Systems Management and Operations (TSMO) Plan* – ODOT completed a comprehensive TSMO Plan in 2017. The TSMO Plan reflects the Department's commitment to operations and defines many policies, procedures, and activities that will enhance ODOT's capabilities to maximize its abilities to manage its transportation network.
- *DriveOhio* – Established in 2018, DriveOhio is the state's focal point for automated and connected vehicle technology on the ground and in the air. Supported by ODOT, DriveOhio works to ensure that Ohio's regulatory environment and public policies are conducive to the development of the infrastructure and technologies needed for smart mobility and safer roads.
- ITS Architecture – ODOT completed a Statewide ITS Architecture Report in early 2016 using Version 7.1 of the National ITS Architecture as a basis. The scope of the architecture is the entire state and draws on the many regional ITS architectures that have been previously developed. Specific details on the status of project specific relationships to regional ITS Architectures are located in the Appendices.

1.2 Concept of ATDM Systems

The ATDM concept is the capability of an agency to improve trip reliability, safety, and throughput of the surface transportation system by dynamically managing and controlling travel and traffic demand, and available capacity, based on prevailing and anticipated conditions, using one or a combination of real-time operational strategies.

To the maximum extent possible, ATDM systems should be developed so ODOT builds on existing infrastructure to address safety impacts. In the case of SmartLane, the ATDM systems enhance operations through actively managing the individual lane use, including the shoulder as a travel lane when needed. Use of the shoulder as a travel lane to accommodate significant variations in demand will allow ODOT to save on construction costs associated with the construction of a traditional, full travel lane.

The Federal Highway Administration (FHWA) defines several strategies that can be integrated within an ATDM corridor. Based on the needs of stakeholders, agency policies, and limitations of existing highway geometrics, stakeholders can determine the best strategy or combination of strategies that address specific corridor needs.

Table 1-2 shows the array of possible strategies to consider including the specific strategies for several different variations of ATDM proposed or already established in Ohio:

The primary applications for Ohio's ATDM corridors include different combinations of Part-Time Shoulder Use (PTSU), Lane Control (LC), and Variable Speed Limits (VSL) to accommodate different traffic needs and environments.

- **Part-Time Shoulder Use** is the temporary conversion of a roadway's shoulder to a travel lane. PTSU is used to alleviate congestion and keep traffic flowing efficiently.
- **Lane Control** uses overhead variable message signs or signals to indicate whether or not a lane is open, closed or slowing for travel.
- **Variable Speed Limits** are speed limits that change based on roadway conditions (traffic, inclement weather, etc.). VSL are changed and signaled using small dynamic message signs.

ODOT is using or proposing to use three variations of ATMD: 1) PTSU+LC+VSL, 2) VSL Only, and 3) PTSU+VSL.

Table 1-2. FHWA ATDM Strategies

ATDM STRATEGY	DESCRIPTION	PTSU+LC +VSL	VSL	PTSU +VSL
Variable Speed Limits (VSL)	Adjusts speed limits based on real-time traffic, roadway, and/or weather conditions	X	X	X
Dynamic Lane Use Control	Dynamically closing or opening individual traffic lanes and providing advance warning of the closures to merge traffic into adjoining lanes using lane control signs	X		
Queue Warning	Real time displays of warning messages along a roadway to alert motorists that queues or significant slowdowns exist ahead	X	X	X
Part-Time Shoulder Use (e.g., HSR)	The use of the shoulder as a travel lane(s) based on congestion levels during peak periods and in response to incidents or other conditions	X		X
Adaptive Ramp Metering	Traffic signals on ramps to dynamically control the rate vehicles enter the freeway			
Transit Signal Priority	Manages traffic signals by using sensors or probe data to detect bus approaches and elongating the green phase to allow buses to maintain accurate schedules arrivals			
Adaptive Signal Control	Continuously monitors arterial traffic conditions and intersection queuing to dynamically adjust timing to optimizes capacity			
Dynamic Junction Control	Dynamically allocating lane access on mainline and ramp lanes in interchange areas with high traffic volumes			
Lane Reversal	Use of lane control signals to reverse the direction of travel for individual lanes in response to demand			
Dynamic Merge Control	Dynamically managing entry of vehicles into merge areas			

Source: FHWA ATDM Operations (https://ops.fhwa.dot.gov/atdm/approaches/atm.htm)

1.3 General Roles and Responsibilities

Roles and Responsibilities of the stakeholders typically involved with ATDM projects are shown in **Table 1-3**. More detailed, project specific descriptions of stakeholders are provided in the Appendices.

Table 1-3. General Roles and Responsibilities

AGENCY/STAKEHOLDER (TYPE)	ROLES AND RESPONSIBILITIES
ODOT District	General maintenance of the roadway (e.g., surface repair, static signing, snow, and ice management), public information, design, and construction oversight.
ODOT Office of Roadway Engineering	Review of ATDM projects.
ODOT Office of Traffic Management	Through the Statewide TMC, provide primary command and control of network of DMS/VSL, and CCTV supporting lane control of SmartLane project. Coordinating adaptation of I-90 VSL control software for SmartLane project.
ODOT Office of Traffic Operations	Assist with design scope, Traffic/ITS Engineering, and heavy involvement with construction coordination of ITS device installation and configuration. Maintenance of ITS Field Devices and supporting network communications.
ODOT Freeway Service Patrols	Assist with the verification, clearance, and temporary traffic control for traffic incidents. Provide verification shoulder lane is clear prior to opening to traffic.
Municipal Public Services	Municipality-owned resources within project limits (fiber, devices, etc.)
Local Transit Authority	Bus routes that may be part of a corridor or impacted by it.
Metropolitan Planning Organizations	Stewards of Regional ITS Architecture.
Utility Providers	Power will need to be installed to a variety of new ITS devices.
John Glenn Columbus International Airport (customer)	Major trip generator located on the eastern end of the project limits.
Emergency Responders (Fire)	Provides Traffic Incident Management (TIM) services and routinely serves as Incident Commander during large scale crashes.
Emergency Responders (Police, SHP, Sheriff)	Speed enforcement and TIM services.
Towing and Recovery Companies	Provides TIM services.

1.4 Functional Requirements

The requirements of the ATDM strategies throughout the state have been consolidated into a single table. **Table 1-4** includes a list of functional requirements, sorted by service package functional objects consistent with the latest version of Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT Version 9.0) and then matched to the specific ATDM project. The intent is to minimize duplicating multiple tables that are fairly similar throughout the report. To that end, the service packages used across the existing and proposed ATDM projects include:

- Traffic Management (TM01)– Infrastructure Based Traffic Surveillance

- Traffic Management (TM06) – Traffic Information Dissemination
- Traffic Management (TM08) – Traffic Incident Management System
- Traffic Management (TM12) – Dynamic Roadway Warning
- Traffic Management (TM20) – Variable Speed Limits
- Traffic Management (TM22) – Dynamic Lane Management and Shoulder Use
- Public Safety (PS08) – Roadway Service Patrols
- Data Management (DM01) – ITS Data Warehouse

Some of the requirements have been refined since the first iteration of the I-670 SmartLane SEA for several reasons. First, there is a new version of ARC-IT that provides a more comprehensive view of ATDM type projects. Also, ODOT has built several enabling systems (e.g., ATMS, data warehouse), and day-to-day operations on how the systems interact are stable and well understood.

Table 1-4. ATDM Project Functional Requirements

ARC-IT SERVICE PACKAGE FUNCTIONAL OBJECT	ARC-IT ID	REQUIREMENT	PTSU+LC+VSL	VSL	PTSU+VSL
A. Archive Data Repository	01	The TMC shall collect data from centers.	X	X	X
	03	The TMC shall store collected data in an information repository.	X	X	X
	04	The TMC shall perform quality checks on collected data.	X	X	X
	11	The TMC shall respond to requests for archive data from archive data users (centers, field devices).	X	X	X
	12	The TMC shall provide a mechanism for archive data users to request archive data by meta-data range.	X	X	X
	06	The TMC shall provide the capability to perform data management strategies on the incoming field data such as aggregation and statistical measures before the data is stored in the archive.	X	X	X
	07	The TMC shall respond to requests from the administrator interface function to select and manage data stored in the archive.	X	X	X
B. Traffic Management Center (TMC) Data Collection	01	The TMC shall collect traffic management data such as operational data, event logs, etc.	X	X	X
	02	The TMC shall assign quality control metrics and meta-data to be stored along with the data. Meta-data will include attributes that describe the source and quality of the data and the conditions surrounding the collection of the data.	X	X	X
	03	The TMC shall receive and respond to requests from ITS Archives for either a catalog of the traffic data or for the data itself.	X	X	X
	04	The TMC shall be able to produce sample products of the data available.	X	X	X
C. Roadway Basic Surveillance	01	The field element (i.e., detector) shall collect, process, digitize, and send traffic sensor data (speed, volume, and occupancy) to the TMC for further analysis and storage, under center control.	X	X	X
	02	The field element (i.e., CCTV) shall collect, process, and send traffic images to the TMC for further analysis and distribution.	X	X	X

ARC-IT SERVICE PACKAGE FUNCTIONAL OBJECT	ARC-IT ID	REQUIREMENT	PTSU+LC+VSL	VSL	PTSU+VSL
	04	The field element (i.e., detector and CCTV) shall return system operational status to the TMC.	X	X	X
	05	The field element (i.e., detector and CCTV) shall return system fault data to the controlling center for repair.	X	X	X
D. TMC Basic Surveillance	01	The TMC shall monitor, analyze, and store traffic sensor data (speed, volume, occupancy) collected from field elements under remote control of the TMC.	X	X	X
	02	The TMC shall monitor, analyze, and distribute traffic images from CCTV systems under remote control of the TMC.	X	X	X
	04	The TMC shall distribute road network conditions data (raw or processed) based on collected and analyzed traffic sensor and surveillance data to other centers.	X	X	X
	06	The TMC 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).	X	X	X
	07	The TMC shall remotely control devices to detect traffic.	X	X	X
E. Roadway Traffic Information Dissemination	01	The field element shall include dynamic message signs (DMS) for dissemination of traffic and other information to drivers, under TMC 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).	X	X	X
	03	The field element (i.e., DMS) shall provide operational status for the driver information systems equipment to the TMC.	X	X	X
	04	The field element (i.e., DMS) shall provide fault data for the driver information systems equipment to the TMC for repair.	X	X	X
F. TMC Traffic Information Dissemination	01	The TMC shall remotely control dynamic messages signs for dissemination of traffic and other information to drivers.	X	X	X
	03	The TMC shall collect operational status for the driver information systems equipment (DMS, HAR, etc.).	X	X	X
	04	The TMC shall collect fault data for the driver information systems equipment (DMS, HAR, etc.) for repair.	X	X	X
	06	The TMC shall distribute traffic data to maintenance and construction centers, transit centers, emergency management centers, parking facilities, and traveler information providers.	X	X	X
	07	The TMC shall distribute traffic data to the media.	X	X	X
	08	The TMC shall provide the capability for TMC personnel to control the nature of the data that is available to non-traffic operations centers and the media.	X	X	X
	09	The TMC shall collect current lane configurations status for the driver information systems equipment (DMS, HAR, etc.).	X	X	X
	10	The TMC shall provide traffic information in both data stream and graphical display.	X	X	X

ARC-IT SERVICE PACKAGE FUNCTIONAL OBJECT	ARC-IT ID	REQUIREMENT	PTSU+LC+VSL	VSL	PTSU+VSL
G. Roadway Incident Detection	01	The field element (i.e., detection and CCTV) shall collect, process, and send traffic images to the TMC for incident detection and further analysis.	X	X	X
	03	The field element's video devices (i.e., CCTV) shall be remotely controlled by a TMC.	X	X	X
	04	The field element (i.e., detection and CCTV) shall provide operational status and fault data for the incident detection devices to the TMC.	X	X	X
H. TMC Incident Detection	02	The TMC shall collect and store traffic flow and image data from the field equipment to detect and verify incidents.	X	X	X
	04	The TMC shall exchange incident and threat information with emergency management centers as well as maintenance and construction centers; including notification of existence of incident and expected severity, location, time, and nature of incident.	X	X	X
	05	The TMC shall support requests from emergency management centers and border inspection systems to remotely control sensor and surveillance equipment located in the field.	X	X	X
	06	The TMC shall provide road network conditions and traffic images to emergency management centers to support the detection, verification, and classification of incidents.	X	X	X
	07	The TMC shall provide video and traffic sensor control commands to the field equipment to detect and verify incidents.	X	X	X
I. TMC Incident Dispatch Coordination	04	The TMC shall exchange incident information with emergency management centers and the media including description, location, traffic impact, status, expected duration, and response information.	X	X	X
	07	The TMC shall provide road network conditions and traffic images to emergency management centers, maintenance and construction centers, and traveler information service providers.	X	X	X
J. Emergency Response Management	06	The TMC shall allocate the appropriate emergency services, resources, and vehicle(s) to respond to incidents, and shall provide the capability to override the current allocation to suit the special needs of a current incident.	X	X	X
K. Roadway Warning	01	The field element (i.e., detection) shall monitor for hazardous traffic conditions, including queues.	X	X	X
	02	The field element (i.e., detection) shall monitor for hazardous road surface and local weather conditions.		X	
	04	The field element (i.e., detection) shall provide collected sensor data to the TMC.	X	X	X
	05	The field element (i.e., detection) shall autonomously identify potentially hazardous conditions and activate warning signs to approaching motorists.		X	
	06	The field element (i.e., DMS) shall receive commands from the TMC that activate warning signs to approaching motorists.	X	X	X
	07	The field element (i.e., detection and DMS) shall collect operational status of the warning system field equipment and report the operational status to the TMC.	X	X	X

ARC-IT SERVICE PACKAGE FUNCTIONAL OBJECT	ARC-IT ID	REQUIREMENT	PTSU+LC+VSL	VSL	PTSU+VSL
	08	The field element (i.e., detection and DMS) shall monitor the warning devices and report faults to the TMC.	X	X	X
L. TMC Roadway Warning	01	The TMC shall monitor data on traffic, environmental conditions, and other hazards collected from sensors along the roadway.	X	X	X
	02	The TMC shall identify hazardous road weather and surface conditions.		X	
	03	The TMC shall identify hazardous traffic conditions including queues.	X	X	X
	05	The TMC shall issue control commands to field equipment warning drivers approaching the identified hazardous conditions.	X	X	X
	07	The field element shall collect operational status of the warning system field equipment and report the operational status to the controlling center.	X	X	X
	08	The field element shall monitor the warning devices and report faults to the controlling center.	X	X	X
M. Roadway Environmental Monitoring	01	The field element (i.e., RWIS) shall include surface and sub-surface environmental sensors that measure road surface temperature, moisture, icing, salinity, and other measures.		X	
	02	The field element (i.e., RWIS) shall include environmental sensors that measure weather conditions including temperature, wind, humidity, precipitation, and visibility.		X	
	04	The field element's (i.e., RWIS) environmental sensors shall be remotely controlled by a TMC.		X	
	07	The field element (i.e., RWIS) shall provide environmental sensor equipment operational status to the TMC.		X	
	08	The field element (i.e., RWIS) shall provide environmental sensor equipment fault indication to the TMC.		X	
	10	The field element (i.e., RWIS) shall provide weather and road surface condition data to centers.		X	
N. Roadway Variable Speed Limits	01	The field element (i.e., RWIS and detection) shall monitor traffic and environmental conditions along the roadway.	X	X	X
	03	The field element (i.e., VSL sign) shall receive commands from the controlling center that establish speed limits.	X	X	X
	04	The field element (i.e., VSL sign) shall display the current speed limits to drivers.	X	X	X
	07	The field element (RWIS, detection, and VSL signs) shall monitor and report faults to the TMC.	X	X	X
O. TMC Environmental Monitoring	01	The TMC shall remotely control environmental sensors that measure road surface conditions including temperature, moisture, icing, salinity, and other measures.		X	
	02	The TMC shall remotely control environmental sensors that measure weather conditions including temperature, wind, humidity, precipitation, and visibility.		X	

ARC-IT SERVICE PACKAGE FUNCTIONAL OBJECT	ARC-IT ID	REQUIREMENT	PTSU+LC+VSL	VSL	PTSU+VSL
P. TMC Variable Speed Limits	01	The TMC shall monitor data on traffic and environmental conditions collected from sensors along the roadway.	X	X	X
	02	The TMC shall calculate and set suitable speed limits based on measured data,	X	X	X
	03	The TMC shall control field equipment that posts the current speed limits and displays additional information such as basic safety rules and current traffic information to drivers.	X	X	X
	04	The TMC shall monitor the operational status of the variable speed limit equipment, including fault reports.	X	X	X
	05	The TMC shall provide center personnel current system status and respond to control data from TMC personnel regarding variable speed limits.	X	X	X
	06	The TMC shall provide the current speed limits and additional information such as basic safety rules and current traffic information to drivers.	X	X	X
Q. Roadway Dynamic Lane Management and Shoulder Use	01	The field element (i.e., traffic detection) shall measure traffic conditions per lane, under TMC control.	X	X	X
	03	The field element (i.e., DMS) shall receive lane management control information from the TMC.	X		X
	04	The field element (i.e., DMS) shall provide guidance and information to drivers regarding current lane configuration and status.	X	X	X
	09	The field element (i.e., DMS) shall monitor operational status of the dynamic lane control equipment and report operational status to the TMC.	X		X
	10	The field element (i.e., detection and DMS) shall identify and report fault conditions to the TMC.	X		X
R. TMC Dynamic Lane Management and Shoulder Use	01	The TMC shall remotely monitor and control dynamically managed travel lanes.	X		X
	02	The TMC shall monitor traffic conditions and demand measured per lane.	X		X
	07	Based on the collected data and operator input, the TMC shall determine suggested and required lane control configuration changes.	X		X
	08	The TMC shall support temporary use of shoulders as travel lanes.	X		X
	09	The TMC shall activate lane management field equipment that is used to dynamically manage specific lanes and shoulders.	X		X

Table 1-5 shows how the ARC-IT Version 9.1 service packages align with Statewide ITS Architecture service packages that used Version 7.1 of the National ITS Architecture.

Table 1-5. Statewide ITS Architecture Service Packages

STATEWIDE ITS ARCHITECTURE VERSION 7.1		PROJECT ARCHITECTURE ARC-IT VERSION 9.1	
SERVICE PACKAGE NO.	SERVICE PACKAGE NAME	SERVICE PACKAGE NO.	SERVICE PACKAGE NAME
ATMS01	Network Surveillance	TM01	Infrastructure-Based Traffic Surveillance
ATMS06	Traffic Information Dissemination	TM06	Traffic Information Dissemination
ATMS08	Traffic Incident Management System	TM08	Traffic Incident Management System
ATMS23	Dynamic Roadway Warning	TM12	Dynamic Roadway Warning
ATMS22	Variable Speed Limits	TM20	Variable Speed Limits
ATMS23	Dynamic Lane Mgmt. and Shoulder Use	TM22	Dynamic Lane Mgmt. and Shoulder Use
EM04	Roadway Service Patrol	PS08	Roadway Service Patrols
AD2	ITS Data Warehouse	DM01	ITS Data Warehouse

1.5 Interface Requirements

The interface requirements for the project are closely linked to the Statewide ATMS project, which includes a SmartLane/ATDM module that allows ODOT to operate a suite of ATDM applications including SmartLane and VSL. **Figure 1-3** Illustrates a high-level schematic of the ATDM strategies and interfaces throughout the state.

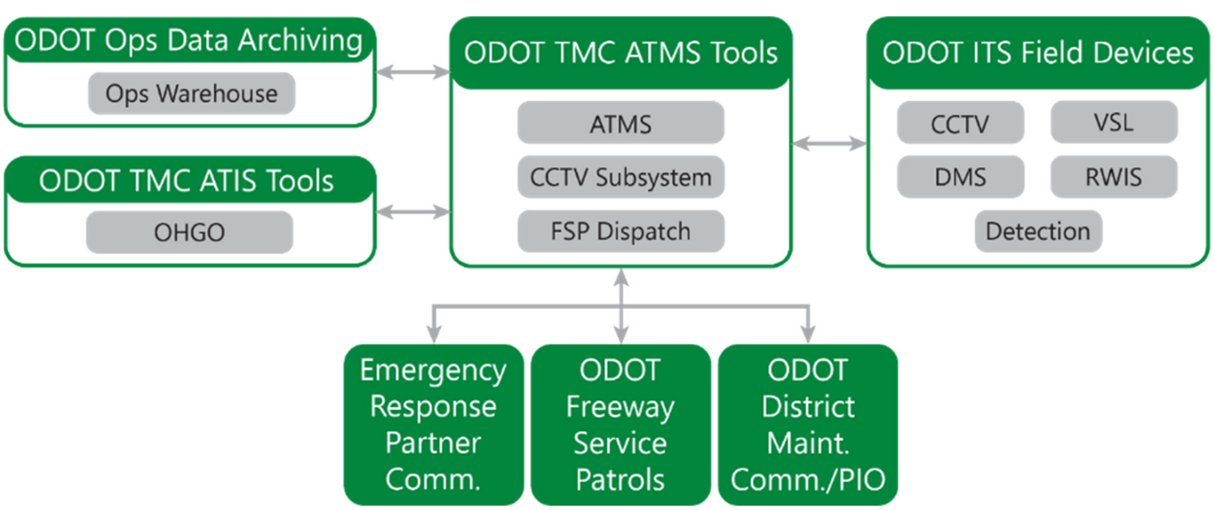

Figure 1-3. High Level Interface Diagram

The more detailed interface diagrams are shown in **Appendix F** as a series of Physical Architecture Diagrams partitioned by ITS Service Package. An ARC-IT definition is included for reference and a brief description of how the service package is envisioned to be used across the array of ATDM applications.

1.6 ITS Standards

There are many applicable standards listed below associated with the projects that will be integrated into plans and specifications. Standards 6-12 below are associated with the existing ATMS software that included requirements to support SmartLane and VSL operations.

1. Ohio Department of Transportation Office of Roadway Engineering Traffic Engineering Manual (TEM), July 21, 2023 Revision
2. Ohio Department of Transportation Intelligent Transportation Systems (ITS) Standard Construction Drawings (SCDs), ITS-10.10 thru ITS-76.10
3. Ohio Department of Transportation 2023 Construction and Materials Specifications, July 21, 2021 Update
4. Ohio Department of Transportation Construction Administration Manual of Procedures, 2017
5. NFPA 70 National Electric Code (NEC)
6. American Association of State Highway and Transportation Officials (AASHTO) / Institute of Transportation Engineers (ITE)
    a. ITE Traffic Management Data Dictionary (TMDD), Version 3.1
7. American Society for Testing Materials (ASTM)
    a. ASTM E2468-05 *Standard Practice for Metadata to Support Archived Data Management Systems*
    b. ASTM E2665-08 *Standard Specifications for Archiving ITS-Generated Traffic Monitoring Data*
8. The National Transportation Communications for Intelligent Transportation System Protocol (NTCIP)
    a. NTCIP 1201 *Global Object Definitions*
    b. NTCIP 1203 *Object Definitions for Dynamic Message Signs (DMS)*
    c. NTCIP 1204 Object Definitions for Environmental Sensor Station Interface Standard
    d. NTCIP 1205 *Object Definitions for Closed Circuit Television (CCTV) Camera Control*
    e. NTCIP 1209 *Data Element Definitions for Transportation Sensor Systems (TSS)*
9. Institute of Electrical and Electronics Engineers (IEEE)
    a. Incident Management Standards Group
10. International Standards Organization (ISO)
    a. ISO 15784-2 - ITS Data Exchange Bundle
11. Internet Engineering Task Force (IETF)
    a. IETF RFC 6353 Transport Layer Security (TLS) for Simple Network Management Protocol (SNMP)

   b. IETF RFC 793 Transmission Control Protocol (TCP)

12. Web Wide Web Consortium (W3C)

   a. Web Services Description Language (WSDL), Version 1.1

1.7 General System Operations and Management

Several procedural and resource issues related to the ATDM project system operations and management have been defined in accordance with Section 940.11 (c) (7) and Section 13 of the ODOT Traffic Engineering Manual.

1.7.1 Functions

1.7.1.1 Traffic Management Center

The roadways are monitored and managed by the Statewide TMC in Columbus, which is part of the Office of Traffic Management. Operators will be responsible for implementing sign maps, speed limit revisions, and other messaging as outlined in the Concept of Operations (ConOps). The operator will also be responsible for communicating and coordinating with emergency responders and ODOT field staff to implement sign maps and speed limit revisions as part of incident management. **Figure 1-4** shows a picture of a typical ATDM workstation at the TMC.

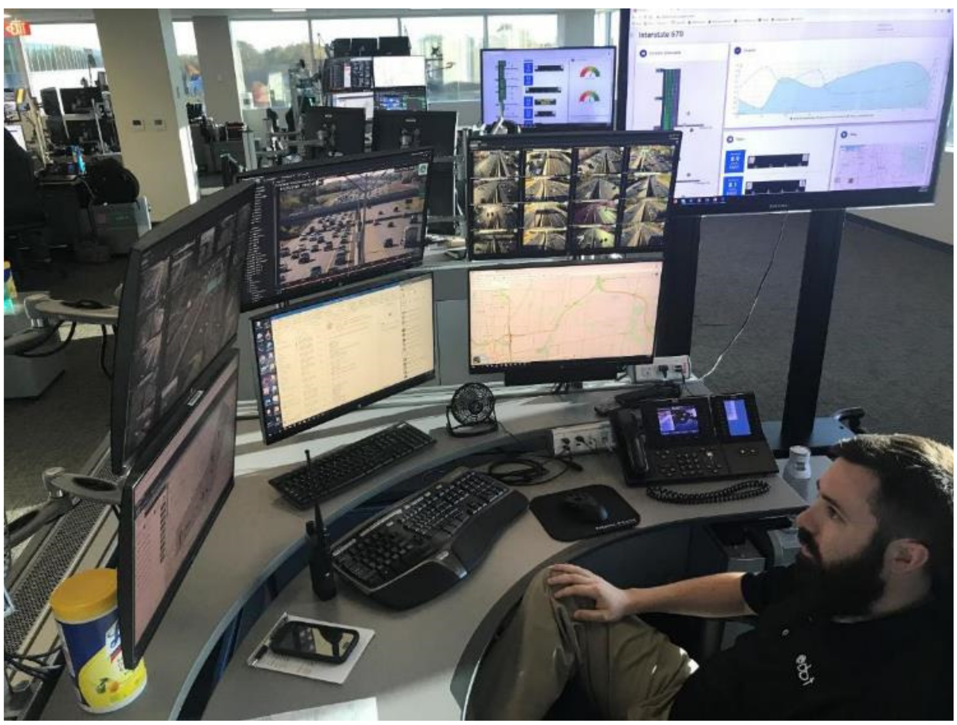

Figure 1-4. Statewide TMC ATDM Workstation

1.7.1.2 Part-Time Shoulder Use

ODOT will observe the behavior of the shoulders and will fine tune the open/close timing to best fit actual congestion conditions. This does not mean the open/close times will vary day by day, but rather that ODOT will measure travel speeds upon completion of the improvements and revise the operating time for the SmartLane to reflect actual congestion times. ODOT desires to keep the start/close time consistent for the traveling public, to minimize the number of changes.

1.7.1.3 Variable Speed Limit Signing

The TMC will observe traffic and implement different reductions in speed based on prevailing conditions. Speed reductions for locations with part-time shoulder use are primarily used to manage congestion and traffic incidents. VSL may also be used to reduce speeds during inclement weather, however speeds can be reduced for any situation that helps provide for safer travel conditions.

1.7.1.4 Traffic Incident Management

The TMC will observe the roadway and implement different signing strategies to manage traffic in response to various incidents. TIM Plans have or will be developed and exercised on a routine basis due to the introduction of new SmartLane and VSL operations in the project areas with emergency responder stakeholders. Specific details on TIM stakeholders are provided in the project-specific portions of the report.

1.7.2 Resources:

1.7.2.1 DOT Staff/Facilities

Due to the nature of active freeway management, ODOT has added a higher-level operator position category to recognize the added attention required to operate SmartLane and VSL. Dedicated workstations will be provided for the active freeway management activities.

1.7.2.2 Operations Staff Training

Thorough training and documentation related to the various ATDM systems are important to ensure that ITS operations and maintenance are consistent and efficient. Several issues are directly relevant:

- ODOT should schedule training for all levels of staff. Each staff level will have its own responsibilities, ranging from TMC managers, who deal with staffing and budget issues, to operators dealing with equipment, monitoring, control and reporting functions while maintenance technicians will be responsible for preventive and response maintenance.
- Designated Operations and maintenance staff should be required to complete a structured “hands-on” training program. Training of staff should be consistent with existing ITS training programs.

1.7.2.3 External Partners

Coordination with various responders such as local police/fire departments and Freeway Service Patrol is ongoing, but continued feedback and modification to the operational concept will be needed to assure SmartLane and VSL systems operate well. First responders will continue to have final authority on the scene of the incident, and the ODOT TMC will need to implement sign maps and open/close the SmartLane or modify speed limits as directed by the incident commander. Ongoing stakeholder engagement will be performed through local traffic incident management groups and targeted stakeholder meetings as needed.

1.7.2.4 External Services

Freeway Service Patrol (FSP) – The FSP contract will be modified in the SmartLane and VSL projects areas to dedicate a tow capable vehicle to perform the debris removal, quick clearance, protect the queues and incident management tasks.

Towing – ODOT’s outstanding contract(s) will be modified to revise the response time and services outlined above.

Power Service – Additional power connections will be required and meters or flat access agreements will need to be added.

1.7.2.5 Maintenance Support

The ITS components of the different varieties of ATDM projects will be handled by Statewide ITS Maintenance through the Office of Traffic Operations. Traditional lighting maintenance will continue to be handled using District maintenance contracts. Striping and barrier repair contracts are also anticipated to meet the required level of service and are not required to be modified.

As ODOT continues to advance ATDM systems throughout the state, additional staff and technicians will need to be added to provide quick response to critical issues. In the event current staff cannot make it to the ATDM site, the Districts may be asked to send a technician to check site conditions, power, communications, etc. ODOT should also consider building up the capacity of ITS Specialist Technicians in the districts to have a minimum level of training to help respond to conditions that Central Office Traffic Operations cannot respond to within the required timeframe.

1.7.3 General Daily ATDM Operations

Daily operation of the ATDM systems require a higher level of oversight compared to traditional operations due to the active nature of managing traffic. At a high level, a series of steps are routinely performed including:

- Operation Readiness and System Check – This step includes ATDM system readiness, software readiness, daily operation log preparation and system check.
- System Turn-on – During the peak periods, part-time shoulder use systems should be turned on to help regulate traffic flow along the roadway based on traffic achieving certain congestion thresholds. The general steps for system turn-on include:
    1. Sweeps
        - As needed for part-time shoulder use applications, ODOT District Maintenance performs mechanical sweeping of the route to remove debris.
        - Freeway Service Patrol drives the SmartLane route to remove any debris.
        - TMC initiates systematic viewing of CCTVs installed along SmartLane route.
    2. Freeway Service Patrol ends drive of the SmartLane route
    3. Speeds reduced on DMS by the TMC
    4. SmartLane opened by the TMC
    5. Visual confirmation of DMS messaging from the TMC
    6. VSL is triggered based on weather and other travel conditions
- System Monitoring and Observation Data Collection – After the SmartLane and VSL systems are activated, the TMC Operator should use CCTV cameras and other sources to monitor the system operation and traffic conditions. The TMC Operator should also collect and document various observation data pertaining to system operation.
- Troubleshooting – When a failure (e.g., loss of communication, detector failure) is identified prior to or during operation, the TMC Operator should verify and document the failure. The TMC Operator should perform preliminary troubleshooting before reporting the failure into the maintenance database.
- Failure Reporting – To maintain high system availability, the TMC Operator should report failures if they cannot be resolved via preliminary troubleshooting. Once failure reports are received, the Office of Traffic Operations then performs remote maintenance checks and ITS Network checks to see if repairs can me made remotely prior to dispatching an ITS

technician. If needed and Traffic Operations cannot get to the site in the required time, Districts are requested to troubleshoot issues in the field.

- System Turn-off – After traffic congestion levels reduce below designated thresholds, the SmartLane systems is set to its default state
- Reporting – The TMC operator should prepare a daily report upon completion of SmartLane system operation. Daily reports should include information for turn-on and turn-off timings, location, length of queues, listing of emergency or special events, etc. A weekly report should be prepared to provide a weekly debriefing on the SmartLane system operation.

Figure 1-5 through Figure 1-7 illustrate example user interfaces being used to manage different ATDM systems around the state.

Figure 1-5. Example Part-Time Shoulder Use + Lane Control + Variable Speed Limit Screenshot (Opening Day of I-670 SmartLane- 2019)

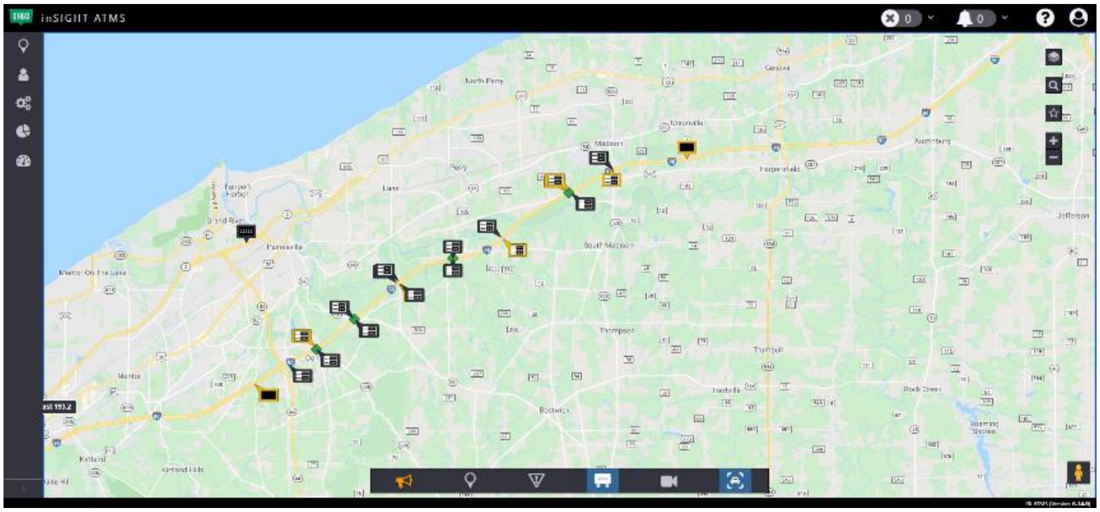

Figure 1-6. Example Variable Speed Limit System User Interface

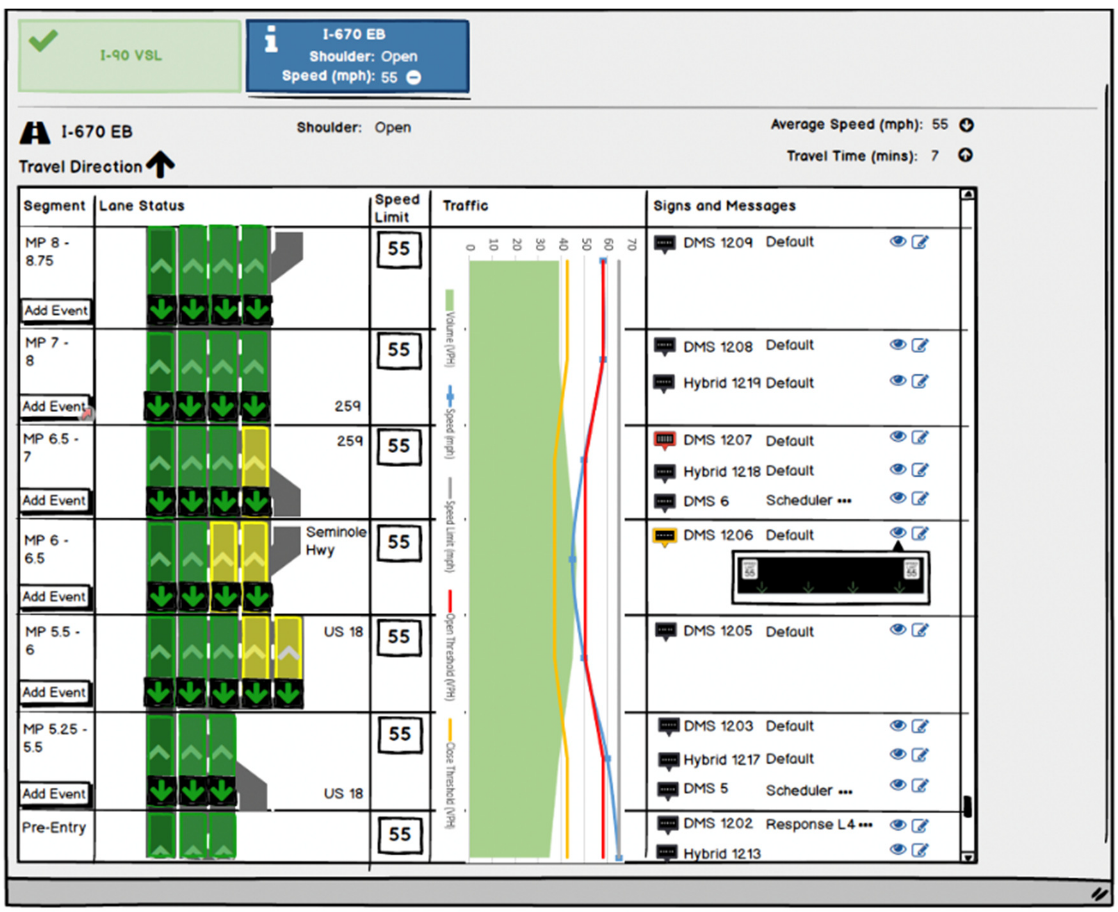

Figure 1-7. Sample Wireframe under development for Part-Time Shoulder Use + Lane Control + Variable Speed Limits using new ATMS

1.8 Testing and Verification

ODOT implements a variety of compliance review and acceptance testing activities to ensure minimum project specifications are adhered to throughout the project.

The Contractor will submit Contract Items in adherence with the Traffic Authorized Products (TAP) list and Qualified Products List (QPL) where applicable. To the extent possible, technology items will be required to be procured from the TAP and QPL to ensure proven interoperability with existing ITS operational technology. VSL equipment is not currently on the TAP list. VSL will be specified on a case-by-case basis per plan notes as approved via ODOT Traffic Operations to ensure interoperability, technical, and functional requirements are met.

Project representatives will approve items that meet the requirements outlined in the Project Specifications, meet the guidelines within the TAP/QPL and have established a high degree of confidence on previous projects where applicable.

Upon Contract Item approval, the selected Contractor will purchase, receive, transport, and install Contract Items as detailed in the Contract Plans and Specifications. Contractor is responsible to protect, maintain, and test (where applicable) the installed Contract Item until final acceptance by the Department. Upon final acceptance, the Department retains ownership of the Contract Item, except where specifically noted otherwise.

For DMS, ODOT has established an acceptance testing procedure that includes factory testing, initial testing, a 60-day burn-in and 30-day testing period where the capabilities of each sign are exercised including communications between the site and the TMC. **Figure 1-8** shows factory testing for the I-670 SmartLane DMS.

Figure 1-8. DMS Factory Acceptance Testing for Part-Time Shoulder Use + Lane Control + Variable Speed Limits

ODOT also has established standardized checklists for DMS and CCTV installation. The checklists are located in **Appendix H**.

The functional requirements have been also translated into a sample testing traceability matrix in **Appendix G** that can be refined as projects move towards preliminary engineering, final engineering, and procurement.

Also, it is important to maintain testing and verification records since FHWA reserves the right to review during or after a project is completed.

1.9 Configuration Management

Configuration Management (CM) is the practice of handling changes systematically so that a system maintains its integrity over time. CM involves the policies, procedures, techniques, and tools to manage, evaluate proposed changes, track the status of changes, and maintain an inventory of system and support documents as the system changes. CM programs and plans provide the technical and administrative direction to the development and implementation the procedures, functions, services, tools, processes, and resources that are required for successful development and support of a TMC.

CM has been critical to the roll-out of the new Statewide ATMS software to ensure correct and uninterrupted functionality of existing ITS field devices and will continue to be critical as it matures. The Approved Product List (APL) is a method ODOT uses to assess potential impacts of introducing new or updated products to the organization's operational technology.

What needs to be formally established within ODOT is a CM Review Board that enables parties responsible for TMC operations, ITS Design, APL Review, and ITS Maintenance to formally discuss and document proposed changes to fully understand the potential dependencies and impacts, report back on how changes impacted ODOT's operational technology, and document the changes in a location(s) that allows for future troubleshooting if required.

Table 1-6 highlights the different elements of change management and how it is anticipated to be handled as part of ODOT ATDM Projects.

Table 1-6. ATDM Configuration Management

<table>
<tr><th>CM ACTVITY</th><th>DESCRIPTION</th><th>ODOT APPROACH</th></tr>
<tr><td>Configuration Identification</td><td>Defines the product and its CM documentation Identification</td><td>Dual identification between Offices of Traffic Management and Traffic Operations</td></tr>
<tr><td>Change Management</td><td>Control changes to a product and its configuration documentation</td><td rowspan="2">Joint group that meets periodically to discuss APL ITS hardware items that need to be coordinated with ATMS or other Office of Traffic Operations software and proposed ATMS software modifications that may impact field equipment firmware or software</td></tr>
<tr><td>Configuration Status Accounting</td><td>Provide status and information about a product and its configuration documentation</td></tr>
<tr><td>Configuration Audits</td><td>Verify consistency of configuration documentation and application of process</td><td>Perform and document a formal audit on an annual basis or in coordination with major ATMS software updates</td></tr>
</table>

1.10 System Maintenance

1.10.1 ITS Infrastructure Maintenance

ODOT Central Office Traffic Operations will perform routine maintenance on the ODOT ITS Roadway equipment that is part of the various ATDM systems.

District electrical maintenance staff will be asked to help make safe or troubleshoot ATDM systems in the event Traffic Operations staff cannot get to the field location in a timely manner.

DMS mounted on full span gantries will be accessible from a catwalk into the sign to allow for maintenance without closing a lane of traffic, improving safety of both ODOT staff and the public, and minimizing disruption to traffic flow. DMS mounted on cantilever structures will be accessible from maintenance vehicles from the shoulder (or part-time shoulder use) following all required traffic control procedures. No DMS or part of a DMS shall be mounted over normally traveled mainline lanes which would require lane closures for maintenance. Post-mounted signs (e.g., VSL signs) can be accessed from the roadside without requiring a lane closure. Proper and safe access for maintenance vehicles and personnel shall be considered in the design.

RWIS maintenance is performed through a contractor and managed by the Office of Maintenance Operations.

1.10.2 Roadway Maintenance

In general, the level of service for maintenance will be increased on all shoulders to be used for traffic. This means that sweeping, pavement repairs, striping and other maintenance activities will be performed as frequently as the mainline.

Debris removal will be performed daily prior to the opening of the shoulder. The TMC will use CCTV to inspect the shoulder prior to opening and will send a list of locations with debris for removal to the Freeway Service Patrol for pickup. Broken down vehicles will be tasked to one of the tow companies on ODOT's standing contracts. The contracts will be revised to set the needed response times for each corridor.

Sweeping and drainage cleanout will be done more frequently, per specific project location and scheduling. Though more frequent than standard, supplemental maintenance is not expected to be a daily or weekly occurrence.

District operations should take caution around ITS field equipment when performing normal operations (e.g., mowing) to not damage the signs, cabinets, poles, underground pull boxes, etc.

1.10.3 Snow and Ice Control

Where shoulders are used for traffic, ODOT will plow in the same sequence/priority as before but will add the shoulder(s) used for traffic to the plowing schedule after the main travel lanes.

Currently ODOT plows the middle and right lanes to the outside shoulder, and the left lane to the inside shoulder. There will be situations where the shoulder will not be opened during severe events so the inside shoulder can be used for snow storage. ODOT has contingency plans for treatment/transfer of the stored snow, such as an overnight gang plow operation to move from the left to right shoulder. The shoulders will be brined with the lanes when pre-treatment is called for.

In locations of part-time shoulder use during significant rain events, the posted speed will be reduced to provide safe travel. This will address anticipated spread from the median drainage into the SmartLane(s). The operator will have the authority to close the shoulder during a severe rain event, particularly if any median drains become blocked and ponding becomes a concern.

Beyond part-time should use, no special snow and ice control are required, beyond requesting snowplow drivers to slow down so they do not throw large amounts of heavy snow or debris onto ITS equipment.

2 Concept of Operations

The original *Statewide Active Traffic Management (ATM) Study Concept of Operations* was initially submitted in September 2016 and finalized in March 2017. ODOT investigated various ATDM approaches to improve travel in selected corridors throughout the state to improve traffic operations and safety.

The Concept of Operations for the I-670 SmartLane Project was originally defined in the report.

The purpose of the ConOps is to provide ODOT and associated stakeholders with the operational concept for the proposed ATDM project. The ConOps communicates ODOT's needs and expectations and presents an understanding of how to meet those needs. Several portions of the ConOps for the different ATDM varieties are reflected throughout the SEA document.

In general, the ATDM projects will collect or react to the following information:

- Situation Update – current roadway, shoulder, incident status or confirmation
- Flow Data – speed, volume, occupancy data from traffic lanes (including shoulder)
- Roadside Image – capture of real-time traffic images from specific locations
- Environmental data – current surface transportation environmental conditions
- Operational Override Command – request from operator (activation of display, selection of response plan, editing of plan, etc.)

The ATDM projects would then generate the following information:

- Traffic Image Request – request specific real-time traffic images from specific locations
- Request for Response Confirmation – alerts operator of recommended system response (including operations plan, displays) based on roadway, situation, and other inputs
- Driver Information – provision of speed, lane status or queue warning displays (for control, regulatory and advisory information displayed on the roadway)
- Road Status – provision of traffic flow, lane status, queue information (for traveler information purposes)
- Status Update – lane and speed control information to the operation system

The key elements and operations scenarios help to illustrate the concept of operations for each project type planned throughout the state:

1. Part-Time Shoulder Use + Lane Control + Variable Speed Limits
2. Variable Speed Limits Only
3. Part-Time Shoulder Use + Variable Speed Limits

2.1 Part-Time Shoulder Use + Lane Control + Variable Speed Limits

PTSU decisions will be built around data collection and condition monitoring, data processing, and information and control output.

2.1.1 Key Elements

2.1.1.1 Data Collection and Condition Monitoring

The system will perform data collection and condition monitoring activities using a series of sensors, each serving as an input to a data processing and decision support software that will serve as the core of the SmartLane central system elements. The devices will collectively generate specific data that will capture traffic data and environmental conditions as the basis for formulating proactive lane management strategies.

Surveillance providing full coverage of the SmartLane project area will be used to verify queuing and congestion conditions and to ensure shoulder lanes are clear of vehicles or other obstructions.

2.1.1.2 Data Processing and Decision Support

The PTSU system will need to process the collected data and offer meaningful information that will optimize the operations of the roadway. The processing and associated decision support will likely come in the form of a centralized software installed at the Statewide TMC.

While the initial operations of PTSU will likely be manual in nature, the full build-out will rely largely on automated operations, appropriate decision support functions will ultimately need to be implemented so strategies such as queue warning are tied to actual downstream traffic flows, weather conditions, and lane closures. Specific response plans would be selected based on "operational rules" and specific traffic flow parameters. Upon TMC Operator verification, fine-tuning (if necessary) and approval, the response plans would then be deployed.

An added level of routine operations is expected from operators at the Statewide TMC. To that end, enhanced operator workstations will provide accessibility to SmartLane decision support plans as well as device display information, permitting direct control or override of specific response plans or portions thereof, as needed to reflect the desired operational strategy.

2.1.1.3 Information and Control Output

Information displays that clearly show whether the shoulder is open as a travel lane will be installed along the roadway. Information display configurations have taken several forms in different ATDM projects around the country and have not been standardized on a national level.

2.1.2 Operational Scenarios

Before traffic is allowed to use the left shoulder as a travel lane, sweeping of the lane should be completed to determine if debris, stopped vehicles, stored snow, ponding water, and other obstructions would prevent opening of the left shoulder to traffic. Sweeping consists of three different methods:

- Mechanical Sweep – This process involves driving a street sweeper through the shoulder to remove debris. Mechanical sweeping is generally not necessary since the presence of traffic on the shoulder on a regular basis tends to keep it clear of debris. The current plan is to provide a mechanical sweep of the left shoulder once every three weeks.
- Vehicle Sweep – This process involves driving a vehicle (typically a freeway service patrol vehicle or law enforcement vehicle) through the shoulder lane to remove any large objects (if encountered) and verify that no vehicles are stopped or parked on the shoulder.
- Camera Sweep – This process involves visually scanning the left shoulder using the CCTV cameras in the TMC.

Numerous operational scenarios along with associated lane closure signing were also defined. The scenarios have been adjusted to reflect current operations of the PTSU + LC + VSL projects and provided in **Table 2-1.**

Table 2-1. Part-Time Shoulder Use + Lane Control + Variable Speed Limit Scenarios

<table>
<tr><th>SCENARIO</th><th>DESCRIPTION</th></tr>
<tr><td>1. Normal Conditions – Off Peak</td><td>All signs in the corridor will display the same information, as shown in the table below.
<table>
<tr><th colspan="3">Display on Signs</th></tr>
<tr><th>Speed Limit</th><th>Left Shoulder</th><th>Through Lanes</th></tr>
<tr><td>65</td><td>X</td><td>↓</td></tr>
</table>
The speed limit should only be reduced in a maximum of 10 mph increments. The reduced speed limit should be in effect for at least 60 seconds before instituting another speed limit reduction. A reduced speed limit should be displayed for a minimum of 10 minutes before the speed limit is increased.</td></tr>
<tr><td>2. Normal Conditions – Peak Periods</td><td>During the typical weekday peak period, traffic congestion will increase and speeds will decrease. The left shoulder should be opened to traffic to increase capacity when traffic volumes and speeds indicate the need. Prior to opening the left shoulder to traffic, a sweep should be done. A vehicle sweep should be conducted prior to scheduled opening of the shoulder. A camera sweep should be completed when left shoulder opening is imminent. All signs in the corridor should be updated simultaneously so no conflicting information is presented.
<table>
<tr><th rowspan="2">Phase</th><th rowspan="2">Observations</th><th colspan="3">Display on Signs</th><th rowspan="2">Comments</th></tr>
<tr><th>Speed Limit</th><th>Left Shoulder</th><th>Through Lanes</th></tr>
<tr><td>1</td><td>Steady flow.
Normal operation.</td><td>65</td><td>X</td><td>↓</td><td>A vehicle sweep should be conducted every weekday peak period prior to the left shoulder opening to traffic. A camera sweep should also be performed at this time in anticipation of the left shoulder opening to traffic.</td></tr>
<tr><td>2</td><td>Speeds decreasing.
Traffic volumes increasing.</td><td>55</td><td>↓</td><td>↓</td><td>When measured average speeds fall to 55 mph at two locations in the corridor for a duration of at least five minutes, the speed limit should be lowered to 55 mph and the left shoulder opened to traffic. The speed limit should be kept at 55 mph for at least 60 seconds before moving to another phase. It is anticipated that this phase will have a duration of two to three hours unless speeds continue to fall and phase 3 is implemented. If Phase 3 is not implemented, proceed to Phase 7.</td></tr>
<tr><td>3</td><td>Speeds decreasing.
Traffic volumes increasing.</td><td>45</td><td>↓</td><td>↓</td><td>Optional phase that will only be used if speeds continue to fall after the left shoulder is opened to traffic. If measured average speeds fall to 45 mph at two locations in the corridor, the speed limit should be lowered to 45 mph while keeping the left shoulder opened to traffic.</td></tr>
<tr><td>4</td><td>Speeds decreasing.
Traffic volumes increasing.</td><td>35</td><td>↓</td><td>↓</td><td>Phase 4 will only be used if Phase 3 is implemented. If measured average speeds fall to 35 mph at two locations in the corridor, the speed limit should be lowered to 35 mph while keeping the left shoulder open to traffic.</td></tr>
<tr><td>5</td><td>Speeds increasing.
Traffic volumes decreasing.</td><td>45</td><td>↓</td><td>↓</td><td>Phase 5 will only be used if Phase 4 is implemented. As speeds begin trending upward, the speed limit should be raised to 45 mph while keeping the left shoulder open to traffic.</td></tr>
<tr><td>6</td><td>Speeds increasing.
Traffic volumes decreasing.</td><td>55</td><td>↓</td><td>↓</td><td>Phase 6 will only be used if Phase 5 is implemented. As speeds begin trending upward, the speed limit should be raised to 55 mph while keeping the left shoulder open to traffic.</td></tr>
<tr><td>7</td><td>Speeds increasing.
Traffic volumes decreasing.</td><td>55</td><td>X</td><td>↓</td><td>The decision on when to close the left shoulder to traffic will be largely based on observations of traffic density and experience. Measured average speeds cannot be relied upon in making the decision, since the speed limit will be set at 55 mph, and many drivers will suppress their speed accordingly. The left shoulder should not be closed to traffic until there is a high level of confidence that the loss of capacity with its closing will be more than offset by the reduction in traffic volumes such that speeds can increase once the left shoulder is closed and speed limit raised. The intent is that once the left shoulder is closed to traffic at the end of the weekday peak period it will not be opened again. This phase has a duration of 60 ± 5 seconds. The yellow “X” should not be displayed for a longer time.</td></tr>
<tr><td>8</td><td>Steady flow.
Normal operation.</td><td>65</td><td>X</td><td>↓</td><td>Resume normal operation flow.</td></tr>
</table>
Note: “Measured average speed” means the average speed of each lane at a single location</td></tr>
</table>

SCENARIO	DESCRIPTION
	Normal process will be to go through Phases 1-2-7-8. If measured speeds fall below 35 mph, then the process will be to go through Phases 1-2-3-4-5-6-7-8. Regardless of which phasing is used, only one cycle will normally be used per weekday peak period. The left shoulder should only be opened and closed once per day for the weekday peak period. (Extenuating circumstances could dictate reopening of the left shoulder after it has been closed after the weekday peak period, but this would be the exception.) Allow at least 60 seconds between speed limit changes. When closing the left shoulder to traffic, the yellow "X" should only be displayed for 60 ± 5 seconds (i.e., 55 to 65 seconds). It is preferred that the left shoulder be opened to traffic at approximately the same time every weekday peak period for driver expectancy, based on historical data. This could be adjusted based on observed traffic volumes and speeds. The closing of the left shoulder at the end of the weekday peak period should be based on observed traffic volumes and speeds.
3. Bottleneck/ Congestion – Off Peak Period	Congestion may build on the corridor during times other than the weekday peak period. If the congestion is relatively consistent along the corridor, and if measured average speeds fall to 55 mph or lower at two locations in the corridor for a duration of at least five minutes, the speed limit should be reduced to 55 mph throughout the corridor and the left shoulder open to traffic (Phase 2), with all signs changed at the same time to display the same message. If the congestion is localized or exhibiting atypical patterns, signs may be adjusted as necessary in accordance with ODOT's VSL Guidance to address corridor-specific conditions. A vehicle sweep and camera sweep of the left shoulder should be done before opening it to traffic. If a vehicle sweep cannot be done within a reasonable time, then the left shoulder can be open to traffic with just a camera sweep at the discretion of the TMC operator and in consideration of the queue of traffic that is developing. A queue of traffic presents an inherent hazard to the motorist. A judgment call must be made as to the relative hazard of the queue of traffic and allowing traffic to drive on the left shoulder without a vehicle sweep. If the decision is made to open the left shoulder to traffic, the phases as described in the table under "Typical Weekday peak period Operation" should be followed. The 55 mph speed limit should be displayed for a minimum of 10 minutes before returning to 65 mph. If congestion continues to worsen, consideration should be given to reducing the speed limit to 45 mph (Phase 3)
4. Work Zone / Maintenance	For scheduled maintenance/construction operations, a strategy can be devised in advance to facilitate traffic flow through the area. This may include closing of one or more through lanes to traffic, opening the left shoulder to traffic, and/or reducing the speed limit. Consideration should be given as to the location of the work along the corridor, and which lanes will be affected. Through lanes can be closed to traffic by displaying a yellow "X," followed by a red "X." The yellow "X" should only be displayed for 60 ± 5 seconds (i.e., 55 to 65 seconds). Speed limit reductions should be made in 10 mph increments, with a minimum of 60 seconds between reductions. If the decision is made to open the left shoulder to traffic, follow the phases as described in the table under "Typical Weekday peak period Operation." A vehicle sweep and camera sweep of the left shoulder should be done before opening it to traffic. Unless the maintenance/construction activity is consistent along the corridor, each sign in the corridor will likely have different displays.
5. Crashes	The signs in the corridor can be used in response to non-scheduled incidents, such as crashes, to facilitate traffic flow through the area. This may include closing of one or more through lanes to traffic, opening the left shoulder to traffic, and/or reducing the speed limit. Consideration should be given as to the location of the incident along the corridor, and which lanes are being affected.

SCENARIO	DESCRIPTION
	Through lanes can be closed to traffic as needed by displaying a yellow "X," followed by a red "X." The yellow "X" should only be displayed for 60 ± 5 seconds (i.e., 55 to 65 seconds). Speed limit reductions should be made in 10 mph increments, with a minimum of 60 seconds between reductions, if possible. Larger reductions or shorter durations between reductions may be necessary in some cases, based on the severity of the incident. If the decision is made to open the left shoulder to traffic, the phases as described in the table under "Typical Weekday peak period Operation" should be followed. A camera sweep of the left shoulder should be done before opening it to traffic. A vehicle sweep may be impractical for non-scheduled incidents. If a vehicle sweep cannot be done within a reasonable time, then the left shoulder can be open to traffic with just a camera sweep at the discretion of the TMC operator and in consideration of the queue of traffic that is developing. A queue of traffic presents an inherent hazard to the motorist. A judgment call must be made as to the relative hazard of the queue of traffic and allowing traffic to drive on the left shoulder without a vehicle sweep. Each sign in the corridor will likely have different displays based on the location and nature of the incident. Traffic should be diverted around a planned or unplanned event to one side only. Traffic should not be allowed to divert around both sides simultaneously.
6. Weather Incident	The signs in the corridor can be used to lower the speed limit in the corridor in response to weather-related events. Speed limit reductions should be made in 10 mph increments, with a minimum of 60 seconds between reductions, if possible. Each sign in the corridor should display the same speed limit. It is not expected that there would be a need to consider opening the left shoulder to traffic during a weather-related event.
7. Diversion when nearby route is closed or severely congested	In the event a nearby route is closed due a major traffic incident, the SmartLane would be opened to help manage the additional traffic volumes.
8. Road Closure (All Lanes)	In the event of a major crash or other event necessitating a complete closure of I-670, the ATDM system can provide advance information to motorists well in advance of the closure, indicating ramps that should be used to exit the roadway as well as supporting police activities/responder activities.
9. Failure Conditions	The reliability of ITS hardware has continually increased over the years, and the ATDM system will be designed and installed to minimize operational problems. This includes monitoring diagnostics to immediately identify to the TMC Operator when and where a problem has occurred, and the nature of the problem (e.g., loss of communications, loss of power). When failures do occur, the ATDM signs should go "blank." As the lane signs are always displaying some sort of symbol even during "normal conditions" (e.g., GREEN ARROW, RED X), a blank sign will indicate to the driver that there is a problem with the system. This would be the case where the driver can see the next ATDM sign upstream. The ATDM system also can be designed such that it will continue to provide the desired functionality, even if this operation is in some form of degraded mode. Potential failure scenarios and the resulting system operation in this regard are noted below: *Loss of power at a sign* – Battery back-up capability may be provided for the ATDM gantries to continue sign displays (perhaps with reduced light intensity) and communications. *Loss of communications at a sign* – In the event of communication failures, the signs should automatically go to either a blank out condition or a default message "Sign Under Maintenance." In the case of the SmartLane operation as stated above this condition would be dependent on whether the driver can see the next sign upstream in the series. Another possibility is to provide wireless connections between the signs

SCENARIO	DESCRIPTION
	(where line-of-sight exists) such that any display stored in the sign controller can be selected with minimal bandwidth requirements. *Sign Controller Failure* – Assuming that all of the signs for a single-sign gantry are operated by a single controller at the gantry, it may be feasible to include a second controller at the gantry as a "hot" standby should the primary controller fail. *Detector failures* – Algorithms for calculating and displaying speed advisories will be able to function effectively up to some threshold of missing data. When the threshold is reached, the system will revert to a back-up schedule or manual mode of operation.

2.2 Variable Speed Limits Only

2.2.1 Key Elements

The VSL system is built around data collection and condition monitoring, data processing, and information and control output.

2.2.1.1 Data Collection and Condition Monitoring

The system will perform data collection and condition monitoring activities using a series of sensors including RWIS, each serving as an input to a data processing and decision support software that will serve as the core of the VSL system elements. The devices will collectively generate specific data that will capture traffic data and environmental conditions as the basis for formulating proactive speed management strategies.

Surveillance providing complete coverage of the VSL project area will be used to verify weather, queuing, and congestion conditions.

2.2.1.2 Data Processing and Decision Support

The VSL system will need to process the collected data and offer meaningful information that will optimize operations of the roadway. The processing and associated decision support will come in the form of a centralized ATMS software installed at the Statewide TMC. The software will need to accommodate operations of a series of VSL signs.

While the initial operations of the VSL project was manual in nature, the full build-out relies largely on automated operations, appropriate decision support functions will need to be implemented to accommodate strategies such as weather conditions or incident related traffic congestion. Specific response plans would be selected based on "operational rules" and specific traffic flow parameters. Upon TMC Operator verification, fine-tuning (if necessary) and approval, the response plans would then be initiated and notifications sent to the appropriate enforcement agencies and response partners.

An added level of routine operations is expected from operators at the Statewide TMC. To that end, enhanced operator workstations will provide accessibility to VSL decision support plans as well as device display information, permitting direct control or override of specific response plans or portions thereof, as needed to reflect the desired operational strategy.

2.2.1.3 Information and Control Output

Information displays that clearly show variable, regulatory speed limits will be installed at regular intervals along the roadway. Additional static signs reinforcing motorists they are entering an area with VSL will also be required.

2.2.2 Operational Scenarios

The March 2020 ODOT VSL Policy highlights how the VSL systems are configured to react to several different operational scenarios related to weather, traffic incidents, and congestion. The policy also defines how the system is to be used in the event a work zone is set-up in the vicinity of the VSL system.

1. All VSL Corridors will be operated through the ODOT Statewide TMC and will require remote communications. A VSL operations tool will be utilized by a TMC Specialist to determine the appropriate speed limit to post on each VSL sign.
2. TMC Specialists shall log each instance of a speed limit change. The Specialist shall confirm VSL signs are displaying modified speeds before logging. Changes may be verified through either video surveillance, or through software controlling the VSL sign that communicates with the TMC to confirm the speed and timestamp of change. Access to this information will be provided to law enforcement if requested.
3. The lowered speed limit should be applied according to

4. **Table** 2-2. Warranting conditions may be adjusted as necessary in the table to address corridor specific concerns.
5. Any of the conditions in the table warrants a reduction. The lowest warranted speed limit should be used. The speed limit displayed shall not be lower than 30 mph.
6. The lowered speed limit should be displayed at least ½ mile in advance of the incident/weather condition that warrants a speed reduction.
7. Where possible, a step down procedure of reduced speeds should be followed. If spacing of VSL signs is greater than 1.5 miles, and/or speed limit step down is not practical, the reduced speed limit should be posted on the sign before the condition. If the sign prior to the condition is not at least ½ mile in advance, post to the two signs prior to the warranting condition.
8. In cases where multiple conditions exist in noncontiguous portions of the corridor, they should be treated as separate events when greater than two miles apart and the appropriate step-down procedure followed for each. When events are less than two miles apart and/or it is not practical to follow a step-down procedure for each, the reduced speed from the first event may be continued to the second.
9. Lower speeds should be posted to a VSL sign when a warranting condition is reported or observed. Once a lowered speed is posted, the lowered speed should be displayed for at least 15 minutes before returning to the original posted speed.
10. If Changeable/Dynamic Message Signs (CMS/DMS) are available along the corridor, they should display informational/warning messages in conjunction with the VSL.
11. If a National Weather Service (NWS) product indicates scattered but severe weather conditions that may change significantly over a short distance and/or timeframe, then a moderate reduction of speed may be warranted over a section of the corridor.
12. An established point of contact from the District may receive requests from local law enforcement or other district personnel to lower the speed along the corridor. Using engineering judgement, the District may then contact the TMC to request a lower speed be posted. When contacting the TMC, details about the location should include direction, mile marker, requested speed, and condition that warrants request.
13. Collection of speed and weather data shall be directly measured through roadside sensors. Data verification may be made through CCTV and staff observations.
14. If the VSL sign(s) loses communication, the permanent speed limit posted immediately prior to the VSL zone takes precedence.
15. If the VSL sign(s) lose power along the corridor, the permanent speed limit posted immediately prior to the VSL zone takes precedence.

Table 2-2. Example of VSL Operational Scenarios

Table 1: Speed Reductions for Variable Speed Limit Zones

Severity Level	Warranting Conditions						Resulting Variable Speed Limit (VSL)				
	Weather										
	National Weather Service (NWS) Alert	Pavement Conditions "Measured" (or Visual)	Visibility	Precip Conditions	Incidents	Congestion	Original 70 mph	Original 65 mph	Original 60 mph	Original 55 mph	Original 50 mph
0		"Dry" or "Trace" (Dry) "Wet" or "Chemically wet" (wet)	Good; ≥ 0.5 miles	"Light" Precip	No lanes and/or Shoulder blocked	If measured speeds fall below the resulting VSL for a given severity level for a minimum of 5 minutes, then post for that severity level.	70	65	60	55	50
1	NWS Product Advisory/ Warning Issued** or significant weather event impacting any area of corridor***		Fog; < 0.5 miles	"Moderate" Precip (Heavy Rain or Moderate Snow)			60	60	55	55	50
2		"Ice Watch" (Snow Covered Road, Wet road <33 Deg)	Poor; < 0.25 miles	"Heavy" Snowfall	Lanes blocked & traffic > 50MPH		50	50	50	50	45
3		"Ice Warning" (Blowing/Drifting Snow, Icy pavement)	Poor; < 0.1 miles		Lanes blocked & traffic < 50MPH		40	40	40	40	40
4	Full road closure or other high impact situation*						30	30	30	30	30

*Verify with District personnel before posting for Level 4 Severity

**Conditions that could warrant a reduction along the entire corridor

***Agreed upon by County Personnel and TMC

****Route specific table - Appendix A

Work Zone Considerations

1. In the event a Work Zone Speed Limit is active on a portion of the VSL corridor, the lower of the VSL and ODOT Traffic Engineering Manual (TEM) policies controls the speed displayed on the VSL signs. See ODOT Traffic Engineering Manual Table 1297-7 Warranted Work Zone Speed Limits for Work Zones on High Speed (>55 mph) Multi-Lane Highways: https://www.dot.state.oh.us/Divisions/Engineering/Roadway/DesignStandards/traffic/TEM/Documents/TEM%20Part12_071919.pdf
2. Plan specific notes shall be developed for use when a work zone will exist along a VSL corridor.
3. When a work zone with Digital Speed Limits (DSL) extends beyond the limits of a VSL corridor, the DSL signs shall be used inside the VSL zone with additional WORK ZONE (G20-H5bP) plaque added above and immediately adjacent to the VSL sign. Outside the VSL corridor the DSL technology is to be utilized and adhered to according to the WZ policy. The contractor must coordinate with the Statewide TMC.
4. In cases where the VSL spacing is greater than one mile, the project shall install permanent approved VSL signs in the work zone to adhere to spacing requirements per Standard Construction Drawing MT-104.10. Due to the complexities involved with this work, especially as pertains to the supplying of electrical energy to the VSL signs, this work should be described in detail in the plans and paid for under separate pay item(s). It should not be included in the 614 lump sum "Maintaining Traffic" pay item.
5. In the case of a non-standard traffic alignment within a work zone, the approved VSL hardware should be installed on a crash compliant temporary support and/or in a protected area so it can be remotely operated by the TMC the same as the permanent VSL signs.

6. If Changeable/Dynamic Message Signs (CMS/DMS) are available along the corridor, they may be used to display informational/warning messages regarding the presence of workers ahead.

Other ITS Devices (as part of VSL System)

Speed Sensors

1. Density or Speed detection devices should be spaced no more than the maximum for VSL sign spacing. It is recommended that devices are at each sign along the mainline.

Road Weather Information System

1. Pavement conditions should be determined using the output from RWIS stations and verified visually. If RWIS pavement condition is in error or is visually incorrect, conditions may be determined by visual observation.
2. Precipitation conditions should be based on conditions from "Precip Intensity" output from RWIS data. If RWIS precipitation condition is in error or is visually incorrect, conditions may be determined by visual observation.
3. RWIS sensors should be spaced at a maximum distance of 5 miles along the corridor for weather based VSL systems, or 10 miles for congestion based systems. Each station shall have at a minimum the ability to measure pavement condition, visibility, and precipitation intensity.

CCTV Cameras

1. Where feasible, CCTV cameras should be spaced such that every VSL sign along the corridor is visible to the TMC Specialist. Cameras should be spaced no more than two miles apart along the corridor to monitor weather and traffic patterns.
2. If available, video analytics may be used to record speed along the corridor.

Dynamic Message Signs (DMS)

1. Dynamic Message Signs (DMS) may be used along the corridor to supplement the VSL signs to provide more information for the motoring public.

2.3 Part-Time Shoulder Use + Variable Speed Limits

2.3.1 Key Elements

The SmartLane system will be built around data collection and condition monitoring, data processing, and information and control output.

2.3.1.1 Data Collection and Condition Monitoring

The system will perform data collection and condition monitoring activities using a series of sensors, each serving as an input to a data processing and decision support software that will serve as the core of the SmartLane central system elements. The devices will collectively generate specific data that will capture traffic data and environmental conditions as the basis for formulating proactive lane management strategies.

Where Part-time Shoulder Use is installed, surveillance providing full coverage will be used to verify queuing and congestion conditions and to ensure shoulder lanes are clear of vehicles or other obstructions.

2.3.1.2 Data Processing and Decision Support

The SmartLane system will need to process the collected data and offer meaningful information that will optimize the operations of the roadway. The processing and associated decision support will come in the form of a centralized software installed at the Statewide TMC. The software will need to accommodate deployment of messaging that displays a combination of variable speed limits and dynamic lane/shoulder management.

While the initial operations of the SmartLane project will likely be manual in nature, the full build-out will rely largely on automated operations, appropriate decision support functions will ultimately need to be implemented so strategies such as queue warning are tied to actual downstream traffic flows, weather conditions, and lane closures. Specific response plans would be selected based on "operational rules" and specific traffic flow parameters. Upon TMC Operator verification, fine-tuning (if necessary) and approval, the response plans would then be deployed.

An added level of routine operations is expected from operators at the Statewide TMC. To that end, enhanced operator workstations will provide accessibility to SmartLane decision support plans as well as device display information, permitting direct control or override of specific response plans or portions thereof, as needed to reflect the desired operational strategy.

2.3.1.3 Information and Control Output

Information displays that clearly show speed limits, SmartLane status (i.e., open or closed), and traffic incident information will be installed at regular intervals along the roadway. Information display configurations have taken several forms in different ATDM projects around the country and have not been standardized on a national level, but their standardization as much as possible is expected throughout the state.

2.3.2 Operational Scenarios

Operators in the ODOT TMC in Columbus will be able to:

A.) Open and close the left shoulder for use as a travel lane

B.) Alter the speed limit.

Several operational scenarios are presented in **Table 2-3** that outline how the SmartLane System is anticipated to react under different scenarios.

Table 2-3. Part-Time Shoulder Use + Variable Speed Limits Scenarios

<table>
<tr><th>SCENARIO</th><th>DESCRIPTION</th></tr>
<tr><td>1. Normal Conditions – Off Peak</td><td>All signs in the corridor will display the same information, as shown in the table below.
<table>
<tr><th colspan="2">Display on Signs</th></tr>
<tr><th>Variable Speed Limit</th><th>Left Shoulder</th></tr>
<tr><td>65</td><td>X</td></tr>
</table>
To minimize speed differentials, the speed limit should only be reduced in a maximum of 10 mph increments. The reduced speed limit should be in effect for at least 60 seconds before instituting another speed limit reduction. A reduced speed limit should be displayed for a minimum of 10 minutes before the speed limit is increased.</td></tr>
<tr><td>2. Normal Conditions – Typical</td><td>During the typical weekday peak period, traffic congestion will increase and speeds will decrease. The left shoulder should be opened to traffic to increase capacity when traffic volumes and speeds indicate the need.</td></tr>
</table>

SCENARIO	DESCRIPTION
weekday peak period	Before traffic is allowed to use the left shoulder as a travel lane, sweeping of the lane should be completed to determine if debris, stopped vehicles, stored snow, ponding water, and other obstructions would prevent opening of the left shoulder to traffic. Sweeping consists of three different methods.

- Mechanical Sweep – This process involves driving a street sweeper as needed through the shoulder to remove debris. Mechanical sweeping is generally not necessary since the presence of traffic on the shoulder on a regular basis tends to keep it clear of debris. The current plan is to provide a mechanical sweep of the left shoulder once every three weeks.
- Vehicle Sweep – This process involves driving a vehicle (typically a freeway service patrol vehicle or law enforcement vehicle) through the shoulder lane to remove any large objects (if encountered) and verify that no vehicles are stopped or parked on the shoulder.
- Camera Sweep – This process involves visually scanning the left shoulder using the CCTV cameras in the TMC.

All signs in the corridor should be updated simultaneously so no conflicting information is presented.

Phase	Observations	Display on Signs		Comments
		Variable Speed Limit	Left Shoulder	
1	Steady flow. Normal operation.	65	X	A vehicle sweep should be conducted every weekday prior to the peak period in anticipation of the left shoulder opening to traffic. A camera sweep should also be conducted at this time in anticipation of the left shoulder opening to traffic.
2	Speeds decreasing. Traffic volumes increasing.	55	↓	When measured average speeds fall to 55 mph at two locations in the corridor for a duration of at least five minutes, the speed limit should be lowered to 55 mph and the left shoulder opened to traffic The speed limit should be kept at 55 mph for at least 60 seconds before moving to another phase. It is anticipated that this phase will have a duration of two to three hours unless speeds continue to fall and phase 3 is implemented. If Phase 3 is not implemented, proceed to Phase 7.
3	Speeds decreasing. Traffic volumes increasing.	45	↓	This is an optional phase that will only be used if speeds continue to fall after the left shoulder is opened to traffic. If measured average speeds fall to 45 mph at two locations in the corridor, the speed limit should be lowered to 45 mph while keeping the left shoulder opened to traffic.
4	Speeds decreasing. Traffic volumes increasing.	35	↓	. Phase 4 will only be used if Phase 3 is implemented. If measured average speeds fall to 35 mph at two locations in the corridor, the speed limit should be lowered to 35 mph while keeping the left shoulder open to traffic.
5	Speeds increasing. Traffic volumes decreasing.	45	↓	Phase 5 will only be used if Phase 4 is implemented. As speeds begin trending upward, the speed limit should be raised to 45 mph while keeping the left shoulder open to traffic.
6	Speeds increasing. Traffic volumes decreasing.	55	↓	Phase 6 will only be used if Phase 5 is implemented. As speeds begin trending upward, the speed limit should be raised to 55 mph while keeping the left shoulder open to traffic.
7	Speeds increasing. Traffic volumes decreasing.	55	X	The decision on when to close the left shoulder to traffic will be largely based on observations of traffic density and experience. Measured average speeds cannot be relied upon in making the decision, since the speed limit will be set at 55 mph, and many drivers will suppress their speed accordingly. The left shoulder should not be closed to traffic until there is a high level of confidence the loss of capacity with its closing will be more than offset by the reduction in traffic volumes such that speeds can increase once the left shoulder is closed and speed limit raised. The intent is that once the left shoulder is closed to traffic at the end of the weekday peak period it will not be opened again. This phase has a duration of 60 ± 5 seconds. The yellow "X" should not be displayed for a longer time.
8	Steady flow. Normal operation.	65	X	Resume normal operation flow.

Note: "Measured average speed" means the average speed of each lane at a single location.

Normal process will be to go through Phases 1-2-7-8. If measured speeds fall below 35 mph, then the process will be to go through Phases 1-2-3-4-5-6-7-8. Regardless of which phasing is used, only one cycle will normally be used per weekday peak period. The left shoulder should only be opened and closed once per day for the weekday peak period. (Extenuating circumstances could dictate reopening of the left shoulder after it has been closed after the weekday peak period, but this would be the exception.)

Allow at least 60 seconds between speed limit changes. When closing the left shoulder to traffic, the yellow "X" should only be displayed for 60 ± 5 seconds (i.e., 55 to 65 seconds).

SCENARIO	DESCRIPTION
	It is preferred that the left shoulder be opened to traffic at approximately the same time every weekday peak period for driver expectancy, based on historical data. This could be adjusted based on observed traffic volumes and speeds. The closing of the left shoulder at the end of the weekday peak period should be based on observed traffic volumes and speeds.
3. Bottleneck/ Congestion – Off Peak Period	Congestion may build on the corridor during times other than the weekday peak period. If the congestion is relatively consistent along the corridor, and if measured average speeds fall to 55 mph or lower at two locations in the corridor for a duration of at least five minutes, the speed limit should be reduced to 55 mph throughout the corridor and the left shoulder open to traffic (Phase 2), with all signs changed at the same time to display the same message. If the congestion is localized or exhibiting atypical patterns, signs may be adjusted as necessary in accordance with ODOT's VSL Guidance to address corridor-specific conditions. A vehicle sweep and camera sweep of the left shoulder should be done before opening it to traffic. If a vehicle sweep cannot be done within a reasonable time, then the left shoulder can be open to traffic with just a camera sweep at the discretion of the TMC operator and in consideration of the queue of traffic that is developing. A queue of traffic presents an inherent hazard to the motorist. A judgment call must be made as to the relative hazard of the queue of traffic and allowing traffic to drive on the left shoulder without a vehicle sweep. If the decision is made to open the left shoulder to traffic, the phases as described in the table under "Typical Weekday Peak Period" should be followed. The 55 mph speed limit should be displayed for a minimum of 10 minutes before returning to 65 mph. If congestion continues to worsen, consideration should be given to reducing the speed limit to 45 mph (Phase 3)
4. Work Zone / Maintenance	For scheduled maintenance/construction operations, a strategy will be devised in advance to facilitate traffic flow through the area. This may include closing of one or more through lanes to traffic, opening the left shoulder to traffic, and/or reducing the speed limit. Consideration should be given as to the location of the work along the corridor, and which lanes will be affected. Speed limit reductions should be made in 10 mph increments, with a minimum of 60 seconds between reductions. If the decision is made to open the left shoulder to traffic, the phases as described in the table under "Typical Weekday Peak Period" should be followed. A vehicle sweep and camera sweep of the left shoulder should be performed before opening it to traffic. Unless the maintenance/construction activity is consistent along the corridor, each sign in the corridor will likely have different displays.
5. Crashes	The signs in the corridor can be used in response to non-scheduled incidents, such as crashes, to facilitate traffic flow through the area. This may include opening the left shoulder to traffic, and/or reducing the speed limit. Consideration should be given as to the location of the incident along the corridor, and which lanes are being affected. Speed limit reductions should be made in 10 mph increments, with a minimum of 60 seconds between reductions, if possible. Larger reductions or shorter durations between reductions may be necessary in some cases, based on the severity of the incident. If the decision is made to open the left shoulder to traffic, the phases as described in the table under "Typical Weekday Peak Period" should be followed. A camera sweep of the left shoulder should be done before opening it to traffic. A vehicle sweep may be impractical for non-scheduled incidents. If a vehicle sweep cannot be done within a reasonable time, then the left shoulder can be open to traffic with just a camera sweep at the discretion of the TMC operator and in consideration of the developing traffic queue. A queue of traffic presents an inherent hazard to the motorist. A judgment call must be made as to the relative hazard of the queue of traffic and allowing traffic to drive on the left shoulder without a vehicle sweep. Each sign in the corridor will likely have different displays based on the location and nature of the incident.

SCENARIO	DESCRIPTION
	Traffic should be diverted around a planned or unplanned event to one side only. Traffic should not be allowed to divert around both sides simultaneously.
6. Crash in SmartLane	In the event of a crash in the SmartLane, the facility will need to be closed. The SmartLane sign immediately upstream would need to be changed to a red "X" alerting nearby motorists of an immediate hazard. Subsequent upstream signs would be changed to the yellow "X" until the SmartLane is cleared. Once cleared, all signs would have a red "X" until the SmartLane is opened back up.
7. Weather Incident	The signs in the corridor can be used to lower the speed limit in the corridor in response to weather-related events. Speed limit reductions should be made in 10 mph increments, with a minimum of 60 seconds between reductions, if possible. Each sign in the corridor should display the same speed limit. It is not expected that there would be a need to consider opening the left shoulder to traffic during a weather-related event.
8. Diversion when nearby route is closed or severely congested	In the event a nearby route is closed due a major traffic incident, the SmartLane would be opened to help manage the additional traffic volumes.
9.Road Closure (All Lanes)	In the event of a major crash or other event necessitating a complete closure of the SmartLane corridor, the DMS installed as part of the system can provide advance information to motorists well in advance of the closure, indicating ramps that should be used to exit the roadway as well as supporting police activities/responder activities. Speed limits reductions can also be used to allow for slowing down traffic on the approach to diversion routes and minimize potential for back of queue crashes.
10.Failure Conditions	The reliability of ITS hardware has continually increased over the years, and the SmartLane system will be designed and installed to minimize operational problems. This includes monitoring diagnostics to immediately identify to the TMC Operator when and where a problem has occurred, and the nature of the problem (e.g., loss of communications, loss of power). When failures do occur, the SmartLane signs should go "blank." The SmartLane system also can be designed such that it will continue to provide the desired functionality, even if this operation is in some form of degraded mode. Potential failure scenarios and the resulting system operation in this regard are noted below: *Loss of power at a sign* – Signs will go blank in the event of power failure and the speed limit reverts back to the last speed limit sign prior to entering the SmartLane area. *Loss of communications at a sign* – In the event of communication failures, the signs should automatically go to either a blank out condition or a default message "Sign Under Maintenance." *Sign Controller Failure* – Assuming that all of the signs for a single-sign location are operated by a single controller at the structure, it may be feasible to include a second controller at the gantry as a "hot" standby should the primary controller fail. *Detector failures* – Algorithms for calculating and displaying speed advisories will be able to function effectively up to some threshold of missing data. When the threshold is reached, the system will revert to a back-up schedule or manual mode of operation.

3 References

1. Final Report for Determining Candidate Active Traffic and Demand Management Strategies, August 2016
2. Statewide Active Traffic Management Study Concept of Operations - September 12, 2016 (Revised Submission March 15, 2017)
3. Traffic Engineering Manual - Part 13 – Intelligent Transportation Systems
4. Ohio Manual of Uniform Traffic Control Devices - 2012 Edition
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6. ODOT Intelligent Transportation Systems (ITS) - <www.transportation.ohio.gov/programs/traffic-operations/its>
7. Conceptual Hard Shoulder Running ITS Device Location Report, September 2017
8. Central Ohio Regional ITS Architecture Update, 2021
9. Ohio Kentucky Indiana Regional Council of Governments (OKI) Regional ITS Architecture, 2016
10. Northeast Ohio Areawide Coordinating Agency (NOACA) Regional ITS Architecture, 2019.
11. FRA-71-18.52 Feasibility Study, December 2021

Appendices Overview

First, as a way to organize and collect lessons learned, **Appendix A** is assembled to be a location for documenting lessons learned and areas for opportunity. Other appendices are organized by ODOT projects according to their ATDM Project Type. The table below lists the projects and the figure below shows the different project locations around the state.

Appendices Organization

APPENDIX	PROJECT TYPE
B	**Part-Time Shoulder Use + Lane Control + Variable Speed Limit Projects**
B1	Project Name: I-670 SmartLane
B2	Future
C	**Variable Speed Limit Projects**
C1	Project Name: I-90 VSL
C2	Future
D	**Part-Time Shoulder Use + Variable Speed Limit Projects**
D1	Project Name: I-275 SmartLane
D2	Project Name: I-71 SmartLane
Additional Appendices and Sub-Appendices can be added as new similar or variations of Project Types are defined.	

ATDM Project Location Map

Four additional appendices are included after the project appendices. They are as follows:

- Project Architecture (Interface) Diagrams
- Sample Requirements Testing Compliance Matrix
- I-275 Alternatives Modeling Technical Memorandums
- ODOT ITS Field Equipment Installation Checklists

Appendix A Deployed Projects Lessons Learned

A1 Deployed Projects Lessons Learned

By project type, this section captures lessons learned during different phases of project development including planning, preliminary and final design, procurement, construction, testing/acceptance, initial operations, and final operations and maintenance. As new project types are deployed throughout the state, additional lessons learned tables can be added.

Table A-1. Part-Time Shoulder Use + Lane Control + Variable Speed Limit Projects Lessons Learned

PROJECT PHASE	LESSONS LEARNED
Planning	No comments.
Preliminary and Final Design	No comments.
Procurement	The large dynamic message boards were new products to ODOT, thus alternate bid procurement was used to allow for flexibility with selection. Delivery times and past performance on other construction projects along with bid prices were used as selection criteria.
Construction	Start coordinating new power services as soon as possible. These services had the potential to delay the project.
Testing/Acceptance	Offsite testing is an advantage to view operations and troubleshoot problems prior to installation and having to work over traffic.
Initial Operations	1. Activation of the SmartLane and VSL cannot rely only on sensor data. The initial plan was to activate the system when a threshold was met for volume per lane. However, by the time that threshold was met, congestion had already started to build, which the SmartLane could not counteract. Activation is now dependent on experience, observation, and sensor data. 2. TMC has learned to favor cameras at a higher height of 60-70 feet compared to mounting them on sign structures. Even though there may be 100% camera coverage when mounted to sign structures, coverage can be improved and of greater use when mounted higher. 3. Lesson learned is that the SmartLane has stayed cleaner than anticipated. Preliminary plan was to dedicate the FSP tow truck and have ODOT forces mechanical broom the SmartLane daily. However, experience has shown that camera coverage and having FSP drive the SmartLane daily prior to activation is sufficient to avoid debris buildup. In addition, dome cameras with analytics configured to detect and notify the TMC of objects in the SmartLane has assisted with visual 'sweeping.'
Final Operations (including maintenance)	Interim completion dates need to be set for the contractor to install and make the system functional for ODOT to make its connections and accept operation about 30 days prior to turn on date. Allow time for unexpected issues during setup and testing. Dedicate significant time to configure the dome cameras with analytics. Specify times to fix SmartLane overnight for next morning operation.

Table A-2. Variable Speed Limit Projects Lessons Learned

PROJECT PHASE	LESSONS LEARNED
Planning	The desire or need to install the VSL system prior to the next winter season created challenges that may have been avoidable without an accelerated schedule. It was determined to pre-purchase as many materials and equipment as possible in advance of the construction contract award to minimize the impact of lead times on the construction schedule. However, there were delays with fabrication and delivery times, so the contractor was also delayed in completing the project. Contractor was paid for delays while waiting on materials. If time was not a factor, then fiber optic communications would have been selected over cellular modems.
Preliminary and Final Design	In order to meet the project schedule of completing by the next winter season, cellular modems were selected for communications. This mode led to inconsistent communications because of the lack of cellular coverage in the rural location. If time was not one of the driving factors, then fiber optic cable would have been the more reliable mode of communication to install with the project.
Procurement	Due to the accelerated nature of the project, the software specified was purchased on a low-bid basis and it also was required to support operations of the I-670 SmartLane project. Additional requirements that fully defined VSL and SmartLane would have been beneficial and reduced issues related to developing custom software.
Construction	No comments.
Testing/Acceptance	Purchasing significant portions of the equipment in advance and supplying to the contractor placed an added burden on ODOT related to interoperability and testing prior to handing over to the contractor for installation.
Initial Operations	Initial plan was to activate the lower speed limits based on CCTV images and RWIS sensor data, however, this proved impractical. Communications from the RWIS sensor can be intermittent. In addition, local experience of how fast winter weather can move in proved that the VSLs need to be activated soon than what sensor data indicated about pavement conditions.
Final Operations (including maintenance)	The concept now is to lower the speed limit by 5 mph when weather is anticipated, such as the start of a winter storm warning, and lower it another 10 mph once it begins to snow. Communication systems are now being upgraded to fiber optics with a redundant leased line from internet providers.

Appendix B Part-Time Shoulder Use + Lane Control + Variable Speed Limit Projects

B1 I-670 SmartLane

A1.1 Project Scope

B1.1.1 Scope Description

The I-670 SmartLane project was a first of its kind in Ohio. As an early candidate based on the Statewide 2016 ATDM Report, it included strengthening the inside shoulder to allow for part-time should use during peak periods. The technology use to manage SmartLane included detection, surveillance, and full span dynamic message signs that allow for lane control, variable speed limits, and traffic incident alerts.

B1.1.2 General Location

The roadway segment as shown in **Figure B-1** was selected as the pilot because a successful implementation of SmartLane offered greater travel time reliability and average speed benefits compared to the westbound direction. Additionally, the inside shoulder is wide throughout the corridor, providing adequate room and minimizing the geometric trade-offs. Operating the SmartLane on the inside also has the benefit of avoiding conflicts between entering/exiting traffic that would occur on an outside shoulder installation. Lastly, the westbound shoulder is narrower than the eastbound in some superelevated sections (12’-9” WB vs. 15’3” EB), which made for a less costly initial installation due to fewer stretches of widening.

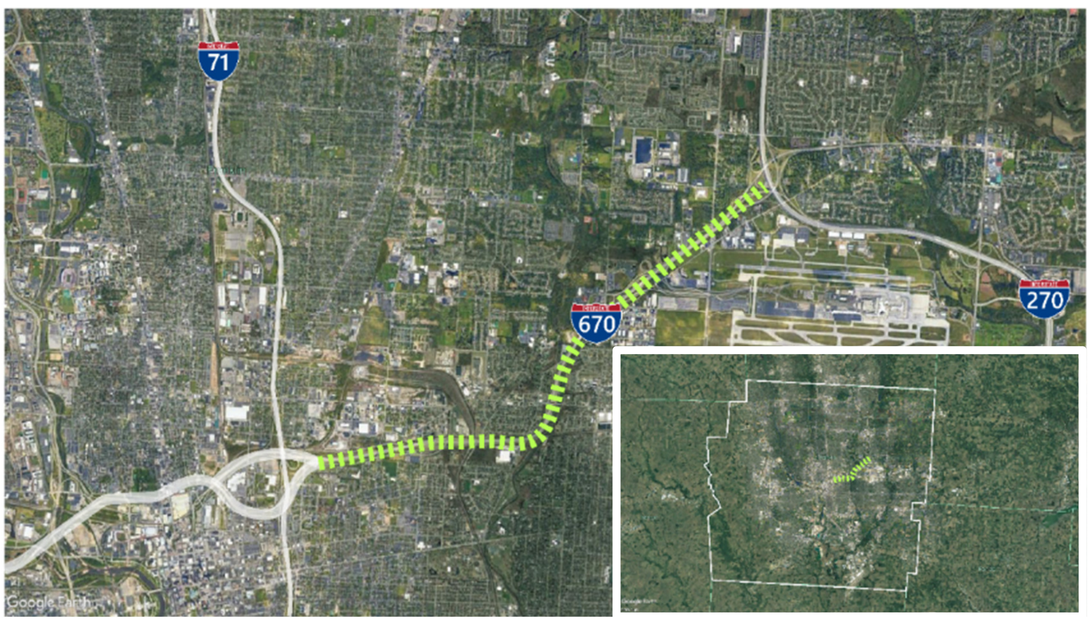

Figure B-1. I-670 SmartLane Project Area

B1.1.3 Project Background

In 2016, ODOT published the Final Report for Determining Candidate Active Traffic and Demand Management (ATDM) Strategies study. Due to substantial congestion, the I-670 corridor was identified as a candidate for Part-Time Shoulder Use, or also known as Hard Shoulder Running (HSR). The concept evolved in Ohio to be named SmartLane indicating converting an existing shoulder to a travel lane during peak travel hours or other periods of high congestion using dynamic lane control signs along with other ITS technology to monitor and manger the roadway.

B1.1.4 Conceptual Alternatives

In 2017, a consultant completed a Feasibility Study for ODOT that evaluated alternatives for addressing congestion and safety issues at I-670/US 62 interchange. The Feasibility Study noted that improvements to the interchange would be necessary on order to accommodate additional capacity that would be provided on I-670 of the SmartLane concept were implemented. The study evaluated and compared three build alternatives and a no-build alternative based on safety, traffic operations, impacts, maintenance of traffic/constructability, and design geometrics.

B1.1.5 Interagency Coordination and Possible Effects on Neighboring Communities

As the project was being planned and plans were in preliminary stages, ODOT engaged the emergency responders in the vicinity of the proposed SmartLane project to work through expectations related to traffic incident response.

B1.1.6 Additional Project Information

PID	104674
Location	Columbus, OH; Gahanna, OH
ELLIS Project Description	Part 1: Hard shoulder running installation (branded as SmartLane) on FRA-670 between IR-71 and IR-270. Approximately between 5.03-10.39 SLM. The project also includes improvements to the 670/270/62 interchange and along IR 270 NB (SLM 32.94 to 35.84) to improve congestion and safety due to a weave. Part 2: WB IR 670 resurfacing. Approximately between 5.03-10.39 SLM.

A1.2 Elements of Regional Architecture in Project

Originally drafted by the Mid-Ohio Regional Planning Commission (MORPC) in 1999 and most recently updated in 2017, the Central Ohio Regional ITS Architecture addresses the 7-County region surrounding the City of Columbus and consists of Franklin, Delaware, Licking, Fairfield, Pickaway, Madison, and Union Counties (see map in **Figure B-2**).

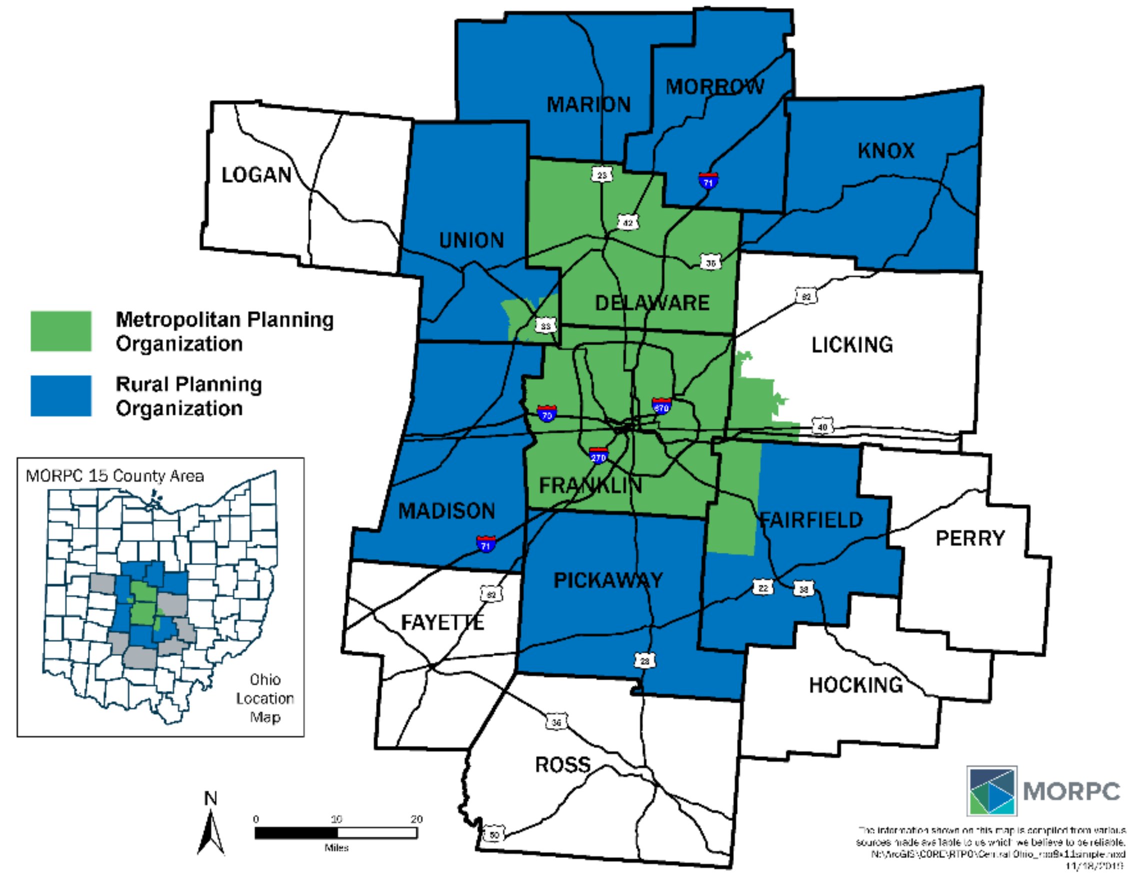

Figure B-2. MORPC Geographic Boundaries

As part of the systems engineering process and federal regulations regarding federally funded ITS projects, the I-670 EB SmartLane project should align with the associated regional ITS architectures.

MORPC last updated the regional ITS Architecture in 2015 to version 7 of the National ITS Architecture. **Table B-1** lists the service packages in the regional architecture and how they correlate to the I-670 SmartLane project. The next time MORPC updates the architecture, it will need to update to the latest version of ARC-IT.

Table B-1. MORPC ITS Architecture Service Packages

REGIONAL ITS ARCHITECTURE VERSION 7.0		PROJECT ARCHITECTURE ARC-IT VERSION 9.0	
SERVICE PACKAGE NO.	SERVICE PACKAGE NAME	SERVICE PACKAGE NO.	SERVICE PACKAGE NAME
ATMS01	Network Surveillance	TM01	Infrastructure-Based Traffic Surveillance
ATMS06	Traffic Information Dissemination	TM06	Traffic Information Dissemination
ATMS08	Traffic Incident Management System	TM08	Traffic Incident Management System
	Not in Version 7.0	TM12	Dynamic Roadway Warning
ATMS22	Not in Regional ITS Architecture	TM20	Variable Speed Limits
ATMS23	Not in Regional ITS Architecture	TM22	Dynamic Lane Mgmt. and Shoulder Use
EM04	Roadway Service Patrol	PS08	Roadway Service Patrols
AD2	ITS Data Warehouse	DM01	ITS Data Warehouse

A1.3 Roles and Responsibilities

Table B-2 highlights the roles and responsibilities of various stakeholders participating in the I-670 EB SmartLane Pilot Project.

Table B-2. Participating Agency Roles and Responsibilities

AGENCY/STAKEHOLDER (TYPE)	ROLES AND RESPONSIBILITIES
ODOT District 6 (infrastructure owner)	General maintenance of the roadway (e.g., surface repair, static signing, snow, and ice management), public information, design, and construction oversight.
ODOT Office of Roadway Engineering (infrastructure owner)	Review of SmartLane and other innovative ATDM projects.
ODOT Office of Traffic Management (infrastructure owner)	Through the Statewide TMC, provide primary command and control of network of DMS/VSL, and CCTV supporting lane control of SmartLane project. Coordinating adaptation of I-90 VSL control software for SmartLane project.
ODOT Office of Traffic Operations (infrastructure owner)	Assist with design scope, Traffic/ITS Engineering, and heavy involvement with construction coordination of ITS device installation and configuration. Maintenance of ITS Field Devices and supporting network communications.
ODOT Freeway Service Patrols (emergency responder)	Assist with the verification, clearance, and temporary traffic control for traffic incidents. Provide verification shoulder lane is clear prior to opening to traffic.
City of Columbus Public Service (municipal infrastructure owner)	Through an MOU with ODOT, the city has fiber optic cabling located within the project limits.

AGENCY/STAKEHOLDER (TYPE)	ROLES AND RESPONSIBILITIES
City of Gahanna Public Service (municipal infrastructure owner)	Project located within municipality limits.
Central Ohio Transit Authority (system user)	Several COTA bus routes use the I-670 freeway between downtown and the airport.
Mid-Ohio Regional Planning Commission (regional planner)	Steward of Regional ITS Architecture.
Utilities within the project limits (stakeholder / utility provider)	Power will need to be installed to a variety of new ITS devices.
John Glenn Columbus International Airport (customer)	Major trip generator located on the eastern end of the project limits.
City of Columbus FD (emergency responder)	Provides Traffic Incident Management (TIM) services and routinely serves as Incident Commander during large scale crashes.
City of Columbus Police (emergency responder)	Speed enforcement and TIM services.
Ohio State Patrol (emergency responder)	Speed enforcement and TIM services.
Franklin County Sheriff (emergency responder)	Speed enforcement and TIM services.
City of Gahanna Division of Police (emergency responder)	Speed enforcement and TIM services.
Mifflin Township FD (emergency responder)	Provides TIM services.
Towing and Recovery Companies (emergency responder)	Provides TIM services.

The primary agency responsible for daily operations of the SmartLane project is the ODOT Statewide TMC. The TMC will be responsible for command and control of the new systems proposed as part of the SmartLane pilot project including:

1. Opening and closing of the SmartLane outside of the normal operating schedule.
2. Modification of the normal operating schedule of the SmartLane.
3. Control of any messages posted on the Dynamic Message Signs.
4. Control of CCTV cameras.
5. Control of speeds displayed on Variable Speed Limit Signs.
6. In coordination with emergency responders, serve as official designee to proclaim opening and closing of other travel lanes as traffic incidents, maintenance and/or construction activities and weather conditions change.

A1.4 Project Maintenance Plan

Refer to Section 1.10 System Maintenance above for cross-cutting considerations and approaches to system maintenance that apply to all project maintenance plans. This subsection is included here for supplemental information or issues unique to this project.

In Central Ohio, District 6 lets annual indefinite quantity/indefinite delivery contracts for electrical maintenance. Non-ITS components such as highway lighting will be addressed using this work-order style contract.

The 5th Avenue Garage is the closest ODOT garage to I-670 and provides routine roadway maintenance services. However, 5th Avenue is occasionally placed solely on night shift to service roadways during off-peak hours, so resources are pulled from the Westerville, Grove City, or Hilliard garages as needed.

Sweeping will be performed every weekday before peak traffic and drainage cleanout will be more frequent than standard but not expected to be a daily or weekly occurrence.

A1.5 Alternative Systems and Procurement Options

A1.5.1 Alternative Systems Options

Several alternatives were considered as part of the previously completed ConOps report. The report discussed several typical lane control signing messages. Originally, the use of chevrons (>>) in combination the word MERGE was a preferred signing strategy as shown in **Figure B-3**. However, after further investigation, similar applications being used around the country are considered experimental and require additional evaluation. While ODOT is considering the option of submitting an official Request to Experiment with the chevrons on the SmartLane project, alternative text based only alternatives have been developed as shown in **Figure B-4**. If the Request to Experiment is approved, the chevrons will be used (Note: The Request to Experiment was not submitted and the sign messages in **Figure B-4** were used).

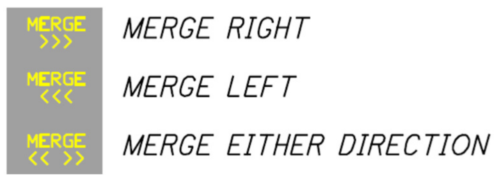

Figure B-3. Original Proposed Merge Lane Control Sign Messages with Chevrons

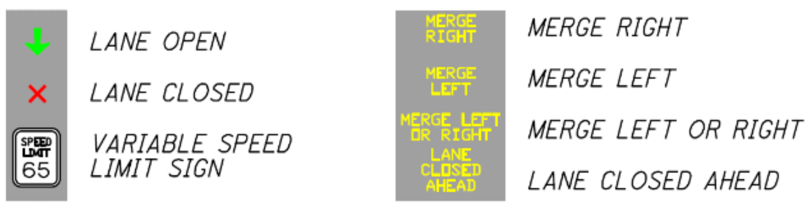

Figure B-4. Proposed Lane Control Sign Messages

A1.5.2 Sign Gantry Alternatives

In the initial development stages of the project, two phased solutions were envisioned for the I-670 SmartLane EB Hard Shoulder Running Project. An Interim Solution and a Long-Term Solution were proposed. A third hybrid solution was added.

A1.5.2.1 Interim Solution Gantry Alternative

In the Interim Solution, a series of structures with cantilever arms were proposed to be installed along the median of I-670 EB. Displays would be mounted overhead to these cantilever structures for lane control over the inside shoulder. No other lane control displays would be available using this configuration and would provide Open/Closed control of the left shoulder lane only. Additional lane status over the shoulder would be unavailable, and no control of any other travel lanes would be available.

A1.5.2.2 Long-Term Solution Gantry Alternative

The Long-Term Solution utilizes gantries spanning the full width of I-670 EB and full-matrix Dynamic Message Signs to provide active control of the left shoulder, as well as all other eastbound travel lanes. This would provide Open/Closed control of all travel lanes, providing greater flexibility of control. In addition to left shoulder lane control, individual lanes can be opened and closed to provide access to Emergency, Police and Maintenance vehicles during traffic incidents, construction/maintenance operations and other lane-specific hazards.

A1.5.2.3 Mixed Gantry-Cantilever Solution Alternative

A third solution was presented where full-size sign gantries and cantilever arm structures would be mixed every-other structure. This would provide additional functionality of the overall system by allowing the posting of special messages on each gantry structure, while cutting costs by substituting cantilever arm structures for some of the gantries. The cost savings would come at the expense of individual control of each lane for Emergency, Police and Maintenance vehicles due to increased spacing in between gantry structures. The lack of persistent lane control notification may prevent effective individual closures of travel lanes.

A1.5.2.4 Recommended Gantry Alternative

ODOT has selected the Long-Term Solution for enhanced control, flexibility, roadway efficiency and future upgradeability. The other options do not provide the extensive capability of controlling all lanes of roadway traffic at each structure to clear lanes for Emergency, Police, Maintenance, Construction, and other official personnel, which is a key advantage to the Long-Term Solution. The latest conceptual gantry drawing is shown in **Figure B-5**.

Figure B-5. Conceptual SmartLane Gantry Rendering

A1.5.3 Operations and Maintenance Design Considerations

Several operations and maintenance design considerations were considered in early project planning including:

- DMS enclosures and support structures were designed to accommodate maintenance to be performed by accessing a walk-in enclosure to minimize need for lane closures.
- Snow plowing and storage was considered recognizing SmartLane will need to be used a location to store snow during significant winter events.
- Three levels of sweeping of SmartLane before opening (mechanical, freeway Service Patrol Drive through, and cameras).

A1.5.4 Proprietary Equipment Needs

There was no proprietary equipment needed as part of the project.

A1.5.5 Procurement Options

Design-Build was considered for project delivery but was rejected in favor of Design-Bid-Build (DBB) so that ODOT could retain closer control of the design process. It was anticipated that unfamiliar issues would arise during project development that would require clarification/direction to the designer. A design-bid-build process would allow for this direction without incurring change orders, which would be necessary on a design-build contract. Additionally, DBB was desirable because this is the pilot installation of SmartLane in Ohio, and many of the scope/project development/review requirements were not available early enough in the process to provide a schedule benefit.

Software procurement was evaluated by ODOT Central Office from an expectation that the initial operation is the first of a tiered approach to SmartLane implementation. The initial operation will be static, with a full physical buildout capable of supporting a dynamic operation. Once ODOT has developed its TMC and supporting software (i.e., Buckeye Traffic 2.0), ODOT can implement the dynamic operation. The procurement of these tools (TMC upgrade and next generation software) will take funds and time beyond those allocated to the SmartLane project, so ODOT took the approach of acquiring a software package capable of supporting the initial static operation only, without precluding the future upgrade.

After determining that only the initial, static, operation would be in the opening day operation, ODOT evaluated procurement of a software package that would meet that set of requirements. These requirements (interface with TMC, change sign maps in response to VSL guidance), were very similar to those outlined in another VSL installation under development on I-90 in Northeast Ohio, so ODOT opted to procure/support one piece of software for both installations to minimize initial cost and ongoing support resources. Separate procurement was considered but rejected because there was not sufficient difference between the two installations to warrant a separate piece of software, and the associated costs.

Separate procurement of the DMS boards was evaluated, but schedule benefits were too minimal to warrant assuming some of the fit-up, transport and storage risks that would be incurred by ODOT procuring the hardware separate from the main project. A similar evaluation of advance procurement for the fiber led to rejection of early procurement on that item.

The I-670 SmartLane EB Hard Shoulder Running Project was advertised through the ODOT Office of Contract Sales Construction Management online system. Contractor selection was made via the competitive bidding process.

Appendix C Variable Speed Limit Projects

C1 I-90 Variable Speed Limit (VSL) System

C1.1 Project Scope

C1.1.1 Scope Description

The project includes installation of signs that change regulatory speed limits based on existing weather conditions or traffic incidents, supplemental surveillance, communications infrastructure, and updates to existing road weather information stations (RWIS).

C1.1.2 General Location

The project is located along a 16-mile stretch I-90, a four-lane divided facility in Lake County, in northeast Ohio and shown in **Figure C-1** where US 20 is the primary parallel arterial and alternate route during major traffic incidents.

Figure C-1. I-90 Variable Speed Limit Project Area

C1.1.3 Project Background

Because of its proximity to Lake Erie, northeast Ohio experiences a significant amount of snowfall every year as shown in **Figure C-2**. In particular, and due to lake effect snow phenomenon, the area in the vicinity of the project area averages between 80 and 120 inches of snowfall per year. The segment of I-90 experiences a much higher crash rate than the state average. Over a 10-year period from 2005-15, there have been 13 occasions during snow events where there were anywhere from 11 to 36 crashes in one day. Some of the crashes were multi-vehicle pile ups. The winter weather seems to be a major contributing factor, with a crash rate that is 255% higher during the winter months versus other months of the year (Source: LAK-90 Segment Analysis, 2005-2015 Crash Data, ODOT, 2016). During periods of lake effect snow and associated squalls, conditions on I-90 can deteriorate quickly to a point where the segment can become unsafe for travel with white-out conditions and rapid accumulation of snow and ice. One way to help mitigate the crashes that result from motorists traveling too fast for conditions is to slow down traffic through advisory or regulatory speeds based on prevailing roadway conditions.

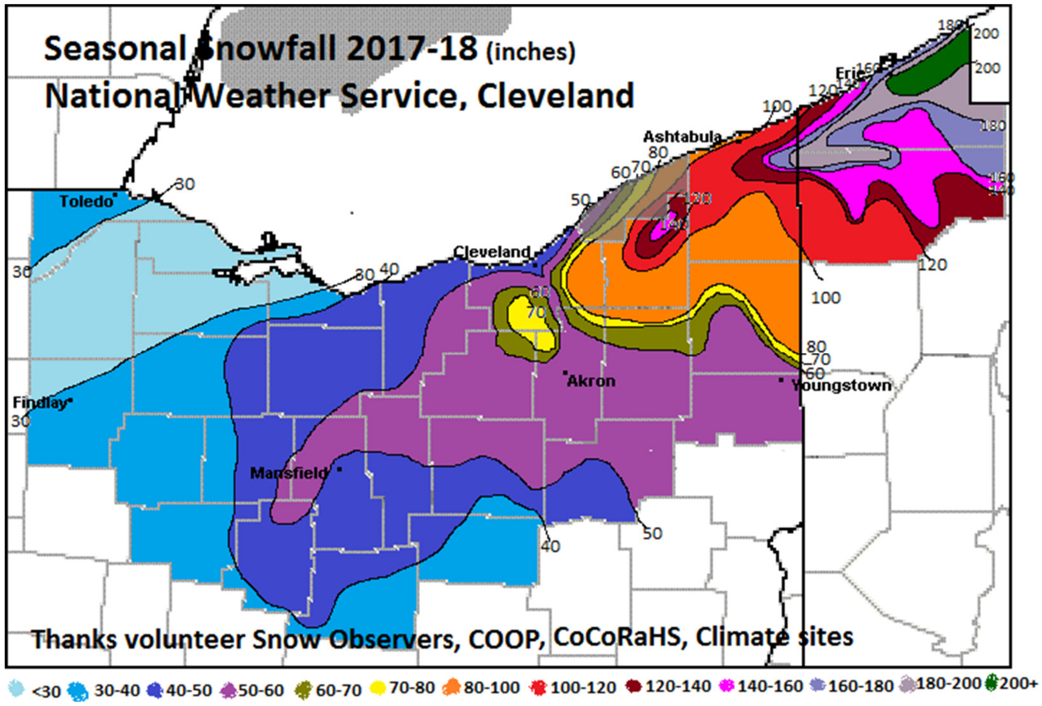

Figure C-2. Seasonal Snowfall, 2017-18 (Source: National Weather Service)

C1.1.4 Conceptual Alternatives

Early alternatives explored the year before the VSL project included lowering the speed limit on a seasonal basis. The solution was deemed ineffective, especially for motorists not familiar with the region. Another option employed along the I-90 corridor was a coordinated effort by the media and local agencies to leverage social media to alert motorists of pending travel issues due to forecast weather.

A VSL system based on weather conditions was the path forward to improve safety along I-90. Advisory variable speed limits were discounted early because research indicated their relative effectiveness compared to regulatory VSL. For example, the *FHWA Guidelines for the Use of Variable Speed Limit Systems in Wet Weather (2012)* indicates a regulatory VSL system is preferable over an advisory VSL system because of the ability to enforce speeds, leading to a higher level of compliance.

ODOT explored statutory changes to allow for regulatory VSL to be used on a pilot basis. In 2017 and 2019, modifications were made to Ohio Revised Code to allow variable speed limits on a limited basis throughout the state. Language directly from Ohio Revised Code 4511.21 (H)(3)(a) includes:

> *For purposes of the safe and orderly movement of traffic upon any portion of a street or highway under the jurisdiction of the director, the director may establish a variable speed limit that is different than the speed limit established by or under this section on all or portions of interstate six hundred seventy, interstate two hundred seventy-five, and interstate ninety commencing at the intersection of that interstate with interstate seventy-one and continuing to the border of the state of Ohio with the state of Pennsylvania. The director shall establish criteria for determining the appropriate use of variable speed limits and shall establish variable speed limits in accordance with the criteria. The director may establish variable speed limits based upon the time of day, weather conditions, traffic incidents, or other factors that affect the safe speed on a street or highway. The director shall not establish a variable speed limit that is based on a particular type or class of vehicle. A variable speed limit established by the director under this section is effective when appropriate signs giving notice of the speed limit are displayed at the location.*

C1.1.5 Interagency Coordination and Possible Effects on Neighboring Communities

Several agencies were involved in developing the initial VSL system.

- The Lake County Sherriff's Office was engaged and developed a partnership with ODOT to help refine VSL system concepts.
- The ODOT Lake County Manager was also engaged because many of its citizen would benefit from a VSL system.
- Media was a partner, especially when it came to educating motorists of how the VSL system would be used.
- Lake County Ohio Traffic Incident Management (OTIM) Group was the group of emergency responders who routinely discussed and debriefed responses to major traffic incidents along I-90.
- The National Weather Service (NWS) worked with ODOT to help develop criteria of when to lower speed limits leveraging FHWA's Every Day Counts, Round 4 (EDC-4) where the Pathfinder process enabled ODOT, the NWS, and private weather service providers to collaborate on clear, consistent road weather messaging for the public.

C1.1.6 Additional Project Information

PID	105911
Location	Concord, OH; LeRoy, OH; Madison, OH
ELLIS Project Description	Install variable speed limit signs along I-90 in Lake County from approximately SR-44 to SR-528. Work will include camera and speed detector installation.

C1.2 Elements of Regional Architecture in Project

Originally drafted by the Northeast Ohio Areawide Coordinating Agency (NOACA) in October 2000 and most recently updated to ARC-IT in 2019, the Northeast Ohio Regional ITS Architecture addresses the 5-County region surrounding the City of Cleveland and consists of Cuyahoga, Geauga, Lake, Lorain, and Medina Counties as shown in **Figure C-3**.

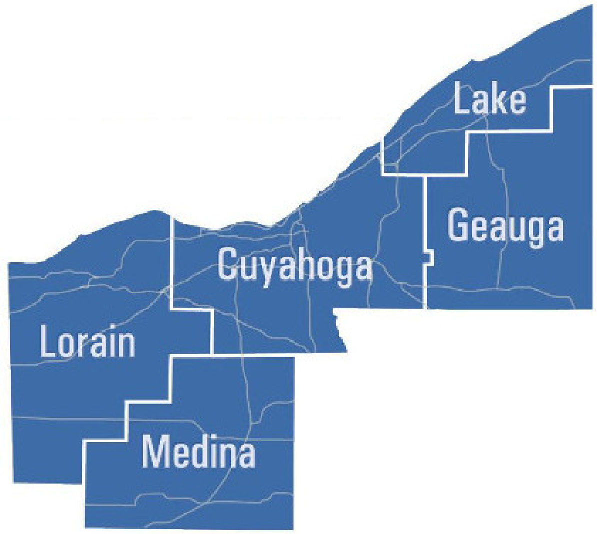

Figure C-3. NOACA Geographic Boundaries

As part of the systems engineering process and federal regulations regarding federally funded ITS projects, the I-90 VSL project should align with the associated regional ITS architectures.

Table C-1 lists all the service packages in the regional ITS Architecture and whether they are included in the project. In this case, because of the relatively recent update, the service packages at the regional and project level align very well.

Table C-1. NOACA ITS Architecture Service Packages

REGIONAL ITS ARCHITECTURE ARC-IT VERSION 8.2		PROJECT ARCHITECTURE ARC-IT VERSION 9.0	
SERVICE PACKAGE NO.	SERVICE PACKAGE NAME	SERVICE PACKAGE NO.	SERVICE PACKAGE NAME
TM01	Network Surveillance	TM01	Infrastructure-Based Traffic Surveillance
TM06	Traffic Information Dissemination	TM06	Traffic Information Dissemination
TM08	Traffic Incident Management System	TM08	Traffic Incident Management System
TM12	Dynamic Roadway Warning	TM12	Dynamic Roadway Warning
TM20	Variable Speed Limits	TM20	Variable Speed Limits
PS08	Roadway Service Patrol	PS08	Roadway Service Patrols
DM01	ITS Data Warehouse	DM01	ITS Data Warehouse

C1.3 Roles and Responsibilities

Table C-2 highlights the roles and responsibilities of various stakeholders participating in the I-90 VSL Project.

Table C-2. Participating Agency Roles and Responsibilities

AGENCY/STAKEHOLDER (TYPE)	ROLES AND RESPONSIBILITIES
ODOT District 12 (infrastructure owner)	General maintenance of the roadway (e.g., surface repair, static signing, snow, and ice management), public information, design, and construction oversight. The District 12 Public Information Officer (PIO) played a significant role through extensive media outreach during planning, construction, and initial operations of the VSL system. Support for long-term traffic incident closures.
ODOT Office of Roadway Engineering (infrastructure owner)	Review of innovative ATDM projects.
ODOT Office of Traffic Management (infrastructure owner)	Through the Statewide TMC, provide primary command and control of dynamic signs, CCTV and RWIS supporting VSL operations.
ODOT Office of Traffic Operations (infrastructure owner)	Assist with design scope, Traffic/ITS Engineering, and heavy involvement with construction coordination of ITS device installation and configuration. Maintenance of ITS Field Devices and supporting network communications.
ODOT Freeway Service Patrols (emergency responder)	Assist with the verification, clearance, and temporary traffic control for traffic incidents.
Utilities within the project limits (stakeholder / utility provider)	Power will need to be installed to a variety of new ITS devices.
Ohio State Patrol (emergency responder)	Speed enforcement and TIM services.
Lake County Sheriff (emergency responder)	Speed enforcement and TIM services.
Towing and Recovery Companies (emergency responder)	Providers of TIM services.
Other Fire and EMS Agencies	Providers of TIM services including Madison Fire, Perry Township Fire, Concord Township Fire, and Painesville Township.
National Weather Service-Cleveland	Provider of weather-related advisories and warnings including snow squalls. Also helped ODOT develop weather-related criteria for determining VSL system speeds.

C1.4 Project Maintenance Plan

Refer to Section 1.10 System Maintenance above for cross-cutting considerations and approaches to system maintenance that apply to all project maintenance plans. This subsection is included here for supplemental information or issues unique to this project.

In Northeast Ohio, District 12 lets annual indefinite quantity/indefinite delivery contracts for electrical maintenance. Non-ITS components such as highway lighting will be addressed using this work-order style contract. Also, District 12 helps out with simple ITS maintenance activities when Central Office Traffic Operations needs immediate assistance.

No special or additional roadway maintenance is required for the VSL system.

No special or additional snow and ice control are required for the VSL system beyond making plow drivers aware that too much pile up around VSL signs can cause damage.

C1.5 Alternative Systems and Procurement Options

C1.5.1 Alternative Systems Options

Under a very accelerated schedule, several alternative systems were considered in the initial build-out of the VSL system. The options explored were related to telecommunications, strategies for purchasing equipment and strategies for securing command and control software.

- Telecommunications – three options were explored: fiber optic cabling direct to the VSL roadside signs, cellular wireless data modems, or a leased circuit solution. Both the fiber and leased circuit solutions were eliminated as an option due to the project schedule requirements. Initially the system was built with cellular data modems connecting the VSL signs to the TMC. Just recently, a new project has been constructed to provide more reliable connectivity using fiber optic cabling and communications infrastructure.

C1.6 Alternative Systems Options

C1.6.1 Operations and Maintenance Design Considerations

From the June 2020 VSL Policy Document:

1. A warning sign should be used approximately ¼ to ½ mile in advance of the first VSL sign entering the VSL corridor in each direction using one of the options shown in **Figure C-4**.

Option 1. W3-H5b (48" x 48")

Option 2. (144" x 48")

Option 3. (72" x 96")

Figure C-4. VSL Advance Signing Options

2. VSL signs should be installed following the guidance in **Table C-3**.

Table C-3. Variable Speed Limit Sign Spacing

SYSTEM USE	PREFERRED SPACING (MILE)	MAXIMUM SPACING (MILE)
Congestion	0.5 - 1	1.5
Weather	1-2	3

3. VSL speed limit signs should be dual mounted or mounted overhead if 3 or more lanes exist at the installation location. VSL signs may be dual mounted at the beginning of a VSL zone, or in areas of high traffic volumes and/or high percentage of trucks for greater emphasis**. Figure C-5** shows an example advance static VSL sign and an operational sign along I-90.

Figure C-5. Variable Speed Limit Signs on I-90

4. Flashing beacons may be installed with each VSL sign in order to draw attention to reduced speeds. If flashing beacons are used, they should be installed on all VSL signs throughout the entire corridor and conform to the standards in OMUTCD Section 4L.
5. For each entrance ramp along the VSL corridor, VSL signs should be installed along the mainline per guidance found in OMUTCD 2E.38 where possible; otherwise, adjust, as necessary. When following OMUTCD 2E.38, a warning sign (W3-H5b) should be placed on the ramp to warn drivers of the VSL ahead.
6. A standard speed limit sign shall be posted at the end of the VSL zone in each direction.
7. Prior to the new VSL zone implementation, ODOT will notify the appropriate law enforcement agencies of the intended zone and should consider partnering with these law enforcement agencies to maximize compliance.

C1.6.2 Proprietary Equipment Needs

There were no proprietary equipment needs required as part of the project. The proposed purchasing mechanisms were all competitive.

C1.6.3 Procurement Options

The three main areas related to procurement included design services, ITS Field Equipment, and Software.

- Professional Design Services – ODOT chose to work closely with an engineering firm to rapidly develop plans. Other options such as design-build were deemed inappropriate because this was the first time a VSL system has been constructed in Ohio.
- ITS Field Equipment Procurement – Two options were explored for securing the ITS field equipment: purchase as part of the construction contract, or purchase equipment in advance and provide to the contractor. With schedule constricting choices on the project, ODOT decided to procure as much equipment as possible then provide it to be installed by the contractor. VSL signs, cameras, detectors, and communications equipment were procured in advance. The challenge with this solution is it placed extra burden on ODOT for testing prior to handing over to the contractor for installation. If there would have been more time, the burden would have been shifted to the contractor to verify interoperability of components.
- Software Procurement – Several options were explored related to providing the command and control software required for the VSL system including:
    - Expand existing Buckeye Traffic software currently support TMC operations
    - Purchase new through an RFP
    - Purchase new through Construction Project
    - Use interim tools and wait until the new ATMS system was deployed

At the time the Buckeye Traffic software was ending it useful life and investing time into the product was deemed unproductive especially since several of the employees that developed the initial software had left ODOT. Purchasing new through an RFP and waiting for a new ATMS to replace Buckeye Traffic did not meet the project schedule constraints. ODOT decided to secure as part of the construction project with the concept that it may be retired once a new ATMS was built-out several years in the future.

Appendix D Part-time Shoulder Use + Variable Speed Limit Projects

D1 I-275 SmartLane

D1.1 Project Scope

D1.1.1 Scope Description

Improvements are proposed to include strengthening the shoulder, dynamic message signs to make motorists aware of SmartLane status and other roadway conditions, closed circuit television cameras, traffic detectors and ground mounted variable speed limit signs.

Improvements to the I-275 corridor for the SmartLane will have multiple benefits for commerce and the traveling public. The project will promote economic development along the I-275 corridor and surrounding counties. Investment in the I-275 infrastructure (pavement) will help reduce congestion, travel costs, and emissions while improving safety. Implementation of intelligent transportation systems and monitoring along the I-275 corridor will help maintain Ohio's role as a leader in innovative transportation management.

Improving the movement of goods and services by way of quality infrastructure will help Ohio face the challenge of meeting the demands of current and future transportation and commerce needs.

The main difference in scope of the proposed I-275 project compared to the original I-670 project in Columbus is use of fewer full span dynamic message signs and no individual dynamic lane control capabilities.

D1.1.2 General Location

I-275 is the major loop serving the Cincinnati region, connecting residents of Ohio, Kentucky, and Indiana. The proposed project will expand about 6.5 miles of I-275 for a SmartLane in northeast Hamilton County, from Reed-Hartman Road at the western end to Loveland-Madeira Road at the southeast. The portion of I-275 to be expanded passes through suburbs of Cincinnati including Sharonville, Blue Ash, Montgomery, and Indian Hill, Ohio. All of the proposed work falls within the Cincinnati urbanized area as shown in **Figure D-1**.

The project builds on the existing roadway infrastructure of the I-275 loop. Within the project limits, I-275 intersects with I-71, and the I-75 interchange is located 2.5 miles to the west. The area surrounding the project also connects to multimodal transportation infrastructure including two railways and US Bike Route 21, also known as the Little Miami Scenic Trail. US Route 42, the western terminus of the project, serves as a connection from I-275 to the Norfolk Southern Sharonville Intermodal Terminal, a truck and rail yard.

Figure D-1. I-275 SmartLane Project Area Map

D1.1.3 Project Background

The proposed SmartLane project along I-275 will provide an additional travel lane using the median shoulder during peak periods and major traffic incidents to help reduce congestion and traffic backups. This in turn will enhance both passenger and commercial freight movements in the region.

One of the strategies that came out of the TSMO and ATDM plans was implementation of SmartLanes in congested urban areas. The SmartLane provides an additional travel lane via the median shoulder for use during peak (congested) travel hours. In the non-peak hours, the shoulder reverts to its normal function. This innovative design solution and accompanying technology will help to improve the mitigation of safety risks on the interstate.

FHWA's publication on the Use of Freeway Shoulders for Travel – Guide for Planning, Evaluating, and Designing Part-Time Shoulder Use as a Traffic Management Strategy concludes that there is a link between changes in congestion and changes in the safety performance of a roadway when part-time shoulder use is in operation: "The application of the HSM freeway crash prediction models indicate reducing congestion (by increasing capacity) can offset the increase in crashes associated with increasing the number of lanes while reducing lane and shoulder width".

The ATDM study compared AM & PM peak speeds on I-275 in the year 2040 for a no-build scenario and a SmartLane scenario. The congested speed in the peak direction of travel during the AM and PM peak periods improves by 7 to 9 miles per hour compared to the no-build alternative. This increase in peak travel speeds correlates to a reduction in congestion and congestion-related crashes.

Utilizing ODOT's GIS Crash Analysis Tool and Transportation Information Mapping System, a safety analysis was conducted for the section of I-275 proposed for implementation of a SmartLane. From the years 2015-2017, there were a total of 1,071 crashes reported. Of the total 1,071 crashes, there were 2 fatal crashes and 27 serious injury crashes. Of the 1,071 crashes, 50% were rear end crashes, 21% were sideswipe passing crashes, and 12% were fixed object crashes. The AM peak from 6 AM-9 AM accounted for 20% of the total crashes and the PM peak from 4 PM -7 PM accounted for 37% of the total crashes. By introducing the SmartLane during the AM and PM peak hours and reducing the congestion experienced by road users, the number of crashes occurring during these time periods will be reduced.

Lastly, one of the strategies laid out in the Ohio Strategic Highway Safety Plan (SHSP) is to advance the use of new technologies and roadway designs that reduce rear end crashes. Reducing the amount of congestion on I-275 by introducing the SmartLane will help to reduce rear end crashes.

D1.1.4 Conceptual Alternatives

To assess the feasibility of different ATDM strategies, ODOT developed a series of alternatives using microsimulation models to measure their relative efficacy.

An alternatives analysis, including a No Build scenario, was performed for the project area. A consultant hired by ODOT conducted several iterative alternative analyses over a 6-month timeframe in 2020. The results of the analysis are documented in three technical memos that can be found in their entirety in **Appendix A**. The technical memos include:

- **Alternative Analysis Memo #1** – 6/18/2020 Preliminary Traffic Analysis Memorandum
- **Alternative Analysis Memo #2** – 10/19/2020 HAM-275 Smart Lane Certified Traffic Analysis Technical Memorandum
- **Alternative Analysis Memo #3** – 11/9/2020 **-** HAM-275 Smart Lane Certified Traffic Supplemental Analysis Memorandum

The following text is excerpted from the memos for the purposes of describing the Alternative Analysis results.

Alternative Analysis Memo #1 – 6/18/2020 Preliminary Traffic Analysis Memorandum

Summary:

Mott MacDonald explored the installation of peak period hard shoulder running permitted via dynamic message signage (Smart Lane) along I-275 from US 42 to Loveland-Madeira Road in Hamilton County. The purpose of this project is to address congestion and safety along the I-275 corridor.

As part of this analysis, Mott MacDonald examined No Build and Build conditions for opening year 2022 and design year 2042. The proposed Smart Lane will operate in one direction during the appropriate peak period. The proposed Smart Lane operation would be WB during the AM peak, and EB during the PM peak. Mott MacDonald also examined the use of ramp metering in conjunction with the Smart Lane EB during the PM peak.

Conclusions:

Based on the analysis conducted using planning level traffic, the memo presented the following conclusions:

- A WB Smart Lane is warranted between Loveland-Madeira and US 42 and is likely warranted from at least Wards Corner Road to US 42.
- An EB Smart Lane identical in implementation to the WB Smart Lane does not appear to be effective and may harm mainline operations more than the No Build condition due to capacity constraints introduced by an EB lane drop.
- Ramp metering EB entrance ramps within the Smart Lane helps mainline operation, at the cost of heavy queueing and spillback on the metered entrance ramps in the PM peak period.
- Generally, EB operations are most heavily impacted by the diverge area of the I-275/I-71 interchange area; consideration should be given to capacity improvements at this spot location.

Alternative Analysis Memo #2 – 10/19/2020 HAM-275 Smart Lane Certified Traffic Analysis Technical Memorandum

Summary:

Mott MacDonald explored the installation of peak period hard shoulder running permitted via dynamic message signage, commonly referred to as Smart Lane, in varying locations along the I-275 corridor between US 42 and SR 28 in Hamilton and Clermont County. The purpose of the proposed Smart Lane project is to address congestion and safety along this portion of the I-275 corridor. This analysis was conducted using Certified Traffic provided by ODOT District 8 on September 25, 2020 and supplements the analysis that was completed using planning level traffic, dated June 18, 2020.

The purpose of this analysis is to examine various alternatives for both the westbound and eastbound direction, including:

- No Build scenario
- Various Smart Lane scenarios
- Ramp Metering Only scenario
- Combination of Smart Lane and Ramp Metering

For all analyses, the Opening Year is 2022, and the Design Year is 2042. Smart Lane will operate in only one direction per peak period, with westbound operation in the AM peak, and eastbound operation in the PM peak period. Thus, all westbound results reported represent AM conditions, and all eastbound results reported represent PM conditions.

Recommendations:

In the Westbound Direction:

- Smart Lane Only alternative between Loveland-Madeira Road and US 42

In the Eastbound Direction:

- No Build alternative
- Targeted capacity improvements along EB I-275 approaching the I-71 interchange
- Reconsider Smart Lane alternatives when the HAM-275-35.00 structure over Little Miami River is next scheduled for widening/replacement

Alternative Analysis Memo #3 – 11/9/2020 - HAM-275 Smart Lane Certified Traffic Supplemental Analysis Memorandum

Summary:

This memo provided supplemental analysis to the HAM-275 Smart Lane Certified Traffic Analysis Technical Memorandum dated October 19, 2020. For this analysis, two additional alternatives were explored to determine what benefits could be realized. The following additional alternatives were explored for the eastbound 2022 and 2042 PM Peak Period:

- No Build + Ramp Metering at the Loveland-Madeira Entrance Ramp to EB I-275 only
- Eastbound Smart Lane from immediately east of the I-275/I-71 interchange to SR 28 in Clermont County

Recommendations:

In the eastbound direction, assuming no future work to the I-275 EB structure over the Little Miami River:

- No Build Alternative
- Targeted capacity improvements:
    - I-275 EB diverge to I-71

- EB merge from Montgomery Road to I-275 EB

In the eastbound direction, assuming widening of the I-275 EB structure over the Little Miami River:

- Smart Lane Alternative from US 42 to SR 28

Overall Summary

After careful review of the analysis results, ODOT is recommending the HAM-275 Smart Lane alternative for the westbound direction only, be advanced in two phases as shown in **Figure D-2**:

- Phase 1 – Loveland Madeira Road (Little Miami River Bridge- approximately mile marker 53) to just prior to Reed-Hartman interchange (approximately mile marker 48)
    - This will allow space for traffic to get organized after the influx of I-71 traffic headed westbound and prior to the westbound I-275 curve.
- Phase 2 – Loveland Madeira Road (Little Miami River Bridge) to SR 28 (Main Street) in Clermont County
    - This phase is dependent on the availability of funding to widen the river bridge as well as construct the necessary shoulder and traffic control infrastructure to operate Smart Lane.

Figure D-2. Recommended I-275 SmartLane Phases (Westbound Direction Only)

D1.1.5 Interagency Coordination and Possible Effects on Neighboring Communities

As part of the project, several meetings have been held with project partners and communities including:

- Emergency Responders Meeting – A meeting was held with the Ohio State Highway Patrol, local agency emergency responders, freeway service patrol contractors, and local towing companies to discuss details of the project and how crashes would be handled. One of the main outcomes of the meeting was making more robust video available to emergency responders beyond what is offered in the ODOT OHGO application.
- District 8 Ohio Traffic Incident Management (OTIM) Group – The SmartLane project has been discussed as part of the region's OTIM Group, which meets periodically to discuss best practices and debrief response to major incidents.

D1.1.6 Additional Project Information

PID	94256
Location	Cincinnati, OH; Sharonville, OH; Blue Ash, OH
ELLIS Project Description	Resurface and perform pavement repair on portions of HAM-275 between US 42 and the Clermont County line. Implement SmartLane by installing dynamic message boards and variable speed limit signs.

D1.2 Elements of Regional Architecture in Project

Most recently updated by the Ohio Kentucky Indiana (OKI) Regional Council of Governments in 2016, the OKI Regional ITS Architecture addresses the 3-state, 8-County region surrounding the City of Cincinnati and consists of Butler, Warren, Hamilton, and Clermont Counties in Ohio, Boone, Kenton, and Campbell Counties in Kentucky, and Dearborn County in Indiana, as shown in **Figure D-3**. The 2016 OKI Regional ITS Architecture Update was developed through a series of stakeholder meetings and by reviewing the 2008 OKI Regional ITS Plan document, which included a regional ITS architecture.

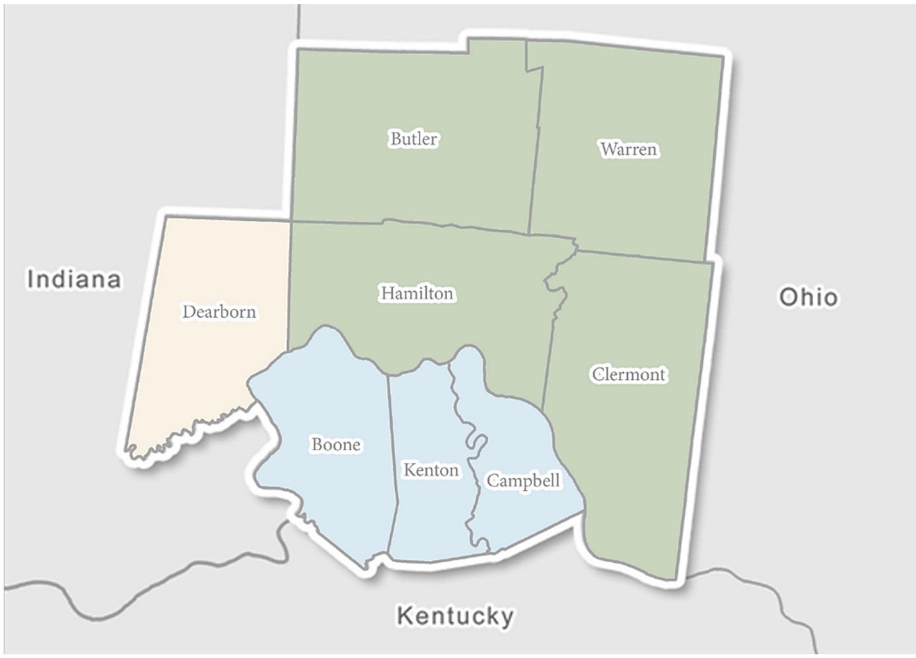

Figure D-3. OKI Geographic Boundaries

As part of the systems engineering process and federal regulations regarding federally funded ITS projects, the I-275 SmartLane project should align with the associated regional ITS architectures.

Table D-4 highlights the service packages for the proposed SmartLane pilot project. Since the OKI updated the Regional ITS Architecture in 2016 using a now outdated version, the next major update planned every ten years (2026) will need to include integration of the services proposed as part of the I-275 SmartLane Project.

Table D-4. OKI ITS Architecture Service Packages

REGIONAL ITS ARCHITECTURE NATIONAL ITS ARCHITECTURE VERSION 7.1		PROJECT ARCHITECTURE ARC-IT VERSION 9.0	
SERVICE PACKAGE NO.	SERVICE PACKAGE NAME	SERVICE PACKAGE NO.	SERVICE PACKAGE NAME
ATMS01	Network Surveillance	TM01	Infrastructure-Based Traffic Surveillance
ATMS06	Traffic Information Dissemination	TM06	Traffic Information Dissemination
ATMS08	Traffic Incident Management System	TM08	Traffic Incident Management System
	Not in version 7.1	TM12	Dynamic Roadway Warning
ATMS22	Variable Speed Limits	TM20	Variable Speed Limits
ATMS23	Dynamic Lane Mgmt. and Shoulder Use	TM22	Dynamic Lane Mgmt. and Shoulder Use
EM04	Roadway Service Patrol	PS08	Roadway Service Patrols
AD2	ITS Data Warehouse	DM01	ITS Data Warehouse

D1.3 Roles and Responsibilities

Table D-5 highlights the roles and responsibilities of various stakeholders participating in the I-275 SmartLane Project.

Table D-5. Participating Agency Roles and Responsibilities

AGENCY/STAKEHOLDER (TYPE)	ROLES AND RESPONSIBILITIES
ODOT District 8 (infrastructure owner)	General maintenance of the roadway (e.g., surface repair, static signing, snow, and ice management), public information, design, and construction oversight.
ODOT Office of Roadway Engineering (infrastructure owner)	Oversight of geometric and other roadway design features for SmartLane and other innovative ATDM projects.
ODOT Office of Traffic Management (infrastructure owner)	Through the Statewide TMC, provide primary command and control of network of DMS/VSL, and CCTV supporting lane control of SmartLane project. Coordinating adaptation of I-90 VSL control software for SmartLane project.
ODOT Office of Traffic Operations (infrastructure owner)	Assist with design scope, Traffic/ITS Engineering, and heavy involvement with construction coordination of ITS device installation and configuration. Maintenance of ITS Field Devices and supporting network communications.
ODOT Freeway Service Patrols (emergency responder)	Assist with the verification, clearance, and temporary traffic control for traffic incidents. Provide verification shoulder lane is clear prior to opening to traffic.
City of Cincinnati Public Service (municipal infrastructure owner)	Project located within municipality limits.
City of Sharonville Public Service (municipal infrastructure owner)	Project located within municipality limits.
City of Blue Ash Public Service (municipal infrastructure owner)	Project located within municipality limits.
Southwestern Ohio Regional Transit Authority (system user)	One SORTA bus route (route 71) use the I-275 freeway between I-71 and Montgomery Rd.
Ohio Kentucky Indiana Regional Council of Governments (regional planner)	Steward of Regional ITS Architecture.
Utilities within the project limits (stakeholder / utility provider)	Power will need to be installed to a variety of new ITS devices.
City of Cincinnati FD (emergency responder)	Provides Traffic Incident Management (TIM) services and routinely serves as Incident Commander during large scale crashes.
City of Cincinnati Police (emergency responder)	Speed enforcement and TIM services.
Ohio State Highway Patrol (emergency responder)	Speed enforcement and TIM services.
Hamilton County Sheriff (emergency responder)	Speed enforcement and TIM services.
City of Sharonville Division of Police (emergency responder)	Speed enforcement and TIM services.

AGENCY/STAKEHOLDER (TYPE)	ROLES AND RESPONSIBILITIES
City of Blue Ash Division of Police (emergency responder)	Speed enforcement and TIM services.
City of Sharonville FD (emergency responder)	Provides TIM services.
City of Blue Ash FD (emergency responder)	Provides TIM services.
Towing and Recovery Companies (emergency responder)	Provides TIM services.

The primary agency responsible for daily operations of the SmartLane project is the ODOT Statewide TMC. The TMC will be responsible for command and control of the systems proposed as part of the SmartLane pilot project including:

- Opening and closing of the SmartLane.
- Modification of the normal operating schedule of the SmartLane.
- Control of any messages posted on the Dynamic Message Signs.
- Control of CCTV cameras.
- Control of speeds displayed on Variable Speed Limit Signs.
- In coordination with emergency responders, serve as official designee to proclaim opening and closing of other travel lanes as traffic incidents, maintenance and/or construction activities and weather conditions change.

D1.4 Project Maintenance Plan

Refer to Section 1.10 System Maintenance above for cross-cutting considerations and approaches to system maintenance that apply to all project maintenance plans. This subsection is included here for supplemental information or issues unique to this project.

Based on estimates from previous similar work on I-670 SmartLane, the ITS infrastructure maintenance is anticipated to be approximately 5% of the ITS construction costs, or approximately $90,000 per year.

In Southwest Ohio, District 8 lets annual indefinite quantity/indefinite delivery contracts for electrical maintenance. Non-ITS components such as highway lighting will be addressed using this work-order style contract.

ODOT Hamilton County – Blue Ash Outpost is the closest garage to the I-275 SmartLane project area and will perform daytime roadway maintenance within the project area. ODOT's main Hamilton County garage (Carthage) has a night shift crew that will perform maintenance and perform a drive thru of the SmartLane each weeknight to remove any debris.

Sweeping will be performed on an as-needed basis to keep the SmartLane in the same condition as a regular travel lane. Drainage cleanout will be more frequent than standard but not expected to be a daily or weekly occurrence.

The monthly cost for mechanical sweeping is anticipated to be approximately $5,000.

D1.5 Alternative Systems and Procurement Options

D1.5.1 Alternative Systems Options

Several alternatives were considered as part of the previously completed ConOps report. The report discussed several typical lane control signing messages.

Also, numerous operational scenarios along with associated lane closure signing were also defined.

D1.5.2 Dynamic Sign Alternatives

In the initial development stages of the project, several alternatives for dynamic sign alternatives were considered. One constant beyond signing alternatives is the need to provide robust field communications with full camera coverage of the SmartLane facility with a combination of camera and detection types.

D1.5.2.1 Option 1: Similar Configuration as I-670 SmartLane.

Option 1 explored early was to use the same concept used for the I-670 SmartLane with large dynamic message signs spanning the left shoulder and the travel lanes spaced approximately every ½ mile. Since the I-670 SmartLane was ODOT's first ATDM project, the ultimate build was very comprehensive to maximize its impact. While being very versatile, the massive DMS also required costly sign gantry structures. For I-275, using a similar configuration as I-670 was deemed to be too costly.

D1.5.2.2 Option 2: Separate SmartLane and VSL Signs

Option 2 considered using a series cantilever structured to show when the status of whether SmartLane is open or closed and a series of ground-mounted variable speed limits. The option was not used because there is a need to provide supplemental information in the event of a crash or other traveler information.

D1.5.2.3 Option 3: Hybrid of Full Span and Cantilever SmartLane and VSL Signs

A combination of Options 1 and 2 includes installing several cantilever structures showing status of SmartLane along with several full span DMS that allow for a combination of SmartLane status and space for other traveler information. The option also leverages the structure vertical uprights to mount the VSL signs.

D1.5.2.4 Recommended Dynamic Signing Alternative

ODOT has selected Option 3 as the most effective alternative when it comes to cost and effectiveness. The latest conceptual drawing is shown in **FigureD-4. FigureD-5** and **FigureD-6** illustrate a conceptual mock-up of what the two types of installation will look like along the corridor.

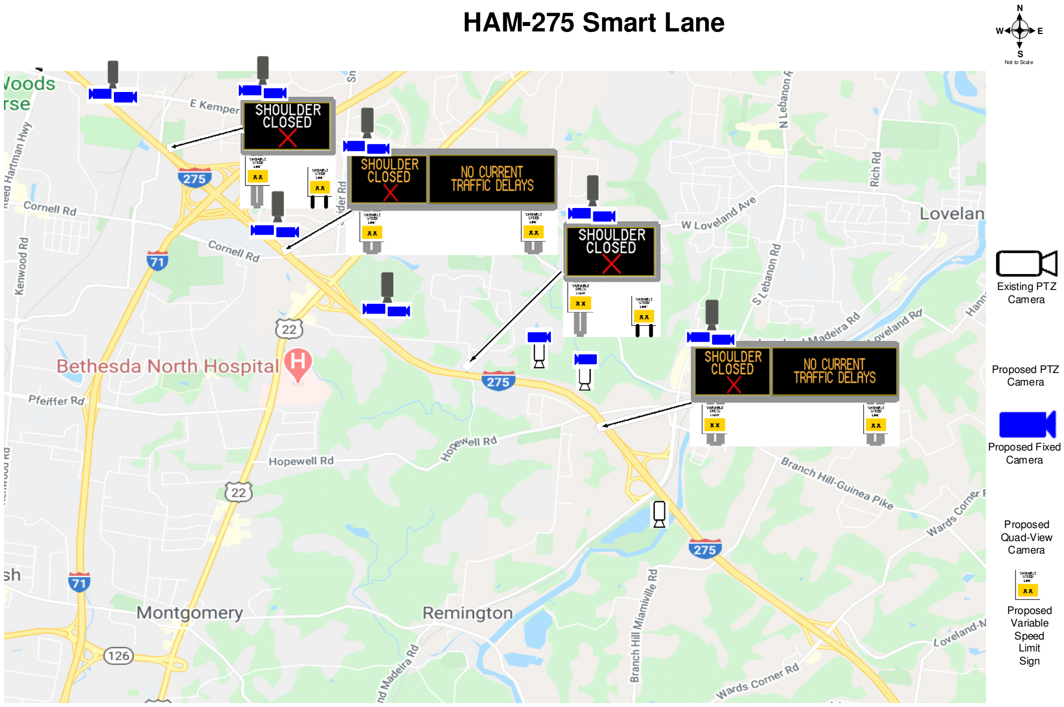

Figure D-4. Preferred I-275 SmartLane and VSL Location Map

Figure D-5. I-275 SmartLane Full Span Preferred Alternative

Figure D-6. I-275 SmartLane Cantilever Structure Preferred Alternative

D1.5.3 Operations and Maintenance Design Considerations

The I-275 SmartLane is being planned to be operated remotely from the Statewide TMC in Columbus. As the project concept has been developed, several considerations related to maintenance have been considered:

- Dynamic Message signs will be designed to be maintained from a catwalk with ground access from a shoulder to minimize the need for lane closures. In the event a lane closure is required to perform maintenance, it will be scheduled outside of peak periods.
- Variable speed limit signs should be able to be maintained from a ladder or truck without the need for lane closures.
- Other detection and camera technology will be located so it they can be maintained from the shoulder during non-peak periods.
- Pavement spread for the westbound, median shoulder for I-275 has been checked between Reed Hartman and I-71 using a 10 year storm and a 40 mph design speed. The 8' allowable spread into the SmartLane was not exceeded. Within the limits of median barrier, if the proposed design results in a shoulder width less than or equal to 4' wide, then surveyed pavement spread calculations are needed and additional inlets may be needed.
- A design exception for shoulder use is being reviewed as of May 2021. The I-275 design speed is 70mph, and the SmartLane will also be designed for 70 mph, subject to design exception. Note that shoulder width is established by functional classification (and design year ADT for non-interstate facilities). Per the ODOT Location and Design Manual (Volume 1), a 10-foot treated (i.e., paved) shoulder would be required, but the bare minimum shoulder width allowed is four feet, with a design exception. Acceptance of 55 mph for SmartLane is based on ODOT guidance to reduce posted speed to 55 mph if this was a construction zone with 11-foot lanes and 2-foot offsets. The I-275 SmartLane will be 12 feet with a four-foot shoulder, thus better than the work zone example.

D1.5.4 Proprietary Equipment Needs

The current scope for the pending design-build package specifies requirements for the VSL signs proposed for the project. However, ODOT's preference is to specify an Alternate Bid or possibly Proprietary bid for signs that will be identical to others used in the state to provide for maintenance consistency. The options for determining feasibility of available options are currently being explored.

D1.5.5 Procurement Options

This project will be procured through ODOT's Design-Build process. Originally PID #94256 per ELLIS was to be just "Resurface and perform pavement repair on portions of HAM-275 between US 42 and the Clermont County line" and was scheduled as a design-bid-build procurement process for FY2023.

The District submitted a TSMO funding application to widen the shoulders as part of the project in anticipation of installing a SmartLane as recommended in the statewide ATDM study.

Given the timing of the available funds for TSMO and the pavement preventative maintenance project it was recommended that the two be combined and procured through design-build in FY2022. This would allow for the combining of funds and the projects to achieve construction efficiencies while negating the need to impact the traveling public with multiple projects is a short time frame. Both projects could have been combined and procured design-bid-build but the development time for the SmartLane design would have caused a delay in construction and this would have negatively impacted the District's pavement maintenance schedule for this facility.

The Design-Build procurement achieves all funding, impact, cost, and schedule goals for the combined projects.

<Add Appendix D2 here once Stand alone Memo complete>

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Appendix E For Future Applications

Appendix F Project Architecture (Interface) Diagrams

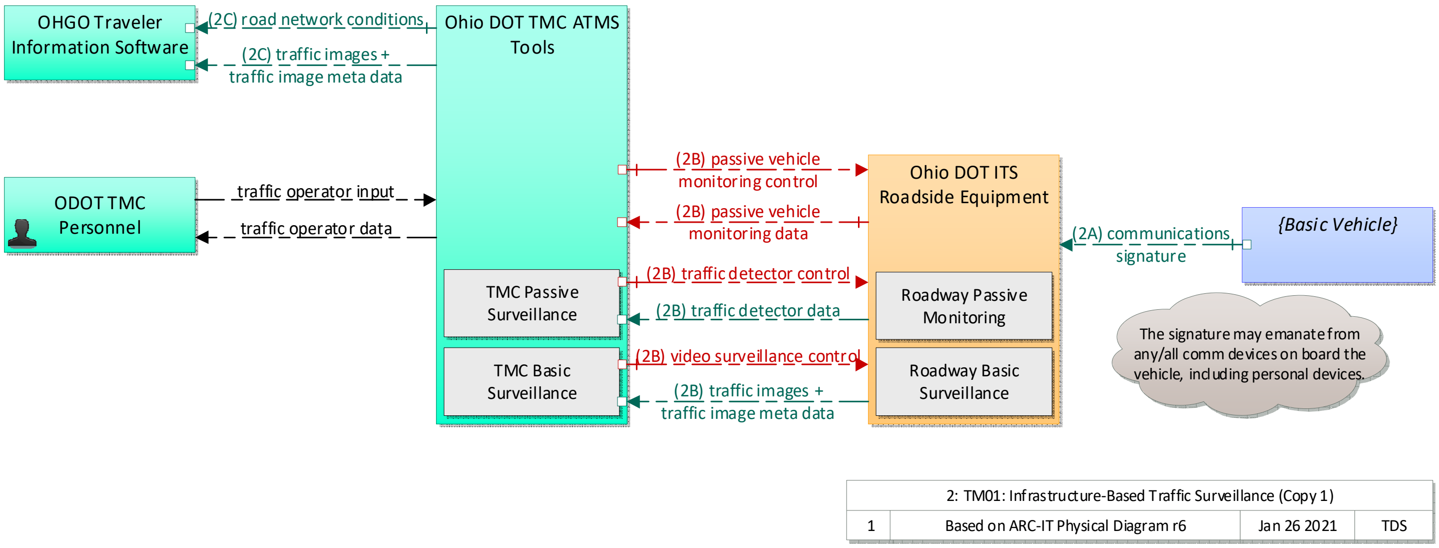

Figure F-1. Infrastructure-Based Traffic Surveillance (TM01)

ARC-IT Description: This service package includes traffic detectors, other surveillance equipment, the supporting field equipment, and Center to Field communications to transmit the collected data back to the Traffic Management Center. 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 system sends data back to the Traffic Management Center). 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 census data for traffic strategy development and long range planning. The collected data can also be analyzed and made available to users and the Traveler Information Center physical object.	
Applicable to: ☒ PTSU+LC+VSL ☒ VSL ☒ PTSU+VSL	**Ohio ATDM Context:** Infrastructure based traffic surveillance is the foundation upon which the ATDM applications are constructed including cameras, different types of detectors and the communications infrastructure that enables transmission of data and control from the field to the TMC.

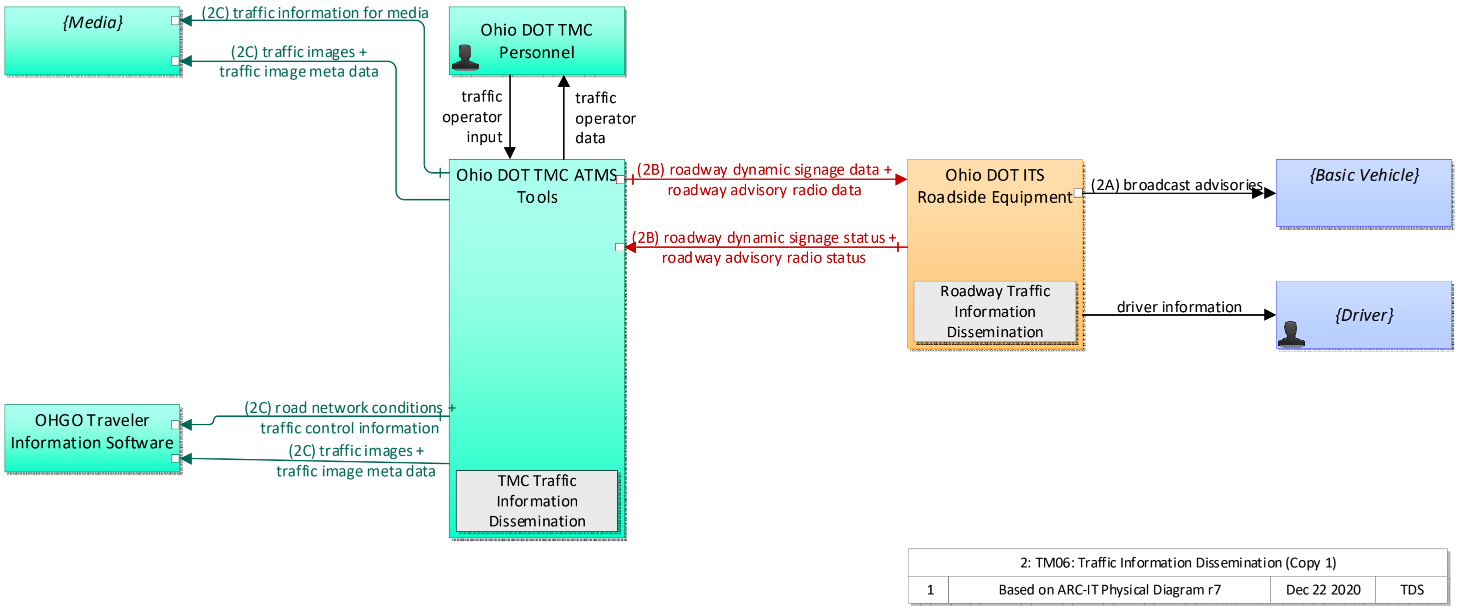

Figure F-2. Traffic Information Dissemination (TM06)

ARC-IT Description: This service package provides driver information using roadway equipment such as dynamic message signs or highway advisory radio. 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. This package also covers the equipment and interfaces that provide traffic information from a traffic management center to the media (for instance via a direct tie-in between a traffic management center and radio or television station computer systems), Transit Management, Emergency Management, and Transportation Information Centers.	
Applicable to: ☒ PTSU+LC+VSL ☒ VSL ☒ PTSU+VSL	**Ohio ATDM Context:** Traffic Information Dissemination includes the dynamic message signs that are critical in relaying conditions of the SmartLane and other traffic incident information to motorists.

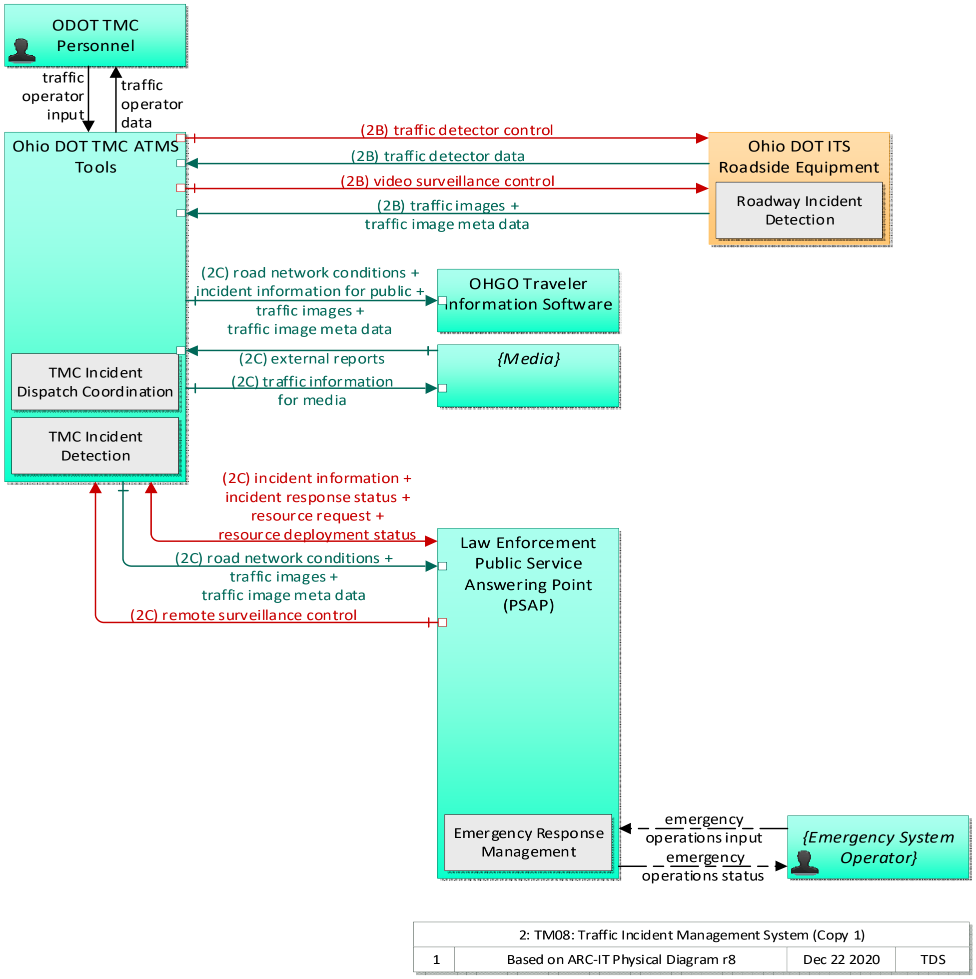

Figure F-3. Traffic Incident Management System (TM08)

<table>
<tr><td colspan="2">ARC-IT Description: 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) and through regional coordination with other traffic management, maintenance and construction management and emergency management centers as well as rail operations and event promoters. Information from these diverse sources is 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 centers. 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 CAD system or through other communication with emergency personnel. The coordination can also extend to tow trucks and other allied response agencies and field service personnel.</td></tr>
<tr><td>Applicable to:
☒ PTSU+LC+VSL
☒ VSL
☒ PTSU+VSL</td><td>Ohio ATDM Context: Traffic Incident includes the management of planned and unplanned traffic incidents in the vicinity of ATDM. It includes the detection, tracking and response to clear crashes or respond to planned congestion due to special events or construction. Communications between the TMC and Emergency Responders in the vicinity of ATDM is particularly important in the event requires the unplanned closure of a SmartLane.</td></tr>
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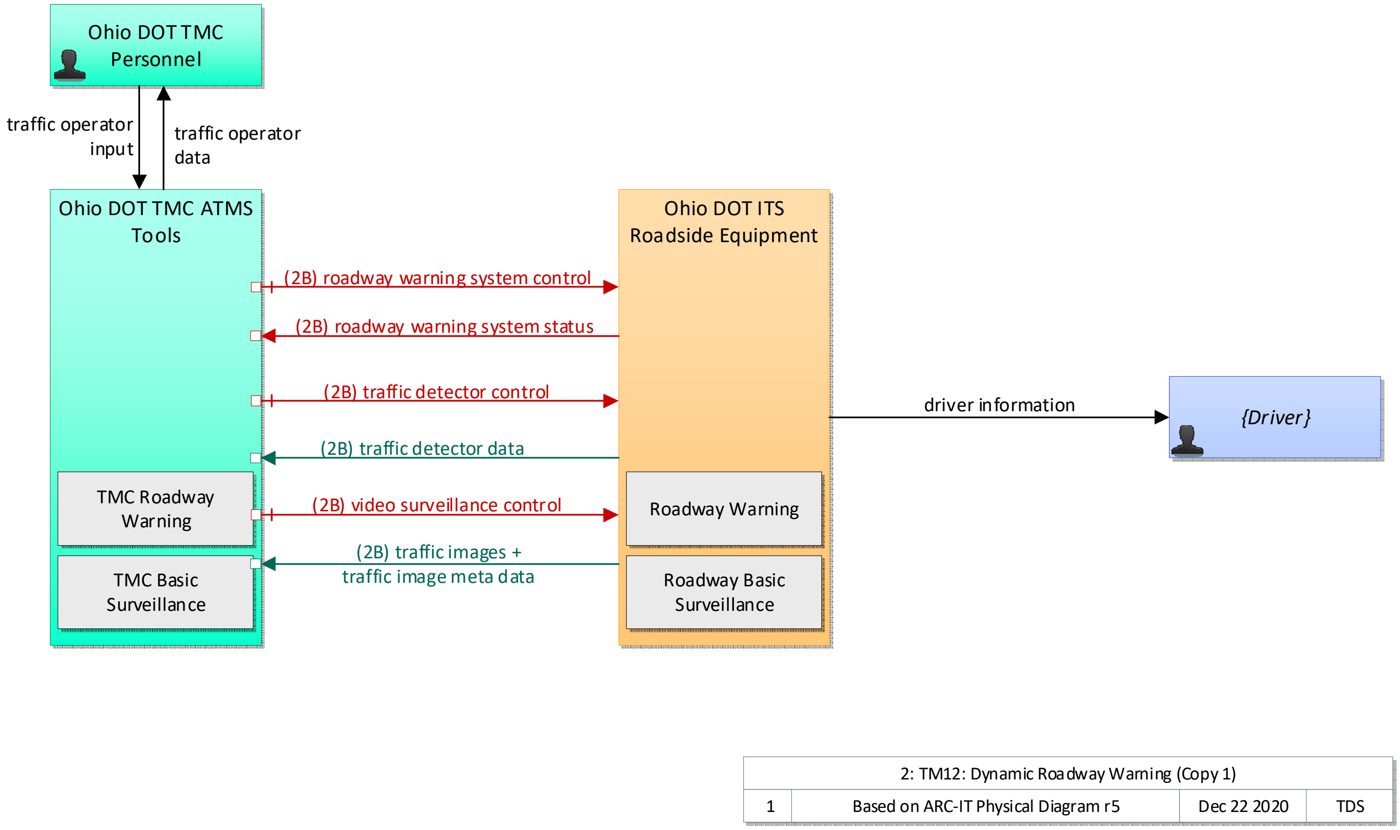

Figure F-4. Dynamic Roadway Warning (TM12)

ARC-IT Description: This service package includes systems that dynamically warn drivers approaching hazards on a roadway. Such hazards include roadway weather conditions, road surface conditions, traffic conditions including queues, obstacles or animals in the roadway and any other transient event that can be sensed. These dynamic roadway warning systems can alert approaching drivers via warning signs, flashing lights, in-vehicle messages, etc. Such systems can increase the safety of a roadway by reducing the occurrence of incidents. The system can be centrally monitored and controlled by a traffic management center or it can be autonomous.	
Applicable to: ☒ PTSU+LC+VSL ☐ VSL ☒ PTSU+VSL	**Ohio ATDM Context:** Dynamic Roadway Warning includes the ability of the TMC either in a manual or automated fashion to warn motorists that conditions warrant extra attention such as crash, rapidly changing weather conditions, (i.e., black ice, fog, etc.) or rapidly moving queue.

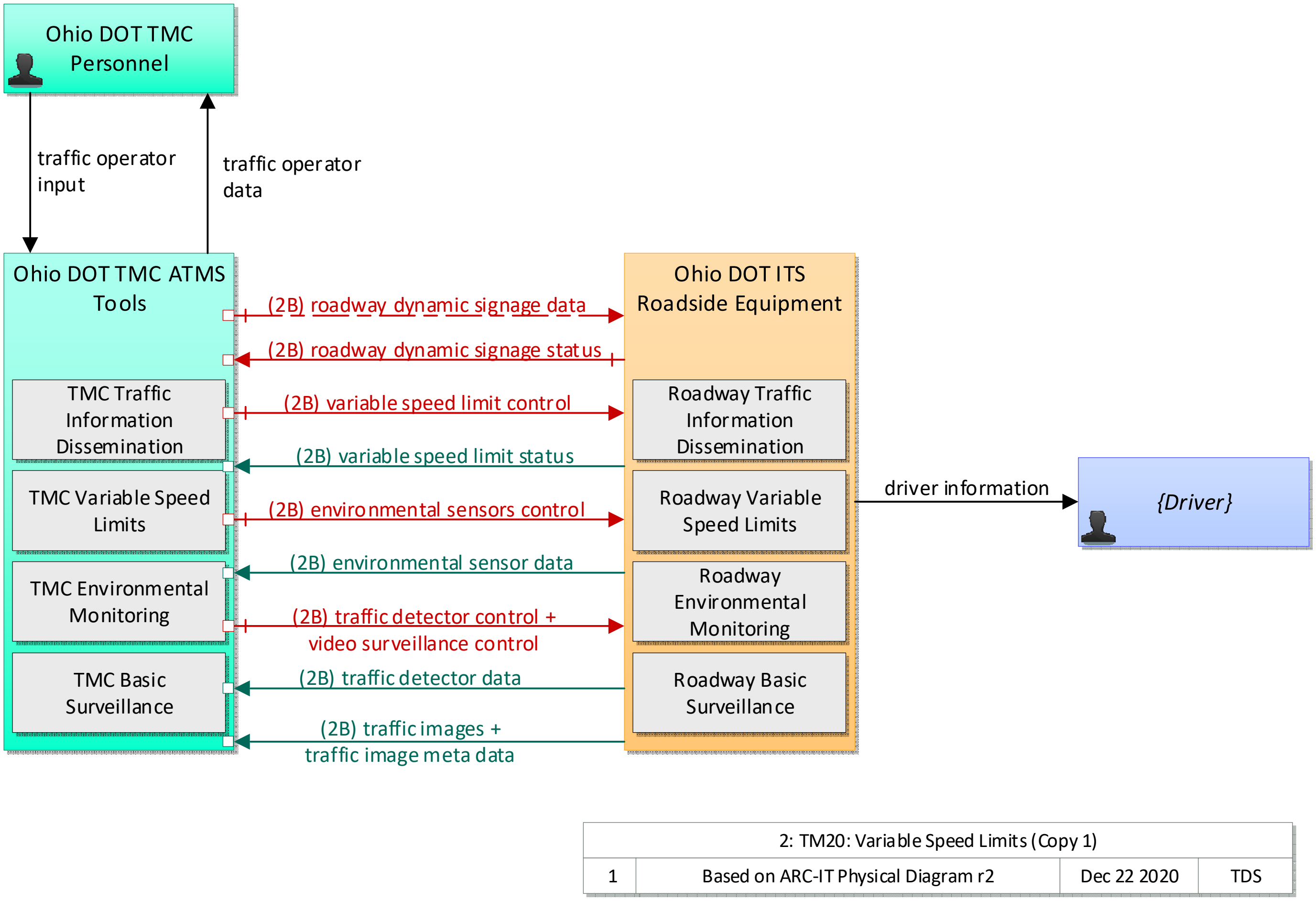

Figure F-5. Variable Speed Limits (TM20)

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ARC-IT Description: This service package sets variable speed limits along a roadway to create more uniform speeds, to promote safer driving during adverse conditions (such as fog), and/or to reduce air pollution. Also known as speed harmonization, this service monitors traffic, and environmental conditions along the roadway. Based on the measured data, the system calculates and sets suitable speed limits, usually by lane. Equipment over and along the roadway displays the speed limits and additional information such as basic safety rules and current traffic information. The system can be centrally monitored and controlled by a traffic management center or it can be autonomous.

This service establishes variable speed limits and communicates the speed limits to drivers. Speed warnings and enforcement of speeds limits, including variable speed limits, is covered in the TM17-Speed Warning and Enforcement service package.

Variable speed limits are an Active Traffic Management (ATM) strategy and are typically used in conjunction with other ATM strategies (such as TM22-Dynamic Lane Management and Shoulder Use and TM23-Dynamic Roadway Warning).

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Applicable to:
☒ PTSU+LC+VSL
☒ VSL
☒ PTSU+VSL

</td><td>

Ohio ATDM Context: In the case of the I-90 VSL, changing the speed on dynamic signs is the method associated with warning motorists of conditions related to changing weather conditions. In the SmartLane application, speeds are reduced as a tactic to manage traffic and safety by optimizing traffic flow.

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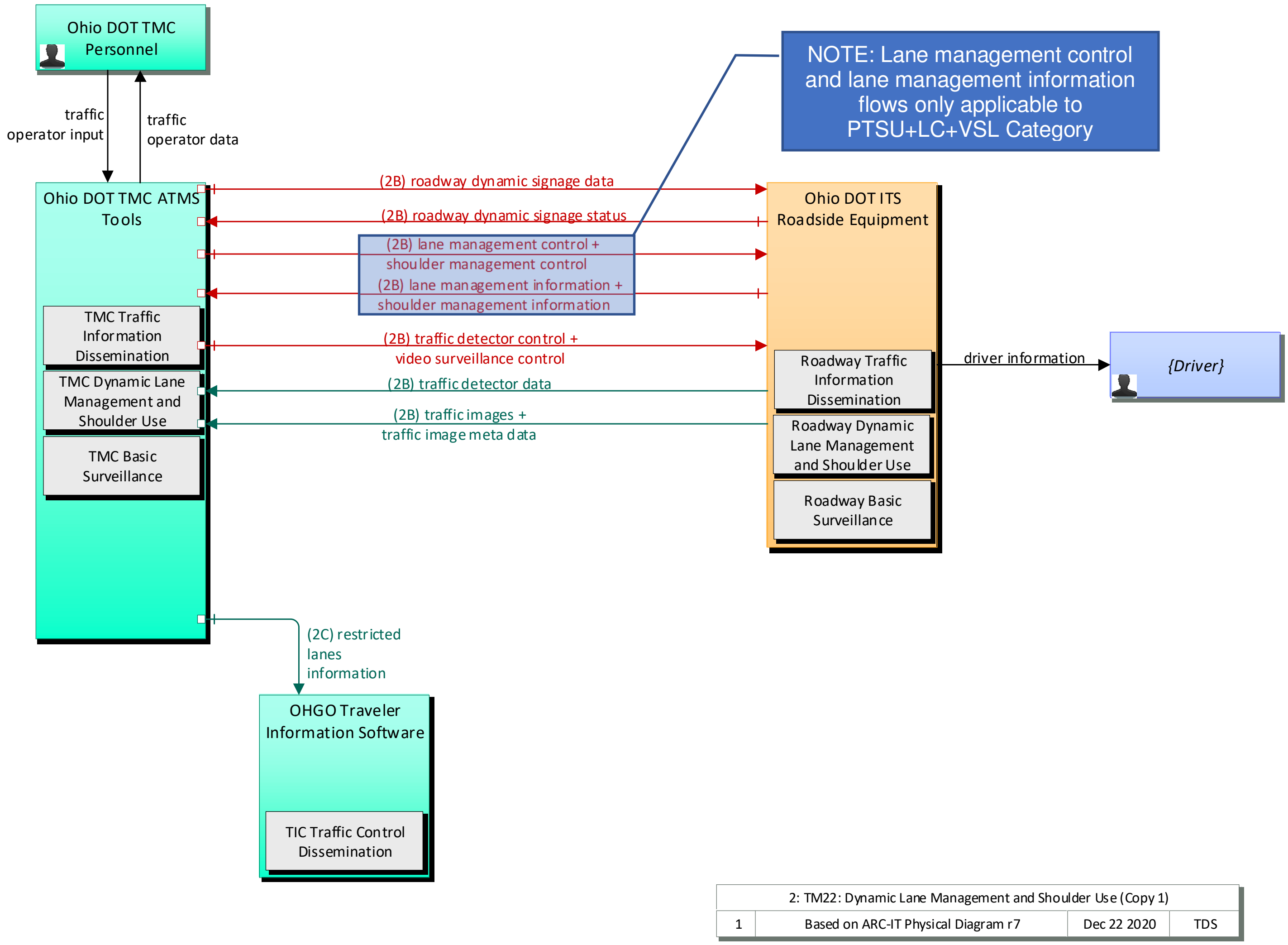

Figure F-6. Dynamic Lane Management and Shoulder Use (TM22)

ARC-IT Description: This service package provides for active management of travel lanes along a roadway. The package includes the field equipment, physical overhead lane signs and associated control electronics that are used to manage and control specific lanes and/or the shoulders. This equipment can be used to change the lane configuration on the roadway according to traffic demand and lane destination along a typical roadway section or on approach to or access from a border crossing, multimodal crossing, or intermodal freight depot. This package can be used to allow temporary or interim use of shoulders as travel lanes. The equipment can be used to electronically reconfigure intersections and interchanges and manage right-of-way dynamically including merges. Also, lanes can be designated for use by special vehicles only, such as buses, high occupancy vehicles (HOVs), vehicles attending a special event, etc. Prohibitions or restrictions of types of vehicles from using particular lanes can be implemented. The lane management system can be centrally monitored and controlled by a traffic management center or it can be autonomous. This service also can include automated enforcement equipment that notifies the enforcement agency of violators of the lane controls. Dynamic lane management and shoulder use is an Active Traffic Management (ATM) strategy and is typically used in conjunction with other ATM strategies (such as TM20-Variable Speed Limits and TM12-Dynamic Roadway Warning).	
Applicable to: ☒ PTSU+LC+VSL ☐ VSL ☒ PTSU+VSL	**Ohio ATDM Context:** The service package represents the main element of SmartLane. I-670 SmartLane uses both dynamic lane management and part-time shoulder use while I-275 SmartLane is anticipated to only use part-time shoulder use.

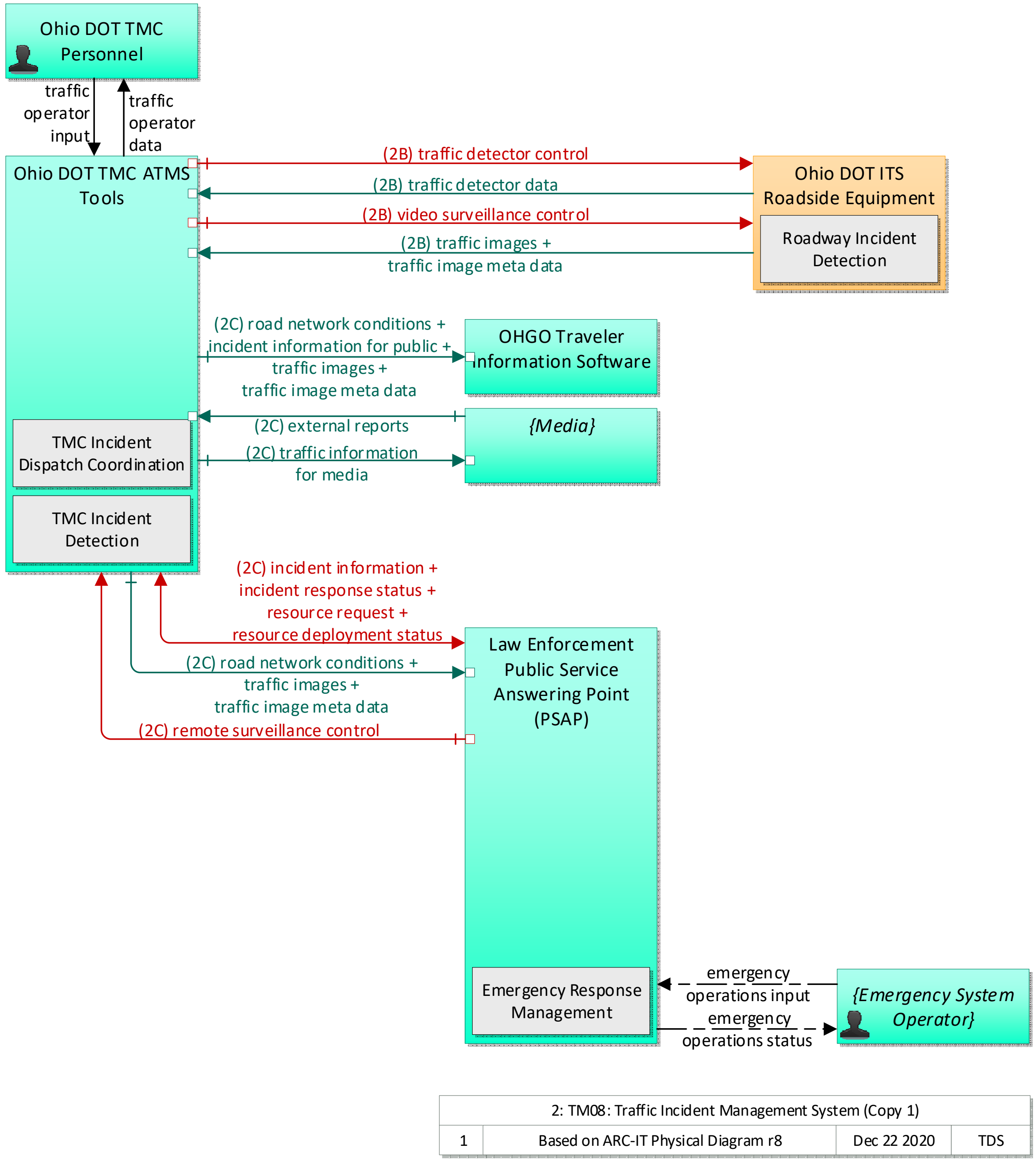

Figure F-7. Roadway Service Patrols (PS08)

ARC-IT Description: This service package supports roadway service patrol vehicles that monitor roads and aid motorists, offering rapid response to minor incidents (flat tire, accidents, out of gas) to minimize disruption to the traffic stream. If problems are detected, the roadway service patrol vehicles will provide assistance to the motorist (e.g., push a vehicle to the shoulder or median). The service package monitors service patrol vehicle locations and supports vehicle dispatch to identified incident locations. Incident information collected by the service patrol is shared with traffic, maintenance and construction, and traveler information systems.	
Applicable to: ☒ PTSU+LC+VSL ☐ VSL ☒ PTSU+VSL	**Ohio ATDM Context:** The ODOT Freeway Service Patrols play an integral role in the operations of SmartLane because they provide the critical function of ensuring the shoulder is clear of debris prior to opening. They also play a key role in rapidly clearing traffic incidents along the roadway and making motorists aware of the queue during larger, longer term incidents.

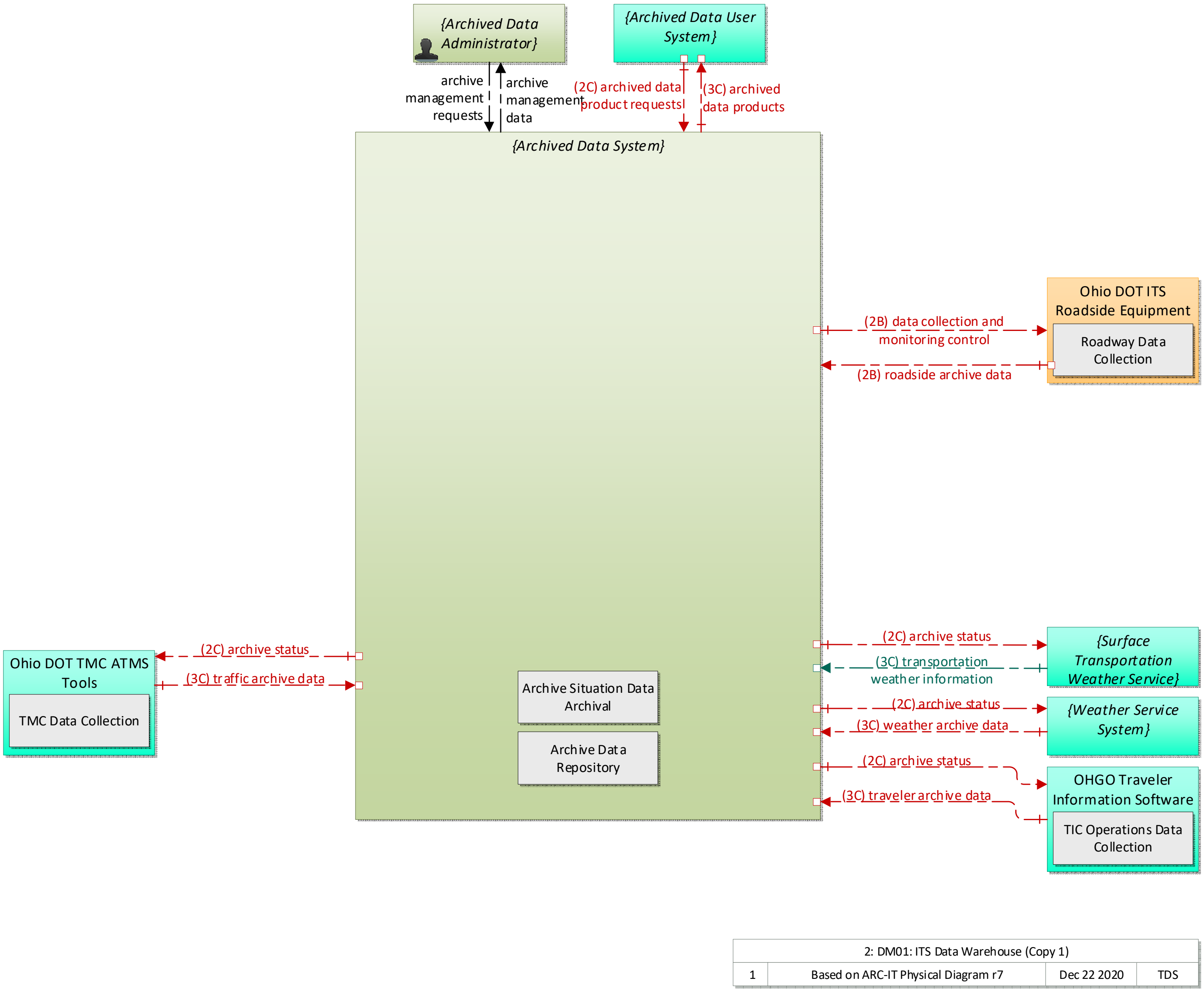

Figure F-8. ITS Data Warehouse (DM01)

ARC-IT Description: This service package provides access to transportation data to support transportation planning, condition and performance monitoring, safety analysis, and research. Configurations range from focused repositories that house data collected and owned by a single agency, district, private sector provider, or research institution to broad repositories that contain multimodal, multidimensional data from varied data sources covering a broader region. Both central repositories and physical distributed ITS data repositories are supported. Requests for data that are satisfied by access to a single repository in the ITS Data Warehouse service package may be parsed by the local repository and dynamically translated to requests to other repositories that relay the data necessary to satisfy the request. The repositories could include a data registry capability that allows registration of data identifiers or data definitions for interoperable use throughout a region.	
Applicable to: ☒ PTSU+LC+VSL ☒ VSL ☒ PTSU+VSL	**Ohio ATDM Context:** All of the data collected by the ITS field devices is archived for future performance measurement, ultimately offering insight that can lead to continuous improvement of ATDM throughout Ohio.

Appendix G Sample Requirements Testing Compliance Matrix

ATDM GENERALIZED TRACEABILITY MATRIX					
FUNCTIONAL REQUIREMENT[1]	**SOURCE DOCUMENT[2]**	**SOURCE DOCUMENT REFERENCE[3]**	**TEST[4]**	**PASS/FAIL[5]**	**CORRECTIVE ACTION [6]**
The center shall collect data from centers.	ARC-IT SPFO - Archived Data Repository	01	Validate that new ATDM data that comes into ATMS is collected in ITS Data Warehouse		
The center shall store collected data in an information repository.	ARC-IT SPFO - Archived Data Repository	03	Validate that new data that comes into ATMS is collected in ITS Data Warehouse		
The center shall perform quality checks on collected data.	ARC-IT SPFO - Archived Data Repository	04	Validate there are automated procedures in place to determine the quality of data (e.g., missing data, values outside statistical norms, etc.)		
The center shall respond to requests for archive data from archive data users (centers, field devices).	ARC-IT SPFO - Archived Data Repository	11	Validate that queries for specific data returns what is requested.		
The center shall provide a mechanism for archive data users to request archive data by meta-data range.	ARC-IT SPFO - Archived Data Repository	12	Validate that users can specify the range of data based on meta-data definitions.		
The center shall provide the capability to execute methods on the incoming field data such as aggregation and statistical measures before the data is stored in the archive.	ARC-IT SPFO - Archived Data Repository	06	Validate user defined aggregation and statistical measures are performed and the data is properly archived for future use.		
The center shall respond to requests from the administrator interface function to select and manage data stored in the archive.	ARC-IT SPFO - Archived Data Repository	07	Validate administrator can configure how data is stored in the archive.		
The center shall collect traffic management data such as operational data, event logs, etc.	ARC-IT SPFO - TMC Data Collection	01	Validate data is being collected by the ATMS for all new detectors, signs, and cameras		

[1] List of Functional Requirements from Section 1.3.
[2] Source Document can be plans, specifications, special provisions, etc. where the requirement is found.
[3] Source Document Reference is the section, item number, page, etc. from this source document.
[4] How will this requirement be tested?
[5] (To be completed after installation) Results of the test.
[6] (To be completed after installation) Corrective action taken.

ATDM GENERALIZED TRACEABILITY MATRIX					
FUNCTIONAL REQUIREMENT[1]	**SOURCE DOCUMENT[2]**	**SOURCE DOCUMENT REFERENCE[3]**	**TEST[4]**	**PASS/FAIL[5]**	**CORRECTIVE ACTION [6]**
The traffic management center shall assign quality control metrics and meta-data to be stored along with the data. Meta-data may include attributes that describe the source and quality of the data and the conditions surrounding the collection of the data.	ARC-IT SPFO - TMC Data Collection	02	Validate quality control rules are included in ATMS software and verify sample data properly provides anticipated quality measure range. Inspect and confirm meta-data includes documentation that comprehensively defines each field for future use.		
The traffic management center shall receive and respond to requests from ITS Archives for either a catalog of the traffic data or for the data itself.	ARC-IT SPFO - TMC Data Collection	03	Verify the ITS Data Warehouse can download Meta-data and user defined range of data from the ATMS.		
The traffic management center shall be able to produce sample products of the data available.	ARC-IT SPFO - TMC Data Collection	04	Verify the ATMS can generate a report on the range, completeness, and quality of the data available for download.		
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.	ARC-IT SPFO - Roadway Basic Surveillance	01	Perform field calibration to validate tuning of traffic sensors, validate communications system data transfer, and confirm data packet receipt by ATMS.		
The field element shall collect, process, and send traffic images to the center for further analysis and distribution.	ARC-IT SPFO - Roadway Basic Surveillance	02	Field verification that image can be seen locally, validate communications system image transfer, and conform TMC CCTV subsystem receives images at a rate that meets specifications.		
The field element shall return sensor and CCTV system operational status to the controlling center.	ARC-IT SPFO - Roadway Basic Surveillance	04	Demonstrate how the ATMS responds when equipment is properly functioning.		
The field element shall return sensor and CCTV system fault data to the controlling center for repair.	ARC-IT SPFO - Roadway Basic Surveillance	05	Demonstrate how the ATMS responds when equipment comes under different failure conditions (e.g., power, communications, etc.).		
The center shall monitor, analyze, and store traffic sensor data (speed, volume, occupancy) collected from field elements under remote control of the center.	ARC-IT SPFO - TMC Basic Surveillance	01	Perform tests on the ATMS to verify its ability to analyze and store traffic sensor data. Validate analysis functions work properly on sample data sets.		
The center shall monitor, analyze, and distribute traffic images from CCTV systems under remote control of the center.	ARC-IT SPFO - TMC Basic Surveillance	02	Validate CCTV subsystem can detect status, provide error reports, and distribute images to internally to TMC workstations, and externally with partner agencies.		

ATDM GENERALIZED TRACEABILITY MATRIX					
FUNCTIONAL REQUIREMENT[1]	**SOURCE DOCUMENT[2]**	**SOURCE DOCUMENT REFERENCE[3]**	**TEST[4]**	**PASS/FAIL[5]**	**CORRECTIVE ACTION [6]**
The center shall distribute road network conditions data (raw or processed) based on collected and analyzed traffic sensor and surveillance data to other centers.	ARC-IT SPFO - TMC Basic Surveillance	04	Validate road network condition information is properly aggregated and made available to OHGO traveler information system and XML feed shared with others is properly being published.		
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).	ARC-IT SPFO - TMC Basic Surveillance	06	Validate database exists and perform sampling of geolocated devices to verify location is correct.		
The center shall remotely control devices to detect traffic.	ARC-IT SPFO - TMC Basic Surveillance	07	For detection, validate configuration settings can be uploaded to update the field device local settings. For CCTV, validate pan-tilt-zoom capabilities meet latency specifications.		
The field element shall include dynamic message 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).	ARC-IT SPFO - Roadway Traffic Information Dissemination	01	Follow ODOT's Acceptance Testing for DMS.		
The field element shall provide operational status for the driver information systems equipment (DMS, HAR, etc.) to the center.	ARC-IT SPFO - Roadway Traffic Information Dissemination	03	Follow ODOT's Acceptance Testing for DMS.		
The field element shall provide fault data for the driver information systems equipment (DMS, HAR, etc.) to the center for repair.	ARC-IT SPFO - Roadway Traffic Information Dissemination	04	Follow ODOT's Acceptance Testing for DMS.		
The center shall remotely control dynamic messages signs for dissemination of traffic and other information to drivers.	ARC-IT SPFO - TMC Traffic Information Dissemination	01	During 30-day burn-in test, exercise DMS functionality daily. Ideally validate with field personnel or nearby CCTV.		
The center shall collect operational status for the driver information systems equipment (DMS, HAR, etc.).	ARC-IT SPFO - TMC Traffic Information Dissemination	03	Follow ODOT's Acceptance Testing for DMS.		

ATDM GENERALIZED TRACEABILITY MATRIX					
FUNCTIONAL REQUIREMENT[1]	**SOURCE DOCUMENT[2]**	**SOURCE DOCUMENT REFERENCE[3]**	**TEST[4]**	**PASS/FAIL[5]**	**CORRECTIVE ACTION [6]**
The center shall collect fault data for the driver information systems equipment (DMS, HAR, etc.) for repair.	ARC-IT SPFO - TMC Traffic Information Dissemination	04	Follow ODOT's Acceptance Testing for DMS.		
The center shall distribute traffic data to maintenance and construction centers, transit centers, emergency management centers, parking facilities, and traveler information providers.	ARC-IT SPFO - TMC Traffic Information Dissemination	06	Validate new data sources are integrated into ODOT Traveler Information XML feed.		
The center shall distribute traffic data to the media.	ARC-IT SPFO - TMC Traffic Information Dissemination	07	Validate new data sources are integrated into ODOT Traveler Information XML feed and new CCTV images are included in media feed.		
The center shall provide the capability for center personnel to control the nature of the data that is available to non-traffic operations centers and the media.	ARC-IT SPFO - TMC Traffic Information Dissemination	08	Validate procedure for turning off one, multiple, or all CCTV images to the media.		
The center shall collect current lane configurations status for the driver information systems equipment (DMS, HAR, etc.).	ARC-IT SPFO - TMC Traffic Information Dissemination	09	Validate ATMS can provide status of SmartLane (i.e., open/closed) to OHGO traveler information system.		
The center shall provide traffic information in both data stream and graphical display.	ARC-IT SPFO - TMC Traffic Information Dissemination	10	Validate ATMS provides traffic information in a data stream and graphical display.		
The field element shall collect, process, and send traffic images to the center for incident detection and further analysis.	ARC-IT SPFO - Roadway Incident Detection	01	Verify ATMS generates Incident alerts based on characteristics of detected traffic flow.		
The field element shall provide operational status and fault data for the incident detection devices to the traffic management center.	ARC-IT SPFO - Roadway Incident Detection	04	Testing same as for traffic detectors in TMC Basic Surveillance		
The center shall collect and store traffic flow and image data from the field equipment to detect and verify incidents.	ARC-IT SPFO - TMC Incident Detection	02	Testing same as for traffic detectors in TMC Basic Surveillance		

ATDM GENERALIZED TRACEABILITY MATRIX					
FUNCTIONAL REQUIREMENT[1]	**SOURCE DOCUMENT[2]**	**SOURCE DOCUMENT REFERENCE[3]**	**TEST[4]**	**PASS/FAIL[5]**	**CORRECTIVE ACTION [6]**
The center shall exchange incident and threat information with emergency management centers including notification of existence of incident and expected severity, location, time, and nature of incident.	ARC-IT SPFO - TMC Incident Detection	04	Validate SOPs are updated to include any new stakeholders involved with incident response in the vicinity of ATDM installation.		
The center shall support requests from emergency management centers to remotely control sensor and surveillance equipment located in the field.	ARC-IT SPFO - TMC Incident Detection	05	Validate SOPs are updated to include any new stakeholders involved with incident response in the vicinity of ATDM installation.		
The center shall provide road network conditions and traffic images to emergency management centers to support the detection, verification, and classification of incidents.	ARC-IT SPFO - TMC Incident Detection	06	Validate emergency management centers in the vicinity of ATDM installations have access to video viewing and other traveler information about the facility.		
The center shall provide video and traffic sensor control commands to the field equipment to detect and verify incidents.	ARC-IT SPFO - TMC Incident Detection	07	Testing same as for traffic detectors in TMC Basic Surveillance		
The center shall exchange incident information with emergency management centers including description, location, traffic impact, status, expected duration, and response information.	ARC-IT SPFO - TMC Incident Dispatch Coordination	04	Validate SOPs are updated to include any new stakeholders involved with incident response in the vicinity of ATDM installation.		
The center shall provide road network conditions and traffic images to emergency management centers and traveler information service providers.	ARC-IT SPFO - TMC Incident Dispatch Coordination	07	Validate emergency management centers in the vicinity of ATDM installations have access to video viewing and other traveler information about the facility.		
The center shall allocate the appropriate emergency services, resources, and vehicle (s) to respond to incidents, and shall provide the capability to override the current allocation to suit the special needs of a current incident.	ARC-IT SPFO - Emergency Response Management	06	Validate TMC's capability to shift freeway service patrol resources as required to assist with traffic incident management and SmartLane operations.		
The field element shall monitor for hazardous traffic conditions, including queues.	ARC-IT SPFO - Roadway Warning	01	Validate how traffic detectors monitor traffic queues and creates alerts when user defined thresholds are met.		
The field element shall monitor for hazardous road surface and local weather conditions.	ARC-IT SPFO - Roadway Warning	02	For VSL – demonstrate how deteriorating weather conditions are captured by RWIS and brought into the ATMS for decision making.		

ATDM GENERALIZED TRACEABILITY MATRIX					
FUNCTIONAL REQUIREMENT[1]	**SOURCE DOCUMENT[2]**	**SOURCE DOCUMENT REFERENCE[3]**	**TEST[4]**	**PASS/FAIL[5]**	**CORRECTIVE ACTION [6]**
The field element shall provide collected sensor data to the controlling center.	ARC-IT SPFO - Roadway Warning	04	Testing same as for traffic detectors in TMC Basic Surveillance. RWIS System Acceptance testing includes sensor calibration certificates, compass confirmation, and site tuning to meet performance specifications.		
The field element shall autonomously identify potentially hazardous conditions and activate warning signs to approaching motorists.	ARC-IT SPFO - Roadway Warning	05	Validate process for capturing local RWIS data and automatically reducing speeds on VSL.		
The field element shall receive commands from the controlling center that activate warning signs to approaching motorists.	ARC-IT SPFO - Roadway Warning	06	Follow ODOT's Acceptance Testing for DMS.		
The field element shall collect operational status of the warning system field equipment and report the operational status to the controlling center.	ARC-IT SPFO - Roadway Warning	07	Follow ODOT's Acceptance Testing for DMS.		
The field element shall monitor the warning devices and report faults to the controlling center.	ARC-IT SPFO - Roadway Warning	08	Follow ODOT's Acceptance Testing for DMS.		
The center shall monitor data on traffic, environmental conditions, and other hazards collected from sensors along the roadway.	ARC-IT SPFO - TMC Roadway Warning	01	Demonstrate how ATMS monitors hazards across data sources.		
The center shall identify hazardous road weather and surface conditions.	ARC-IT SPFO - TMC Roadway Warning	02	Demonstrate how ATMS defines hazardous weather and surface conditions and determines if an alert should be generated based on use defined thresholds.		
The center shall identify hazardous traffic conditions including queues.	ARC-IT SPFO - TMC Roadway Warning	03	Demonstrate how ATMS defines hazards for traffic queueing and determines if an alert should be generated based on use defined thresholds.		
The center shall issue control commands to field equipment warning drivers approaching the identified hazardous conditions.	ARC-IT SPFO - TMC Roadway Warning	05	Follow ODOT's Acceptance Testing for DMS.		
The field element shall collect operational status of the warning system field equipment and report the operational status to the controlling center.	ARC-IT SPFO - TMC Roadway Warning	07	Follow ODOT's Acceptance Testing for DMS.		

ATDM GENERALIZED TRACEABILITY MATRIX					
FUNCTIONAL REQUIREMENT[1]	**SOURCE DOCUMENT[2]**	**SOURCE DOCUMENT REFERENCE[3]**	**TEST[4]**	**PASS/FAIL[5]**	**CORRECTIVE ACTION [6]**
The field element shall monitor the warning devices and report faults to the controlling center.	ARC-IT SPFO - TMC Roadway Warning	08	Follow ODOT's Acceptance Testing for DMS.		
The field element shall include surface and sub-surface environmental sensors that measure road surface temperature, moisture, icing, salinity, and other measures.	ARC-IT SPFO - Roadway Environmental Monitoring	01	RWIS System Acceptance testing includes sensor calibration certificates, compass confirmation, and site tuning to meet performance specifications.		
The field element shall include environmental sensors that measure weather conditions including temperature, wind, humidity, precipitation, and visibility.	ARC-IT SPFO - Roadway Environmental Monitoring	02	RWIS System Acceptance testing includes sensor calibration certificates, compass confirmation, and site tuning to meet performance specifications.		
The field element's environmental sensors shall be remotely controlled by a traffic management center.	ARC-IT SPFO - Roadway Environmental Monitoring	04	Validate communications between ATMS and RWIS devices that meet project specifications.		
The field element shall provide environmental sensor equipment operational status to the controlling center or maintenance vehicle.	ARC-IT SPFO - Roadway Environmental Monitoring	07	Validate RWIS can send RWIS operational status to the ATMS.		
The field element shall provide environmental sensor equipment fault indication to the controlling center or maintenance vehicle.	ARC-IT SPFO - Roadway Environmental Monitoring	08	Validate RWIS can send RWIS fault status to the ATMS.		
The field element shall provide weather and road surface condition data to centers.	ARC-IT SPFO - Roadway Environmental Monitoring	10	Validate all of the surface and weather condition information is being captured by ATMS (and passed onto ITS Datawarehouse).		
The field element shall monitor traffic and environmental conditions along the roadway.	ARC-IT SPFO - Roadway Variable Speed Limits	01	For VSL primarily operated from weather data, confirm installation of VSL signs, RWIS, and other detection. For VSL primarily operated from traffic data, confirm installation of VSL signs and detection.		
The field element shall receive commands from the controlling center that establish road speed limits.	ARC-IT SPFO - Roadway Variable Speed Limits	03	Follow ODOT's Acceptance Testing for DMS.		

ATDM GENERALIZED TRACEABILITY MATRIX					
FUNCTIONAL REQUIREMENT[1]	SOURCE DOCUMENT[2]	SOURCE DOCUMENT REFERENCE[3]	TEST[4]	PASS/FAIL[5]	CORRECTIVE ACTION [6]
The field element shall display the current speed limits to drivers.	ARC-IT SPFO - Roadway Variable Speed Limits	04	Follow ODOT's Acceptance Testing for DMS.		
The field element shall monitor and report faults to the controlling center.	ARC-IT SPFO - Roadway Variable Speed Limits	07	Follow ODOT's Acceptance Testing for DMS.		
The traffic center shall remotely control environmental sensors that measure road surface conditions including temperature, moisture, icing, salinity, and other measures.	ARC-IT SPFO - TMC Environmental Monitoring	01	RWIS System Acceptance testing includes sensor calibration certificates, compass confirmation, and site tuning to meet performance specifications.		
The traffic center shall remotely control environmental sensors that measure weather conditions including temperature, wind, humidity, precipitation, and visibility.	ARC-IT SPFO - TMC Environmental Monitoring	02	RWIS System Acceptance testing includes sensor calibration certificates, compass confirmation, and site tuning to meet performance specifications.		
The center shall monitor data on traffic and environmental conditions collected from sensors along the roadway.	ARC-IT SPFO - TMC Variable Speed Limits	01	For VSL primarily operated from weather data, confirm ATMS can monitor VSL signs, RWIS, and other detection. For VSL primarily operated from traffic data, confirm ATMS can monitor VSL signs and detection.		
Based on the measured data, the center shall calculate and set suitable speed limits.	ARC-IT SPFO - TMC Variable Speed Limits	02	Validate process to generate recommended speed limits based on detectors, RWIS, and other inputs.		
The center shall control field equipment that posts the current speed limits and displays additional information such as basic safety rules and current traffic information to drivers.	ARC-IT SPFO - TMC Variable Speed Limits	03	Follow ODOT's Acceptance Testing for DMS.		
The center shall monitor the operational status of the variable speed limit equipment, including fault reports.	ARC-IT SPFO - TMC Variable Speed Limits	04	Follow ODOT's Acceptance Testing for DMS.		
The center shall provide center personnel current system status and respond to control data from center personnel regarding variable speed limits.	ARC-IT SPFO - TMC Variable Speed Limits	05	Validate process for changing the roadway speed limit.		
The center shall provide the current speed limits and additional information such as basic safety rules and current traffic information to drivers.	ARC-IT SPFO - TMC Variable Speed Limits	06	Follow ODOT's Acceptance Testing for DMS.		

ATDM GENERALIZED TRACEABILITY MATRIX					
FUNCTIONAL REQUIREMENT[1]	**SOURCE DOCUMENT[2]**	**SOURCE DOCUMENT REFERENCE[3]**	**TEST[4]**	**PASS/FAIL[5]**	**CORRECTIVE ACTION [6]**
The field element shall measure traffic conditions per lane, under center control.	ARC-IT SPFO - Roadway Dynamic Lane Management and Shoulder Use	01	For SmartLane, validate speed, occupancy volume measurement on a per lane basis.		
The field element shall receive lane management control information from the controlling center.	ARC-IT SPFO - Roadway Dynamic Lane Management and Shoulder Use	03	Validate routine for receiving messages at DMS and VSL under different SmartLane operational scenarios.		
The field element shall provide guidance and information to drivers regarding current lane configuration and status.	ARC-IT SPFO - Roadway Dynamic Lane Management and Shoulder Use	04	Validate messages sent to DMS and VSL are displayed correctly under different SmartLane operational scenarios.		
The field element shall monitor operational status of the dynamic lane control equipment and report operational status to the controlling center.	ARC-IT SPFO - Roadway Dynamic Lane Management and Shoulder Use	09	Follow ODOT's Acceptance Testing for DMS.		
The field element shall identify and report fault conditions to the controlling center.	ARC-IT SPFO - Roadway Dynamic Lane Management and Shoulder Use	10	Follow ODOT's Acceptance Testing for DMS.		
The center shall remotely monitor and control dynamically managed travel lanes.	ARC-IT SPFO - TMC Dynamic Lane Management and Shoulder Use	01	Validate full viewing coverage of SmartLane facility through fixed and PTZ cameras.		
The center shall monitor traffic conditions and demand measured per lane.	ARC-IT SPFO - TMC Dynamic Lane Management and Shoulder Use	02	For SmartLane, validate monitoring of speed, occupancy, and volume measurements on a per lane basis.		

ATDM GENERALIZED TRACEABILITY MATRIX					
FUNCTIONAL REQUIREMENT[1]	**SOURCE DOCUMENT[2]**	**SOURCE DOCUMENT REFERENCE[3]**	**TEST[4]**	**PASS/FAIL[5]**	**CORRECTIVE ACTION [6]**
Based on the collected data and operator input, the center shall determine suggested and required lane control configuration changes.	ARC-IT SPFO - TMC Dynamic Lane Management and Shoulder Use	07	Validate process the ATMS takes to suggest different lane control configurations.		
The center shall support temporary use of shoulders as travel lanes.	ARC-IT SPFO - TMC Dynamic Lane Management and Shoulder Use	08	Verify system has capabilities and business processes in place to safely open and close SmartLane based on congestion, crashes, and weather conditions.		
The center shall activate lane management field equipment that is used to dynamically manage specific lanes and shoulders.	ARC-IT SPFO - TMC Dynamic Lane Management and Shoulder Use	09	Follow ODOT's Acceptance Testing for DMS.		

Appendix H ITS Site Inspection Checklists

ODOT DMS
INSPECTION CHECKLIST

Project Number ______________________________ Date __________

Project Engineer ______________________________

Contractor ______________________________

Final Inspector ______________________________

Location ______________________________

DMS/Make/Model No: ________________________ Cabinet Type: ___________________________

Meets	Deficient	N/A	**GENERAL CHECKS:**
☐	☐	☐	1. Does the site need clearing and grubbing? *CMS 201.03*
☐	☐	☐	2. Is the DMS in good condition? *OTO Handbook 1500.1*
☐	☐	☐	3. Is duct seal installed on conduit entrances to the DMS enclosure?
☐	☐	☐	4. Does the DMS structure appear to be in good condition and unused holes plugged?
☐	☐	☐	5. Were pictures taken of the overall site, pole(s), cabinet(s) inside and outside, pull boxes, etc.? What are the picture numbers?
☐	☐	☐	6. Damage by vehicle /mower?
☐	☐	☐	7. Is there any slope washouts?
☐	☐	☐	11. Is there a work pad at base of DMS structure? *CMS 633.11*
☐	☐	☐	12. Are the warranty stickers on DMS?
☐	☐	☐	13. Is there varmint screening at the pole base of the DMS structure? *ITS-30.13*
☐	☐	☐	14. Are there fiber markers? (if applicable)

Comments:

Meets	Deficient	N/A	**CONTROLLER & CABINET:**
☐	☐	☐	1. Is the work pad in place and in good condition? *No major cracking (CMS 633.11)*
☐	☐	☐	2. Is all field wiring neatly arranged and routed to prevent being pinched when the cabinet door is closed and free of debris? *OTO Handbook 1800.3.9 & 1801.3.9*
☐	☐	☐	4. Are all wire terminals tight? *OTO Handbook 1800.3.9 & 1801.3.9*
☐	☐	☐	5. Is the conduit sealed with a removable sealing compound (duct seal)? *No foam sealer!* (*CMS 625.12)*
☐	☐	☐	6. Is the cabinet air filter in place and clean? Front and/or Back *OTO Handbook 1800.3.8 & 1801.3.8*
☐	☐	☐	7. Were air filters changed? *OTO Handbook 1800.3.8 & 1801.3.8*
☐	☐	☐	8. Are there operation manuals and cabinets print in the cabinet?
☐	☐	☐	9. Is there any damage or water infiltration? *OTO Handbook 1800.2 & 1801.2*

☐	☐	☐	10. Are locks easy to open? (need lubrication?) *OTO Handbook 1800.3.2 & 1801.3.2*
☐	☐	☐	11. Is there a workpad around 3 sides of the cabinet? *SS 809.09*
☐	☐	☐	12. Is grounding below 25 ohms?
☐	☐	☐	13. Is there de-ox on the incoming power wires?
☐	☐	☐	14. Are the washers and nuts tight on the anchor bolts?

Comments:

Meets	Deficient	N/A	POWER SERVICE:
☐	☐	☐	1. Is the power service and pole in good condition? *CMS 625.15*
☐	☐	☐	2. Are there 2 pad locks on the disconnect switch? *CMS 625.15.B*
☐	☐	☐	3. All service hardware shall have connections sealed as to have no water leaks? *CMS 632.24*
☐	☐	☐	4. Does the Power Service have Deox on the lugs/terminations?
☐	☐	☐	5. Is there any rust/corrosion in the disconnect switch?
☐	☐	☐	6. Is there duct seal in the bottom of the disconnect switch?
☐	☐	☐	7. Is the grounding below 25 ohms?
☐	☐	☐	8. Was the power service installed per plan?

Comments:

Meets	Deficient	N/A	PULL BOXES:
☐	☐	☐	1. Are there bolts in the pull box lid? *Shall be hex head bolts* (*CMS 725.06, 725.07, 725.08)*
☐	☐	☐	2. Are all the openings around conduits or knockouts sealed? *CMS 625.12*
☐	☐	☐	3. Are all tags/labels in place and legible? *ITS-14.11, ITS-14.20*
☐	☐	☐	4. Are drains installed in pull boxes? Is there water in the pull boxes? *CMS 625.12, ITS-14.10*
☐	☐	☐	5. Is there duct seal in conduit from 32" pull box to cabinet? (both in pull box and cabinet) *ITS-14.11*
☐	☐	☐	6. Is there duct seal in conduit from 18" pull box to cabinet (both in pull box and cabinet) *CMS 625.12*
☐	☐	☐	7. Is there a concrete pad around all 32" pull boxes? *ITS-14.11*
☐	☐	☐	8. Are pull boxes at grade? *CMS 625.11*
☐	☐	☐	9. Are cables stored neatly?
☐	☐	☐	10. Are conduits cut to be no more than 6 inches from the wall? *ITS-14.10*

Comments:

Meets	Deficient	N/A	OPERATIONAL CHECKS:
☐	☐	☐	1. Do all the pixels on the sign work? (From visible current message) *OTO Handbook 1500.1 & 1500.3*
☐	☐	☐	2. Daktronics Commissioning Report received?

Comments:

ODOT CCTV
INSPECTION CHECKLIST

Project Number ______________________ Date ______________________

Project Engineer ______________________

Contractor ______________________

Final Inspector ______________________

Location ______________________

Camera/Make/Model No. ______________________

Meets	Deficient	N/A	GENERAL CHECKS:
☐	☐	☐	1. Does the site need clearing and grubbing?
☐	☐	☐	2. Is the camera and pole in good condition? *SS 809.05 & 809.06A*
☐	☐	☐	3. Is the camera pole plumb?
☐	☐	☐	4. Is the camera's field of view free of obstruction? *SS 809.05*
☐	☐	☐	5. Were pictures taken of the overall site, pole(s), cabinet(s) inside and outside, pull boxes, etc.? What are the picture numbers?
☐	☐	☐	6. Damage by vehicle /mower?
☐	☐	☐	7. Is there any slope washouts?
☐	☐	☐	8. Is the quick-link present holding lowering cable inside the pole hand-hole? *ITS-12.10*
☐	☐	☐	9. Is the setscrew present in the pole hand-hole where the lowering unit winch connects? *SS 809.06B*
☐	☐	☐	10. Is the lowering unit cable tie-knot installed correctly? *SS 809.06*
☐	☐	☐	11. Does the camera lowering unit latch and unlatch fine? *OTO Handbook 1401.3A*
☐	☐	☐	12. Are the pole coupling holes plugged (with threaded PVC) if not used? *SS 809.06A*
☐	☐	☐	13. Does the pole hand-hole cover have hex-screws (6 generally) present and functional? *SS 809.06*
☐	☐	☐	14. Is the lowering unit positioned at least 90 degrees from the hand hole?
☐	☐	☐	15. Is there a work pad at base of pole? *OTO Handbook 1800.3.23*
☐	☐	☐	16. Are the warranty stickers on CCTV and field box? (if equipped)
☐	☐	☐	17. Are there fiber markers? (if applicable)

Comments:

Meets	Deficient	N/A	**OPERATIONAL CHECKS:**
☐	☐	☐	1. Is the camera lowering unit fully functional and in good condition? *OTO Handbook 1401.3*
☐	☐	☐	2. Does the camera function correctly (video/PTZ, etc.)? Check OHGO timestamp when leaving site *SS 809.05*
☐	☐	☐	3. Does local camera control box function correctly (video/PTZ, etc.)? (if equipped) SS *809.05*
☐	☐	☐	4. Does the camera Ethernet connection work? For camera pole with lowering devices and dual Ethernet blocks, do all 8 wires in Ethernet cable (CAT5E generally) test successfully? *OTO Handbook 1401.3.D*

Comments:

Meets	Deficient	N/A	**CONTROLLER & CABINET:**
☐	☐	☐	1. Is the work pad in place and in good condition? *No major cracking (CMS 633.11)*
☐	☐	☐	2. Is all field wiring neatly arranged and routed to prevent being pinched when the cabinet door is closed and free of debris? *OTO Handbook 1800.3.9 & 1801.3.9*
☐	☐	☐	3. Are all wire terminals tight? *OTO Handbook 1800.3.9 & 1801.3.9*
☐	☐	☐	4. Is the conduit sealed with a removable sealing compound (duct seal)? *No foam sealer! (CMS 625.12)*
☐	☐	☐	5. Is the cabinet air filter in place and clean? Front and/or Back *OTO Handbook 1800.3.8 & 1801.3.8*
☐	☐	☐	6. Were air filters changed? *OTO Handbook 1800.3.8 & 1801.3.8*
☐	☐	☐	7. Are there operation manuals and cabinet prints in the cabinet?
☐	☐	☐	8. Is there any damage or water infiltration? *OTO Handbook 1800.2 & 1801.2*
☐	☐	☐	9. Are locks easy to open? (need lubrication?) *OTO Handbook 1800.3.2 & 1801.3.2*
☐	☐	☐	10. Is there a work pad around 3 sides of the cabinet? *SS 809.09*
☐	☐	☐	11. Is grounding below 25 ohms? *CMS 625.16*
☐	☐	☐	12. Is there de-ox on the incoming power wires?
☐	☐	☐	13. Are the washers and nuts tight on the anchor bolts?

Comments:

Meets	Deficient	N/A	POWER SERVICE:
☐	☐	☐	1. Is the power service and pole in good condition? *CMS 625.15*
☐	☐	☐	2. Are there 2 pad locks on the disconnect? *CMS 625.15.B*
☐	☐	☐	3. All service hardware shall have connections sealed as to have no water leaks? *CMS 632.24*
☐	☐	☐	4. Does the Power Service have Deox on the lugs/terminations?
☐	☐	☐	5. Is there any rust/corrosion in the disconnect switch?
☐	☐	☐	6. Is there any duct seal in the bottom of the disconnect switch?
☐	☐	☐	7. Is the grounding below 25 ohms? *CMS 625.16*
☐	☐	☐	8. Was the power service installed per plan?

Comments:

Meets	Deficient	N/A	PULL BOXES:
☐	☐	☐	1. Are there bolts in the pull box lid? *Shall be hex heads only (CMS 725.06, 725.07, 725.08)*
☐	☐	☐	2. Are all the openings around conduits or knockouts, sealed? *CMS 625.12*
☐	☐	☐	3. Are all tags/labels in place and legible? *ITS-14.11, ITS-14.20*
☐	☐	☐	4. Are drains installed in pull boxes? Is there water in the pull boxes? *CMS 625.12*
☐	☐	☐	5. Is there duct seal in conduit from 32” pull box to cabinet? (both in pull box and cabinet) *ITS-14.11*
☐	☐	☐	6. Is there duct seal in conduit from 18” pull box to cabinet (both in pull box and cabinet) *CMS 625.12*
☐	☐	☐	7. Is there a concrete pad around all 32” pull boxes? *ITS-14.11*
☐	☐	☐	8. Are pull boxes at grade? *CMS 625.11*
☐	☐	☐	9. Are conduits cut to be no more than 6 inches from the wall? *ITS-14.10*
☐	☐	☐	10. Are the cables stored neatly?

Comments: