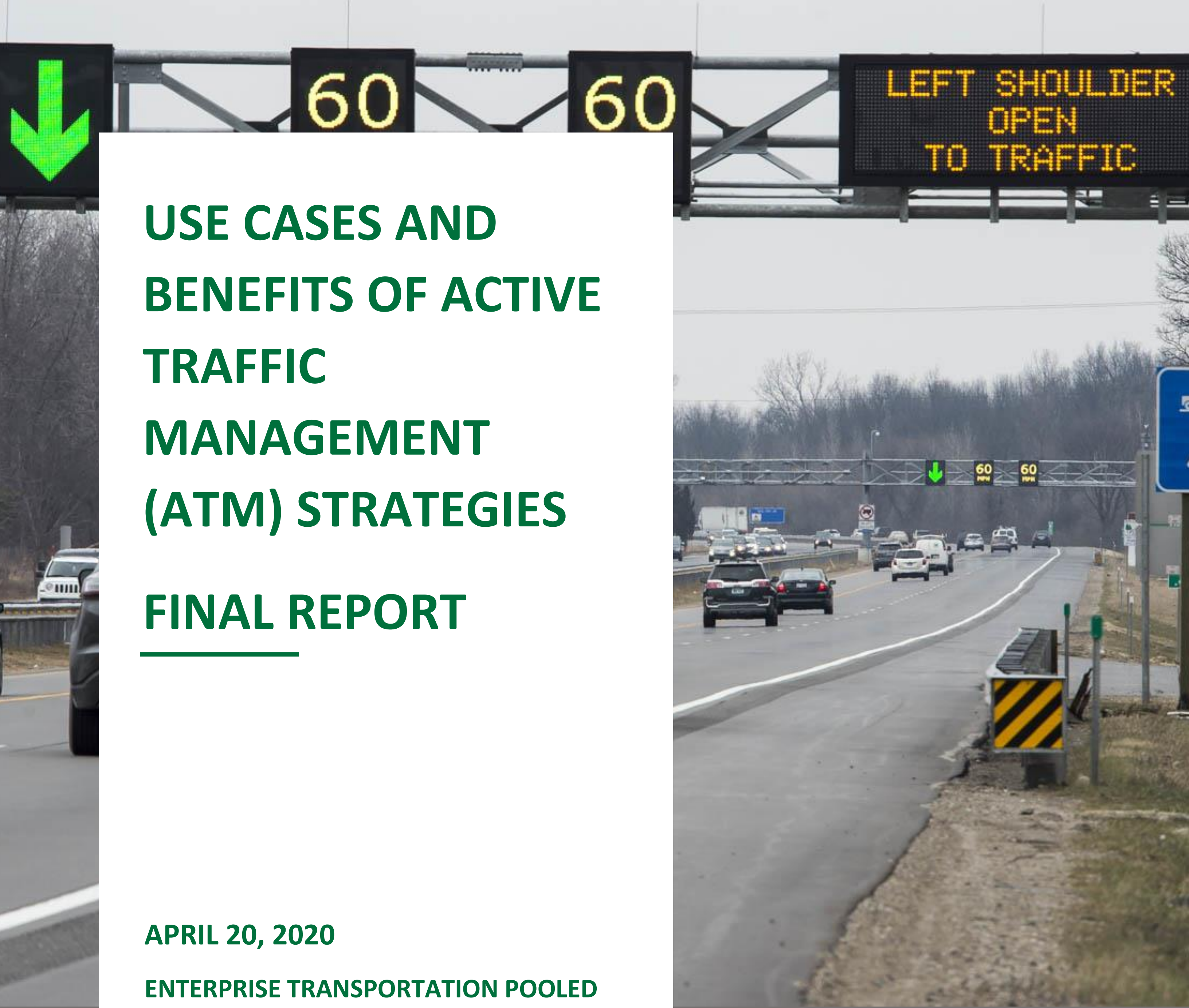


USE CASES AND BENEFITS OF ACTIVE TRAFFIC MANAGEMENT (ATM) STRATEGIES

FINAL REPORT

APRIL 20, 2020

ENTERPRISE TRANSPORTATION POOLED FUND STUDY TPF-5(359)

Prepared by:
Athey Creek Consultants

ENTER PRISE

Technical Report Documentation Page

1. Report No. ENT-2020-3	2. Government Accession No.	3. Recipients Catalog No.	
4. Title and Subtitle Use Cases and Benefits of Active Traffic Management (ATM) Strategies		5. Report Date April 20, 2020 6. Performing Organization Code	
7. Author(s) Jeremy Schroeder		8. Performing Organization Report No.	
9. Performing Organization Name and Address Athey Creek Consultants 2610 Lexington Terrace West Linn, OR 97068		10. Project/Task/Work Unit No. 11. Contract (C) or Grant (G) No. 2019-0045	
12. Sponsoring Organization Name and Address ENTERPRISE Pooled Fund Study TPF-5 (359) Michigan DOT (Administering State) PO Box 30050 Lansing, MI 48909		13. Type of Report and Period Covered FINAL Report 14. Sponsoring Agency Code	
15. Supplementary Notes Final Report available at: http://enterprise.prog.org/Projects/2020/ATM-Strategies.html			
16. Abstract Active Transportation Management (ATM) encompasses a suite of strategies that give agencies the ability to dynamically manage recurrent and non-recurrent congestion based on prevailing and predicted traffic conditions. ATM approaches focus on influencing travel behavior with respect to lane/facility choices and operations. ATM deployments are still relatively new in the United States with few deployments prior to 2010, however the number of deployments has increased in the past decade nationwide. ENTERPRISE conducted this project to identify resources and document lessons learned related to the development and deployment of ATM strategies, with an emphasis on deployments in urban areas that include multiple applications (e.g. Variable Speed Limits (VSLs), dynamic queue warning, part-time shoulder running).			
17. Key Words Active Traffic Management, ATM, ENTERPRISE		18. Distribution Statement No restrictions	
19. Security Class (this report) Unclassified	20. Security Class (this page) Unclassified	21. No. of Pages 31	22. Price

Acknowledgements

This Use Cases and Benefits of Active Traffic Management (ATM) Strategies report was prepared for the ENTERPRISE Transportation Pooled Fund TPF-5(359) program (http://enterprise.prog.org/). The primary purpose of ENTERPRISE is to use the pooled resources of its members from North America and the United States federal government to develop, evaluate, and deploy Intelligent Transportation Systems (ITS).

The cover page photo is provided courtesy of the Michigan Department of Transportation.

Project Champion

Jennifer Foley, Michigan Department of Transportation, was the ENTERPRISE Project Champion for this effort. The Project Champion serves as the overall lead for the project.

ENTERPRISE Members

The ENTERPRISE Board consists of a representative from each of the following member entities of the program:

- Illinois Department of Transportation
- Iowa Department of Transportation
- Kansas Department of Transportation
- Michigan Department of Transportation
- Minnesota Department of Transportation
- Ontario Ministry of Transportation
- Pennsylvania Department of Transportation
- Texas Department of Transportation
- Wisconsin Department of Transportation

Project Participants

ENTERPRISE would like to acknowledge and thank the following transportation agencies who provided input to this project through interviews:

- Central Florida Expressway
- Indiana Department of Transportation
- Nevada Department of Transportation
- Ohio Department of Transportation
- South Dakota Department of Transportation
- Wisconsin Department of Transportation

Table of Contents

1.0 Introduction

Active Traffic Management (ATM) encompasses a broad array of strategies that give agencies the ability to dynamically manage recurrent and non-recurrent congestion based on prevailing and predicted traffic conditions. ATM approaches focus on influencing travel behavior with respect to lane/facility choices and operations. Several examples are provided from California, Minnesota, and Washington State in Figure 1, Figure 2, and Figure 3 below. ATM deployments are still relatively new in the United States with few deployments prior to 2010, however the number of deployments has steadily increased nationwide. ATM strategies have been deployed in many scenarios, including:

- Urban and rural locations
- Temporary applications for a short-term deployment until a larger reconstruction project can be funded or as part of work zone intelligent transportation system (ITS)
- Permanent, long-term solutions
- Single or multiple locations

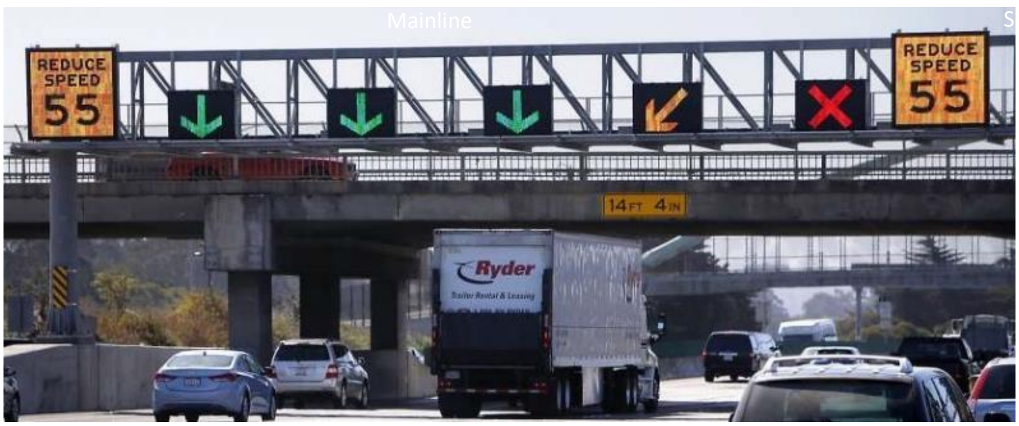


Figure 1: ATM Lane Use Control Signage on I-80 in the San Francisco Bay Area (Source: Caltrans)

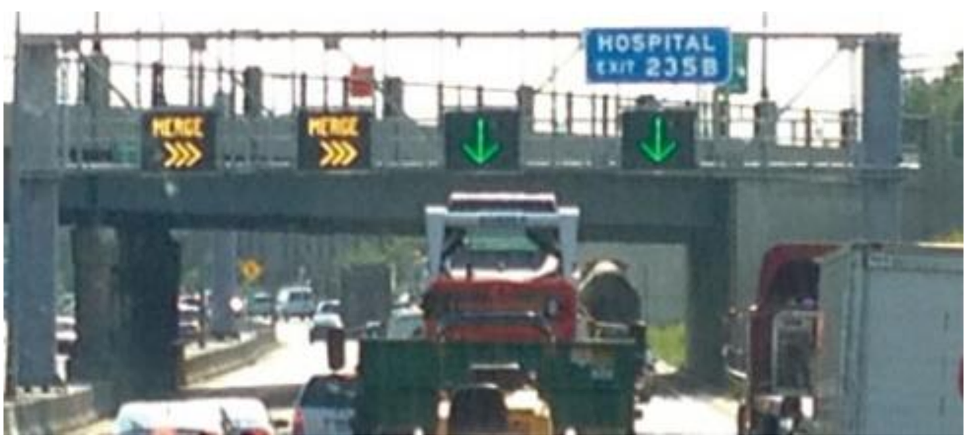


Figure 2: ATM Lane Use Control Signage on I-94 in Minneapolis (Source: FHWA)

Figure 3: ATM Lane Use Control Signage on Northbound I-5 in Seattle (Source: WSDOT)

ENTERPRISE conducted this project to identify resources and document lessons learned related to the development and deployment of ATM strategies, with an emphasis on deployments in urban areas that include multiple applications, e.g. Variable Speed Limits (VSL), queue warning, part-time shoulder running. As a first step for this project, an online literature search and Transportation Research International Documentation (TRID) database search was conducted to identify ATM resources (e.g. FHWA resources, agency-specific reports or evaluations). To enhance the literature search, several interviews were conducted in February and March 2020 with agency staff who have recently implemented or are currently planning ATM deployments that are not yet documented. A primary purpose of these interviews was to understand the current state of practice and document how newer ATM deployments may be implemented differently than deployments in other locations based on lessons learned from peer agencies.

This document includes the following sections:

- 2.0 Available Resources – Summarizes ATM resources found through an online and TRID database search, including FHWA resources, Department of Transportation (DOT) documentation, and other relevant literature.
- 3.0 Interview Findings – Presents a summary of responses from interviews conducted with transportation agencies that have recently deployed or are planning to deploy ATM deployments.

Additionally, Appendix A: ATM Related Documents notes resources not available online, but compiled on an ENTERPRISE member-only webpage. Appendix B: Interview Discussion Questions and Interview Summaries includes the complete set of discussion questions used to facilitate input from transportation agency staff during project interviews and a summary of each interview.

2.0 Available Resources

This section summarizes the literature search that was conducted to identify available ATM resources, with an emphasis on those published within the past three years. Efforts for this task focused on deployments in the United States, particularly larger-scale ATM deployments with multiple applications, such as VSLs, queue warning, part-time shoulder running, and lane control for managed lanes or incidents in urban areas.

Through agency contacts and an online search, including a scan of FHWA resources and a review of the TRID database, 28 resources were identified that are summarized in Table 1. Table 1 is organized by the type of resource:

- **Determining feasibility.** Three resources found can assist agencies with identifying the appropriate ATM strategy or strategies and assessing the feasibility of deployment.
- **Implementation.** Collectively, these resources can help assist agencies with implementation.
    - National resources include an implementation and operations guide, a capability maturity framework to advance active management practices in general, and a framework focusing on dynamic shoulder use.
    - State resources include design requirements and concept of operations.
- **State of the practice.** Collectively, these resources can assist agencies in understanding the design, implementation, operations, and maintenance of various ATM deployments.
    - Several national resources synthesize ATM deployments across the United States or internationally, such as VSLs or arterial ATM strategies.
    - Ten resources were identified that document or evaluate a specific ATM deployment.
- **Ongoing Projects and Research.** Finally, a research report on ATM displays and several ongoing efforts that have not yet been published are included, in the event they are of interest to a deploying agency.

Though many of the key resources are published and available online, there are a number of unpublished documents that were used to inform this project, primarily provided through direct contacts with agencies that have summarized their ATM planning and/or lessons learned, for internal use. This project gathered several of these unpublished resources which (with the agencies' approval) are available on the ENTERRISE member-only website. Appendix A provides a listing of the unpublished ATM related documents available on ENTERPRISE member-only website.

Table 1: Summary of Identified ATM Resources

Linked Resource, Publishing Entity, and Year Published	Summary
Determining Feasibility: National ATM Resources and Guidance Documents	
Active Management Capability Maturity Framework (CMF) Tool https://ops.fhwa.dot.gov/tsmoframeworktool/tool/adm/index.htm FHWA, 2020	• Self-evaluation tool intended to help agencies or regions assess role of demand management practices in a TSMO context. • Help develop implementation plan to move to higher capability levels. • Modeled similar to AASHTO Systems Operations and Maintenance Guidance to assess demand management capability in nine dimensions.
Active Management Screening Tool (AMST) https://active-traffic.tti.tamu.edu/tools Texas A&M Transportation Institute, 2014	• Helps agencies assess regional potential of active management strategies, providing structured guidance and information in all areas and levels of transportation planning. • Directly links the transportation planning process with operations by providing information on which operational strategies to include in the regional transportation plan that have potential to provide the most benefit to the regional transportation network. • Ascertains major attributes about candidate corridors to determine suitable and appropriate active management strategies, and which strategy and companion support facility and program needs best respond to corridor mobility, safety, and environmental needs.
Active Traffic Management Feasibility and Screening Guide https://ops.fhwa.dot.gov/publications/fhwahop14019 FHWA, 2015	Assists agencies and planning organizations with making informed ATM investment decisions by presenting a process to follow as they consider ATM deployment at the feasibility and screening analyses level to: 1. Determine feasibility of ATM strategies before committing significant resources toward project development and design activities, 2. Identify specific roadway segments most suited for appropriate ATM strategies, and 3. Understand expected costs and range of benefits.
Implementation: National ATM Resources and Guidance Documents	
Active Traffic Management Implementation and Operations Guide https://ops.fhwa.dot.gov/publications/fhwahop17056 Federal Highway Administration (FHWA), 2017	Provides agencies practical guidance on how to strategically and effectively implement and operate ATM strategies with stepwise approach of: 1. The system engineering process, 2. Comprehensive planning, and 3. Capabilities, organizational, and design considerations.

Linked Resource, Publishing Entity, and Year Published	Summary
Decision Support Framework and Parameters for Dynamic Part-Time Shoulder Use: Considerations for Opening Freeway Shoulders for Travel as a Traffic Management Strategy https://ops.fhwa.dot.gov/publications/fhwahop19029/fhwahop19029.pdf FHWA, 2019	• Provides agencies relevant information and best practices for operating dynamic part time shoulders on freeways. • Explains how to optimize part-time shoulder opening based on speed and volume conditions observed or modeled on the freeway, and methods for determining specific "decision parameters" for opening the shoulder are presented. • Assists in determining if this strategy is appropriate where no part-time shoulder use is in place, or where static part-time shoulder use is in place.
Use of Freeway Shoulders for Travel — Guide for Planning, Evaluating, and Designing Part-Time Shoulder Use as a Traffic Management Strategy https://ops.fhwa.dot.gov/publications/fhwahop15023/index.htm FHWA, 2016	• Provides guidance for planning, design, implementation, and day-to-day operation of shoulder use. • Includes sections for analyzing mobility, safety, and environmental impacts, as well as costs and benefits. • Describes a wide variety of design and operational concepts for shoulder use, and how a performance based practical design process guides the planning of facilities with shoulder use. • Includes case studies of deployments and signage used.
Implementation: State and Site-Specific ATM Resources and Design Documents	
Demonstrating Performance-Based Practical Design through Analysis of Active Traffic Management – New Jersey Case Study https://ops.fhwa.dot.gov/publications/fhwahop16087/fhwahop16087.pdf FHWA, 2016	• Illustrates performance-based practical design (PBPD) approach to analyze and make tradeoffs when examining freeway ATM strategies. • New Jersey case study of developing ATM recommendations, a Concept of Operations and an ATM Implementation Plan.
Nevada DOT Active Traffic Management System Concept of Operations (not available online; posted on ENTERPRISE member website) Nevada DOT, 2019	• Description of current system, ATM applications, concepts for the proposed system, and operational scenarios. • This document includes updates that were made to reflect modifications to ATM operations, including symbols and graphics that will be displayed.
Ohio DOT SmartLane Systems Engineering Analysis (not available online; posted on ENTERPRISE member website) Ohio DOT, 2017	• Developed for the I-670 ATM deployment, includes concept of operations, roles and responsibilities for participating agencies, ITS architecture, project needs, high-level requirements, alternative system configurations analysis, procurement options, testing procedures and standards, and procedures and resources for ATM system operation and management.

Linked Resource, Publishing Entity, and Year Published	Summary
Ohio DOT Statewide Active Traffic Management Study Concept of Operations (not available online; posted on ENTERPRISE member website) Ohio DOT, 2017	• Describes current statewide systems and enhancements that will be needed to support ATM. • Provides operational scenarios and concepts for ATM deployments on select corridors, e.g. hard shoulder running on I-275 and I-670. • Details needs, training, performance measures, and other anticipated changes.
Washington State DOT Intelligent Transportation Systems: Design Requirements https://www.wsdot.wa.gov/NR/rdonlyres/DB6840D0-7F67-49E3-88C6-7BE61A59AE2B/0/ITSdesignrequirements.pdf Washington State DOT, 2018	• Includes sections related to design and installation of small and large variable message signs, lane control signs, and side-mounted signs specifically used in ATM deployments.
State of the Practice: National ATM Resources and Guidance Documents	
Active Traffic Management for Arterials https://www.nap.edu/download/22537 National Cooperative Highway Research Program (NCHRP), 2013	• Documents practices associated with designing, implementing, and operating ATM on arterials. • Includes information on ATM strategies to actively manage traffic and congestion on arterials; situations and operating conditions in which ATM strategies have been successfully and unsuccessfully deployed on arterials; and system and technology requirements for implementation.
Active Traffic Management: The Next Step in Congestion Management https://international.fhwa.dot.gov/pubs/pl07012/atm_eu07.pdf FHWA, 2007	• Foundational scan report of ATM practices in Denmark, England, Germany, and the Netherlands. • Recommendations for U.S. ATM implementation to optimize existing infrastructure, emphasize customer orientation, focus on trip reliability, provide consistent messages to roadway users, and prioritize operations in planning, programming, and funding processes.
Best Practices and Outreach for Active Traffic Management https://texashistory.unt.edu/ark:/67531/metapth303663 University Transportation Center for Mobility, 2011	• Inventories ATM deployments overseas and in the U.S. • Includes information for developing an ATM website. • Summarizes best practices and general guidelines for ATM deployment.
Synthesis of Active Traffic Management Experiences in Europe and the United States http://www.ops.fhwa.dot.gov/publications/fhwahop10031/sec4.htm FHWA, 2010	• Describes ATM practices in both the U.S. and Europe. • Compiles lessons learned, experiences, operational results, and benefits. • Discusses potential benefits and challenges of techniques deployed for systemwide active management.
Synthesis of Variable Speed Limit Signs https://ops.fhwa.dot.gov/publications/fhwahop17003/fhwahop17003.pdf FHWA, 2017	• Synthesis with a comprehensive review of current practices on VSL operations, particularly U.S. deployment experiences. • Successful and best practices from the perspectives of planning and policy, design, deployment, and standards, operations and maintenance, and outcomes.

Linked Resource, Publishing Entity, and Year Published	Summary
State of the Practice and Evaluation: State and Site-Specific ATM Evaluations and Resources	
Evaluation of Adaptive Ramp Metering on I-80 in the San Francisco Bay Area https://ctedd.uta.edu/wp-content/uploads/2019/07/EvaluationOfAdaptiveRamp_CTEDD_2019.pdf USDOT University Transportation Center, The University of Texas at Arlington, 2018	• Before/after evaluation of Smart Corridor implementation on 19 miles of I-80 in the Bay area using travel time reliability measures, efficiency measures, and a user opinion survey. • Results show that the marginal improvements in freeway operations based on reliability and efficiency are underappreciated by the users.
Illinois Tollway I-90 Smart Corridor ATM Before & After Study Final Report (not available online; posted on ENTERPRISE member website) Illinois Tollway, 2018 (?)	• Evaluates the full-gantry ATM system on I-90 that included dynamic lane use control, dynamic shoulder lanes, and queue warning. • Measured mobility improvements and used video analysis to identify changes in driver behavior for inadvisable and compliant lane change maneuvers.
Michigan DOT US-23 Active Traffic Management State of the Practice Report (not available online; posted on ENTERPRISE member website) Michigan DOT, 2014	• Reports best practices and lessons learned from other ATM locations outside of Michigan. • Details case studies from ATM deployments in Seattle, Minneapolis, Northern Virginia, and England.
Michigan DOT US-23 ATM Success Management Summary (not available online; posted on ENTERPRISE member website) Michigan DOT, 2014	• Presents goals and targets for the US-23 ATM deployment, e.g. system reliability goal of 97.5% system availability during peak periods.
Minnesota DOT Smart Lanes: Active Traffic Management (not available online; posted on ENTERPRISE member website) Minnesota DOT, 2017	• Describes Minnesota ATM deployments on I-35W and I-94, including symbols, design, costs, operations, maintenance, and available studies and findings of the implemented ATM strategies.
Minnesota Urban Partnership Agreement: National Evaluation Report http://www.dot.state.mn.us/rtmc/reports/hov/20130419MnUPA_Evaluation_Final_Rpt.pdf USDOT, 2013	• Provides description and analysis of ATM system deployed on the I-35W corridor south of downtown Minneapolis, as well as related pricing and congestion reduction strategies.
Nevada DOT Active Traffic Management Fact Sheet http://ndotprojectneon.com/wp-content/uploads/2016/04/ATM.pdf Nevada DOT, 2016	• Fact sheet that provides a general overview of active traffic management for travelers.

Linked Resource, Publishing Entity, and Year Published	Summary
Ohio DOT Evaluation of Maintenance Procedures for Hard Shoulder Running, Phase 1 https://cdm16007.contentdm.oclc.org/digital/collection/p267401ccp2/id/17668 Ohio DOT, 2019	• Identifies and recommends safe, efficient, and cost-effective procedures and equipment for Ohio DOT which keep the hard shoulder clear of debris for use by traffic.
Ohio DOT Final Report for Determining Candidate Active Traffic and Demand Management Strategies Executive Summary (not available online; posted on ENTERPRISE member website) Ohio DOT, 2016	• A feasibility study that examines and recommends appropriate ATM strategies for deployment on various freeway corridors in Ohio based on anticipated delay and travel time reliability improvements.
Ohio DOT I-670 Smart Lane project website and FAQ http://www.dot.state.oh.us/districts/D06/projects/SmartLane/Pages/default.aspx, http://www.dot.state.oh.us/districts/D06/projects/SmartLane/Documents/Frequently%20Asked%20Questions.pdf Ohio DOT, 2020	• Project website about the I-670 Smart Lane and frequently asked questions (FAQ) about shoulder use and active traffic management for travelers.
Seattle/Lake Washington Corridor Urban Partnership Agreement: National Evaluation Report https://rosap.ntl.bts.gov/view/dot/3496 USDOT, 2014	• Provides description and analysis of ATM systems deployed on the I-90, SR-520 corridors east of downtown Seattle, as well as related pricing and congestion reduction strategies.
US-23 Flex Route – First Active Traffic Management (ATM) System in Michigan https://static1.squarespace.com/static/59c3ed7b197aeabbd2a51a3b/t/5b2a506a575d1f5530722623/1529499755034/TS06_Paper15631.pdf Intelligent Transportation Society of America Annual Meeting, 2018	• Describes design, technology, software, construction, and operations of dynamic, flex shoulder lane on US 23 in Michigan. • Describes challenges encountered during planning, design, construction, and system management phases of the project. • Details active monitoring processes, as well as anticipated and preliminary benefits.
Virginia DOT Evaluation of the Impact of the I-66 Active Traffic Management System, Phase I and Phase II http://www.virginiadot.org/vtrc/main/online_reports/pdf/17-r5.pdf http://www.virginiadot.org/vtrc/main/online_reports/pdf/19-R7.pdf Virginia Transportation Research Council (VTRC), 2016, 2019	• The I-66 ATM Phase I evaluation covers the first five months of operation, while Phase II considers long-term impacts with two years of data. Both studies analyze operational and safety impacts. • Operational measures of effectiveness for both studies include ATM utilization rate, average travel time, and travel time reliability. For safety measures, the empirical Bayes method was used with safety performance functions developed for Virginia. • The hard shoulder running ATM component created most of the improvements on I-66, while other components showed limited effect.

Linked Resource, Publishing Entity, and Year Published	Summary
Wisconsin DOT Mitchell Interchange Traffic Operations Plan v2.0 (not available online; posted on ENTERPRISE member website) Wisconsin DOT, (no date)	• Standard operating procedures for lane control signage at the I-94 / I-43 / I-894 interchange in Milwaukee County. • Includes protocols for incident management and sign displays for various lane closure scenarios.
Ongoing Projects and Research: National ATM Resources and Guidance Documents	
Active Traffic Management: Comprehension, legibility, distance, and motorist behavior in response to selected variable speed limit and lane control signing https://www.fhwa.dot.gov/publications/research/safety/16037/index.cfm FHWA, 2016	• Describes series of experiments that developed and tested alternative signs focusing on lane control signs (LCS) and VSL signs and used the deployments in Minnesota and Washington as inputs to sign development. • Research results are discussed for lab and field studies that determined the comprehension of ATM signs and respective legibility distances.
Planning and Evaluating Active Traffic Management Strategies https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3632 NCHRP 03-114 [Ongoing] Lit review available: http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP03-114_LiteratureReview-Revised.pdf	• Guide for agencies to plan and evaluate ATM for recurrent and nonrecurrent conditions. • Helps identify: conditions of locations that would benefit from ATM; performance goals; ATM strategies to meet those goals; deterministic, simulation, and other analysis tools for evaluation, scenario planning, and analyzing system performance in real-time; performance data for real-time system monitoring and operations, agency dashboard, performance trend analysis, and performance-based planning; budget and staffing plan for installing, operating, and maintaining ATM; and institutional and other barriers associated with ATM deployment, maintenance, and operation.
Proposed Practices for the Application of Dynamic Lane Use Control https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3986 NCHRP 03-123 [Ongoing]	• Objective is to develop traffic control recommendations for the application of dynamic lane use control, including reversible lanes, hard shoulder running, dynamic junction control, and toll plaza applications.
Principles and Guidance for Presenting Drivers with Dynamic Information on Active Traffic Management https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3987 NCHRP 03-124, 2020	• Developed principles and guidance for presenting drivers with dynamic information that can be frequently updated based on real-time conditions to improve effectiveness of ATM strategies. • Addresses ATM information drivers want and need, how much information a driver can process given context and distractions, and media to deliver this information.

Additionally, because peer agencies are often a key resource for agencies that are planning a new ATM deployment, a list describing select planned and deployed ATM systems and points of contact are presented in Table 2. This list is inclusive of most major deployments in urban areas that feature multiple ATM strategies, e.g. lane control signs for every lane, queue warning, and dynamic shoulder use. Note that this table includes planned ATM deployments, which are italicized, and discontinued ATM deployments, which are underlined.

Table 2: Summary of Select Planned, Operational, and Discontinued ATM Deployments and Points of Contact

State & Route	Lane Control	Variable Speed	Dynamic Shoulder	Queue Warning	Other Strategy	System Details (*Note: Italicized text indicates planned or discontinued deployments.*)	Point of Contact as of March 2020
CA: I-80	x	x		x	x	System includes dynamic alternate routing on arterials; in San Francisco Bay Area.	-
CO: US 36, I-25 South	x	x		x		System includes advisory dynamic speeds and a High Occupancy Toll (HOT) lane is on each corridor; in Denver area.	-
FL: SR 417	*x*		*x*	*x*	*x*	*Planned deployment in Orlando area managed by Central Florida Expressway Authority.*	*Bryan Homayouni* *bryan.homayouni@cfxway.com*
IL: I-90	x	x	x	x		Includes a transit-only Flex Lane; located northwest of Chicago and managed by Illinois Tollway.	Elyse Morgan emorgan@getipass.com
MI: US 23	x	x	x	x		Includes dynamic flex lane on left shoulder and dynamic advisory speeds; in Ann Arbor.	Jennifer Foley foleyj3@michigan.gov
MN: I-35W, I-94	x	x	x	x	x	A short dynamic left shoulder segment on I-35W extended a HOT lane to a major interchange. Dynamic junction control was used on a large dynamic message sign on I-94. System removed in 2018.	Brian Kary brian.kary@state.mn.us
NV: I-15, I-515 / US 95 / US 93	x	x		x		Part of Project Neon, a major construction project centered on I-15 interchange with US 95/US 93/I-515 in Las Vegas, a series of extra-large dynamic message sign (DMS) span all lanes on those corridors to actively manage traffic.	Rod Schilling roschilling@dot.nv.gov

State & Route	Lane Control	Variable Speed	Dynamic Shoulder	Queue Warning	Other Strategy	System Details (*Note: Italicized text indicates planned or discontinued deployments.*)	Point of Contact as of March 2020
OH: I-670, *I-275*	x	x	x	x		System only in eastbound direction on I-670 in Columbus area; left shoulder. *Similar system planned for I-275 northeast of Cincinnati with DMS to support lane control signage only over left shoulder lane.*	John MacAdam john.macadam@dot.ohio.gov
OR: SR 217	x*	x		x*	x	Signs used only for advisory speeds; supplemental DMS provide travel time and incident information. *Software was pre-programmed with lane use control capabilities for future use, as necessary.	-
SD: I-29, I-90		*x*				*Planned deployments in rural Interstate corridors for improved road weather management during snow events.*	*Dave Huft dave.huft@state.sd.us*
VA: I-66	x	x	x	x	x	Hard shoulder running during peak periods in peak directions began in 1992 on right shoulder of 7-mile segment in Northern Virginia. Dynamic lane control, queue warning, and dynamic speed limits installed in 2015 for all lanes on a longer segment allowed dynamic shoulder lane operations for real-time conditions. Entire system removed in 2017 due to a highway widening reconstruction project.	Michael Fontaine michael.fontaine@virginia.gov
WA: I-90, I-5 North, SR 520	x	x		x	x	System also includes static signs with dynamic numbers that provide travel times for alternate routes; in Seattle area.	Vinh Dang dangv@wsdot.wa.gov
WI: US 12 / US 14 / US 18 / US 151			*x*			*Planned deployment in Madison area to support part-time shoulder operations on left shoulder.*	*Elizabeth Lloyd-Weis elizabeth.lloydweis@dot.wi.gov*
WY: I-80, I-25, others					x	Deployments in rural Interstate corridors and passes for road weather management during snow events to reduce speed differential and crashes.	Vince Garcia vince.garcia@wyo.gov

3.0 Interviews

To enhance the literature search described in Section 2.0 a series of interviews were conducted. The purpose of the interviews were to:

- Document how agencies deployed (or plan to deploy) ATM, particularly in ways that differed from peer agencies based on lessons learned from other deployments.
- Gather available documentation and resources. The collected documents and resources are provided in Table 1.

Interviewed Agencies

- Central Florida Expressway
- Indiana DOT
- Nevada DOT
- Ohio DOT
- South Dakota DOT
- Wisconsin DOT

Staff from six agencies were interviewed in February and March 2020 that were known to have plans to deploy ATM strategies: Central Florida Expressway (CFX), Indiana DOT, Nevada DOT, Ohio DOT, South Dakota DOT, and Wisconsin DOT. This section highlights key findings from these agency interviews. See Appendix B for complete interview details.

Five interviewed agencies are deploying urban ATM strategies for congestion reduction, while the South Dakota DOT ATM deployment is a rural deployment focused on increasing safety during adverse road weather conditions. These ATM deployments are summarized in Table 3.

Table 3: Summary of ATM Deployments for Interviewed Agencies

Agency	System Details
Central Florida Expressway	Planned ATM deployment near Orlando being constructed as part of highway reconstruction, in the near term for incident management and in the long term for enhanced mobility, to add dynamic shoulder use on median shoulder, lane control signage, queue warning, and possibly VSLs.
Indiana DOT	In very early planning stages to possibly deploy one or more ATM strategies on I-80/I-94 in northwest Indiana, and may cooperatively deploy and/or operate ATM with Illinois.
Nevada DOT	Part of a major construction project centered on the I-15 interchange with US 95/US 93/I-515 in Las Vegas, a series of extra-large DMS span all lanes on those corridors to actively manage traffic with lane control signage, VSLs, and queue warning became operational in March 2020.
Ohio DOT	ATM deployment only in eastbound direction on I-670 in Columbus that includes dynamic shoulder use on the median shoulder, lane control signage over each lane, VSLs, and queue warning, and became operational in October 2019. A similar system with less ITS infrastructure is planned for I-275 northeast of Cincinnati with DMS and lane control signs only over the median shoulder for dynamic operations.
South Dakota DOT	Planned ATM deployment of variable speed limits in two rural Interstate corridors for improved road weather management during snow events. Supporting legislation permits the use of VSLs starting in July 2020.
Wisconsin DOT	Planned ATM deployment in Madison to support part-time shoulder operations on median shoulder. Construction is scheduled to begin in 2021.

Key items in common for all six interviewed agencies are that:

- All have leveraged experiences and lessons learned from similar deployments, or plan to, for design, operations, and maintenance.
- All deployments generally have design and operations that are similar to other deployments around the country.
- All noted considerations for ATM design, operations, and maintenance are generally similar to current ITS practices, but with modifications or adjustments. For instance, operations and maintenance activities may require new agreements, training, or additional staff. Specific examples include:
  - Regarding design, CFX noted that ATM deployment considerations are similar to other ITS deployments given similar challenges with communications and power.
  - Regarding operations, Nevada DOT created a new agreement with the regional traffic management center (TMC) to include ATM operations with other ITS, which changed the hours of operation, but not staffing yet. As an exception, Ohio DOT has specialists dedicated to ATM operations, while a separate group of operators manage other ITS operations.
  - Regarding maintenance, Ohio DOT conducts ITS maintenance in-house and will continue to do so, but will give a higher priority to ATM devices.

Of the six agencies interviewed, two locations (Indiana DOT and South Dakota DOT) were in the early planning stages:

- Indiana DOT, possibly in partnership with Illinois DOT for deployment and operations, has not yet determined which ATM strategy or strategies, if any, will be deployed on the I-80/I-94 urban corridor in northwest Indiana.
- South Dakota DOT plans to deploy VSLs on two rural Interstate corridors, but has not yet made design, operations, or maintenance decisions.

The following bullets highlight key findings from the remaining four interviews with agencies (CFX, Nevada DOT, Ohio DOT, and Wisconsin DOT) that are further along in the planning and deploying of ATM strategies.

- Three locations (CFX, Nevada, and Ohio) are deploying a full gantry ATM system that allows for lane control displays.
- Three locations (CFX, Ohio, and Wisconsin) are deploying part-time shoulder use in the left (median) shoulder. CFX is doing this with ATM signage over each lane, the Wisconsin deployment will have ATM signage over the shoulder lane plus standard DMS, and Ohio is implementing both of these approaches, with ATM signage over each lane in Columbus and a lighter ITS approach in Cincinnati.
- Two locations (CFX and Ohio) identified limited sight distance as a design constraint for part-time shoulder use, e.g. limiting the ability for drivers to safely navigate a curve and see if a queue is immediately downstream. As a result, CFX is considering the use of VSLs. Ohio DOT worked to eliminate a restriction on a curve segment with limited sight distance that initially required the VSLs to display 45 mph for shoulder operations, instead of the preferred 55 mph display on VSLs that would increase flexibility for shoulder operations; this was achieved approximately 5 months after going live with shoulder operations. With this approach, Ohio DOT’s ATM specialist gives special attention to

monitoring the curve where sight distance is a concern and immediately lowers the VSL if any queue is observed in that vicinity.

- All four locations (CFX, Nevada, Ohio, and Wisconsin) are using approved symbols from the Manual of Uniform Traffic Control Devices (MUTCD): green arrow, yellow X, and red X, as well as speed limit and guide sign displays, where applicable. For example, Nevada DOT initially intended to use a downward diagonal yellow arrow to indicate a merge as some early ATM deployments have done, but this was not permitted to do so by the Federal Highway Administration (FHWA).

Nevada DOT provided a number of lessons learned from their very recent experience with planning, system integration, public outreach, and deployment. Specific examples include:

- Design-build technical provisions always include some give and take, so it is important to write the technical provisions well and understand the contractor's intent for design and implementation.
- Integration requires a number of subsystem tests and lane configuration changes before integration can be done to make sure things are working properly. Even though this is following a deployment plan and timeline, Nevada DOT did not emphasize from the field the importance and need to have everything in place as outlined in the technical provisions in order for the contractor to be successful with integration and testing in a timely manner.
- Public outreach has been a huge component, as Nevada DOT heard about the importance of public outreach from the Minnesota DOT and tried to apply that lesson.
- Keeping stakeholders in the loop, including law enforcement and Department of Motor Vehicles (DMV), is important to ensure relevant statutes are applicable for enforcing VSLs and HOVs. While weekly project meetings occasionally included some education and outreach, more targeted outreach with specific stakeholder groups every 3-6 months helped to ensure continued understanding given a number of personnel changes between early planning and going live for many stakeholder groups.

Additionally, Ohio DOT shared early benefits from the first several months of the I-670 ATM operations. The deployment has been a huge success by facilitating free flow speed, incurring minimal crashes, and providing more reliable travel times. Before construction started, travel time through the 4.5-mile corridor at rush hour was 7-35 minutes, resulting in really poor travel time reliability when travelers would leave at the same time of day. After ATM activation, travel time through the corridor is almost always 5-6 minutes.

Appendix A: ATM Related Documents

The resources listed in Table A-1 are not available online, but have been compiled and made available on the ENTERPRISE member-only website for reference.

Table A-1: Summary of Identified ATM Resources Available on ENTERPRISE Member-Only Website

Resource, Publishing Entity, and Year Published	Summary
Illinois Tollway I-90 Smart Corridor ATM Before & After Study Final Report Illinois Tollway, 2018 (?)	• Evaluates the full-gantry ATM system on I-90 that included dynamic lane use control, dynamic shoulder lanes, and queue warning. • Measured mobility improvements and used video analysis to identify driver behavior changes for inadvisable and compliant lane change maneuvers.
Michigan DOT US-23 Active Traffic Management State of the Practice Report Michigan DOT, 2014	• Reports best practices and lessons learned from other ATM locations. • Details case studies from ATM deployments in Seattle, Minneapolis, Northern Virginia, and England.
Michigan DOT US-23 ATM Success Management Summary Michigan DOT, 2014	• Presents goals and targets for the US-23 ATM deployment, e.g. system reliability goal of 97.5% system availability during peak periods.
Minnesota DOT Smart Lanes: Active Traffic Management Minnesota DOT, 2017	• Describes ATM deployments on I-35W and I-94 in Minneapolis-St. Paul area, including symbols, design, costs, operations, maintenance, and available studies and findings of the implemented ATM strategies.
Nevada DOT Active Traffic Management System Concept of Operations Nevada DOT, 2019	• Description of current system, ATM applications, concepts for the proposed system, and operational scenarios. • Updated version reflects modifications to ATM operations, including symbols and graphics that will be displayed.
Ohio DOT Final Report for Determining Candidate Active Traffic and Demand Management Strategies Executive Summary Ohio DOT, 2016	• A feasibility study that examines and recommends appropriate ATM strategies for deployment on various freeway corridors in Ohio based on anticipated delay and travel time reliability improvements.
Ohio DOT SmartLane Systems Engineering Analysis Ohio DOT, 2017	• Developed for the I-670 ATM deployment, includes concept of operations, agency roles and responsibilities, ITS architecture, project needs, high-level requirements, alternative system configurations analysis, procurement options, testing procedures and standards, and procedures and resources for ATM operations and management.

Resource, Publishing Entity, and Year Published	Summary
Ohio DOT Statewide Active Traffic Management Study Concept of Operations Ohio DOT, 2017	• Describes current statewide systems and changes to support ATM. • Provides operational scenarios and concepts for ATM deployments on select corridors, e.g. hard shoulder running on I-275 and I-670. • Details needs, training, performance measures, and other changes.
Wisconsin DOT Mitchell Interchange Traffic Operations Plan v2.0 Wisconsin DOT, (no date)	• Standard operating procedures for lane control signage at the I-94 / I-43 / I-894 interchange in Milwaukee County. • Includes protocols for incident management and sign displays for various lane closure scenarios.

Appendix B: Interview Discussion Questions and Interview Summaries

Discussion questions were developed and distributed to staff from the Central Florida Expressway, Indiana DOT, Nevada DOT, Ohio DOT, and Wisconsin DOT to use as a guide during interviews. These questions are presented below, followed by the interview summaries.

1. What are the types and locations of ATM strategies that are currently deployed and/or being considered for deployment in your jurisdiction? (e.g., dynamic lane use control, dynamic shoulder lanes, variable speed limits, queue warning, dynamic junction control, dynamic lane reversal, and/or dynamic merge control in permanent or temporary deployments)
2. Please describe considerations made for ATM installation (e.g., selected corridor and location, sign type, placement distance, placement frequency per gantry or location, applications and content, display format, software selection and installation). Are any new innovations or technologies being used?
3. Please describe considerations made for ATM maintenance (e.g., design considerations, expertise and staffing, special contracts).
4. Please describe challenges encountered and how they were overcome, lessons learned, and what you would do differently if you did the ATM deployment again.
5. Please describe how the decisions were made at your agency to do ATM-related activities with in-house staff versus contracting, i.e. design, operations, and maintenance activities.
6. What resources did your agency use or compile during ATM planning and design? (e.g., documents, guidance, peer deployments) Are you able to share any of these resources with us?

Central Florida Expressway *(Bryan Homayouni interviewed on February 4, 2020)*

Background. Central Florida Expressway (CFX) manages a network of tolled highways in the Orlando area. With increasing congestion on SR 417, CFX is planning an expansion from four to six total lanes along almost 20 miles of the corridor from SR 528 to I Drive, but realized that expansion may not solve long-term congestion issues during peak periods over the course of the 20 year design life of the roadway. However, expanding the highway to eight lanes would drastically increase costs, so part time shoulder use was examined as an alternative for providing increased capacity. Consequently, CFX has initiated 5 projects to widen SR 417 and 3 projects to widen SR 429 with provisions to allow for dynamic shoulder use in the median shoulder lane.

Design and Operations. CFX is installing gantries with lane control signs, 19-foot wide inside median shoulders and base with subgrades to prepare the corridor for future dynamic shoulder use to alleviate recurring congestion. This application will be initially used for incident management purposes only. Part-time shoulder use will be employed at a later date when traffic volumes reach to levels that merit the application. As such, the shoulder will still have rumble strips in the initial deployment because it is not expected to be used very often in the short term. However, the installed signs will help to acclimate travelers to shoulder use.

CFX is developing a Concept of Operations to support and coordinate shoulder use activities. For incident management operations, the lane control sign will display a red X at the crash location and the shoulder will be opened to relieve congestion. CFX uses sidefire radar detection for volumes and speed and toll transponder readings combined with software processing capabilities to support an extensive travel time system. This helps CFX understand trends and hotspots on the system, and will be used to determine when it is time to implement a dynamic or time of day part time shoulder.

The corridor has sight constraints that make it difficult for the inside shoulder to meet 70 mph speed criteria along the entire corridor, so design is being done in a manner to minimize speed differential and the potential use of variable speed limits is being investigated for the part-time shoulder use application. The ATM design borrows from similar ATM applications and recommendations from other states, e.g. ½-mile gantry spacing, lane control signs over each lane including some with an extra DMS. Some gantries will include a legend to indicate the meanings of the ATM symbols, e.g. red X means closed. Having signs over each lane will help CFX to maximize use of the incident management application. It is a challenge to insert gantries every ½ mile for consistent sign spacing given other signs in the corridor. CFX is looking at four different types of gantries, and possibly to install a DMS over the lane control signs on some gantries which adds an extra layer of complexity.

The red X, yellow X, green arrow are probably the symbols that will be used. CFX is still evaluating the potential use of VSL, given limited success in the area with that application, but VSLs may be used to mitigate the sight distance issues. CFX plans for either software development or to procure software off-the-shelf to support ATM operations. CFX is considering an approach to automate clearing the shoulder lane for operations using either thermal detection or camera analytics in addition to a manual camera scan or drive through.

For CFX, this ATM deployment is not very different from other types of ITS deployments given similar challenges with communications and power. It was a unique challenge for CFX to know when to pull the trigger to proceed with ATM; specifically, thinking ahead on this reconstruction project to anticipate the future need of shoulder use by installing signs and gantries and preparing the base for shoulder use, even if it was not going to be used right away. Interagency coordination is a key part of this ATM deployment since CFX will operate ATM in conjunction with FDOT and will have to coordinate activities with law enforcement and responders.

Staffing. CFX does not have a TMC, and instead partners with Florida DOT District 5 through a Memorandum of Understanding (MOU). CFX is learning from other agencies about the number of operators needed. CFX expects to need some additional staff at the TMC, either through the MOU with District 5, or by adding additional CFX staff.

The CFX ITS maintenance contractor has robust technical expertise, and the contract includes preventative maintenance and labor rates to be as flexible as possible to support new deployments such as those to support connected vehicles and ATM. Response times are included in this contract, and would make ATM a high priority response. CFX expects to increase the ITS maintenance budget accordingly, and recognizes efficiencies gained by having a single maintenance contract.

ATM Experience. CFX has several previous experiences with active management. CFX piloted wrong way driving in 2015, which was unique at the time, and continues pushing forward in this area. CFX also uses an innovative travel time system and a dynamic curve warning system.

ATM Resources. CFX has reached out to vendors to help identify equipment requirements, sign sizes, and wiring diagrams, for example. CFX also looked at deployments in Virginia, Michigan, and other states to help determine that dynamic shoulder use is an effective and viable approach. CFX has received a lot of great feedback that has been leveraged in planning and designs, as well as future operations and staffing needs. CFX understands that other agencies have clear results on what works.

Indiana DOT *(Amber Thomas interviewed on February 7, 2020)*

Background. Indiana DOT is in the very early planning stages to potentially deploy one or more ATM strategies on the I-80/I-94 corridor in northwest Indiana from I-65 west into Illinois, and may be cooperatively deployed and/or operated into Illinois to I-90. Funds were identified in mid-2019 to hire a consulting firm from beginning to end to identify the feasibility for hard shoulder running, VSLs, ramp metering, building another lane, and other options that might work, if any. Indiana DOT sought consultants with experience by initially conducting an RFI, followed by two rounds of scoring for RFPs: a preliminary score to weed out inexperienced consultants and a second round face to face interview to select the best team. This firm will provide support as a resulting RFP goes through design elements and gets ready for construction.

Design and Operations. The ATM studies underway consider a variety of items, including cost, anticipated performance of the installation, service life, reliability, enforcement capability, public understanding/acceptance/compliance, and staffing resources for operations.

Staffing. Indiana DOT anticipates project deployment, operations, and maintenance activities will be made similar to that in conventional activities, i.e. a function of in-house expertise, available time (work load), and efficiency. ATM operations would likely be integrated with TMC operations, which currently manages DMS and Hoosier helpers in the corridor. Staffing would need to be increased and new training conducted on ATM. Maintenance considerations would depend on the option chosen.

If Indiana DOT coordinates with Illinois on a deployment, it may be operated as a single system from one location. A previous widening project was treated as one project managed out of Illinois, and Illinois DOT invoiced Indiana DOT. Deploying ATM across jurisdictional borders like this would be new.

ATM Experience. Indiana DOT has experience with a variety of ATM strategies, including adaptive traffic signal control, queue warning in construction zones, fixed DMS, and portable DMS in construction zones. Additionally, Indiana DOT is in active design development of ramp metering, VSLs, and dynamic shoulder lanes.

ATM Resources. Indiana DOT challenges are principally in the two areas of familiarity or awareness of new ATM treatments and, related to that, the difference in project development versus conventional infrastructure projects. Those challenges are overcome by outreach to other state DOTs that have already deployed ATM strategies like Ohio and Michigan; consultation with FHWA staff and other FHWA resources; and from self-learning through credible published materials, i.e. web content from groups such as TRB, ITE, AASHTO, and FHWA that includes research, syntheses of others' experiences, and NHI courses. Indiana reached out directly to the consultant community who worked with Michigan or Ohio, for instance, and sometimes had paperwork that was not readily accessible online.

Nevada DOT *(Rod Schilling and Jeff Lerud interviewed on February 6, 2020)*

Background. Nevada DOT implemented ATM on I-15 and I-515/US-93/US-95 in central Las Vegas as part of a larger design-build construction project called Project NEON. This project included expansion of the high occupancy vehicle (HOV) network. ATM operations, depicted in Figure B-1 are planned to go live in early March 2020.

Design and Operations. The Las Vegas ATM deployment includes full-size, full-matrix, full-color DMS that span the full width of lanes, i.e. not individual lane control signs:

- "Type 1" DMS are large enough for lane control symbols along the bottom with room on the upper half for messaging;
- "Type 2" DMS are a narrower strip that are wide enough for lane control symbols, but can also be configured for messaging; and
- "Type 3" DMS are smaller, side-mounted signs.

Originally, 52 gantries were planned, but this was reduced to 42 with the others planned to be installed on later projects. Forty of these have "Type 2" DMS, with twelve "Type 1" DMS upstream of interchanges to assist drivers with decision making. This approach was decided following a peer exchange with Minnesota DOT.

The ATM symbols will be a green arrow, yellow X, and red X that include text for additional explanation. Additionally, the system will be used for VSLs, work zone applications, and displaying static guidance signage, when applicable. The general purpose and HOV lanes are treated independently for VSLs, with no more than a 15 mph differential speed between these lanes. Additionally, the HOV lane will be open to all when 2 or more general purpose lanes are impacted. The VSLs will display speeds of 35-65 mph.

Nevada DOT had to build a new software module for the ATM system and performed an upgrade to the central software system software to integrate the newly developed ATM module. This includes a test corridor for operators to become familiar with the ATM capabilities.

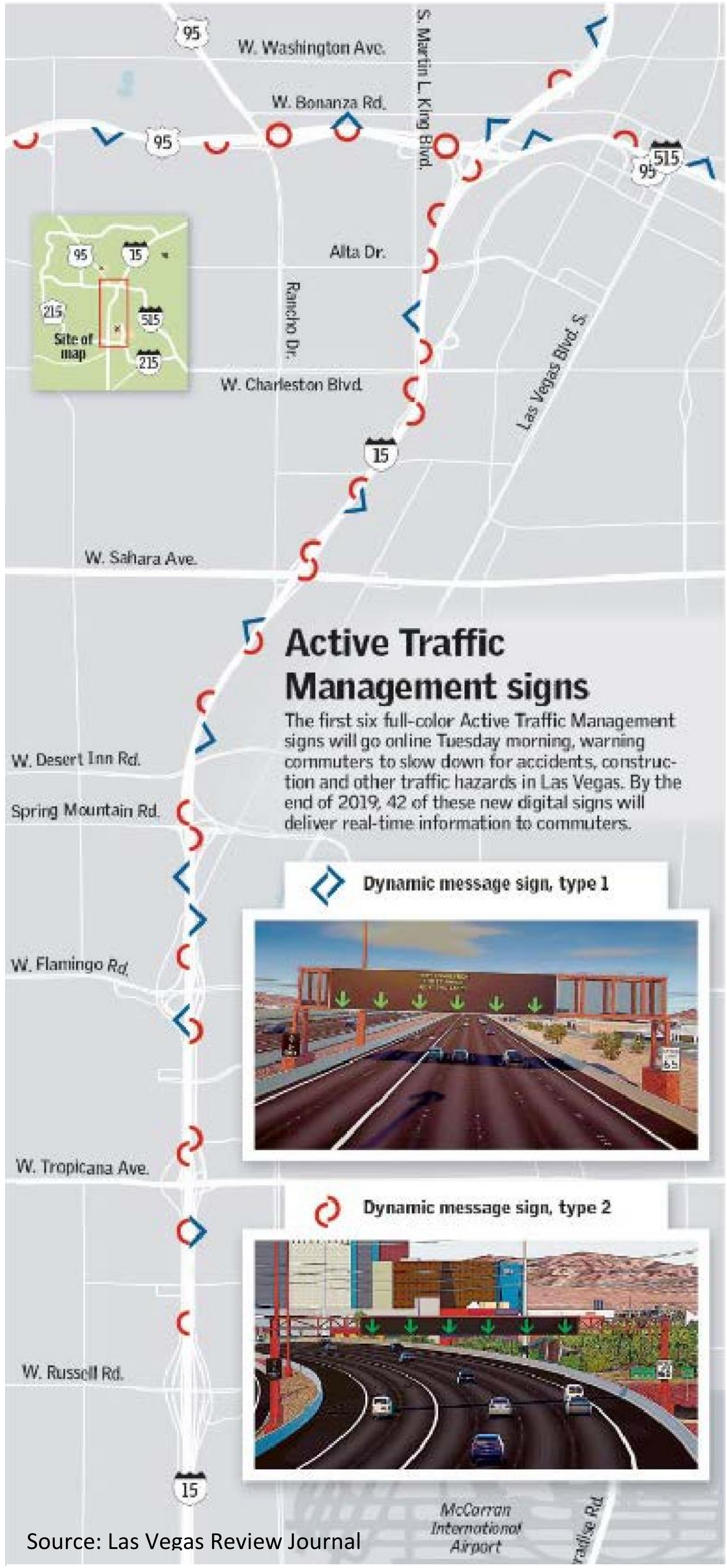
Based on Minnesota DOT's experience, Nevada DOT wanted to include maintenance and right-of-way (ROW) access points. However, given ROW constraints Nevada DOT was not able to provide this at these locations. Nevada DOT tried to get a fully-enclosed "New Jersey style" gantry to access signs, but this is only included on eight gantries because of the cost.

Nevada DOT identified several lessons learned from this deployment:

- Design-build technical provisions always include some give and take, so it is important to write the technical provisions well and understand the contractor's intent for design and implementation.

- Early-action ATM signage were originally intended to be in place for the larger Project NEON construction project, but this did not come to fruition.
- Be flexible for the innovation.
- Integration requires a number of subsystem tests and lane configuration changes before integration can be done to make sure things are working properly. Even though this is following a deployment plan and timeline, Nevada DOT did not emphasize from the field the importance and need to have everything in place as outlined in the technical provisions in order for the contractor to be successful with integration and testing in a timely manner. Nevada DOT is training the TMC operators and are going through what is automatic, what is manual, and how to trust it. The TMC operators need to ask questions, learn about it, and play with the ATM system before they feel comfortable applying it.
- FHWA did not grant a request for experimentation on the downward diagonal yellow arrow, so minor revisions were needed to the ConOps and outreach materials.
- Nevada DOT would have wanted to set up a virtual TMC sooner than implementation of both HOV lanes and the ATM system.

Public outreach has been a huge component, including outreach



Source: Las Vegas Review Journal

Figure B-1: ATM Deployment in Las Vegas, Nevada.

conducted for the HOV lanes. The HOV lanes received some negative press, so Nevada DOT feels pressured to make sure the ATM activation goes smoothly and no one is caught off guard. Nevada DOT learned from the Minnesota DOT that public outreach was a huge component and tried to apply that lesson.

Additionally, it has been important to Nevada DOT to keep stakeholders in the loop, including law enforcement and Department of Motor Vehicles (DMV), to ensure relevant statutes are applicable for enforcing VSLs and HOVs, e.g. interpretation of double solid line vs. single solid line. Project NEON included weekly meetings with stakeholders, which would occasionally include some education and outreach. However, meeting attendees do not always report information back to others at their agency, so more targeted outreach with specific stakeholder groups every 3-6 months helped to ensure continued understanding. As an example, the Nevada Highway Patrol, which is co-located in the TMC, was highly involved in the ConOps development. However, five years later it was important for Nevada DOT and public outreach staff to talk with Nevada Highway Patrol to have a mutual understanding and expectations for operations enforcement. There have been a lot of personnel changes between ConOps and going live for many stakeholder groups.

Staffing. Nevada DOT created a new agreement with the Regional Transportation Commission (RTC) of Southern Nevada Freeway and Arterial System of Transportation (FAST) TMC to include ATM. Staffing has not yet changed but the hours of operation did. The TMC is 24/7 as Nevada DOT District staff did dispatch, but FAST is not and so District staff will work off-hours. Staffing needs will be re-examined staffing after the ATM system goes live.

The agreement with FAST also includes pay-by-device for operation and maintenance, where ATM is a separate component from other ITS devices but treated similarly. Nevada DOT worked with the District and FAST to determine those terms and limits. Nevada DOT will be tracking the ATM assets within the Nevada Transportation Asset Management Plan (TAMP), which includes ITS and tracks the lifecycle of devices and maintenance needs, for example.

ATM Resources. Nevada DOT produced information for DMV outreach to inform drivers how to drive the corridor and understand the ATM signs. Nevada DOT sees the advantage of repeating this information to improve traveler understanding of ATM.

Ohio DOT *(John MacAdam interviewed on February 25, 2020)*

Background. Ohio DOT identified a 4.5-mile segment of eastbound I-670 in Columbus as a prime location for hard shoulder running and other ATM strategies as part of a statewide Active Transportation and Demand Management (ATDM) study conducted for the agency's Transportation System Management and Operations (TSMO) program. This project was included as part of a larger reconstruction project of the I-270/I-670 interchange and was completed in October 2019.

A second, related project that was identified in the aforementioned ATDM study is currently being planned for I-275 near Cincinnati.

Design and Operations. The I-670 deployment uses the median shoulder for eastbound traffic. Ohio DOT has had bus-on-shoulder use in the Columbus area for a number of years through a partnership with Central Ohio Transit Authority (COTA), the local transit agency. Because it was Ohio DOT's first experience with a major ATM deployment and very visible, the project on I-670 was designed "conservatively" to future proof it and provide flexibility to ensure success given a lot of pressure to get it right. This deployment was the first time for Ohio DOT in several ways, including using this size of sign, shown in Figure B-2; having full color, full matrix signs; using this new software; implementing dynamic shoulder use; and using camera analytics. Ohio DOT saw this deployment as an opportunity to try new things, e.g. new sign technologies and cameras, new incident management philosophies that had to be explained to the local responders, new philosophy (driving on the shoulder) that had to be communicated to the public, and corridor operations by new TMC staff positions. Ohio DOT had planned to replace ATMS software anyway, but will not be replacing it with the software implemented for this deployment.

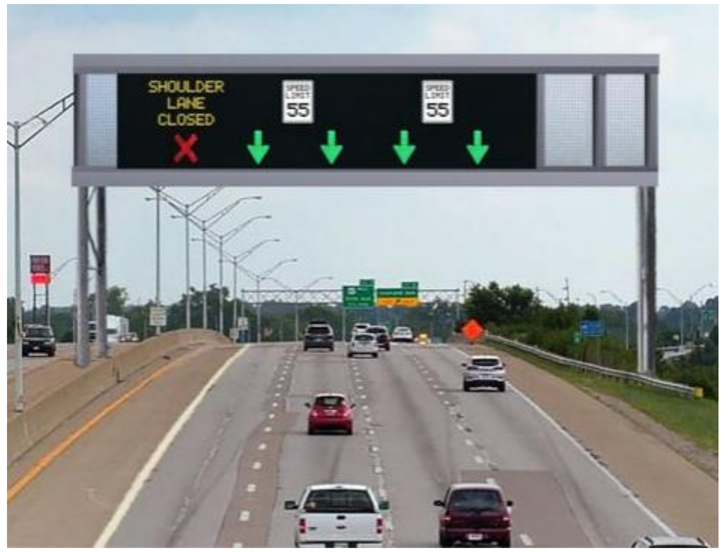


Figure B-2: Depiction of ATM Deployment on I-670 in Columbus, Ohio

The I-670 deployment includes lane control signage over every lane at about ¾-mile spacing to support part-time shoulder use, VSLs, and incident management. Design choices for the deployment were based on a "future friendly" option to help Ohio DOT understand the possibilities with ATM. Before opening the shoulder lane to traffic, the lane is physically driven by freeway safety patrol and visibly swept by the ATM specialist who first lowers speeds from 65 to 55 mph to open the lane. The VSL sign displays allow Ohio DOT to do temporal and spatial VSLs, and are shared on the Ohio DOT traveler information website, along with whether the shoulder lane is opened or closed to traffic.

The I-670 segment includes a design limitation where the horizontal sight distance initially prevented Ohio DOT raising VSLs above 45 mph when the shoulder lane was open. Ohio DOT worked to eliminate that restriction in order to operate the shoulder when VSLs display 55 mph, which was achieved about 5 months after going live with shoulder operations. With this approach, the ATM specialist is hyper-focused on the curve where sight distance is a concern and would immediately lower the VSL if they see any queue occurring in that vicinity.

The I-275 ATM deployment on the northeast side of Cincinnati almost duplicates the I-670 ATM deployment, but with lighter ITS. This project includes the same type of applications and is approaching the design stage. Preliminarily, however, the deployment includes just one lane control sign over the hard shoulder. This deployment will address heavy peak-hour traffic in the morning. Ohio DOT notes that it costs more to operate, install, power, maintain, and provide structures for larger signs, while a similar amount of incident management can be done without signage over every lane by using a DMS to display incident messages, e.g. “right two lanes closed ahead, merge left”. Moreover, incident management is the least used of the three ATM strategies on I-670. At one point, Ohio DOT considered placing static signs for shoulder use, but wanted to be able to actively manage operations. After the I-275 ATM deployment opens, Ohio DOT plans to compare results from the two models, i.e. light ITS or full lane control signage, to see which works better overall and compare the impact of both.

Ohio DOT noted a blurred line between planning and operations throughout the I-670 project when developing the ATM Concept of Operations, standard operating procedures, TMC training documentation, getting the ATM software to work, and determining how ATM messages look and feel, ODOT leaned a lot on Michigan DOT’s experiences. Ohio DOT developed general recommended ATM gantry spacing based on weather-based or congestion-based ATM approaches, and site-specific spacing was chosen based on logistics of where power is available and interchange spacing.

Staffing. Ohio DOT already had 24/7 operations at the TMC, but previously this was more for monitoring purposes, as there was less active management before. Ohio DOT sees active management as the future at the TMC, and ATM fits in with the long-term vision.

Ohio DOT decided to treat staffing differently for ATM operations. Specifically, Ohio DOT has four levels of TMC staff. ATM is operated by a specialist, not an operator. Typically, an operator is a staff member who manages an entire region. However, an ATM specialist is distinctly in charge of ATM operations, while also being tasked with quality assurance (QA) on other systems, e.g. queue warning or ramp metering applications. Specialists are on standby when not scheduled to be at the TMC, since things happen outside of the PM peak hour when ATM is used. Specialists can operate the ATM system remotely. The specialist completes all actions for ATM operations, and other TMC operators can call them when needed. That said, other TMC operators are trained to turn on the initial ATM message before the specialist is contacted.

Regarding maintenance, the Ohio DOT Traffic Operations group does ITS maintenance activities, including the new ATM deployment. Ohio DOT has the capability to conduct ATM maintenance in-house, with ATM among the highest priorities.

ATM Experience. To date, the I-670 ATM deployment has been a huge success, by facilitating free flow speed, incurring minimal crashes, and providing more reliable travel times. Before construction started, travel time through the 4.5-mile corridor at rush hour was 7-35 minutes, resulting in really poor travel time reliability when travelers would leave at the same time of day. After ATM activation, travel time through the corridor is almost always 5-6 minutes.

Operations have been adjusted since the ATM deployment started. During the first week of hard shoulder operations, Ohio DOT waited until conditions started to worsen and bottlenecks to build before making a judgement call about opening the lane, i.e. this is not a time of day system. Now, the Ohio DOT ATM specialist knows to open the lane just before those bottlenecks form, making a judgement based on experience using speed data, volume data, and cameras. Additionally, Ohio DOT initially deployed safety patrol and tow trucks in this corridor but have since deployed those elsewhere since they were not being used after the ATM was activated. The shoulder lane also does not need to be swept as often since less debris accumulates with traffic driving there now.

Finally, Ohio DOT also operates a standalone VSL deployment on I-90 east of Cleveland that is weather-responsive for snow squalls.

ATM Resources. Ohio DOT shared the Concept of Operations, TMC Training guide, and other resources developed for the I-670 ATM deployment.

South Dakota DOT *(Dave Huft interviewed on March 12, 2020)*

Background. The South Dakota legislature recently enacted legislation to permit VSL pilots on two 10-mile segments of Interstates in South Dakota: on I-90 between Sturgis and Tilford and I-29 between Brookings and the Ward exit. The two pilot corridors were selected because the weather is sometimes worse there than other areas of the Interstate due to topography and these segments experience higher winter crash rates than other locations on the Interstate. Legislation was required because the law stated that only the transportation commission was authorized to set speed limits, and it is not feasible for this group to approve each individual VSL change.

Design and Operations. While the legislation is expected to allow VSL use starting in July 2020, South Dakota DOT (SDDOT) plans to immediately begin the systems engineering and design process. Currently, the vision for VSL sign spacing is to replace each static sign with an electronic VSL sign, but more electronic VSL signs may be needed in the corridor. New equipment will be needed to support VSLs, e.g. there is an RWIS near the Ward exit but another is needed on the north end of the I-29 pilot location; SDDOT expects to have a minimum of two RWIS in each corridor, but may install more.

The pilot deployments will include an extensive evaluation to examine the reliability of system components, erroneous reporting of conditions or downtime, and the ability to determine when speed limits should be imposed and at what level. A goal for the deployment is to gain system intelligence rather than rely on personal interpretation of conditions each time the VSL is activated, but there will be a learning phase. With the legislation being passed, it is important now for SDDOT to show that the VSL systems work; there is already interest in deploying more VSLs on other corridors.

SDDOT has a couple logistical challenges to consider as the VSL system is deployed. There is a surface reconstruction project planned on I-90 in 2022 that could complicate the VSL installation; SDDOT does not want to delay the installation but may have to replace some equipment if it is impacted. Similarly, a new interchange is being planned on I-29 in that VSL corridor and construction activities may disrupt traffic and affect the VSL equipment.

Staffing. SDDOT does not have a TMC, so the agency will have to figure out a staffing arrangement for who will implement, monitor, and operate the VSL system; there is reluctance to initiate a TMC. As SDDOT gains experience, the hope is to move to a truly more dynamic and more immediately managed system without high-level approvals on implemented speeds.

ATM Resources. The Wyoming experience with VSL has been very positive and they have been operating VSLs for a decade, so they are a good case study to reference and show the good results. SDDOT also plans to talk with other agencies that operate VSL deployments, such as Ohio DOT and Oregon DOT.

Wisconsin DOT *(Elizabeth Lloyd-Weis interviewed on February 3, 2020)*

Background. A dynamic, part-time shoulder use project in the Madison area is currently advancing for both directions of a 10-mile corridor that experiences capacity issues at certain times of day. A Concept of Operations has been drafted and construction is scheduled to begin in 2021. Expansion was not feasible in the near-term so dynamic shoulder use is being implemented as an interim solution until reconstruction can occur. When it becomes operational, dynamic shoulder use is expected to occur during set time periods based on peak hours, but also include special event and incident operations.

Design and Operations. Dynamic shoulder use will occur on the left (median) shoulder and a single DMS will be placed over the shoulder lane every ½ mile. While sign dimensions are not finalized, 4'x5' signs are currently proposed for shoulder lane control, and supported by other DMS on other gantries. It is expected that three MUTCD symbols will be used for operations: green arrow, yellow X, and red X. Additionally, the interchanges in this corridor are relatively close together, with 12 interchanges in about 10 miles; this is closer interchange spacing than other deployments like Michigan DOT, so WisDOT recognized a need to modify that design. To initiate shoulder operations, WisDOT plans to conduct a visual scan with cameras, i.e. camera tour verification, along with manual clearing of the shoulder lane by freeway service team (FST) staff. Maintenance access and lane closures are also being discussed, given this deployment will add a lot of ITS in the median. When planning this deployment, cost has been a major factor in the decisions being made, including initial costs and costs for ongoing maintenance. Generally, this deployment will have similar design, technologies, and operations as other existing dynamic shoulder deployments.

Staffing. One identified challenge is the long-term staffing needs to operate and maintain the dynamic shoulder, and having the staff support that is needed. Regarding design, operations, and maintenance of this ATM deployment, the dynamic shoulder is being treated similarly to other ITS activities. It is recognized that existing staffing will not meet the needs of the new dynamic shoulder deployment, but WisDOT is working within the existing ITS framework. For example, the dynamic shoulder deployment will become part of the WisDOT ITS maintenance contract; WisDOT is considering whether response times will need to be different and what maintenance staff would need to be available, recognizing that this will incur higher costs than other ITS maintenance needs.

ATM Experience. This is the first true ATM project for WisDOT, although a variety of similar ITS efforts have been deployed.

Lane control systems at the Mitchell Interchange in Milwaukee County have been operational for 8 years but are rarely activated. This system that is operated from a control room managed by the Wisconsin State Patrol, and is grouped with other ITS operations. These are used to advise of both unplanned traffic incidents and planned lane closures, e.g. an overnight lane closures for LED light replacement in the tunnels. The Mitchell Interchange Traffic Operations Plan (MITOP) is used for standard operating procedures (SOP). The TMC Control Room Operator handling the incident makes the decision to activate the signs when an incident occurs in one of the tunnels. The Control Room Engineer along with the Control Room Operator or Supervisor will generally make the decision to use them for planned lane closures. In the ATMS, these signs are currently treated as stand-alone devices and not included as part of a recommended response for planned or unplanned events. This means that a Control Room Operator or Supervisor must go into the sign properties and manually select the appropriate graphic, based on the lane(s) closed. In addition, they need to closely monitor the lane closure to make sure the sign displays are manually taken down once lanes are opened.

Other deployed systems around the state to note include:

- Actuated flashers for queue warning at one off-ramp location near Eau Claire that are activated by microwave sensors;
- Overheight warning beacons;
- Speed incident detection systems on curves that provide a warning if vehicles are traveling too fast;
- Wrong way driving systems; and
- Intersection conflict warning systems.

ATM Resources. To learn more about ATM, FHWA conducted a workshop in Madison for WisDOT that was specific to this dynamic part-time shoulder use project. Region staff have also conducted other information gathering activities, including a visit to Michigan to learn about the ATM deployment there.