# EVOLVING AND PHASING OUT LEGACY ITS DEVICES AND SYSTEMS

# FINAL REPORT

October 25, 2019

**ENTERPRISE TRANSPORTATION POOLED FUND STUDY TPF-5(359)**

**Prepared by:**
**Athey Creek Consultants**

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16. Abstract
Transportation agencies across the country have deployed numerous Intelligent Transportation Systems (ITS) devices and systems, some of which have been in place for more than 25 years. As technology changes, it is important to evaluate these "legacy" devices and systems to determine if needs have changed; whether these devices and systems should be replaced, reused, or evolved in other ways; or whether it is beneficial to continue their operation. This project documented nearly 60 case studies, including decision factors, criteria, approaches, and tools agencies use to help guide decision-making when evolving and phasing out ITS devices and systems. Based on the case studies, a set of criteria and applicable tools was developed for ten common ITS devices and systems. These criteria are intended to assist agencies with identifying and navigating through multiple considerations while assessing ITS devices and systems to determine potential evolutions or eliminations. In addition, multiple overarching tools used by agencies to guide decisions for managing ITS devices and systems were documented.

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## Project Champion

Pierce Sube, Pennsylvania 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.

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

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# 1.0 Introduction

Transportation agencies across the country have deployed numerous Intelligent Transportation Systems (ITS) devices and systems, some of which have been in place for more than 25 years. As technology changes, it is important to evaluate these "legacy" devices and systems to determine if needs have changed; whether these devices and systems should be replaced, reused, or evolved in other ways; or whether it is beneficial to continue their operation. For example, Highway Advisory Radio (HAR) is deployed to broadcast messages to motorists over the radio. However, since initial HAR deployments, transportation agency traveler information websites, mobile apps, and third-party applications have been developed to also provide traveler information, leading some agencies to consider whether to continue operating HAR. Another example is the location and placement of Dynamic Message Signs (DMS), which may be periodically re-evaluated based on factors such as motorist travel patterns and the frequency of messages posted.

The ENTERPRISE Pooled Fund Study conducted this research to help increase members' understanding of agency practices for evolving and phasing out ITS devices and systems. This project documented nearly 60 case studies, including decision factors, criteria, approaches, and tools transportation agencies use to help guide decision-making when evolving and phasing out ITS devices and systems. Based on the case studies, a set of criteria and applicable tools was developed for ten common ITS devices and systems, seperated into two categories.

This project documented nearly 60 case studies, including decision factors, criteria, approaches, and tools transportation agencies use to help guide decision-making when evolving and phasing out ITS devices and systems.

- Category 1: ITS devices and systems that interface with motorists as the primary use
    - Highway Advisory Radio
    - Traveler information phone service
    - Traveler information websites and mobile apps
    - Signs and traffic control devices (DMS, Intelligent Lane Control Signals (ILCS), Intersection Conflict Warning System (ICWS), and remotely operated gates)
- Category 2: ITS devices and systems that are primarily used for transportation operations
    - Traffic detection (physical field detectors and probe data)
    - Monitoring devices (devices for monitoring road-weather and tunnel conditions)
    - Traffic cameras
    - Traffic Management Center (TMC) facilities and operator support (Advanced Traffic Management Systems (ATMS), video walls, and decision support tools)
    - ITS communications systems (infrastructure and service providers)
    - Agency-owned devices and software versus service-based solutions

There are likely other ITS devices and systems that have been phased out or evolved which were not documented as part of this project. This research was not intended to be a comprehensive state of practice review of all ITS systems and devices. Rather, the intent was to gather diverse examples of agencies that have evolved or phased out ITS devices and systems, for the purpose of identifying common decision factors, criteria, tools, and lessons learned, many of which can be translated across devices and systems.

This report includes the following sections:

- 2.0 Project Approach – Describes the steps conducted to complete the research.
- 3.0 Terms to Describe Change to ITS Devices and Systems – Defines each term used to describe how ITS devices and systems have changed, are changing, or have been phased out.
- 4.0 Literature Search, Outreach and Case Studies – Presents applicable literature, describes outreach efforts, and lists the case studies that were documented in this project.
- 5.0 ITS Devices and Systems: Changes, Decision Factors, Tools and Criteria – Provides a brief summary of the case studies (type of change, decision factors) and presents the detailed criteria for agencies to consider when assessing the ten common ITS devices and systems that this project focused on.
- 6.0 Planning and Management Tools and Approaches – Summarizes 17 over-arching planning and management tools and approaches that agencies are using to help guide decisions as they make decisions regarding evolving or phasing out ITS devices or systems at a program level.
- 7.0 Summary – Summarizes selected key findings and lessons learned.

## 2.0 Project Approach

The research approach for this project included the following steps:

- ***Literature Search and Outreach*** – An online literature search and TRID database search were conducted to identify applicable publications and any relevant case studies from agencies that have evolved or phased out ITS devices or systems. In addition, outreach to ENTERPRISE members and to national groups that focus on ITS and Transportation Systems Management and Operations (TSMO) identified agencies to contact for additional case study development.
- ***Agency Interviews and Case Studies*** – Interviews with selected agency representatives were conducted to gather case study data for ITS devices and systems that are evolving or that have been evolved or phased out. Additional information was gathered via email correspondence as needed. Case studies were documented for each ITS device or system, including how ITS devices and systems were evolved or phased out, decision factors that led to these changes, and any applicable tools or approaches used to help guide decisions.

  This project did not complete a comprehensive "state of practice" review for each ITS device and system documented in the case studies. Rather, the intent was to gather diverse examples of ITS devices and systems that have been evolved or phased out (or are currently being evolved in some way), for the purpose of identifying common decision factors, criteria, tools, and lessons learned, many of which can be translated across devices and systems.
- ***Case Study Assessment*** – Case studies were reviewed, and similar ITS devices and systems were grouped together to identify common decision factors, criteria, and tools.
- ***Criteria and Tools for Evolving or Phasing Out Common ITS Devices and Systems*** – Data from the case study assessment was used to develop a set of criteria and applicable device or system-specific tools for ten common ITS devices and systems.
- ***Summary of Planning and Management Tools*** – Several overarching tools and approaches used by agencies to plan for and manage ITS devices and systems were summarized.

Figure 1 illustrates the project steps.

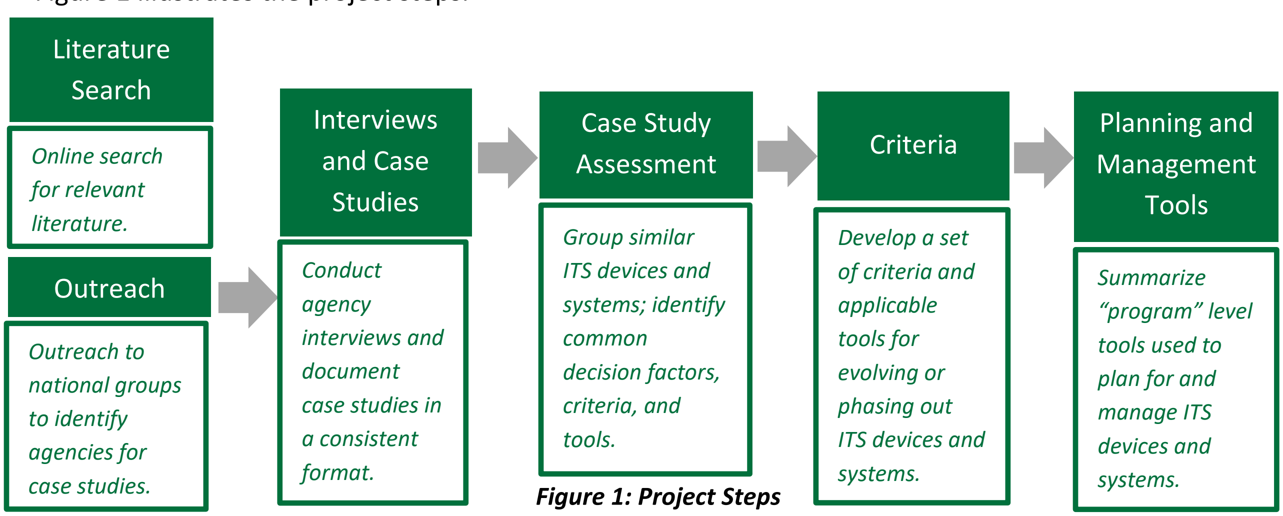


***Figure 1: Project Steps***

## 3.0 Terms to Describe Change to ITS Devices and Systems

It is important to define what is meant by each term used to describe how ITS devices and systems have changed, are changing, or have been phased out. Below are the terms used to describe the evolution of ITS devices and systems, for the purposes of this project:

- ***Eliminate/Phase Out*** – Devices or systems have been eliminated from use by an agency altogether. These devices or systems are no longer being used for an ITS purpose.
- ***Discontinue Component*** – An individual component or feature within a system has been eliminated.
- ***Replace/Upgrade*** – Devices or systems have been replaced via significant upgrades to new technologies, systems, or services.
- ***Remove*** – One or more devices or systems in various locations have been removed from operation, but other devices or systems of the same type remain operational.
- ***Relocate*** – One or more devices or systems have been physically moved from one location to another location while retaining their overall purpose and physical condition/state.
- ***Reuse*** – Devices, systems, or their components have been reused for a similar purpose as the original deployment.
- ***Repurpose*** – Devices or systems have been reused for a different purpose than their original deployment purpose.
- ***Evolve*** – Devices and systems have changed in terms of what they are used for, how they interact with motorists, the types of devices deployed, the methods by which they operate, types of information provided, or agency philosophy.

In some cases, a device or system may be undergoing changes in multiple categories at the same time. For instance, during the time when a type of device is being phased out from use on a statewide basis, individual devices may be relocated or parts reused to extend the life of a device in another location during transition to a fully eliminated status. Furthermore, agencies are often in various stages of changing their ITS devices. For example, some devices or systems have completely undergone a transition (e.g. eliminated, repurposed, relocated), while others are still transitioning to a changed state (evolving).

# 4.0 Literature Search, Outreach, and Case Studies

This section presents outcomes of a literature search and outreach efforts conducted to identify transportation agencies to participate in interviews and provide case study data. A listing of the case studies documented for this research is provided in Section 4.3.

## 4.1 Literature Search

The body of published literature documenting transportation agencies' practices for evolving of phasing out ITS devices and systems is not substantial. Agencies that operate these devices and systems continually assess performance and make modifications as needed, however they rarely have the need or the opportunity to formally document why they are making changes to their ITS infrastructure or services.

Agencies rarely have the need or opportunity to formally document why they are making changes to their ITS infrastructure or services.

The publications that were most relevant to this project focus on traveler information phone systems and other traveler information mechanisms. The two most relevant findings from the literature are summarized below.

The *Next Generation Traveler Information System: A Five Year Outlook* (FHWA, 2015) report provides information agencies can use to help guide decisions as they evolve their traveler information solutions. Though the report does not contain "case study" examples of evolving or phasing out ITS devices or systems, it provides the following recommendations for agencies: 1) understand your agency's core goals and objectives; 2) monitor technology trends; 3) know your audiences; and 4) implement data-driven decisions (e.g. analytics, usage). Specific to considerations for evolving Interactive Voice Responsive (IVR)-based 511 phone systems, the report states: "Given this general direction and the quickly growing use of alternatives, it appears that 511/IVR is a technology which is starting to shift into the later phases of its lifecycle. Like all technology, transitions, the exact timing is uncertain and decisions about changes will need to be made on a case-by-case basis in response to the needs of key traveler populations." The importance of tracking performance and determining quantifiable milestones is noted, and a tracking framework for 511 phone service might include the following items:

- Identify user segments using 511 phone; understand in relation to overall population
- Determine if they are using 511 phone exclusively
- Determine actual impact of 511 phone use on traveler behavior
- Determine whether user segments are likely to transition to other solutions
- Plot 511/IVR usage and impact trends against similar technologies

The report *Evaluation of Rural 511 Phone Service* (North/West Passage Pooled Fund, 2018) documented the status and trends of 511 phone service at several transportation agencies, to assist agencies in determining their future role for traveler information. Three agencies documented in this report indicated that they had eliminated or evolved 511 phone service (Kentucky Transportation Cabinet, Missouri DOT, and North Carolina DOT). As such, these three examples are included as case studies for this project. The case studies are described in Appendix A and are summarized in Section 5.1.2.

## 4.2 Outreach

In addition to the literature search, outreach to national groups that focus on ITS and TSMO as well as to ENTERPRISE members was conducted to identify agencies to participate in interviews and provide case study data. The following groups sent correspondence to their respective distribution lists on behalf of ENTERPRISE, to invite agency participation in this research:

- AASHTO Committee on Transportation System Operations (CTSO)
- I-95 Corridor Coalition Operations Academy
- National Operations Center of Excellence (NOCoE) newsletter

This outreach resulted in 12 agencies that participated in interviews to provide case studies for this project. A complete list of agencies represented in the case studies can be found in the following section.

## 4.3 Case Studies

This section provides a listing of the agencies selected for case studies and the ITS devices or systems that were documented as case studies for each agency. As noted in the sections above, a few case studies were drawn from the literature; however, the majority of case studies were generated via phone interviews and/or email correspondence with the agencies identified through targeted outreach. Agencies represented in the case study summaries include:

- Alaska Department of Transportation and Public Facilities (AK DOT&PF)
- California Department of Transportation (Caltrans)
- Delaware DOT (DelDOT)
- Illinois Department of Transportation (IDOT)
- Iowa Department of Transportation (Iowa DOT)
- Kentucky Transportation Cabinet (KYTC)
- Maryland Department of Transportation State Highway Administration (MDOT SHA)
- Massachusetts Department of Transportation (MassDOT)
- Michigan DOT (MDOT)
- Minnesota Department of Transportation (MnDOT)
- Missouri Department of Transportation (MoDOT)
- North Carolina Department of Transportation (NCDOT)
- Ohio Department of Transportation (ODOT)
- Ontario Ministry of Transportation (MTO)
- Pennsylvania Department of Transportation (PennDOT)
- Wisconsin Department of Transportation (WisDOT)

Many of the agencies provided information for more than one ITS device or system. Appendix A contains case study summaries presented in alphabetical order by agency. Each case study summary includes:

- ***Agency*** – Name of agency
- ***Information Source(s)*** – Individual(s) and date of interview or email correspondence; or literature source as applicable

- ***ITS Devices or Systems in the Case Study Summary*** – Listing of the specific ITS devices or systems documented
- ***Agency Tools Used to Inform Decision-Making (if applicable)*** – Any overarching tools used to assess current ITS devices and systems, determine changes, and plan for future ITS investments

A separate case study was documented for each ITS device or system. Each ITS device or system "case study" provides the following details:

- ***Overview*** – Brief summary of how the device or system has been (or is being) eliminated, phased out, or evolved
- ***Decision Factors*** – The key factors used when making the decision to evolve or phase out the device or system
- ***Feedback*** – Any feedback the agency received following changes to the device or system
- ***Tools Used to Inform Decisions (if applicable)*** – Describes any tools used to assess the need to evolve or eliminate the device or system

Figure 2 shows a screenshot of a partial Case Study Summary as documented from Ohio DOT.

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**"Evolving and Phasing Out ITS Systems/Devices"**
**Case Study Summary – Ohio DOT**

| | |
|---|---|
| **Agency** | Ohio Department of Transportation (ODOT) |
| **Information Source(s)** | 4/9/19 Interview with Jason Yeray and Bryan Comer, Ohio DOT |
| **ITS Devices or Systems in this Case Study** | 1) Radar Speed Detection Devices (eliminated)<br>2) Loop Detection Devices for ITS Operations (eliminated)<br>3) Highway Advisory Radio Systems (phasing out, re-purposing, re-using)<br>4) Selective Deployment of DMS (evolving)<br>5) Communications for ITS Devices and Operations (evolving)<br>6) Transition Communications Provider Services to FirstNet (evolving)<br>7) Upgrade ATMS Software (replacing) |
| **Tools to Guide Decision-Making** | • ITS Device Replacement Planning<br>• Device Consistency<br>• Centrally Located ITS Operations Function<br>• IT Services Integrated with ITS Office |

| **ODOT Case Study #1 – Radar Speed Detection Devices (eliminated)** | |
|---|---|
| **Overview** | ODOT eliminated radar speed detection devices used to determine travel times for posting to DMS and other traveler information mechanisms. Instead of radar devices, ODOT is now using 3rd party probe data to provide speed data. |
| **Decision Factors** | • **Alternative** – 3rd party probe data is now being utilized to provide vehicle speeds to determine travel times.<br>• **Cost** – ODOT has seen substantial cost savings by utilizing 3rd party probe data.<br>• **Performance/Quality** – Probe data is accurate and timely enough for ODOT uses, although there is a little more of a lag time in delivery and thus accuracy compared to roadside speed detection devices.<br>• **Maintenance** – Use of 3rd party data will reduce the resources required to maintain roadside detection devices that are impacted by weather-related issues. |
| **Feedback** | None noted; not a public-facing device. |

***Figure 2: Partial Screenshot of Ohio DOT Case Study Summary (See Appendix A for full case studies)***

In total, the project documented 59 device/system case studies and 17 overarching planning and management tools used by agencies to assist with decision for evolving and phasing out ITS devices and systems. Table 1 lists the case studies documented for this project.

***Table 1: Case Studies for Evolving and Phasing out ITS Systems and Devices***

**Alaska DOT&PF**
- 4th Generation 511 System *(evolving, discontinuing component)*
- Decreased Use of Permanent DMS in the Central Region *(evolving)*
- Communications for Traffic Signals and Connected Vehicles (*evolving*)

**Caltrans**
- ATMS Software (*replacing*)
- Highway Advisory Radio (*evolving*)
- Vehicle Detection (*evolving*)
- Traffic Cameras (*evolving*)
- TMC Video Walls (*evolving*)

**Delaware DOT**
- Communications Systems (*evolving*)
- Software Systems for TMC Operations and Traveler Information (*evolving*)
- Travel Advisory Radio (*evolved*)
- Non-Intrusive Weather Monitoring Devices (*evolving*)
- Bluetooth Traffic Detection Devices (*evolved*)

**Illinois DOT**
- Statewide Traveler Information Phone Service (*eliminating*)

**Iowa DOT**
- 511 Citizen Reporting Feature (*discontinued component*)
- 511 3G Website (*discontinued component*)
- Highway Advisory Radio (*eliminated*)
- DMS (*removing, relocating, reusing*)
- Intersection Conflict Warning Systems (*removed, evolved*)
- Automated/Remotely Operated Interstate Gates (*eliminated*)

**Kentucky Transportation Cabinet**
- 511 Phone Service *(eliminated)*

**Maryland DOT SHA**
- 511 Phone Service (*evolving*)

**Massachusetts DOT**
- Traffic Detection (*evolving*)
- Analog to Digital Traffic Cameras (*evolving*)
- Highway Advisory Radio (*phased out, repurposed*)
- Tunnel Monitoring Technologies (*evolving*)
- DMS Management System (*eliminated*)

**Michigan DOT**
- No specific device case studies; overarching obsolescence planning tool

**Minnesota DOT**
- 511 Citizen Reporting Feature (*discontinued component*)
- 511 3G Website (*discontinued component*)
- Intelligent Lane Control Signals (*eliminated*)

**Missouri DOT**
- Highway Advisory Radio (*eliminated*)
- Bypass Map Layer on Statewide Traveler Information Map (*evolving*)
- Traffic Detection Devices (*evolving*)
- 511 Phone Service *(eliminated)*

**North Carolina DOT**
- 511 Phone Service *(evolved)*

**Ohio DOT**
- Radar Speed Detection Devices (*eliminated*)
- Loop Detection Devices for ITS Operations (*eliminated*)
- Highway Advisory Radio System (*phasing out, repurposing, reusing*)
- Selective Deployment of DMS (*evolving*)
- Communications for ITS Devices and Operations (*evolving*)
- Transition Communications Provider Services to FirstNet (*evolving*)
- Upgrade ATMS Software (*replacing*)

**Ontario Ministry of Transportation**
- Vehicle Detection Stations (removing, *evolving*)
- Fiber to Wireless Communication for Control of DMS (*evolving*)
- CCTV Video Streaming On-Demand (*evolving*)
- Central Software ATMS to Field-based “Field Traffic Master” (*evolving*)
- Automated DMS Signing Strategy for Road Closures (*evolving*)
- Transition from Agency-owned ITS Systems to Service-based Solutions (*evolving*)

**Pennsylvania DOT**
- Highway Advisory Radio (*eliminating, reusing, repurposing*)
- 511 Phone Service (*evolving*)
- Color Dynamic Message Signs (*evolving*)
- Conversion of a Traffic Management Center into an Incident Command Center for Emergency Operations (*evolved*)
- Traffic Detection (*evolving*)

**Wisconsin DOT**
- Highway Advisory Radio (*eliminating*)
- 511 Phone Service (*replacing*)
- Trip Routing Tool on 511 Website (*discontinuing component)*
- Advanced Traffic Management System (*replaced*)
- Dynamic Message Signs (*relocating*)
- Build Fleet of Temporary ITS Devices (*reusing, evolving*)

# 5.0 ITS Devices and Systems: Changes, Decision Factors, Tools, and Criteria

Upon initial review of the case studies described in the previous section, two categories were identified to group the ITS devices and systems: Category 1) ITS devices and systems that interface with motorists as the primary use; and Category 2) ITS devices and systems that are primarily used for transportation operations. These categories are not mutually exclusive for some devices. For example, the primary purpose of DMS are to provide on-road information to motorists about approaching conditions. However, DMS also serve as an important tool for managing traffic conditions. Table 2 shows the ITS devices and systems that are included in each category.

***Table 2: ITS Devices and Systems by Case Study Category***

| Category 1: ITS Devices and Systems Interface with Motorists as Primary Use | Category 2: ITS Devices and Systems Primary Use for Transportation Operations |
|---|---|
| • Highway Advisory Radio<br>• Traveler Information Phone Service<br>• Traveler Information Websites and Mobile Apps<br>• Signs and Traffic Control Devices (DMS, ILCS, ICWS, and remotely operated gates) | • Traffic Detection (physical field detectors and probe data)<br>• Monitoring Devices (devices for monitoring road-weather and tunnel conditions)<br>• Traffic Cameras<br>• TMC Facilities and Operator Support (ATMS, video walls, and decision support tools)<br>• ITS Communications Systems (infrastructure and service providers)<br>• Agency-owned Devices and Software versus Service-based Solutions |

For each of the ten ITS devices and systems listed in Table 2, this section presents:

- An overview of the relevant case studies;
- Summary of key decision factors;
- Any device-specific or system-specific tools used to help guide decision-making; and
- Summary of detailed criteria and applicable tools

For each device or system grouping, the criteria and applicable tools were derived through review of detailed information provided in each case study. Similar criterion were grouped together under high-level decision factors (e.g. cost vs. benefits, usage, motorist feedback, coverage/access, alternative(s); maintenance/monitoring, etc.) These criteria are intended to assist agencies with identifying and navigating through multiple considerations while assessing ITS devices and systems for potential evolutions or eliminations.

## 5.1 ITS Devices and Systems that Interface with Motorists

The following ITS devices and systems are included in Category 1, where the primary use is to interface with motorists:

- Highway Advisory Radio
- Traveler Information Phone Service
- Traveler Information Websites and Mobile Apps
- Signs and Traffic Control Devices (DMS, ILCS, ICWS, and remotely operated gates)

The devices and systems in this category are used to provide pre-trip or en-route information to motorists, or for traffic control functions. Some of these devices and systems are also critical for traffic operations. For example, traffic operators regularly utilize DMS and other traveler information mechanisms to encourage motorists to make travel choice changes in order to help reduce congestion. However, the primary common factor for devices and systems in this category is their interaction with motorists.

### 5.1.1 Highway Advisory Radio

Highway Advisory Radio (HAR) is used to provide traveler information to motorists via broadcast radio, typically accessed from inside vehicles.

**Case Studies for Highway Advisory Radio**

There were eight case studies documented related to HAR. The table below provides a list of these case studies. For each case study, the type of change is noted, along with a brief description of the change, and the decision factors indicated in the case studies. See Appendix A for the complete case study summaries.

***Table 3: Case Studies for Highway Advisory Radio***

| Agency and Case Study | Type of Change | Description of Change | Decision Factors |
|---|---|---|---|
| Iowa DOT #3 Highway Advisory Radio | Eliminated | Eliminated HAR in December 2016. A steady process was used to shut down the sites, first ending communication to CARS/511, removing signs, and allowing the Federal Communications Commission (FCC) license to expire. | • Expensive to maintain<br>• Difficult to monitor<br>• Alternatives |
| MoDOT #1 Highway Advisory Radio | Eliminated | Eliminated HAR, except in a tunnel system location as required per the National Fire Protection Association (NFPA). Removed signs, turned off the broadcast, and removed infrastructure as a part of other roadway projects. | • Alternatives<br>• Usage and public input<br>• Aging equipment |
| WisDOT #1 Highway Advisory Radio | Eliminating | Removing HAR sites through attrition. | • Usage/motorist feedback<br>• Alternatives<br>• Access from vehicle<br>• Coverage |

| Agency and Case Study | Type of Change | Description of Change | Decision Factors |
|---|---|---|---|
| PennDOT #1a Highway Advisory Radio | Eliminating, reusing, repurposing | No longer installing new HAR sites. Converting in-place HAR signs to inform motorists of conditions being reported on 511 phone. During transition, reusing components from non-operational HAR devices to extend the life of other in-place devices. | • Access from vehicle<br>• Coverage<br>• Cost<br>• Safety<br>• Ability to track usage<br>• Other strategic considerations |
| MassDOT #3 Highway Advisory Radio | Phased out, repurposed | Phased out HAR for ongoing traveler information. Maintaining HAR systems at district offices to deploy for project-specific information (e.g. for trucker advisories on construction projects that impact freight movements.) | • Alternatives<br>• Access from vehicle |
| ODOT #3 Highway Advisory Radio | Phasing out, repurposing, reusing | Phasing out non-critical HAR locations and no longer deploying new HAR sites. Removing beacons from signs but leaving static signs in place, so motorists can tune into the broadcast if they desire. Salvageable parts are being used to support higher-priority HAR sites. | • Antiquated technology<br>• Coverage<br>• Alternatives<br>• Limited ITS budget |
| Caltrans #2 Highway Advisory Radio | Evolving | Maintaining HAR in rural areas and mountain passes with spotty cellular coverage. Migrated to digital HAR system to make remote access and management easier. Limited number of "Super HARs" used for better overall coverage. | • Perceived usage<br>• Safety<br>• Coverage<br>• Ease of operations and maintenance |
| DelDOT #3 Travel Advisory Radio | Evolved | Provides statewide travel advisories through "Travel Advisory Radio," an AM radio channel that uses synchronized transmitters for statewide coverage. | • Need for statewide coverage |

**Changes, Decision Factors, Tools, and Criteria for Highway Advisory Radio**

From review of these case studies, the following changes were noted:

- Eliminated or are phasing out HAR, especially permanent HAR sites
- Repurposing HAR sites from traditional radio broadcast to alternate uses

- During transition to phase out, reusing components from some HAR sites to extend the life of other in-place sites
- Retaining and improving HAR or other radio-based traveler information, to serve certain geographical areas or demographic groups

The main decision factors for eliminating or changing HAR were: coverage, access from vehicles, usage (primarily from anecdotal observations), motorist feedback, cost relative to benefits, and adequate or improved alternatives. Other factors included safety, maintenance/monitoring considerations, aging field devices, technology obsolescence, and overall efficiency.

Tools and resources used to help guide decision-making, as cited by agencies in the case studies, included:

- ***Motorist outreach:*** WisDOT utilized HAR to request input regarding the HAR service itself. A message was broadcast on HAR indicating that WisDOT was considering retiring the service and asking motorists to call a number to provide input on this potential change. Though a few responses were in favor of retaining HAR, most feedback indicated a low need for the service.

- ***Assessment of current and future conditions***: PennDOT conducted a field review of current HAR quality and assessed challenges with in-vehicle radios finding AM stations due to signal strength. In addition, consideration was given to the direction of future vehicles, which in some cases are no longer being equipped with AM radio. A cost saving analysis was also conducted.

Detailed criteria and applicable tools, organized by high-level decision factors for HAR, are summarized in Table 4. These detailed criteria and applicable tools were derived through review of information provided in each case study, and similar criterion were grouped together under high-level decision factors. These criteria are intended to assist agencies with identifying and navigating through multiple considerations while assessing HAR for potential changes.

***Table 4: Highway Advisory Radio - Detailed Criteria and Applicable Tools by High Level Decision Factors***

| High-Level Decision Factors | Detailed Criteria and Applicable Tools |
|---|---|
| Cost vs. Benefits | • Expenses due to ongoing maintenance issues with HAR sites<br>• Consideration of investment priorities, with available alternatives for traveler information<br>• Cost saving analysis with HAR elimination or evolution |
| Usage | • Anecdotal observations indicating diminishing HAR usage (e.g. no feedback from the public after phasing out HAR, increases in usage of other traveler information mechanisms)<br>• Anecdotal observations indicating HAR usage (e.g. usage by motorists who are not tech-savvy or upper age demographic) |
| Motorist Feedback | • Formal surveys or targeted requests for input from HAR users |
| Coverage/Access | • Declining access from vehicles, due to trend toward newer vehicles not being equipped with AM radio |

| High-Level Decision Factors | Detailed Criteria and Applicable Tools |
|---|---|
| | • Ability to decipher HAR broadcasts (e.g. static/ interference) where signal strength is low<br>• Access/coverage compared to other information mechanisms<br>– Limited broadcast range of AM radio; cellular coverage typically more available<br>– Consideration of HAR as primary means in rural areas and mountain passes where cellular coverage is spotty<br>• Field review of HAR coverage and quality<br>• Use of synchronized transmitters for increased coverage |
| Alternative(s) | • Use of portable HAR devices for special purposes (e.g. emergencies, construction sites, truck-specific information)<br>• Newer or better traveler information mechanisms in place:<br>– DOT-operated websites, social media, mobile apps, and on-road DMS<br>– Non-DOT mechanisms: radio/TV stations, third-party providers (Waze, Google), future in-vehicle technologies |
| Maintenance/ Monitoring | • Reliability of device components (e.g. flashing beacons)<br>• Reliability of communications to remote sites, to control beacons<br>• Difficulty in monitoring sites – inability to understand operability status and track usage<br>• Improved remote access and management with digital HAR system |
| Aging Devices/ Antiquated | • Equipment nearing end of life cycle<br>• Obsolescence due to declining use of AM radio by drivers |
| Safety | • Safety concerns with tuning to HAR station while driving, especially manual/dial tuning with low signal strength<br>• Distraction potential with various traveler information options:<br>– Some options considered less distracting than HAR (e.g. hands-free or one-touch access with voice activated commands for dialing, mobile apps)<br>– Some options considered more distracting than HAR (e.g. if touch dialing or maneuvering on smartphone) |

### 5.1.2 Traveler Information Phone Service

Traveler information phone service, often accessed by dialing 511, provides information about road-weather conditions, incidents, road construction, and other conditions that could impact motorist trips.

**Case Studies for Traveler Information Phone Service**

There were seven case studies documented related to traveler information phone service. The table below provides a list of these case studies. For each case study, the type of change is noted, along with a brief description of the change, and decision factors as described in the case studies. See Appendix A for the complete case study summaries.

*Table 5: Case Studies for Traveler Information Phone Service*

| Agency and Case Study | Type of Change | Description of Change | Decision Factors |
|---|---|---|---|
| KYTC<br>511 Phone Service | Eliminated | Discontinued 511 phone service in 2016. A state-run website and mobile traveler information partnership with WAZE are in place to provide traveler information. | • Usage<br>• Input from Motorists<br>• Cost |
| MoDOT #4<br>511 Phone Service | Eliminated | Discontinued 511 phone service available only in the St. Louis area. The service was initiated for a major construction project, funded through sponsorship ads with no direct cost to MoDOT. When the service was terminated, MoDOT was unable to find a vendor under the sponsorship model. | • Cost |
| IDOT<br>Statewide Traveler Information Phone Service | Eliminating | Shutting down the statewide traveler information phone service. During transition, the message directs callers to the website for traveler information. The service will soon be reduced to a voicemail box for callers to record roadway complaints which, with VoIP conversion, can be emailed to appropriate staff for follow up. | • Cost |
| NCDOT<br>511 Phone Service | Evolved | Discontinued the IVR-based feature and now provides information via a combination of live operators (utilizing inmates from a women's penitentiary) and recorded messages. | • Cost<br>• Efficiency<br>• Customer Satisfaction |
| MDOT SHA<br>511 Phone Service | Evolving | In 2017, Maryland DOT SHA changed its 511 phone service from an IVR system to a simple list of major events statewide. The agency is evaluating and considering sunsetting the telephone service, retaining web and social media, and developing a mobile app. | • Usage<br>• Customer Feedback<br>• Cost Savings<br>• Available Services / Alternatives<br>• Customer Base<br>• Maintenance<br>• Continuity of a Base Level of Service |
| PennDOT #1b<br>511 Phone Service | Evolving | Changing the IVR feature on 511 phone to broadcast region- | • Access from vehicle<br>• Coverage |

| Agency and Case Study | Type of Change | Description of Change | Decision Factors |
|---|---|---|---|
| | | specific messages and offer real-time access to information once the user initiates a call. Converting HAR signs to inform motorists of conditions being reported in 511. | • Cost<br>• Safety<br>• Ability to track usage<br>• Other strategic considerations |
| WisDOT #2<br>511 Phone Service | Replacing | Replacing the current 511 system with a new system that has greater functionality, is more user friendly, and includes all the features of the existing system. | • Alternatives<br>• Usage<br>• Cost<br>• Motorist feedback<br>• Equity |

**Changes, Decision Factors, Tools, and Criteria for Traveler Information Phone Service**

Case studies related to traveler information phone service highlight the following changes:

- Complete elimination of traveler information phone service (e.g. 511)
- Discontinuing Interactive Voice Response (IVR) system, replacing it with recorded messages, live operators, or region-specific messages generated from other traveler information sources
- Replacing 511 phone service as part of an upgrade to the statewide traveler information system

The main decision factors for making changes to traveler information phone service were: usage, cost, feedback from motorists, access/equity for various user groups, efficiency, and safety. Agencies that eliminated 511 phone service cited cost savings and declining usage as primary factors. Agencies that have retained the service but modified it from an IVR-based system indicated that the cost and complexity of IVR systems were at the forefront of the decision, but noted that phone access serves customers who may not use mobile apps or websites, and it could be less distracting than other mechanisms with hands-free dialing capabilities.

Tools used to help guide decision-making for traveler information phone service, as cited by agencies in the case studies, included:

- ***Usage Tracking*** - Several agencies track the number of calls into 511 phone service over time. For instance, PennDOT and WisDOT track the number of calls and the locations from which calls originate. Agencies often compare these usage statistics to other traveler information mechanisms, to help with investment decisions. KYTC noted a 40% decrease in 511 calls use over a two-year period, while visitors to the website and mobile app increased during the same period. Similarly, MDOT SHA indicated that calls to the 511 phone service dropped from approximately 60,000 per month in 2012 to approximately 10,000 per month in 2017.

- ***Motorist surveys*** – WisDOT is administering a public survey to motorists at rest areas to gather input for their next generation 511 system update, including gathering input on how motorists use the overall 511 system, including web and phone. Additionally, KYTC conducted a survey of

Kentucky drivers, which revealed that a majority obtain information through digital content providers such as Waze and Google.

Detailed criteria and applicable tools, organized by high-level decision factors for traveler information phone service, are summarized in Table 6. These detailed criteria and applicable tools were derived through review of information provided in each case study, and similar criterion were grouped together under high-level decision factors. These criteria are intended to assist agencies with identifying and navigating through multiple considerations while assessing traveler information phone service for potential changes.

***Table 6: Traveler Information Phone Service - Detailed Criteria and Applicable Tools by High Level Decision Factors***

| High-Level Decision Factors | Detailed Criteria and Applicable Tools |
|---|---|
| Usage | • Declining usage of 511 phone service – systematic tracking over time<br>– Number of calls, origination locations of calls, duration of calls<br>• Increased usage of other traveler information mechanisms (e.g. web, mobile app) compared to 511 phone service<br>• Focus on traveler information mechanisms that are most effective during high usage periods (e.g. weather events) |
| Cost | • Cost savings to discontinue 511 phone service altogether (or costs to continue)<br>• Cost savings to discontinue IVR-based system<br>– Often significant cost savings to discontinue IVR<br>– Compare to alternatives such as recorded messages, text to voice reports from Road Condition Reporting System, or live operators<br>– Considers complexity of various systems and resources to maintain<br>• Overall cost to operate and maintain multiple traveler information mechanisms<br>• Cost of 511 phone service relative to other mechanisms |
| Motorist Feedback | • Motorist surveys – to determine how motorists obtain information via DOT-operated services or 3rd party providers<br>• IVR usability (e.g. ability to understand voice commands, cumbersome menu options, voice recognition in noisy environments)<br>• Usefulness of information (e.g. minor incidents that don't impact traffic)<br>• Customer preferences (e.g. speaking to live operators or IVR) |
| Access/Equity | • Access to cellular service around the state is typically good<br>• Assessment of equity to various motorist populations, to access alternatives to 511 phone service |
| Efficiency | • Complexity of IVR based phone systems |
| Alternative(s) | • Emergence of private sector services for traveler information (e.g. Waze, Google maps, local media stations)<br>• More demographic sectors are looking for information though other media compared to voice-based telephone services (i.e. mobile apps)<br>• Continuity of service by maintaining phone service but discontinuing IVR |
| Safety | • Distraction potential with phone use while driving: |

| High-Level Decision Factors | Detailed Criteria and Applicable Tools |
|---|---|
| | – Minimized distraction with hands-free access via Bluetooth equipped vehicles and voice-activated phone capabilities<br>– Manual dialing could still be a concern<br>– Relatively safe compared to other mechanisms (e.g. touch-activated mobile apps, radio tuning for HAR) |

### 5.1.3 Traveler Information Websites and Mobile Apps

Traveler information websites and mobile apps are offered by many transportation agencies and third-party providers to share travel times, road-weather conditions, incidents, road construction, route guidance, and other relevant information.

**Case Studies for Traveler Information Websites and Mobile Apps**

Seven case studies were documented for traveler information websites and mobile apps. The table below provides a list of these case studies. For each case study, the type of change is noted, along with a brief description of the change, and the decision factors as described in the case studies. See Appendix A for the complete case study summaries.

***Table 7: Case Studies for Traveler Information Websites and Mobile Apps***

| Agency and Case Study | Type of Change | Description of Change | Decision Factors |
|---|---|---|---|
| Iowa DOT #2<br>511 3G Website | Discontinued component | Eliminated the 511 3G website that had been used for viewing 511 information on early edition mobile devices. | • Need for streamlined approach |
| MnDOT #2<br>511 3G Website | Discontinued component | Discontinued 511 3G website that was developed for viewing on early generation mobile devices, such as the Blackberry. | • Outdated/antiquated<br>• Improved alternative |
| Iowa DOT #1<br>511 Citizen Reporting Feature | Discontinued component | Eliminated the citizen reporting feature that allowed citizens to report road conditions for display on 511. | • Usage<br>• Did not achieve intended outcomes<br>• Cost vs. benefits<br>• Alternative in place |
| MnDOT #1<br>511 Citizen Reporting Feature | Discontinued component | Eliminated 511 citizen reporting feature that allowed citizens to report road conditions via a web-based platform. | • Usage<br>• Cost vs. benefits<br>• Improved alternative |
| WisDOT #3<br>Trip Routing Tool on 511 Website | Discontinuing component | Eliminating the trip routing tool (on the 511 website) that provides travel time information between two points because the system is not able to identify | • Motorist Feedback<br>• Alternatives in Place |

| Agency and Case Study | Type of Change | Description of Change | Decision Factors |
| --- | --- | --- | --- |
| | | detour routes during road closures. | |
| AKDOT&PF #1<br>4th Generation 511 System | Evolving, Discontinuing component | Evolving to a 4th generation 511 system to be more automated and easier to use on a mobile platform. Eliminating the "Text View" feature on the full 511 website. | • Enhanced usability from mobile devices<br>• Usage |
| MoDOT #2<br>Bypass Map Layer on Statewide Traveler Information Map | Evolving | Added a layer to the statewide traveler information map that generates pre-defined bypasses for incidents on interstates and major routes. Bypasses are viewable through a mobile app or desktop and provide directions to navigate around the incident. | • Improved traveler information<br>• Reduced incident clearance times and congestion |

**Changes, Decision Factors, Tools, and Criteria for Traveler Information Websites and Mobile Apps**

Case studies related to traveler information websites and mobile apps highlighted the following changes:

- Discontinued a component or feature, including:
  - Eliminated the 3G website, which was developed for use on early edition mobile devices
  - Discontinued various features, including citizen reporting capability for populating road conditions, a trip routing tool, and a text view feature
- Evolving traveler information websites and mobile apps for enhanced usability and functionality

The primary decision factors for evolving or phasing out traveler information systems (full systems or components) were: usage, performance (especially when compared to alternatives), justification of costs versus benefits, outdated/antiquated devices and systems, motorist feedback, enhanced usability, improved information, and efficiency.

Tools and resources used to help guide decision-making, as cited by agencies in the case studies, included:

- ***Web analytics services*** – Nearly all agencies reported using a web analytics service such as Google Analytics to track and report website traffic/visits on a regular basis. This usage information helps to guide decisions about future generations of 511 systems and overall investments.
- ***Market research*** - MnDOT has utilized results from an in-depth market research analysis, which included a survey of 511 users, to identify user preferences and usage habits.

Detailed criteria and applicable tools, organized by high-level decision factors for traveler information websites and mobile apps, are summarized in Table 8. These detailed criteria and applicable tools were derived through review of information provided in each case study, and similar criterion were grouped together under high-level decision factors. These criteria are intended to assist agencies with identifying and navigating through multiple considerations while assessing traveler information websites and mobile apps for potential changes.

***Table 8: Traveler Information Websites and Mobile Apps - Detailed Criteria and Applicable Tools by High-Level Decision Factors***

| High-Level Decision Factors | Detailed Criteria and Applicable Tools |
|---|---|
| Operational Need/Benefit | • Contribution to congestion reduction and/or safety (e.g. providing bypass information via enhanced website features reduces incident clearance times and backups) |
| Performance/ Alternative(s) | • Accuracy of alternative features or processes<br>• Timeliness of alternative features or processes<br>• Ability to provide more consistent information to motorists<br>• Assessment of performance against intended outcomes of various features<br>• Consideration of tools widely available to the public to disseminate traveler information (3rd party navigation apps) |
| Cost vs. Benefits | • Assessment of overall costs and benefits<br>– Considers initial development costs<br>– Considers staff time required to manage feature(s), set up user credentials, train users<br>– Considers whether benefits justify resources expended |
| Usage | • Usage of traveler information from various platforms<br>– Accessed from websites<br>– Accessed from mobile devices<br>• Usage of specific web pages and/or features by motorists<br>• Usage of features by other users (e.g. citizen reporters, DOT users reporting road conditions)<br>• Web analytics services (e.g. Google Analytics) to track and report traffic/visits to traveler information mechanisms |
| Antiquated Systems | • Understanding of current technologies to access websites and mobile apps; assessment of outdated devices and platforms |
| Motorist Feedback | • Market research to identify user preferences and habits<br>• Unsolicited input from motorists reporting inaccurate or incomplete information |
| Efficiency | • Streamlined websites/platforms to minimize resources required to manage |
| Usability/ Improved Information | • Usability from mobile devices – enhanced features, real-time access, ease of use on mobile platforms<br>• Ability for agency to provide unique information (e.g. compared to 3rd party traveler information apps) |

### 5.1.4 Signs and Traffic Control Devices

Signs and traffic control devices that have an ITS component (e.g. automated or dynamic features) are used by agencies to provide on-road information to motorists or to guide traffic.

## Case Studies for Signs and Traffic Control Devices

Eight case studies were documented for signs and traffic control devices. The table below provides a list of these case studies. For each case study, the type of change is noted, along with a brief description of the change, and the decision factors as described in the case studies. See Appendix A for the complete case study summaries.

***Table 9: Case Studies for Signs and Traffic Control Devices***

| Agency and Case Study | Type of Change | Description of Change | Decision Factors |
|---|---|---|---|
| AKDOT&PF #2 Decreased Use of Permanent Dynamic Message Signs in the Central Region | Evolving | Decreasing use of permanent DMS signs in the Central Region, with focus on use for traffic-related messages over public service messages. Planning to deploy portable DMS with capability to transmit locations/messages for automatic ingest into 511 systems. | • Usefulness of messages to drivers<br>• Streamlined operations<br>• Alternative |
| Iowa DOT #4 Dynamic Message Signs | Removing, relocating, reusing | Attempting to limit increase in the number of DMS statewide. As new high-priority sites are identified, a “cascading” strategy is used to identify sites for removal, replacement, or relocation. Parts from DMS near end of life are used to extend life of DMS in critical locations. | • Priorities for existing and proposed DMS sites<br>• Stage in equipment life cycle |
| ODOT #4 Selective Deployment of DMS | Evolving | Selectively deploying new DMS and replacing existing DMS. Replacing aging DMS in existing locations. | • Aging technology |
| WisDOT #5 Dynamic Message Signs | Relocating | Assessing the potential to relocate DMS to higher priority locations to ensure the best use of DMS for operational needs. | • Input from motorists<br>• Usage<br>• Local understanding of operational needs |
| PennDOT #2 Color Dynamic Message Signs | Evolving | Exploring uses for color DMS. Gathering input from TMC operators and districts; determining modifications to ATMS software/coding to control full-color DMS. | • Research-based design guidance<br>• Cost<br>• Input from DOT users |
| MnDOT #3 Intelligent Lane Control Signals (ILCS) in ATM System | Eliminated | Phased out ILCS that were part of an Active Traffic Management (ATM) system. ILCS were removed from operation after no noticeable crash reduction or congestion reduction was observed. | • High maintenance costs<br>• Justification of costs vs. effectiveness/benefits<br>• Alternative |

| Agency and Case Study | Type of Change | Description of Change | Decision Factors |
|---|---|---|---|
| Iowa DOT #5 Intersection Conflict Warning Systems | Removed, Evolved | Removed ICWS at two-way stop controlled, divided expressway intersections. Plan to add mainline warning to all in-place ICWS. | • Geometric modification<br>• Lessons learned from other states |
| Iowa DOT #6 Automated / Remotely Operated Interstate Gates | Eliminated | Eliminated the functionality to remotely operate interstate gates, now operated manually during intestate closures. | • Maintenance issues<br>• Alternative in-place |

**Changes, Decision Factors, Tools, and Criteria for Signs and Traffic Control Devices**

Case studies related to signs and traffic control devices primarily focused on:

- Limited or decreased deployment of DMS, often accompanied by a strategy to relocate functioning DMS to more critical locations or reuse device parts to extend the life of other DMS
- Evolving from mono-chromatic to full-color DMS
- Eliminating or evolving advisory signs and traffic control devices such as Intelligent Lane Control Signals, Intersection Conflict Warning Systems, and remotely operated interstate gates

The most common decision factors for changes to these devices were: operational need/usage, aging devices, operational impact, feedback from motorists, and cost. A trend toward decreasing DMS includes identifying high-priority placement locations and implementing relocation and reuse strategies. Elimination or evolution of advisory signs and traffic control devices is heavily based upon an assessment of benefits (e.g. congestion reduction, safety) compared to the cost to operate and maintain the devices.

Tools and resources used to help guide decision-making, as cited by agencies in the case studies, include:

- ***DMS placement scoring matrix*** – In 2018, Iowa DOT completed a DMS inventory using a scoring matrix to identify priorities for existing and proposed DMS sites. Criteria for the scoring matrix includes: 1) DMS location type (justification category); 2) traffic volumes; 3) crash history; 4) existing DMS usage history; and 5) Iowa DOT TMC staff value (TMC input). Each criterion was normalized into a 1-10 scale and each DMS location was assigned a score for each criterion, based on the 1-10 scale. Scores from the 5 criteria were weighted equally to arrive at a total score for each DMS location. Details on the scoring process and matrix can be found in the *Iowa DOT Intelligent Transportation Systems (ITS) and Communications Systems Service Layer Plan* (Iowa DOT, 2018). The agency plans to continue assessing DMS locations and usage on a regular basis. Figure 3 shows a partial screenshot of the Iowa DOT placement scoring matrix.

| | | | | | | Justification Categories | | | | | | Volumes | Crashes | DMS Usage | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 2 | 3 | 4 | 5 | Sum | Category Score | AADT Score | Crash Score | Usage Score | TMC Input | Overall Score |
| ID | TS ID | Route | Direction | MM | Location | 8 | 6 | 2 | 5 | | 20% | 20% | 20% | 20% | 20% | 100% |
| 1 | 2 | I-35 | SB | 88.4 | Corp Woods | 1 | 1 | 1 | 1 | 21 | 10 | 9 | 10 | 10 | 10 | 97 |
| Prop 19 | | I-35/80 | NB | 125.43 | US 6 | 1 | 1 | 1 | 1 | 21 | 10 | 10 | 8 | | 10 | 95 |
| 212 | 26 | I-35/80 | SB | 126.9 | Douglas | 1 | 1 | 1 | 1 | 21 | 10 | 10 | 9 | 9 | 9 | 94 |
| Prop 59 | | I-35/I-80 | WB | 129.1 | 86th Street | 1 | 1 | 1 | 1 | 21 | 10 | 9 | 8 | | 10 | 93 |
| 655 | 298 | I-35/I-80 | WB | 132.4 | Beaver | 1 | 1 | 1 | 1 | 21 | 10 | 8 | 9 | 10 | 10 | 93 |
| 23 | 37 | I-235 | WB | 2.65 | 17th St | 1 | 1 | 1 | 1 | 21 | 10 | 6 | 10 | 10 | 10 | 92 |
| 658 | 349 | I-235 | WB | 4.89 | Bogey | 1 | 1 | 1 | 1 | 21 | 10 | 6 | 10 | 10 | 10 | 92 |
| 4 | 4 | I-80 | WB | 139.56 | 4-Mile | 1 | 1 | 1 | 1 | 21 | 10 | 8 | 7 | 10 | 10 | 90 |
| 24 | 31 | I-235 | WB | 10.8 | Washington | 1 | 1 | 1 | 1 | 21 | 10 | 7 | 9 | 9 | 9 | 88 |
| Prop 60 | | I-235 | EB | 0.72 | 50th St | 1 | 1 | 1 | 1 | 21 | 10 | 9 | 8 | | 8 | 88 |
| 125 | 375 | I-35/80 | WB | 135.65 | 2nd Ave | | 1 | 1 | 1 | 13 | 6 | 8 | 10 | 10 | 10 | 87 |
| 45 | 355 | I-80 | EB | 454.5 | Spring Street | 1 | 1 | 1 | 1 | 21 | 10 | 6 | 9 | 9 | 9 | 86 |
| 25 | 99 | I-235 | WB | 13.15 | DM Broadway | | 1 | 1 | 1 | 13 | 6 | 7 | 9 | 10 | 10 | 84 |
| 76 | 347 | I-235 | WB | 7.5 | 19th St | | 1 | 1 | 1 | 13 | 6 | 6 | 10 | 10 | 10 | 84 |
| 657 | 300 | I-80 | WB | 141 | Between 65N and 65S | 1 | 1 | 1 | 1 | 21 | 10 | 6 | 10 | 8 | 7 | 82 |
| Prop 18 | 38 | I-35/80 | EB | 133.8 | NW 2nd Ave | | 1 | 1 | 1 | 13 | 6 | 8 | 9 | | 10 | 81 |
| 26 | 100 | I-235 | EB | 12.75 | Euclid | 1 | 1 | 1 | 1 | 21 | 10 | 7 | 7 | 8 | 8 | 80 |
| 211 | 36 | I-35/80 | EB | 124.57 | Hickman NB | | 1 | 1 | 1 | 13 | 6 | 10 | 4 | 10 | 10 | 80 |
| 69 | 96 | I-74 | EB | 2.5 | Duck Creek | 1 | 1 | 1 | 1 | 21 | 10 | 5 | 10 | 7 | 7 | 79 |
| 3 | 3 | I-80 | EB | 120.63 | Jordan Creek | 1 | 1 | 1 | 1 | 21 | 10 | 5 | 4 | 10 | 10 | 77 |
| Prop 13 | | I-80 | EB | 2.06 | Expressway Street | 1 | 1 | 1 | 1 | 21 | 10 | 7 | 9 | | 5 | 77 |
| 403 | 225 | I-74 | EB | 1.56 | Lincoln Road | 1 | 1 | 1 | 1 | 21 | 10 | 6 | 10 | 10 | 2 | 76 |
| 302 | 265 | I-29 | NB | 146.6 | SC Barb | 1 | 1 | | 1 | 19 | 9 | 3 | 8 | 9 | 9 | 76 |
| Prop 10 | | I-80 | EB | 0.2 | I-29 | 1 | 1 | 1 | 1 | 21 | 10 | 6 | 9 | | 5 | 75 |
| 653 | 296 | I-80 | EB | 122.2 | I-80 @ 60th | 1 | 1 | 1 | 1 | 21 | 10 | 7 | 7 | 4 | 8 | 72 |
| 63 | 248 | I-380 | NB | 18.37 | Wilson Ave | 1 | 1 | 1 | 1 | 21 | 10 | 5 | 8 | 5 | 8 | 72 |
| 218 | 19 | I-35/80 | SB | 124.72 | Hickman SB | 1 | 1 | 1 | 1 | 21 | 10 | 10 | 8 | 4 | 4 | 72 |
| 22 | 32 | I-235 | EB | 6.15 | 31st St | | 1 | 1 | 1 | 13 | 6 | 6 | 8 | 8 | 8 | 72 |
| Prop 20 | | I-35/80 | EB | 130.34 | I72nd Street | 1 | 1 | 1 | 1 | 21 | 10 | 8 | 1 | | 10 | 71 |
| 656 | 299 | I-235 | EB | 11.7 | Guthrie | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |

***Figure 3: Iowa DOT DMS Placement Scoring Matrix (partial screenshot)***

- ***Independent research studies***
  - While exploring the potential to evolve to full-color DMS, PennDOT commissioned a human factors study to evaluate the visibility and comprehensibility of various DMS message designs, with focus on full-color DMS for travel time displays and route displays. To compliment the research findings, PennDOT is gathering input from TMC operators and districts and exploring how the ATMS software/coding would need to be modified to control full-color DMS.
  - Intelligent Lane Control Signals (ILCS) have been evaluated through research that has studied the effectiveness of MnDOT's Active Traffic Management (ATM) System deployed on two major freeways in the Minneapolis-St. Paul metro area. Though ILCS used for advanced incident notification (e.g. crashes, roadwork, lane blockage) were found to be relatively effective in terms of drivers moving out of impacted lanes, no noticeable crash reduction was seen. ILCS that provided advisory speed limits were not found to result in crash reduction or congestion reduction.

Detailed criteria and applicable tools, organized by high-level decision factors for signs and traffic control devices, are summarized in Table 10. These detailed criteria and applicable tools were derived through review of information provided in each case study, and similar criterion were grouped together under high-level decision factors. These criteria are intended to assist agencies with identifying and navigating through multiple considerations while assessing signs and traffic control devices for potential changes.

*Table 10: Signs and Traffic Control Devices - Detailed Criteria and Applicable Tools by High-Level Decision Factors*

| High-Level Decision Factors | Detailed Criteria and Applicable Tools |
| --- | --- |
| Operational Need/Benefit | • Local understanding of operational needs<br>• Traffic volumes in vicinity of DMS placement<br>• Critical locations for DMS messaging<br>• Input from traffic operators regarding usefulness of DMS locations<br>• Input from traffic operators regarding feasibility and usage of full-color DMS<br>• Research on effectiveness in terms of impact on operations (e.g. congestion)<br>• Need for advanced/automated functionality |
| Alternative(s) | • Consideration of alternative to permanent DMS:<br>– Portable DMS that automatically transmit location and message info to 511 systems for real-time display to travelers<br>• Consideration of future alternative to on-road DMS:<br>– CAV technologies with in-vehicle messages about road/traffic conditions<br>• Increased frequency of DMS spacing as alternative to ILCS:<br>– More cost-effective than ILCS; more informative to motorists due to flexibility with type of messages that can be posted to DMS for multiple purposes |
| Cost vs. Benefits | • Justification of costs vs. effectiveness<br>– Considers capital, operations, maintenance costs<br>– Evaluates effectiveness in terms of crash reduction and mobility benefits<br>• Considers capital investment and additional features (e.g. no significant cost increase for full-color DMS, with additional benefit of multiple display options)<br>• Considers resources needed to update supporting systems, such as ATMS functionality to control full-color DMS or specialty signs/ATM systems |
| Usage | • Usage history (frequency, type of messages posted) for DMS locations |
| Maintenance | • Significance of maintenance resources for:<br>– Premature equipment failures<br>– Difficulty obtaining components with limited vendors<br>– Troubleshooting and repairing devices that often don't work properly |
| Aging Device/ Antiquated | • Existing devices stage in equipment life cycle<br>• Reuse of components to extend life of other devices<br>• Understanding of changing technologies<br>• Potential for DMS to become obsolete with increase in connected/automated vehicles |
| Motorist Feedback | • Public input noting blank DMS/lack of usage |
| Safety | • Crash history downstream of DMS placement<br>• Research on effectiveness in terms of crash reduction<br>• Lessons learned from other states, for less common devices such as ICWS |
| Efficiency | • Streamlined workflow for posting and removing messages |
| Improved Information to Motorists | • Accuracy/timeliness of messages - improved with fewer DMS to manage<br>• Usefulness to drivers, with DMS placed for traffic-related messages rather than general public service messages<br>• Human factors research to guide message designs for full color DMS – See *Evaluation of Colored VMS Boards* PennDOT research report |

| High-Level Decision Factors | Detailed Criteria and Applicable Tools |
|---|---|
| | • Understanding of the information that motorists can comprehend on a DMS |
| Combined Decision Factors | • Iowa DOT DMS Placement Criteria / Scoring Matrix - See *Iowa DOT Intelligent Transportation Systems (ITS) and Communications Systems Service Layer Plan* |

## 5.2 ITS Devices and Systems Primarily Used for Transportation Operations

The following ITS devices and systems are included in Category 2, where the primary use is for transportation operations:

- Traffic Detection (physical field detectors and probe data)
- Monitoring Devices (devices for monitoring road-weather and tunnel conditions)
- Traffic Cameras
- TMC Facilities and Operator Support (ATMS, video walls, and decision support tools)
- ITS Communications Systems (infrastructure and service providers)
- Agency-owned Devices and Software versus Service-based Solutions

The devices and systems in this category are used by traffic operators or other agency staff to manage transportation operations as a primary purpose. This includes physical facilities and supporting systems such as video walls and Advanced Traffic Management Systems (ATMS), as well as devices and infrastructure (e.g. monitoring devices, traffic data collection mechanisms, ITS communications infrastructure). Some of the devices and systems in this category, such as traffic cameras, also interface with motorists if they are connected to traveler information systems that display images or live video. However, the main purpose of these devices and systems is to support transportation operations.

### 5.2.1 Traffic Detection

Transportation agencies commonly use traffic detection to collect data such as traffic volumes, lane occupancy, speeds, and vehicle classifications. The resulting data is used for real-time operations and for planning, research, and analysis. Traffic detection collection mechanisms can include field detectors or probe data from third-party providers.

**Case Studies for Traffic Detection**

Eight case studies were documented for traffic detection. The table below provides a list of these case studies. For each case study, the type of change is noted, along with a brief description of the change, and the decision factors as described in the case studies. See Appendix A for the complete case study summaries.

*Table 11: Case Studies for Traffic Detection*

| Agency and Case Study | Type of Change | Description of Change | Decision Factors |
|---|---|---|---|
| ODOT #1: Radar Speed Detection Devices | Eliminated | Eliminated radar speed detection devices and now using third-party probe data. | • Cost<br>• Performance/Data quality<br>• Maintenance<br>• Alternative |
| MassDOT #1: Traffic Detection | Eliminated | Retired legacy loop detection system for real-time traffic operations. Using Bluetooth and pursing an agreement for third party traffic data. | • Maintenance<br>• Less disruption to operations<br>• Improved alternatives |
| PennDOT #4: Traffic Detection | Evolving | Procuring third-party real-time statewide speed data, with limited deployment of detection equipment. Vehicle detection equipment left in place for future Connected Vehicle applications. | • Effective resource allocation<br>• Operational needs and usage |
| MoDOT #3: Traffic Detection Devices | Evolving | Phasing out radar, Bluetooth, and Wi-Fi; transitioning to probe data. | • Cost (infrastructure and maintenance)<br>• Accuracy |
| Caltrans #3: Vehicle Detection | Evolving | Considering probe data to replace some field detector stations. | • Improved operability and data saturation<br>• Suitable alternative |
| ODOT #2: Loop Detection Devices for ITS Operations | Eliminated | Eliminated in-pavement loop detectors for ITS operations. Transitioned to non-intrusive detection devices. Considering traffic cameras with analytics capability rather than radar. | • Alternatives<br>• Maintenance |
| MTO #1: Vehicle Detection Stations | Removing, Evolving | Plans to remove 30-50% of vehicle detection stations and related equipment including in-pavement loop detectors. Installing non-intrusive devices such as radar, microwave and Bluetooth. | • Longer life cycle<br>• Less disruption to operations<br>• Alternatives<br>• Operational needs<br>• Maintenance cost and effort |
| DelDOT #5: Bluetooth Traffic Detection Devices | Evolved | Changed from portable, briefcase style Bluetooth devices to full trailer units, enabling real-time data collection. | • Improved capability |

**<u>Changes, Decision Factors, Tools, and Criteria for Traffic Detection</u>**

Case studies related to traffic detection revealed the following evolutions:

- Using or considering probe data to replace some or all physical field detectors

- Replacement of pavement intrusive devices (e.g. loop detectors) with non-intrusive devices such as radar, Bluetooth, or microwave
- Use of updated Bluetooth technology, to enable real-time data collection

The main decision factors for evolving traffic detection techniques included: improved performance (resulting in less disruption to operations), less maintenance, lower cost (or more effective resource allocation), adequate or improved accuracy, operational needs/usage, and adequate or improved alternatives.

Tools and resources used to help guide decision-making, as cited by agencies in the case studies, include:

- ***Performance management tools***: Caltrans uses the web-based Performance Measurement System (PeMS) to track the number and location of field detector stations that are operational/non-operational on an on-going basis. With only 70-75% of stations operational, this tool has helped to identify a potential need for improved data penetration.

- ***Data evaluation/validation:*** MoDOT has learned from work conducted by the I-95 Corridor Coalition, which has completed data validations comparing probe data to traffic data collected by more traditional methods, as part of the Vehicle Probe Project. On a smaller scale, MoDOT has completed its own validation that showed improved accuracy with probe data.

Detailed criteria and applicable tools, organized by high-level decision factors for traffic detection, are summarized in Table 12. These detailed criteria and applicable tools were derived through review of information provided in each case study, and similar criterion were grouped together under high-level decision factors.  These criteria are intended to assist agencies with identifying and navigating through multiple considerations while assessing traffic detection for potential changes.

***Table 12: Traffic Detection - Detailed Criteria and Applicable Tools by High-Level Decision Factors***

| High-Level Decision Factors | Detailed Criteria and Applicable Tools |
|---|---|
| Performance | • % up-time of field detectors<br>• Performance management tools (e.g. Caltrans Performance Measurement System (PeMS)- http://pems.dot.ca.gov/) to track operational status (% up-time) of field detectors<br>• Impacts to operations when field detectors are displaced<br>• Improved capabilities – such real-time data collection or use for multiple purposes (e.g. video analytics software for use of cameras for monitoring and traffic data collection)<br>• Coverage (e.g. probe data available in rural areas where field devices not deployed; spacing requirements for loops vs. Bluetooth for calculating travel times) |
| Maintenance | • Resources required to maintain or replace detectors displaced by roadwork or weather operations/snowplows<br>• Safety impacts, considering traffic control needed during maintenance or replacement of field detectors |

| | |
|---|---|
| Cost | • Cost comparisons:<br>– Traditional devices vs. probe data<br>– Intrusive devices vs. non-intrusive devices<br>• Includes costs for equipment, infrastructure such as communications, maintenance, and operations<br>• Considers life-cycle costs, including resources to maintain/replace devices to maintain sufficient operations |
| Accuracy | • Validation that lower-cost options are sufficiently accurate<br>• I-95 Corridor Coalition Vehicle Probe Project - data validation findings https://i95coalition.org/projects/vehicle-probe-project/ |
| Operational Needs/Usage | • Comprehensive review of traffic data needs - for uses such as travel times, traffic system algorithms, and reporting to FHWA<br>• Actual usage of traffic data |
| Alternatives | • Assessment of available alternatives (e.g. intrusive devices, non-intrusive devices, probe data) |

### 5.2.2 Monitoring Devices

Transportation agencies utilize monitoring devices to detect and communicate conditions that could impact motorist travel and safety. Data from these devices is used to monitor conditions, make appropriate operational or maintenance decisions, or provide related information to the traveling public.

**Case Studies for Monitoring Devices**

Two case studies were documented for monitoring devices. The table below provides a list of these case studies. For each case study, the type of change is noted, along with a brief description of the change, and the decision factors as described in the case studies. See Appendix A for the complete case study summaries.

***Table 13: Case Studies for Monitoring Devices***

| Agency and Case Study | Type of Change | Description of Change | Decision Factors |
|---|---|---|---|
| DelDOT #4: Non-Intrusive Weather Monitoring Devices | Evolving | Plans to deploy infrared monitoring devices to replace in-pavement "puck" sensors for detecting road-weather conditions (e.g. friction, ice, temperature.) Includes fixed devices and mobile devices mounted to maintenance vehicles. | • More robust operations<br>• Overall cost<br>• Accuracy<br>• Better coverage (with mobile units) |
| MassDOT #4: Tunnel Monitoring Technologies | Evolving | Considering a new technology that analyzes digital camera images to detect flames or smoke, rather than using linear heat detectors for fire monitoring in tunnels. These cameras, if equipped with analytics, | • Maintenance and operations<br>• Efficient use of cameras for multiple purposes |

| Agency and Case Study | Type of Change | Description of Change | Decision Factors |
|---|---|---|---|
| | | could also be used to detect traffic incidents and congestion in tunnels. | |

**<u>Changes, Decision Factors, Tools, and Criteria for Monitoring Devices</u>**

Case studies in this group focused on implementing newer, innovative technologies for detecting and monitoring various conditions:

- Non-intrusive road weather monitoring (e.g. friction, ice, temperature)
- Tunnel fire monitoring technologies (e.g. flames, smoke, heat)

The main decision factors for evolving these devices were: improved performance (better coverage, more robust operations), less maintenance, lower cost, improved accuracy, and improved efficiency.

Tools and resources used to help guide decision-making, as cited by agencies in the case studies, include:

- ***Pilot testing:*** Based on positive results with pilot testing of infrared devices for detecting road weather conditions, DelDOT plans to move forward with deploying non-intrusive sensors to replace in-pavement "puck" detectors throughout the state.
- ***Continual assessment of emerging technologies:*** MassDOT cited a practice in which they routinely evaluate ITS infrastructure needs and consider new technologies to support traditional ITS systems and their extensive tunnel system.

Detailed criteria and applicable tools, organized by high-level decision factors for monitoring devices, are summarized in Table 14. These detailed criteria and applicable tools were derived through review of information provided in each case study, and similar criterion were grouped together under high-level decision factors. These criteria are intended to assist agencies with identifying and navigating through multiple considerations while assessing monitoring devices for potential changes.

***Table 14: Monitoring Devices - Detailed Criteria and Applicable Tools by High- Level Decision Factors***

| High-Level Decision Factors | Detailed Criteria and Applicable Tools |
|---|---|
| Performance | • Continual evaluation of new devices/technologies<br>• Pilot testing of new technologies, to verify performance<br>• % up-time of field devices<br>• Operational impacts when field detectors are displaced<br>• Coverage (e.g. mobile units for road-weather data collection cover more area than in-pavement field detectors) |
| Maintenance | • Resources required to maintain or replace detectors displaced by roadwork or weather operations/snowplows |
| Cost | • Cost comparisons, including equipment, infrastructure such as communications, maintenance, and operations<br>• Consideration of resources required to maintain/replace devices to maintain sufficient operations |

| High-Level Decision Factors | Detailed Criteria and Applicable Tools |
|---|---|
| Accuracy | • Validation that lower-cost, lower maintenance options are sufficiently accurate<br>• DelDOT pilot study (*report pending publication*) - Evaluated accuracy of (non-intrusive) infrared road-weather sensors against pavement-intrusive "puck" sensors and found non-intrusive devices to produce accurate data |
| Efficiency | • Use of devices for multiple purposes – e.g. video analytics software to use traffic cameras for tunnel monitoring and incident detection |

### 5.2.3 Traffic Cameras

Traffic cameras are a key tool used by traffic operators to view and monitory traffic and related road conditions in real-time. In some agencies, they are also used to feed traveler information systems that display images or video streams to the public.

**Case Studies for Traffic Cameras**

The two case studies documented for traffic cameras. The table below provides a list of these case studies. For each case study, the type of change is noted, along with a brief description of the change, and the decision factors as described in the case studies. See Appendix A for the complete case study summaries.

***Table 15: Case Studies for Traffic Cameras***

| Agency and Case Study | Type of Change | Description of Change | Decision Factors |
|---|---|---|---|
| Caltrans #4: Traffic Cameras | Evolving | Upgrading from analog to digital traffic cameras, to accommodate distribution of live video streaming and .jpg images. | • Enhanced information to motorists |
| MassDOT #2: Analog to Digital Traffic Cameras | Evolving | Replacing analog cameras with digital cameras, to eliminate the need for point to point wiring and to allow for capturing video. | • Antiquated technology<br>• Efficient deployment and operations<br>• Increased functionality<br>• Cost |

**Changes, Decision Factors, Tools, and Criteria for Traffic Cameras**

Both case studies related to traffic cameras noted a conversion from analog cameras to digital cameras.

Decision factors contributing the change from analog to digital cameras were: increased functionality (i.e. enhanced information to motorists and traffic operators by enabling live video streaming), need to upgrade an technology, cost, and more efficient deployment and operations.

There were no specific tools noted to help guide agency decisions around converting traffic cameras from analog to digital technology.

Detailed criteria, organized by high-level decision factors for traffic cameras, are summarized in Table 16. These detailed criteria were derived through review of information provided in each case study, and similar criterion were grouped together under high-level decision factors. These criteria are intended to assist agencies with identifying and navigating through multiple considerations while assessing traffic cameras for potential conversion from analog to digital technology.

***Table 16: Traffic Cameras - Detailed Criteria by High-Level Decision Factors***

| High-Level Decision Factors | Detailed Criteria |
|---|---|
| Performance | • Ability to provide video streaming and .jpg images - enhanced information to motorists and traffic operators |
| Antiquated Technology | • Need to replace antiquated devices (analog cameras) with updated technology (digital cameras) |
| Cost | • Cost comparison: analog vs. digital cameras<br>• Includes costs for equipment, infrastructure such as communications, maintenance, and operations<br>• Considers need for costly analog to digital converters when leaving analog cameras in place |
| Efficiency | • Ease of deployment (digital cameras eliminate need for point to point wiring; ability to tap into in-place communications network rather than installing long runs of analog connectivity)<br>• Flexibility for multiple applications (digital cameras can use 5G protocol) |

### 5.2.4 TMC Facilities and Operator Support

The facilities and tools used by traffic operators on a daily basis to monitor conditions, control field devices, respond to incidents, and provide messages to the traveling public are critical to overall transportation operations.

**Case Studies for TMC Facilities and Operator Support**

There were nine case studies documented for TMC facilities and operator support. The table below provides a list of these case studies. For each case study, the type of change is noted, along with a brief description of the change, and the decision factors as described in the case studies. See Appendix A for the complete case study summaries.

***Table 17: Case Studies for TMC Facilities and Operator Support***

| Agency and Case Study | Type of Change | Description of Change | Decision Factors |
|---|---|---|---|
| PennDOT #3: Conversion of a TMC into an Incident Command Center for Emergency Operations | Evolved | Modifying a TMC into an Incident Command Center for winter storms and other emergency operations. Changing the existing videowall to a lower cost alternative created from eight, 43” monitors. | • Cost<br>• Operational needs |
| Caltrans #5: TMC Video Walls | Evolving | Transitioning many of its TMC video walls from analog to digital. | • Improved efficiency and flexibility |

| Agency and Case Study | Type of Change | Description of Change | Decision Factors |
|---|---|---|---|
| | | | • Ease of operations and maintenance |
| Caltrans #1:<br>ATMS Software | Replacing | Upgrading ATMS software. Plans to replace it with a statewide ATMS that will use open source software developed by another state DOT. | • Maintenance/updates<br>• Outdated hardware<br>• Increased capabilities |
| ODOT #7:<br>Upgrade ATMS Software | Replacing | Procuring new ATMS software for statewide use. This will replace older software that was developed internally by ODOT staff. | • Resources to update older software<br>• Improved technology/ functionality |
| WisDOT #4:<br>Advanced Traffic Management System | Replaced | Phased out a 25-year old ATMS and implemented a new system with enhanced features such as decision support and the ability to conduct corridor management. | • Antiquated system<br>• Need for advanced features<br>• Compromises |
| MassDOT #5:<br>DMS Management System | Eliminated | Retired DMS management system that was more than 20 years old; replaced it with a multi-functional ATMS. | • Antiquated/outdated<br>• Alternative<br>• Increased efficiency |
| MTO #4:<br>Central Software ATMS to Field-based “Field Traffic Master” | Evolving | Transforming ATMS components and functions from a central software system into portable, scalable, and secure software system in the field. | • Operations/maintenance costs<br>• Efficient integration<br>• Rapid deployment |
| MTO #3:<br>CCTV Video Streaming On-Demand | Evolving | Considering streaming video from CCTV cameras “on-demand” rather than continuous streaming, for traffic operations. Using artificial intelligence (AI) logic to correlate events to on-demand streaming -- as operators enter an incident location, nearby cameras become available for streaming. | • Cost/Resources<br>• Energy footprint<br>• Operational needs |
| MTO #5:<br>Automated DMS Signing Strategy for Road Closures | Evolving | Replacing manual decision-making by traffic operators with an automated signing strategy application to determine road closure messages for DMS. | • Efficiency<br>• Consistency of signing strategies<br>• Accuracy of DMS messages |

**Changes, Decision Factors, Tools, and Criteria for TMC Facilities and Operator Support**

Case studies related to Traffic Management Center (TMC) facilities and operator support focused on various facets of TMC functions to support operators with traffic operations tasks, including:

- Lower-cost configurations and updated technologies for TMC video walls

- Major upgrades or replacement of ATMS systems and DMS management software
- Transforming central ATMS functions into portable field units
- Replacing or supplementing manual tasks with automated tools for TMC operator support (e.g. on-demand video streaming and automated decision support for DMS signing strategy)

The main decision factors for making changes to TMC facilities and operator support were: changing operational needs; enhanced features; need to replace antiquated technologies; lower costs (equipment and maintenance); improved efficiency; and improved traffic operations services.

A specific approach that guided decision-making, as noted in the case studies, included:

- ***Cost and Operational Needs Analysis*** – When PennDOT converted one of its district TMCs to an Incident Command Center (ICC) for winter storms and other major emergencies, they decommissioned the in-place videowall and replaced it with a lower-cost configuration of eight, 43" monitors. During the decision-making process, PennDOT completed a cost analysis of enhancements that would have been needed to upgrade existing videowall software; ensured they had a full understanding of operational needs during ICC activations; and acknowledged the department's emphasis on continual improvement of winter operations.

Detailed criteria and applicable tools, organized by high-level decision factors for TMC facilities and operators support, are summarized in Table 18. These detailed criteria and applicable tools were derived through review of information provided in each case study, and similar criterion were grouped together under high-level decision factors. These criteria are intended to assist agencies with identifying and navigating through multiple considerations while assessing TMC facilities and operator support mechanisms for potential changes.

***Table 18: TMC Facilities and Operator Support - Detailed Criteria and Applicable Tools by High-Level Decision Factors***

| High-Level Decision Factors | Detailed Criteria and Applicable Tools |
|---|---|
| Performance | • Improved functionality (e.g. upgraded ATMS with features such as messaging plans, alternate routes, wrong-way driving detection, integration with third-party data)<br>• Improved robustness of updated systems, resulting in less impact on operations<br>• Improved consistency and accuracy with automated support tools |
| Cost | • Cost comparisons – includes equipment, infrastructure such as communications, maintenance, and operations<br>• Deployment cost (e.g. computer/monitors configuration is significantly lower cost than full videowall)<br>• Cost and operational needs analysis – gather information to fully understand the operational needs when identifying costs and making cost comparisons<br>• Operation and maintenance costs - especially systems that run in complex environments or devices/systems with high bandwidth requirements |
| Efficiency | • Potential to leverage ATMS software and modules already developed by other states<br>• Integration efficiency and flexibility with related systems |

| High-Level Decision Factors | Detailed Criteria and Applicable Tools |
|---|---|
| | • Reduction in energy footprint (e.g. on-demand video streaming vs. continuous streaming)<br>• Increased operator efficiency with automated support tools<br>• Ability to streamline multiple functions with a single system vs. multiple platforms<br>• Ability to deploy rapidly (e.g. ATMS field units) |
| Maintenance | • Ease of maintenance (e.g. updates to ATMS software code) |
| Operational Need/Benefit | • Operational uses and need for advanced capabilities, for example:<br>– Lower-cost computer/monitors setup is adequate for emergency operations vs. full TMC operations<br>– Constant video streaming does not offer enhanced situational awareness, as operators can't manually monitor hundreds of cameras simultaneously |
| Antiquated Technology | • Limitations of outdated hardware or software<br>• Robustness of outdated systems<br>• Systems that are reaching end of life cycle |

### 5.2.5 ITS Communications Systems

ITS communications infrastructure and services are used to transfer data between field devices and traffic management systems. In addition, agencies are increasingly implementing new (or revising existing) infrastructure to support emerging technologies and systems.

**Case Studies for ITS Communications Systems**

There were five case studies that focused on ITS communications systems. The table below provides a list of these case studies. For each case study, the type of change is noted, along with a brief description of the change, and the decision factors as described in the case studies. See Appendix A for the complete case study summaries.

***Table 19: Case Studies for ITS Communications Systems***

| Agency and Case Study | Type of Change | Description of Change | Decision Factors |
|---|---|---|---|
| DelDOT #1: Communications Systems | Evolving | Transitioning from copper to fiber for backbone communications. Upgraded wireless communications from 220 MHz to 900 MHz and is now migrating to 4.9 GHz. | • Bandwidth requirements<br>• Technology evolution<br>• Expanded coverage |
| ODOT #5: Communications for ITS Devices and Operations | Evolving | Updating communications infrastructure to newer technologies. Replaced dial up modems with cellular. Converting T1 lines to ethernet or fiber. Replacing serial radio with high-speed ethernet wireless point to point radio. | • Cost<br>• Performance |

| Agency and Case Study | Type of Change | Description of Change | Decision Factors |
|---|---|---|---|
| AKDOT&PF #3: Communications for Traffic Signals and Connected Vehicles | Evolving | Moving away from copper wiring for traffic signal systems and connected vehicle communications. Decreasing use of 900 MHz radio and some WiFi. Supplementing existing communications with 4G LTE, 5G, or DSRC to accommodate future needs for connected vehicles and adaptive signal control. | • Decreased reliance on copper wiring infrastructure<br>• Evolving needs for signal systems and CAV infrastructure<br>• Cost |
| MTO #2: Fiber to Wireless Communication for Control of DMS | Evolving | Changing from fiber to wireless for controlling some DMS. Prior policy had been to install fiber with new roadway construction; now asses each situation on a case-by-case basis, based on operational needs. | • Accelerated deployment of DMS<br>• Cost/resources<br>• Simplified maintenance<br>• Improved performance |
| ODOT #6: Transition Communications Provider Services to FirstNet | Evolving | Transitioning some ITS devices to the First Responder Network Authority (FirstNet) communications network. | • Cost<br>• Simple conversion |

**Changes, Decision Factors, Tools, and Criteria for ITS Communications Systems**

Case studies related to ITS communications systems revealed common evolutions as follows:

- Transitioning from traditional communications (e.g. copper wiring, T1) to newer technologies (e.g. high-speed ethernet, fiber, cellular, Wi-Fi, point-to-to point radio) for ITS devices
- Implementing 4G LTE, 5G, or DSRC to accommodate future needs for connected vehicles and advanced signal systems
- Changing from fiber to wireless for controlling DMS
- Moving ITS devices to the First Responder Network Authority (FirstNet) communications network

The main decision factors for evolving communications infrastructure were: improved performance (e.g. bandwidth, latency, reliability), lower and more stable costs, improved efficiency, simplified maintenance, ability to meet current and future operational needs, decreased reliance on aging/antiquated infrastructure, and better coverage.

There were no specific tools noted to help guide agency decisions for these case studies.

Detailed criteria, organized by high-level decision factors for ITS communications systems, are summarized in Table 20. These detailed criteria tools were derived through review of information provided in each case study, and similar criterion were grouped together under high-level decision factors. These criteria are intended to assist agencies with identifying and navigating through multiple considerations while assessing communications systems for potential changes.

*Table 20: Communications Infrastructure - Detailed Criteria by High-Level Decision Factors*

| High-Level Decision Factors | Detailed Criteria |
|---|---|
| Performance | • Bandwidth requirements<br>• Latency requirements<br>• Security requirements<br>• Increased speed for data transfer<br>• Increased reliability<br>• Up-time of devices, improved with less dependence on aging communications infrastructure |
| Cost | • Cost comparisons among various communications mechanisms:<br>– Considers capital investment and simplified maintenance<br>– Considers operational needs and performance advantages<br>– Considers cost of supporting services to ensure security<br>– Considers cost of devices plus monthly service fees<br>• Stability of ongoing costs, less likely to fluctuate over time |
| Efficiency | • Ease of conversion (e.g. with FirstNet, where in-place modems are supplied by AT&T, FirstNet's service provider)<br>• Accelerated deployment of ITS devices |
| Maintenance | • Simplified diagnostics and repair |
| Operational Need | • Need to support adaptive signal systems (increased bandwidth)<br>• Need for comm's infrastructure to support CAV operations (short-range, low latency, increased bandwidth) |
| Antiquated Technology | • Decreased reliance on older infrastructure such as copper wiring<br>• Need for upgraded communications capabilities to support newer field devices with expanded features |
| Coverage | • Need for increased communications coverage area to support improved and expanded field devices |

### 5.2.6 Agency-owned Devices and Software versus Service-based Solutions

Transportation agencies are continually faced with decisions regarding procurement, purchase, ownership, operations, and maintenance of various ITS devices, systems, and software. Though many agencies may operate under both in-house ownership and outsourcing models depending on the device or system, some agencies may be moving toward one model or the other for specific applications or as an overall agency philosophy.

**Case Studies for Agency-owned Devices and Software versus Service-based Solutions**

There were three case studies that focused on a preference toward either agency-owned devices or service-based solutions. The table below provides a list of these case studies. For each case study, the type of change is noted, along with a brief description of the change, and the decision factors as described in the case studies. See Appendix A for the complete case study summaries.

*Table 21: Agency-owned Devices and Software versus Service-based Solutions*

| Agency and Case Study | Type of Change | Description of Change | Decision Factors |
|---|---|---|---|
| MTO #6: Transition from Agency-owned ITS Systems to Service-based Solutions | Evolving | Transitioning from agency-owned ITS devices and systems to service-based solutions. Procured a service-based queue warning system and determining procurement methods for service-based ITS solutions. | • Efficient use of resources |
| WisDOT #6: Build Fleet of Temporary ITS Devices | Evolving, Reusing | Building a fleet of temporary ITS devices (e.g. cameras, DMS) by purchasing devices for construction projects and reusing them on future projects. WisDOT supplies the devices to the construction contractor for deployment and operation during construction. | • Minimal disruption to ITS services<br>• Efficient use of resources |
| DelDOT #2: Software Systems for TMC Operations and Traveler Information | Evolving | An in-house software development team has developed most software systems for TMC operations and traveler information, rather than purchasing "off the shelf" software. | • Performance<br>• Efficiency |

__Changes, Decision Factors, Tools, and Criteria for Agency-owned versus Service-based Solutions__

Case studies related to agency-owned devices and software vs. service-based solutions included:

- Transitioning from agency-owned ITS devices and systems to service-based solutions, for various applications and technologies
- Building a fleet of agency-owned temporary ITS devices for construction projects, rather than use of contractor-supplied temporary ITS devices
- In-house ITS software development and use, as opposed to procuring off-the-shelf software

The main decision factors for these changes were largely attributed to better performance and improved efficiency. Two different agency philosophies were noted, including an agency that noted a trend toward procuring ITS system solutions rather than owning and operating them, a preference for in-house software development, and an evolution to build a fleet of temporary ITS equipment in-house. In each case, the agencies indicated efficiencies for their chosen approach.

There were no specific tools noted to help guide decision-making for these case studies.

Detailed criteria, organized by high-level decision factors for agency-owned versus service-based solutions, are summarized in Table 22. These detailed criteria were derived through review of information provided in each case study, and similar criterion were grouped together under high-level decision factors. These criteria are intended to assist agencies with identifying and navigating through multiple considerations while assessing agency-owned versus service-based solutions for potential changes.

*Table 22: Agency-owned versus Service-based Solutions - Detailed Criteria by High Level Decision Factors*

| High-Level Decision Factors | Detailed Criteria |
|---|---|
| Performance | • Historical experience with "off-the-shelf" software not performing as expected<br>• Better customization with in-house software development<br>• Minimized disruption to ITS operations and services with agency-owned temporary ITS field devices |
| Efficiency | • Streamlined system delivery, operations, maintenance by contractor, with less internal agency handoffs for planning, design, deployment, oversight<br>• Agency staffing constraints<br>• Seamless continuation of ITS operations during roadwork activities, with agency-owned temporary devices<br>• Streamlined initial development and updates with in-house software<br>• Ease of integration and streamlined security protocols with in-house software |

# 6.0 Planning and Management Tools and Approaches

In addition to the device-specific and system-specific tools documented in Section 5, the case studies also documented several overarching planning and management tools and approaches used by agencies at a "program" level, to plan for and manage ITS devices and systems. These tools and approaches were grouped into similar categories (e.g. statewide ITS and TSMO planning, asset management) and are summarized in this section. See Appendix A for the full case study summaries.

Table 23 shows the Planning and Management Tools and Approaches as documented in the case studies.

***Table 23: Planning and Management Tools and Approaches***

| Categories | Planning and Management Tools and Approaches |
|---|---|
| Statewide ITS and TSMO Planning | • Regional Operations Plans (PennDOT)<br>• Transportation Systems Management and Operations Traffic Infrastructure Process (WisDOT)<br>• GIS Application for TSMO Planning (PennDOT)<br>• Comprehensive Systems Engineering Process (MassDOT)<br>• Overarching Criteria and Considerations (MTO) |
| Asset Management | • Asset Management Planning (MoDOT)<br>• Transportation Management System (TMS) and other Asset Tracking Tools (MoDOT)<br>• Asset Management Software (WisDOT) |
| Strategic Technology Obsolescence Planning | • ITS Device Obsolescence and Modernization Planning (Michigan DOT)<br>• Antiquated ITS Devices Effort (PennDOT)<br>• ITS Device Replacement Planning (ODOT)<br>• Device Consistency (ODOT)<br>• Continual Evaluation of ITS Technology Needs (MassDOT) |
| Organizational and Agency Philosophy Approaches | • Centrally Located ITS Function within DOT (ODOT)<br>• IT Services Integrated within ITS Office (ODOT) |
| Motorist Input | • Customer Surveys and Motorist Feedback (WisDOT)<br>• "Grassroots" Customer Feedback (DelDOT) |

## 6.1 Statewide ITS and TSMO Planning

The following statewide ITS and TSMO planning approaches and tools were cited by agencies as means to help guide decision-making for evolving or phasing out ITS devices and systems:

- ***Regional Operations Plans***: PennDOT is developing Regional Operations Plans (ROPs) for each of their four RTMC regions (TSMO Regions) across the state. These plans will be used to identify projects for future grant opportunities as well as future operations and maintenance costs. The Central Region's ROP, which is the most recently updated of the four regions, contains a detailed analysis of regional transportation needs and operational issues, with a prioritized list of projects (often including ITS infrastructure improvements) for short-term and long-term implementation.

- ***TSMO-TIP:*** WisDOT, in partnership with the University of Wisconsin Traffic Operations and Safety (TOPS) Laboratory, designed and implemented the Transportation Systems Management and Operations Traffic Infrastructure Process (TSMO-TIP) to review and assess the state's TSMO infrastructure system. The [TSMO-TIP] is a web-based application that consists of a Needs Analysis Tool and a Benefits Tool to assist with project development and to provide a consistent, transparent process to prioritize TSMO investment priorities for the most benefit and advancement. The TSMO-TIP flowchart in Figure 4 shows detailed tasks for the TSMO-TIP process.

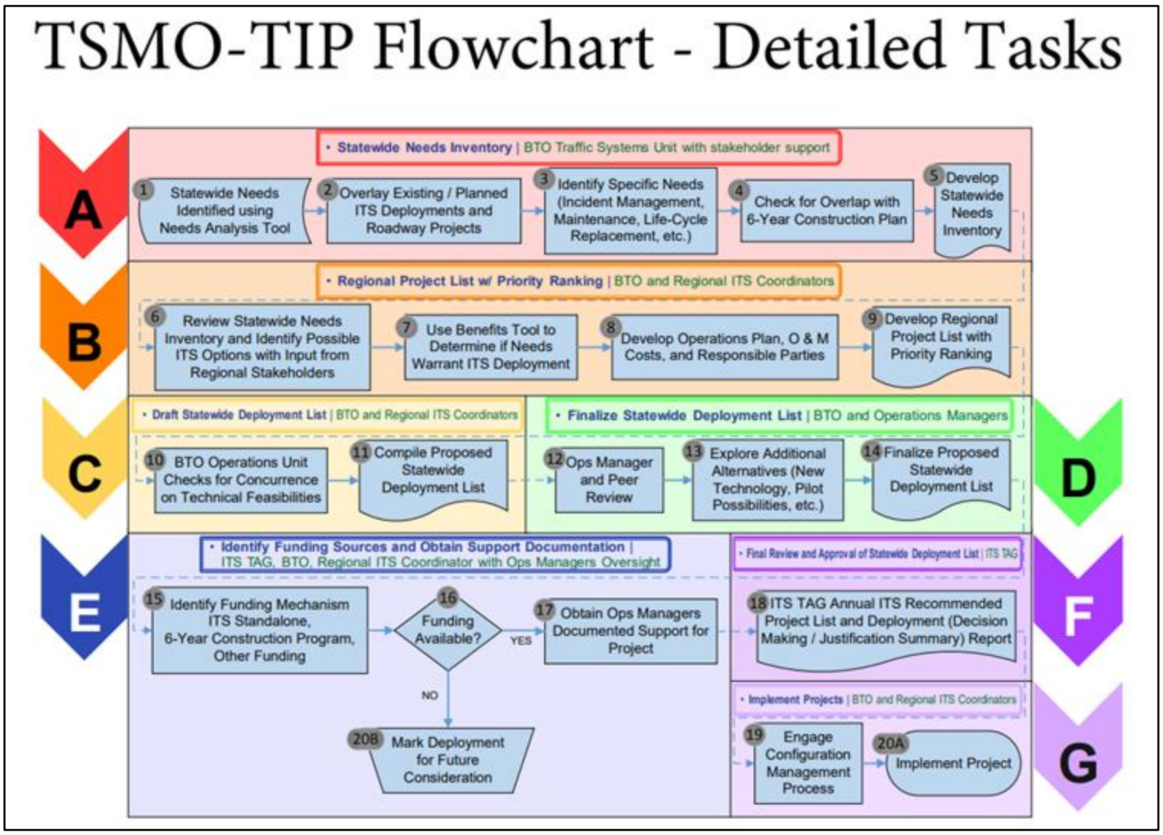


***Figure 4: Wisconsin DOT TSMO-TIP Flowchart***

- ***GIS Application for TSMO Planning:*** PennDOT developed a GIS web application (OneMap) so that information such as ITS device locations, congestion information, and crash data can be combined for better visualization and analysis.

- ***Comprehensive Systems Engineering Process:*** When the former Massachusetts Highway Department, Turnpike Authority, and Port Authority merged in 2009, MassDOT inherited ITS and tunnel monitoring systems from each of these agencies. Up to 50 systems and subsystems were in place to access signs, cameras, sensors, and other ITS field equipment. In 2012, MassDOT initiated a systems engineering effort to integrate these systems. A unique aspect of this integration effort is an urban tunnel system which requires monitoring of CO levels, ventilation, and other facility life-safety systems.

- ***Overarching Criteria and Considerations:*** Ontario Ministry of Transportation (MTO) evaluates the depreciation of equipment and systems based on the following considerations and requirements:
  - End of life cycle device/system
  - Arrival of new technologies
  - Obsolete business needs and depreciated technologies
  - Streamline and simplify deployment, operations, and maintenance (agile systems engineering process)
  - Reduce Energy Footprint and operations/maintenance costs
  - Accelerating and rapid deployment

## 6.2 Asset Management

The following asset management planning and tools were cited by agencies as means to help guide decision-making for evolving or phasing out ITS devices and systems:

- ***Asset Management Planning***: MoDOT is focusing on asset management planning in two phases:
  - Phase 1 – Roads and bridges
  - Phase 2 – Mobility assets including ITS devices

  This asset management planning effort will improve the reliability of ITS device inventory information and help MoDOT proactively plan for replacements. This, in turn, will lessen budget impacts by spreading out investments over time and help to make better long-term decisions.

- ***Transportation Management System (TMS) and other Asset Tracking Tools:*** MoDOT has created an internal transportation management system (TMS) that includes a set of tools and a database to enter and store information about assets including installation dates and components. Some third-party tools are used for ITS and department-wide assets as well.

- ***Asset Management Software:*** WisDOT is upgrading its asset management software, which could be a useful evaluation tool for life cycle management of ITS devices and systems.

## 6.3 Strategic Technology Obsolescence Planning

The following strategic technology obsolescence planning strategies and tools were cited by agencies as approaches to help guide decision-making for evolving or phasing out ITS devices and systems:

- ***ITS Device Obsolescence and Modernization Planning:*** Michigan DOT has initiated an effort to create a 5-year ITS Device Modernization Plan (DMP). MDOT's current practice is to repair or replace ITS devices based on periodic inspections. The new ITS DMP will implement a proactive approach to planning, and will evaluate all ITS devices, environmental sensor stations (ESS), and connected and automated vehicle (CAV) devices that have reached a state of technical obsolescence and/or a high probability of failure over the next 5-10 years. Maintenance of the ITS DMP will include an annual evaluation of ITS devices for state of the practice, device maintenance history, and device technological characteristics. The annual evaluation will also involve determining device value to the motoring public and recommend device removal. MDOT's initial ITS Device Modernization Plan is expected to be complete by the end of 2019.

- ***Antiquated ITS Devices Effort:*** PennDOT has instituted a framework for addressing antiquated ITS devices. The framework defines "The Five Rs of ITS Device Maintenance" – Repair, Refurbish, Replace, Relocate, and Remove. This guidance is used to assess options for in-place devices and guide investment decisions. Appendix B shows PennDOT's "Five Rs of ITS Device Maintenance."

- ***ITS Device Replacement Planning:*** ODOT requires a 5-year warranty on ITS device purchases. As a result, each device is assessed at the end of the warranty period and devices are routinely replaced with the same or improved technologies. This significantly reduces the need to repair and maintain obsolete technologies. With limited resources for ITS, ODOT regularly assesses the overall system to help make investment decisions.

- ***Device Consistency:*** ODOT deploys consistent types of ITS devices. For example, they primarily utilize one DMS vendor and have deployed only 4-5 different types/models of cameras. This allows staff to build expertise with installation and maintenance, limits the need for training on several types of devices, and improves interoperability.

- ***Continual Evaluation of ITS Technology Needs:*** MassDOT routinely evaluates its ITS infrastructure needs and considers new technologies to support both its traditional ITS systems and extensive tunnel system. As technologies near end-of-life, funding is allocated to update and replace obsolete technologies. System security is also important and may require technology updates.

## 6.4 Organizational and Agency Philosophy Approaches

The following organizational and agency philosophy approaches were cited by agencies as approaches to help guide decision-making for evolving or phasing out ITS devices and systems:

- ***Centrally Located ITS Operations Function:*** ODOT's ITS Operations and Maintenance function is centrally located and provides statewide oversight of standards, specs, qualified products lists, and maintenance.

- ***IT Services Integrated with ITS Office:*** To streamline operations, ODOT's ITS office supplies its own IT network services and does not rely on central DOT or statewide IT staff for daily ITS network/system needs. They have a good relationship with centralized IT staff and work with them regularly for more advanced networking solutions within the core network and to ensure standards involving security, routing, and related protocols are met.

## 6.5 Motorist Input

The following motorist input techniques were cited by agencies as approaches to help guide decision-making for evolving or phasing out ITS devices and systems:

- ***Customer Surveys and Motorist Feedback:*** WisDOT values motorist input and has collected feedback from the public in a variety of ways including broadcasting a phone number on HAR for motorists to call to provide input on the possibility of retiring HAR, distributing a survey at rest areas to gather input for a new 511 system, and documenting unsolicited calls from the public on issues related to traveler information phone and web-based systems, and blank or unused DMS.

- ***"Grassroots" Customer Feedback:*** Because Delaware is a small state, feedback related to traffic operations (e.g. traveler information, overall traffic issues, etc.) from the general public is often provided to DelDOT at a "grassroots" level. This public feedback is communicated via calls to the DOT or during regular events attended by traffic management staff, DOT leaders, and even state legislators. This "grassroots" feedback provides a steady stream of valuable input that is used by DelDOT to help make decisions about changes and improvements to ITS devices and systems.

## 7.0 Summary

The ENTERPRISE Pooled Fund Program conducted this research to help increase members' understanding of agency practices for evolving and phasing out ITS devices and systems. The project investigated and documented decision factors, criteria, tools, and approaches used by agencies to determine the evolution of "legacy" ITS devices and systems.

The project documented nearly 60 case studies which were used to develop a set of decision factors with detailed criteria and applicable tools for evolving or phasing out common ITS devices and systems. Though this research did not conduct a comprehensive state-of-practice review of each ITS device or system, the results provide a number of valuable insights regarding how agencies are evolving these devices and systems, along with the types of considerations and approaches used when making decisions. In addition, multiple overarching planning and management tools and approaches were summarized.

Selected key findings and lessons learned include:

- ***Highway Advisory Radio (HAR):*** While the majority of agencies represented in the case studies have eliminated HAR or are in the process of doing so, Caltrans has retained HAR in rural areas and mountain passes where cellular coverage is spotty, and DelDOT has improved technologies to offer statewide traveler information radio service. The main decision factors for eliminating or changing HAR were lack of coverage, declining access from vehicles, usage (primarily from anecdotal observations), motorist feedback, cost relative to benefits, and adequate or improved alternatives.

- ***Traveler Information Phone Service:*** Agencies that eliminated traveler information phone service (e.g. 511 phone service) cited cost savings and declining usage as primary factors. Agencies that have retained the service but modified it from an IVR-based system indicated that the cost and complexity of IVR systems were at the forefront of the decision. It was noted that phone access serves customers who may not use mobile apps or websites, and it could be less distracting with hands-free dialing capabilities.

- ***Traveler Information Websites and Mobile Apps:*** The majority of case studies highlighted agencies that had eliminated a specific component or feature of traveler information websites or mobile apps, or were conducting a major "next generation" upgrade that would change multiple features. Usage tracking and motorist input were utilized heavily to help agencies with these decisions.

- ***Signs and Traffic Control Devices:*** Several agencies noted a trend toward limited or decreased use of DMS, often implementing relocation and reuse strategies to retain DMS in high-priority locations. This trend appears to be driven by changing operational needs, an understanding of actual usage patterns, and a future environment where in-vehicle messaging could reduce the need for on-road DMS.

- ***Traffic Detection:*** Case studies revealed a movement away from in-pavement traffic detection devices due to disruption in data collection operations (e.g. roadwork, snow plowing), especially when the data is feeding real-time systems such as computation of travel times displayed to motorists. A trend toward probe data to replace physical detectors was seen, with growing confidence in the accuracy of probe data through national testing and individual agency evaluations.

- ***Monitoring Devices:*** Case studies focused on implementing newer, innovative technologies such as non-intrusive road weather monitoring devices and fire monitoring devices in tunnels. The main driving factors for updating these technologies were improved performance (better coverage, more robust operations) and less maintenance. Agencies noted a strong need to continually assess emerging technologies and the importance of pilot testing prior to full implementation.

- ***Traffic Cameras:*** Both agencies that discussed traffic cameras are in the process of upgrading from analog to digital cameras, which will enable live video streaming and enhance visual information for motorists and traffic operators.

- ***TMC Facilities and Operator Support:*** Agencies that are upgrading/replacing ATMS software cited increased efficiency and improved functionality with newer systems. Unique changes include PennDOT's plans to deploy a lower-cost alternative to a full-sized videowall using multiple monitors and MTO's transition from a centrally-located ATMS to portable field units. While the predominant decision factors were cost and efficiency, attention is also given to fully understanding operational needs to ensure these needs are being met as changes are made.

- ***ITS Communications Systems:*** Agencies are upgrading older communications (e.g. copper wiring, T1) to newer technologies (e.g. high-speed ethernet, fiber, cellular, Wi-Fi) for ITS devices and planning for connected vehicles. Evolving operational needs and performance requirements (bandwidth, coverage, latency) appear to be the primary factors driving these evolutions.

- ***Agency-owned Devices versus Service-based Solutions:*** Two different philosophies for owning and operating ITS devices and systems and a preference for in-house TMC software development were noted. In each case, the agencies cited increased efficiencies for their chosen approach.

- ***Public Feedback Following Changes***: Agencies reported very limited feedback from the public after making changes to ITS devices and systems. Of the 59 case studies, only a few reported any public feedback following the changes. Caltrans has received some anecdotal evidence that HAR is being used through calls received when HAR information isn't accurate. In addition, Maryland DOT SHA received minimal public comments (less than 10) in reaction to the change from an IVR-based 511 phone system to a simple list of major events statewide.

- ***Decision Factors, Criteria, and Tools for Common ITS Device and Systems***: Section 5 provides detailed criteria and applicable tools for the ten groupings of ITS devices and systems. These criteria are intended to assist agencies with identifying and navigating through multiple considerations, to determine potential evolutions or eliminations.

- ***Planning and Management Tools to Guide Decision-Making***: Several over-arching tools and approaches used by agencies to plan for and manage ITS assets are described in Section 6. The use of these tools and approaches indicate the importance of systematically and proactively planning for technology obsolescence, assessing new technologies, and considering changing operational environments.

Tables 24 and 25 summarize the case studies documented in this project, by type of change and number of case studies and agencies.

***Table 24: Overview of Case Studies for Motorist-Facing ITS Devices and Systems***

| ITS Device or System | Type of Change | Number of Case Studies and Agencies |
|---|---|---|
| Highway Advisory Radio | Eliminated or phasing out HAR | 6 (Iowa DOT, MoDOT, WisDOT, PennDOT, MassDOT, ODOT) |
| | Repurposing HAR sites from traditional radio broadcast to alternate uses | 3 (PennDOT, MassDOT, ODOT) |
| | During transition to phase out, reusing components from some HAR sites to extend the life of other in-place sites | 2 (PennDOT, ODOT) |
| | Retaining and evolving/improving HAR or other radio-based traveler information, to serve certain geographical areas or demographic groups | 2 (Caltrans, DelDOT) |
| Traveler Information Phone Service | Complete elimination of traveler information phone service | 3 (KYTC, MoDOT, IDOT) |
| | Replacing IVR feature with recorded messages, live operators, or region-specific messages generated from other traveler info sources | 3 (NCDOT, PennDOT, MDOT SHA) |
| | Replacing/upgrading 511 phone service as part of an upgrade to the statewide traveler information system | 1 (WisDOT) |
| Traveler Information Websites and Mobile Apps | Eliminated 3G website (system component), developed for use on early edition mobile devices | 2 (Iowa DOT, MnDOT) |
| | Discontinued other features/components such as citizen reporting for populating road conditions, a trip routing tool, and a text view feature | 4 (Iowa DOT, MnDOT, WisDOT, AKDOT&PF) |
| | Evolving traveler information websites and mobile apps for enhanced usability and functionality | 2 (AKDOT&PF, MoDOT) |
| Signs and Traffic Control Devices | Limited or decreased deployment of DMS; often also relocating functioning DMS to more critical locations or reusing parts to extend the life of other DMS | 4 (AKDOT&PF, Iowa DOT, ODOT, WisDOT) |
| | Evolving from mono-chromatic to full-color DMS | 1 (PennDOT) |
| | Eliminating or evolving advisory signs and traffic control devices (e.g. Intelligent Lane Control Signals, Intersection Conflict Warning Systems, and remotely operated interstate gates) | 3 (MnDOT, Iowa DOT, Iowa DOT) |

*Table 25: Overview of Case Studies for ITS Devices and Systems Primarily used for Transportation Operations*

| ITS Device or System | Type of Change | Number of Case Studies and Agencies |
|---|---|---|
| Traffic Detection | Using or considering probe data to replace some or all physical field detectors | 5 (ODOT, MassDOT, PennDOT, MoDOT, Caltrans) |
| | Replacing pavement intrusive devices (e.g. loop detectors) with non-intrusive devices such as radar, Bluetooth, or microwave | 3 (ODOT, MassDOT, MTO) |
| | Use of updated Bluetooth technology, to enable real-time data collection | 1 (DelDOT) |
| Monitoring Devices | Non-intrusive road weather monitoring (e.g. to detect friction, ice, temperature) | 1 (DelDOT) |
| | Tunnel fire monitoring technologies (e.g. to detect flames, smoke, heat) | 1 (MassDOT) |
| Traffic Cameras | Analog to digital traffic cameras | 2 (Caltrans, MassDOT) |
| TMC Facilities and Operator Support | Lower-cost configurations and updated technologies for TMC video walls | 2 (PennDOT, Caltrans) |
| | Major upgrades or replacement of ATMS systems and DMS management software | 4 (Caltrans, ODOT, WisDOT, MassDOT) |
| | Transforming central ATMS functions into portable field units | 1 (MTO) |
| | Replacing or supplementing manual tasks with automated tools for TMC operator support | 2 (MTO) |
| ITS Communications Systems | Transitioning from traditional communications (e.g. copper wiring, T1) to newer technologies (e.g. high-speed ethernet, fiber, cellular, Wi-Fi, point-to-to point radio) for ITS devices | 2 (DelDOT, ODOT) |
| | Implementing 4G LTE, 5G, or DSRC to accommodate future needs for connected vehicles and advanced signal systems | 1 (AKDOT&PF) |
| | Changing from fiber to wireless for controlling DMS | 1 (MTO) |
| | Moving ITS devices to the First Responder Network Authority (FirstNet) communications network | 1 (ODOT) |
| Agency-owned Devices and Software versus Service-based Solutions | Transitioning from agency-owned ITS devices and systems to service-based solutions, for various applications and technologies | 1 (MTO) |
| | Building a fleet of agency-owned temporary ITS devices for construction projects, rather than use of contractor-supplied temporary ITS devices | 1 (WisDOT) |
| | In-house ITS software development and use, as opposed to procuring of-the-shelf software | 1 (DelDOT) |

This project documented numerous case studies, tools, and approaches highlighting how agencies are determining the evolution of their ITS devices and systems. While there is no roadmap or checklist to determine exactly when and how to evolve or phase out these devices and systems, the project utilized case study data to organize decision factors, criteria, tools, and approaches that can be used by agencies to assist with navigating through multiple considerations when making these decisions.

# Appendix A: Case Study Summaries

**Alaska Department of Transportation and Public Facilities (AKDOT&PF)**

- Case Study #1: 4th Generation 511 System (evolving, discontinuing component)
- Case Study #2: Decreased Use of Permanent DMS (evolving)
- Case Study #3: Communications for Traffic Signals and Connected Vehicles (evolving)

**California Department of Transportation (Caltrans)**

- Case Study #1: ATMS Software (replacing)
- Case Study #2: Highway Advisory Radio (evolving)
- Case Study #3: Vehicle Detection (evolving)
- Case Study #4: Traffic Cameras (evolving)
- Case Study #5: TMC Video Walls (evolving)

**Delaware Department of Transportation (DelDOT)**

- Case Study #1: Communications Systems (evolving)
- Case Study #2: Software Systems for TMC Operations and Traveler Information (evolving)
- Case Study #3: Travel Advisory Radio (evolved)
- Case Study #4: Non-Intrusive Weather Monitoring Devices (evolving)
- Case Study #5: Bluetooth Traffic Detection Devices (evolved)

**Illinois Department of Transportation (IDOT)**

- Case Study: Statewide Traveler Information Phone Service (eliminating)

**Iowa Department of Transportation (Iowa DOT)**

- Case Study #1: 511 Citizen Reporting Feature (discontinued component)
- Case Study #2: 511 3G Website (discontinued component)
- Case Study #3: Highway Advisory Radio (eliminated)
- Case Study #4: Dynamic Message Signs (removing, relocating, reusing)
- Case Study #5: Intersection Conflict Warning Systems (removed, evolved)
- Case Study #6: Automated / Remotely Operated Interstate Gates (eliminated)

**Kentucky Transportation Cabinet (KYTC)**

- KYTC Case Study – 511 Phone System (eliminated)

**Maryland DOT State Highway Administration (MDOT SHA)**

- 511 Phone Service (evolving)

**Massachusetts DOT (MassDOT)**

- Case Study #1: Traffic Detection (evolving)
- Case Study #2: Analog to Digital Traffic Cameras (evolving)
- Case Study #3: Highway Advisory Radio (phased out, repurposed)
- Case Study #4: Tunnel Monitoring Technologies (evolving)
- Case Study #5: DMS Management System (eliminated)

**Michigan Department of Transportation (MDOT)**

- No device or system case studies (Tool: ITS Device Obsolescence and Modernization Planning)

**Minnesota Department of Transportation (MnDOT)**

- Case Study #1: 511 Citizen Reporting Feature (discontinued component)
- Case Study #2: 511 3G Website (discontinued component)
- Case Study #3: Intelligent Lane Control Signals (eliminated)

**Missouri Department of Transportation (MoDOT)**

- Case Study #1: Highway Advisory Radio (eliminated)
- Case Study #2: Bypass Map Layer on Statewide Traveler Information Map (evolving)
- Case Study #3: Traffic Detection Devices (evolving)
- Case Study #4: 511 Phone System (eliminated)

**North Carolina Department of Transportation (NCDOT)**

- Case Study #1: 511 Phone System (evolved)

**Ohio Department of Transportation (ODOT)**

- Case Study #1: Radar Speed Detection Devices (eliminated)
- Case Study #2: Loop Detection Devices for ITS Operations (eliminated)
- Case Study #3: Highway Advisory Radio Systems (phasing out, repurposing, reusing)
- Case Study #4: Selective Deployment of DMS (evolving)
- Case Study #5: Communications for ITS Devices and Operations (evolving)
- Case Study #6: Transition Communications Provider Services to FirstNet (evolving)
- Case Study #7: Upgrade ATMS Software (replacing)

**Ontario Ministry of Transportation (MTO)**

- Case Study #1: Vehicle Detection Stations (removing, evolving)
- Case Study #2: Fiber to Wireless Communication for Control of DMS (evolving)
- Case Study #3: CCTV Video Streaming On-Demand (evolving)
- Case Study #4: Central Software ATMS to Field-based "Field Traffic Master" (evolving)
- Case Study #5: Automated DMS Signing Strategy for Road Closures (evolving)
- Case Study #6: Transition from Agency-owned ITS Systems to Service-based Solutions (evolving)

**Pennsylvania Department of Transportation (PennDOT)**

- Case Study #1: Highway Advisory Radio (eliminating, reusing, repurposing) and 511 Phone Service (evolving)
- Case Study #2: Color Dynamic Message Signs (evolving)
- Case Study #3: Conversion of a Traffic Management Center into an Incident Command Center for Emergency Operations (evolved)
- Case Study #4: Traffic Detection (evolving)

**Wisconsin Department of Transportation (WisDOT)**

- Case Study #1: Highway Advisory Radio (eliminating)
- Case Study #2: 511 Phone Service (replacing)
- Case Study #3: Trip Routing Tool on 511 Website (discontinuing component)
- Case Study #4: Advanced Traffic Management System (replaced)
- Case Study #5: Dynamic Message Signs (relocating)
- Case Study #6: Build Fleet of Temporary ITS Devices (reusing, evolving)

## “Evolving and Phasing Out ITS Devices and Systems”

## Case Study Summary – AKDOT&PF

| | |
|---|---|
| **Agency** | Alaska Department of Transportation and Public Facilities (AKDOT&PF) |
| **Information Source(s)** | • 4/2/19 interview with Lisa Idell-Sassi, AKDOT&PF<br>• 4/3/19 interview with Val Rader, AKDOT&PF |
| **ITS Devices or Systems in this Case Study** | 1) 4th Generation 511 System (evolving, discontinuing component)<br>2) Decreased Use of Permanent DMS in the Central Region (evolving)<br>3) Communications for Traffic Signals and Connected Vehicles (evolving) |

| **AKDOT&PF Case Study #1: 4th Generation 511 System (evolving, discontinuing component)** | |
|---|---|
| **Overview** | Alaska DOT&PF is currently evolving to a 4th generation 511 system, to be more automated and easier to use on a mobile platform. As part of this upgrade to a 4th generation 511 system, the “Text View” feature on the full 511 website will be eliminated. “Text View” shows all events in text format and can be sorted by region, highway, type, location/milepost, description, or time of event. AKDOT&PF plans to maintain 511 phone service due to its high usage in rural areas. |
| **Decision Factors** | • **Enhanced Usability from Mobile Devices** – The goal for the next 511 mobile system is to be more automated, more real-time, and easier to use on a mobile platform. The new system will maximize features for mobile devices and be more responsive, adapting to different mobile screen sizes.<br>• **Usage** – Currently, usage from mobile devices is much higher than use of the full 511 website, driving the need to evolve to a system that is more accommodating to mobile users. The “Text View” feature on the full 511 website is being eliminated because it is not widely accessed. |
| **Feedback** | None – not yet implemented. |
| **Tools Used to Inform Decisions** | AKDOT&PF uses Google Analytics to monitor 511 web usage monthly for performance measures and to help make decisions about future generations of the 511 system. |

| **AKDOT&PF Case Study #2: Decreased Use of Permanent DMS in the Central Region (evolving)** | |
|---|---|
| **Overview** | The use of Dynamic Message Signs (DMS) varies by region at AKDOT&PF. The Central Region is moving toward decreased use of permanent DMS signs and plans to instead deploy more portable DMS in which locations and messages are automatically |

| | |
|---|---|
| | ingested into 511 systems for viewing by travelers. While this case study documents decision factors for decreased use of DMS in the Central Region, other AKDOT&PF regions may deploy additional DMS based on needs within the region. |
| **Decision Factors** | • **Usefulness of Messages to Drivers** – AKDOT&PF allows some general public service messages to be posted to DMS but would prefer to utilize DMS for traffic-related messages as the primary purpose.<br>• **Streamlined Operations** – Reducing the number of DMS will help streamline the workflow of posting and removing messages and help increase DMS message accuracy and timeliness. The current process involves the Anchorage Police Department posting messages since they are a 24/7 operation and have the best situational awareness in the field. The DOT maintains DMS infrastructure and assists with posting messages as needed.<br>• **Alternative** – AKDOT&PF plans to increase deployments of portable DMS that allow messages and sign coordinates to be automatically sent to 511 systems for display to travelers. Portable DMS can be housed in maintenance stations and moved to different locations when needed and messages could be instantly available on 511. |
| **Feedback** | None – not yet implemented. |

| **AKDOT&PF Case Study #3:<br>Communications for Traffic Signals and Connected Vehicles (evolving)** | |
|---|---|
| **Overview** | AKDOT&PF is moving away from using copper wiring for traffic signal systems and future connected vehicle communications. The agency is also decreasing use of 900 MHz radio communication and some WiFi, due to bandwidth requirements. AKDOT&PF plans to supplement existing mechanisms with other types of communications such as 4G LTE, 5G, or DSRC to accommodate future needs for connected vehicles and adaptive signal control. |
| **Decision Factors** | • **Decreased Reliance on Copper Wiring Infrastructure** – There are 280 signals connected by copper wiring in Anchorage. AKDOT&PF has invested in a fiber backbone, so new systems are connected using this fiber infrastructure. AKDOT&PF is also evolving to a more cellular-based infrastructure and does not plan to install additional copper wiring. Communications will be supplement fiber with 4G LTE, 5G, and radio as needed.<br>• **Evolving Communications Needs for Signal Systems and CAV Infrastructure -**<br>– AKDOT&PF will soon implement adaptive signal control. High resolution is required for performance measures. Greater bandwidth is needed.<br>– Currently, AKDOT&PF is installing fiber for all new backbone infrastructure needs. However, connected vehicles will require increased bandwidth and low latency. DSRC or cellular networks will be implemented for short-range connected vehicle communications. AKDOT&PF is working on the security |

| | |
|---|---|
| | aspect of a 4G LTE or 5G network to potentially increase bandwidth to accommodate these new technologies.<br>• **Cost –** The high overall cost of Wide Area Network infrastructure is a key factor in reducing reliance on this communication mechanism. This is primarily driven by the cost of the Multi-Protocol Label Switching (MPLS) service for telecom, which offers latency and security benefits but is expensive when used with services that do not require low latency, e.g. video, etc. |
| **Feedback** | N/A – not yet implemented. |

“Evolving and Phasing Out ITS Devices and Systems”

Case Study Summary – Caltrans

| | |
|---|---|
| **Agency** | California Department of Transportation (Caltrans) |
| **Information Source(s)** | 4/25/19 Interview with Brian Simi and Steve Hancock, Caltrans |
| **ITS Devices or Systems in this Case Study** | 1) ATMS Software (replacing)<br>2) Highway Advisory Radio (evolving)<br>3) Vehicle Detection (evolving)<br>4) Traffic Cameras (evolving)<br>5) TMC Video Walls (evolving) |

| **Caltrans Case Study #1: ATMS Software (replacing)** | |
|---|---|
| **Overview** | Caltrans is in the process of upgrading its ATMS software and plans to replace it with a statewide ATMS system that will use open source software developed by another state DOT. |
| **Decision Factors** | • **Maintenance/Updates** – The current ATMS source code was developed many years ago. Some districts used source code that Caltrans owned while larger districts used a proprietary version, making it difficult to bring in vendors to make updates.<br>• **Outdated Hardware** – The capabilities of older hardware platforms are limited by the current software code. Caltrans plans to utilize a virtual machine platform and operating system that is more robust.<br>• **Increased Capabilities –** Caltrans will benefit by leveraging software and modules other states have developed (e.g. wrong-way driving detection/alerts, use of third party data, and others). |
| **Feedback** | N/A – not a public-facing device. |

| Caltrans Case Study #2: Highway Advisory Radio (evolving) | |
|---|---|
| **Overview** | Caltrans has considered phasing out Highway Advisory Radio (HAR) due to the prevalence of traveler information available via smart phones. However; in rural areas and mountain passes with inclement weather and where cellular connection is spotty, HAR is likely to remain a primary means to obtain traveler information.<br>Caltrans has switched to a digital HAR system in order to make remote access and management easier. A limited number of "Super HARs" are also used, which typically results in better overall coverage within the area. |
| **Decision Factors** | • **Perceived Usage** – HAR is somewhat of an institutional technology within Caltrans. Some region staff who have operated HAR for several years believe that their customers (motorists) rely on it. HAR is also believed to be used by travelers who are not tech-savvy or are in an upper demographic age bracket.<br>• **Safety** – Some concern exists regarding motorists needing to rely on smart phones while driving as a primary means for obtaining traveler information, if HAR was eliminated.<br>• **Coverage** - In rural areas and mountain passes with inclement weather and where cellular connection is spotty, HAR is likely to remain a primary means for providing traveler information.<br>• **Ease of Operations and Maintenance** – The change to a digital HAR system was made in order to improve remote access and management of the system. |
| **Feedback** | Caltrans has received some anecdotal evidence that HAR is being used through calls received when HAR information isn't accurate. |

| Caltrans Case Study #3: Vehicle Detection (evolving) | |
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| **Overview** | Detection devices to identify vehicle speeds and occupancy are currently located approximately every half mile. These devices consist primarily of inductive loops but also include some radar. Caltrans is considering purchasing third party data to supplement or replace some detection data. So far, an official policy or guidance has not been established. Caltrans will continue to maintain vehicle detection stations in rural areas for reporting to FHWA. |
| **Decision Factors** | • **Increased Operability and Data Saturation** - Caltrans has installed 4,000-5,000 vehicle detection stations statewide, and it is a challenge to keep them operational. Currently, approximately 70-75% of stations are operational, and there is a desire to increase data saturation.<br>• **Alternative** – Third party probe data is a potential alternative to vehicle detection data. Caltrans is initiating research to demonstrate whether third party data will meet their needs for performance measures reports, travel times, and delays. Since vehicle detection devices are generally not deployed in rural areas, probe data would allow for some data to be collected in those areas. |

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| **Feedback** | N/A – not yet implemented. |
| **Tools Used to Inform Decisions** | The Caltrans Performance Measurement System (PeMS) is a web-based data management system that receives and stores vehicle detector station data for viewing and performance management. This system is used as a tool to track the number and location of stations that are operational/non-operational on an on-going basis, which has helped identify a potential need for improved data saturation. |

| **Caltrans Case Study #4: Traffic Cameras (evolving)** | |
|---|---|
| **Overview** | Caltrans is upgrading from analog to digital traffic cameras. This will accommodate the distribution of live video streaming and .jpg images. |
| **Decision Factors** | **Enhanced Information to Motorists** – As Caltrans replaces their camera systems, live video will be available in addition to still images, providing motorists with additional information about real-time traffic and road weather conditions. |
| **Feedback** | None noted. |

| **Caltrans Case Study #5: TMC Video Walls (evolving)** | |
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| **Overview** | Caltrans is transitioning many of its Traffic Management Center (TMC) video walls from analog to digital. Video walls offer situational awareness to TMC visitors and are useful for large events. They are also used by California Highway Patrol (CHP) where CHP staff are co-located in the TMC. |
| **Decision Factors** | • **Improved Efficiency and Flexibility** – Digital systems offer direct view LED systems, are more flexible with video management systems, and are more efficient.<br>• **Ease of Operations and Maintenance** – Digital video wall systems require less maintenance and are easier to manage. |
| **Feedback** | None noted. |

# “Evolving and Phasing Out ITS Devices and Systems”

## Case Study Summary – DelDOT

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| **Agency** | Delaware Department of Transportation (DelDOT) |
| **Information Source(s)** | 5/8/19 interview with Don Weber and Jeff Van Horn, DelDOT |
| **ITS Devices or Systems in this Case Study** | 1) Communications Systems (evolving)<br>2) Software Systems for TMC Operations and Traveler Information (evolving)<br>3) Travel Advisory Radio (evolved)<br>4) Non-Intrusive Weather Monitoring Devices (evolving)<br>5) Bluetooth Traffic Detection Devices (evolved) |
| **Tools to Guide Decision-Making** | “Grassroots” Customer Feedback |

| **DelDOT Case Study #1: Communications Systems (evolving)** | |
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| **Overview** | DelDOT’s communications systems have evolved substantially. This includes transitioning from copper to fiber for backbone communications. For wireless communications, DelDOT has upgraded from 220 MHz to 900 MHz and is now migrating to 4.9 GHz. |
| **Decision Factors** | • **Bandwidth Requirements –** Upgraded cameras and traffic signals require additional bandwidth. Transitioning to 4.9 GHz offers much greater bandwidth to accommodate the increasing needs of these updated devices.<br>• **Technology Evolution** – Field device technologies and communications capabilities have improved over time, driving the need to evolve and upgrade with these technology improvements.<br>• **Expanded Coverage–** With improved and expanded ITS devices, the area served by the communications system has grown. |
| **Feedback** | None noted. |

| **DelDOT Case Study #2: Software Systems for TMC Operations and Traveler Information (evolving)** | |
|---|---|
| **Overview** | An in-house software development team within DelDOT, Electronic Operations (EOps), has developed most software systems for TMC operations and traveler information rather than purchasing “off the shelf” software. In addition, a traveler information mobile app and website were developed to stream travel advisory radio, integrate transit, and provide a travel map. EOps understands the nuances of DelDOT’s devices |

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| | and the IT security protocols and continues to develop customized modules and programming changes as new business needs or enhancements are identified. |
| **Decision Factors** | • **Performance** – Buying "off the shelf" software often did not perform as expected to meet DelDOT's needs, so they moved to in-house development, which allows for better customization and more streamlined updates as new needs arise.<br>• **Efficiency** – DelDOT decided to develop their traveler information app internally due to a history of integration and IT security protocol issues and found internal development to be a more efficient process. |
| **Feedback** | The TMC ITS Technicians provide constant feedback on the EOps program and use it continuously throughout the day. The software is constantly tweaked to their needs to improve efficiency. Public feedback related to the mobile app is received through the Google and Apple applications programs as well as via email, messages, and public meetings. It is generally well received, and DelDOT takes into consideration the feedback in order to modify the app accordingly. |

| **DelDOT Case Study #3: Travel Advisory Radio (evolved)** | |
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| **Overview** | DelDOT operates Travel Advisory Radio, an AM radio channel with statewide coverage. Travel Advisory Radio is similar to HAR, but with its synchronized transmitters, it operates day and night and has better coverage than HAR. |
| **Decision Factors** | **Need for Statewide Coverage –** Improved technology has allowed DelDOT to implement synchronized transmitters, enabling statewide radio coverage. |
| **Feedback** | None noted. |

| **DelDOT Case Study #4: Non-Intrusive Weather Monitoring Devices (evolving)** | |
|---|---|
| **Overview** | Deployments of infrared monitoring devices to replace in-pavement "puck" sensors for detecting road-weather conditions such as friction, ice, and temperature have been successful. Some of these infrared devices are permanently mounted at fixed locations, while others are mobile units mounted on maintenance vehicles. Based on positive results with pilot testing, DelDOT plans to move forward with deploying non-intrusive sensors throughout the state. |
| **Decision Factors** | • **More Robust Operations** – In-pavement sensors collect road-weather data and alert maintenance staff when road maintenance is needed, but routine maintenance frequently damages the pucks. For example, asphalt milling operations often destroy puck sensors, and bridge deck sealing projects often seal over the sensors, making them non-operational. Use of non-intrusive infrared devices offers less disruption to data collection because they are more consistently operational, compared to in-pavement sensors. |

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| | • **Cost** – Infrared devices are comparable in capital cost, but infrared sensors/devices have a lower overall cost since there is less need for maintenance.<br>• **Accuracy** – A pilot study sponsored by FHWA (report pending publication) evaluated the accuracy of DelDOT's non-intrusive devices against intrusive puck sensors and found the non-intrusive sensors to produce more accurate data than the puck sensor systems.<br>• **Better Coverage (with mobile units) –** Because mobile devices are mounted to maintenance vehicles, they collect data on every type of roadway as the vehicle conducts maintenance. This results in increased data collection coverage as the puck sensors are not installed on all roads. |
| **Feedback** | None - not a public-facing device. |

| **DelDOT Case Study #5: Bluetooth Traffic Detection Devices (evolved)** | |
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| **Overview** | DelDOT changed from using portable, briefcase style Bluetooth detection devices to full trailer units with either portable or permanent Bluetooth. |
| **Decision Factors** | **Improved Capability** – In the past, briefcase style devices collected historical traffic data. With Bluetooth devices, DelDOT can obtain real-time data and origin-destination information for estimating travel times. Bluetooth readers also extend into Maryland to allow DelDOT to anticipate incoming traffic. |
| **Feedback** | None – not a public-facing device. |

| **DelDOT – Tools to Guide Decision-Making** | |
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| **Overview** | **"Grassroots" Customer Feedback** – Because Delaware is a small state, feedback related to traffic operations (e.g. traveler information, overall traffic issues, etc.) from the general public is often provided at a "grassroots" level. This public feedback is communicated via calls to the DOT or during regular events attended by traffic management staff, DOT leaders, and even state legislators. This "grassroots" feedback provides a steady stream of valuable input that is used by DelDOT to help make decisions about changes and improvements to ITS devices and systems. |

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# "Evolving and Phasing Out ITS Devices and Systems"

## Case Study Summary – Illinois DOT

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| **Agency** | Illinois Department of Transportation (IDOT) |
| **Information Source** | Kevin Price, Illinois DOT (email correspondence 4/17/19 and 7/26/19) |
| **ITS Device or System in this Case Study** | Statewide Traveler Information Phone Service (eliminating) |

| **IDOT Case Study – Statewide Traveler Information Phone Service (eliminating)** | |
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| **Overview** | As of April 2019, the Illinois DOT statewide traveler information phone system is in the process of being shut down. During the transition, the message directs callers to go to the Illinois DOT website for traveler information. By the end of 2020, the agency plans to reduce the phone service to a voicemail box for callers to record roadway complaints which, with VoIP conversion, can be emailed to appropriate staff for follow up. The Chicago metro traveler information phone service remains active. |
| **Decision Factors** | **Cost** – The decision to shut down the service was made when the building phone system changed over to VoIP. At that time, there was an examination of the cost of conversion as well as the continued cost to maintain the phone service. |
| **Feedback** | Note noted. |

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# "Evolving and Phasing Out ITS Devices and Systems"

## Case Study Summary – Iowa DOT

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|---|---|
| **Agency** | Iowa Department of Transportation (Iowa DOT) |
| **Information Source(s)** | 1/28/19 interview with Sinclair Stolle and Tim Simodynes, Iowa DOT |
| **ITS Devices or Systems in this Case Study Summary** | 1) 511 Citizen Reporting Feature (discontinued component)<br>2) 511 3G Website (discontinued component)<br>3) Highway Advisory Radio (eliminated)<br>4) Dynamic Message Signs (removed, relocated, reused)<br>5) Intersection Conflict Warning Systems (removed, evolved)<br>6) Automated / Remotely Operated Interstate Gates (eliminated) |

| **Iowa DOT Case Study #1: 511 Citizen Reporting Feature (discontinued component)** | |
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| **Overview** | Iowa DOT eliminated its 511 citizen reporting feature in October 2017; in place since 2015, for approximately 2 years. The citizen reporting feature allowed citizens to report road conditions for display on 511. |
| **Decision Factors** | • **Usage** – The overall number of road condition reports from citizen reporters was low.<br>• **Did Not Achieve Intended Outcomes** – Because citizen reports were made using the 511 website, reports were often made several minutes to hours after driving the road segment. This made it difficult to accurately report the location and condition experienced. The intended purpose of the citizen reporting feature was to obtain more accurate/timely road condition reports. This outcome was not achieved, given challenges with after-the-fact reporting.<br>• **Cost vs. Benefits** – The citizen reporting feature was initiated as part of an overall philosophy to try emerging technologies and practices for traveler information services. The initial cost and operations/maintenance cost of the feature was relatively low. However, the internal DOT process to set up user credentials and conduct training was cumbersome and required staff time. Overall, the benefits of the feature did not justify the costs incurred.<br>• **Alternative in Place** – Road condition reports are made by DOT maintenance staff as conditions change. Quality control is performed by TMC staff every 2 hours by checking weather radar, plow cameras and traffic cameras to verify that road conditions showing on 511 are accurate. This process works well, and the overall road condition accuracy and timeliness was not enhanced by citizen reporting. |
| **Feedback** | No feedback was received following this change. |

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| **Tools Used to Inform Decisions** | • None specific to the 511 citizen reporting feature.<br>• Iowa DOT reviews web usage statistics using Google analytics for their various web sites, but this doesn't show a breakdown of usage by specific features/tools in 511. |

| **Iowa DOT Case Study #2: 511 3G Website (discontinued component)** | |
|---|---|
| **Overview** | Iowa DOT eliminated its 511 3G website in December 2018. It was launched 2010 and in use for approximately 8 years. The 3G website was used for viewing 511 information on early edition mobile devices. |
| **Decision Factors** | **Need for Streamlined Approach**: Iowa DOT utilized Google analytics to see how many users were accessing the 511 3G website and from what type of device. If on a mobile device, users were not accessing the 3G site as their first access point to 511. Iowa DOT identified a need to streamline its 511 websites. The new 511 system planned for implementation soon, will have one website. |
| **Feedback** | None noted. |
| **Tools Used to Inform Decisions** | Iowa DOT utilized Google analytics to see how many users were accessing the 511 3G website and from what type of device. |

| **Iowa DOT Case Study #3: Highway Advisory Radio (eliminated)** | |
|---|---|
| **Overview** | Iowa DOT eliminated its use of Highway Advisory Radio (HAR) devices in December 2016. A steady process was used to shut down the sites, first ending communication to CARS/511, removing signs, and allowing the Federal Communications Commission (FCC) license to expire. Some HAR sites have been expensive to remove due to how the sites were constructed with a heavy-duty gel at the base of the antenna. |
| **Decision Factors** | • **Expensive to Maintain** – The HAR sites had a lot of maintenance issues, making them expensive to maintain. The flashing beacons on the static signs (i.e. tune to channel message) did not work reliably. Staff encountered difficulty controlling the flashing beacons (e.g. turning them on/off when high-priority messages were available), likely due to unreliable communications to the sites.<br>• **Difficult to Monitor** – HAR sites were difficult to monitor. Staff didn't know when they were not working and also couldn't track usage.<br>• **Alternatives**:<br>– Portable HAR devices are available for use during significant incidents such as disasters (e.g. flooding, tornados, etc.)<br>– Several alternatives exist to communicate information about road conditions, including DOT-operated 511 and social media, on-road DMS, and non-DOT media mechanisms such as radio and TV stations. These alternatives are considered to be better than encouraging drivers to tune to a radio station while driving, from a safety standpoint. |

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| **Feedback** | No substantive feedback from traveler information users. |

| **Iowa DOT Case Study #4: Dynamic Message Signs (removing, relocating, reusing)** | |
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| **Overview** | Iowa DOT is attempting to limit any increase in the total number of Dynamic Message Signs (DMS) statewide. Using a scoring matrix, they have prioritized existing and proposed DMS sites. As new high-priority sites are identified "cascading" strategies are used to remove, replace, and relocate DMS for the benefit of the overall network. DMS near the end of their life cycle may be used for parts to help extend the life of DMS in more critical locations. |
| **Decision Factors** | The following criteria are used to identify priorities for existing and proposed DMS sites:<br>• **DMS location type**<br>• **Traffic volumes**<br>• **Crash history**<br>• **Existing DMS usage history**<br>• **Iowa DOT TMC staff value**<br><br>• **Stage in Equipment Life Cycle**: In addition to the criteria above, DMS that are close to the end of their life cycle are candidates for replacement or can be used for parts to extend the life of other DMS. |
| **Feedback** | None noted. |
| **Tools Used to Inform Decisions** | DMS Placement Criteria / Scoring Matrix:<br>• In 2018, Iowa DOT completed a DMS inventory and used a scoring matrix to identify priorities for existing and proposed DMS sites.<br>• Criteria for the scoring matrix: 1) DMS location type; 2) traffic volumes; 3) crash history; 4) existing DMS usage history; and 5) Iowa DOT TMC staff value.<br>– Scoring: Each criterion was normalized into a 1-10 scale; each DMS location was then assigned a score based on this scale.<br>– Total score per DMS location: Scores from the 5 criteria listed above were weighted equally (20%) to arrive at a total score for each DMS location.<br>• Additional details can be found in the *Iowa DOT Intelligent Transportation Systems (ITS) and Communications Systems Service Layer Plan*: https://iowadot.gov/TSMO/ServiceLayerPlan3.pdf<br>• Iowa DOT plans to continue assessing locations and usage of DMS on a regular basis, using the scoring matrix noted above. |

| Iowa DOT Case Study #5: Intersection Conflict Warning Systems (removed, evolved) | |
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| **Overview** | Iowa DOT had 7 Intersection Conflict Warning Systems (ICWS) at two-way stop controlled, divided expressway intersections. Two of those systems have been removed because an interchange was constructed to replace the intersection itself. Iowa DOT also plans to upgrade all of their in-place ICWS to add a mainline warning, in addition to the current warning for minor road drivers at the stop-controlled intersection. |
| **Decision Factors** | • **Geometric Modification –** In two cases, the decision was made to build an interchange to replace the intersection, thus eliminating the need for an ICWS.<br>• **Lessons Learned from Other States:** Iowa DOT followed MnDOT's practice after several ICWS deployments in Minnesota included mainline warnings. |
| **Feedback** | None noted. |

| Iowa DOT Case Study #6: Automated / Remotely Operated Interstate Gates (eliminated) | |
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| **Overview** | Iowa DOT eliminated the functionality to remotely operate interstate gates. The gates are still in place at the closure locations and are manually swung into place for intestate closures. The automated/ITS feature was in place for approximately 5 years. |
| **Decision Factors** | • **Maintenance Issues –** The automated functionality of the gates often didn't work properly. The gates aren't used very often as they are primarily used during significant events such as severe winter storms. Staff needed to perform ongoing testing, maintenance, and repairs in order to troubleshoot issues and make repairs.<br>• **Alternative In-Place** – On-site staffing is required for all interstate closures, reducing the need for remote operation of gates. Law enforcement staff need to be present, to direct traffic off the impacted highway. On-site staff are also needed to close the manual gates that are located at entrance ramps. |
| **Feedback** | No feedback received. |

## "Evolving and Phasing Out ITS Devices and Systems"
## Case Study Summary – Kentucky Transportation Cabinet

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| **Agency** | Kentucky Transportation Cabinet (KYTC) |
| **Information Source(s)** | *Evaluation of Rural 511 Phone Service* (North/West Passage Pooled Fund, 2018) |
| **ITS Devices or Systems in this Case Study** | 511 Phone System (eliminated) |

| **KYTC Case Study – 511 Phone System (eliminated)** | |
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| **Overview** | The Kentucky Transportation Cabinet (KYTC) discontinued 511 phone service in 2016. A state-run traveler information website and mobile traveler information in partnership with WAZE are in place to provide traveler information. |
| **Decision Factors** | • ***Usage*** – 40% decrease in 511 phone service use over a two year-period, while visitors to the traveler information website and mobile app increased during the same time period.<br>• ***Input from Motorists*** – A survey of Kentucky drivers revealed that a majority get information through digital content providers such as Waze and Google.<br>• ***Cost*** – A significant annual cost savings was seen with the discontinuation of the 511 phone service and mobile app, which was provided by the same contractor. |
| **Feedback** | None noted. |

## “Evolving and Phasing Out ITS Devices and Systems”

## Case Study Summary – Maryland DOT SHA

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| **Agency** | Maryland DOT State Highway Administration (MDOT SHA) |
| **Information Source** | Glenn McLaughlin and Joey Sagal, MDOT SHA (email correspondence 8/5/19) |
| **ITS Device or System in this Case Study** | 511 Phone Service (evolving) |

| **MDOT SHA Case Study #1 – 511 Phone Service (evolving)** | |
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| **Overview** | In 2017, Maryland DOT SHA changed its 511 phone service from an Interactive Voice Response (IVR) system to a simple list of major events statewide. The agency is evaluating and considering sunsetting the telephone service, retaining web and social media, and developing a mobile app. |
| **Decision Factors** | • **Usage -** Prior to implementing the change, calls to the 511 phone service had dropped from approximately 60,000 per month in 2012 to approximately 10,000 per month in 2017.<br>• **Customer Feedback** – Most customer comments received regarding the performance of the system indicated that the menu system was cumbersome, the voice recognition didn’t perform well when called from a noisy environment (such as a vehicle) and the events reported often were too minor to impact traffic (e.g. a disabled vehicle on the shoulder).<br>• **Cost Savings** – Without the IVR, the operating cost of the phone service dropped by approximately 70%.<br>• **Available Services** – The industry has evolved since the launch of 511 and there are excellent private sector services (e.g. Waze, Google maps, local media stations, etc.) that provide similar travel information services.<br>• **Customer Base** – More demographic sectors are looking for information though other media than voice-based telephone services (i.e. mobile apps).<br>• **Maintenance** – As currently configured (during the 2017 redesign), the 511 service became an extension of the CHART ATMS, and as such the maintainability of the system architecture between the data source (the ATMS) and the user interface (web and IVR) is more reliable and easier to maintain.<br>• **Continuity of a Base Level of Service** – Rather that discontinuing the 511 phone service entirely, it was decided that maintaining a simple statewide report would |

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| | keep the service active and available for communicating with the public in case of any areawide emergencies. |
| **Feedback** | Maryland DOT SHA received minimal public comments (less than 10) in reaction to the change from an IVR system to a simple list of major events statewide.<br>The phone service usage continues to track at about 8,000 to 10,000 calls per month in 2019, with peaks during winter months to approximately 20,000 calls. |

## "Evolving and Phasing Out ITS Devices and Systems"

## Case Study Summary – MassDOT

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| **Agency** | Massachusetts Department of Transportation (MassDOT) |
| **Information Source(s)** | 4/1/19 interview with Lorenzo Parra, Marco Pereira, Michael Fitzpatrick, and Eusebius Oyigbo (MassDOT) |
| **ITS Devices or Systems in this Case Study** | 1) Traffic Detection (evolving)<br>2) Analog to Digital Traffic Cameras (evolving)<br>3) Highway Advisory Radio (phased out, repurposed)<br>4) Tunnel Monitoring Technologies (evolving)<br>5) DMS Management System (eliminated) |
| **Tools Used to Guide Decisions** | • Systems Engineering Process<br>• Continual Evaluation of Technology Needs |

| **MassDOT Case Study #1: Traffic Detection (evolving)** | |
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| **Overview** | MassDOT retired its legacy loop detection system for real-time traffic operations. The ITS Unit turned over the in-place infrastructure to the Traffic Data Collection section for long-term planning applications including collecting speed, volume, and vehicle classification data, primarily for reporting to the FHWA. Bluetooth is currently being used to collect traffic data for real-time operations, such as for estimating travel times, and MassDOT is pursuing an agreement to procure 3rd party traffic data to supplement Bluetooth data. |
| **Decision Factors** | • **Maintenance** – In-pavement loop detectors are burdensome from a maintenance perspective; snow plows often displace the devices.<br>• **Disruption to Operations** - Though it was most efficient to replace loops during a pavement construction project, waiting to do so resulted in disruption to detection functionality until the devices could be replaced.<br>• **Alternatives** – Bluetooth is a better method of collecting speeds because the devices can be placed further apart, compared to loop detectors, to gather data needed to estimate point to point travel times. MassDOT is also pursuing an agreement to procure 3rd party traffic data to supplement Bluetooth data. |
| **Feedback** | None (not a public-facing device/system). |

| MassDOT Case Study #2: Analog to Digital Traffic Cameras (evolving) | |
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| **Overview** | MassDOT is updating their camera technology by replacing analog cameras with digital cameras, to eliminate the need for point to point wiring and allow for capturing video. |
| **Decision Factors** | • **Antiquated Technology –** Analog cameras are an older technology that needs to be wired point to point.<br>• **Efficient Deployment and Operations** – Digital cameras are easier to deploy for video displays and offer more flexibility for applications. They can use 5G protocol and need only an IP address to set up. Digital cameras can be wireless or wired, so the devices don't necessarily need to be physically wired during installation. With digital technology, MassDOT will be able to simply tap into the in-place communications network as opposed to installing long runs of analog connectivity.<br>• **Increased Functionality** – Replacing analog cameras with digital cameras allows for the ability to capture video.<br>• **Cost** – MassDOT is working to update their camera infrastructure to eliminate the need for costly analog to digital converters. |
| **Feedback** | None (not a public-facing device). |

| MassDOT Case Study #3: Highway Advisory Radio (phased out, repurposed) | |
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| **Overview** | MassDOT still has Highway Advisory Radio (HAR) in place, but no longer uses it for ongoing traveler information. MassDOT maintains HAR systems at district offices to deploy for providing project specific information to targeted communities. For example, MassDOT may deploy their repurposed HAR to issue trucker advisories on construction projects that impact the movement of freight. |
| **Decision Factors** | • **Alternatives –** Advancements in other traveler information systems, such as websites and mobile apps, have reduced the need for HAR. MassDOT also uses AM/FM over-ride in tunnels. AM/FM over-ride is similar to HAR but over-rides approximately 10 radio stations being broadcast in vehicles. The over-ride is seldom used but is used in emergencies when it is not practical to use HAR.<br>• **Access from Vehicle –** As drivers' use of radio in-vehicle has declined, radio-based mechanisms to broadcast traveler information (including HAR and the AM/FM over-ride) are becoming obsolete. |
| **Feedback** | None noted. |

| MassDOT Case Study #4: Tunnel Monitoring Technologies (evolving) | |
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| **Overview** | MassDOT uses various technologies to detect and monitor conditions in tunnels. For fire detection, linear heat detectors are currently in use. These linear heat detectors are mechanical devices that function like a smoke detector; a metallic strip expands to trip an alarm, sending an alert. In an effort to transition away from use of linear heat detection, MassDOT is considering a new technology that analyzes images from digital cameras to detect flames or smoke from pixellation. Cameras equipped with analytics software are also used to detect traffic incidents and congestion in tunnels; a new analytics module is currently being vetted. |
| **Decision Factors** | • **Maintenance and Operations** – Especially in the corrosive tunnel environment, MassDOT has encountered maintenance and operations issues with mechanical systems such as linear heat detection.<br>• **Efficient Use of Cameras for Multiple Purposes** – If MassDOT implements cameras within tunnels for fire detection, the cameras would produce digital images at the pixel level. This camera analytics software would be able to detect many different conditions, making it flexible for multiple purposes. |
| **Feedback** | None (not a public-facing device/system). |

| MassDOT Case Study #5: DMS Management System (eliminated) | |
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| **Overview** | In 2017, MassDOT retired their legacy Dynamic Message Sign (DMS) management system that was over 20 years old and replaced it with an ATMS system. |
| **Decision Factors** | • **Antiquated/Outdated** – This DMS management system was reaching its end of life and was not stable with its primitive communication infrastructure.<br>• **Alternative** – The legacy DMS management system was replaced with a multi-functional ATMS system.<br>• **Increased Efficiency** – Prior to implementing the new ATMS, Highway Operations was using multiple, separate DMS control platforms running at the same time. With the advent of ATMS, MassDOT reduced this to two systems and can now post the same messages on several platforms. |
| **Feedback** | None (not a public-facing device/system). |

| MassDOT – Tools to Guide Decision-Making | |
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| **Overview** | MassDOT uses the following tools to review ITS assets and help guide decisions for evolving or phasing out ITS devices and systems:<br>• **Systems Engineering Process** – The former Massachusetts Highway Department, Turnpike Authority, and Port Authority, merged into MassDOT approximately 10 |

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| | years ago. Therefore in 2009, MassDOT inherited ITS and tunnel monitoring systems from each of these agencies. Up to 50 systems and subsystems were in place to access signs, cameras, sensors, and other ITS field equipment. In 2012, a systems engineering process was initiated to integrate these systems. A unique aspect of this overall integration effort is MassDOT's urban tunnel system. This tunnel environment requires monitoring of CO levels, ventilation, and other facility life-safety systems. As such, ITS technologies are an integral part of an integrated transportation management system that includes both traditional systems and life-safety systems.<br>• **Continual Evaluation of Technology Needs** – MassDOT routinely evaluates its ITS infrastructure needs and considers new technologies to support both its traditional ITS systems and extensive tunnel system. As technologies near end-of-life, funding is allocated to update and replace obsolete technologies. System security is also important and may require technology updates. |

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# "Evolving and Phasing Out ITS Devices and Systems"

## Case Study Summary – Michigan DOT

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| **Agency** | Michigan Department of Transportation (MDOT) |
| **Information Source(s)** | 4/29/19 interview with Mike Wroblewski, MDOT |
| **ITS Devices or Systems in this Case Study** | Specific devices/systems are not included in this case study. See the "Tools to Guide Decision Making" section below for details about MDOT's statewide ITS device obsolescence and modernization planning effort. |
| **Tool(s) to Guide Decision Making** | **ITS Device Obsolescence and Modernization Planning**<br>Michigan DOT has initiated an effort to create a 5-year ITS Device Modernization Plan (DMP). MDOT's current practice is to repair or replace ITS devices based on periodic inspections. The new DMP will implement a proactive approach to ITS device planning, and will evaluate all ITS, environmental sensor stations (ESS), and connected and automated vehicle (CAV) devices that have reached a state of technical obsolescence and/or a high probability of failure over the next 5-10 years. This effort will also develop a plan for prioritizing the modernization of the resulting sites and a methodology for implementation that considers all aspects of the cost and delivery timelines (mobility, scale, logistics).<br><br>Maintenance of the DMP will include an annual evaluation of ITS devices for state of the practice, device maintenance history, and device technological characteristics. The annual evaluation should also involve determining device value to the motoring public and recommending device removal.<br><br>The DMP is expected to be complete by the end of 2019, and MDOT has dedicated annual resources to implement the plan.<br><br>Decision Factors for Initiating the ITS Device Modernization Plan (DMP):<br>• **Aging ITS Infrastructure**: Many devices have been in place for several years. MDOT recognized a need to assess and implement new technologies for improved safety and performance, as well as lower maintenance costs.<br>• **Statewide Consistency**: MDOT's 7 regions had been initiating separate efforts to assess and update ITS devices, so there was a need for a consistent, statewide approach. |

ENTERPRISE

## "Evolving and Phasing Out ITS Devices and Systems"

## Case Study Summary - MnDOT

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| **Agency** | Minnesota Department of Transportation (MnDOT) |
| **Information Source(s)** | 511 Citizen Reporting and 511 3G Website:<br>• 1/9/19 email from Kelly Braunig, MnDOT<br>• 1/15/19 interview with Kelly Braunig, MnDOT<br><br>Intelligent Lane Control Signals (ILCS) in ATMS System:<br>• 3/29/19 Interview with Brian Kary, MnDOT<br>• *SMART LANES: Active Traffic Management* (August 2017) – provided by Brian Kary, MnDOT |
| **ITS Devices or Systems in this Case Study Summary** | 1) 511 Citizen Reporting Feature (discontinued component)<br>2) 511 3G Website (discontinued component)<br>3) Intelligent Lane Control Signals (eliminated) |

| **MnDOT Case Study #1: 511 Citizen Reporting Feature (discontinued component)** | |
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| **Overview** | MnDOT eliminated its 511 Citizen Reporting feature in July 2018. The citizen reporting feature allowed citizens to report road conditions via a web-based platform. These reports were then used to assist MnDOT convey road condition information on 511. The feature was initiated in November 2015; in use for approximately 2.5 years. |
| **Decision Factors** | • **Usage** – The number of citizen reporters who reported road conditions was very low.<br>• **Cost vs. Benefits** - MnDOT reviewed the number of individuals reporting road conditions through the citizen reporting feature versus the maintenance/operational cost of the feature. The cost of the feature far outweighed the benefits from the few citizen reporters who used it.<br>• **Improved Alternative** – At the time the citizen reporting feature was eliminated, MnDOT had made a decision to launch a Maintenance Decision Support System (MDSS)/Segments automated system which will provide much more frequent, accurate, and useful road condition information, compared to MnDOT's current reporting methods. The MDSS/Segments system, to be implemented in 2020, will provide road condition updates every 30 minutes, with more accurate and useful road condition data from numerous sources including Road Weather Information Stations (RWIS), National Weather Service, on-road data collected by plows, and Surface Weather Observation Stations (ASOS/AWAS). |
| **Feedback** | No feedback was received by MnDOT following this change. |

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| **Tools Used to Inform Decisions** | • MnDOT uses monthly usage statistics to evaluate features in all of its 511 systems, including 511 phone, websites (full-featured and low-band), and mobile app.<br>• MnDOT has also utilized results from an in-depth market research analysis, which included a survey of 511 users, to identify user preferences and usage habits. |

| **MnDOT Case Study #2: 511 3G Website (discontinued component)** | |
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| **Overview** | MnDOT discontinued its 511 3G website in July 2018. The 3G website was developed many years ago for viewing via early generation mobile devices, such as the Blackberry. |
| **Decision Factors** | • **Outdated/Antiquated –** At the time it was eliminated, the 3G website was quite antiquated. It was text-based only, with a condensed view, and not interactive.<br>• **Improved Alternative –** When the MnDOT 511 mobile app was released in 2013, this replaced the need for the 3G website, as the mobile app is much more user friendly and contains additional features. |
| **Feedback** | No feedback was received by MnDOT following this change. |
| **Tools Used to Inform Decisions** | • MnDOT uses monthly usage statistics to evaluate features in all of its 511 systems, including 511 phone, websites (full-featured and low-band), and mobile app.<br>• MnDOT has also utilized results from an in-depth market research analysis, which included a survey of 511 users, to identify user preferences and usage habits. |

| **MnDOT Case Study #3: Intelligent Lane Control Signals (eliminated)** | |
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| **Overview** | MnDOT phased out Intelligent Lane Control Signals (ILCS) that were part of an Active Traffic Management (ATM) system deployed on I-35W and I-94. ILCS was a series of overhead signs spaced at approximately ½ mile increments over each lane, spanning 18 miles on I-35W and 8 miles on I-94. Installed between 2009 and 2012, ILCS displayed graphics above each lane of traffic to inform drivers of various conditions such as status of HOV/HOT lanes, incidents ahead, and to communicate advisory variable speed limits.<br>• ILCS for Incident Notification:<br>– ILCS used for advanced incident notification (e.g. crashes, roadwork, lane blockage) for impacted lanes were removed from operation in the fall of 2018 after being in place for 8-10 years.<br>– Though these ILCS were relatively effective in terms of seeing drivers moving out of impacted lanes, no noticeable crash reduction was seen.<br>• ILCS for Variable Speed Limits:<br>– ILCS that provided advisory speed limits were removed from operation in 2015, after being in place for 4-5 years. |

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| | – The use of ILCS for this purpose did not result in crash reduction or congestion reduction. MnDOT operates an extensive ramp metering system which has been proven to improve throughput. Therefore, it may not be possible to realize a cumulative effect from additional speed harmonization strategies such as ILCS indicating variable speed limits; this strategy might work better in areas that don't already have ramp metering in place at close spacing.<br><br>MnDOT noted that ILCS have potential application for notification for the use of additional capacity such as shoulder lanes. |
| **Decision Factors** | • **High Maintenance Costs**:<br>– Equipment Failures - The ILCS equipment was failing sooner than expected, resulting in high costs to maintain the signs.<br>– Difficulty Obtaining System Components **-** The ILCS equipment vendor who had been providing maintenance services and spare parts went out of business, making it difficult to maintain the current system. MnDOT began removing lower priority ILCS signs to keep higher priority signs in place; however, this could not be sustained. MnDOT ultimately determined it would be too expensive to remove and replace existing ILCS signs with another product and to retrofit new signs with existing structures and systems.<br>• **Justification of Costs vs. Effectiveness/Benefits:** Research on the effectiveness of the system indicated no noticeable change in crash reduction and no noticeable change in throughput. Because of the significant cost that would have been required to replace the system in its entirety, the cost of continuation was not justified based on its benefits.<br>• **Alternative:** MnDOT is deploying Dynamic Message Sings (DMS) at more frequent spacing (1-2 mile spacing) in the corridors that previously had ILCS deployed. This is a more cost effective alternative to ILCS and more informative to motorists due to increased flexibility of messages that can be posted for multiple purposes. |
| **Feedback** | MnDOT received essentially no feedback from the public following the removal of lane control signals, including no contact from the media. |
| **Tools Used to Inform Decisions** | Several research efforts have been conducted to understand the effectiveness of MnDOT's ATMS system:<br>• John Hourdos, Stephen Zitzow, and Seraphin Abou. *Effectiveness of Urban Partnership Agreement Traffic Operations Measures in the I-35W Corridor*. (2013)<br>• John Hourdos. *Evaluation of the Effectiveness of ATM Messages Used During Incidents.* (2016)<br>• John Hourdos. *Investigation of the Impact of the I-94 ATM System on the Safety of the I-94 Commons High Crash Area.* (2014)<br>• Katie Turnbull, Kevin Balke, Mark Burris, et al. *Urban Partnership Agreement: Minnesota Evaluation Report.* (2013)<br>• Eil Kwon, Chongmyung Park. *Development of Freeway Operational Strategies with IRIS-in-Loop Simulation*. (2012) |

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| | • Eil Kwon, Chongmyung Park. *Development of Freeway Operational Strategies for Minnesota Freeway Corridors.* (2015)<br>• P. Jenior, R. Dowling, B. Nevers. *Use of Freeway Shoulders for Travel*. (2016)<br><br>A summary that includes MnDOT's Smart Lanes ILCS system experience, titled "SMART LANES: Active Traffic Management (August 2017)" is available by request from MnDOT's Regional Transportation Management Center (RTMC). |

# “Evolving and Phasing Out ITS Devices and Systems”
## Case Study Summary – MoDOT

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| **Agency** | Missouri Department of Transportation (MoDOT) |
| **Information Source(s)** | Information for case studies on Highway Advisory Radio, Bypass Map Layer Statewide Traveler Information Map, and Traffic Detection Devices:<br>• 5/7/19 interview with Ashley Buechter and Alex Wassman, MoDOT<br>Information for case study on 511 Phone Service:<br>• *Evaluation of Rural 511 Phone Service* (North/West Passage Pooled Fund, 2018) |
| **ITS Devices or Systems in this Case Study** | 1) Highway Advisory Radio (eliminated)<br>2) Bypass Map Layer on Statewide Traveler Information Map (evolving)<br>3) Traffic Detection Devices (evolving)<br>4) 511 Phone System (eliminated) |
| **Tools to Guide Decision-Making** | • Asset Management Planning<br>• Transportation Management System (TMS) and other Asset Tracking Tools |

| **MoDOT Case Study #1: Highway Advisory Radio (eliminated)** | |
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| **Overview** | MoDOT eliminated Highway Advisory Radio (HAR) in 2013-14, with the exception of a tunnel system location where it is required per the National Fire Protection Association (NFPA). MoDOT first removed the signs and turned off the HAR broadcast and has slowly removed the remainder of the infrastructure over time as a part of other roadway projects. |
| **Decision Factors** | • **Alternatives** – Newer technologies are being used to provide traveler information, including the MoDOT statewide traveler information map and smartphone app; regional traveler information websites (KCScout, Gateway Guide, Ozarks Traffic); and third-party traveler information providers such as Google and Waze.<br>• **Usage and Public Input –** Though no formal study was completed, MoDOT had not received many comments from the public about HAR while a noticeable increase in web hits and Twitter feeds was seen. If the agency had received negative feedback after turning off the HAR broadcast, MoDOT would have reconsidered its decision; however, no feedback was received after the change.<br>• **Aging Equipment** – HAR equipment was nearing end of life cycle, and a decision needed to be made about whether to replace the equipment or discontinue the service. |
| **Feedback** | No feedback was received after the change to eliminate HAR. |

| MoDOT Case Study #2: Bypass Map Layer on Statewide Traveler Information Map (evolving) | |
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| **Overview** | In 2018, MoDOT added a map layer to their statewide traveler information map website that generates pre-defined bypasses for I-70 and I-44 during incidents. The bypass map layer, which considers truck and work zone restrictions when providing bypass routes, is viewable on a mobile app or desktop and provides directions to travel around the incident. This change significantly improves upon the limited information provided via on-road DMS. MoDOT plans to add more pre-defined bypasses for other interstates and routes across Missouri. |
| **Decision Factors** | • **Improved Traveler Information –** Prior to implementing this map layer, MoDOT communicated information via on-road DMS indicating "road closed ahead, use alternate route," with no bypass information. The new map layer also provides more complete information than 3rd party mobile apps that only provide the shortest path without considering truck restrictions for weight, width, and work zones.<br>• **Reduced Incident Clearance Times and Congestion** – By providing bypass information, incident clearance times and backups are reduced, providing overall freeway traffic management benefits. |
| **Feedback** | No public feedback has been received, however, MoDOT has shared the new feature with various groups and has received positive response. |

| MoDOT Case Study #3: Traffic Detection Devices (evolving) | |
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| **Overview** | The total number of radar, Bluetooth, and Wi-Fi units are being reduced as MoDOT transitions to using probe data to determine travel times for posting on DMS. They plan to retain some physical detectors for lane-by-lane volumes and occupancy at critical locations. Some Bluetooth sensors will be retained to supplement probe data at strategic locations, such as long ramps. |
| **Decision Factors** | • **Infrastructure Costs –** Detection devices require significant infrastructure including fiber or wireless (cell or point to point radio), electricity, and related upgrades. MoDOT finds it is more cost effective to purchase data when compared to the cost of infrastructure.<br>• **Maintenance Costs –** Detection devices require annual preventative maintenance at each location. Because detectors are spaced 1 mile apart on freeways, there have been many devices to maintain. Purchasing probe data is less expensive than the overall cost necessary to install, maintain, and upgrade detectors.<br>• **Accuracy** – MoDOT has learned from work conducted by the I-95 Corridor Coalition, which has completed data validation efforts comparing probe data to traffic data collected by more traditional methods, as part of the Vehicle Probe Project. On a smaller scale, MoDOT has completed its own validation that showed improved accuracy with probe data. |

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| **Feedback** | None (not a public facing device). |

| **MoDOT Case Study #4: 511 Phone System (eliminated)** | |
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| **Overview** | Missouri DOT (MoDOT) discontinued its 511 phone service that was available only in the St. Louis area. Traveler information is instead provided through a statewide traveler information website, mobile app, and a customer service phone line. |
| **Decision Factors** | ***Cost*** - The previous 511 phone service was initiated as part of a major construction project and funded through sponsorship advertisements, with no direct cost to MoDOT. When the system was terminated, MoDOT was unable to find another vendor to provide the service under this type of sponsorship model. |
| **Feedback** | None noted. |

| **MoDOT – Tools to Guide Decision-Making** | |
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| **Overview** | • **Asset Management Planning** – MoDOT is focusing on asset management planning in two phases:<br>– Phase 1 – Roads and bridges<br>– Phase 2 – Mobility assets including ITS devices<br>The asset management planning effort will improve the reliability of ITS device inventory information and help MoDOT proactively plan for replacements. This, in turn, will lessen budget impacts by spreading out investments over time and assist with making better long-term decisions.<br>• **Transportation Management System (TMS) and other Asset Tracking Tools** – MoDOT has created and maintained an internal transportation management system (TMS) that includes a set of tools and a database to enter and store information about assets including installation dates and components. Some third-party tools are used for ITS and department-wide assets as well. |

# “Evolving and Phasing Out ITS Devices and Systems”
## Case Study Summary – North Carolina DOT

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| **Agency** | North Carolina Department of Transportation (NCDOT) |
| **Information Source(s)** | *Evaluation of Rural 511 Phone Service* (North/West Passage Pooled Fund, 2018) |
| **ITS Devices or Systems in this Case Study** | 511 Phone System (evolved) |

| **NCDOT Case Study – 511 Phone System (evolved)** | |
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| **Overview** | NCDOT evolved its 511 phone service by discontinuing the IVR-based feature and now provides information via a combination of live operators (utilizing inmates from a women’s penitentiary) and recorded messages. |
| **Decision Factors** | • ***Cost*** – The revised means of providing information (live operators and recorded messages) carries a lower cost than the IVR-based system.<br>• ***Efficiency/Staffing Resources*** – The operator-based service supplemented by recorded messages is less complex and requires less staff time than the IVR-based system.<br>• ***Customer Satisfaction*** – The live operators achieve a high level of customer satisfaction, and callers prefer speaking to a live person. |
| **Feedback** | None noted. |

## “Evolving and Phasing Out ITS Devices and Systems”

## Case Study Summary – Ohio DOT

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| **Agency** | Ohio Department of Transportation (ODOT) |
| **Information Source(s)** | 4/9/19 Interview with Jason Yeray and Bryan Comer, Ohio DOT |
| **ITS Devices or Systems in this Case Study** | 1) Radar Speed Detection Devices (eliminated)<br>2) Loop Detection Devices for ITS Operations (eliminated)<br>3) Highway Advisory Radio Systems (phasing out, repurposing, reusing)<br>4) Selective Deployment of DMS (evolving)<br>5) Communications for ITS Devices and Operations (evolving)<br>6) Transition Communications Provider Services to FirstNet (evolving)<br>7) Upgrade ATMS Software (replacing) |
| **Tools to Guide Decision-Making** | • ITS Device Replacement Planning<br>• Device Consistency<br>• Centrally Located ITS Operations Function<br>• IT Services Integrated with ITS Office |

| **ODOT Case Study #1 – Radar Speed Detection Devices (eliminated)** | |
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| **Overview** | ODOT eliminated radar speed detection devices used to determine travel times for posting to DMS and other traveler information mechanisms. Instead of radar devices, ODOT is now using 3rd party probe data to provide speed data. |
| **Decision Factors** | • **Alternative –** 3rd party probe data is now being utilized to provide vehicle speeds to determine travel times.<br>• **Cost** – ODOT has seen substantial cost savings by utilizing 3rd party probe data.<br>• **Performance/Quality** – Probe data is accurate and timely enough for ODOT uses, although there is a little more of a lag time in delivery and thus accuracy compared to roadside speed detection devices.<br>• **Maintenance** – Use of 3rd party data will reduce the resources required to maintain roadside detection devices that are impacted by weather-related issues. |
| **Feedback** | None noted; not a public-facing device. |

| **ODOT Case Study #2 – Loop Detection Devices for ITS Operations (eliminated)** | |
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| **Overview** | ODOT eliminated in-pavement loop detectors that were used to collect vehicle data for ITS operations such as ramp metering and signals. ODOT’s planning office still uses |

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| | the loop detectors on a limited basis to obtain traffic counts and vehicle occupancies, but they are also phasing them out. |
| **Decision Factors** | • **Alternatives** – ODOT has transitioned to non-intrusive detection devices. They are also considering using traffic cameras with analytics capability instead of radar.<br>• **Maintenance** – Road construction projects were routinely tearing out the in-pavement loops. Non-intrusive devices are easier to maintain and safer, as it reduces the need for traffic control during installation and maintenance. |
| **Feedback** | None received. |

| **ODOT Case Study #3 – Highway Advisory Radio Systems (phasing out, repurposing, reusing)** | |
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| **Overview** | ODOT has several Highway Advisory Radio (HAR) broadcast sites in place statewide; however, they are no longer deploying new sites and will continue to phase out non-critical HAR locations. Most transmitter sites are still operational, but ODOT is removing beacons from the signs indicating that a specific message is being broadcast. The static signs will remain in place, so motorists can tune into the broadcast if they desire. As sites are phased out, parts that are salvageable are being used to support higher-priority sites. |
| **Decision Factors** | • **Antiquated Technology –** HAR technology is an older technology and uses AM radios to receive broadcast information.<br>• **Coverage –** HAR broadcasts are prone to static and interference.<br>• **Alternatives –** In the next several years, in-vehicle technologies will likely be used for traveler information. ODOT's mobile app (OHGO) sends push notifications and serves as a routing tool when incidents are identified on a user's route. OHGO is used more often than other traveler information mechanisms. DMS currently are used more often than HAR in high-priority locations, but ODOT is being selective about where to deploy DMS.<br>• **Limited ITS Budget** – ODOT needs to prioritize investments in order to effectively allocate its limited ITS budget. |
| **Feedback** | ODOT has not received complaints about eliminating HAR broadcasts. However, they do receive complaints from motorists about not being able to hear HAR broadcasts due to lack of coverage or static. |

| **ODOT Case Study #4 – Selective Deployment of DMS (evolving)** | |
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| **Overview** | ODOT is very selective about deploying Dynamic Message Signs (DMS.) Their DMS system is 10-15 years old and they do replace DMS in existing locations. |
| **Decision Factors** | **Aging technology** – ODOT expects DMS to become obsolete in the next 15 years as the use of connected vehicles increases. |

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| **Feedback** | None received. |

| ODOT Case Study #5 – Communications for ITS Devices and Operations (evolving) | |
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| **Overview** | ODOT is updating its communications infrastructure to reflect newer available technologies. Dial up modems have been replaced by cellular modems. Initially, some modems were 3G, but those are being phased out and replaced with 4G, and 5G is also being considered. Existing T1 lines are being converted to ethernet or fiber to reduce costs and increase bandwidth, and serial radio communication is being replaced with high-speed ethernet wireless point to point radio. |
| **Decision Factors** | • **Cost** – New technologies have lower cost with increased performance (e.g. Telecom providers charge a high cost and have low bandwidth).<br>• **Performance –** Ethernet and fiber are faster, provide increased bandwidth capabilities, and are more reliable than T1 lines. |
| **Feedback** | None. |

| ODOT Case Study #6 – Transition Communications Provider Services to FirstNet (evolving) | |
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| **Overview** | ODOT is beginning to transition some ITS devices such as cameras, traffic signals, and DMS to the First Responder Network Authority (FirstNet) communications network. FirstNet gives priority to the DOT for safety-sensitive purposes which includes most ITS operations. |
| **Decision Factors** | • **Cost** –ODOT has found that the overall cost of cellular devices and monthly service fees is lower on FirstNet, compared to other providers. FirstNet also provides stability of pricing since it is Government-owned and is required to keep prices stable (or offer lower prices).<br>• **Ease of Conversion** – The conversion to FirstNet has been simple and efficient, especially where in-place modems were already supplied by AT&T, FirstNet's provider service. ODOT will consider using other services on a case by case basis, for non-safety critical devices. |
| **Feedback** | None. |

| ODOT Case Study #7 – Upgrade ATMS Software (replacing) | |
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| **Overview** | ODOT's Traffic Management Center currently uses older ATMS software that was developed internally by ODOT staff. This software is being phased out and a new ATMS software system will soon be procured for statewide use. |

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| **Decision Factors** | • **Resources –** ODOT determined it was becoming too difficult and resource-intensive for internal staff (programmers, IT) to continuously update their existing ATMS software.<br>• **Improved Technology/Functionality –** Selecting a new technology will allow ODOT to more effectively keep up with changing needs and increase functionality. |
| **Feedback** | None – not yet implemented. |

| **ODOT – Tools to Guide Decision-Making** | |
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| **Overview** | • **ITS Device Replacement Planning** – ODOT requires a 5-year warranty, on ITS device purchases. As a result, each device is assessed at the end of the warranty period and devices are routinely replaced with the same or improved technologies. This significantly reduces the need to repair and maintain obsolete technologies. With limited resources for ITS, ODOT regularly assesses the overall system to help make investment decisions.<br>• **Device Consistency** – ODOT deploys consistent types of ITS devices. For example, they primarily utilize one DMS vendor and have deployed only 4-5 different types/models of cameras. This allows staff to build expertise with installation and maintenance, limits the need for training on several types of devices, and improves interoperability.<br>• **Centrally Located ITS Operations Function** - ODOT's ITS Operations and Maintenance function is centrally located and provides statewide oversight of standards, specs, qualified products lists, and maintenance.<br>• **IT Services Integrated within ITS Office** – To streamline operations, ODOT's ITS office supplies its own IT network services and does not rely on central DOT or statewide IT staff for daily ITS network /system needs. They have a good relationship with centralized IT staff and work with them regularly for more advanced networking solutions within the core network and to ensure standards involving security, routing, and related protocols are met. |

## "Evolving and Phasing Out ITS Devices and Systems"

## Case Study Summary - MTO

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| **Agency** | Ontario Ministry of Transportation (MTO) |
| **Information Source(s)** | • 3/5/19 email from Hoi Wong<br>• 3/13/19 Interview with Hoi Wong and Wendy Ng |
| **ITS Devices or Systems in this Case Study** | 1) Vehicle Detection Stations (removing, evolving)<br>2) Fiber to Wireless Communication for Control of DMS (evolving)<br>3) CCTV Video Streaming On-Demand (evolving)<br>4) Central Software ATMS to Field-based "Field Traffic Master" (evolving)<br>5) Automated DMS Signing Strategy for Road Closures (evolving)<br>6) Transition from Agency-owned ITS Systems to Service-based Solutions (evolving) |
| **Overarching Criteria and Considerations** | MTO ITS system staff evaluate the depreciation of equipment and systems based on the following considerations and requirements:<br>• End of life cycle device/system<br>• Arrival of new technologies<br>• Obsolete business needs and depreciated technologies<br>• Streamline and simplify deployment, operations, maintenance – agile system engineering process<br>• Reduce Energy Footprint and operations/maintenance costs<br>• Accelerating and rapid deployment |

| **MTO Case Study #1: Vehicle Detection Stations (removing, evolving)** | |
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| **Overview** | MTO plans to remove 30-50% of Vehicle Detection Stations (VDS) and related equipment (i.e. induction loops, Advance Traffic Controller, network gears, etc.) in the next 18 months. |

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| **Decision Factors** | • **Life Cycle:** The life cycle of induction loops is significantly reduced due to snow plowing and roadwork activities.<br>• **Less Disruption to Operations:** When pavement-intrusive loop detectors are damaged during snow plowing and roadwork, it is disruptive to operations while the devices are being repaired or replaced.<br>• **Alternatives in Place:** MTO has installed non-pavement intrusive detection such as radar, microwave, and Bluetooth, to meet real-time operational needs.<br>• **Changing Operational Needs**: Traditionally, VDS data has supported ATMS functions such as Automatic Incident Detection (AID) algorithms and congestion message signing. MTO currently is no longer running AID and changed the focus on travel time message signing instead of congestion signing.<br>• **Maintenance Costs and Effort:** VDS maintenance budgets and efforts will be significantly reduced. |
| **Feedback** | None noted. |

| **MTO Case Study #2: Fiber to Wireless Communication for Control of DMS (evolving)** | |
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| **Overview** | MTO is changing communication methodology from fiber to wireless communication for controlling some Dynamic Message Signs (DMS). Prior policy had been to install fiber when a new section of road was constructed; MTO now assesses each situation on a case-by-case basis, based on the operational needs along each section of roadway. |
| **Decision Factors** | • **Accelerated Deployment of DMS:** Deployment of additional DMS can be accelerated, especially in rural areas (where cellular service is available).<br>• **Cost/Resources:** The change to wireless communication for some DMS is reducing the communication infrastructure capital investment and maintenance efforts. Bandwidth requirements are low for DMS, and the capital/operational cost for wireless communication is limited to a modem and a monthly service fee.<br>• **Simplified Maintenance:** Diagnostic efforts are simplified since the responsibility to troubleshoot and repair issues is delegated to the wireless service provider.<br>• **Improved Performance:** Use of wireless communication is improving DMS uptime using point-to-point communication by reducing the dependency on the aging fiber backbone equipment. |
| **Feedback** | None noted. |

| **MTO Case Study #3: CCTV Video Streaming On-Demand (evolving)** | |
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| **Overview** | MTO is considering streaming video from CCTV cameras “on-demand” rather than continuous video streaming for Traffic Operations Centre (TOC) operations. MTO is |

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| | establishing Artificial Intelligence (AI) logic to correlate events (i.e. road closures, incidents) to the streaming on-demand relationship. For instance, as operators enter an incident location, cameras in the vicinity become available for streaming. This change is being considered at a policy level. It is operationally feasible; however, this would have implications to video feeds that are available to the media. |
| **Decision Factors** | • **Cost/Resources:** Reduces communication infrastructure and bandwidth requirements.<br>• **Energy Footprint:** Reduces energy footprint from streaming video from hundreds of cameras continuously.<br>• **Operational Need:** Constant streaming does not offer operators enhanced situational awareness because Traffic Operations Centre staff cannot manually monitor hundreds of cameras simultaneously. |
| **Feedback** | None noted. |

| **MTO Case Study #4: Central Software ATMS to Field-based "Field Traffic Master" (evolving)** | |
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| **Overview** | MTO is transforming its Advanced Traffic Management System (ATMS) components and functions from a Central Software System into a portable, scalable, and secure software system running in an Advanced Traffic Controller, MTO's Field Traffic Master (FTM), which is essentially an "ATMS-in-a-box." Traditional ATMS receive data from field devices, perform data processing, and send data/commands back to the field. In this new environment, ATMS functions will transition from a centric system architecture operation to edge computing (field environment) deployments. Seven (7) FTM units are currently in production in the field. MTO will continue to deploy additional FTM units and plans to transition to de-centralized units/systems for functions such as ramp metering, travel times, and congestion-related messaging. |
| **Decision Factors** | • **Operation/Maintenance Costs:** Operation and maintenance costs are reduced. The current ATMS Central Software System is running in a complex central computing environment that requires intensive resources to maintain and operate.<br>• **Efficient Integration:** FTM can be deployed as standalone ATMS anywhere without significant central system investments and integration efforts.<br>• **Rapid Deployment:** Rapid deployment and diagnostics can be achieved, especially in rural locations, as integration with a Central Software System is not required. |
| **Feedback** | None noted. |

| **MTO Case Study #5: Automated DMS Signing Strategy for Road Closures (evolving)** | |
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| **Overview** | MTO is replacing manual decision-making by traffic operators for road closure signing management with a rule-based, automated signing strategy application. The |

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| | application will determine signing/messaging for road closure messages posted to DMS. The manual decision-making task is especially challenging during the construction season when closures are changing daily and multiple DMS need to be activated, de-activated, or changed. The new application will be implemented in May 2019. Road closure and DMS management data will be collected for future analytics and machine learning algorithm enhancements. |
| **Decision Factors** | • **Efficiency:** Automating the task of managing overall DMS messaging for roadwork will simplify the TOC's workflow and streamline the operator's decision-making process. For instance, multiple road closures often "compete" for messaging on the same sign, and operators need to decide which closure to post. This change will reduce resources (operator time and effort) needed to implement messaging/signing strategies, especially during the construction season.<br>• **Consistency/Accuracy**: This change will help maintain consistency in signing strategies and accuracy of road closure messages posted to DMS. |
| **Feedback** | None noted. |

| **MTO Case Study #6: Transition from Agency-owned ITS Systems to Service-based Solutions (evolving)** | |
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| **Overview** | MTO is transitioning from agency-owned ITS devices and systems to more service-based solutions for ITS applications.<br><br>*Queue Warning System Solution:* MTO is in the process of replacing an MTO-deployed turnkey Queue End Warning System with a service-based Queue Detection and Stop Vehicle (QD/SV) solution. This service-based solution will include design, build, operation, and maintenance of all software, hardware, communication, and infrastructure to provide QD/SV functions.<br><br>*Agency Procurement Methods:* At the policy level, MTO is also investigating potential procurement methods and processes to facilitate rapid, service-based deployments of ITS solutions. Traditional ITS systems and devices are owned, operated, and maintained by MTO. These individual devices and systems are considered as product (non-service) items included in a construction or rehabilitation contract. Because current ITS procurement methods and processes are tailored to construction and rehabilitation requirements, new methods and processes need to be developed to support evaluation and procurement of service-based ITS solutions. |
| **Decision Factors** | **Efficient Use of Resources**: MTO ownership of individual ITS devices and system components requires intensive resources and internal staff support to deploy, operate, monitor, and maintain. It is more efficient to delegate these responsibilities to a contractor – due to internal staffing constraints and the ability to streamline system delivery and operations by eliminating the need to hand off responsibilities among multiple agency offices and individuals (e.g. construction to operations to maintenance, etc.) |

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| **Feedback** | None noted. |

ENTERPRISE

## "Evolving and Phasing Out ITS Devices and Systems"

## Case Study Summary – PennDOT

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| **Agency** | Pennsylvania Department of Transportation (PennDOT) |
| **Information Source(s)** | 2/5/19 interview with Doug Tomlinson, Pierce Sube, and Jerome Frederick, PennDOT |
| **ITS Devices or Systems in this Summary** | 1) Highway Advisory Radio (eliminating, reusing, repurposing) and 511 Phone Service (evolving) - Estimated implementation in 2020<br>2) Color Dynamic Message Signs (evolving)<br>3) Conversion of a Traffic Management Center into an Incident Command Center for Emergency Operations (evolved)<br>4) Traffic Detection (evolving) |
| **Tools to Guide Decision Making** | Planning Tools:<br>• Regional Operations Plans<br>• GIS Application for TSMO Planning<br>• Antiquated ITS Devices Effort |

| **PennDOT Case Study #1:<br>1a) Highway Advisory Radio (eliminating, reusing, repurposing) and 1b) 511 Phone Service (evolving)** | |
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| **Overview** | PennDOT is making the following changes to HAR and 511 phone service:<br>(Estimated implementation in 2020)<br>• **Eliminate**: PennDOT is no longer installing new Highway Advisory Radios (HAR) and is looking to convert HAR signs for use as a tool to inform motorists of conditions being reported in 511.<br>• **Evolve**: The Interactive Voice Response (IVR) feature on 511 phone will be changed to broadcast region-specific messages. The new system will convert information from PennDOT's Road Condition Reporting System (RCRS) to voice messages that contain road weather and traffic conditions near where the call originates from, using a geofenced area. PennDOT can also enter customized messages into the system for broadcast via 511 phone as needed. PennDOT considers the information to be similar to a radio station traffic report at predefined time periods, but the 511 version will offer real-time access to the information that begins as soon as the user calls.<br>• **Reuse:** Beacons and modified HAR signs (converted to a 511 message) will be activated during times when there are critical messages being broadcast on 511 phone, such as white out conditions, severe thunderstorms, traffic queues, etc. |

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| | • **Repurpose:** During transition to phase out HAR completely, components from some non-operational HAR devices are being reused to extend the life of other in-place devices in Districts across the state. |
| **Decision Factors** | • **Access from Vehicle -** Access to AM radio from vehicles is declining. It can be difficult to tune to AM radio in vehicles (e.g. without a "dial" it can be difficult to tune to a station using scanning buttons that don't stop at the HAR station due to signal strength.) AM radio is being eliminated in some newer vehicles, including electric vehicles.<br>• **Coverage:** AM/HAR coverage is not consistent across the state, and different frequencies need to be used. Messages broadcast on HAR can be difficult to hear/decipher in locations where coverage is spotty. In contrast, cellular phone service is available almost everywhere in the state, especially on limited access roadways, making 511 phone a more consistent way to access information.<br>• **Cost -** The new phone system is less complex and less than half the cost of the previous system. The agency is leveraging equipment already in the field and may be able to add a replacement panel for existing signs.<br>• **Safety –** Dialing 511 could be considered less distracting than tuning to an AM radio station. When using 511, motorists would be able to dial once then listen to road conditions. It may be a hands-free operation, depending on bluetooth and voice-activated phone capabilities in the vehicle.<br>• **Ability to Track Usage** – PennDOT is unable to track motorist usage of HARs. However, PennDOT can access usage statistics for 511 phone to determine the number of calls received by area/location and use metrics to guide decision making.<br>• **Other Strategic Considerations –** Use of PennDOT's 511 systems rises dramatically during the winter, so decisions for improving 511 are largely driven by winter enhancements**.** |
| **Feedback** | None received; Implementation is estimated in 2020. |
| **Tools Used to Inform Decisions** | • PennDOT uses 511 statistics to track the number of calls and locations from where calls originate.<br>• Field review of HAR quality and challenge with finding AM stations<br>• Understanding the direction of future vehicles<br>• Cost saving analysis |

| **PennDOT Case Study #2: Color Dynamic Message Signs (evolving)** | |
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| **Overview** | PennDOT is looking at future needs and exploring uses for color Dynamic Message Signs (DMS). A recent research project with Pennsylvania State University (Penn State), *Evaluation of Colored VMS Boards,* evaluated the visibility and comprehensibility of |

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| | various DMS message designs in an attempt to determine optimal designs. Much of the focus was on the use of full-color DMS for travel time displays and route displays.<br><br>Research results showed that the best design for comprehensibility and visibility of DMS signs would entail the following: (1) messages would display only time information, not travel distance information; (2) route numbers would be displayed by numbers rather than shields; (3) monochromatic signs would be used, but if colored DMS are used, the best use of color would be to display a congested travel time in red; and (4) the background would be black. (Guler, Kersavage, and Pietrucha, 2018). The final research report can be found at: www.dot7.state.pa.us/BPR_PDF_FILES/Documents/Research/Complete%20Projects/Operations/Evaluation_of_Colored_VMS_Boards.pdf<br><br>To compliment the research findings, PennDOT is gathering input from TMC operators and districts regarding potential changes. They will also explore how the ATMS software/coding would need to be modified to control full-color DMS. In addition, PennDOT may display time and distance information simultaneously on DMS, as needed. After additional assessment, PennDOT plans to update its DMS Operating Guidelines to reflect any changes in guidance for use of full-color DMS. |
| **Decision Factors** | • **Research-Based Design Guidance –** Results from the Penn State human factors research will help guide agency standards for use of colored DMS.<br>• **Cost** – Full-color DMS signs offer multiple display options without significant cost increase compared to monochrome DMS. PennDOT is assessing what would be needed (cost, feasibility) to update their ATMS software to operate full-color DMS.<br>• **Input from DOT Users (Feasibility/Preferences) -** Input from TMC operators and district representatives that deploy and use DMS is used to supplement research findings and cost data. This input on usage and feasibility is providing additional data for the overall assessment. |
| **Feedback** | None received; not fully implemented. |
| **Tools Used to Inform Decisions** | • Targeted human factors research was used as a tool to help guide decision making.<br>• Understanding of changing technology<br>• Overall usage of travel time messages on DMS<br>• Understanding of the information that motorists can comprehend on a DMS. |

| **PennDOT Case Study #3: Conversion of a Traffic Management Center into an Incident Command Center (ICC) for Emergency Operations (evolved)** | |
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| **Overview** | Establishment of four Regional Traffic Management Centers in PennDOT has reduced the need for TMCs in some of the district offices. In one location, PennDOT is modifying a TMC that's no longer used into an Incident Command Center that is active during winter storms and other major district-wide emergency operations. Upgrade to a new video management software created an issue with viewing some cameras on |

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| | the existing video wall. Transition to new software to correct the issue would come at a significant cost. This cost was deemed to not be justified based on the number of ICC activations throughout the year.<br><br>The existing videowall is being decommissioned and changed to one created from eight, 43” monitors. The monitors will be wall-mounted and connected to a high-end computer. The result will function as a video wall at a far lower cost. |
| **Decision Factors** | • **Cost** – From an equipment standpoint, the computer with multiple monitors can be deployed much lower cost than the software needed for the existing videowall. The estimated cost for the computer, monitors, and other accessories is less than $10,000.<br>• **Operational Needs** – The new equipment setup will meet the operational needs of the ICC during activations. |
| **Feedback** | None received; Equipment has been ordered, but the system is not yet implemented. Based on district feedback, PennDOT may consider expansion to other districts around the state. |
| **Tools Used to Inform Decisions** | • Cost analysis of videowall enhancements needed to view video<br>• Understanding of operations during ICC activations<br>• Emphasis on continual improvement of winter operations |

| **PennDOT Case Study #4: Traffic Detection (evolving)** | |
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| **Overview** | PennDOT has been procuring third-party real-time statewide speed data for several years. To decrease equipment redundancy, deployment of new traffic detection equipment is limited to locations where the quality of third-party speed data is insufficient or where volumes have been deemed to be critical. Even when no longer in use, vehicle detection equipment is being left in place for future Connected Vehicle applications. |
| **Decision Factors** | • **Effective Resource Allocation**: ITS maintenance continues to grow each year, so PennDOT is working to ensure the available funding is effectively allocated.<br>• **Operational Needs and Usage:**<br>- In most cases, district TMCs were not using the volume information captured by vehicle detectors.<br>- Travel time information on PennDOT’s DMS uses third-party speed data for the calculation. |
| **Feedback** | The districts with the largest number of detection devices were in support of the direction to move towards third-party data. If specific applications are identified where detection equipment is needed, districts work with central office for approval.<br><br>In addition, the Delaware Valley Regional Planning Commission (DVRPC) required PennDOT to keep some devices operational on interstates in the region, as a means for reporting data to FHWA. |

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| **Tools Used to Inform Decisions** | • Fiscal trends<br>• Applications and uses of the available data |

| **PennDOT – Planning Tools to Guide Decision-Making** | |
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| **Overview** | In addition to device-specific tools noted in the case studies above, PennDOT uses the following planning tools to review ITS assets and help guide decisions for evolving or phasing out ITS devices/systems:<br>• **Regional Operations Plans –** A Regional Operations Plan~~s~~ (ROP) is being developed for each of the four RTMC regions across the state. These plans will be used to identify projects for future grant opportunities as well as future operations and maintenance costs.<br>• **GIS Application for TSMO Planning** –A GIS web application (OneMap) was developed so that information such as ITS device locations, congestion information, and crash data can be combined for better visualization and analysis.<br>• **Antiquated ITS Devices Effort** – PennDOT has instituted a framework for addressing antiquated ITS devices. The framework defines "The Five Rs of ITS Device Maintenance" – Repair, Refurbish, Replace, Relocate, and Remove. This guidance is used to assess options for in-place devices and guide investment decisions. |

ENTERPRISE

# "Evolving and Phasing Out ITS Devices and Systems"

## Case Study Summary – WisDOT

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| **Agency** | Wisconsin Department of Transportation (WisDOT) |
| **Information Source(s)** | 2/27/19 interview with David Karnes and Mark Lloyd, WisDOT |
| **ITS Devices or Systems in this Case Study** | 1) Highway Advisory Radio (eliminating)<br>2) 511 Phone Service (replacing)<br>3) Trip Routing Tool on 511 Website (discontinuing component)<br>4) Advanced Traffic Management System (replaced)<br>5) Dynamic Message Signs (relocating)<br>6) Build Fleet of Temporary ITS Devices (reusing, evolving) |
| **Tools to Guide Decision Making** | • Transportation Systems Management and Operations Traffic Infrastructure Process (TSMO-TIP)<br>• Asset Management Software |

| **WisDOT Case Study #1: Highway Advisory Radio (eliminating)** | |
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| **Overview** | WisDOT first deployed Highway Advisory Radio (HAR) in the 1990s and currently operates 14-15 HARs statewide, plus some portable HAR devices. WisDOT is not actively removing HAR sites; rather HAR sites will be removed through attrition. To date, two (2) HAR sites have been eliminated. |
| **Decision Factors** | • **Usage / Motorist Feedback**: Usage of HAR has diminished over time. WisDOT requested input from HAR users by broadcasting a message on HAR indicating that the DOT was considering retiring the service and asking motorists to call a number to provide input. WisDOT received a few responses in favor of HAR, but most feedback indicated a low need for HAR service.<br>• **Alternatives**: Motorists are receiving information other ways such as 511 website, and 3rd party traveler information mobile apps. Therefore, HAR is no longer an investment priority for the DOT.<br>• **Access from Vehicle** - Some newer vehicles aren't equipped with AM radio.<br>• **Coverage** – The broadcast range for AM radio is limited, so HAR serves a very small sub-set of the public, so investments to keep HAR operational are not warranted since similar information is available more effectively through other services. |
| **Feedback** | For the two HAR sites that are no longer broadcasting information, WisDOT has not received any negative feedback. |

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| **Tools Used to Inform Decisions** | WisDOT utilized public outreach through a request for input that was broadcast on HAR to communicate the potential for the DOT to retire this service. |

| **WisDOT Case Study #2: 511 Phone Service (replacing)** | |
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| **Overview** | WisDOT will soon issue an RFP to procure a next generation 511 website and 511 phone system. As a part of this update, WisDOT will abandon their current 511 system and replace it with a new system that has greater functionality, is more user friendly, and includes all the features of the existing system. WisDOT is currently surveying motorists and local partners to gather input on how they use the 511 system and to identify any environmental justice (i.e. equity) concerns in terms of serving various motorist populations. WisDOT's new 511 service is expected to change over the next year. |
| **Decision Factors** | • **Alternatives**: The WisDOT 511 website continues to grow in popularity, especially during major weather events and special events.<br>• **Usage**: WisDOT is seeing significantly fewer people using IVR-based 511 service. There is an order of magnitude difference between usage of the 511 website and 511 phone service.<br>• **Cost:** The 511 phone service represents a significant cost of the overall 511 system.<br>• **Motorist Feedback:**<br>WisDOT has received feedback from motorists regarding the 511 phone service user experience:<br>– The phone system does not understand the requested route; callers need to be very specific about the route they are requesting information on.<br>– Callers must use specific words. In comparison, the public is familiar with systems such as Siri and Alexa which are more sophisticated IVR systems.<br>WisDOT is administering a public survey to motorists at rest areas to gather input for the next generation 511 system update, such as:<br>– How do travelers use the overall 511 system including web and phone?<br>– Do motorists use 3rd party mobile apps that are external to DOT traveler information systems?<br>• **Equity/Environmental Justice**: WisDOT is in the process of assessing any potential environmental justice concerns in terms of equity to various motorist populations. For example, can users access traveler information via other alternatives if the 511 phone service is eliminated? |
| **Feedback** | Change not yet implemented. |
| **Tools Used to Inform Decisions** | WisDOT utilizes usage stats for 511 phone and 511 website to help with decisions. Tracking of 511 phone usage includes number of calls, where calls originate from, and |

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| | duration of calls. Tracking of 511 website usage includes number of website hits, unique IP addresses seeking information, and time users are on each page. WisDOT also uses public/motorist surveys as a decision-making tool. |

| **WisDOT Case Study #3: Trip Routing Tool on 511 Website (discontinuing component)** | |
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| **Overview** | In 2017, WisDOT implemented a trip routing tool to provide travel time information between two points, on the 511 website. The intent of this feature was to create a profile for typical routes and alert users when travel times changed. However, if there is a road closure or a major incident along the user's typical route, the system is not able to identify a detour route. |
| **Decision Factors** | • **Motorist Feedback:** WisDOT received calls from users during a recent major flooding event that included road closures, indicating that the trip routing tool was inaccurate because it didn't show detours.<br>• **Alternatives in Place:** Other dynamic trip routing tools (e.g. 3rd party mobile apps with route guidance) are widely available to the public to disseminate this type of information. |
| **Feedback** | Change not yet implemented. |

| **WisDOT Case Study #4: Advanced Traffic Management System (replaced)** | |
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| **Overview** | WisDOT recently phased out their 25-year old ATMS system and implemented a new system that went live during the summer of 2018. The new system has enhanced features such as decision support and the ability to conduct corridor management. |
| **Decision Factors** | • **Antiquated System:** WisDOT needed a more stable system; the old system was antiquated and highly customized.<br>• **Need for Advanced Features:** Decision support features such as messaging plans are now available. Future implementation will include impacts of closures on overall system, ability to conduct corridor management, and alternate routes.<br>• **Compromises:** The previous system was good at identifying device issues that required maintenance, while the new system has fewer trouble-shooting tools. |
| **Feedback** | TMC Operators have had a positive response. The new system is more intuitive, has a useful map interface, and includes decision support. |

| **WisDOT Case Study #5: Dynamic Message Signs (relocating)** | |
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| **Overview** | WisDOT is actively assessing DMS devices and how they are utilized, including relocating DMS to higher priority locations such as high-incident areas and freeway construction zones, to ensure the best use of the DMS for operational needs. |

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| **Decision Factors** | • **Input from Motorists:** Received calls from the public with regular questions on blank DMS signs; DMS signs displaying safety messages received fewer calls. WisDOT was challenged to take a look at DMS locations.<br>• **Usage:** DMS usage is being tracked and monitored to understand how often messaging is posted to each DMS.<br>• **Local Understanding of Operational Needs:** WisDOT relies on input from ITS engineers in each region to supplement DMS usage data, to further understand DMS needs and to assist with decisions around placement/location strategies. |
| **Feedback** | Change not yet implemented. |
| **Tools Used to Inform Decisions** | WisDOT is tracking usage of DMS by tracking how often messaging is on the sign. |

| **WisDOT Case Study #6: Build Fleet of Temporary ITS Devices (reusing, evolving)** | |
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| **Overview** | As major roadway construction projects displace permanent ITS devices (e.g. cameras, DMS), temporary devices are used to continue ITS operations during construction. WisDOT is strategically building a fleet of temporary ITS devices by purchasing devices for one construction project and reusing them for future construction projects. In these cases, WisDOT owns the devices and supplies them to the contractor for deployment and operation during construction. |
| **Decision Factors** | • **Minimal Disruption to ITS Services:** During roadway construction, it is especially important to retain ITS operations and services with minimal disruption.<br>• **Efficient Use of Resources:** WisDOT can efficiently continue ITS operations during roadway construction by reusing DOT-owned temporary devices. |
| **Feedback** | No feedback noted. |

| **WisDOT – Tools to Guide Decision-Making** | |
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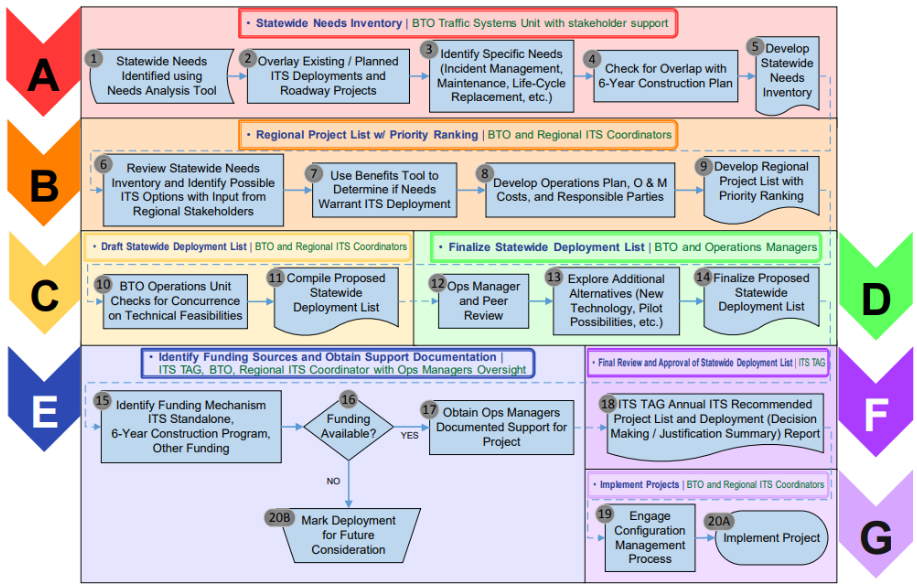
| **Overview** | In addition to specific tools noted in the case studies above, WisDOT uses the following tools and processes to review ITS assets and help guide decisions for evolving or phasing out ITS devices and systems:<br>1. **Transportation Systems Management and Operations Traffic Infrastructure Process (TSMO-TIP)** https://topslab.wisc.edu/research/tsmo/tip/<br>WisDOT, in partnership with the University of Wisconsin TOPS Lab, designed and implemented the TSMO – TIP process to review and assess the state's TSMO infrastructure system. The TSMO-TIP is a web-based application that consists of a Needs Analysis Tool and a Benefits Tool to assist with project development and to provide a consistent, transparent process to prioritize TSMO investment priorities |

for the most benefit and advancement. The TSMO-TIP flowchart below shows the detailed tasks for the TSMO-TIP process.

# TSMO-TIP Flowchart - Detailed Tasks




## 2. Asset Management Software

WisDOT is in the process of upgrading its asset management software. This could be a useful evaluation tool for life cycle management of ITS devices and systems.

## Appendix B: The FIVE Rs of ITS Device Maintenance (PennDOT)

# PennDOT- The FIVE Rs of ITS Device Maintenance

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| REPAIR | A device will be repaired when parts fail, and the maintenance contractor can easily provide those parts at a reasonable cost. As a “rule of thumb,” after a component for a device is repaired three times, consideration should be given to retiring the component, or evaluating if the device itself can be efficiently repaired in the future.<br><br>At this time, begin to compare the repair B/C to that of the other options listed. |
| REFURBISH | A refurbished device will keep the same skeleton/housing and structure, but have the “guts” removed, and replaced with parts that bring the device into compliance with today’s standards.<br><br>A refurbished device should also be accompanied with a new warranty. When considering the cost of refurbishing a device, compare the refurbish B/C to the replacement B/C to determine if a device should actually be replaced. |
| REPLACE | A device should be replaced when it is determined that it can no longer be repaired effectively, when parts are no longer available, or the supporting structure needs to be replaced. A device should also be replaced if the replacement B/C is greater than that of refurbishment.<br><br>When a device has reached its end-of-life, and before it is replaced, consider if the need for the device still exists, or whether operations would benefit from relocating the device. |
| RELOCATE | A device should be considered for relocation when the current location no longer provides the maximum amount of coverage, the current location no longer meets standards, or other newer devices in the area / along the corridor provide more information to the motorists or the TMC.<br><br>After determining a device should be relocated, consider if the existing device/structure can be utilized, or if it should be refurbished or replaced.<br><br>This option should strongly be considered when planned or active construction projects are nearby. |
| REMOVE | The device should be removed when it is no longer needed to advise motorists of an event, or in the case of equipment such as vehicle detectors, may no longer provide meaningful information to the TMC.<br><br>As with relocation, this option should strongly be considered when planned or active construction projects are nearby. |

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