Establishing goals and measuring results is essential to running a successful organization and meeting public expectations. Accordingly, the Wisconsin Department of Transportation (WisDOT) developed the MAPSS Performance Dashboard to review five key goals and over-arching performance measures that guide in achieving the Department's mission "to provide leadership in the development and operation of a safe and efficient transportation system."

Department-wide performance measures are a top priority. They provide a powerful tool to inform the public and policymakers about the department's progress in fulfilling its mission to provide for the reliable, predictable and safe movement of people and freight across the statewide and Great Lakes regional highway network.

To aid in this mission, WisDOT established a Traffic Operations Infrastructure Plan (TOIP). The goal of TOIP was to integrate operations into WisDOT planning processes. TOIP development crafted a methodology and associated tools to strategically evaluate potential operational improvements from technology applications, improved communications, and intelligent transportation systems (ITS) in a manner similar to traditional highway improvement projects. The planning effort has resulted in a quantifiable method for that evaluation, designed to build upon current WisDOT planning and programming processes.

As this program has evolved, the focus has broadened to comprehensive transportation systems management and operations (TSM&O) and improved business practices. TSM&O involves integrated strategies to optimize the performance of existing infrastructure through the implementation of multimodal and intermodal, cross-jurisdictional systems, services, and projects designed to preserve capacity and improve security, safety, and reliability of the transportation system. TSM&O includes:

- Actions such as traffic detection and surveillance, use of probe data and connected vehicles, corridor management, freeway management, arterial management, active transportation and demand management, work zone management, emergency management, traveler information services, parking management, traffic control, commercial vehicle operations, freight management, and coordination of highway, rail, transit, bicycle, pedestrian operations along with the potential future considerations of congestion pricing and automated enforcement; and
- Coordination of the implementation of regional transportation system management and operations investments (such as traffic incident management, traveler information services, emergency management, roadway weather management, intelligent transportation systems, communication networks, data collection on the system, and information sharing systems) requiring agreements, integration, and interoperability to achieve targeted system performance, reliability, safety, and customer service levels.

- Plans to retire system components that no longer provide sufficient benefit to warrant continuation or are technologically obsolete.

Research in TSM&O effectiveness shows that moving beyond a collection of strategy applications to an effective TSM&O program requires a set of deliberate change management actions to improve agency capabilities. This has resulted in the development of a "Capability Maturity Model" (CMM). The CMM is a concept to support self-evaluation and identification of critical priority "next steps to" placing TSM&O activities on a path to improved outcomes on a continuing basis. CMM key dimensions include:

- Business Process
- Systems and Technology
- Performance Measurement
- Culture
- Organization and Workforce
- Collaboration

WisDOT has participated in CMM assessments and is currently developing a CMM implementation plan that will be reflected in the future TSM&O Infrastructure Plan.

The intent of this State of the State report is to:

- Present an inventory and description of current WisDOT traffic operations/ITS infrastructure,
- Describe the current extent of and future plan for ITS deployment as described in the TOIP, and
- Begin defining the framework to increase benefits of the existing and future infrastructure through use of new/different technologies and data sources and apply a more comprehensive planning/business approach.

ITS Deployment in Other States

ITS deployment planning and device installation has been researched in other Midwestern states to see how WisDOT compares to other states in the region. Surveys were sent to the state DOTs from Indiana, Iowa, Michigan, Minnesota, Missouri and South Dakota. These states were selected because their geographical features are similar to Wisconsin: states in the Midwest that are mostly rural with two to three major urban areas. Responses were received from most of the states.

ITS Device Deployment

Monitoring national efforts in deploying new technologies and determining their cost effectiveness is a critical step in developing the TSM&O Infrastructure Plan. As part of this effort, regional states were surveyed on their ITS deployments. The surveyed states were asked about the ITS devices that were currently deployed in their states, and as an optional response, the number of devices deployed. For a full breakdown of specific devices, see Appendix E.

Table 3: ITS Device Deployment							
ITS Device	**WI**	**IN**	**IA**	**MI**	**MN**	**MO**	**SD**
Traffic Detectors for Travel Times	340 Sites	100+ detector sites	394 side-fire radar sensors	428 microwave sensors	5,500 loop detectors; 230 Wavetronix	800 detectors / microwave radars; 70 Bluetooth	No
Dynamic Message Signs	106	100+	120	179	184	Approx 250	Yes
CCTV Cameras	291	300+	300+	406	600	700	Yes
Interconnect Traffic Signals	Yes	2,600	Yes	1,300	No Response	1,300	Yes
Ramp Gates	571?	No	4	No	No Response	No	Yes
Ramp Meters	140	No	No	No	441	Yes	No
Highway Advisory Radio	15 Stations	Yes	12 Stations	Yes	Yes	Yes	Yes

The states were also asked if there was other ITS technology that they currently have deployed, ITS devices that are planned on being deployed within the next six years, ITS devices that are being retired and if they are planning on purchasing traffic data from an outside source within the next six years.

Other Existing ITS Technology:

Iowa
- Five Interstate main-line automated closure gates
- 10 iCones (Doppler Radar)

Michigan
- 54 Road Weather Information System (RWIS) / Environmental Sensor Station (ESS)

Minnesota
- 300 Lane Control Signals
- Intelligent Lane Control Signals

New Technology Planned within the Next Six Years:

Indiana
- Integrating third party data (INRIX) into their data set and utilizing it for roadway operations
- Wi-Fi Sensors instead of Bluetooth sensors

Iowa
- Variable Advisory Speed Limits
- Low-Clearance, Vehicle Height Detection and Warning Systems
- Ramp Meters

Michigan
- Dedicated Short Range Communications equipment (controllers, converters, and radios) to support Connected Vehicle Applications

Missouri

- Colored or high-resolution DMS

South Dakota

- Adaptive signal control signals

ITS Technology to be Retired:

Indiana

- Highway Advisory Radio
- Bluetooth Sensors

Iowa

- Automated Interstate closure gates if no reliable product can be located

South Dakota

- Highway Advisory Radio

Plans to Use Traffic Data from an Outside Source:

Indiana

- Currently receiving real time INRIX data and working with Purdue University to integrate the data into daily operations

Iowa

- Purchased INRIX data for the entire state for March 2014 – February 2015, with the option to extend two additional years

Michigan

- Currently use HERE (formerly Navteq) for probe data. Recently reselected HERE for next 3-5 years.

Missouri

- Currently using HERE

<u>ITS Deployment in Other States Conclusions</u>

With existing ITS device deployment, WisDOT is comparable to other Midwestern states with the number of travel time traffic detectors, dynamic message signs, CCTV cameras, interconnected traffic signals and the use of highway advisory radio. Wisconsin has considerably more ramp gates than the other Midwest states. Only two of the six states surveyed currently use ramp meters, but one additional state is planning on deploying ramp meters within the next six years.

Future TSM&O Infrastructure Plan

The evolution underway to more comprehensive TSM&O and improved business practices also includes a new approach to planning for future TSM&O infrastructure, and this section of the report outlines a framework to follow moving forward. The foundation of the plan begins with identifying the purpose and need for improvements to the management or operations of WisDOT facilities. This needs assessment is based on WisDOT priorities for high priority routes for consideration, as well as data availability. Following this is the identification and prioritization of locations for deployments or systems for improvements, which depend on the nature of the issues, the economic assessment, and types of devices, data, software, and other considerations.

ITS infrastructure and maintenance investments should be based on:

1. Asset management approach
2. Performance Management (Reliability, Vehicle Delay, Safety)
3. Smart Workzone
4. Benefit : Cost
5. Ability to operate and maintain
6. Partnership opportunities
7. Long-term maintenance costs

Retiring Existing Infrastructure and Services

A key consideration within the TSM&O infrastructure plan is deciding which devices or systems no longer provide sufficient benefit to warrant continuation. This could be due to declining benefit-cost ratios, budget reductions, or the recognition that shifting to private sector services is more cost effective or provides better customer service. Some examples of these include the following:

- Retire permanent Highway Advisory Radio (HAR)
- Investigate reduced fiber system needs in the future
- Investigate reduced detection needed due to growth of probe data over time
- Private sourced traveler information in the future
- Investigate if BTO should maintain control and maintenance responsibilities of existing fiber optics or to turn control over to another State department. A survey is being prepared to send to other state DOTs regarding ownership and maintenance of fiber optic facilities needed for state ITS devices.

The benefit-cost ratio for ITS devices in a corridor should be calculated regularly to ensure the operation of the devices is necessary. The method and schedule of the calculation should be included within the TSM&O.

TSM&O Planning Framework

The geographic coverage begins with a focus on the nine interstate corridors included in the MAPSS mobility measures. The Connections 2030 long-range transportation plan identifies 37 corridors around the state. Of those, nine cover the current interstate system. Upon the US 41 to I-41 conversion, there will be ten corridors, defined as follows:

- Badger State: I-94, I-90/94, and I-39/90/94 between US 53 South of Eau Claire and US 51 North of Madison, 163 miles;

- Capitol: I-94 between I-39/90 East of Madison (the Badger Interchange) and I-43 in Milwaukee (the Marquette Interchange), 70 miles;
- Chippewa Valley: I-94 between the Minnesota state line and US 53 South of Eau Claire, 70 miles;
- Coulee Country: I-90 between the Minnesota state line and I-94 near Tomah, 45 miles;
- Glacial Plains: I-43 between I-39/90 near Beloit and I-94 in Milwaukee (the Mitchell Interchange), 66 miles;
- Hiawatha: the I-94 North-South section between the Marquette Interchange in Milwaukee and the Illinois state line, 39 miles;
- South Central Connector: I-39/90 between US 51 North of Madison and the Illinois state line, 55 miles;
- Titletown: I-43 between the Marquette Interchange and US 41 in Green Bay, 119 miles;
- Wisconsin River: I-39 between I-90/94 near Portage and WIS 29 South of Wausau, 103 miles; and
- (forthcoming) Fox Valley: I-41 between I-94 in Milwaukee and I-43 in Green Bay, 133 miles.

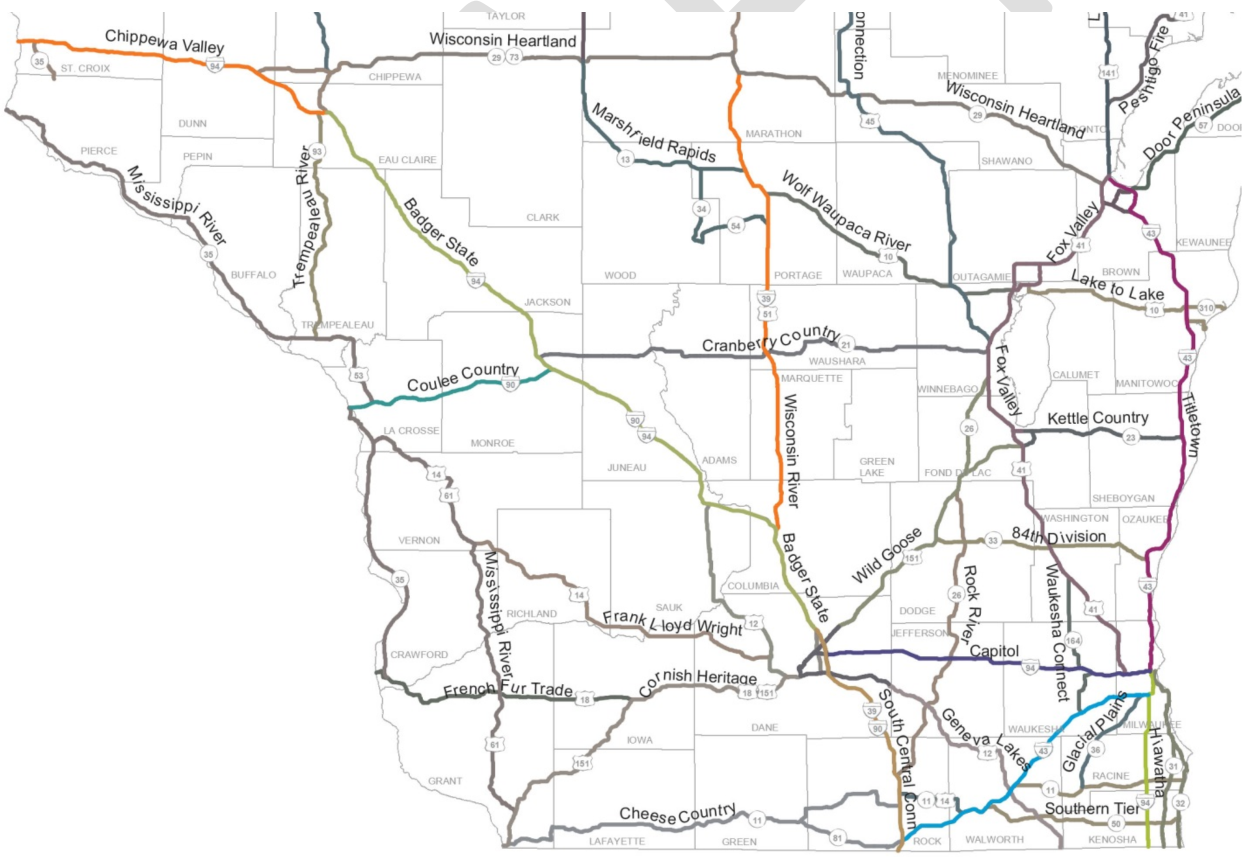


Figure 3: Connections 2030 and MAPSS Interstate Corridors

In addition to these statewide interstate segments, the TSM&O plan must include:

- Arterial Management in urban corridors and urban areas, such as Madison, Milwaukee, and others to be determined in the plan
- Other key arterial routes
- Work zones
- Multimodal and transit facilities
- Connected Vehicles
- Designated Long Truck Routes

The ITS needs for non-interstate arterial routes currently identified in the TOIP will be evaluated. Evaluation of ITS needs for specific corridors and local roads should be completed prior to project scoping. The placement and implementation of ITS devices will be prioritized and placed as funds become available. This evaluation can be done to assist with the scoping for reconstruction or 3R projects, whether on a state route, a connecting highway, or a local programs project.

Recognizing that the methodology and data availability for routes and facilities varies, the approach to arterial TSM&O planning will encompasses the Arterial Integration Management (AIM) plan, a separate effort underway in 2013-2014 that includes pilot evaluation segments.

Since the completion of the various components of the original TOIP between 2008 and 2011 (see Appendix A), there has been a substantial increase in various ITS deployments (see Appendix B). But, there are also a number of advances in software systems and data integration that are now enabling the streamlining of the TSM&O planning process. Chief among these are the spatial database now in place for all ITS and ITSNet inventory, and geographic information systems (GIS) tools, applications, and mapping.

Referring to the ITS Business Cycle graphic, the TOIP completed the boxes shown on the bottom for GIS, analysis, planning, and investment. Other elements of the cycle were in various states of completeness at that time.

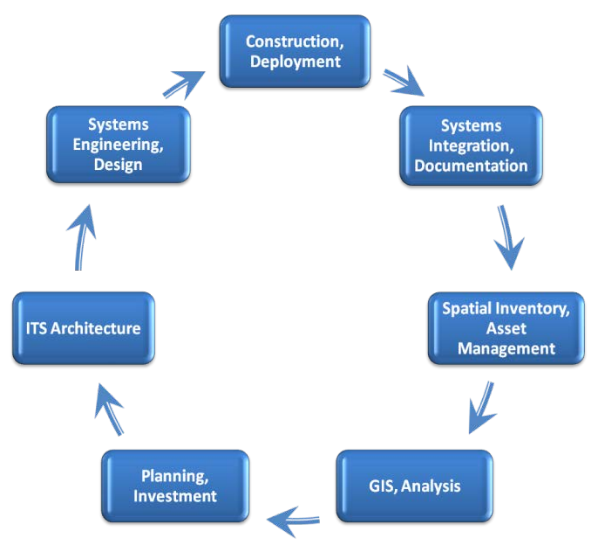


Figure 4: WisDOT ITS Business Cycle

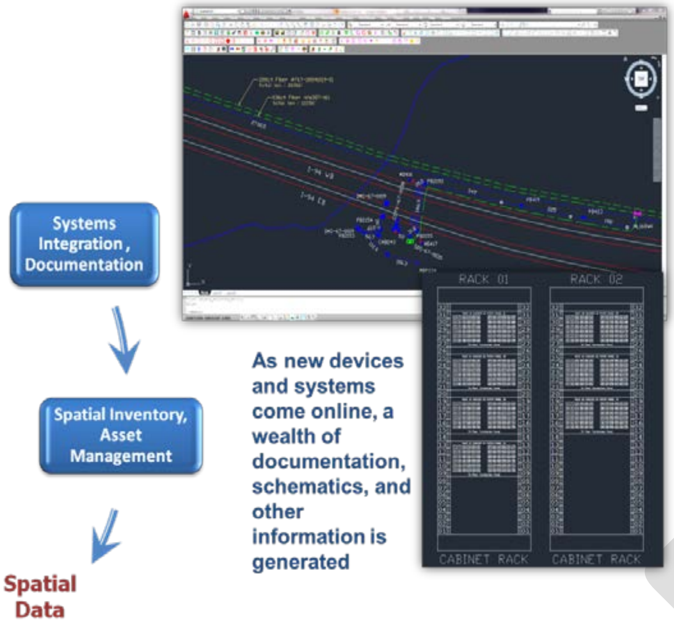


Figure 5: ITS/ITSNet Spatial Inventory

In 2010 as the original TOIP components were nearing completion, BTO contracted with the TOPS Lab to implement, host, and update the ITS/ITSNet spatial inventory. From early 2013, this has housed all WisDOT traffic operations inventory in an Oracle Spatial database, utilizing the SpatialInfo software suite, including detail on as-builts, fiber cables, optical equipment, inside plant connections, documentation, GIS metadata, and other attributes.

This fills a critical gap in the business cycle by injecting a versatile and dynamic inventory system that provides GIS, online mapping, and analysis for planning and agency investment decisions. This system now fuels the information necessary for asset management and maintenance activity. There are multiple ways to interface with the inventory, including an AutoCAD front end, web mapping, and standards-based data exchange formats such as JSON or XML.

With existing ITS/ITSNet assets in a spatial database, GIS analysis and mapping is now enabled and streamlined. This has allowed rapid development of mapping products, both online and PDF or other formats. More critically for TSM&O planning purposes, this has afforded WisDOT the opportunity to execute more sophisticated spatial analysis for TSM&O infrastructure planning. An example of this was prompted by the influx of about $10 million for communications, signals, and ITS improvements. With the spatial database utilized via ArcGIS, the TOPS Lab was able to provide information for what is entailed to connect all of the approximately 1,000 traffic signals to the ITSNet fiber network along the state highway system, the output of which included graphics and distance estimates broken down by WisDOT region.

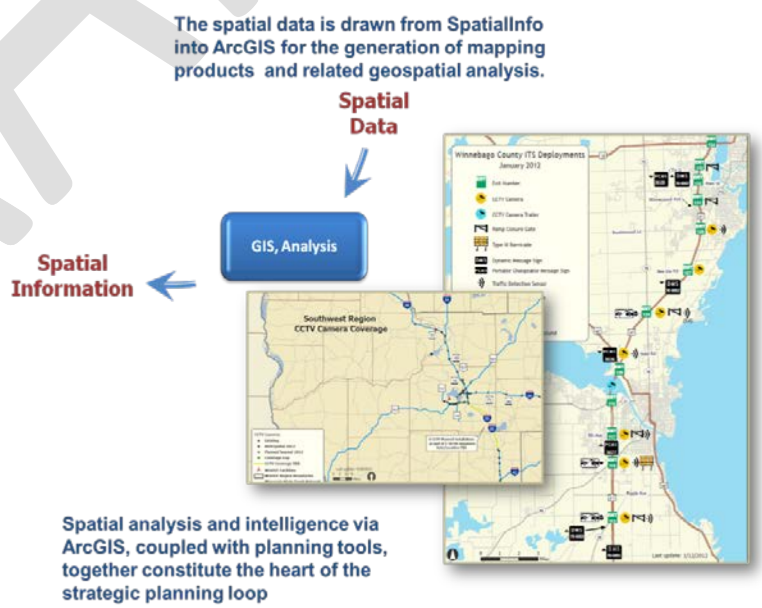


Figure 6: ITS, GIS, and Mapping

In addition to SpatialInfo being used for fiber cable asset management, Cartegraph software is used for ITS asset management for other ITS devices. Cartegraph tracks installation and maintenance records for DMS, CCTV cameras, count stations, ramp gates, ramp meters, wireless detection stations and state owned signals. Cartegraph is being used as a decision making tool regarding ITS assets by assisting with decisions where to put available financial resources for tasks such as maintenance or equipment updates. A next generation software for Cartegraph is currently being considered.

Figure 7: TSM&O Planning Component

Lastly for this TSM&O infrastructure planning framework, the GIS power is coupled with operational and safety data for needs assessment, analysis, and graphical depictions to aid the planning and prioritization process.

<u>Needs Assessment</u>

TSM&O strategies and solutions offer many benefits, but issues and needs must first be identified for targeted, cost effective, and responsible use of WisDOT resources. TSM&O related needs may exist in the following categories:

- Capacity
- Maintenance and Operations
- Safety
- Security
- Freight movement
- Work zones
- Reliability
- Customer service

A successful plan must include stakeholder input; data driven methodology; and transparent, reproducible processes. The TOIP had some success in that regard, including relying on the wealth of operational and safety data maintained and updated regularly within MetaManager. The data inputs from MetaManager, mentioned earlier in this report, included several measures of facility usage, performance, and safety. It also included measures of adverse winter weather and special event impacts, from other sources. With stakeholder input, other subjective considerations are incorporated, such as the weighting factors and the inclusion of certain corridors due to their classification.

The TSM&O infrastructure plan will improve upon that needs assessment process in a number of ways, some of which are already underway in 2014. First, it will include a great deal of data integration and automation. Rather than a cumbersome manual process updated every two years, it will be updated three times per year each time the MetaManager data is refreshed. It will not be limited to just the input factors from the TOIP. Stakeholders will be free to add or remove factors of interest, as well as adjust the weighting of them. This will enable, for example, a view of TSM&O needs due primarily to freight, growth, safety, or other factors, thus improving stakeholder understanding of system performance and operational needs. Input for these factors should be solicited from WisDOT Region Operations and Planning staff, Bureau of Highway Maintenance, Division of Transportation Investment Management, regional planning agencies such as SEWRPC, and large urban communities.

Second, GIS spatial analysis tools will be used to compare the existing spatial inventory data with the results of the new data analysis through the TSM&O needs assessment. The GIS spatial analysis will review potential ITS deployment gaps in corridors and how the TSM&O should address the gaps. For example, although a segment of freeway may show problematic TSM&O issues, if it is already saturated with ITS assets, services, and technologies, it may no longer be a priority for further TSM&O investment.

Third, key new enhancements, technologies, or expansions to be explored as part of a new TSM&O infrastructure plan include:

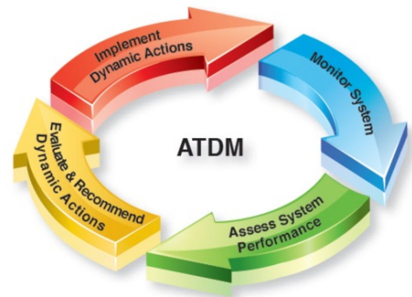
- Arterial coverage in addition to what is already included in Connections 2030, incorporating the AIM plan mentioned earlier, and with an eye toward supporting WisDOT Regions in identifying signal system arterial infrastructure
- New and refined classes of input data such as the winter road condition archive from 511, travel reliability metrics calculated from newly available probe data, improved special event traffic indicators, and weather related crash indicators
- Expanded spectrum of technology applications such as mobile detection or Connected Vehicle technologies
- Incorporation of the FIIPS geometry as an overlay for the tracking purposes, which is targeted toward supporting WisDOT Regions in their ITS deployment prioritizations

The output from the needs assessment phase will include detailed maps, both online and printable, with color coded TSM&O needs levels and segment and corridor rankings for WisDOT prioritization purposes.

<u>TSM&O Strategies and Solutions</u>

Following the updated needs assessment, the TSM&O infrastructure plan will identify potential improvements to meet those needs. TSM&O encompasses a broad spectrum of strategies and solutions. Some strategies and solutions will be specific to mode, data type, or device and others will be more systems or services based. Below is a sample list of the strategies and solutions. This list is not meant to be exhaustive and the TSM&O plan will elaborate on some of the strategies and solutions. The list below does not include ITS technologies currently used by WisDOT such as DMS, traffic cameras and ramp meters. The current technologies should be evaluated because they may still be the most cost effective alternative. The installation of non-ITS devices, such as ramp gates and lighting, should also be addressed in the TSM&O.

The advisability of any improvement depends on several factors. Some issues point to certain solutions over others. For example, a segment with a recurring bottleneck but better than average safety performance may suggest improving corridor management instead of increasing incident response service. An improvement must fit into the long-term goals and direction of the Department (strategic, resourcing, IT and support networks). A proposed improvement must have a benefit-cost ratio greater than one and it is preferable to select the most appropriate alternative with the largest cost-benefit ratio. An improvement must also be financially justified. There must be budget available for the improvement or funds must be freed up by reduced expenditure in another area.



A. Traffic Management
   1. Integrated Corridor Management (ICM)
      - Arterial specific deployments
   2. Active Traffic Management (ATM)
   3. Active Transportation and Demand Management (ATDM)
B. Information and Control Systems
   1. Next Gen Asset Management
   2. Next Gen Advanced Traffic Management System (ATMS)
   3. Road Weather Information System (RWIS) Integration
   4. Automatic Traffic Recorder (ATR) equipment consolidation
C. Performance Management Systems
   1. Regional Integrated Transportation Information System (RITIS)
   2. Iteris Performance Management System (iPeMS)
   3. Traffic Operations Performance Management System (TOPMS)
D. Multimodal Operations
   1. Transit
      a. Buses
      b. Zimride
      c. Zipcar
      d. Uber / Lyft
E. Detection and Surveillance
   1. Detection stations (DTSD vs. DTIM)
F. Alternative Data Sources (Google, Waze, probe data, Bluetooth, Wi-Fi)
   1. Describe alternate data sources
   2. How will the sources be used
   3. Automated Vehicle Location (AVL) in WisDOT managed fleet
   4. Probe data pilot corridor, e.g., I-39/US 51 north of the split with I-90/94
G. Communications Infrastructure
   1. Fiber network maintained by the State (BTO or other State agency) or privatized fiber network

H. Freight Services
   1. Opportunities with Drivewyze
   2. Truck parking monitoring and availability
I. Traveler Information
   1. Future of 511
J. Emerging Technologies
   1. Connected / Autonomous Vehicles
      - 2017 Connected Vehicle test bed (potential/hypothetical)
      - Identify fiber optic network needs for connected vehicle operations
      - Develop a Connected Vehicle test corridor with adaptive capabilities in Madison or Milwaukee (Bluemound / Wisconsin parallel to I-94 E-W)

<u>Implementing Improvements</u>

Finally, the TSM&O infrastructure plan will lay out the process and business considerations for adding to or expanding TSM&O devices, services, or systems. Regardless of benefits, the implications on programming and budgeting cannot be overstated, and implementation must carefully consider these elements.

- Integration of mobility performance measures into decision making processes for arterials and freeway segments (user delay cost, reliability, incident clearance)
- Prioritizing investments
  - Benefit-cost analyses
  - Life cycle, long term operation, and maintenance costs
- Funding sources and programming
- Business process change to track ITS costs
- Operating and maintaining systems and equipment

Appendix A – TOIP History and Description

History

Cambridge Systematics was selected as the lead consultant for the project in late 2006. The concept was originally named ITS Sketch Plan, then Traffic Operations Sketch Plan, and settled on Traffic Operations Infrastructure Plan. Through its development, the TOIP groundwork had good participation and buy-in from Bureau staff from both DTSD and DTIM.

The original TOIP methodology and final report was completed in May 2008. It is explicitly structured around the Connections 2030 planning framework. The technology areas include detection, incident management, traffic signal systems, surveillance, ramp and highway traffic flow management, communications, and traveler warning and information.

The original TOIP received the FHWA & FTA Transportation Planning Excellence Award[1].

In 2009, a TOIP Implementation Plan was completed which refined the locations to install ITS devices. This plan also included the development of a project scheduling and implementation tracking tool to monitor progress on TOIP project implementation. As part of the implementation plan, Economic Analyses for each region were also performed to provide benefit/cost analysis of deploying ITS elements.

In 2010, the first biannual TOIP Update was initiated which applied newer data reflecting current patterns. It also included additional ITS technologies not considered in the original report.

The 2011, the TOIP Communication System Layer (CSL) was completed to identify statewide communication infrastructure needs and develop detailed deployment plans considering communications connectivity to related devices.

TOIP Description

The TOIP is first and foremost an operational needs identification framework. It builds off of the Connections 2030 Long-Range Transportation Plan[2] and its 37 identified corridors. Within the overarching objective of improving corridor management, the TOIP seeks to assess the 37 Connections 2030 corridors from an operational standpoint, rank them, and target specific corridors for operational improvements. Between the WisDOT central bureaus and the individual regions, a corridor vision would be followed by identification and implementation of specific operational improvements.

The primary source of input data is WisDOT's MetaManager dataset. MetaManager is a comprehensive source of spatial data on the state trunk network that is updated three times per year. From MetaManager, the TOIP draws in per-link data on current and future traffic volumes, truck

[1] http://www.fhwa.dot.gov/planning/tpea/2008/#aw

[2] http://www.dot.state.wi.us/projects/state/connections2030.htm

percentages, current and future levels of service (LOS), crash rates, crash severities, and volume growth. To this is added information on adverse weather, special events, and - later -travel times from a national probe dataset.

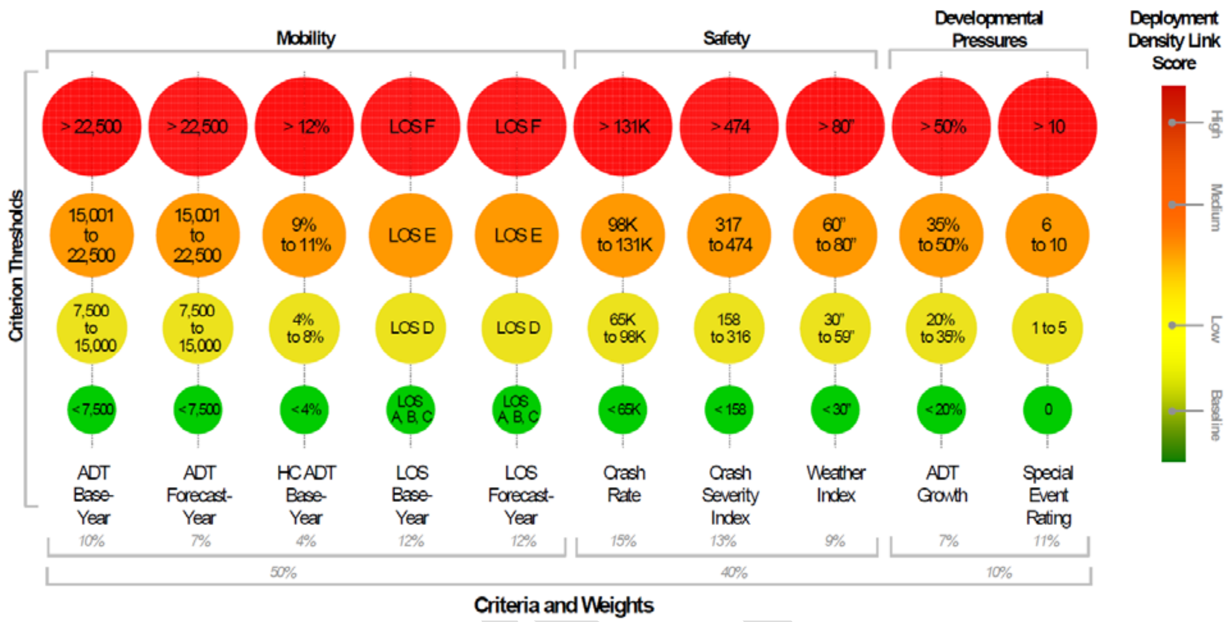


Figure 1: Original TOIP Criteria and Thresholds

Operational performance was calculated for every MetaManager link, aggregated by direction into what was called a Deployment Density Class (DDC), and ultimately rolled up into corridor wide summary measures. Based on this method, 14 of the 37 corridors were identified as Priority or Emerging Priority Corridors. The Implementation Plan[3] took these corridors and added specific detail including device deployment locations, cost estimates, linkages with upcoming construction projects, and benefit-cost assessments. Where the implementation and refinement plan did show specific device deployment recommendations in specific places, this was not data driven but was based on engineering judgment of the consultant at the time in collaboration with WisDOT staff.

Communications Systems Layer (CSL)

In 2010, the TOIP CSL[4] was completed, identifying statewide communications infrastructure needs, deployment plans, and cost estimates for further ITS connectivity. The WisDOT ITS fiber network communication system (ITSNet) is dedicated to traffic safety and operations. It connects the major cities around the state, provides for high speed, high capacity, reliable and redundant communications for the WisDOT Bureau of Traffic Operations (BTO). In the original TOIP effort, it was recognized that the next step from a needs assessment is identifying gaps. These include gaps in device locations themselves, e.g., high need stretches with no camera coverage, as well as gaps in electrical service and communications, the last of which is the target of the CSL.

[3] http://www.topslab.wisc.edu/its/toip/implementation.php

[4] More information on the CSL is at http://www.topslab.wisc.edu/its/toip/csl/

For planning the supporting fiber network expansion, an inventory of the existing devices and network infrastructure was developed. A geospatial database was created using ArcGIS, connecting the existing deployment and network with the proposed devices identified on the TOIP implementation plan, WisDOT offices, STOC, and other agencies that will be using the fiber network. The outcome of the CSL was a statewide fiber expansion plan, and not to mention the beginnings of a drastically improved ITS and ITSNet inventory system[5].

Biannual Updates

The TOIP continues to be maintained by the TOPS Lab, including biannual updates using new MetaManager data. The first update used 2010 MetaManager data (completed in 2011), reflecting newer traffic patterns. Corridor priority scores changed to different extents for all corridors, and the rankings altered slightly. Changes were due principally to traffic volume, LOS, crash rate, percent trucks, and infrastructure improvements (thereby improving operations and lower the relative need). The Wisconsin Heartland corridor (WIS 29 between Eau Claire, Wausau, and Green Bay) was added to the Emerging Priority list.

As part of the 2013 update (using 2012 data), the same methodology was done to replicate what came previously and provide a basis for comparison. The results are summarized in the following bar chart. In addition to that work, the TOPS Lab has been working to improve the methodology and process, including bringing the methodology fully into the ArcGIS environment, automating the process to enable more frequent updates (as much as three times per year following each MetaManager release), and incorporating new contributing factors such as travel times from the newly available national probe dataset.

[5] This utilizes SpatialInfo, http://www.topslab.wisc.edu/its/inventory/, which has become the foundation of mapping applications and traveler information data.

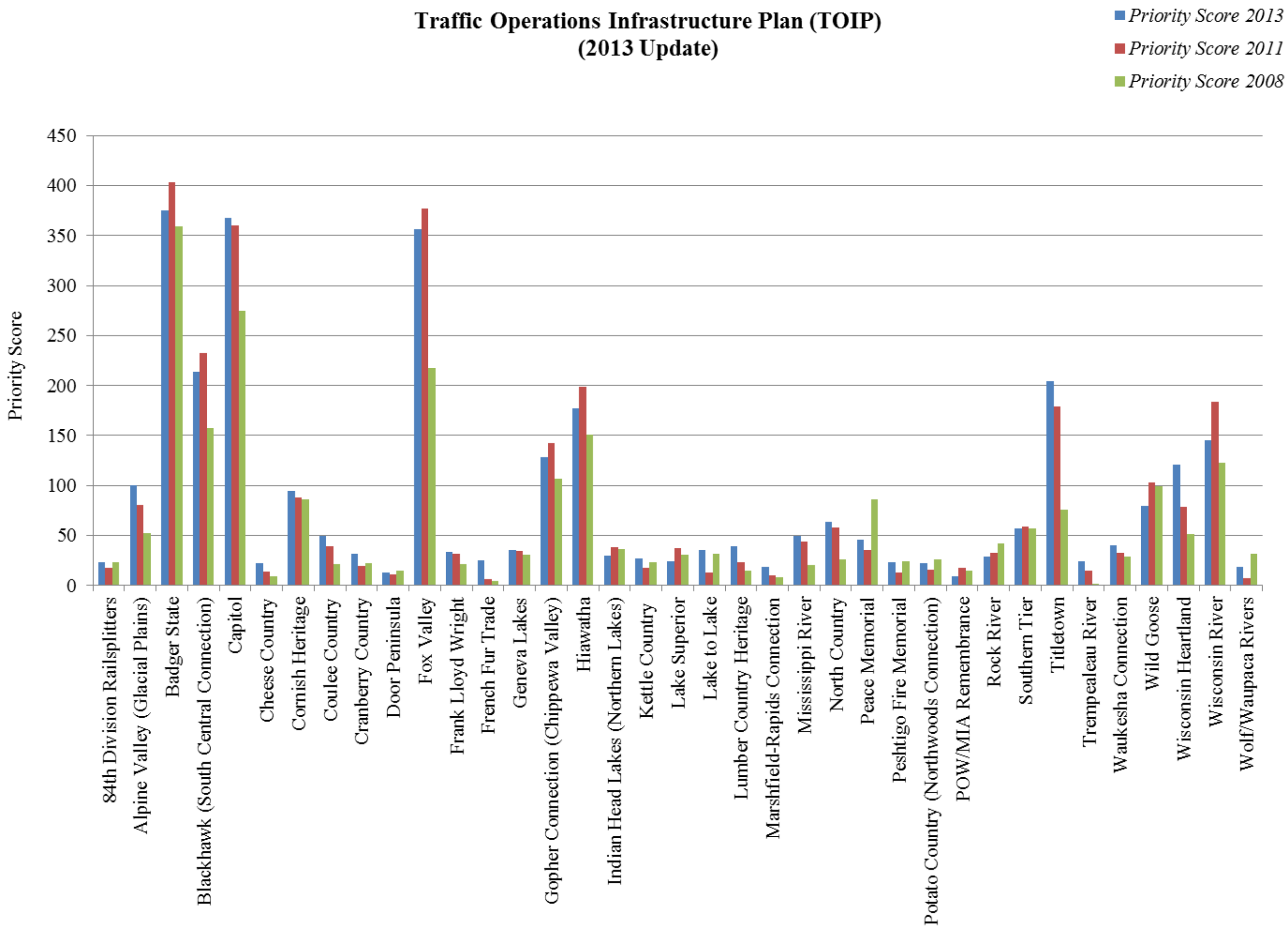


Figure 2: Corridor Priority Rankings

Operational Strategies

ITS traffic management tools are designed to improve the safety and efficiency of the statewide freeway system by reducing incidents and relieving traffic congestion.

Some different types of ITS traffic management tools include, but are not limited to:

Traveler Warning and Information

- Dynamic Message Signs (DMS) (permanent and portable)
- Highway advisory radio (HAR)
- Traveler information systems
    - Traffic Incident Alerts (TIA)
    - Main 511 site and phone system
    - 511 Projects
    - 511 Winter Roads System (WRS)
- Road weather information system (RWIS) and environmental sensor stations (ESS)

Traffic Flow Management

- Ramp meters
- Traffic signal systems, including adaptive signals
- Variable speed limit systems
- Work zone detection
- Lane Closure System (LCS)

Incident Management and Surveillance

- Closed circuit television cameras (CCTV)
- Non ITS management tools
    - Ramp gates
    - Crash investigation sites

Detection

- Over height detection
    - Flood alarms
- Traffic detection
    - Radar, microwave
    - Loops
    - Bluetooth
    - Wi-Fi
    - Probe data, e.g., Inrix, HERE, TomTom

Communications

- ITSNet network, including fiber routes, wireless communications, field equipment, communication huts, network switches, etc.

There are many benefits of these ITS traffic management tools, which include:

- Detailed information about current travel conditions and times in urban regions enables travelers to make informed decisions about how they travel.
- Agencies are able to respond faster and more efficiently to interruptions in travel caused by emergencies, accidents, breakdowns, weather and increased congestion.
- Reduced congestion improves air quality, decreases noise pollution and lowers fuel consumption.
- Trucks and other commercial vehicles are able to move through urban regions with minimal delays, helping the freight industry maintain lower costs to consumers.

Appendix B – Current TOIP Deployment Status

Table 1 below shows the deployment of ITS devices in the 37 corridors identified in the TOIP. By the end of 2014, it is estimated that 80% of the deployment of ITS devices recommended in the TOIP will be complete and by the end of the six year program, 87% of the ITS devices will be deployed. The number of devices shown includes devices that were installed before the TOIP was completed in May 2008.

Table 2 presents the current value of the ITS devices currently deployed in Wisconsin and the annual operating expenses associated with the ITS devices.

Table 1: TSM&O Infrastructure Plan Deployment Outlook

	Cameras				DMS				Detection				Ramp Meters			
Corridor	*In the TOIP*	*By 2014*	*By 2020*	*Not in the program*	*In the TOIP*	*By 2014*	*By 2020*	*Not in the program*	*In the TOIP*	*By 2014*	*By 2020*	*Not in the program*	*In the TOIP*	*By 2014*	*By 2020*	*Not in the program*
Badger State (North)	12	11	12	0	7	4	7	0	3	2	3	0	0	0	0	0
Badger State (Central)	7	3	5	2	0	1	1	0	7	3	5	2	0	0	0	0
Badger State (South)	11	5	9	2	0	1	1	0	11	8	2	1	0	0	0	0
Capitol Corridor	5	5	5	0	2	0	0	2	5	5	5	0	0	0	0	0
Fox Valley	3	3	3	0	0	1	1	0	1	1	7	0	0	0	0	0
South Central Connection	6	6	6	0	1	1	1	0	7	7	7	0	0	0	0	0
Hiawatha	5	5	5	0	1	1	1	0	8	8	8	0	4	2	4	0
Wisconsin River (Part 1)	3	0	0	3	0	0	0	0	3	0	3	0	0	0	0	0
Wisconsin River (Part 2)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chippewa Valley	8	8	8	0	4	0	4	0	3	1	3	0	0	0	0	0
Wild Goose	0	0	0	0	0	0	0	0	3	0	0	3	0	0	0	0
Peace Memorial	5	1	1	4	1	1	1	1	0	0	0	0	0	0	0	0
Cornish Heritage	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Titletown	3	3	3	0	0	0	0	0	3	0	0	3	0	0	0	0
Southern Tier	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Glacial Plains	2	2	2	0	0	0	0	0	0	3	3	0	0	0	0	0
Coulee Country	1	1	1	0	0	0	0	0	1	2	2	0	0	0	0	0
Ozaukee County	5	1	1	4	1	1	1	0	5	5	5	0	5	2	2	0
North Milwaukee	32	30	30	2	6	6	6	0	34	34	34	0	49	40	40	0
Central Milwaukee	25	25	25	0	4	4	4	0	28	28	28	0	30	26	26	0
South Milwaukee	32	31	31	1	7	11	11	0	42	42	42	0	47	44	44	0
Waukesha	16	16	16	0	4	10	10	0	27	27	27	0	19	10	10	0
Northwest Madison	9	6	6	3	2	2	2	0	19	15	19	0	19	5	5	2
Southwest Madison	5	1	1	4	0	1	1	0	5	0	0	5	0	0	0	2
Southeast Madison	27	22	24	3	15	16	16	0	44	38	38	6	20	7	7	0
Northeast Madison	14	10	12	2	4	3	3	1	18	11	15	3	9	0	0	0
Racine/Kenosha	14	10	10	4	3	1	3	0	19	15	15	4	0	0	0	0

Janesville/Beloit	11	11	11	0	0	4	4	0	15	15	15	0	0	0	0	0
Eau Claire/Chippewa Falls	21	8	14	7	7	2	5	2	13	0	7	6	0	0	0	0
Fond du Lac	4	3	3	1	0	0	0	0	0	3	3	0	0	0	0	0
Oshkosh	8	8	8	0	2	7	7	0	6	7	7	0	0	0	0	0
Appleton	24	18	18	6	7	5	5	2	25	15	20	5	2	0	0	0
Green Bay	23	18	23	0	4	10	10	0	24	16	24	0	15	0	0	0
Wausau	8	8	8	0	4	5	5	0	20	20	20	0	0	0	0	0
Hudson	4	4	4	0	3	1	1	0	5	4	1	0	0	0	0	0
Superior	6	3	5	1	6	4	4	2	0	0	0	0	0	0	0	0
La Crosse	5	5	5	0	2	3	3	0	5	5	5	0	0	0	0	0
Totals	365	291	315	50	97	106	118	10	409	340	373	38	219	136	138	4

Table 2 - Planned DMS & CCTV Installations 2014-2017

Region	Device	2013	2014	2015	2016	2017	Total New 2014-17	Total 2017
NC	DMS	4	1	0	0	0	1	5
	CCTV	6	1	0	0	0	1	7
NE	DMS	11	6	0	0	1	7	18
	CCTV *	39	1	18	2	0	21	60
NW	DMS	4	5	7	0	0	12	16
	CCTV	14	18	0	0	0	18	32
SE	DMS	37	14	5	0	1	20	57
	CCTV	174	13	23	1	0	37	211
SW	DMS	19	24	0	0	0	24	43
	CCTV	60	26	14	0	0	40	100
Total Statewide	DMS	75	125	137	137	139		
	CCTV	293	352	407	410	410		

*Does not include cameras at lift bridges

Table 3: TSM&O Infrastructure Plan Cost Compilation							
	Ramp Meters	**Detection**	**CCTV**	**DMS**	**Fiber**		
CURRENT DEPLOYMENT VALUE	$ 11,730,000	$ 9,415,000	$ 14,250,000	$ 14,075,000	$ 37,725,000	***Total Value***	***$ 87,195,000***
ANNUAL OPERATING EXPENSES							
Annual ITS Device Maintenance	$ -	$ -	$ -	$ -	$ -	***Total Cost***	***$ 1,367,800***
Annual IT Services for ITS	$ -	$ -	$ -	$ -	$ -	***Total Cost***	***$ 105,227***
Annual Utility	$ 119,232	$ 90,384	$ 71,820	$ 110,208	$ -	***Total Cost***	***$ 391,644***
Annual Deployment Maintenance and Operations Total Cost							***$ 1,864,671***

Appendix C – ITS Deployment Planning Documents in Other Midwestern States

Midwestern states were asked if their ITS deployment decisions were based on a document similar to WisDOT's TOIP. Only one state (Indiana) said they currently have a document similar to the TOIP to evaluate locations where ITS devices should be deployed and which ITS devices to use. One state (Michigan) said they do not have a plan similar to the TOIP, but they do have a six-year ITS investment plan which documents planned ITS-related projects for the upcoming six years. Two other states (Iowa and Missouri) responded that they are currently developing a statewide Transportation Management and Operations (TSM&O) strategic plan to address ITS priorities and plans.

The *Indiana Department of Transportation Traffic Management Strategic Deployment Plan* was completed by INDOT in December 2008. Comparing the WisDOT TOIP to the INDOT document, the following was observed:

- Similarities
  - Cambridge Systematics worked on both documents. The WisDOT TOIP was completed in May 2008 and INDOT completed their document in December 2008. Cambridge Systematics may have based some of INDOT's plan on the TOIP because the intent of both plans is similar.
  - Both DOTs consulted their respective state's 2030 long range transportation plans for making ITS deployment recommendations
  - Both DOTs express the importance of including ITS in improvement projects
  - Deployment maps for both states in the documents were similar
  - The deployment plan horizon is similar for both plans. INDOT's deployment plan extends to the year 2020 and WisDOT's TOIP extends to 2019.

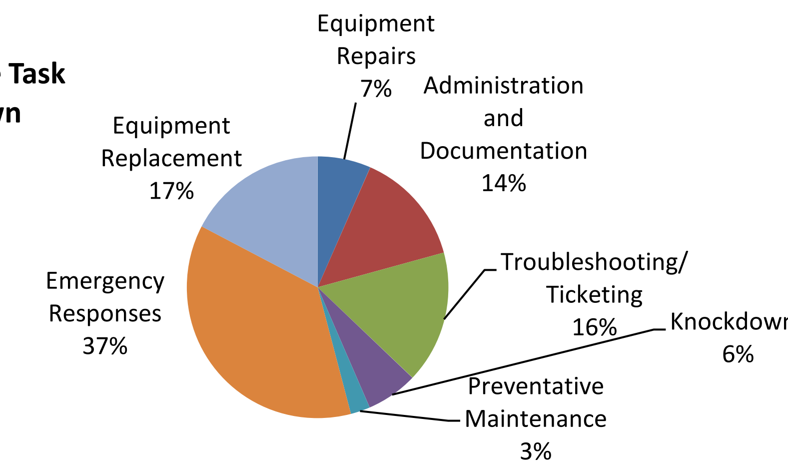
- Differences

INDOT	WisDOT
- Focuses on interstates and freeways	- Focuses on interstates, freeways and non-access controlled highways
- Material and installation costs of ITS devices estimated	- Material, installation, operations, maintenance and replacement costs of ITS devices estimated
- Includes specific deployment of ITS in standalone projects in specified years	- Used as an ITS deployment plan for consideration and inclusion in improvement projects
- Established over 100 performance measures to evaluate ITS needs	- Used 9 performance measures to evaluate ITS needs

APPENDIX D Costs

REGIONAL MAINTENANCE COSTS - Calendar Year 2013 (See Task Breakdown)								
MONTH	**SE REGION**	**SW REGION**	**NE REGION**	**NW REGION**	**NC REGION**	**EQUIPMENT REPAIRS (ALL REGIONS)**	**ADMINISTRATION/ DOCUMENTATION AND TROUBLESHOOTING/TICKETING**	**TOTAL**
JANUARY 2013	$47,245.00	$18,639.00	$2,200.00	$700.00	$880.00	$3,957.00	$38,955.00	$112,576.00
FEBRUARY 2013	$62,453.95	$11,763.00	$2,300.00	$ -	$ -	$4,795.00	$23,100.00	$104,411.95
MARCH 2013	$20,276.45	$2,890.00	$1,450.00	$1,150.00	$1,200.00	$2,480.00	$35,941.50	$65,387.95
APRIL 2013	$29,590.11	$11,272.40	$3,330.00	$350.00	$800.00	$580.00	$28,507.50	$74,430.01
MAY 2013	$28,786.60	$37,530.00	$5,690.00	$700.00	$560.00	$13,501.00	$35,910.00	$122,677.60
UNE 2013	$47,512.30	$12,580.00	$2,700.00	$ -	$400.00	$1,256.00	$22,575.00	$87,023.30
JULY 2013	$30,760.00	$14,960.00	$4,000.00	$ -	$3,005.00	$-	$29,820.00	$82,545.00
AUGUST 2013	$19,603.00	$6,260.00	$2,200.00	$1,450.00	$400.00	$10,106.00	$33,600.00	$73,619.00
SEPTEMBER 2013	$25,039.95	$10,307.00	$2,960.00	$12,435.02	$ -	$3,823.00	$29,190.00	$83,754.97
OCTOBER 2013	$11,935.50	$5,380.00	$1,400.00	$350.00	$ 400.00	$29,333.00	$34,650.00	$83,448.50
NOVEMBER 2013	$15,122.95	$700.00	$3,350.00	$ -	$ -	$8,558.00	$29,190.00	$56,920.95
DECEMBER 2013	$13,879.05	$4,550.00	$740.00	$ -	$800.00	$848.00	$24,622.50	$45,439.55
	$352,204.86	***$136,831.40***	***$32,320.00***	***$17,135.02***	***$8,445.00***	***$79,237.00***	***$366,061.50***	
							Total Regional Maintenance Costs	***$ 992,234.78***

Maintenance Task Breakdown



TASK BREAKDOWN	***Cost Per Task***
Equipment Repairs	$79,237.00
Administration and Documentation	$169,600.00
Troubleshooting/ Ticketing	$196,461.00
Knockdowns	$76,569.00
Preventative Maintenance	$29,030.00
Emergency Responses	$441,337.00
Equipment Replacement	$207,766.00
	$1,200,000.00

EQUIPMENT REPLACEMENT (Lifecycle Equipment Purchases in 2013)	
Repair Lowering Device Hardware	$5,900.00
RAMP UPGRADES HARDWARE	$82,910.00
UPGRADE Radios Wausau	$20,920.00
RSG2100 SPARES	$25,496.00
COHU Camera SPARE	$18,300.00
2070A parts	$54,240.00
Total Equipment Replacement Costs	***$207,766.00***

Total Regional Maintenance Costs	***$ 992,234.78***
Equipment Replacement Costs	***$ 207,766.00***
	$ 1,200,000.78

SIGNALS AND LIGHTING	

APPENDIX D Costs (continued)

Traffic signal and lighting maintenance is performed through a combination of DOT electricians, county staff under RMA agreements and electrical maintenance and utility locating contracts. Maintenance activities include emergency response to reported equipment malfunctions and preventative maintenance activities to ensure proper systems operation.

CY 2013 Signal and Lighting Maintenance *		
SW Regional Electrical Staff (165 signals)	$	451,319
SE Regional Electrical Staff (475 signals)	$	585,090
NE Regional Electrical Staff (122 signals)	$	315,287
NC Regional Electrical Staff (99 signals)	$	192,851
NW Regional Electrical Staff (126 signals)	$	220,028
NW Region Utility Locating Contract	$	85,000
NW Region Total	*$*	*305,028*
SE Regional Electrical Staff (475 signals)	$	585,090
SE Region Lighting Maintenance RMA	$	155,515
SE Region Utility Locating Contracts	$	210,000
SE Region "Open Loop" Contract	$	119,996
SE Region Lifecycle Replacement Cpntracts	$	379,953
SE Region Total	*$*	*1,450,554*
Signal and Lighting Maintenance Materials **	$	950,000
	$	**4,250,128**

** Staff and contracted labor costs not including materials or equipment*

*** Maintenance materials include upgrade electronic components and materials necessary to repair or replace malfunctioning equipment. Some materials costs are recovered as 3rd party damage claims.*

Planned DMS & CCTV Installations 2014-2017

Region	Device	Total as of 2013	2014 New	2015 New	2016 New	2017 New	Total New 2014-17	Total 2017
NC	DMS	4	1	0	0	0	1	5
	CCTV	6	1	0	0	0	1	7
NE	DMS	11	6	0	0	1	7	18
	CCTV *	39	1	18	2	0	21	60
NW	DMS	4	5	7	0	0	12	16
	CCTV	14	18	0	0	0	18	32
SE	DMS	37	14	5	0	1	20	57
	CCTV	174	13	23	1	0	37	211
SW	DMS	19	24	0	0	0	24	43
	CCTV	60	26	14	0	0	40	100
Total Statewide	DMS	75	125	137	137	139		
	CCTV	293	352	407	410	410		
Maintenance Costs**	DMS	$ 75,535.00	$ 51,010.00	$ 12,383.00	$ -	$ 959.00		$139,887.00
	CCTV	$ 289,013.00	$ 58,244.00	$ 54,505.00	$ 2,973.00	$ -		$404,735.00
Power Costs***	DMS	$ 50,625.00	$ 33,750.00	$ 8,100.00	$ -	$ 675.00		$ 93,150.00
	CCTV	$ 86,435.00	$ 17,405.00	$ 16,225.00	$ 885.00	$ -		$120,950.00
O&M Total		**$ 501,608.00**	**$ 160,409.00**	**$ 91,213.00**	**$ 3,858.00**	**$ 1,634.00**		**$758,722.00**

*Does not include cameras at lift bridges

** Maintenance costs based on 2013 average repairs and preventative maintenance

*** Average power costs based on FY14 statewide utility billing

APPENDIX E

ITS Deployment in Other States - Response States

QUESTIONS		South Dakota	Missouri	Indiana	Michigan	Minnesota	Iowa
The State of Wisconsin established a plan to evaluate locations where ITS devices should be deployed and which ITS devices to use in those locations named the Wisconsin Traffic Operations Infrastructure Plan (TOIP). Planners and designers reference the TOIP when deciding if a project should have ITS devices included in the design and construction. Does your state have a similar plan to assist with decisions regarding ITS deployment on a project?		No	At the moment, we do not have any statewide plan to guide our ITS (or other traffic operations) decisions. We are in the very early stages of developing a statewide Transportation Systems Management & Operations (TSMO) plan that, among other things, should address our ITS priorities and plans.	http://www.in.gov/indot/files/TMC_TrafficManagementStrategicPlan_v2-4.pdf	We don't have a plan similar to the TIOP. However, we do have a six-year ITS Investment plan which documents planned ITS-related projects for the upcoming six years.		Iowa is in the process of selecting a consultant to assist with the development of a Transportation Systems Management and Operations (TSM&O) Strategic Plan which will include planning future ITS and needs.
What ITS devices are currently used in your state (please answer Yes / No / Don't Know). Optional – What is the approximate number of the devices deployed?							
Traffic Detectors for Travel Times (loop detectors, microwave, Bluetooth)		No	Yes, we use all three. We probably have around 800 detectors/microwave radars in the St. Louis and Kansas City regions. We also have a handful of Bluetooth devices in St. Louis and our Springfield region is working to deploy around 70 or so Bluetooth detectors on a grid type network throughout the region. We also recently started using probe data from HERE on a statewide level. It covers approximately 11,000 miles of state roads.	We use all but do not use the Bluetooth for the travel time sign calculations. (Hundreds of detector sites including side fire radar, microloop, loop, weigh in motion etc)	428 (All microwave)	5,500 loop detectors; 230 virtual detectors (Wavetronix)	394 side-fire radar traffic sensors. No loop detectors, No microwave, 2 Bluetooth (for portable use)
Dynamic Message Signs		Yes – overhead permanent dynamic message signs. Yes – portable dynamic message signs that can be deployed at a few locations where bases exist for them (they can also be deployed on construction or in emergencies anywhere). No – color display.	Yes, we have 250 or so DMS statewide. We don't have any color DMS. Most installations are side mounts.	Overhead and portable devices. Travel Time signs side mounted, No color displays. (Approx 60 overhead, 25 portable, 22 Travel Time signs)	179. Primarily side-mounted, although we have a handful of overhead (probably 10% or less)	184	64 Overhead, 50 Side Mounts, 6 Color Display (color signs are smaller for special uses)
CCTV Cameras		Yes – we use these at our rest areas.	Yes, we have about 700 cameras statewide.	Yes (approximately 300 cameras)	406	600	300+
Interconnected Traffic Signals		Yes	Yes, we have approximately 1,300 connected signal systems.	Yes (2,600 signals statewide, More than 1,500 a part of systems either time based, wireless, fiber or hardwire interconnected. Approximately 170 pulling high resolution data to our databases.	1,300		In Iowa we will assist with the initial cost of traffic signals on our highways, but it is up to the cities to maintain them. However, we do have requirements that traffic signals within X feet of one another be interconnected - which I believe is adhered to quite well.
Ramp Gates		Yes	No	No	No		4
Ramp Meters		No	Yes, we use ramp meters on I-435 in Kansas City.	No	No	441	No
Highway Advisory Radio		Yes	We have HAR in some regions, but I'm not sure it's ever utilized anymore.	Yes	Yes	Yes	6 AM, 4 FM, 2 portable AM

Other					54 RWIS/ESS Stations	300 Lane control signals; Intelligent Lane Control Signals	5 Interstate main-line automated closure gates. We also own 10 iCones (Doppler radar) which we have only used once so far.
Are there any new types of ITS devices that are not currently deployed in your state that you are planning on deploying within the next six years?		Looking into adaptive signal control systems.	Possibly colored or high-resolution DMS.	We are currently working on integrating third party data (INRIX) into our data set and utilizing it for many of our operations.	Dedicated Short Range Communications equipment (controllers, converters, and radios) to support Connected Vehicle applications.		Variable Advisory Speed Limits - planned trial segment this winter. Two low-clearance, vehicle height detection and warning systems. Possibly Ramp Meters.
		☐					
Are there any ITS devices that you currently use that you will be phasing out within the next six years?		Highway Advisory Radio is becoming more and more obsolete.	Not likely	The life of the Highway Advisory Radio is questionable. We are unsure of how effective they are but no plans yet. Bluetooth is also questionable due to a shrinking data set. We may investigate the possibility of scanning wifi devices as opposed to Bluetooth. All of our Bluetooth deployments are in house developed technology.	N/A		Automated Interstate closure gates if we cannot find a reliable product with good product support.
		☐					
Are you using or plan on using within the next six years an outside source, such as Google or Inrix, to provide real time traffic data? If yes, what is your source?		Not to my knowledge.	We are currently using HERE as noted above.	Yes, we are currently receiving real time INRIX data and working with Purdue University to integrate the data into our daily operations.	We already use an outside source for probe data. Our contract has been HERE (formerly Navteq). We recently re-selected HERE for our next 3-5 year period, but have not completed that contract yet.		We purchased INRIX data for the entire state of Iowa for March 2014 - February 2015, with the option to extend two additional years.