MDOT ITS Investment Plan

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EXECUTIVE SUMMARY

Statewide Intelligent Transportation Systems (ITS) investment strategy can inform regional decisions by establishing general principles, and coordinating certain inter-regional projects and research efforts. MDOT's ITS Program Office tracks ITS equipment deployment statewide. As of August 2013, MDOT has information on more than 1,200 existing and programmed for FY 2012-2015 ITS equipment installations. This list includes:

- Closed Circuit Television (CCTV) Cameras
- Dynamic Message Sign (DMS)
- Travel Time Sign (TTS)
- Microwave Vehicle Detection Systems (MVDS)
- Environmental Sensor Stations (ESS)
- Communication Nodes/Hubs

Additional ITS investment options not included in the standard ITS spreadsheet include the following:

- Advanced Signal Controllers
- Probe Vehicle Data Collection
- DSRC Roadside Equipment
- Weigh-In-Motion Stations
- Research and Pilot Projects (e.g., truck parking)
- Border Crossing Applications

Best practices for measuring the performance and benefits of ITS systems and devices are not yet established within the ITS industry. It is often difficult to perform a rigorous evaluation of ITS projects using state-of-art systems without established and accepted benefits and costs. Long-term effective deployments of ITS systems, however, will require such formal evaluation procedures. The ability of ITS strategies to contribute to statewide transportation goals and objectives is highly dependent on the level of integration with the transportation planning process.

Despite this lack of clear consensus on metrics and costs and benefits at the industry level, Michigan's ITS program is considered to be successful and beneficial. Future ITS investments and deployments should incorporate performance measurement as an integral element of the system, and Michigan has efforts underway to establish such measures. Data regarding performance measurements will allow future ITS investment decisions to be mainstreamed into MDOT's highway program planning and transportation asset management processes. The integration of ITS investments with traditional planning and management operations likely will increase the efficacy of investment decisions across the agency to meet MDOT's statewide and regional strategies and performance goals.

ITS investment decisions should involve a formal evaluation addressing the following questions:

1. Does the investment support MDOT's mission and Strategic Plan?
2. What is the estimated benefit/cost ratio or return-on-investment (ROI) for the investment (and how does it occur over time)?
3. Can external funding be leveraged in the investment?
4. Is the investment providing a service or product that could be better provided by other means, (e.g., private sector provision)?
5. Is the investment expected to provide quantifiable improvement to one or more performance metrics, (e.g., safety, congestion, maintenance costs, etc.)?
6. Does the investment consider operations and maintenance costs and a replacement strategy?

A cursory investigation of traditional ITS devices with regard to these questions suggests that investments in ITS are justified on the basis of a benefit/cost analysis, but that in many cases the data are insufficient to permit a rigorous analysis.
INTRODUCTION

MDOT is currently operating under a Statewide Intelligent Transportation System (ITS) Architecture and Deployment Plan that was adopted in February 2010. The statewide plan coordinates ITS deployment within eight regional ITS Architectures that support ITS deployments in the State of Michigan. These eight apply to:

- Grand Region
- Bay Region
- Superior Region
- North Region
- Grand Valley Metropolitan Council (GVMC) Region
- Southeast Michigan Council of Governments (SEMCOG) Region
- Tri-County Regional Planning Commission (TCRPC) Region
- Southwest Region

This document, the 2013 MDOT ITS Investment Plan, considers ITS deployment and investment with a distinctly long-term view. As currently planned, this document will be updated biennially to reflect the latest research and innovations in ITS technologies. The ITS Investment Plan will inform future ITS programming at the regional and statewide level, as well as research priorities.

This document is divided into three sections:

- **Factors Influencing ITS Deployment**, describes the primary external and internal influences on ITS investment decision-making. This includes federal and state policy, established ITS architectures and standards, available external funding, and information relating to benefits and costs of ITS assets.

- **Existing Deployments**, summarizes what is known about statewide ITS assets that have been installed or are programmed for near-term installation. The summary of statewide assets is generally limited to those assets tracked by the MDOT ITS Program Office. These assets are presented with respect to distribution by region and by corridor.

- **MDOT Priorities and ITS Investment Options**, opens with a brief discussion of how ITS investment relates to MDOT’s core mission and department-wide strategic planning. This informs the development of a series of questions that may be asked when considering ITS investment options. Finally, these questions are used as a basis to explore several ITS investment options.

A key takeaway from this plan is that it is difficult to express the costs and benefits of ITS systems in a way that is both accurate and precise. Many of the costs of ITS deployments are difficult to quantify. Even if capital investment for an installation is known with some precision, related operational costs are often difficult to categorize. For example, many data-gathering ITS instruments are useful only when combined with an Advanced Traveler Information System (ATIS) operated by a Transportation Operations Center (TOC). Thus, the costs and benefits of the TOC, ATIS, and individual ITS installations can be difficult to disaggregate and perhaps are best evaluated as a system.

Many of the benefits of ITS systems are difficult to measure. Previous ITS planning efforts have pointed out a need to develop clear performance measures for ITS. Much work remains to be done to develop and measure performance metrics, and this is one area that future ITS investments should address. Complicating benefit/cost analyses for ITS systems is the difficulty in placing a value on non-monetary benefits. For example, even if the safety benefits of an ITS system where known, it is difficult to assign a dollar value to a potential reduction in crashes and injuries. A rigorous benefit/cost analysis would also compare ITS solutions to non-ITS solutions. Such intricacies make it difficult to provide specific (asset type and location) ITS investment recommendations in a forward-looking statewide plan such as this. As such, this document is intended to be used as a decision-support tool for state and regional ITS programming decisions.
FACTORS INFLUENCING ITS DEPLOYMENT

Many ITS investment decisions in Michigan are enacted on a regional level. MDOT regions are responsible for specific asset selection and site location. Statewide ITS investment strategy can inform regional decisions by establishing general principles, and coordinating certain inter-regional projects and research efforts.

In addition to the local factors affecting ITS decisions, a statewide approach to planning is also influenced by national and global considerations such as federal regulation and market trends. This chapter touches on many of the broad considerations that influence ITS deployment and investment decisions on both state and regional levels.

FEDERAL REGULATION OF ITS

In federal law, intelligent transportation systems are defined as:

"... electronics, photonics, communications, or information processing used singly or in combination to improve the efficiency or safety of a surface transportation system (23 USC 501)"

The most recent federal transportation funding bill, Moving Ahead for Progress in the 21st Century (MAP-21), passed in 2012, confirmed that infrastructure-based intelligent transportation system capital improvement projects are eligible for federal highway program funds under the newly established national highway performance program (MAP-21 SEC. 1106, 23 USC 119). ITS projects are also eligible for federal funds under the surface transportation program (23 USC 133).

INTEGRATION OF ITS INVESTMENT HIGHWAY PROGRAMMING

A 2006 Michigan ITS pre-deployment study noted that many early ITS projects were developed with earmarked funds. This means that ITS projects often did not go through a formal evaluation process as do highway, bridge, or transit program investments. Currently, this is no longer the case, and thus ITS projects are more subject to system-wide selection processes.

The ability of ITS strategies to contribute to statewide transportation goals and objectives is highly dependent on the level of integration with the transportation planning process. The 2006 pre-deployment study introduced the use of the ITS Deployment Analysis System (IDAS). This tool is available at:


The Federal Highway Administration (FHWA) offers guidance to improve such integration. These approaches are reflected in FHWA Register 23 CFR parts 450 and 500 and FTA 49 CFR part 613.

NATIONAL ITS ARCHITECTURE

The National ITS Architecture maintained by the ITS Joint Program Office (JPO) defines the functions, the physical entities, and the data flows that connect ITS functions and physical subsystems together into an integrated system. Version 7.0 of the National ITS Architecture was published by the U.S. Department of Transportation (USDOT) in January 2012.

NATIONAL ITS STANDARDS

A clear and universal set of standards are essential in designing an effective and interoperable National ITS Architecture. There are numerous activities and efforts to create standards for ITS and connected vehicle technology both for communication and for data structure and management. The Research and Innovative Technology Administration (RITA) of the USDOT has participated in the development of standards critical to the connected transportation system. Information regarding this program is available at http://www.standards.its.dot.gov.

NHTSA SAFETY REGULATION

The future direction of ITS in Michigan and nationwide is highly uncertain, pending notice of regulatory intent from the National Highway Traffic Safety Administration (NHTSA) regarding 5.9 Gigahertz (GHz) Dedicated Short Range
Communications (DSRC)-based communication technology. Many industry stakeholders predict that NHTSA will post a notice of intent to mandate a DSRC transceiver in future vehicles. If this DSRC mandate is placed in effect, then it may be the responsibility of state and/or local transportation agencies to deploy and maintain supportive infrastructure, including 5.9 GHz DSRC Roadside Equipment (RSE). However, until such time as a mandate is in place with clear directives to state DOTs, early investment in DSRC based technology beyond development-focused testbeds may be considered a risky investment strategy and will not be pursued in most regions.

**Michigan Statewide ITS Architecture**

MDOT is currently operating under a *Statewide ITS Architecture and Deployment Plan*, adopted in February 2010. The adoption of the statewide plan followed the adoption of eight regional ITS architectures pertaining to the following areas of the state:

- Superior Region
- North Region
- Bay Region
- Grand Region
- Southwest Region
- Southeast Michigan Council of Governments (SEMCOG) Region
- Tri-County Regional Planning Commission (TCRPC)
- Grand Valley Metropolitan Commission (GVMC)

MDOT transportation project selection is generally performed at the regional level, though final project selection and approval of the ITS 5-year plan is occurring at the statewide level. Generally, this also applies to ITS projects. A complicating factor is that the MDOT regional architectures do not perfectly overlap with MDOT's operational regions. The Michigan Statewide ITS Architecture and Deployment Plan addresses "statewide ITS needs and services" and identifies interregional needs (HNTB Michigan and Kimley-Horn 2010).

**ITS Systems for Improved Safety**

Determination of selected sites to deploy ITS equipment should include an evaluation and critical assessment of any problems or inefficiencies that the proposed system is expected to address. The safety of transportation system users is foremost among MDOT's priorities. Michigan's roads have become increasingly safe over the past decade as shown in Figure 1 and Figure 2 (MTCF 2013).

As shown in Figure 2, Michigan road safety statistics have improved significantly over the last decade, but have leveled-out recently. A breakdown of accident types in 2012 for fatal and incapacitating accidents is given in Figure 3.
As shown in Figure 3, nearly half of all fatal and incapacitating crashes in the State of Michigan are single-vehicle incidents. Preventing single-vehicle incidents represents the greatest potential for further reducing serious crashes, yet may be the most difficult category of crashes for traditional ITS systems to prevent.

An additional consideration is that even though MDOT routes carry the bulk of traffic in Michigan, less than half of all traffic deaths occur on these routes. As shown in Figure 4, more than half of all traffic fatalities occur on local (city and county) routes.

In 2012, fatal crashes occurred at the rate of approximately one death per one-hundred-million vehicle miles traveled. While crashes that result in death or serious injury are rare, MDOT is committed to continual reducing the crash rate and maintaining the safety and comfort of all users of state transportation facilities and services.

When traffic safety statistics are normalized to one million vehicle miles travelled, crash rates and death rates are higher on MDOT-owned U.S. and State routes than on either Interstates or local routes. For the year 2011, crash and fatality rates per million vehicle miles travelled is shown in Figure 5 and Figure 6, respectively.

The relatively high rate of crashes and deaths on non-freeway trunklines suggests that MDOT's safety-goals could be furthered by expanding safety-related ITS deployments onto non-freeway routes.

Many ITS investments improve safety indirectly. Though many ITS projects emphasize improving the efficiency of the transportation system, efficiency is related to safety. Free-flowing traffic generally leads to less conflicts and less crashes.
One of the most comprehensive ITS Cost Databases is maintained by USDOT at:

http://www.itscosts.its.dot.gov/

The purpose of the ITS Costs Database is to support informed decision-making by transportation planning agencies. The ITS Costs Database contains estimates of ITS costs that can be used for developing project cost estimates during the planning process or preliminary design phase, and for policy studies and cost-benefit analyses. The drawback of the database is that most cost information was entered before 2005.

MDOT ITS Program Office tracks ITS deployment statewide and estimates the value of ITS assets. Table 1 provides a summary of ITS capital costs (including all project costs) per unit installed.

Table 1: Estimated ITS Capital Costs (MDOT, 2013)

<table>
<thead>
<tr>
<th>Types of ITS Assets</th>
<th>Cost per Unit ($1,000’s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Closed Circuit Television Camera (CCTV)</td>
<td>79</td>
</tr>
<tr>
<td>Dynamic Message Sign (DMS)</td>
<td>169</td>
</tr>
<tr>
<td>Microwave Vehicle Detector Site (MVDS)</td>
<td>44</td>
</tr>
<tr>
<td>CCTV &amp; MVDS Co-Location (each)</td>
<td>86</td>
</tr>
<tr>
<td>Environmental Sensor Station (ESS)</td>
<td>115</td>
</tr>
<tr>
<td>Visibility Sensor (VS)</td>
<td>5</td>
</tr>
<tr>
<td>Travel Time Sign (each)</td>
<td>45</td>
</tr>
<tr>
<td>Pavement Condition Sensor (PCS)</td>
<td>5</td>
</tr>
<tr>
<td>Communication Towers (each)</td>
<td>1,500</td>
</tr>
<tr>
<td>Backbone Communication Upgrade (each)</td>
<td>10,000</td>
</tr>
<tr>
<td>Fiber Optic Communications (per mile)</td>
<td>85 - 131</td>
</tr>
<tr>
<td>Advanced Traveler Information Systems (ATIS)</td>
<td>5,000 - 10,000</td>
</tr>
</tbody>
</table>

After deployment, ITS assets require routine operations and maintenance (O&M) in order to perform their desired functions. Similar to capital costs, ITS O&M cost data are not readily available. Between FY 2007 and 2010, ITS America shows that MDOT spent about $2.6 million to $5.6 million annually on ITS operations, and $0.2 million to $3.0 million on maintenance (Table 2).

Table 2: MDOT Transportation and ITS Investments, 2007-2010 (ITS America, 2009)

<table>
<thead>
<tr>
<th></th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>MDOT Total Trans-</td>
<td>2,257</td>
<td>2,264</td>
<td>2,507</td>
<td>2,256</td>
</tr>
<tr>
<td>portation Spending</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>($ millions)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total ITS Spending</td>
<td>21.1</td>
<td>18.1</td>
<td>37.6</td>
<td>20.0</td>
</tr>
<tr>
<td>($ millions)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ITS Capital Invest-</td>
<td>18.3</td>
<td>15.2</td>
<td>34.7</td>
<td>11.3</td>
</tr>
<tr>
<td>ment ($ millions)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ITS Operations</td>
<td>2.6</td>
<td>2.6</td>
<td>2.6</td>
<td>5.6</td>
</tr>
<tr>
<td>($ millions)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ITS Maintenance</td>
<td>0.2</td>
<td>0.2</td>
<td>0.3</td>
<td>3.0</td>
</tr>
<tr>
<td>($ millions)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

According to MDOT’s 2012-2016 Five-Year Transportation Program, FY 2012-2016 annual average ITS spending is $18 million, representing 14.2% of total safety and system operations spending or 1.5% of MDOT’s total highway program investment (MDOT, 2012). The addition of congestion mitigation and air quality (CMAQ) related ITS would increase this estimate.
EXISTING DEPLOYMENTS

MDOT’s ITS Program Office tracks ITS equipment deployment statewide. As of August 2013, MDOT has information on over 1,200 existing and programmed for FY 2012-2015 ITS equipment installations. This list includes:

- Closed Circuit television (CCTV) Cameras
- Dynamic Message Sign (DMS)
- Travel Time Sign (TTS)
- Microwave Vehicle Detection Sites (MVDS)
- Environmental Sensor Stations (ESS)
- Communication Nodes/Hubs

The statewide distribution of all ITS installations is shown in Figure 7. ITS installations have been deployed primarily on Interstate highways and interchanges.

DEPLOYMENTS BY ASSET GROUP

Sorted by asset type, MDOT’s CCTV cameras and MVDS installations are the most popular investment. This is not surprising as these assets collect the basic data regarding the roadway system that is used by transportation operations centers (TOC). Information based on MVDS and CCTV sites is used in MDOT operations, and influences the messages displayed on dynamic message and travel time signs. The total existing and future (programmed for FY 2012 – 2015) MDOT ITS assets in Michigan are given in Table 3.

Table 3: MDOT ITS Asset Groups (MDOT, 2013)

<table>
<thead>
<tr>
<th>ITS Asset Groups</th>
<th>Existing</th>
<th>Future</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Closed Circuit Television Camera (CCTV)</td>
<td>376</td>
<td>80</td>
<td>456</td>
</tr>
<tr>
<td>Dynamic Message Sign (DMS)</td>
<td>176</td>
<td>27</td>
<td>203</td>
</tr>
<tr>
<td>Microwave Vehicle Detector Site (MVDS)</td>
<td>415</td>
<td>73</td>
<td>488</td>
</tr>
<tr>
<td>Environmental Sensor Station (ESS)</td>
<td>55</td>
<td>2</td>
<td>57</td>
</tr>
<tr>
<td>Communication Hub/Node/Tower</td>
<td>32</td>
<td>2</td>
<td>34</td>
</tr>
<tr>
<td>Travel Time Sign</td>
<td>7</td>
<td>0</td>
<td>7</td>
</tr>
</tbody>
</table>

DEPLOYMENTS BY CORRIDOR

Most ITS installation projects include deployment of several individual systems along a corridor or region to improve system performance along that region or corridor. Existing and planned ITS installations have been concentrated on Michigan's busiest corridors, primarily Interstates. The I-75/US-23 corridor is the busiest and most strategically important north-south route across the state. The I-94 corridor runs east-west across Michigan's southern tier and is one of the nation’s most important interstate trade corridors. These two corridors attracted the greatest number of ITS deployments in Michigan (Table 4).
Table 4: ITS Assets by Highway Corridor (MDOT, 2013)

<table>
<thead>
<tr>
<th>Route #</th>
<th>All ITS Devices</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-75/US-23</td>
<td>272</td>
</tr>
<tr>
<td>I-94</td>
<td>223</td>
</tr>
<tr>
<td>I-96</td>
<td>204</td>
</tr>
<tr>
<td>US-131</td>
<td>97</td>
</tr>
<tr>
<td>I-275</td>
<td>69</td>
</tr>
<tr>
<td>I-196</td>
<td>60</td>
</tr>
<tr>
<td>I-69</td>
<td>47</td>
</tr>
<tr>
<td>M-10</td>
<td>40</td>
</tr>
<tr>
<td>I-696</td>
<td>35</td>
</tr>
</tbody>
</table>

DEPLOYMENTS BY REGION

In addition, ITS deployments are generally targeted to areas where the risk of traffic crashes and incidents are high, i.e., high-traffic corridors in densely populated areas. As would be expected, the regions that have been most heavily investing in ITS include the Metro region, encompassing most of the Metro-Detroit area, and the Grand Region, surrounding Grand Rapids. Both regions attracted about three quarters of state-wide ITS deployments (Table 5).

Table 5: ITS Asset Value by Region (MDOT, 2013)

<table>
<thead>
<tr>
<th>MDOT Region</th>
<th>Value of ITS Assets ($1,000s)</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bay</td>
<td>14,036</td>
<td>8</td>
</tr>
<tr>
<td>Grand</td>
<td>29,949</td>
<td>18</td>
</tr>
<tr>
<td>Metro</td>
<td>97,230</td>
<td>57</td>
</tr>
<tr>
<td>North</td>
<td>6,284</td>
<td>4</td>
</tr>
<tr>
<td>Southwest</td>
<td>5,787</td>
<td>3</td>
</tr>
<tr>
<td>Superior</td>
<td>6,412</td>
<td>4</td>
</tr>
<tr>
<td>University</td>
<td>10,636</td>
<td>6</td>
</tr>
<tr>
<td>State Total</td>
<td>170,334</td>
<td>100</td>
</tr>
</tbody>
</table>

ITS Regional distribution can also be considered with respect to the raw number of ITS deployments. The total number of different ITS assets recognized by the MDOT ITS Program Office is given in Table 6.

Table 6: ITS Assets by MDOT’s Region (MDOT, 2013)

<table>
<thead>
<tr>
<th>MDOT Region</th>
<th>CCTV</th>
<th>DMS</th>
<th>MVDS</th>
<th>ESS</th>
<th>CommNode</th>
<th>TTS</th>
<th>Total</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bay</td>
<td>17</td>
<td>11</td>
<td>26</td>
<td>1</td>
<td>6</td>
<td>2</td>
<td>63</td>
<td>5%</td>
</tr>
<tr>
<td>Grand</td>
<td>68</td>
<td>26</td>
<td>120</td>
<td>25</td>
<td>5</td>
<td>1</td>
<td>245</td>
<td>20%</td>
</tr>
<tr>
<td>Metro</td>
<td>283</td>
<td>104</td>
<td>262</td>
<td>0</td>
<td>21</td>
<td>1</td>
<td>671</td>
<td>54%</td>
</tr>
<tr>
<td>North</td>
<td>17</td>
<td>8</td>
<td>18</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>43</td>
<td>3%</td>
</tr>
<tr>
<td>Southwest</td>
<td>13</td>
<td>18</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>40</td>
<td>3%</td>
</tr>
<tr>
<td>Superior</td>
<td>15</td>
<td>11</td>
<td>17</td>
<td>28</td>
<td>0</td>
<td>0</td>
<td>71</td>
<td>6%</td>
</tr>
<tr>
<td>University</td>
<td>43</td>
<td>25</td>
<td>36</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>112</td>
<td>9%</td>
</tr>
<tr>
<td>Total</td>
<td>456</td>
<td>203</td>
<td>488</td>
<td>57</td>
<td>34</td>
<td>7</td>
<td>1245</td>
<td>100%</td>
</tr>
</tbody>
</table>
MDOT PRIORITIES AND ITS INVESTMENT OPTIONS

As digital technology continues to advance and evolve, digital applications are becoming increasingly integrated with a variety of systems. The term Intelligent Transportation System is a relic of the early days of digital network applications. Today data analytics ("big data") and ubiquitous digital communication ("the cloud") allow any system to easily become connected, analyzed, and made "intelligent." In the future, it may no longer be appropriate to consider ITS applications as optional applications to support the broader transportation system. At some level, the entire transportation system will be intelligent. Considering this, it is useful to examine MDOT priorities and strategies directly, and investigate novel and potential solutions that may be provided by advanced digital technology, communications, and data analytics.

MDOT's overall mission is as follows:

"Provide the highest quality integrated transportation services for economic benefit and improved quality of life."

To support this core mission, MDOT updated the department-wide strategic plan in 2013. MDOT's strategic planning is organized into seven strategic areas of focus. It is important that ITS investment directly support departmental strategic goals.

It is often difficult to assess the value of ITS deployments because it is not always clear by what metrics or performance goals an ITS system should be evaluated. A Michigan ITS Pre-Deployment study conducted in 2006 noted the lack of information available for ITS investment "decision-making purposes" (Cambridge Systematics and Kimley-Horn 2006). While Michigan's ITS infrastructure has been significantly built-out since 2006, there has not been an effort to capture the effects of ITS deployment. There remains a need to establish and evaluate performance metrics associated with these systems. Further ITS program investments should integrate performance evaluation into the design of future deployments. Such efforts will allow increased certainty for future ITS planning and evaluation efforts.

Intelligent Transportation Systems (ITS), and technologies not traditionally considered ITS technologies, could potentially support all of the Department's strategic areas of focus. Alignment with departmental goals is only one of a set of qualifications by which to judge investment decisions. An example of such questions that should be asked when considering ITS investment is given below:

1. Does the investment support MDOT's Mission and Strategic Plan?
2. What is the estimated benefit/cost ratio or return-on-investment (ROI) time for the investment?
3. Can external funding be leveraged in the investment?
4. Is the investment providing a service or product that could be better provided by other means, (e.g., private sector provision)?
5. Is the investment expected to provide quantifiable improvement to one or more performance metrics, (e.g., crash rate, congestion, maintenance costs, etc.)?
6. Does the investment consider operations and maintenance costs and a replacement strategy?

This section investigates ITS investment options with respect to such considerations. Many of them are traditional ITS elements that are currently captured in MDOT's ITS deployments spreadsheet:

- Closed Circuit Television (CCTV) Cameras
- Dynamic Message and Travel Signs
- Microwave Vehicle Detection Systems (MVDS)
- Environmental Sensor Stations (ESS)
- Communication Network
- Advanced Signal Controllers
- Probe Vehicle Data Collection
- DSRC Roadside Equipment
- Weigh-In-Motion Stations
• Research and Pilot Projects
• Enterprise Database
• Transportation Operations Centers (TOCs) and Advanced Traffic Management Systems (ATMS)

It is often difficult to consider the value of an ITS deployment singularly. In more cases, several ITS assets are deployed together to serve a particular purpose. For example, CCTV, DMS, and MVDS are used in concert to provide ATIS service. ATIS is defined as systems that acquire, analyze, and present information to assist surface transportation travelers making travel choices. The information can include locations of incidents, weather and road conditions, work zones, optimal routes, recommended speeds, and lane restrictions etc.

MDOT uses the Mi Drive traveler information website as well as a system of DMS as the direct link between the transportation operation centers and the public. Based on FHWA RITA information, deployment of an ATIS on a major roadway ranges from $5-$10 million depending on the scope of the project along with the technology used. Subsequent upgrades and improvements to the system can cost from $100,000 to several million depending on the scale of the improvement.

CLOSED-CIRCUIT TELEVISION (CCTV) CAMERAS

MDOT's CCTV cameras are monitored by TOCs in Detroit, Grand Rapids, Lansing, and Port Huron. The cameras allow TOCs to obtain ground-truth information about traffic flow and incidents. Additionally, many cameras provide near real-time still images of traffic and weather conditions via MDOT's Mi Drive website (found at http://mdotnetpublic.state.mi.us/drive/). Camera feeds are governed by MDOT’s video recording and retention policy and generally not recorded or logged by MDOT.

One important use of CCTV cameras is to help TOCs identify and respond to traffic incidents. MDOT's TOCs use the statewide system of ITS cameras and sensors to detect incidents as soon as possible, allowing MDOT and the State Police to quickly deploy and respond to incidents and maintenance issues. MDOT has established a goal of clearing traffic incidents within two hours. This performance goal is measured and tracked, as shown in Figure 8.

![Figure 8: Michigan Trunklines, Percentage of Traffic Incidents Cleared Within Two Hours (Michigan 2013)](image)

Decisions to invest in additional CCTV cameras should consider the objectives of camera installation and the potential for additional cameras furthering such objectives for any proposed location. For example, the probability of a proposed camera capturing information that can be used by MDOT or other response agencies to improve response times or otherwise obtain value from the information should be compared to the cost of installation and ongoing maintenance for that location, as well as video hosting services.

DYNAMIC MESSAGE SIGNS (DMS) AND TRAVEL-TIME SIGNS (TTS)

MDOT has installed over 200 DMS along Michigan roadways. The signs warn drivers of traffic impacts and provide information on alternate routes in and around construction. Most display the “default” real-time travel time information. Real-time travel information is gathered by MVDS and a contracted company using statewide probe data, which is then analyzed by MDOT advanced traffic management system (ATMS) software, and then transmitted to the DMS using various communications medium. These data are collected continuously and updates the signs every three to five minutes (Michigan 2010).

The value of DMS is related to information dissemination generally, but especially information...
that could mitigate congestion. Travelers equipped with information about incidents or delays ahead may re-route or reschedule their trips. It is not clear, however, to what extent, if any, DMS measurably affect traffic patterns. A comprehensive literature review found that cost-benefit analyses of DMS have been inconclusive, and that there is a need to develop models that are capable of measuring the impact of DMS messages on traffic operations (Murthy, Lu, & Raja-ram, 2012). MDOT could make a valuable contribution to ITS and transportation asset management by developing and implementing objective data-based models to measure the effectiveness of DMS. To this end, MDOT currently calculates and tracks a benefits-cost ratio for DMS that have been installed for safety purposes. MDOT has already commenced further research to investigate appropriate methods of ITS benefit/cost analysis, and results are expected to be forthcoming.

**MICROWAVE VEHICLE DETECTION SYSTEMS (MVDS)**

MDOT operates nearly 500 MVDS across the state. These devices are primarily used to provide real-time data to TOC for incident management. The data captured by MDVs may influence the deployment of MDOT service vehicles, police, and emergency vehicles. The data is also used in traveler information systems such as the DMS and Mi Drive website. The deployment and operation of MVDS devices supports such MDOT strategic goals as safety, customer service, and efficiency by helping MDOT service vehicles and State police detect and clear incidents.

As is currently underway at MDOT, investment and deployment decisions for additional MVDSs should be based on current and future research efforts to quantify the potential benefits of each deployment to approximate a benefit/cost ratio. Unique deployment location options would require individual assessment due to the nature of benefits associated with MVDSs. These devices are used by MDOT to quickly identify and respond to traffic congestion. Determining the benefits for a given location would involve determining factors such as:

- The probability of an incident at the proposed location able to be detected by proposed device
- The effects of anticipated incidents on traffic flow at that location
- The estimated social cost of expected incidents (e.g., in opportunity costs of congestion)
- The probability that MDOT or other official response could mitigate the effects of the incident
- The possibility that the incident could be detected and responded to by other means

Considering such questions should quickly provide a reasonable estimate of the benefit/cost ratio of a proposed MVDS at any given location. MDOT should concentrate any further MVDS deployments at locations with the largest estimated payback.

As shown in Figure 9, MDOT's MVDSs are distributed throughout the state with an emphasis on the Detroit metro area and heavily-travelled corridors. Despite this distribution, each MVDS monitors only one single location along the network. Any changes in traffic patterns that occur between MVDSs are not captured. This limitation, along with relatively high installation and maintenance costs associated with MVDSs suggest a need to assess the long-term costs, benefits, and risks associated with additional MVDS deployments. Leduc (2008) has suggested that the use of probe vehicles to collect network-level traffic count (via statistical sampling) and speed data may be more accurate and efficient than any fixed roadside sensors. The potential of probe vehicle data collection is discussed further in the corresponding subsection.
ENVIRONMENTAL SENSOR STATIONS (ESS)

MDOT’s ITS assets include more than 50 existing and planned environmental sensor stations (ESSs) to support the state’s road weather information system (RWIS). The ESS provide information such as temperature (air, surface, and subsurface), humidity, wind speed, barometric pressure, precipitation, and more. This information is primarily used by MDOT and its county partners to support maintenance operations. ESS stations include CCTV cameras, all of which are available to view on MDOT’s Mi Drive website.

MDOT’s ESSs are distributed primarily across the northern lower and upper peninsulas of the state. The combination of frequent winter-weather events and low traffic volumes in this region imply that remote road weather condition observation is a valuable investment. MDOT is currently evaluating its RWIS and will continue to evaluate and track the benefits obtained from ESSs compared to the costs of installation and maintenance of each device. Such metrics can support decisions to further expand MDOT’s coverage of ESSs.

COMMUNICATION NETWORK

In 2012, MDOT commissioned a Connected Vehicle Infrastructure Plan. The impetus of the plan was to develop a roadmap for deployment to prepare for the NHTSA connected vehicle program. The infrastructure plan emphasized that until the NHTSA issues an official notice of intent to mandate connected vehicle technology in the next generation of vehicles, it is premature to invest directly in connected vehicle supportive infrastructure such as DSRC roadside communications equipment. However, there are investments that MDOT could make that would help the department prepare for a future mandate, while serving immediate department needs.

The primary investments recommended by the infrastructure plan include the build-out of a fiber-optic network along state trunklines. This network could serve immediately as an information conduit to signal controllers and other ITS devices. It is difficult to predict the future operating parameters of ITS devices on the roadway network. It is relatively certain, however, that the society-wide trend for further information sharing and digital communication will continue. This makes an investment in high-bandwidth communication within MDOT’s rights-of-way relatively
safe. Unfortunately, communication network build-out projects may not qualify for federal transportation funding. This drawback may negatively impact return-on-investment for general communication infrastructure projects.

The build-out of such a fiber-optic network is probably not needed in the short-term. Existing ITS devices are adequately served by a mix of backhaul strategies including leased communications links. However, a long-term strategy to build-out a dedicated MDOT network could lower costs while increasing capacity and reliability. In agreement with the 2012 Infostructure Plan, it is recommended that MDOT provide fiber-optic backhaul to ITS devices if an immediate need is identified. Otherwise, MDOT expects to lower costs of build-out by bundling the installation of conduit with any major construction project on trunklines.

### Advanced Signal Controllers

According to the 2013 MDOT Connected Vehicle Infostructure Plan, only about 35% of traffic signal locations have the connectivity capability to be integrated into a TOC. The Infostructure Plan recommends that MDOT invest in upgrading traffic signal devices to Internet Protocol (IP) ready ports. Such connections would allow TOC to adjust signal timing if necessary in response to traffic conditions or updated traffic management strategies.

As with communication network investment, it may not be prudent to upgrade traffic signal controllers in the near future unless the signal is already slated for replacement or there is an identified need. As legacy controllers are upgraded, however, MDOT will promote the installation of IP-ready equipment. The integration of the MDOT traffic signal program with the ITS program may allow for increased integration of ITS systems and beneficial strategic planning across the system.

The investment strategy regarding advanced signal controllers may be influenced by future regulatory actions by NHTSA. For example, a mandate to accommodate V2I signalized intersection applications such as signal phase and timing (SPaT). A positive mandate may obligate MDOT to upgrade or replace legacy systems.

### Probe Vehicle Data Collection

Accurate and timely road-network conditions are available in real time to anyone with a high-bandwidth internet connection. Such services are provided by the private sector based on cellular probe data and crowdsourced probes and reports. As pointed out by Leduc (2008), the availability of connected probe-vehicles may soon be able to replace traditional ITS devices in some locations, though these approaches may be inadequate where insufficient numbers of users exist or where lane-level data are needed, for example.

Demonstrating the increasing value of app-based approaches, Figure 13 and Figure 14 show publicly available live traffic data relating to congestion caused by a crash on I-94 near US-23 on April 22, 2013. Figure 13 was obtained from MDOT’s Mi Drive website, while Figure 14 was obtained from Google Maps server with the traffic layer visible. A comparison between the two images shows that the Google Maps data can provide information very similar to what is provided on Mi Drive. Figure 12 shows the traffic information available for this incident, zoomed in to the location where a traffic wave is forming in real-time. Clearly, a more rigorous evaluation of sources such as Google Maps is needed prior to more widespread adoption by DOTs, but this example suggests the potential for such approaches. Furthermore, some connected navigation devices and smartphones running apps such as Waze, may use such information to provide audio and visual warnings to drivers of the impending slowdown.

An additional benefit of using probe vehicles for traffic condition monitoring is that traffic conditions can be provided for any link that has sufficient traffic volume. Thus, Figure 14 shows that Google is able to capture and relay traffic conditions on other major routes within the grid, not just on the highway. Such information can be used by Google's navigation service to provide live-rerouting to drivers.
Several private sector firms offer probe vehicle based data at this time. While free navigation apps like Google Navigate and Waze do not offer logged traffic data, proposals from public agencies may stimulate interest in providing such data. At the present time, various private sector firms do offer logged data (as well as live traffic conditions) as a product to transportation agencies. MDOT has contracted with Here (formerly Navteq) to obtain data such as real-time travel time information and traffic counts. Here, or Navteq, which also provides data to traffic.com, is only one of several private-sector firms offering probe-vehicle based data as a product or service, most of whom provide data by partnering with cellular service providers (Leduc, 2008). MDOT will continually reassess the further investment of ITS installations and services that may be provided more efficiently through private sector or public-private partnerships.

**DSRC ROADSIDE EQUIPMENT**

NHTSA is expected to issue a Notice of Regulatory Intent (NRI) pertaining to whether or not it intends to pursue regulations relating to a possible mandate of DSRC-based communications equipment in consumer light vehicles late in 2013. Until a DSRC connected vehicle program implementation framework is mapped out, with funding schemes identified, MDOT continues to consider investment in DSRC RSE as a risky investment strategy outside research and pilot projects.

**WEIGH-IN-MOTION (WIM) STATIONS**

Though not tracked by the MDOT ITS Program Office, MDOT maintains several weigh-in-motion (WIM) facilities to assist with commercial truck over-loading enforcement. The efficient regulation and movement of freight through the State of Michigan is an important goal to MDOT and other public agencies. Loaded trucks are responsible for most of the wear and tear on Michigan’s roads and bridges. Further, overloaded trucks may be a safety hazard.

Unlike general traffic volume and speed counts and information, there are no convenient private sector sources of truck weight data. Given the
importance of truck weight enforcement and data, MDOT will ensure that a significant number of WIM stations are deployed throughout the state to ensure compliance to load restrictions.

It is important not only to invest in the hardware and equipment to obtain this data, but also to make sure that it is properly utilized. Currently, truck weight data obtained by WIM stations is used in bridge design and engineering. Yet, this data is not yet utilized for pavement design, or as decision support for project selection in asset management processes. MDOT will continue to integrate data use across the agency to ensure that WIM data is available for all applicable purposes.
Figure 13: *Mi Drive* Capture of April 22 Traffic Incident

Figure 14: Google Traffic Capture of April 22 Traffic Incident
MDOT has established itself as a worldwide leader in ITS development by partnering with a range of public and private entities for research projects and test-bed deployments. Not only do such efforts promote the technology and advance ITS development, they also promote economic development initiatives by bringing federal and private sector investments to local projects. MDOT will continue to engage with multiple partners in ITS research, ensuring that the MDOT contribution for any given project is outweighed by the benefits in economic development and potential technological innovation.

**Enterprise Database**

The data collected by traffic data collection systems is valuable only to the extent that it is used. Utilizing such data to support MDOT leadership goals requires that it be stored in a logical and accessible format. MDOT has established itself as a leader in database-supported asset management with the development of the MDOT Transportation Management System (TMS) series of databases in the mid-1990's. While MDOT still uses the TMS system for asset management, the software has not been significantly updated in several years and many of the database features are outdated or in disrepair. The TMS never became the powerful agency-wide data sharing system that it was envisioned to be. Since the development of the original TMS architecture, data management technologies and practices have advanced considerably. A transition from the TMS to a modern data storage and query system represents the greatest possibility for MDOT to support its goals of leadership. A logical and accessible enterprise database is practically necessary to utilize the range of data relevant to a modern transportation agency.

With these objectives, MDOT and the Michigan Department of Technology, Management and Budget (DTMB) are working to develop a Department Wide Enterprise Asset Management System (EAMS).

In separate efforts, the second phase of the Data Use Analysis and Processing (DUAP II) Project and the Data Modernization Assurance & Governance (DMAG) initiative will investigate ways that connected vehicle data can be shared and used across the agency to support performance management. As part of the project, MDOT will review the agency’s internal organizational structure and potential changes that could facilitate data use across the department. The DUAP II project will also be developing an enterprise data management system specifically designed to utilize various data sources and formats.

The EAM effort and DUAP II project is expected to pay off in operational efficiencies and enhanced decision support for asset management resource allocation.

**Traffic Operations Centers (TOC) and Advanced Traffic Management Systems (ATMS)**

Regardless of the specific strategies used to determine investments in ITS field deployments, MDOT's TOCs and ATMS require significant capital expenses and are certain to be central components of the statewide ITS strategy. MDOT will regularly reassess the ability of its TOCs and ATMS to incorporate systemic needs and the latest advancements in ITS technology.
CONCLUSIONS AND RECOMMENDATIONS

ITS deployment and investment decisions are influenced by multiple factors. Most of the specific decisions regarding ITS investments are made by MDOT regions and are influenced by local preferences and priorities. ITS investment decisions are also informed by national policy and national/global market factors. Statewide strategic planning can be useful in the middle area. The MDOT ITS Program Office can provide decision-support to MDOT regions by keeping up-to-date on the latest state-of-the-art approaches and research on ITS. Conversely, the ITS Program Office can contribute to national discussions by communicating lessons learned from local and state products to the broader ITS community.

To date, MDOT has installed hundreds of individual ITS assets. These assets are utilized by TOCs to monitor and manage traffic operations across the state. Michigan's ITS program has been considered successful and beneficial. However, a lack of attention to performance metrics associated with ITS deployment prevents rigorous assessment of the benefits of the system. Michigan's ITS program is typical in this regard; there is a universal need for methods and metrics to assess the benefits and costs of ITS.

ITS investments and deployments should incorporate performance measurement as an integral element of the system to the extent possible. Such data regarding performance measurements will allow future ITS investment decisions to be mainstreamed into MDOT’s highway program planning and transportation asset management processes. Such integration of ITS investments with transportation planning process (including alternative comparisons based on modeling outputs) and management operations would likely increase the efficacy of investment decisions across the agency to meet MDOT’s statewide and regional strategies and performance goals.

ITS investment decisions should involve a formal evaluation addressing the following questions:

1. Does the investment support MDOT’s mission and Strategic Plan?

2. What is the estimated benefit/cost ratio or return-on-investment (ROI) time for the investment?

3. Can external funding be leveraged in the investment?

4. Is the investment providing a service or product that could be better provided by other means, (e.g., private sector provision)?

5. Is the investment expected to provide quantifiable improvement to one or more performance metrics, (e.g., crash rate, congestion, maintenance costs, etc.)?

6. Does the investment consider operations and maintenance costs and a replacement strategy?

A key takeaway from this plan is that it is difficult to express the costs and benefits of ITS systems in a way that is both accurate and precise. Previous ITS planning efforts have pointed out a need to develop clear performance measures for ITS systems. There is still much work to be done to develop and measure performance metrics, and this is one area that future ITS investments should address. A rigorous benefit/cost analysis would also compare ITS solutions to non-ITS solutions. Such intricacies make it difficult to provide specific (asset type and location) ITS investment recommendations in a forward-looking statewide plan such as this.

A cursory investigation of traditional ITS devices with regard to these questions suggests that investments in ITS systems are justified on the basis of a benefit-cost analysis, but that there is insufficient data in many cases to conduct a rigorous analysis. Additionally, many ITS devices are deployed primarily to support ATIS. Future public provision of ATIS may be redundant, given the increasing availability of real-time and even predictive traffic information. MDOT also has ITS programs not integrated with its ITS Program Office; these include as WIM and advanced signal control. Integration or coordination of these programs has great potential for transportation systems performance and improving asset management across the agency.
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