MNDOT STATEWIDE ITS PLAN

JULY 2015

Minnesota GO

A Collaborative Vision for Transportation

ITS

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EXECUTIVE SUMMARY

The state of Minnesota has completed a detailed family of statewide transportation plans to ensure there is a comprehensive approach to all areas of transportation. As the plans have filtered down and become more focused and detailed, the need for a Statewide Intelligent Transportation System (SITSP) Plan was acknowledged. ITS technology is rapidly evolving and the industry is continuously attempting to keep up; therefore, a well thought out guidance with steps towards a statewide approach will greatly benefit the state transportation system and residents.

The purpose of the MnDOT Statewide ITS Plan (SITSP) is to identify immediate, short-term, and mid-term ITS needs to meet the goals and objectives identified in MnDOT's 50 year vision.

Minnesota's ITS will support Minnesota's multimodal transportation system that maximizes the health of people, the environment and the economy by providing effective systems and operations which utilize innovation and cost effective technologies.

Stakeholder engagement with each MnDOT District, planners, and key modal offices helped layout what existing devices are deployed; gaps in the ITS network, technology needs, internal communication structures, processes for new technologies, planning and design procedures, future investment options, areas for growth, and next steps.

During these Stakeholder meetings three investment scenarios were discussed to help everyone understand the actions and policies needed for each and how they would affect ITS planning and implementation in the future. Scenarios were evaluated using the SITSP's vision, goals, strategies and performance measures that support the overall Minnesota GO Vision and the Statewide Multimodal Transportation Plan. Opportunities and risks were compared for each approach to the overall ITS SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis. A specific Next Steps section lays out steps for implementation.

The ITS scenarios include:

APPROACH A: The Fiscal Constraint Investment Scenario involves investment in ITS at planned levels, but shifts away from expansion of new systems and focuses on preservation of the existing ITS infrastructure. With this investment, several ITS devices reach the end of their useful life without funding for their replacement. Over the 10 year horizon, several system components remain unfunded but cannot realistically be considered for decommissioning creating key risks to the transportation system. In this scenario shared services across Districts become more formalized in maintenance, design and system integration to improve efficiency of ITS development and maintenance. ITS is operated and maintained as it is today.

APPROACH B: The Asset Management Investment Scenario recognizes ITS as a key

The purpose of the MnDOT Statewide ITS Plan (SITSP) is to identify immediate, short-term, and mid-term ITS needs to meet the goals and objectives identified in MnDOT's 50 year vision.

> ITS can be defined as the application of advanced information and communications technology to surface transportation in order to achieve enhanced safety and mobility while reducing the environmental impact of transportation.
>
> - USDOT

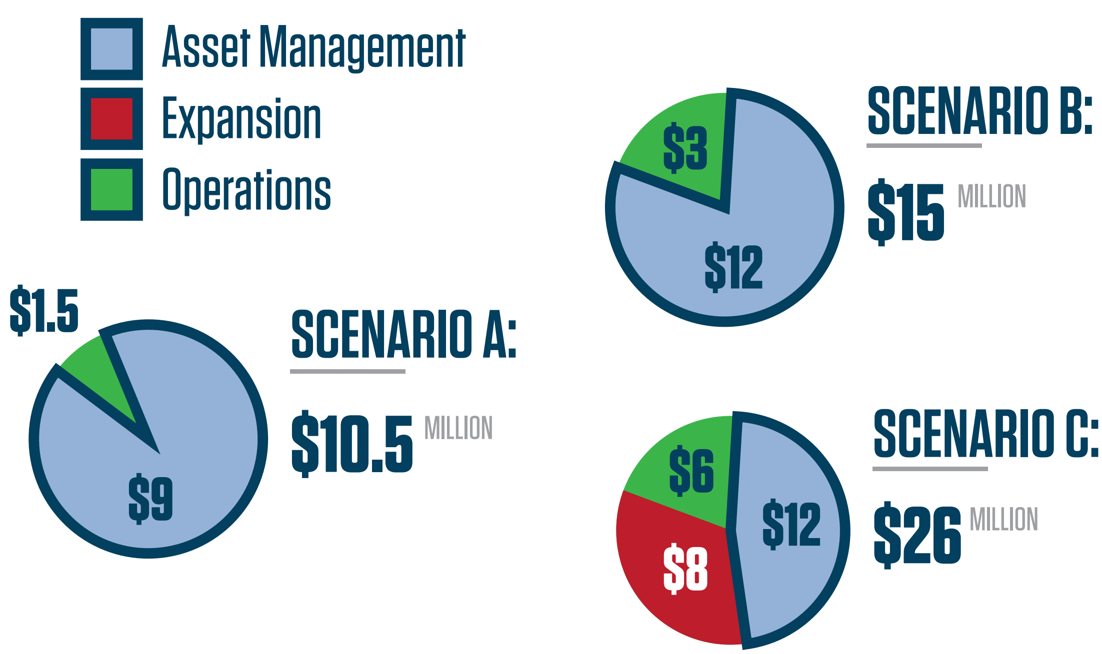
infrastructure system with a return on investment that warrants sufficient increases in ITS funding so that existing devices are replaced as they come to the end of their life. This scenario focuses on preserving the system that is in place or planned for deployment. An increased use of ITS devices is expected as responsibilities shift from deployment and implementation to operations and maximizing the system. Proactive maintenance reduces devices failures and lowers life cycle costs. In this scenario there is no emphasis on expanding systems and actively deploying new technologies.

APPROACH C: In the Optimization Investment Scenario, ITS becomes a highly integrated and optimized network with ITS that maximizes transportation system performance. The fiber backbone and wireless network is expanded to provide real-time communications to ITS technologies around the state. Systems are actively monitored for failures and improvements through asset management systems. Formal agreements and partnerships are created to document planning, design, and operations processes and responsibilities. Performance measures for devices and operations are created and tracked. ITS expansion and future technologies are explored. The management and operations of ITS systems are undertaken at high levels of excellence through planning, capital and operating processes, procedures, and new technologies are actively pursued.

In closing, this plan considers future technologies expected to play a key role in the ITS industry in the future. How the state approaches preparation or actively pursuing these future technologies needs to be planned when identifying policies, procedures, long term investment, and next steps.

Statewide ITS Plan Investment Scenarios

10 YEAR INVESTMENT NEEDS ABOVE BASE



NEXT STEPS

The implementation of this plan will be led by a group chaired by the Assistant Division Director for Operations and comprised of the project management team (PMT) that guided this ITS plan. The PMT consisted of the State Traffic Engineer, Metro Traffic Engineering Manager, RTMC Manager, Freeway Operations Manager, Director of Office of Maintenance, ITS Research and Development Manager, Assistant State Traffic Engineer, Program Manager, Statewide Planning and Transportation Data Analysis, and a District Traffic Engineer.

It was identified that no matter what investment scenario was deemed the best fit with the SITSP's vision, goals, strategies and performance measures, the following key decisions would be required:

FISCAL: Deciding if ITS systems should be contracted, fully maintained, or expanded.

ORGANIZATION: Deciding if ITS devices should all be managed fully by MnDOT and if they should be operated continuously.

Regardless of the investment path chosen, each scenario likely requires a realignment of investment both at the district level and at the agency level to achieve the outcomes of the approach. Some near term steps for both the fiscal and organizational components were identified.

NEAR TERM STEPS- FISCAL:

1. Develop an ITS Implementation Plan.
2. Utilize MnDOT's 2015 Transportation Asset Management Plan to identify funding needs for each year in the STIP.
3. Create a list of ITS assets and costs that are nearing end of life and have no identified replacement funding.
4. Identify near term funding strategy to meet investment gap for ITS assets. Funding strategies can include reallocation of ITS funds typically used for expansion of ITS or reprioritization of funding at the District or state level.
5. If gap funding is not available develop a decommissioning strategy for lower priority ITS assets.

NEAR TERM STEPS- ORGANIZATIONAL:

1. Implement a shared services model for ITS design and integration services.
2. Work with the Minnesota State Patrol to plan transition of ITS systems to MnDOT.
3. Analyze communication investments necessary to establish MnDOT operation of all ITS devices at the RTMC.
4. Identify funding and timing for full transition of ITS operations to MnDOT.
5. Create a budget & implementation plan for transitioning to full MnDOT ITS management.
6. Develop a TSM&O plan for MnDOT.

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CHAPTER ONE

INTRODUCTION TO THE PLAN

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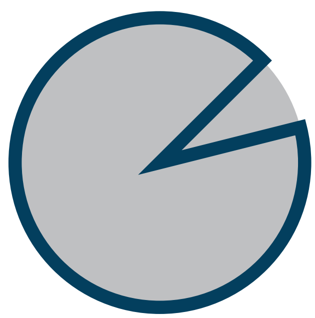
1.0 INTRODUCTION TO THE PLAN

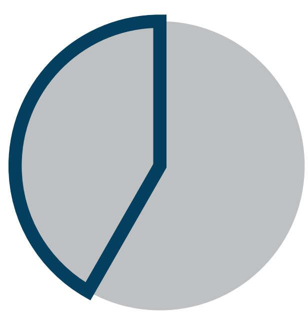
Minnesota's traveling public has developed a strong trust and confidence that "MnDOT can be relied upon to deliver Minnesota's transportation system" [1]. This includes a multimodal transportation system that meets the public's expectations regarding safety, efficiency, economy and reliability as part of their everyday travels. Intelligent Transportation Systems (ITS) support each one of these expectations by improving travel on Minnesota highways through the use of engineered systems, policy, technology and communications that result in a large benefit for the public investment.

The purpose of the **MnDOT Statewide ITS Plan (SITSP)** is to identify immediate, short-term and mid-term ITS needs to meet the goals and objectives identified in **MnDOT's Minnesota GO 50-year Vision**, adopted in 2011, and the **Statewide Multimodal Transportation Plan**, adopted in 2012. This plan will also help identify a statewide vision for ITS moving forward in the current and future economic state, which includes identifying gaps in the system, maintaining the system, and preparing for future technologies. Lastly, this plan will identify specific ITS approaches designed to implement related strategies identified in the Statewide Multimodal Transportation Plan.



There are more than 141,000 miles of roadways in Minnesota

8.5% | The state highway system makes up 12,000 of these miles



In 2010, more than 155 million miles per day were driven on Minnesota's roads

60% | 90 million miles per day were driven on state highways

Source: Statewide Multimodal Transportation Plan

A comprehensive statewide ITS Plan creates a long term approach to ITS by engaging MnDOT stakeholders, staff, and leadership. Through this planning process, a thorough framework and plan has been developed with a vision, goals, strategies and performance measure for implementation over the next decade.

[1] MnDOT Annual Transportation Performance Report 2012, pg. 8
[2] http://www.dot.state.mn.us/minnesotago/index.html
[3] http://www.dot.state.mn.us/minnesotago/SMTP.html

ITS systems have proven benefits in safety, mobility, efficiency, environmental impact and traveler information. A system like ramp metering increases the capacity of an interstate by up to 20% and can delay need for costly investments in expansion of highways. Rural intersection conflict warning systems (RICWS) provide low cost ITS strategies that prevent serious and fatal crashes at rural intersections. A robust 511 traveler information system enables drivers to plan trips so they arrive at their destination on time. And, a fleet of snow plows equipped with the latest technology allow for efficient operations that reduce use of salt and chemicals while providing for safe roads for travel. With these and many other examples of benefits, ITS is a key investment strategy for MnDOT.

Annually MnDOT invests over $14 million to design, operate and maintain ITS and traffic management systems and at least $3 M annually in ITS capital investments. Organizationally, ITS as a strategy is spread across the organization, with investments occurring in each MnDOT District and as part of MnDOT's modal offices.

The MnDOT Statewide ITS Plan (SITSP), by identifying ITS strategies through a shared Vision, will help create a transportation system that is safe, efficient, reliable, effective, consistent and fiscally responsible for the citizens of Minnesota.

What follows in this plan is a linking of the plan to MnDOT's family of transportation plans (Chapter 2) and a description of the existing ITS infrastructure and organization in Minnesota (Chapter 3) and. After setting the stage of what exists in ITS, the plan identifies three investment scenarios (Chapter 4) that could be chosen to follow over the next 10 years and identifies policy issues (Chapter 5) impacting the path forward. The plan closes with recommendations for next steps in implementing the plan and finally a discussion of future ITS systems (Chapter 7) that MnDOT will need to monitor and prepare for as technology rapidly changes the transportation environment in the coming years.

CHAPTER TWO

MNDOT FAMILY OF PLANS

2.0 THE MNDOT FAMILY OF PLANS

MnDOT is responsible for developing plans not only for Intelligent Transportation Systems, but also for modes of travel including transit, walking and biking, freight and passenger rail, aeronautics and highways. These plans, known as modal plans, receive a degree of policy direction from the Statewide Multimodal Transportation Plan, which is also MnDOT's responsibility to develop. These plans are collectively part of MnDOT's "Family of Plans" which establishes statewide planning direction. Subsequent to modal policy plan development, multi-modal investment plans are completed to identify how projected revenues will be spent. **Figure 2-1** highlights the relationship. This relationship flows in both directions for plans as the ITS plan informs needs and investments within the 4 year State Transportation Improvement Program (STIP) and the Maintenance and Highway System Operations (HSOP) plan but is also shaped by the guidance and outcomes the STIP and HSOP. This Statewide ITS Plan (SITSP) includes both policy and investment direction for Intelligent Transportation Systems in Minnesota.

FIGURE 2-1: MNDOT PLANS AND PROGRAMS

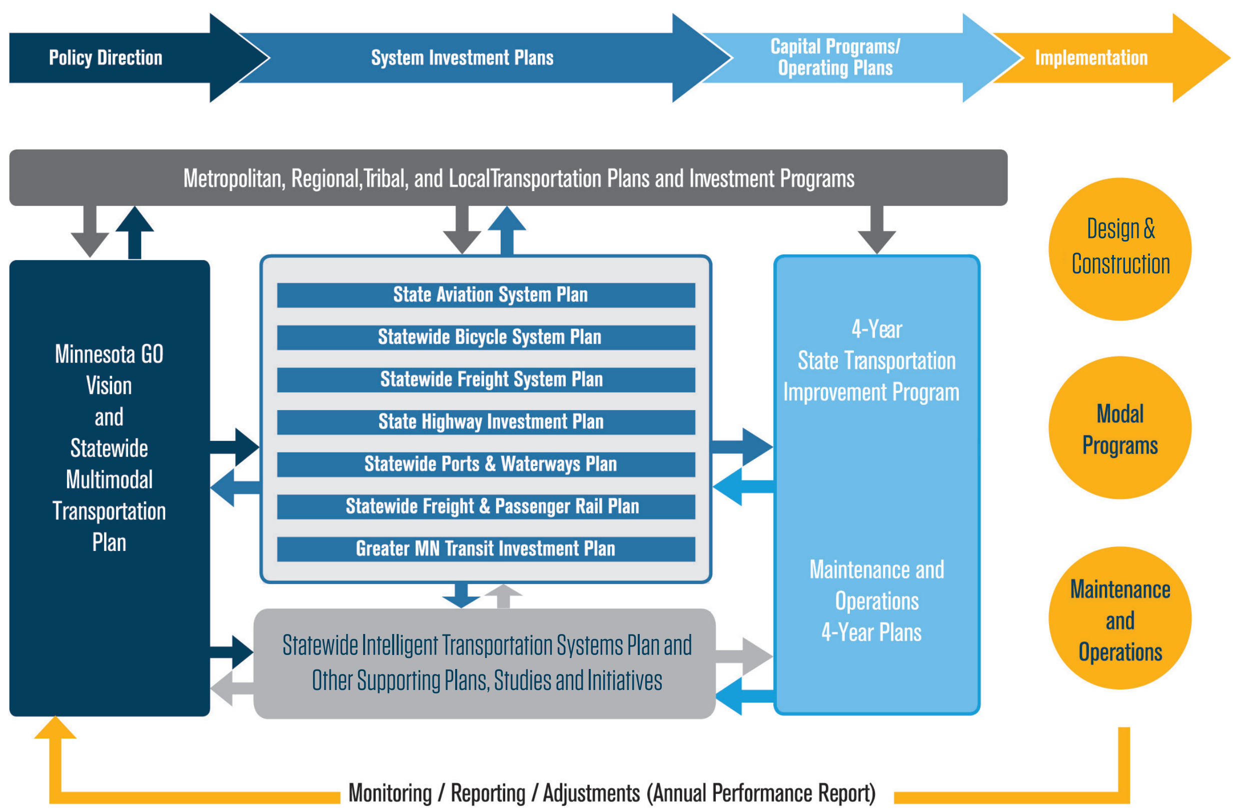
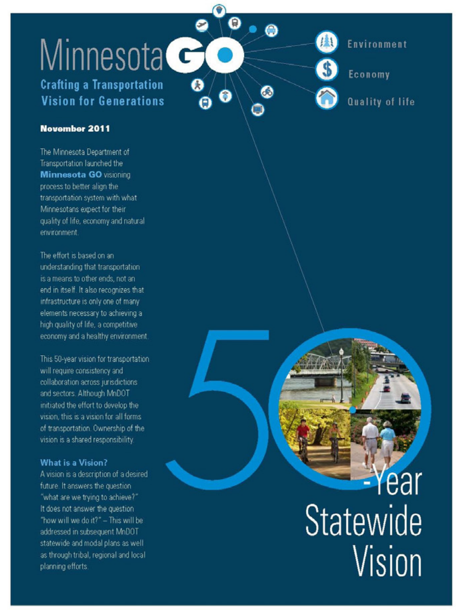


FIGURE 2-2: MINNESOTA GO PRINCIPLES TO ITS PLAN GOALS

MnGO Principle	Statewide Multi-modal Plan Principle	ITS Plan Goal
Integrate Safety	Travler Safety	SAFETY
Ensure regional connections	Critical Connections	MOBILITY
Leverage public investments to achieve multiple purposes	Transportation in Context	FISCAL RESPONSIBILITY & SUSTAINABILITY
Strategically fix the system	Asset Management	OPERATIONS & MAINTENANCE
		ASSET MANAGEMENT
Emphasize Reliable and predictable options	System Security	CONSISTENCY

The Minnesota Go principles link to MnDOT's multi-modal plan principles. As a supporting plan in MnDOT's family of plans, the ITS goals defined in the following pages are connected back to both the principles of the multi-modal plan and ultimately back to the Minnesota Go principles as defined in **Figure 2-2.**

2.1 MINNESOTA GO VISION



In early 2011, MnDOT launched the Minnesota GO 50-year statewide visioning process to better align the transportation system with what Minnesotans expect for their quality of life, economy and natural environment. While federal and state transportation planning requirements have been in place for years, Minnesota's transportation system needed a long-term vision—a destination toward which state and local transportation planning could navigate.

Teaming with the University of Minnesota and the Citizens League, MnDOT asked Minnesotans to help shape a vision that answers the question "what are we trying to achieve?" The SITSP focuses on the specific Vision, Goals, Strategies and Performance Measures that support the Minnesota GO Vision which was adopted in November of 2011.

MINNESOTA GO VISION FOR TRANSPORTATION

Minnesota's multimodal transportation system maximizes the health of people, the environment and our economy. **The system:**

- Connects Minnesota's primary assets—the people, natural resources and businesses within the state—to each other and to markets and resources outside the state and country
- Provides safe, convenient, efficient and effective movement of people and goods
- Is flexible and nimble enough to adapt to changes in society, technology, the environment and the economy

QUALITY OF LIFE

The system:

- Recognizes and respects the importance, significance and context of place—not just as destinations, but also where people live, work, learn, play and access services
- Is accessible regardless of socioeconomic status or individual ability

ENVIRONMENTAL HEALTH

The system:

- Is designed in such a way that it enhances the community around it and is compatible with natural systems
- Minimizes resource use and pollution

ECONOMIC COMPETITIVENESS

The system:

- Enhances and supports Minnesota's role in a globally competitive economy as well as the international significance and connections of Minnesota's trade centers
- Attracts human and financial capital to the state

This Minnesota GO Vision included the following principles to guide future policy and investment decisions for all transportation modes throughout the state, including the use of Intelligent Transportation Systems (ITS). These are listed in no particular order.

The following principles will guide future policy and investment decisions for all forms of transportation throughout the state. These are listed in no particular order. The principles are intended to be used collectively.

Leverage public investments to achieve multiple purposes:
The transportation system should support other public purposes, such as environmental stewardship, economic competitiveness, public health and energy independence.

Ensure accessibility: The transportation system must be accessible and safe for users of all abilities and incomes. The system must provide access to key resources and amenities throughout communities.

Build to a maintainable scale: Consider and minimize long-term obligations—don't overbuild. The scale of the system should reflect and respect the surrounding physical and social context of the facility. The transportation system should affordably contribute to the overall quality of life and prosperity of the state.

Ensure regional connections: Key regional centers need to be connected to each other through multiple modes of transportation.

Integrate safety: Systematically and holistically improve safety for all forms of transportation. Be proactive, innovative and strategic in creating safe options.

Emphasize reliable and predictable options: The reliability of the system and predictability of travel time are frequently as important or more important than speed. Prioritize multiple multimodal options over reliance on a single option.

Strategically fix the system: Some parts of the system may need to be reduced while other parts are enhanced or expanded to meet changing demand. Strategically maintain and upgrade critical existing infrastructure.

Use partnerships: Coordinate across sectors and jurisdictions to make transportation projects and services more efficient.

2.2 SYSTEM VISION AND GOALS

Similar to development of the Minnesota GO 50-year vision for transportation, a vision for Intelligent Transportation Systems (ITS) in the state was developed through collaboration with stakeholders early in the planning process. The vision for ITS provides a description of the desired future and highlights what the State is trying to achieve with its transportation system. The bulk of this Plan answers the question of how the vision can be achieved. **Figure 2-3** shows how an ITS system vision relates to the Minnesota GO Vision and the Statewide Multimodal Transportation Plan.

The six ITS goals through the stakeholder process are:

SAFETY: Utilize Minnesota's Intelligent Transportation System to reduce fatalities and serious injuries through the use of technology to enhance the overall safety of the transportation system.

MOBILITY: Minimize overall travel delay by providing and operating systems that maximize highway capacity, reduce delays and communicate information about road conditions to travelers.

FISCAL RESPONSIBILITY AND SUSTAINABILITY: Establish responsible and sustainable funding for Intelligent Transportation Systems in Minnesota and encourage private investment / research opportunities for continuous improvement.

OPERATIONS AND MAINTENANCE: Provide an Intelligent Transportation System that is reliable and effective for users and improves operational efficiency of systems and MnDOT.

ASSET MANAGEMENT: Improve the management of Minnesota's ITS assets by focusing on risk and life-cycle costs to prioritize maintenance, investment, and system management.

CONSISTENCY: Establish an Intelligent Transportation System that provides consistency statewide with technology, processes and procedures, interoperability, operations and maintenance.

MINNESOTA'S VISION FOR INTELLIGENT TRANSPORTATION SYSTEMS

Minnesota's ITS will support Minnesota's multimodal transportation system that maximizes the health of people, the environment and the economy by providing effective systems and operations which utilize innovation and cost effective technologies

Figure 2-3: Connections to the Vision and Statewide Multimodal Transportation Plan (Example: Safety AND WORK ZONES)

Minnesota GO Vision	**Desired Outcome:** The transportation system in Minnesota provides safe, convenient, efficient and effective movement of people and goods.
	Guiding Principles: Integrate Safety – Systematically and holistically improve safety for all forms of transportation. Be pro-active, innovative and strategic in creating safest options.
Statewide Multimodal Transportation Plan	**Objective:** Traveler Safety – Safeguard travelers, transportation facilities, and services; apply proven strategies to reduce fatalities and serious injuries for all travel modes.
	Strategy: Implement strategic and sustainable engineering solutions to improve traveler safety.
Statewide Intelligent Transportation Systems (ITS) Plan	**Vision:** Minnesota's Intelligent Transportation Systems (ITS) provides a safe and efficient transportation system for users by providing timely and effective communications utilizing innovation and cost effective technologies.
	Goal: Safety - Utilize Minnesota's Intelligent Transportation System (ITS) to reduce fatalities and serious injuries through the use of technology to enhance the overall safety of the transportation system.
	Strategy: Utilize Smart Work Zone technology for specific work zone applications where traffic queuing and delay are anticipated during peak traffic conditions.

GOAL: SAFETY

Utilize Minnesota's Intelligent Transportation System to reduce fatalities and serious injuries through the use of technology to enhance the overall safety of the transportation system.

STRATEGIES

- Support MnDOT's continued efforts in the Toward Zero Deaths (TZD) initiative and work collaboratively with proponents to incorporate all modes into the initiative utilizing ITS.
- Utilize Smart Work Zone technology for specific work zone applications where traffic queuing and delay are anticipated during peak traffic conditions.
- Continue to provide systems for incident management field support, in conjunction with law enforcement, to reduce incident times and facilitate normal traffic conditions.
- Continue to provide ramp metering technology along specific freeway corridors which reduces variances in mainline traffic speeds during peak traffic conditions and results in fewer crashes.
- Plan for V2I technology through revisions to the Statewide ITS Architecture Plan and initiate pilot projects to test the utilization of this technology for Minnesota.
- Continue to utilize ITS technology at intersections to reduce crashes involving sign/signal violations, failure-to-yield and rear-end collisions.
- Utilize advanced signal control technology on congested urban arterials to reduce delays and improve safety.

MNGO PRINCIPLE

Integrate Safety

STATEWIDE MULTI-MODAL PLAN PRINCIPLE

Traveler Safety

ITS PLAN GOAL

Safety

MNGO PRINCIPLE

Ensure regional connections

STATEWIDE MULTI-MODAL PLAN PRINCIPLE

Critical Connections

ITS PLAN GOAL

Mobility

GOAL: MOBILITY

Minimize overall travel delay by providing and operating systems that maximize highway capacity reduce delays and communicate information about road conditions to travelers.

STRATEGIES

- Utilize ITS technology/systems to identify innovative solutions and push efficiency of the system vs. expanding capacity of the transportation system.
- Utilize Systems Engineering protocols to improve the operational effectiveness of ITS
- Utilize ITS technology/systems with the bigger multi-modal plan and use where needed to enhance operations in all modes of travel.
- Provide users more real time data about their trip through the MnDOT Travel Information website, text alerts, social media and/or in field devices (DMS, cameras, other) to improve user mobility.
- Utilize Smart Work Zone technology for specific work zone applications where traffic queuing and delay are anticipated during peak traffic conditions.
- Continue to provide technology for incident management field support, in conjunction with law enforcement, to reduce incident times and facilitate normal traffic conditions.
- Continue to provide ramp metering technology along specific freeway corridors which reduces variances in mainline traffic speeds during peak traffic conditions and results in reduced delay.
- Plan for V2I technology through revisions to the Statewide ITS Architecture Plan and initiate pilot projects to test the utilization of this technology for Minnesota.
- Utilize advanced-signal control technology on congested arterials to reduce travel delays during peak traffic periods.

GOAL: FISCAL RESPONSIBILITY & SUSTAINABILITY

Establish responsible and sustainable funding for Intelligent Transportation Systems in Minnesota and encourage public and private investment / research opportunities for continuous improvement.

STRATEGIES

- Statewide plan creates opportunity for long term planning for operations and capital investment
- Establish an annual budget for ITS capital improvements to meet replacement cycle costs of systems
- Provide resources in the Districts and at MnDOT offices for sufficient staffing to maintain existing ITS systems
- Develop effective method of calculating and sharing with the public, stakeholders and legislators the high Benefit-to-Cost (B/C) and Return-on-Investment (ROI) information that generally results from implementing ITS projects
- Identify additional funding sources for key ITS elements (software, licenses, warranty and communications)
- Share the benefits of ITS in MnDOT's Annual Performance Report
- Encourage ITS technology pilot projects to enhance role in economy
- Coordinate and fund private investment in ITS technologies and sharing of data with MnDOT
- Managed ITS through asset management systems
- Create a new ITS product and service that encompasses all ITS activities within MnDOT
- Continue to invest research and development funding in ITS systems that have potential to help meet transportation system goals

MNGO PRINCIPLE

Leverage public investments to achieve multiple purposes

STATEWIDE MULTI-MODAL PLAN PRINCIPLE

Transportation in Context

ITS PLAN GOAL

Fiscal Responsibility & Sustainability

MNGO PRINCIPLE

Strategically fix the system

STATEWIDE MULTI-MODAL PLAN PRINCIPLE

Asset Management

ITS PLAN GOAL

Operations & Maintenance

GOAL: OPERATIONS & MAINTENANCE

Provide an Intelligent Transportation System to ensure the transportation system is reliable and effective for users and improves operational efficiency of systems and MnDOT.

STRATEGIES

- Provide resources in the Districts, Specialty offices and Modal groups for sufficient staffing to maintain existing ITS systems including troubleshooting, first response, repairs, inventory, training, and preventative maintenance activities
- Establish an annual budget for ITS capital improvements in all MnDOT to meet replacement cycle costs of systems
- Better define/enhance organizational structure for ITS from leadership to technician
- Attract and retain staff with skills in ITS including design, project management, operations and maintenance.
- Provide improved identification of non-working ITS systems/devices and reduced turn-around time to correct the deficiency.
- Share equipment/staffing between Districts (as needed) in order to provide a functioning ITS system that meets the needs of users
- Develop and implement a TSM&O plan for MnDOT
- Provide resources in Districts, offices, and modal groups for sufficient staffing to operating existing ITS systems including verifying operations, calibrating systems, identifying failure levels of subsystems, ensuring overall system performance and training
- Manage new ITS systems through statewide centralized software (i.e IRIS)

GOAL: ASSET MANAGEMENT

Improve the management of Minnesota's ITS assets by focusing on risk and life-cycle costs to prioritize maintenance, investment, and system management.

STRATEGIES

- Incorporate ITS assets into the Transportation Asset Management Plan update (TAMP 2)
- Manage ITS through asset management systems
- Perform analysis of data in the Asset Management System to establish funding needs and priorities for transportation investment.
- Track ITS assets through their full life cycle to establish typical life cycle plans for each major ITS asset.
- Document expected annual preventative maintenance, major maintenance, and replacement timeframes and costs.
- Establish plans for decommissioning ITS assets that have served their useful life and are no longer necessary to meet MnDOT transportation system goals
- Invest in research to test new technologies that can reduce life cycle costs or improve ITS maintenance efficiencies.
- Utilize warranties and innovative contracting methods as a tool in managing ITS assets

MNGO PRINCIPLE

Strategically fix the system

STATEWIDE MULTI-MODAL PLAN PRINCIPLE

Asset Management

ITS PLAN GOAL

Asset Management

MNGO PRINCIPLE

Emphasize Reliable and predictable options

STATEWIDE MULTI-MODAL PLAN PRINCIPLE

System Security

ITS PLAN GOAL

Consistency

GOAL: CONSISTENCY

Establish an Intelligent Transportation System (ITS) that provides consistency statewide for technology, processes and procedures, interoperability, operations and maintenance.

STRATEGIES

- Better define/enhance organizational structure for ITS from leadership to technician
- Link all ITS systems to an updated Statewide ITS architecture.
- Utilize a Systems Engineering process for new ITS systems to provide reliable and consistent outcomes.
- Develop a plan to implement compatible ITS technologies and systems across all MnDOT Districts
- Address aging demographics, security and privacy for ITS that is public information related
- Attract and retain staff with skills in ITS including design, project management, operations and maintenance.
- Include non-traffic systems (FLEET, WIM, RWIS, Transit) in long-range ITS planning
- Establish responsibilities for ITS systems that cross organizational boundaries in regard operations and maintenance
- Continue to update Statewide ITS architecture plan establishing consistency for systems
- Continue to provide approved products list and equipment on state contracts

2.3 PERFORMANCE MEASURES & INDICATORS

Developing and maintaining performance measures are important to be able to gage how you are doing as an Agency towards reaching your ITS goals. Below are performance measures or indicators for each goal:

Goal	Performance Measures / Indicators
SAFETY Utilize Minnesota's Intelligent Transportation System to reduce fatalities and serious injuries through the use of technology to enhance the overall safety of the transportation system.	**A. Fatalities and serious injuries – Measure the number of fatalities and serious injuries on transportation corridors that include ITS technology (Existing Measure).** **B. Smart Work Zones – Measure the number of crashes occurring in construction projects with Smart Work Zone deployment.**
MOBILITY Minimize overall travel delay by providing efficient processes as well as timely and effective communication for our users through innovative technology.	**A. Congestion- The percent of miles of the freeway system is congested. (This is an Existing Measure)** **B. Travel Times – The average time to travel on urban freeway segments during both the AM and PM Peak traffic conditions.** **C. Average Time to Clear Lanes - The average time for all lanes to be cleared as a result of an incident. This time is calculated from the start of the incident to when all lanes are reopened (Existing Measure).**
FISCAL RESPONSIBILITY & SUSTAINABILITY Establish responsible and sustainable funding for Intelligent Transportation Systems in Minnesota and encourage private investment / research opportunities for continuous improvement. Manage to a new product and service items identified as ITS.	**A. District ITS Budgets – District budgets for ITS capital improvements in relation to replacement cycle costs of systems** **B. B/C & ROI – Positive Benefit Cost or Return on Investment for ITS projects that have formal evaluations**
OPERATIONS & MAINTENANCE Provide an Intelligent Transportation System that is reliable and effective for users.	**A. Equipment Uptime – The percent ITS equipment functioning properly. The equipment consists of cameras, Dynamic Message Boards (DMS) and Vehicle Detector Stations (VDS) but can also include on-line tools such as MnDOT's 511 website. This Performance Measure is relevant in both urban and rural Districts.** **B. Redundancy – Measure the % of the statewide ITS system that contains redundancy.**
ASSET MANAGEMENT Improve the management of Minnesota's ITS assets by focusing on risk and life-cycle costs to prioritize maintenance, investment, and system management.	**Performance Measures and Indicators for ITS Assets are currently under development as part of the TAMP 2 planning process. It is the intent of this plan to adopt the measures for the Asset Management Goal that are established in that process which is expected to be completed at the end of 2015.**
CONSISTENCY Establish an Intelligent Transportation System that provides consistency statewide with technology, processes and procedures, interoperability, operations and maintenance.	**A. Consistent Technology – Measure the percent of ITS equipment that is compatible between Districts. Goal would be to purchase and maintain the same ITS equipment and phase out old equipment through replacement.** **B. Statewide ITS Architecture – Measure the % of the ITS system that is incorporated in the statewide ITS Architecture.**

CHAPTER THREE

CURRENT MINNESOTA ITS ENVIRONMENT

This history of ITS in Minnesota covers over four decades of accomplishments. Beginning with ramp metering in 1970, MnDOT and its partners have advanced ITS in the state and nationally. What follows in **Figure 3-1** is a brief history of key highlights of ITS. Many of these highlights are "first" investments where MnDOT's sought to advance transportation by trying new strategies and technologies. Over these decades the technology has changed many times and improved dramatically – these changes will continue and this ITS plan provides a framework for advancing ITS within MnDOT.

FIGURE 3-1: KEY ITS MILESTONES IN MINNESOTA

MnDOT opens a TMC beginning a strategy to actively managed highways to improve system performance	**1972**
MnDOT begins to quickly expand ITS systems to additional freeway corridors	**1980**
MnDOT installs its first fiber optic communication system on I-394, starting a move to fiber as a core communication system for ITS devices	**1989**
MN Guidestar Program is formed linking the public and private sectors in funding and developing innovative ITS solutions	**1991**
ARTIC project opens the first of 9 Traffic Operations Control Centers to manage ITS devices around the State	**1995**
ITS Minnesota formed to support development and use of ITS in Minnesota	**1995**
Statewide ITS Architecture created as a foundation for wholelistically developing ITS systems	**1995**
The Trilogy project becomes one of the first North American demonstrations of real time in-vehicle traveler information systems	**1996**
Gate operations systems installed on I-94 and I-90 for safe closure of Interstates due to winter weather	**1996**
Orion Model Deployment created to design and implement a comprehensive set of ITS technologies and systems to serve as a model for other metropolitan areas	**1997**

1997	CARS becomes a statewide platform for recording traveler information about incidents, construction, and weather- eventually become the data source for 511 and 511mn.org
1998	Road Weather Information System (RWIS) begins to roll out statewide as key tool for winter maintenance operations
1998	Rural Intersection Conflict Warning Systems enter testing phase for reducing fatal and serious injury crashes at intersections. The system has grown to over 60 deployments
1999	IRIS is deployed as MnDOT's core central platform for managing ITS devices. IRIS is eventually released with a license that allows other entities to use the software for their traffic management operations
1999	Autoscope , funded by MnDOT research, is first video based detection system used to operate a traffic signal in the nation.
2000	MnDOT District 3 begins operating its Quick Start ITS program, the first centralized coordinated control of traffic signals, that also includes fixed & mobile Cameras & DMS
2001	State Patrol implements Computer Aided Dispatch system enabling several ITS deployments tied to incident and emergency management
2001	Connect MN Fiber expands ITS communications capabilities on major interstates in greater MN through unique a public private partnership
2002	511 Traveler Info begins and becomes MnDOT's system for phone and web based real time traveler information about road conditions
2003	A multi-function RTMC replaces the TMC, Maintenance and State Patrol Dispatch centers
2004	ROC52 Project in Rochester begins operation of ITS devices using fiber to become the first use of fiber for ITS communication in Greater Minnesota
2005	Intelligent Work Zone Toolbox manual is created to simplify design of ITS for various work zone situations
2005	MnPASS begins on 1-394 as national test of dynamic pricing and HOT lanes- eventually implementing the system on multiple corridors

MnDOT establishes its first ITS Safety Plan	2006
First ramp meter begins operation eventually growing into the second largest system in the U.S	2008
A rapid expansion of ITS for Arterial Traffic Management and Traveler Information Systems begins	2009
Minnesota becomes first state to implement Active Traffic Management Systems with queue warning and dynamic advisory speeds on urban highways	2009
Dynamically priced shoulder lanes are introduced as a first in nation system on I-35W and prove to be a low cost way to safely expand freeway capacity	2009
Mileage Based User Fee (MBUF) concept is tested at a regional scale to understand technology and user impacts of a paying a per mile fee to travel	2010
Metro Transit adds extensive ITS for parking information, real time transit arrival, and trip planning	2010
MnDOT begins to add real time performance management systems to traffic signals to improve management and operations of arterial corridors	2010
Metro District becomes first urban area in the nation to fully instrument its entire freeway network with ITS devices	2011
MnDOT introduces a smart phone app for its 511 Traveler Information System	2013
Minnesota becomes the first state to have a GPS differential correction broadcast (MnCORS- Continuously Operating Reference Station Network) covering the entire state. This network enables high accuracy GPS data which will enable new types of ITS that can only be viable with high accuracy data.	2014

3.0 CURRENT MINNESOTA ITS ENVIRONMENT

MnDOT's ITS organization is primarily focused within the Operations Division with the exception of Modal offices that utilize or manage ITS and Planning and Investment which is within the Modal Planning and Program Management Division. **Figure 3-2** shows the distribution of ITS functions within the organization.

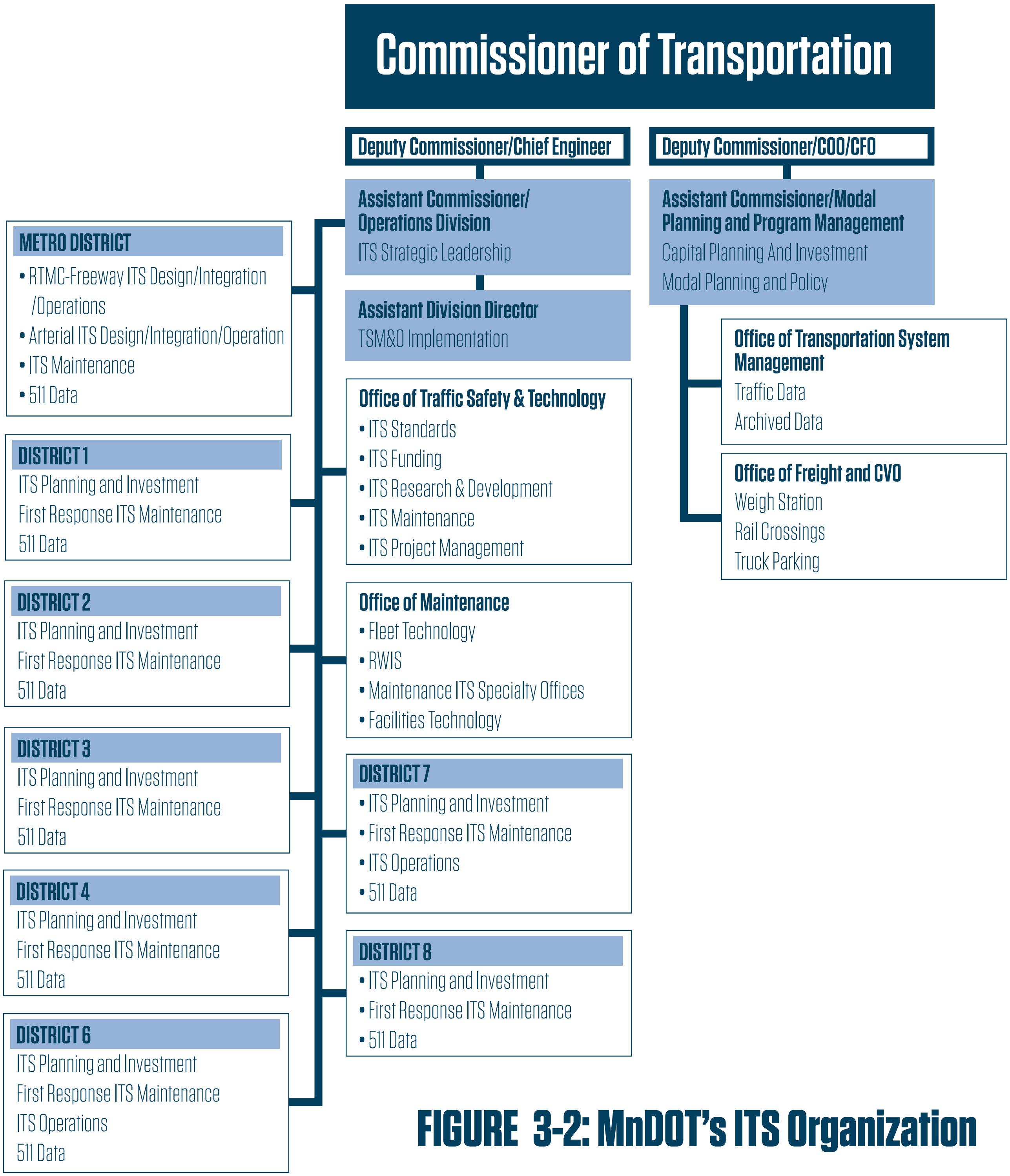


FIGURE 3-2: MnDOT's ITS Organization

MnDOT utilizes a suite of ITS systems to achieve its transportation goals. The most common devices used in most Districts are Traffic Signals, DMS, Cameras and Detectors. **Table 3-1** below lists the number of devices for each District and the distribution between the Metro District and the Greater Minnesota Districts. The Metro District has the bulk of the DMS, Cameras, Detectors and all of the ramp meters and managed lanes reflecting the need to use ITS for improving mobility. Greater Minnesota Districts have a focus on using devices for safety (RICWS) and Traveler Information (RWIS, Road Closure Flashers, DMS).

TABLE 3-1: MnDOT ITS Assets

ITS System	District								Total	Distribution of ITS	
	1	2	3	4	6	7	8	M		Greater MN	Metro
DMS	23	5	29	8	22	19	0	509	615	17%	83%
Cameras	29	0	54	10	55	4	1	657	810	19%	81%
Detectors*	0	0	94	0	130	0	0	5860	6084	4%	96%
Ramp Meters	0	0	0	0	0	0	0	441	441	0%	100%
Signals	84	63	166	66	102	60	52	726	1319	45%	55%
RWIS	21	15	8	9	13	12	10	9	97	91%	9%
RCWIS	4	2	13	8	11	3	12	0	53	100%	0%
Fiber (miles)	9	0	85	115	58	0	0	545	812	33%	67%
Managed Lane Miles	0	0	0	0	0	0	0	35	35	100%	100%

*does not include traffic signal or ATR detectors

3.1 SYSTEM ARCHITECTURE

The Minnesota Statewide Regional ITS Architecture represents a shared vision of how each ITS system works together by sharing information and resources to enhance transportation safety, efficiency, capacity, mobility, and security. The Minnesota Statewide Regional ITS Architecture is a living document that evolves as needs, technology, stakeholders and funding change. The Architecture was last updated in March 2014. Compliance with the National ITS Architecture allows MnDOT to receive Federal funds for ITS projects.

A system architecture and the SITSP are complementary documents. The architecture documents detailed ITS system designs and linkages built around national standards. Whereas the SITSP is linked to MnDOT's other plans and is intended to cover broader issues such as policy, funding, and investment in infrastructure and operations.

Benefits of ITS Architecture

- Identifies current capabilities in the state as well as gaps in services
- Provides a common framework for the planning, design, implementation, integration, and operation of ITS throughout the state
- Enhances the efficiency of ITS planning, project deployment and enhancements, operations, and maintenance
- Improves integration between systems and coordination among stakeholders

http://www.dot.state.mn.us/guidestar/2006_2010/mnitsarchitecture.html

Regional ITS architectures help guide the planning, implementation, and integration of ITS components and systems. The National ITS Architecture is a tool to guide the development of regional ITS architectures. It is a common framework that guides agencies in establishing ITS interoperability and helps them choose the most appropriate strategies for processing transportation information, implementing and integrating ITS components and systems, and improving operations.

MnDOT has found that having an ITS architecture is valuable in assisting the implementation and integration of ITS projects. The ITS architecture is a living document that must be periodically updated as technology changes, national architectures are updated, and MnDOT and its partners and stakeholders vision for transportation evolves.

3.2 ITS PLANNING AND FUNDING

As a key tool MnDOT uses for achieving its vision for transportation, ITS is embedded within MnDOT's planning processes. For capital investment (Ten year Highway Investment Plan, (HIP) and four year State Highway investment Plan (STIP)), ITS projects are identified either as separate projects or when ITS is part of a larger project the ITS systems are part of the project's scope. For asset management, MnDOT is currently developing the Transportation Asset Management Plan (TAMP). TAMP is expected to be a systematic process of maintaining, upgrading and operating physical assets cost-effectively throughout their life-cycle. The TAMP ITS asset management plan will be completed by the end of 2015.

Operations planning that addresses staffing and resources necessary to design, operate and maintain ITS has been documented in two generations of a Highway Systems Operations Plan (HSOP) with the most recent spanning the 2012-2015 timeframe. ITS is also a strategy documented in State and District Safety Plans as well as several modal plans. With ITS embedded across multiple planning processes, with planning updates on various cycles, achieving consistency for ITS planning is a challenging task.

This level of annual funding for ITS is relatively low compared to investments in other infrastructure such as pavements ($240 M annually) and bridges ($190 M annually), but there is often other investment that occurs in ITS which is either one time funding or short in duration. This funding is difficult to plan for but has been an instrumental strategy in building the ITS infrastructure that exists in the State. Federal funding through grants and special programs has often been the funding mechanism in these cases. In the Metro District, the arterial ITS network is being built out though annual awards of federally funded Congestion Mitigation/Air Quality grants. The initial build out of ITS systems in greater Minnesota was accomplished primarily through federal allotments to the Minnesota Guidestar program. And, large grants have funded past ITS investments including the Orion program ($25 M) as well as the MnPASS, ATM, and Transit ITS systems ($133M) for I-35W awarded through the USDOT Urban Partnership Program. As a key example of one time funding, the State provided facility investment funding to build the RTMC, creating a critical hub for ITS that enables additional ITS investment.

Funding of ITS Systems

- $1M annual allocation for ITS investment (either for preservation or new systems) in the Metro District
- $1.5M funds allocated annually by the Traffic Safety and Technology Office for ITS projects in the districts
- Variable levels of funding of ITS components included within traditional highway improvement projects. (for new systems and for replacement of existing systems)
- $500K annual allocation to operate and enhance the 511 system.
- MnDOT operations costs exceed $14M annual for products and services that include ITS. These costs include staffing, facilities, communications, utilities and parts for ITS equipment

Numerous ITS operational tests carried out by MnDOT to develop and test cutting edge technology have occurred through funding provided by MnDOT's Innovative Ideas program and through its annual research investments .

3.3 ITS DEVICES

RAMP METERS: A ramp meter is a device, usually a basic traffic signal together with a controller that regulates the flow of traffic entering freeways according to current traffic conditions. It is the used to manage the rate of vehicles entering the freeway. Ramp meters can be controlled locally based on time-of-day and day-of-week, or via traffic responsive metering where metering is enacted based on volume, occupancy, or speed being obtained by the local freeway detection. MnDOT has been using ramp meters as a traffic management tool since 1970.

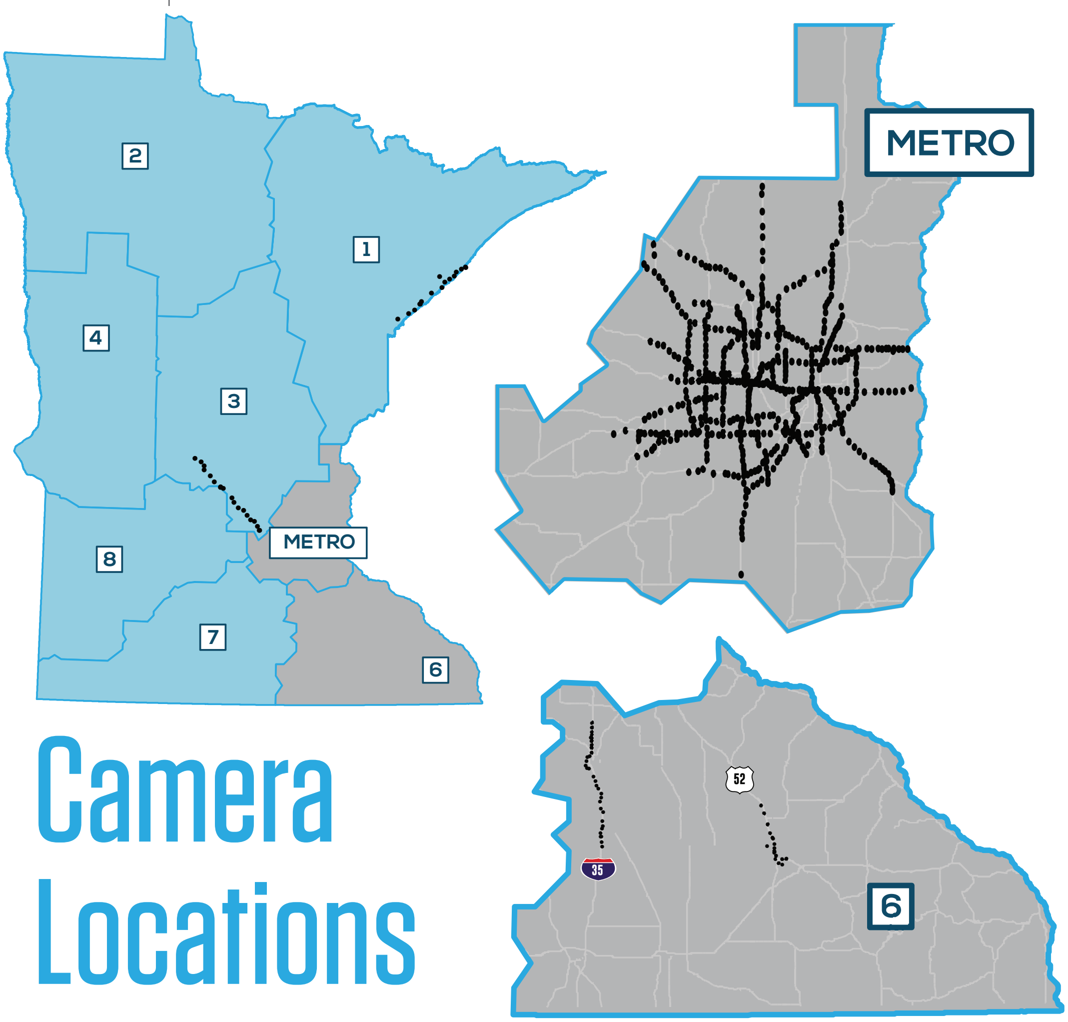
PURPOSE: Ramp metering systems have proven to be successful in decreasing traffic congestion and improving driver safety. Ramp meters are proven to reduce congestion

MnDOT Ramp Meter

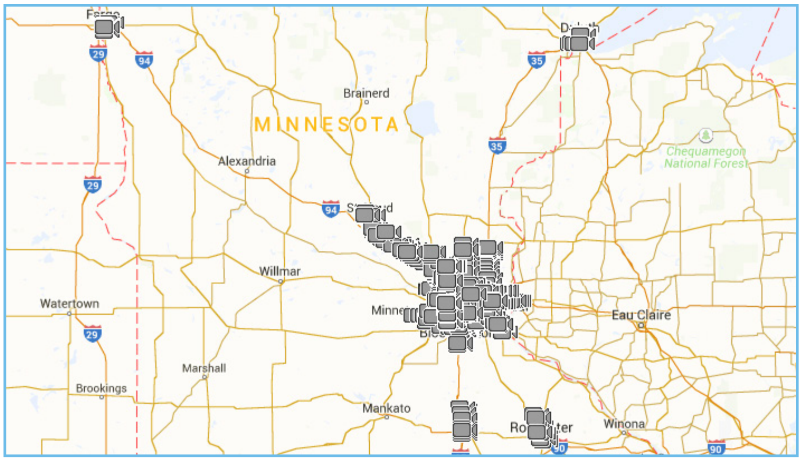
(increase speed and volume) on freeways by managing demand and by breaking up platoons of cars entering a freeway. HOV bypass lanes are used with ramp meters which allow busses and carpoolers to bypass the queue. Ramp meters are generally only used during rush hour or high congestion periods.

CAMERAS: Cameras, also referred to as closed-circuit television (CCTV), are a key ITS resource for monitoring conditions. MnDOT has over 800 cameras on its system, covering all of the Twin Cities freeways and key signalized arterial highways, as well as cameras on regional corridors of I-94, I-35 and Highway 52. Regional centers of Rochester, Owatonna, Duluth, and Fargo/Morehead have cameras on the interstates and highways as well.

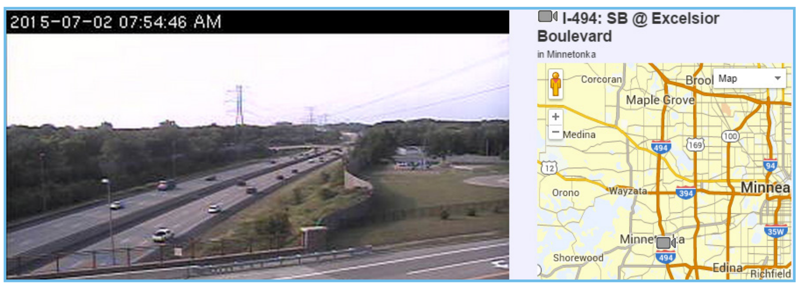
PURPOSE: Cameras are used to verify congestion, monitor system performance, and help manage incidents. The cameras can be used to determine the appropriate response to an unplanned event or incident; variable message sign verification, verification of stranded motorists and incidents, observing local weather and other hazardous conditions, and dispatching of safety personnel.



Camera Locations



Online interactive map of Cameras along Minnesota Highways
Source: http://hb.511mn.org/#cameras/search/layers=cameras



Still camera view of I-494: SB @ Excelsior Boulevard, Minneapolis/St. Paul, MN
Source: http://hb.511mn.org/#cameras/albumView/224

SENSORS: Sensors, also known as detectors, are used for vehicle detection and surveillance and incorporated into new ITS.

The most common type of detection used by MNDOT is in pavement loop detectors but with advances in capabilities and consideration of full life cycle costs as well as the ability to maintain the systems without lane closures have led MnDOT to move towards installing radar detectors in recent years.

PURPOSE: Sensors are used to collect and provide data to control operation of ITS devices and for monitoring conditions. Sensors can collect speed, volume, density, or presence of traffic information as well as condition data such as weather or road surface conditions. The value of a sensor is increased if the data generated by the sensor is available in real time and the data is archived.

DYNAMIC MESSAGE SIGNS: **Dynamic Message Signs (DMS)** (also referred to as Changeable, Variable or Electronic and can be in a fixed location or portable), are often abbreviated DMS, CMS, or VMS, and is a sign system that can present a message to the traveler. Currently MNDOT has 615 DMS.

MINNEAPOLIS-SAINT PAUL RAMP METER STUDY- A DEMONSTRATION OF ITS BENEFITS

In 2000, an experiment was mandated by the Minnesota State Legislature to study the impact of ramp meters. The study involved shutting off all 433 ramp meters in the Minneapolis-St. Paul area for eight weeks to test their effectiveness. The study concluded that when the ramp meters were turned off freeway capacity decreased by 9%, travel times increased by 22%, freeway speeds dropped by 7% and crashes increased by 26%. As a result of the study, MnDOT developed new ramp control strategies including upgrading traffic management software and control strategies and installing ITS sensor to monitor and control ramp queues in real time.

PURPOSE: Dynamic Message Signs are electronic traffic signs often used on roadways to give travelers information about varying conditions or events. The signs warn of traffic congestion, crashes, incidents, work zones, or speed limits on a specific highway segment. They may also ask vehicles to take alternative routes, limit travel speed, warn of duration and location of the incidents or just inform of the traffic conditions. These signs may include weather advisory information. These signs are also used for AMBER Alerts, special event information, public safety, or other information that MnDOT would like to provide to drivers. It is expected that by providing real-time information about conditions ahead, message signs can improve drivers' route selection, reduce travel time, mitigate the severity and duration of incidents and improve the performance of the transportation network.

Dynamic Message Signs Source: 2014 MnDOT ITS Manual

ROAD CLOSURE FLASHERS: Devices that can be remotely activated on approaches to major highways that alert drivers that the major highway is closed due to winter weather conditions. The system is typically composed of a static sign and flashers that alert drivers to the closure when the flashers are active. The purpose is to keep drivers from entering roads when conditions are unsafe for travel. These systems are strategically located to provide drivers sufficient time to find shelter or alternate routes prior to having to enter the roadway that is closed.

INTERSECTION CONFLICT WARNING SYSTEM (ICWS) - ICWS typically consist of static signing, detection and dynamic elements. The predominant system in Minnesota is in rural areas. The goal of the Rural Intersection Conflict Warning System (RICWS) is to reduce the fatal and serious injury crashes at rural non-signalized intersections. RICWS is a statewide project that is deploying intersection conflict warning systems at rural, stop-controlled intersections. These systems address crashes by providing drivers (on both the major and minor roads) with a dynamic warning of other vehicles approaching the intersection. ICWS typically consist of static signing, detection and dynamic elements.

MnDOT is currently deploying 53 RICWS intersections across the state. Each District has additional locations documented in their safety plans that are viable candidates for RICWS and this system is expected to grow if the safety benefits from the first wave of RICWS intersection deployments prove beneficial. A RICWS is often the only affordable and viable safety system that is possible at the higher risk intersections. A RICWS system can resolve the safety risk without the need for more expensive investments such as an interchange.

ELECTRONIC TOLL SYSTEMS: Electronic Toll Collection (ETC) systems are used for automated collection of tolls from moving or stopped vehicles through wireless technologies. The systems that require users to have registered toll accounts, with the use of equipment inside or on the exterior of vehicles, such as a transponder or barcode decal, that communicates with or is detected by roadside or overhead receiving equipment, or with the use of license plate optical scanning, to automatically deduct the toll from the registered user account, or systems that do not require users to have registered toll accounts because vehicle license plates are optically scanned and invoices for the toll amount are sent to the driver.

PURPOSE: Electronic toll systems maintain highway speeds and simply allow vehicles

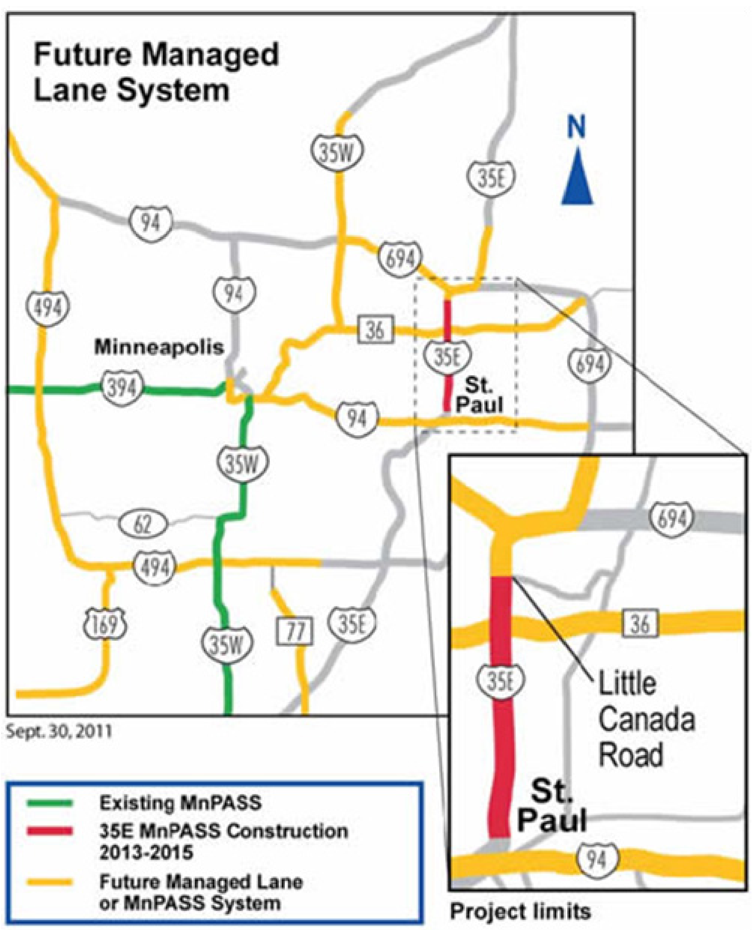


Figure 3-3: MnDOT's MnPASS System Pass

to pay tolls using their toll (transponders) or their vehicle license plates. No toll booths, no attendant staffing, and no collection and management of cash; the operational efficiencies and cost savings are significant. MnDOT's MnPASS toll system currently relies on a system that uses transponders, message signs, and toll readers to manage high occupancy toll lanes on an expanding number of highways in the Twin Cities. See **Figure 3-3.**

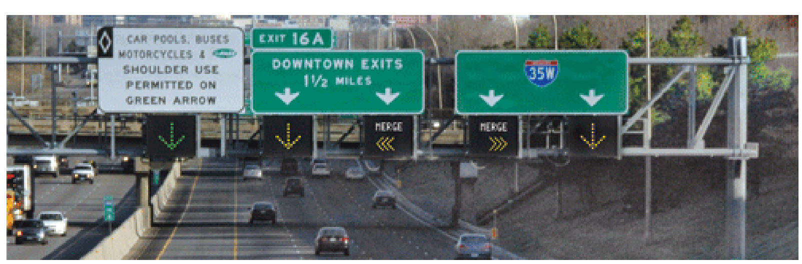
ELECTRONICALLY OPERATED GATES: This includes automatic or remotely controlled gates or barriers that control access to roadway segments or lanes. Traffic gates allow for easy closure when driving conditions are unsafe, maintenance or construction is underway, or when access needs to be prohibited for crashes. Gates that are managed remotely are generally considered under the umbrella of ITS whereas gate that are manually controlled at the site of the gate are considered basic infrastructure. MnDOT currently has electronically operated gates at:

- ✓ Interstate and non-interstate snow and ice closure gates
- ✓ Interstate 394 gate for reversible High Occupancy Toll Lanes
- ✓ At transit stations to control transit flow

PURPOSE: The purpose of using electronically operated gates at interstate on-ramps is to minimize the utilization of law enforcement vehicles and personnel as temporary roadway barriers. If the gate systems are remotely operated, then they are controlled at a central location, thus reducing staff risk to field conditions when the roads must be closed.

INTELLIGENT LANE CONTROL SIGNALS (ILCS) – are dynamic lane signals, called Smart Lanes in Minnesota or Active Traffic Management systems in other regions. These signs are small DMS, one for each lane of traffic, that provide real-time information to help motorists make informed decisions about their commute. The signs are illuminated during traffic incidents to indicate whether lanes are open to traffic. The information provided by these overhead lane signs is real time, designed to help motorists navigate safely through traffic.

Smart Lanes. Real Time. Real Choices. Real Safe.



Minnesota's Smart Lanes
Source: http://www.dot.state.mn.us/smartlanes/

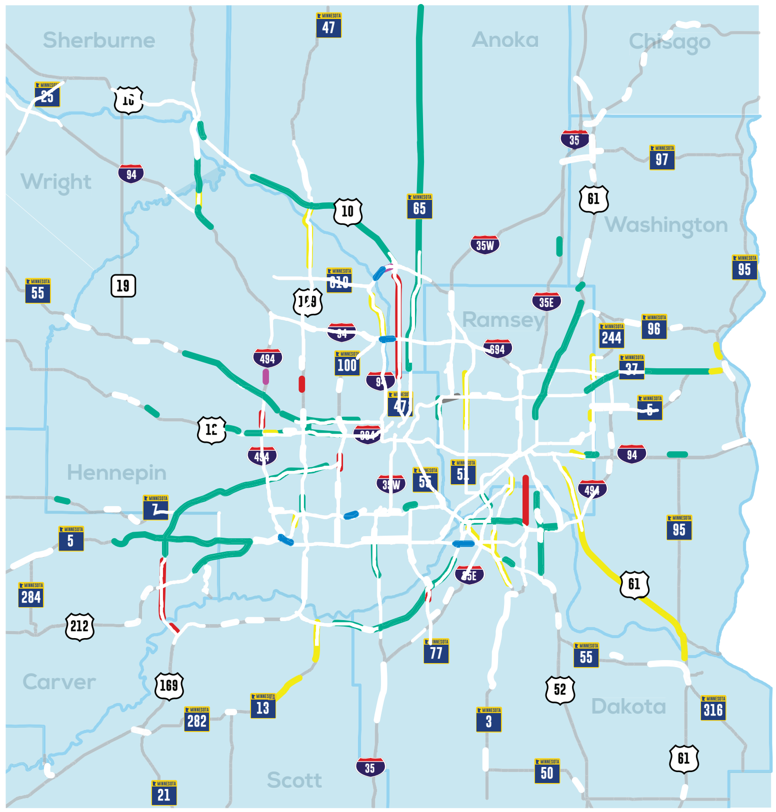
ARTERIAL ITS

TRAFFIC SIGNALS: Traffic signals are devices positioned at intersections or crossings to manage competing flows of traffic (both vehicular and pedestrian and bicycle). Traffic signals are located across the state of Minnesota, but exist in great numbers in the regional centers and the Twin Cities region. The state of Minnesota has traffic signals on state routes, county routes, and local jurisdictional routes. MnDOT maintains and operates over 1,300 signals on state highways. When traffic signals are closely spaced together, they can be coordinated to offer the best progression for traffic.

Traffic signals connected with fiber or wireless technology can be updated or modified remotely. Once a signal is connected to a remote center or system for optimization and management it falls within the umbrella of ITS systems. Currently these ITS signals are concentrated in the Twin Cities and the regional centers of Rochester, Mankato, St. Cloud, Morehead, and Duluth.

ARTERIAL CAMERAS – Similar to freeways, cameras can be used to provide a video feed and real-time data to the internet and phone apps at signalized intersections. Cameras can help manage incidents and unplanned events, as well as routine congestion. However, the predominate use of cameras on an arterial network is to monitor signal timing performance and make adjustments to the signal operations. The arterial cameras greatly improve MnDOT efficiency by allowing troubleshooting and performance monitoring of multiple signals to occur concurrently from a central location.

ARTERIAL DYNAMIC MESSAGE SIGNS – Used on arterials to give travelers information about varying conditions or events. Such signs warn of traffic congestion, crashes, incidents, work zones, speed limits, special events, and time to interstate or destinations. They may also ask vehicles to take alternative routes, limit travel speed, warn of duration and location of the incidents or just inform of traffic conditions. These signs are also used for AMBER Alert or special event information. With the exception of DMS used for special event traffic or parking on arterials, most arterial DMS are positioned on arterial approaches to freeways to inform drivers of conditions on the freeway and allow for drivers to consider rerouting if freeway conditions are poor.



Metro District Arterial ITS: Existing and Planned

LEGEND - STATUS

ACTIVE
2015
2016
2017
2018
2019

COMMUNICATIONS SYSTEMS:

FIBER OPTIC – MnDOT has over 800 miles of fiber optic communications cable installed within their right-of-way on arterials and freeways. A majority of this fiber is located in Twin Cities, but there is fiber in Duluth, Rochester, Fargo/Morehead, as well as along the I-94 between Wisconsin and North Dakota borders, and I-35 and Highway 52 Regional Corridors in District 6. Fiber optic cable provides high speed data connections. In terms of ITS, the fiber system transfers data and video images between devices and management centers. Fiber can also be used to connect signals for optimization and to DMS along the roadside that provide users information. Fiber is an important communication mechanism when cameras are part of a ITS strategy and full motion video is required.

Fiber can be expensive to install and depending on the environment (weather, topography, rural location, etc.) cannot easily be connected to all ITS devices along a corridor or within an area. At these critical links, wireless connections can be made and routed back to the fiber system.

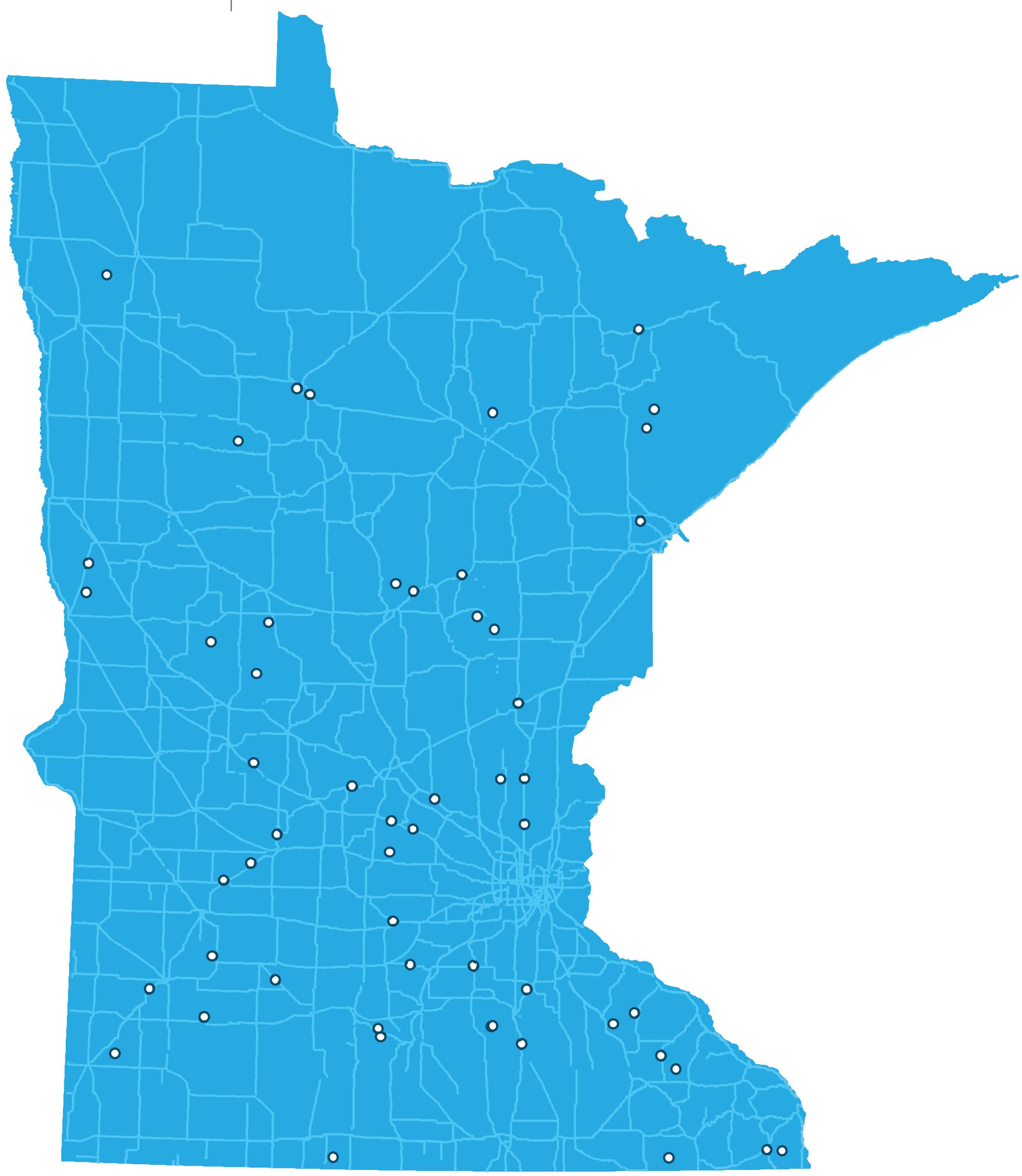
CELLULAR – When communication to a signal or camera or other ITS device can't be connected to a network via fiber, cellular communication is often a more feasible option. Cellular communication allows rural or remote devices to be connected to nearby systems at a more economical and beneficial way. Cellular coverage is continually improving in Minnesota but some areas remain inaccessible to cellular connections. With cellular communication, a site survey is needed to ensure service is available to the ITS device.

800 MHZ - is a wireless radio system for voice communication via radio. Minnesota's 800 MHz radio system is an important component of Statewide operations of the transportation system providing direct connections to the TMCs staff and field personnel. This radio system is used for communications between law enforcement, DOT staff, and local roadway public agencies as part of a emergency services plan. Radio communications are used as a communication link for a very limited number of ITS devices and are often used only because other options are not available or there is a unique location condition that makes the system viable.

ROAD WEATHER INFORMATION SYSTEMS (RWIS) – a road weather information system is a combination of technologies that collects, transmits, and disseminates weather and road condition information. The component of an RWIS that collects weather data is the Environmental Sensor Station (ESS). An Environmental Sensor Station (ESS) is a roadway location with one or more fixed sensors measuring atmospheric, pavement and/or water level conditions. Atmospheric data include air temperature and humidity, visibility distance, wind speed and direction, precipitation type and rate, tornado or waterspout occurrence, lightning, storm cell location and track, as well as air quality. Pavement data include pavement temperature, pavement freeze point, pavement condition (e.g., wet, icy, flooded), pavement chemical concentration, and subsurface conditions (e.g., soil temperature).

MnDOT is currently undertaking a planning study for the expansion of RWIS locations and enhancement to existing systems. This study will identify criteria for where to locate new stations and is expected to be completed in fall of 2015.

PURPOSE: MnDOT utilizes RWIS data to implement three types of road weather management strategies – advisory, control, and treatment. Advisory strategies provide information on prevailing and predicted conditions to both transportation managers and motorists. Control strategies alter the state of roadway devices to permit or restrict traffic flow and regulate roadway capacity. Treatment strategies supply resources to roadways to minimize or eliminate weather impacts. Many treatment strategies involve coordination of traffic, maintenance, and emergency management agencies. Winter maintenance managers utilize road weather information to assess the nature and conditions, make staffing decisions, plan surface treatment strategies, minimize costs (i.e., labor, equipment, materials), and assess the effectiveness of treatment activities.



RWIS Sites

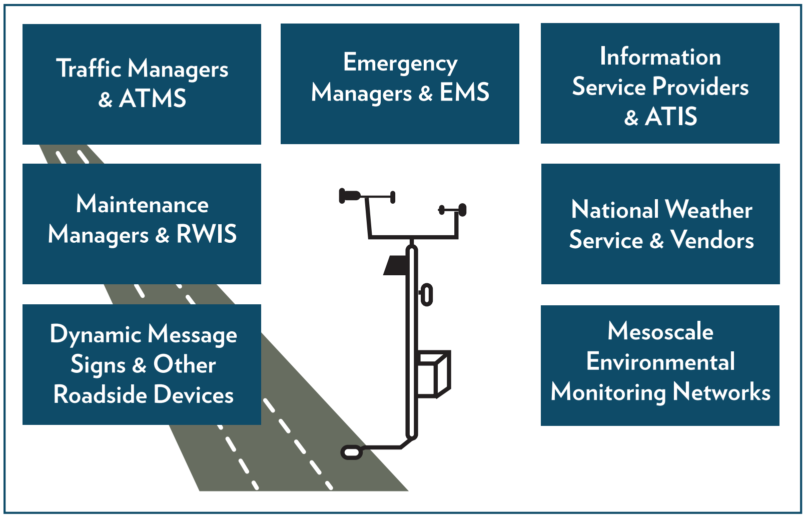


Figure 3-4: Components of RWIS

FLEET. MnDOT has a large fleet of vehicles in service to operate, maintain, and manage its transportation systems. ITS is a key component of two sectors of the fleet, the Maintenance/Snow Plow Truck and the FIRST vehicle. FIRST, the freeway service patrol, is a tool for incident management on the Twin Cities network. To effectively perform their functions, FIRST vehicles are equipped with AVL, DMS, and dispatching systems and integrated into RTMC operations.

Over 800 snow plows are in service in MnDOT's fleet. As a standard design, the snow plows are equipped with maintenance decision support systems (MDSS) and AVL, that basically tell where the vehicle is located and optimize its function through MDSS. MDSS is a system designed to provide support and recommendations for winter operations. Combining AVL with MDSS provides the real-time feedback operators need to function efficiently.

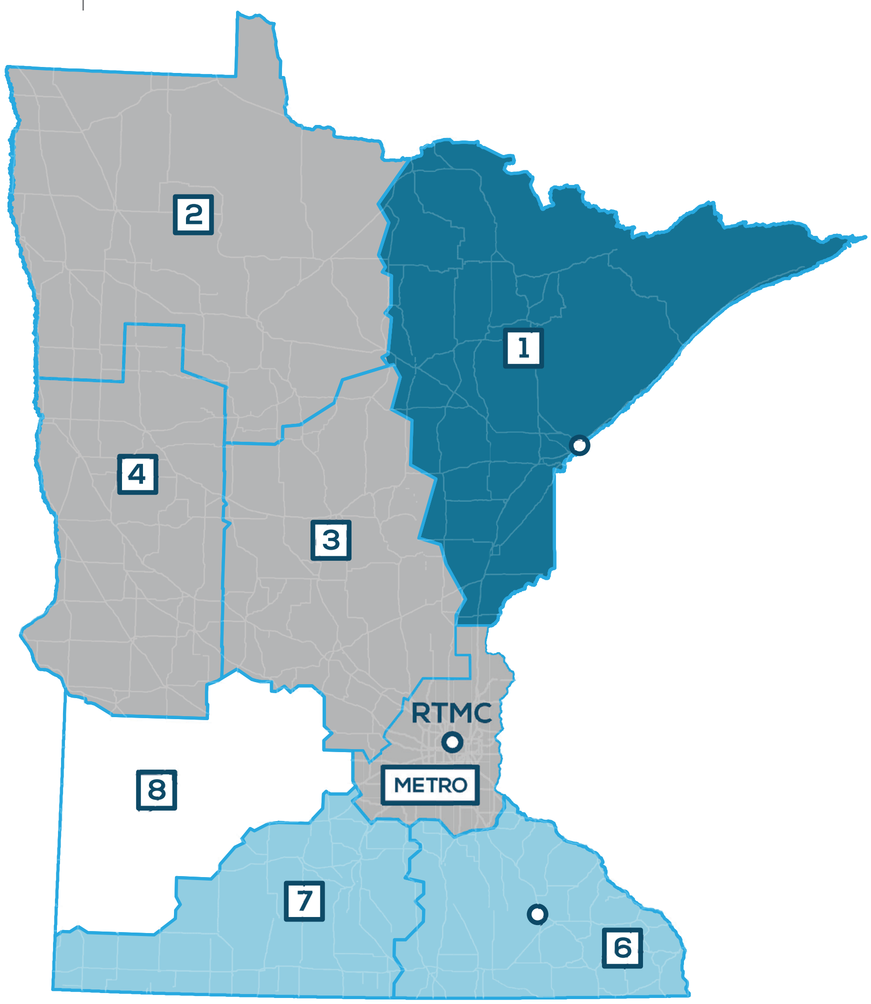
SOFTWARE /CENTRAL SYSTEMS

IRIS – (Intelligent Roadway Information System) is MnDOT's Central ITS Management System control software. IRIS development began in the late 1990s in preparation for moving to the new RTMC and to move MnDOT toward new NTCIP communication standards for ITS devices and communications. IRIS has enabled the support of an increasing number of field devices and is considered a potential control system for any new ITS device. MnDOT has taken advantage of the open source operating systems and programs to eliminate significant ongoing licensing costs and to lower the cost of computer hardware resources.

The main features of IRIS are:

- ✓ Control of DMS (messages and travel times)
- ✓ Central control of ramp meters (input from about 5400 sensors)
- ✓ Control of cameras
- ✓ Control of lane control signals
- ✓ Delivery of data to MnPASS HOT lanes
- ✓ Collection of Sensor data

IRIS is utilized for devices in all Districts and is managed through multiple installations as shown in **Figure 3-5**. IRIS operates as a central control system for ITS and as new systems are developed in future years they often will be engineered to be managed through IRIS.

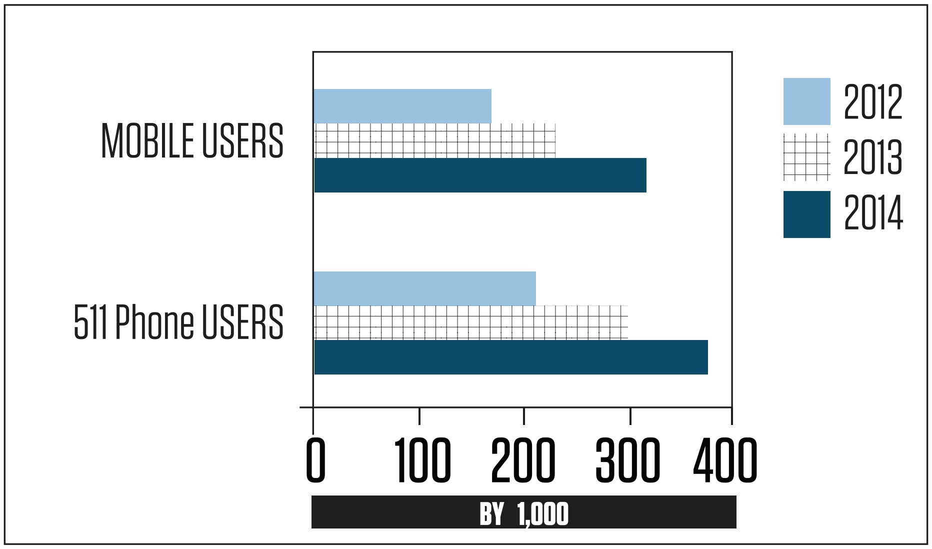


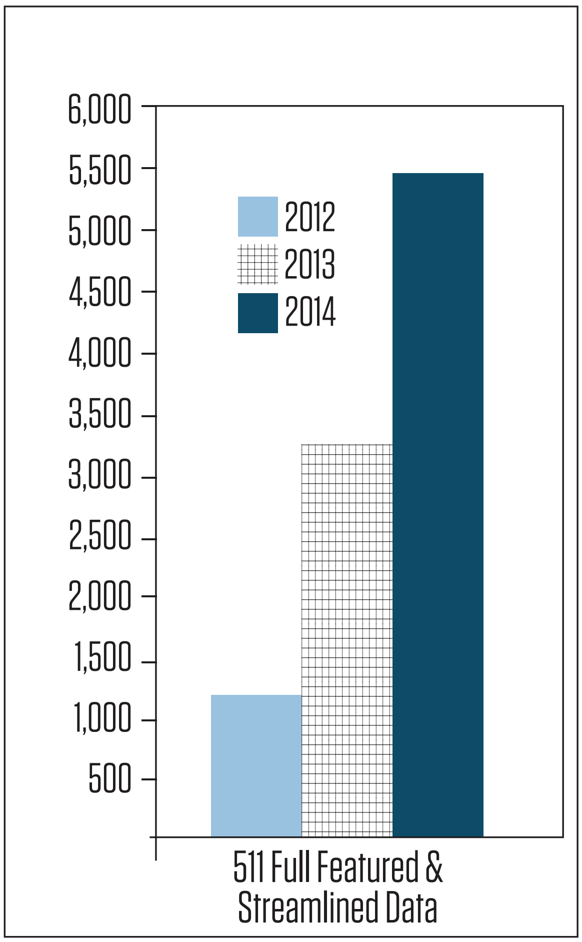
IRIS Device Management

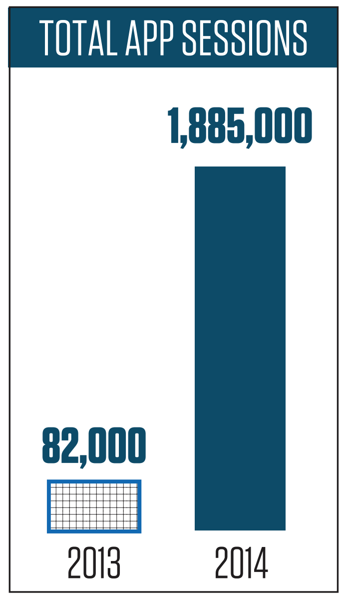
IRIS Server and Connected Districts

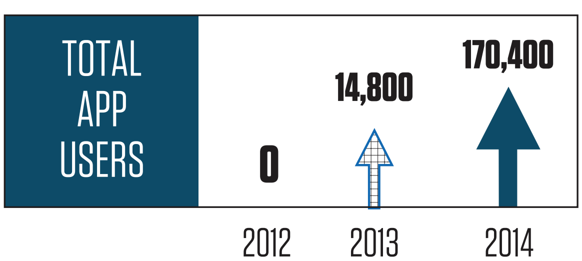
*No ITS Manager through IRIS in District 8

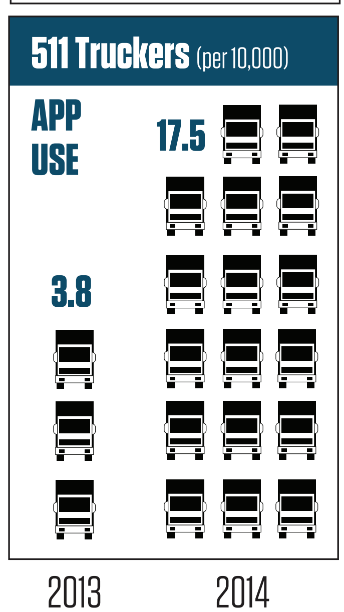
511 Phone, App and Web Usage Continues to Grow











511. 511 is an easy-to-remember traveler information telephone number and is also the brand name for MnDOT traveler information provided on web and mobile applications. 511 provides real-time updates about congestion, incidents, weather-related road conditions, road work, commercial vehicle restrictions, road closures and other events that impact traffic via the phone or Internet. The 511 system includes a phone based interface, an App for smart phones, a website for users to access the road information. MnDOT makes annual investments in the 511 system, often in partnership with other states using the common platform, to continually enhance the information provided to travelers as well as to provide new services and features that meet ever changing user expectations for information.

Data is entered into 511 systems through a program called Condition Acquisition Reporting System, or CARS. CARS includes mechanisms for automated data entry as well as manual entry by operators. Construction information is entered manually as well as winter road conditions. Incident information and traffic information is entered via automated processes.

CAD (computer aided dispatch) CAD is State Patrols' central system for dispatching and incident management. CAD and CARS have an automated data exchange between the State Patrol Dispatch system and the MnDOT statewide reporting system to increase information content on 511 phone and web systems without added entry of events by dispatchers.

VIDEO SWITCH- the video switch manages camera video a central location so it can be distributed to operators and systems on demand. The switch is considered a critical piece of MnDOT's ITS infrastructure. Operators utilize keyboards or software connected to the switch to move and zoom the cameras to detect events or monitory the highway. MnDOT's video switch technology has changed over time and now handles over 800 cameras and numerous outputs for operators and provides images for 511. MnDOT also has digital video recording capabilities as part of the video infrastructure to allow for play back of video to analyze key events that have occurred. The current video switch is nearing its capacity and will require replacement in the next few years.

CONTROL CENTERS

MnDOT ITS devices that are centrally controlled primarily operate out of the RTMC within the Metro District or the South Central Operations Center (SCOC) in District 6 Headquarters in Rochester. The two centers divide up the state geographically, with operations for District 6, 7 and 8 being managed at the SCOC, and the remaining systems in the northern 2/3rds of the state and Metro District controlled from the RTMC. The centers operate 24/7, with the RTMC having MnDOT and State Patrol staff managing devices and performing functions such as dispatching, incident management, and maintenance operations. The SCOC is operated by Minnesota State Patrol Dispatch, who is responsible for operating ITS systems and devices.

The RTMC is staffed with operators that manage four main functions: Metro Freeway Operations, Metro Arterial Operations, Metro Maintenance Operations, State Patrol Emergency 911 Center handling cellular 911 calls for Metro and District's 1 through 4. State Patrol manages ITS devices for District's 1 through 4 from RTMC. The RTMC is designed to increase or decrease staffing levels as conditions change. The number of operators increase during peak period operations, snow events, or major incidents to respond to increasing need manage ITS devices, dispatching, and monitoring. The RTMC is also the hub for communications, servers, and software that manages ITS, fleet and personnel. SCOC is staffed by the State Patrol and provides cellular 911 services for highways in District 6, 7, and 8 as well as managing the ITS devices in those Districts. Both centers are continuously operational throughout the day.

CHAPTER FOUR

MNDOT STATEWIDE ITS INVESTMENT SCENARIOS

Minnesota GO
A Collaborative Vision for Transportation
ITS

4.0 MNDOT STATEWIDE ITS INVESTMENT SCENARIOS

Based on the years of development and operation, MnDOT remains a leader in using ITS to maximize transportation system performance, inform travelers, and maximize operational efficiencies.

For this plan, three approaches to ITS investment are considered as possible scenarios MnDOT could undertake over the next 10 years. The approaches consider operations and capital investments as well as organizational changes. These scenarios were developed based on stakeholder input, ITS system conditions, planned investment, and lastly guidance for organizational development of Transportation Systems Management and Operations (TSM&O).

This section describes three paths MnDOT can take with ITS in the next 10 years and the impacts of these approaches. In the first year of this plan additional analysis of system assets will occur through the Transportation Asset Management Planning Process that will shape the capital investment discussion. At the same time there is policy and organizational issues present in each scenario that need stakeholder input beyond what was undertaken in this plan before a recommendation can be implemented.

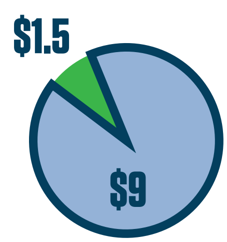
4.1 APPROACH A (Fiscal Constraint Scenario)

In Approach A, capital investment in ITS continues at planned levels ($25M base over 10 years for capital investment) but shifts away from a mix of expansion and preservation towards most investment allocated to preserving the ITS assets already in use. Even with this investment shift to preservation, several ITS devices will reach the end of their useful life without funding for their replacement.

The fiscal constraint scenario will result in a decline in the number of functioning devices and increases in maintenance demands.

The only area of expansion that continues in this scenario is for the Metro District Arterial ITS systems which will continue to expand through 2020 by securing Federal CMAQ funds which can only be used for expansion. MnDOT will also be able to continue to explore new technologies through limited investment in research and small test projects.

Organizationally, Approach A has a path towards more shared services in ITS, with RTMC designers taking a formalized role in leading or overseeing ITS designs in several Greater Minnesota Districts. Shared services are expected to become more formalized in maintenance and system integration in this approach. The shared services model is anticipated to have limited impact under Approach A as the staffing levels are not expected to increase to fully meet needs for design, maintenance and operations.



SCENARIO A:

$10.5 MILLION

- Asset Management
- Expansion
- Operations

10 YEAR INVESTMENT NEEDS ABOVE BASE

OUTCOMES OF APPROACH A - FISCAL CONSTRAINT SCENARIO

- Metro Major Arterial ITS deployments are fully implemented. (all scenarios)
- 511 System is incrementally improved with new features and improved information quality. (all scenarios)
- MnPASS systems are added to two additional corridors. (all scenarios)
- RWIS systems remain a key tool for winter maintenance and add cameras to more locations and there are incremental expansions of RWIS locations. (all scenarios)
- ITS devices are managed through the new Asset Management System. (all scenarios)
- Some current ITS systems reach end of life and are decommissioned due to lack of funds. Systems most at risk for decommissioning are DMS, Smart Lanes signs, and RICWS.
- Operation of ITS systems continues as is, with a split between MnDOT and State Patrol Dispatch, with Metro systems managed by MnDOT and greater Minnesota systems operated through informal sharing of responsibilities for MSP and MNDOT.
- Formal agreements are adopted for shared services of ITS design.
- ITS communication networks remain as is with limited connections between Districts and RTMC. Most ITS devices currently not connected to fiber have limited or no remote monitoring and management capabilities. Mn.IT communication networks are relied upon for some ITS communications.
- Staffing levels for all phases of ITS expand by 2 FTE for maintenance of devices.
- ITS systems are integrated into the regional ITS architecture and planned using systems engineering processes.
- ITS Research and Development investment continues at $500k per year engineering processes. (all scenarios)
- Asset management is elevated as the formal strategy for planning and maintaining the ITS systems. All systems are tracked and maintained through the asset management system and the data is routinely utilized for planning and programming purposes (all scenarios)

KEY ASSUMPTIONS REQUIRED TO ACHIEVE APPROACH A

Though this scenario is considered the status quo of planned ITS deployment and operations, there are several key assumptions that are made for the outcomes to be realized, these include:

- Central ($1.5M) and Metro ($1M) funding for ITS remains at the current levels.
- A formal shared services approach is implemented for Design and Integration of ITS systems, where RTMC leads, or oversees, the Greater Minnesota ITS designs as requested. Staffing resources are assumed to increase at RTMC in this approach.
- Transportation funding for capital and operations occur at levels projected.
- New funding for 2 FTEs
- Two additional FTEs are added to support maintenance and integration of existing ITS systems

Approach B and Approach C assume increases in funding for ITS capital and operating investments but make no assumptions about if this would come from an overall increase in transportation funding or a reallocation of existing funding.

APPROACH A RISKS

Over the 10 year horizon of this scenario there are several ITS components that remain unfunded and either cannot realistically be considered for decommissioning or would require significant costs to decommission. **These are risks unique to Approach A because Approach B and C would fund the replacements of these systems.**

- Dynamic Message Signs ($2.5 M). DMS are highly visible to travelers and an important ITS tool for MnDOT. The typical life of a DMS is 15 years. MnDOT has not currently programmed sufficient funds to meet the replacement cycle of existing DMS. It is estimated that an additional $2.6 M in funds is necessary to replace DMS that reach end of life during this 10 year planning horizon.
- RTMC Video Switch ($1M)- the central system that serves video to operators, dispatchers, media and links the images to traveler info systems will be at capacity by 2016 and have reached end of useful life.
- I-94 and I-35W Smart lane DMS (300 signs- $2 to $6M replacement) – the Active Traffic Management System signs have a high failure rate and parts are no longer available and not covered by a warranty. The signs will need replacement or removed before 2019.
- Rural Intersection Conflict Warning Systems (RICWS) are being installed across the state with a three year warranty for maintenance. As the 58 planned RICWS systems transition to MnDOT for maintenance there may not be sufficient staffing levels in this scenario to adequately maintain all intersections and the safety of the RICWS intersections could decrease.
- The road closure systems installed in District 4, 7 and 8 for closing roads during dangerous winter weather conditions are at the end of life with no funding identified for replacement. A cost for replacement is not available until decisions are made about the feasibility and potential design of a replacement system.
- ITS R&D will be limited to small research projects & observing connected vehicle activities in other states

An inability to invest in replacement of key ITS systems that are at end of life pose a risk to ITS operations that is expected to impact transportation system performance and safety as well as be highly noticeable to the public.

STATEWIDE ITS PLAN - APPROACH A

Outcomes of Fiscal Constraint Scenario

EXPANSION

- Metro Arterial ITS at full build-out
- Two new MnPASS highways
- Incremental improvements in 511
- Incremental expansion of RWIS
- Complete 58 RICWS installations
- ITS fully Implemented in snow plow fleet

DECOMMISSIONED ITS

- 20 DMS
- 35W & I-94 Smartlanes
- Non-interstate Road Closure Systems

ITS COMMUNICATIONS

- No change in statewide communications
- Several ITS devices in non-metro not remotely manageable

OPERATIONS

- No change in how ITS devices are operated
- New agreement between MnDOT and MSP for Operations of Greater Mn ITS systems

STAFFING

- 1 FTE for Metro Traffic Maintenance and Operations
- 1 FTE for statewide Maintenance and Integration

TSM&O*

- Incremental steps taken to advance TSM&O

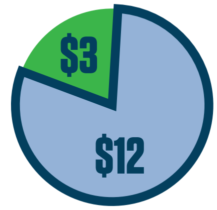
* Transportation Systems Management and Operations

4.2 APPROACH B (Asset Management Scenario)

In this Asset Management Scenario, ITS is recognized as a key infrastructure system with a return on investment that warrants sufficient increases in investment so that existing ITS devices are replaced as they come their end of life. This approach adequately resources the design, integration, maintenance, and operations staffing for managing the assets. The focus remains on preserving systems that are in place or already planned for deployment. Communication systems remain as planned with rural ITS devices connected to fiber only on I-94, I-35, and TH 52 and limited cellular connections to some devices outside of these corridors.

In Approach B, operations begin to transition in a direction of MnDOT managing more of the systems that are currently the responsibility of State Patrol Dispatch. Minor increases(2 FTE) in addition to the 2 new FTES from Approach A, in staffing levels for operations at RTMC along with formal agreements with Districts and State Patrol allow MnDOT to operate all connected ITS devices from the RTMC during peak weekday and weekend times (16 hours per day). Districts also transition roles for winter weather data, assuming full responsibilities for inputting road condition information into 511. These shifts in responsibilities result in increased use of ITS devices and lead to more consistent use of devices across the state which benefits travelers. Proactive maintenance reduces devices failures and lowers life cycle costs.

Approach B requires an additional $5 to $9 Million dollars over current planned spending for capital and systems investment as well as $3M in operations funding to support 4 new FTE and fully funding existing open positions that support ITS planning, maintenance and operations. Additional staffing costs are estimated $3M over the plan timeframe.



SCENARIO B:

$15 MILLION

10 YEAR INVESTMENT NEEDS ABOVE BASE

OUTCOMES OF APPROACH B - ASSET MANAGEMENT SCENARIO

- The safety, mobility, and operational efficiency benefits derived from existing ITS investments will be maintained.
- All ITS assets are maintained and replaced at sufficient level to be fully operational.
- ITS budgets for replacement parts and maintenance are sufficient to meet all asset management needs.
- MnDOT RTMC operates Statewide ITS devices for majority of peak travel times.
- MnDOT Districts assume all responsibilities for data entry into 511 for road conditions, construction, and incidents.
- Investment in 511 includes funding for the automated collection and reporting of road weather information, eventually replacing the need for manual input by MnDOT staff and improving the timeliness of the data.
- Formal agreements are established for a shared service centers for ITS. The service center provides design and integration services to Districts.
- Asset management is elevated as the formal strategy for planning and maintaining the ITS systems. All systems are tracked and maintained through the asset management system and the data is routinely utilized for planning and programming purposes (all scenarios)
- Metro Major Arterial ITS deployments are fully implemented. (all scenarios)
- 511 System is incrementally improved with new features and improved information quality. (all scenarios)
- MnPASS systems are added to two additional highways. (all scenarios)
- RWIS systems remain a key tool for winter maintenance and add cameras to more locations and there are incremental expansions of RWIS locations based on new planning criteria. (all scenarios)
- ITS systems are integrated into the regional its architecture and planned using systems engineering processes. (all scenarios)
- ITS Devices managed through new Transportation Asset Management System (all scenarios)
- ITS Research and Development investment continues at $500k per year engineering processes. (all scenarios)

STATEWIDE ITS PLAN - APPROACH B

Outcomes of Asset Management Scenario

EXPANSION

- Same expansion plans as the Fiscal Constraint Scenario

DECOMMISSIONED ITS

- All devices are maintained at life cycle replacement levels
- Only those devices no longer needed are removed

ITS COMMUNICATIONS

- Statewide virtual ITS network (with Mn.IT) for management of devices at RTMC
- Priority ITS devices are connected for remote management in rural areas

OPERATIONS

- All ITS operations managed through RTMC 16 hours per day
- State Patrol Dispatch manages ITS devices in Greater MN in overnight time periods

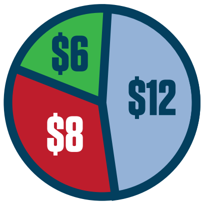
STAFFING

- 2 FTE for RTMC Operations
- 1 FTE for Metro Traffic
- 1 FTE for statewide Maintenance and Integration

TSM&O*

- TSM&O Plan developed & implemented
- Seek to improve TSM&O capabilities in most areas

* Transportation Systems Management and Operations



SCENARIO C:

$26 MILLION

- Asset Management
- Expansion
- Operations

10 YEAR INVESTMENT NEEDS ABOVE BASE

4.3 APPROACH C (Optimization Scenario)

In Approach C, MnDOT's ITS systems become a highly integrated and optimized network that maximizes transportation system performance. MnDOT assumes full responsibility for operations of ITS on state highways across the state 24 hours per day 7 days per week. The RTMC becomes the statewide hub for Operations. Devices are actively monitored and failures are reported and tracked through asset management systems.

To effectively manage the system, ITS devices are connected via fiber or cellular communications for real time and remote management of the systems. A statewide ITS Communication network is established to support the statewide operations and planned expansion. The statewide communication network links District 3, 4 and 6 to RTMC via fiber and District 1, 2, 7, and 8 to RTMC via connections established in partnership with Mn.IT. Traffic signals, RICWS, DMS and other systems which cannot be connected to the fiber network are instead operated, monitored, and maintained with cellular connections. The ability to communicate with each device minimizes impacts to staffing as most issues can be mitigated remotely which maximizes system benefits.

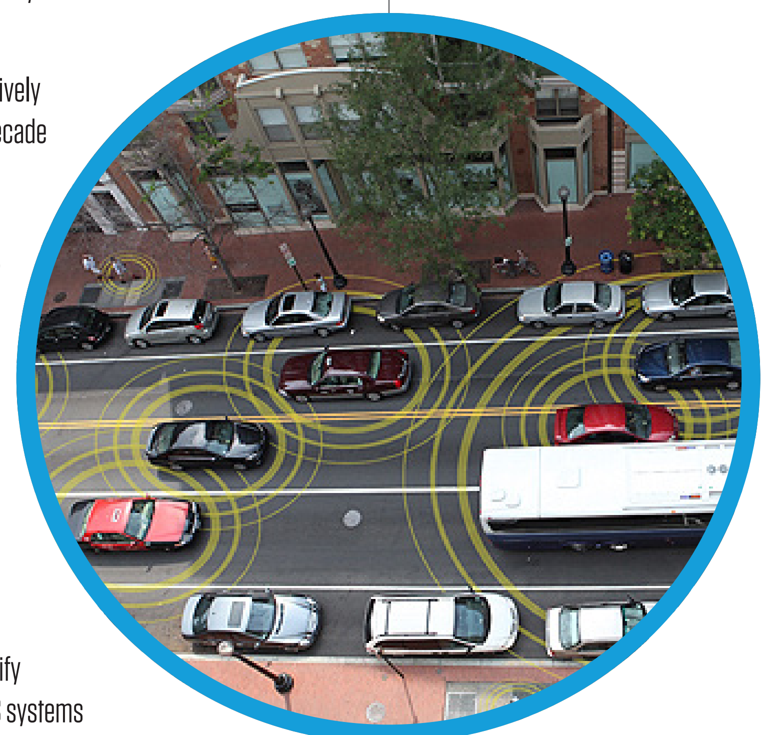
The Optimization Scenario relies on core systems that enable efficient and coordinated management and operations. The Intelligent Roadway Information System (IRIS) expands its platform capabilities, where prudent, to centrally control and monitor more ITS device types. Video platforms evolve to share video effectively to any user needing access. Traffic signal systems are centrally managed through newly procured systems that optimize signals and allow system monitoring and performance analysis. Asset management systems manage work flow, support investment planning, and allow efficient use of resources.

In this Optimization Scenario, formal agreements are in place documenting processes and responsibilities. ITS systems undergo routine evaluations for performance so that performance measures can be tracked. ITS investments are identified through formal planning processes that manage existing assets, systematically expand the ITS network to address system needs, and invest in communications that strategically link systems for efficient and effective ITS management.

Formal Agreements That Advance the Capability and Maturity of MnDOT ITS Systems

- Agreement with Mn.IT on statewide communication infrastructure that defines funding, roles and responsibilities, and plans for expansion to meet ITS needs.
- Shared services agreement between RTMC and Districts and Speciality offices that define services, funding, and decision making authority.
- Agreement with State Patrol that defines roles and responsibilities, system requirements, performance measures, and funding allocations for any systems that require operations by State Patrol Dispatch.

Under this scenario, operators and managers utilize asset management systems and GIS to the fullest potential to manage the ITS system as whole. Organizationally, this approach does not require realignment of resources within the department. Instead, it has modest increases in staffing in all phases of ITS and formal service agreements between each system owners and those supporting units that enable the best approach to designing, maintaining, and operating the systems. System owners can be Districts or Offices.



The optimization scenario positions MnDOT to proactively adopt new technologies that emerge over the next decade which align with the Agency goals and vision for a transportation network. ITS systems help MnDOT achieve performance goals across modes, networks, and functions.

In this scenario, MnDOT's ITS systems begin to integrate into regional or national systems. Integration opportunities for freight management, tolling, traveler information and road weather systems are realized through formal agreements and adoption of standards for data, technologies and communications that enable the integration.

Lastly, planning for emergencies is instituted to identify technology needs and procedures that allow core ITS systems to be operated should an emergency not allow operations from RTMC or Rochester Dispatch Center. To support the effort, redundancy is built into the communication systems for Rochester Dispatch and RTMC to allow rerouting of communications and temporary management and operations and new locations.

Approach C requires an additional $12 to $20 Million for capital investment and $6 to $8 M for staffing over the next 10 years (compared to the Fiscal Constraint Scenario) to implement.

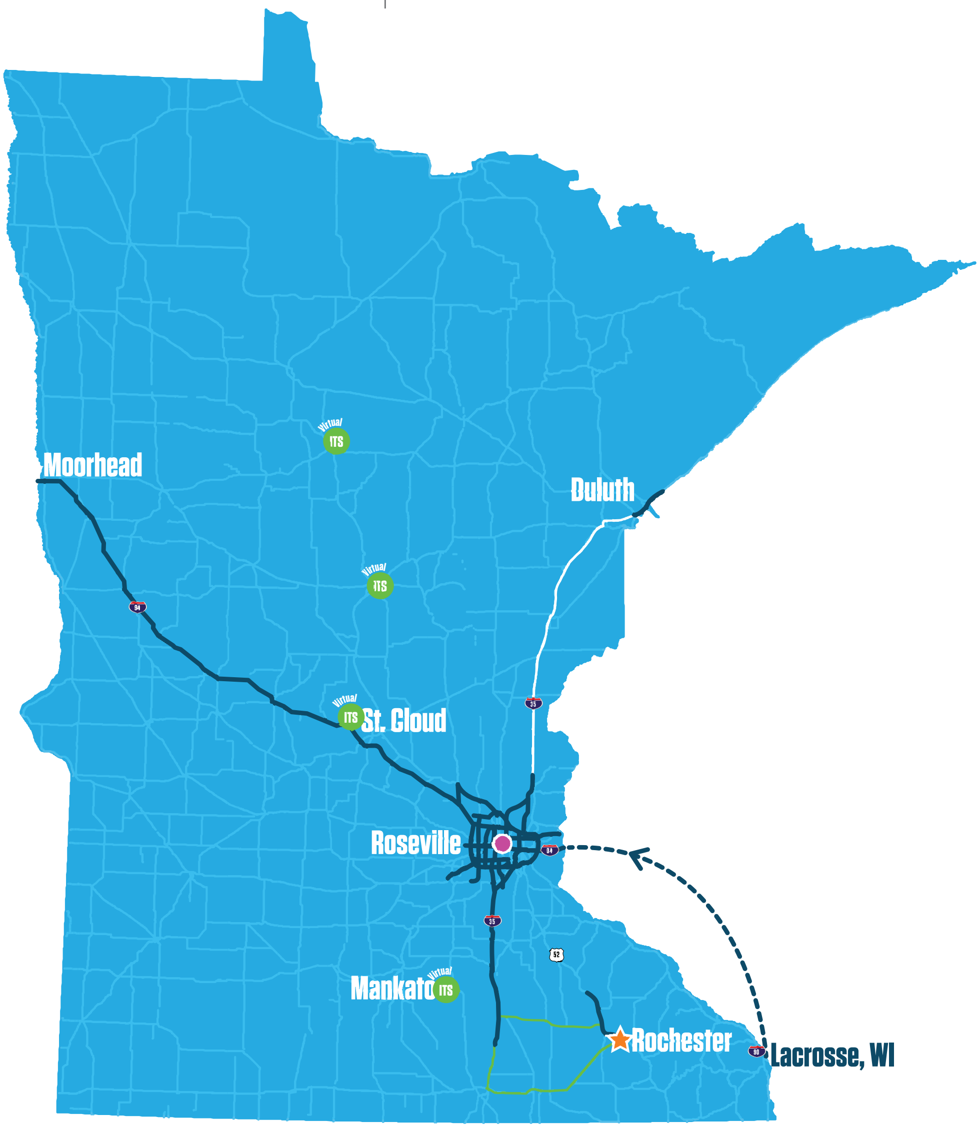
OUTCOMES OF APPROACH C - OPTIMIZATION SCENARIO

- ITS system expansion is completed, including:
    - o Metro District Freeway ITS is fully expanded to all corridors and infill DMS are added to increase density of signs in congested corridors. (New)
    - o DMS, Cameras and Detection are added to I-35, I-94, and US 169, Highway 52 (New)
    - o All RICWS identified in District Safety Plans are installed. (New)
    - o All Metro Major Arterials are instrumented with ITS (all scenarios)
- 511 System is incrementally improved with new features and improved information quality. (all scenarios)
- RWIS systems remain a key tool for winter maintenance and add cameras to more locations and there are incremental expansions of RWIS locations based on new planning criteria. (all scenarios)
- ITS systems are integrated into the regional its architecture and planned using systems engineering processes. (all scenarios)
- ITS devices are managed through the new Asset Management System. (all scenarios)
- ITS Research and Development investment continues at $500k per year engineering processes. (all scenarios)
- MnDOT operates all statewide ITS devices 24 x 7 from the RTMC. (Increase from Approach B)
- All existing ITS assets are maintained and replaced at sufficient level to be operational at set performance levels. (Increase from Approach B)
- MnDOT Districts assume all responsibilities for data entry into 511 for road conditions, construction, and incidents. .(Same as Approach B)
- Investment in 511 includes funding for the automated collection and reporting of road weather information, eventually replacing the need for manual input by MnDOT staff and improving the timeliness of the data. (Same as Approach B)
- MnPASS systems are added to two additional highways. (all scenarios)
- ITS Shared Services approach is expanded so that all offices can utilize a technical center for design, integration, maintenance and operations of technology. This expansion would include Work Zones, Maintenance, Freight, and Facility Management functions. (Increase over Approach B)

MnDOT is a leader in ITS systems because of an approach and organizational structure that actively monitors the development of ITS systems and emerging technologies, invests in research for promising ideas, and has a commitment to capital and operating investment in ITS. This approach is important to continue so MnDOT is ready for the next generation of ITS. In Approach C MnDOT maintains a commitment throughout the organization and ITS remains a key strategy for achieving the Minnesota Go vision of Minnesota.

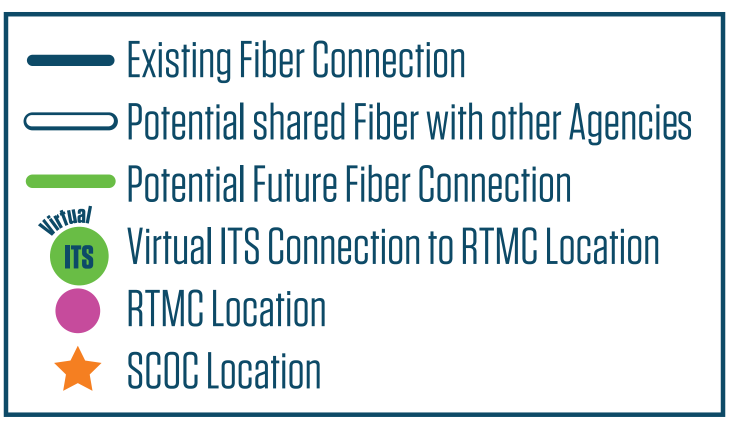
OUTCOMES OF APPROACH C (CONT.)

- Asset management is elevated as the formal strategy for planning and maintaining the ITS systems. All systems are tracked and maintained through the asset management system and the data is routinely utilized for planning and programming purposes (all scenarios).
- Metro traffic signals and supporting ITS are centrally managed. Priority signal systems in Greater Minnesota also utilize the central management system. (Increase from Approach B)
- A statewide ITS Communication network is planned, established, and managed by MnDOT RTMC that connects all key ITS systems to the RTMC to allow remote management of the devices (New) **(See page 58 for communication network concept).**
- Mn.IT (State IT Agency) is engaged to pursue shared (multi-agency, multi-jurisdictional, or public/private) communications systems that support portions of the Statewide ITS communication network (New)
- ITS operations have redundant management capabilities in case central control locations are unavailable due to an emergency (New)
- The management and operations of ITS systems are undertaken at high levels of excellence, including:
    - o They are planned through regional architectures and systems engineering processes.
    - o They are incorporated into capital and operating planning processes.
    - o The systems and procedures are well documented.
    - o The systems utilize standards to the maximum extent possible.
- New and emerging technologies and systems are actively pursued and identified. Viable technology is implemented to help meet MnDOT goals. (New)
- Connected Vehicle systems begin to be deployed as mainstream systems. (New)



MnDOT ITS Communications Network*

*Cellular Communications for ITS devices Not Shown



STATEWIDE ITS PLAN - APPROACH C

Outcomes of Optimization Scenario

EXPANSION/ASSET MGMT.

- All expansion of other scenarios
- Build out of ITS on Hwy 52 and I-35 in D6, Hwy 169 in D7, I-94 in D3/4
- ITS assets replaced at life cycle targets
- 511 road weather is automated

DECOMMISSIONED ITS

- Only those devices no longer needed are removed

ITS COMMUNICATIONS

- Statewide virtual ITS network (with Mn.IT) for management of devices at RTMC
- All ITS devices are connected to RTMC

OPERATIONS

- All ITS operations managed through RTMC 24 x 7
- Improved Emergency Management abilities
- Automated 511 road/weather data input

STAFFING

- 4 FTE for RTMC Operations
- 1 FTE for Metro Traffic
- 1 FTE for statewide Maintenance and Integration
- 2 FTE for ITS Design
- R&D staffing leveraged from other internal offices and groups

TSM&O*

- Core strategy for Agency
- TSM&O Plan developed & implemented
- Seek to achieve highest level of TSM&O in all areas

* Transportation Systems Management and Operations

CHAPTER FIVE

POLICY ISSUES

Minnesota GO
A Collaborative Vision
for Transportation
ITS

5.0 POLICY ISSUES

Like all transportation investments, ITS creates a series of policy issues to address. Overall, as part of the MnDOT Family of Plans, the ITS Statewide Plan is guided by the State Transportation policies. Below are policy areas and risks/opportunities that MnDOT is expected to encounter over the next 10 years with ITS.

LEADERSHIP.

With a long history of success in ITS, MnDOT has a strong leadership approach to ITS. With some exceptions, current ITS systems are mostly planned, designed, operated and maintained with staff in the Operations Division. This organization creates an integrated model for ITS. MnDOT leadership is also actively involved in ITS policy at the national level through organizations such as AASHTO, ITS America, and with the US DOT. This national position is important in keeping MnDOT in a leadership role for shaping ITS investment and policy. Regionally, the Minnesota Guidestar Board and ITS Minnesota organizations allows Agency leadership to engage with industry and other agencies on systems and issues involving ITS. Through planning and funding, MnDOT leadership is also able to shape a vision for ITS as a core system for the Agency to utilize in meeting system level performance goals.

RISK: Potential loss of ITS champions at senior leadership positions can jeopardize funding for both capital and operating investments in ITS if other asset investments become a priority.

OPPORTUNITIES: The adoption of ITS guidelines and a statewide plan allow MnDOT to be well suited for ITS pilot projects and future technologies and serve as a blueprint for investment through leadership changes that inevitably occur.

OPERATIONS.

Operations of ITS devices have a split approach within MnDOT and are an opportunity area for advancing the Agencie's capabilities. Within the Metro District the devices are operated out of the RTMC by MnDOT staff 24 x 7 by traffic and maintenance staff. In greater Minnesota there are shared responsibilities with Minnesota State Patrol for operations. This shared responsibility is not consistent from District to District. The operations vision for ITS devices needs to be evaluated going forward. The need for evaluation is driven by a recent consolidation of Dispatch Centers by the State Patrol but also by a general need for MnDOT to lead operations of ITS systems because it is part of MnDOT's mission to operate the state highways. There is currently no up to date agreement between MnDOT and the State Patrol that covers the relationship and expectations of ITS operations.

RISK: Lack of agreement with Minnesota State Patrol that reflects the current operating agreement creates operational inconsistencies and impacts timely maintenance of devices.

OPPORTUNITIES: There is an opportunity to have MnDOT operate ITS across the state. Using the knowledge of the RTMC in the Metro District as well as to District traffic engineering staff and State Patrol management, document insight and guidance on how to best consolidate management and operations of ITS systems to the RTMC.

MAINTENANCE.

ITS maintenance is a shared responsibility between Districts and Central functions. In the Metro District all freeway ITS is managed by the District, whereas ITS devices on arterial roads have split responsibilities between the District and the central Electrical Services. In the greater Minnesota Districts the maintenance of ITS devices is the sole responsibility staff at the Office of Traffic Safety and Technology. In reality though, due to the geographic scale of the state, District staff typically provide a first line of response for troubleshooting ITS devices that require a field visit.

RISK: The response time for ITS maintenance in the metro area versus the other Districts could be perceived differently by the general public.

OPPORTUNITIES: A consistent procedure for ITS maintenance and response should be developed, no matter the location in the state. Goals towards minimum and maximum response times to field visits could also be created in all areas of the state to further demonstrate system consistency. These goals could vary between Metro and Greater Minnesota systems.

STATEWIDE/DISTRICT/SPECIALTY OFFICE ITS FUNDING.

ITS systems often cross District boundaries with communication operations or ownership. This lack of boundaries for ITS necessitate unique relationships for planning, funding, operations and maintenance. As an example, RWIS systems are planned centrally, managed statewide, utilized at the District level for operations, and have shared funding for maintenance and operations between the Office of Maintenance and a District where a RWIS station is located. In general these arrangements work well, but do create issues with statewide consistency of ITS design and operations.

RISK: Funding for ITS that is provided at the District level is competing against all other investments in that District, creating competing policy challenges when there is a lack of funding to fully investing in needs.

OPPORTUNITIES: By creating one clearinghouse for planning, design, funding, and maintenance and operations of ITS for the entire state, there is an increased opportunity to share ITS technologies and funding and the potential of not competing against other investments within Districts.

INTERAGENCY.

Several ITS systems are dependent on key relationships with other agencies. Key relationships included State Patrol, local governments, and the State IT agency (Mn.IT). In these cases, there is a mix of informal and formal agreements that govern the interagency relationships and ultimately the success of ITS systems.

For local governments, ITS devices that are utilized for intersection operations create the need for interagency agreements on cost share of capital and maintenance investments. MnDOT is typically better positioned to provide the maintenance of devices because they have the scale of implementation that a local agency would not have. A good example of this is with RICWS systems, which by design are almost always an interface between a State and Local road with shared costs.

Mn.IT is a relatively new interagency partner with a big stake in ITS success for MnDOT. Established in 2011, Mn.IT is responsible for several computer systems and portions of the communication network that are utilized by MnDOT's ITS devices. The relationship between MnDOT and Mn.IT necessitates that both agencies are involved in most of the ITS investments. Mn.IT staff develops software, maintains databases, architects. Some networks, and operates communications systems and servers for multiple MnDOT ITS systems.

RISK: Lack of detailed service level agreement with Mn.IT impacts the ability of MnDOT to invest in ITS systems due to uncertain interagency costs and lack of control of system architecture.

OPPORTUNITIES: There is a large opportunity for MnDOT to develop and be flexible and open to interagency negotiations for ITS to further share the capital and operating costs of ITS. Private companies are also looking for ways to improve their capabilities and working with MnDOT might benefit both parties.

SOURCING.

ITS systems have a variety of options to how they are designed, operated and maintained. The options vary by the level of MnDOT and vendor involvement. MnDOT currently has a mix of approaches each depending on the particular system. For Freeway ITS, MnDOT typically designs, integrates, operates and maintains the systems, relying on contractors to construct new systems. For a system like MnPASS Tolling, MnDOT sources some of the operations to a vendor. Sourcing options for any phase of ITS (i.e. design/build/operate/maintain) are determined by funding, internal staffing capacity, and options in the marketplace. MnDOT has increasingly added vendors as key resources for operations and maintenance to manage risks such as lack of internal staff resources.

RISK: MnDOT is unable to sufficiently staff ITS phases to gain full benefits of ITS.

OPPORTUNITIES: There is a large opportunity for MnDOT to develop and be flexible and open to interagency negotiations for ITS, or other sourcing options, to further share the capital and operating costs of ITS.

ITS LOCATES.

One key organization element that is a result of ITS is field locating of underground systems for Gopher State One Call ("call before you dig"). Properly located cables and devices prevent failures of devices due to construction activity. The amount of effort required to locate ITS systems is tied to the amount of construction activity occurring in the right of way and to the number of ITS systems that exist. There is general consensus that resources demands for locating are stretching available staff.

RISK: Lack of staffing limits resources available to properly locate underground systems resulting in damaged devices and added staffing demands to resolve issues and payments for damages to ITS infrastructure..

OPPORTUNITIES: Partnering opportunities may exist with local agencies to share locating responsibilities and improve efficiency of operations.

ITS AND ENFORCEMENT.

ITS systems are currently available in the marketplace that can be used to provide enforcement of traffic. Examples include red light running cameras and speed enforcement. MnDOT's Safety Plans call for use of these systems to improve safety if they are allowed to for use. Current state law prevents MnDOT from using these systems. A red light running camera system was used by the City of Minneapolis but was ordered removed after it was successfully challenged in Court.

RISK: ITS systems utilized for automated enforcement are not legally allowed in the state. If the laws change to permit these systems, there are substantial risks involving data privacy, data accuracy, and operating burden that would need to be carefully evaluated.

OPPORTUNITIES: The ITS based enforcement devices have a proven ability to increase safety or driver compliance with regulations when carefully planned, designed and implemented. Because of the potential of these devices to help MnDOT achieve performance goals MnDOT should continue to pursue opportunities to test and prove the value to possibly enable future legally supported deployments.

DATA.

ITS systems can generate large amounts of data. Common data includes traffic counts, performance data, video, and vehicle information. The data is instrumental in actively controlling ITS devices, in supporting performance measurement, and for planning of systems. The data can include information that is deemed private or sensitive. The Minnesota Government Data Practices Act governs retention of data, protection of private data, access to the data and security of the data. MnDOT ITS data is generally considered public data and available to anyone who requests it.

RISK: ITS systems are not properly designed to enable efficient use of the data they generate for operations, performance measurement, and planning thus reducing the value of the ITS system.

OPPORTUNITIES: Only a fraction of the data generated by MnDOT ITS systems is used to improve highway system performance. The development of tools and analysis, as well as enhancement to staff resources, opens opportunities to deal with the big data sets to enhance the operations of the highway network.

FUNDING.

Transportation funding in Minnesota follows State Constitutional and statutory requirements. These requirements guide how funds can be spent and impose limits on ITS because it deals with software, communications, and technology that was not originally envisioned when many overall transportation funding laws were conceived. Federal funds can be used for software, computers and other systems that are central to many ITS systems. However, as the federal funds flow to MnDOT's budgets they encumber the restrictions similar to state funding unless specifically established to be more flexible for use in areas like ITS systems and operations.

RISK: Key ITS systems like the video switch cannot be replaced because funding requirements prevent use of state road construction dollars.

OPPORTUNITIES: Advanced planning and coordination with the MnDOT's legislative budgeting process can secure the correct type of funding for ITS investments. With key systems needing this coordination the opportunity must be acted on soon to provide sufficient time for the legislative process to occur.

CHAPTER SIX

NEXT STEPS

Minnesota GO
A Collaborative Vision for Transportation
ITS

6.0 NEXT STEPS

Settling on an investment scenario requires the following key decisions:

FISCAL: Deciding if ITS systems should be decreased, fully maintained, or expanded.

ORGANIZATIONAL: Deciding if ITS devices should all be managed by MnDOT and if they should be operated continuously.

Making these decisions in the near term is necessary both to develop support for orderly transition in organizational structures for funding, managing, and operating ITS (if needed) as well as to make key capital investment plans within the timeframe necessary to maintain system level performance. The traditional MnDOT capital process already has available funding allocated to projects and categories over the next four years within the Statewide Transportation Investment Plan (STIP). Within this four year period, major systems like the video switch as well as numerous high cost Dynamic Message signs (DMSs), will need replacement and are not currently funded. At the conclusion of the Transportation Asset Management Planning process in late 2015 sufficient information will be available to decide when existing devices will need to be programmed for replacement funding. Regardless of the investment path chosen, each scenario likely requires a realignment of investment both at the District level and at the agency level to achieve the outcomes of the approach.

It is recommended that the key decisions and next steps will be guided by a implementation group lead by the Assistant Division Director for Operations and comprised of the project management team (PMT) that guided this ITS plan. The PMT consisted of the State Traffic Engineer, Metro Traffic Engineering Manager, RTMC Manager, Freeway Operations Manager, Director of Office of Maintenance, ITS Research and Development Manager, Assistant State Traffic Engineer, Program Manager of Statewide Planning and Transportation Data Analysis, and a District Traffic Engineer. The implementation team could expand to include additional Maintenance representatives. This group is also responsible for development of a detailed TSM&O plan as described in section 7.1.

Through the stakeholder process it was determined that Approach C is the path MnDOT will proceed on over the next 10 years. This decision sets the direction that ITS systems will be maintained and expanded and MnDOT will work toward having all operations of ITS done by MnDOT. The implementation team will need to develop a detailed implementation plan for Approach C, secure funding sources, update policies and procedures, and lead the transition to the new approach. The implementation plan would be encompassed within a TSM&O plan developed by the implementation team.

NEAR TERM STEPS- FISCAL:

- Develop an ITS Implementation Plan.
- Utilize 2015 TAMP to identify funding needs for each year in the STIP.
- Create a list of ITS assets and costs that are nearing end of life and have no identified replacement funding.
- Identify near term funding strategy to meet investment gap for ITS assets. Funding strategies can include reallocation of ITS funds typically used for expansion of ITS or reprioritization of funding at the District or state level.
- If gap funding is not available develop decommissioning strategy for lower priority ITS assets.

NEAR TERM STEPS- ORGANIZATIONAL:

- Implement a shared services model for ITS design and integration services.
- Work with the Minnesota State Patrol to plan transition of ITS systems to MnDOT .
- Analyze communication investments necessary to establish MnDOT operation of all ITS devices at the RTMC.
- Identify funding and timing for full transition of ITS operations to MnDOT.
- Create a budget and implementation plan for transitioning to full MnDOT management of ITS.
- Develop a TSM&O plan for MnDOT. (See below)

6.1 TRANSPORTATION SYSTEMS MANAGEMENT AND OPERATIONS

Transportation Systems Management and Operations (TSM&O) is a set of strategies to anticipate and manage traffic congestion, and minimize the other unpredictable causes of service disruption and delay, thereby maintaining roadway capacity while improving reliability and safety . TSM&O consists of all areas in operations, encompassing daily from traffic management to snow plowing to congestion mitigation to signal operations and much more. More specific strategies are created to address the specialty areas of TSM&O. ITS is one specialty area in TSM&O that has identified specific strategies to manage traffic congestion and improve reliability and safety. These strategies are best used and implementable by transportation agency managers who have control on operations and management of the roadway system and who are involved in ITS as it related to traffic engineering, maintenance, and public safety. The TSM&O framework looks at ways to minimize the impact of both recurring and non-recurring congestion and safety and includes strategies that combine ITS information and communication infrastructure with related field procedures and protocols within a specific operational concept designed to anticipate and mitigate the cause. Each strategy serves one or more functions to anticipate, manage, or reduce travel impacts. MnDOT's TSM&O Plan should be tailored to the organizational structure in the state and align to achieve the goals and objectives identified in the Statewide Transportation Plan and the ITS Plan.

ASSESSMENTS AND ACTIONS

A TSM&O assessment includes an evaluation that measures the current level of activity in certain categories. This evaluation can be evaluated on different scales; local, regional, state, etc, and goals and next steps will then be aligned with the appropriate level of action. The six categories this assessment looks at are:

- ✓ Business Processes
- ✓ Systems and Technology
- ✓ Performance Measurement
- ✓ Culture
- ✓ Organization/Workforce
- ✓ Collaboration

Each category of assessment has a sub-category that helps identify the current level, the next level up, and an Action Plan consisting of a general strategy and related actions to serve as the basis for an agency TSM&O improvement program. The Action Plans are designed to improve capability form the current level indicated in the self-evaluation up to the next level, and establish the basis for continuous improvement.

The following tables (**6-1** and **6-2**) document the current TSM&O assessment in MnDOT as it applies to the AASHTO TSM&O Framework. This assessment was an outcome of regional workshops attended by MnDOT staff in 2014 & 2015. The intent of the assessment is to determine both where MnDOT is currently in terms of its capability and maturity on TSM&O and guidance and next steps it can take to improve its management and operations of ITS to a higher level of achievement. By following recommendations of this plan, MnDOT ultimately seeks to achieve the highest levels of TSM&O achievement.

NEXT STEPS FOR MNDOT TSM&O

MnDOT has strong current capabilities but here are many categories of the TSM&O Assessment where the Agency can take active steps to enhance its management and operations capabilities. **Table 6-2** below identifies the next steps MnDOT should take to enhance its position in the 6 TSM&O focus areas. MnDOT's active continuous improvement culture shows that in many instances the next steps are either underway or already in place. Once these next steps are accomplished another assessment can be undertaken and additional steps taken to further improve MnDOT's TSM&O approach.

Table 6.1: Current Assessment of MnDOT Capabilities for ITS as part of Transportation System Management and Operations

Category	Current Assessment Level	Current Capability Summary	Next Level Guidance Summary	Ultimate TSM&O Goal for MnDOT
Business Processes *(Planning, programming, budgeting, implementation)*	Level 2 Plus	Multiyear statewide TSM&O plan and program exists with deficiencies, evaluation, and strategies	Develop multiyear statewide TSM&O plan and related process improvements	Integrate new operations objectives and processes into department activities as formalized standard operating procedures
Systems & Technology *(Systems engineering, standards and technology interoperability)*	Level 3	Systems and technology standardized, documented and trained statewide, and new technology incorporated	Coordinate and update ITS architectural activities with performance measurement on a continuing basis	Coordinate and update architectural activities with performance measurement on a continuing basis (same as next level)
Performance Measurement *(Measures, data & analytics and utilization)*	Level 2	TSM&O strategies measurement largely via outputs, with limited after-action analyses	Integrate TSM&O organization and staff into overall agency structure and clarify reporting relationships	Develop routine performance management process for continuing improvements in operating policies, procedures, systems and deployments
Culture *(Technical understanding, leadership, outreach, and program authority)*	Level 2 Plus	Agency-wide appreciation of the value and role of TSM&O	Integrate TSM&O organization and staff into overall agency structure and clarify reporting relationships	Create a management and organizational structure for TSM&O equivalent to that of other major agency programs
Organization/Workforce *(Organizational structure and workforce capability development)*	Level 2 Plus	Relationship among roles and units rationalized and core staff capacities identified	Integrate TSM&O organization and staff into overall agency structure and clarify reporting relationships	Create a management and organizational structure for TSM&O equivalent to that of other major agency programs
Collaboration *(Partnerships among levels of government and with public safety agencies and private sector)*	Level 4 Minus	High level of operations coordination institutionalized among key players –public and private	Maintain Current Capabilities	Maintain Current Capabilities (same as next level)

Assessment Scale

The four levels* used for each sub-dimension in AASTHO Guidance for TSM&O are:
Level 1 - Activities and relationships largely ad hoc, informal and champion-driven, substantially outside the mainstream of other DOT activities
Level 2 - Basic strategy applications understood; key processes support requirements identified and key technology and core capacities under development, but limited internal accountability and uneven alignment with external partners
Level 3 - Standardized strategy applications implemented in priority contexts and managed for performance; TSM&O technical and business processes developed, documented, and integrated into DOT; partnerships aligned
Level 4 - TSM&O as full, sustainable core DOT program priority, established on the basis of continuous improvement with top level management status and formal partnerships

**MnDOT further sub-dived the scale into a Level 1-Minus, Level 1-Plus, etc.*

Table 6-2: Next Steps in Development of Transportation System Management and Operations Excellence for MnDOT

Improving Business Processes-(Steps to Move from 2+ to 3)	Current Step in Process Improvement		
	Not Started	**Underway**	**In Place**
Identify opportunities for TSM&O infrastructure integration into planned/ongoing construction projects, both by state DOT and local governments			x
Formalize plan development with other relevant DOT offices (statewide planning, emergency operations, state policy) as well as local government and regional planning entities		x	
Expand stakeholder basis to interests for whom systems reliability is important and seek their involvement in the planning process		x	
Review opportunities for special grants and other forms of federal support for key innovative projects and approaches			x
Develop statewide TSM&O plan	x		
Integrate statewide TSM&O plan into statewide multimodal Long Range Plan	x		
Assess and develop formal multiagency approach to collaborative strategy applications and their continuous improvement	x		

Systems and Technology Guidance (Steps to Move from 2+ to 3)			
Include proactive review of the regional architecture to ensure performance measurement is an integral function	**X**		
Develop concepts of operation for regional operations activities such as major incidents, weather emergencies, etc.; evaluate the ability of the regional architecture to support the requirements as defined by the ConOps	**X**		
Performance Measurement Guidance (Steps to Move from 2+ to 3)			
Review state, local and regional (MPO/RTPA) policy and plans to identify relevant performance measures to determine appropriate range of mission- and customer-related performance measures for operations	**X**		
Consider both agency and system measures related to a full range of measures for mobility/safety/livability/sustainability		**X**	
Identify and establish policy accountability and reporting (internal and external) for systems operational performance		**X**	
Develop outreach program to report measured performance			**X**
Culture (Steps to Move from 2+ to 3)			
Develop vision of TSM&O at maximum implementation based on both current and potential state-of-the-practice	**X**		
Circulate and discuss TSM&O business case, vision, and example program development and present material for discussion at both executive and unit management level	**X**		
Develop a business plan for TSM&O that identifies and specifies the general capabilities needed to support continuous improvement of TSM&O		**X**	
Organization/Workforce (Steps to Move from 2+ to 3)			
Develop case for top level organizational unit status appropriate to formal program of equal importance to mission	**X**		
Develop systems for accountability appropriate to unit responsibilities for TSM&O-related outputs or outcomes	**X**		
Collaboration (MnDOT has achieved level 4)			
No actions are recommended- achieved highest level			

6.2 ITS Investment Criteria

As part of this plan, formal criteria were developed as guidance for planners and managers to determine where the conditions and requirements are met for ITS deployments. The criteria focusses on the most common ITS devices, including, DMS, Cameras, and Sensors. Criteria exists for RICWS and is under development for RWIS.

The goal is to establish criteria for these devices that create statewide consistency in placement of the devices. These guidelines are for planning of new ITS systems. The criteria goes beyond warrants developed in the Enterprise Pooled fund (http://enterprise.prog.org/itswarrants/) for ITS devices in that it includes criteria for spacing of devices as well as system requirements that are necessary to make sure the devices are utilized to maximum extent possible. Device spacing criteria is important as the systems are usually installed at multiple locations as part of an project.

The criteria were developed from a mix of inputs, including :

- ✓ Existing policy (Metro District guidelines for freeway and arterial)
- ✓ A review of the Enterprise Pooled fund warrants
- ✓ A review of the existing placement of ITS devices throughout the state and the characteristics of their location (mainly volume and road type); and
- ✓ Input from MnDOT staff

These criteria will guide decisions on location and funding of ITS over the life of this plan. The criteria are located on the tables on the following pages.

Table 6-3: ITS Cameras – Location Criteria for Statewide ITS Plan

System Location	Purpose of Camera	Camera Spacing Criteria	System Requirements
Urban- Twin Cities	• Incident detection/monitoring • Traveler information • ITS Device verification • Road/Weather monitoring • Construction Monitoring • Performance monitoring	• Freeway: 1 mile spacing with added spot locations where occlusion occurs • Arterial: at each signal on major arterials	• Fiber Optic Communications (Redundant communications for freeway) • Connection to Dispatch Centers that monitor and control DMSs • Dynamic Messages Signs for Incident Messages • Information from cameras is available to operations and maintenance staff • Images from cameras available to traveling public (i.e. 511)
Urban – Regional Center (Interstate and - Trunk Highway)	• Incident detection/monitoring • Traveler information • ITS Device verification • Road/Weather monitoring	• 1 mile spacing on Interstates and major State Highways in Regional Centers • Located on segments with AADT over 15,000 •	• Fiber Optic Communications • Connection to Dispatch Centers that monitor and control DMSs • Dynamic Messages Signs for Incident Messages • Images from cameras available to traveling public
Rural- Interstate and Inter-regional Corridors (IRC)	Option A: • Incident detection/monitoring • Traveler Information • Road Weather Information Option B: • Road Weather information • Detour monitoring	Option A: • 1 to 2 mile spacing, including a camera at each interchange • Located on segments with AADT over 20,000 or truck volumes greater than 4000 HCAADT • Located near high crash locations • Located in areas with well documented drifting and icing issues Option B: • Located at major interchanges and areas with frequent winter weather closures • Located in areas with well documented drifting and icing issues	Option A: • Fiber Optic Communications • Connection to Dispatch Centers that monitor and control DMSs • Dynamic message signs upstream of major interchanges • Images from cameras available to traveling public • Images available to Maintenance Supervisors Option B: • Fiber Optic Communications/Or Cellular • Connection to Dispatch Centers that monitor and control DMS • Dynamic message signs upstream of major interchanges • Images from cameras available to traveling public • Images available to Maintenance Supervisors
Rural-Non-interstate	• Road Weather Information	• Located with RWIS stations or at areas with reoccurring winter weather issues • Located in areas with well documented drifting and icing issues	• Wireless communication that allows images from the cameras • Image quality that is sufficient for travelers and maintenance staff to utilized the image for travel or maintenance planning • Images from cameras available to traveling public

System Location	Purpose of Sensor	Sensor Density Criteria	System Requirements
Urban- Twin Cities	• Collect Information for: ○ Ramp Metering System ○ Traffic Signal Timing ○ Travel Time Information ○ Traveler Information ○ Planning* ○ Performance Management	• Freeway: 1/2 mile spacing with sensor in each lane, and on entrance and exit ramps • Arterial: Sensors for all approaches at ever signal and additional locations as required by the system.	• Fiber Optic Communications (Freeway Required, Arterial Preferred) • Connection to RTMC to process data • Sufficient detection for Travel Time Calculation • Connection to signal control systems if used to signal operations • Archiving of data • Tools for analysis of data
Urban – Regional Center (Interstate and Freeway-Trunk Highway)	• Collect Information for: ○ Traveler Information ○ Planning ○ Performance Management ○ Signal Timing	• 1 mile spacing on Interstates and major State Highways in Regional Centers • Located on approaches to urban area and within urban with AADT over 15,000 • Arterial: Sensors for all approaches at ever signal and additional locations as required by the system.	• Fiber Optic Communications • Connection to Dispatch Centers that monitor information preferred • Connection to signal control systems if used to signal operations • Archiving of data • Tools for analysis of data
Rural- Interstate and Inter-regional Corridors (IRC)	• Collect information for ○ Road Weather Systems ○ Freight and Planning Data*	• Spacing is infrequent and tied to needs to get representative data at a statewide level	• Fiber Optic, Cellular or Dial-up Communication • Connection to Dispatch Center or RTMC that monitor information preferred. • Archiving of data
Variable – Special Use	Collect information for unique systems: • Road/weather information • Construction • Parking Availability • Toll Prices • Truck Weight and Permit Management • Gate operations • Asset Condition Monitoring	• The location and number of special use sensors is directly tied to purpose and design requirements of the ITS system the sensor is collecting information for • The special use can create a need for sensors on any type of state highway or facility	• Requirements depend on special use purpose • There are many types of sensors and the type and capability is a function of system needs, operational considerations, and maintenance practices. • Communication to sensors via fiber, dial-up, or cellular connections are necessary if archiving, remote monitoring and/or integration of the data with other ITS system are required

Table 6-4. ITS Sensors- Location Criteria for Statewide ITS Plan

*NOTE: Data from Sensors provided for planning purposes is a secondary outcome of the system. MnDOT's TDA section has specific criteria and requirements for spacing and location of sensors that are primarily intended to collect planning data. This criteria is found at http://www.dot.state.mn.us/traffic/data/coll-methods.html

System Location	Purpose of DMS	DMS Spacing Criteria	System Requirements

Urban- Twin Cities	• Inform Drivers about
	  ○ Incidents
	  ○ Traveler Travel Time
	  ○ Construction
	  ○ Public Service Info
	  ○ Lane Control
	• Arterial DMS used to inform drivers about Freeway Conditions
		• Freeway: 3 to 4 mile spacing with locations upstream of major route decision points
		• Arterial: on major arterials approaching Freeways
			• Fiber Optic Communications
			• Connection to RTMC to monitor and control DMSs
			• Sufficient detection for Travel Time Messages
			• DMS sized and designed to display all messages and graphics necessary to match the purpose of the specific DMS

Urban – Regional Center (Interstate and Trunk Highway)	• Inform Drivers about:
	  ○ Incidents
	  ○ Traveler information
	  ○ Public Service Info
	  ○ Road Weather
	  ○ Construction
		• 4-7 mile spacing on Interstates and major State Highways in Regional Centers
		• Located on approaches to urban area and within urban with AADT over 15,000
			• Fiber Optic Communications
			• Connection to Dispatch Centers that monitor and control DMSs
			• Cameras with sufficient spacing to detect and monitor incidents within the urban area
			• DMS sized and designed to display all messages and graphics necessary to match the purpose of the specific DMS and be consistent with DMS messages used statewide

Rural Interstate and Inter-regional corridors (IRC)	• Inform Drivers about:
	  ○ Incidents
	  ○ Road/ Weather Conditions
	  ○ Construction
	  ○ Public Service Info (auxiliary purpose)
		• Located on segments with AADT over 20,000 or truck volumes greater than 4000 HCAADT
		• Spacing can be 10 to 20 miles depending on purpose
		• Located near high crash locations
		• Locations should be 2 to 4 miles upstream of interchanges to allow drivers time to decide to divert route.
		• At Interstate locations that will show road weather closure messages should be located in advance of interchanges that have facilities (food /lodging/gas) to accommodate travelers
			• Fiber Optic Communications preferred, Cellular Connection possible
			• Connection to the Dispatch Center or RTMC that monitor and control DMSs
			• Remote maintenance capabilities

Variable – Special Use (portable DMS or DMS sized for specific purpose)	Inform Drivers about a specific condition or event tied to a location or facility:
	• Road/weather conditions
	• Construction
	• Special events
	• Parking Availability
	• Toll Prices
	• Truck Weigh Station Messages
	• Geometric Constrains (curves, height limits)
		• The location of the special use DMS is directly tied to its purpose. The use can create a need for a DMS on any type of state highway.
		• Usually serving a single purpose and display a message that expects a driver to make a decision based on the information. The location of the DMS should be such that the driver has sufficient time to process the information and if necessary take action.
			• Requirements depend on special use purpose.
			• The DMS size is highly variable and dependent on message design and sign purpose.
			• Communication from DMS to central management systems is necessary for:
			  ○ Road weather information
			  ○ Toll Prices
			• All other special uses can have a communication design that either: connects with a center (ex. Toll Prices); is local to the use (ex. Truck weigh station), or is not necessary (ex. Dynamic Speed).

Table 6-5. ITS Dynamic Message Signs- Location Criteria for Statewide ITS Plan

NOTE: AADT and HCAADT threshold criteria reflect levels that are lower than ITS Device Warrants documented in the Enterprise Pooled Fund. The thresholds in these tables reflect the practice of MnDOT and are in-line with past and planned ITS investments.

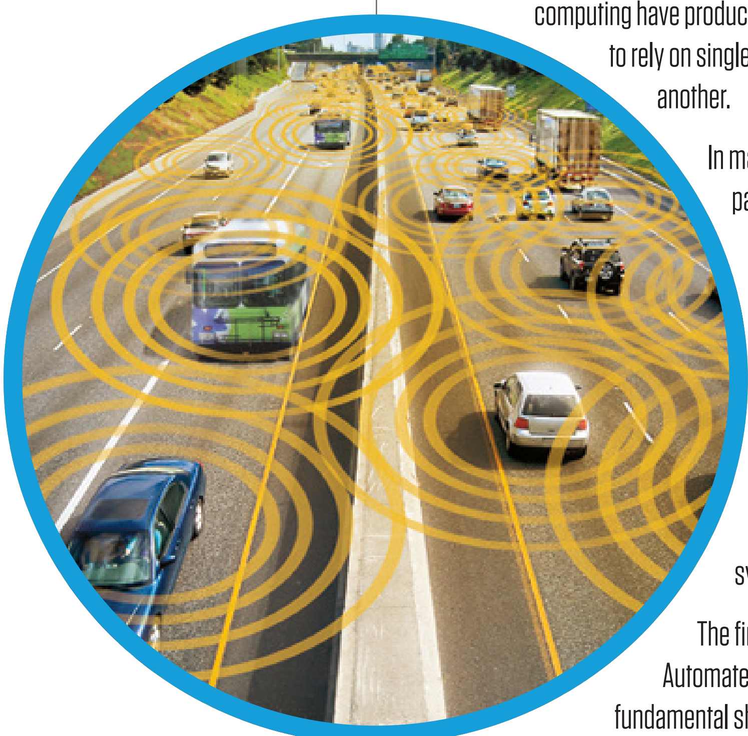
CHAPTER SEVEN

FUTURE SYSTEMS AND POSSIBILITIES

7.0 FUTURE SYSTEMS AND POSSIBILITIES

The first 20 years of ITS deployment were evolutionary; in some respects tracking the growth of computing and communications technology, and in some respects following a "funding available" approach of identifying areas of high need and addressing them in a logical and often step-by-step approach. The systems engineering "V" provided a proven model for advanced planning and stakeholder involvement, updates to an ITS Architecture, design and deployment of field devices, and occasionally a new approach to using existing tools (e.g., active traffic management). In general the process was entirely within the control of MnDOT and its key stakeholders.

Over the past few years we've begun to see glimpses of the future – how other stakeholders in addition to MnDOT can drive the conversation and affect the way people and goods are moved throughout the state. The emergence of "third party data providers" such as INRIX, HERE, WAZE, and Tom Tom has fundamentally altered how current conditions can be collected, synthesized, and distributed. The rapid advancement of Connected and Automated Vehicles by automakers and technology companies has given us an honest probability of reaching Zero Deaths in the state. And the clear shift in consumer acceptance and adoption of mobile technology and computing have produced a generation that one day may not feel the need to rely on single-car ownership as a means to get from one place to another.



In many instances these advances are happening in parallel to MnDOT programs, but the time is coming where they might not always be cooperative and MnDOT will have to evaluate how they engage. It is important for this Strategic Plan to identify the areas technology is changing and growing to make sure that the priorities and strategies listed don't preclude future technologies to the best of its ability. It is also equally important that the state is positioned with the policies, plans, and foundational system in place to be a front runner.

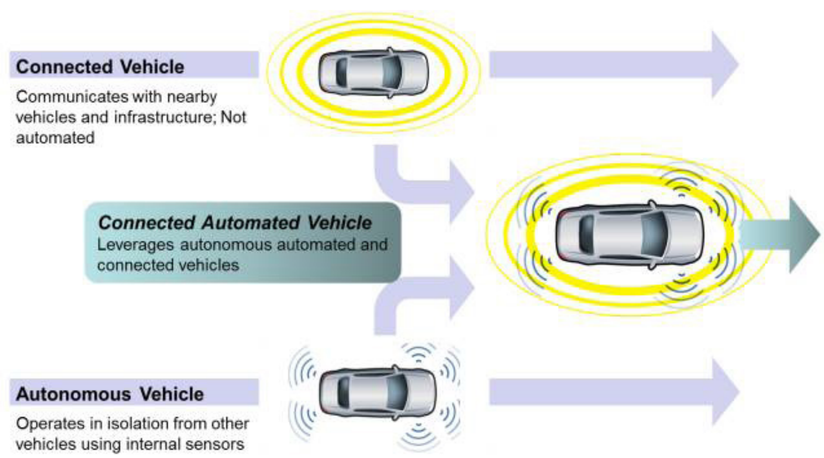
The first stage is to better understand Connected and Automated vehicles, recognizing this could represent the most fundamental shift in how vehicles use our transportation facilities since cars began running on roads in the early 20th Century. The basic terminology can be summarized as follows:

CONNECTED VEHICLES – vehicle to vehicle (V2V), vehicle to infrastructure (V2I), vehicle to anything (V2X) such as pedestrians or mobile devices. Using communication technology to connect the vehicle computer systems for 2-way data sharing

AUTONOMOUS VEHICLES – examples such as the current "Google Car" that use sensors, cameras, LIDAR, GPS, and other on-board technology to operate with reduced/limited/no human interaction.

CONNECTED AUTOMATED VEHICLES – using connectivity among systems to enhance autonomous technology, the computer in the vehicle now has a full array of environmental data on its surroundings, what lies more than a vehicle-length ahead, and how best to function based on the needs of the driver.

DEDICATED SHORT RANGE COMMUNICATIONS (DSRC) – a radio communication medium allocated by the FCC for ITS and public safety purposes (in the 5.9GHz spectrum). The protocol is similar to the WiFi in your home, but it was designed to facilitate large amounts of data transfer at very high speeds and under varying conditions. It has been proven to feature extremely fast connection & reliability which enables safety-related apps. Current cellular technology (even 4G/LTE) does not have enough speed and reliability for safety apps, but is very useful for other apps in the V2X arena and may be a market stimulator for CV/AV applications.

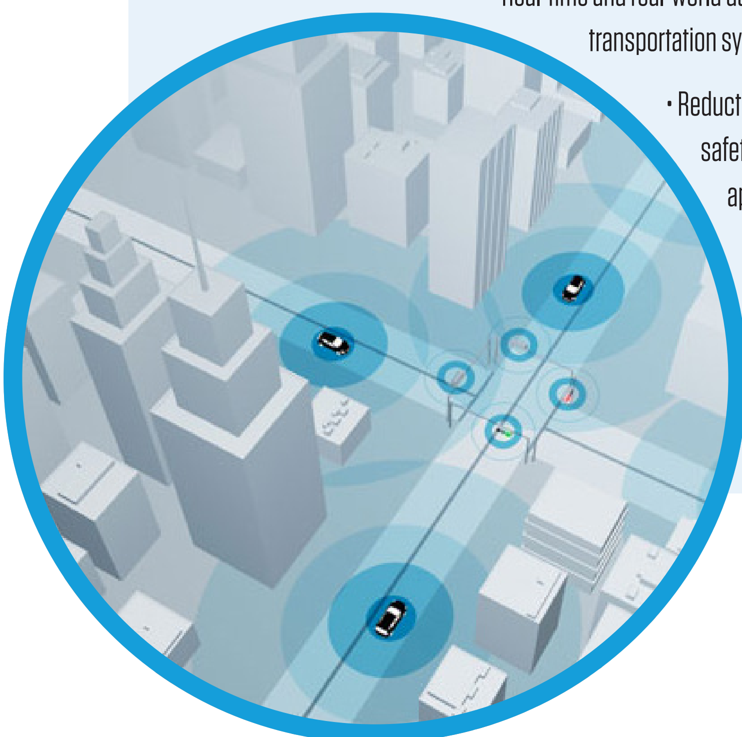


MnDOT has engaged in a number of Connected Vehicle research and pilot projects (many of them in concert with the University of Minnesota and other local stakeholders), and have already proven potential opportunities such as work zone and weather-related V2I applications as well as collecting user fees based on individual vehicle miles traveled as an alternative to using the gas tax as a means for transportation funding. As the automotive industry rolls out future vehicles equipped with advanced DSRC and cellular communication capabilities MnDOT is poised to capitalize on this and consider additional deployments of infrastructure-based connected vehicle technology. As the infrastructure gets deployed, MnDOT can then in turn begin to equip its own fleet of vehicles with V2I and V2V applications, and work with other partners to do the same. This proliferation of connected technology will be occurring nationwide, and will be an important foundational step as vehicle automation continues to come out of Detroit and onto our roads and facilities around the country.

NHTSA has started the regulatory process for requiring V2V communication in light vehicles, with trucks and commercial vehicles expected to follow soon after. Once connectivity is mandated, the marketplace for applications will expand and the market "pull" will dictate the pace of this evolution. The USDOT Strategic ITS Plan 2015-2019 Suggests that vehicle and technology providers will be looking for policy and institutional advances for deployment scenarios and thorough business models for a real-world environment. MnDOT should welcome these advances, by having a well defined ITS program and deployment standards that align with the needs of connected vehicles.

CONNECTED VEHICLE TECHNOLOGY POTENTIAL BENEFITS*

- Increases in safety, mobility, system efficiency, and access to resources for disadvantaged groups, and decreases in negative environmental impacts such as vehicle emissions, the need for physical expansion, and noise
- Decreases in undesirable transportation impacts to the environment and society
- Real-time and real-world data to help with transportation planning and transportation system operations
- Reduction of fatalities through weather related, safety, infrastructure-based, and other applications



*as identified in the USDOT ITS Strategic Plan 2015-2019

Experts agree that automated vehicles will evolve incrementally. Today we're in a period where some of the driving tasks are automated; but the momentum within the automotive and technology sectors is clearly moving toward significant increases in levels of automation. During the life of this Strategic Plan we will have "mixed use" scenarios where vehicles may be controlled by humans or they may be controlled by computers (or a mix). Platooning of commercial trucks and small driverless shuttles in campus settings will both be examples of early adoption. Car sharing and "last mile" driverless shuttles could impact planning and placemaking in urban cities and employment settings.

AUTOMATION TECHNOLOGY POTENTIAL BENEFITS*

- Reduction in number and severity of crashes caused by drivers or other conditions (i.e., weather, pedestrians, roadway conditions, etc.)
- Reduction of aggressive driving
- Expansion of last-mile connectivity for all users and modal options to disable and older users
- Increase in the efficiency and effectiveness of existing transportation systems

*as identified in the USDOT ITS Strategic Plan 2015-2019

During the life of this ITS Plan, there are significant changes that MnDOT will begin to consider and plan for, even if they aren't realized until after the 10-year window:

CHANGING THE LAYOUT OF ROADS AND TRAFFIC PATTERNS – when the drivers on the road are predictable machines rather than unpredictable humans, we could see changes in the need for speed limits, how vehicles merge, visibility issues, signage & wayfinding, intersection design, traffic signals, lane width, etc.

A GREATER DIVIDE IN VEHICLE PROPORTIONS – we could end up accelerating the current divide between city-dwellers traveling in tiny, slow-moving automated vehicles and suburban/rural families moving about in larger multi-passenger shared vehicles.

CHANGING WHO CAN DRIVE – children, elderly, injured, and disabled could gain much-needed mobility. This also changes the paradigm of how this might impact impaired drivers (alcohol or drugs), federal drinking age, enforcement, etc.

LAND USE CHANGES – vehicle sharing concepts could change the need for parking facilities, could actually result in more vehicle miles traveled, all while seeing reduced vehicle ownership. In fact the vehicle ownership model could dramatically shift toward more of a service provision such as taxis, Uber, etc. – which could require more dedicated lanes for discharging and picking up of passengers instead of parking lots.

The USDOT completed a lengthy and detailed update to their 2015-2019 ITS Strategic Plan in April of 2015. This framework plan presents the priorities, strategies, themes, and programs for federal ITS research, development, and adoption. But this plan is also a good guidance tool for states to use and consider where the national programs are progressing. Along with significant stakeholder involvement and close monitoring to changes in the transportation sector and automotive/technology sectors, MnDOT can combine all these trends and continue to update the cycle of plan-execute-measure-adjust-plan.

ITS technologies improve transportation safety and mobility, reduce environmental impacts, and enhance productivity through the integration of advanced communications-based information and electronic technologies into the transportation infrastructure and vehicles.
- USDOT ITS Strategic Plan 2015-2019

Minnesota's goals for transportation around the state align very closely with the priorities and themes identified by the USDOT as part of the strategic plan. These strategic themes helped define the direction for the plan and help prioritize outcomes as new technologies and systems are developed.

ITS PRIORITIES*

- ENABLE SAFER VEHICLES AND ROADWAYS – by developing better crash avoidance for all road vehicles, performance measures, and other notification mechanisms; commercial motor safety considerations; and infrastructure-based and cooperative safety systems
- ENHANCE MOBILITY – by exploring methods and management strategies that increase system efficiency and improve individual mobility
- LIMIT ENVIRONMENTAL IMPACTS – by better managing traffic flow, speeds, and congestion, and using technology to address other vehicle and roadway operational practices
- PROMOTE INNOVATION – by fostering technological advancement and innovation across the ITS world, continuously pursuing a visionary/exploratory research agenda, and aligning the pace of technology development, adoption, and deployment to meet future transportation needs
- SUPPORT TRANSPORTATION SYSTEM INFORMATION SHARING – through the development of standards and systems architectures, and the application of advanced wireless technologies that enable communications among and between vehicles of all types, the infrastructure, and portable devices

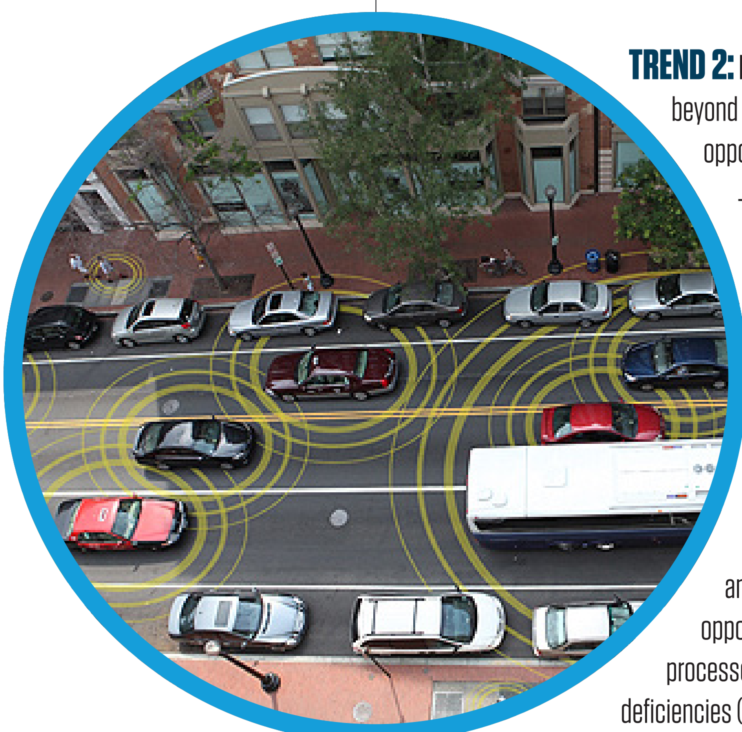
*as identified in the USDOT ITS Strategic Plan 2015-2019

7.1 TECHNOLOGY BEYOND CONNECTED & AUTONOMOUS VEHICLES

Forecasting technology over 10 years is not possible given the pace of change. Looking at MnDOT's ITS system though it is possible to see trends that point to next to future systems and possibilities. The key trends are:

TREND 1: The Core Systems will remain- but the technology will go through upgrades that enhance benefits, return on investment, and operational efficiency.

MnDOT Core ITS systems include cameras, dynamic message signs, ramp meters, traffic signal systems, RWIS, 511, and RICWS. These core systems are supported by communications infrastructure and management systems such as IRIS. All of these systems are likely to be in place in 10 years- but with technology pricing they will be upgraded with improvements in reliability and capability while costs remain similar to current costs. As new devices and approaches become available – including connected vehicle V2I systems – most experts agree they will operate side-by-side with existing technology for a healthy period of time until we have reached a maturation and deployment level that allows MnDOT to begin thinking about full integration and potential reduction in existing systems.



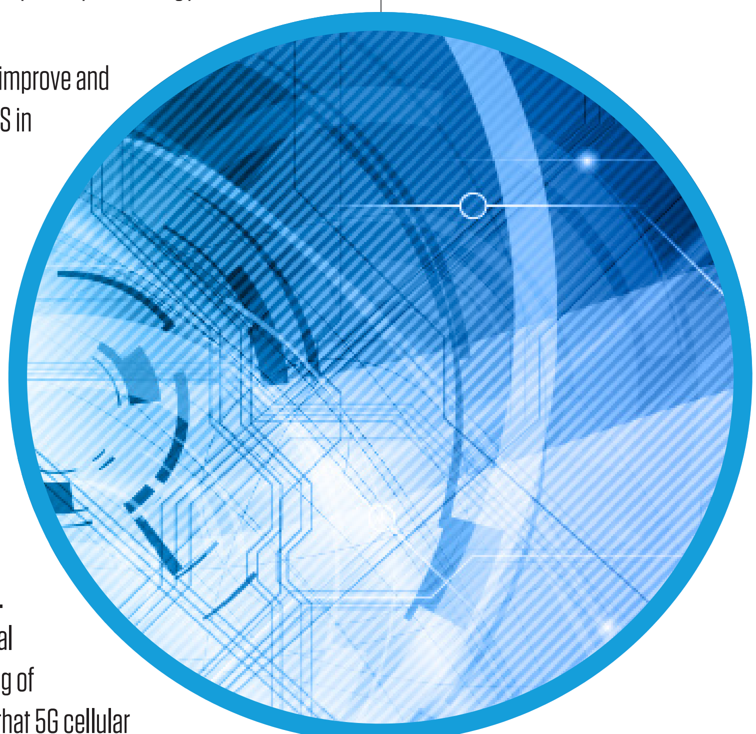
TREND 2: Private Sector Systems will Develop Capabilities beyond what MnDOT can provide to travelers creating opportunity for MnDOT to rethink systems.

Third party data providers and apps for the Web, Smartphones and In-Vehicle Systems are rapidly evolving to provide personalized information that can enhance mobility and safety for travelers in ways that MnDOT will never be able to lead. This is an opportunity for MnDOT to engage with these private parties and supplement their information with data MnDOT already has – but also for MnDOT to gain additional input to support incident management and traffic management strategies. This is also an opportunity for MnDOT to consider supplements to other processes such as using V2I data to help identify pavement deficiencies (pot holes) or supplement weather data in more remote regions and in between gaps with existing infrastructure deployments.

TREND 3: Systems will face pressure to be interconnected beyond the state borders.

For a long time at the national level there has been a vision to have ITS standards and systems that are easy to interconnect and are "borderless" in their application in order to provide users with consistent interaction with ITS and operators with efficient and cost effective systems. There has been some success in this area such as 511 and ITS Architectures, but it is also common to have systems that cannot connect due to funding restrictions, costs or incompatible technology. This is beginning to change as ITS matures as a standard practice and as policy makers begin to require interconnectivity in the interest of system users. At the heart of this push is the user experience. Signal systems should be coordinated by travel patterns not agency ownerships. Users should be able to get traveler information for any system they are using and the information should be consistent. Freight systems should be streamlined across borders to improve the efficiency and reliability of goods movement. The examples of this trend include requirements for interconnected toll systems recently enacted into federal law and NTCIP standards for technology now in use by most ITS vendors. MnDOT is on the forefront of this trend with recent procurements that allow it to connect tolling to other systems; in planning by participating in regional coordination groups that encompass multiple states; and in approach to ITS system design that utilizes standards and open systems as much as possible to enable easier interconnection of systems as well access to multiple vendor technologies that prevent a system lock-in to proprietary technology.

TREND 4: Communication Systems will continue to improve and expand, creating opportunities for MnDOT to expand ITS in ways not financially feasible in the past.



ITS systems are often dependent on having communications for remote monitoring, management and maintenance in order to have fully capable systems. MnDOT has a leading edge fiber optic network that has enabled many of the ITS investments but for much of the state connecting to the network is not viable so other methods such as radio, cellular, or dial-up systems are utilized. The Cellular options have been cost prohibitive or unavailable for many ITS systems but that is changing. Fiber optic networks are expanding and create potential opportunities for public/private or public/public sharing of systems. And during the life of this ITS Plan it is likely that 5G cellular technology will be deployed which will significantly impact the speed and bandwidth that data can be exchanged – as well as opening the door to potential applications we haven't yet envisioned.

7.2 PLANNING FOR THE NEXT GENERATION OF INTELLIGENT TRANSPORTATION SYSTEMS (ITS)

MnDOT is a leader in ITS systems because of an approach and organizational structure that actively monitors the development of ITS systems and emerging technologies, invests in research for promising ideas, and has a commitment to capital and operating investment in ITS. It also places a high value on stakeholder involvement with the public, private, and academic sectors. This approach is important to continue so the Agency is ready for the next generation of ITS. By maintaining MnDOT's commitment throughout the organization- ITS will remain a key strategy for achieving the Minnesota Go vision of Minnesota.

STRENGTHS

- Broad organizational support for ITS investment
- Advanced Organizational capabilities for ITS design and operations
- ITS is flexible and aligns with the vision from the Mn GO plan
- Urban areas have a robust multi-modal system with lots of opportunities for ITS technologies
- MnDOT does a thorough annual performance report
- Generally high ROI with ITS
- Statewide ITS architecture plan in place
- In-place approved products list and equipment is on state contract
- Training in systems engineering and ITS design in place
- Common software platforms

WEAKNESSES

- No set budget for annual ITS capital improvements - except in Metro
- Insufficient capital budget to meet replacement cycle costs of systems
- Insufficient staffing for maintaining existing systems
- ITS systems cross organizational Districts without clear responsibility for funding, operations, etc.
- Districts do things differently, with different ITS technologies and systems
- ROI for ITS projects is not tangible measure to show to public
- Funding restrictions for some key ITS elements (software, licenses, warranty)
- Non-traffic systems are not included in ITS planning (WIM, RWIS, Transit)

OPPORTUNITIES

- Statewide plan creates opportunity for long term planning for operations and capital investment
- Organizational structure for ITS from leadership to technician can be better defined/enhanced
- Asset Management planning process will bring preservation needs to the forefront
- ITS can help provide efficiency to mobility of people and improve safety; aligns with the vision from the GO plan
- ITS systems can improve the operational efficiency of the Agency
- Encourage ITS technology pilot projects to enhance role in economy; aligns with the vision from the GO plan and opens funding opportunities
- Coordinate and encourage private investment in ITS technologies and sharing of data with MnDOT
- ITS can be coordinated with the bigger multi-modal plan and used where needed to enhance operations
- ITS can be used as innovative solutions to push efficiency of the system vs. expanding capacity
- Users want more real time data about their trip, ITS can help with collecting and providing this information
- ITS performance measures identified in this plan need to be included in the annual statewide MnDOT performance report

THREATS

- MnDOT needs to adopt an implementation plan to address all demographics and Districts and needs; urban and rural
- ITS technology is not compatible across state or adjoining states
- ITS that deals with public information needs to address aging demographics, security and privacy
- Other agencies, industries, or legislation can set direction or impose system costs without MnDOT agreement
- Ability to attract and retain staff with skills in ITS
- Internal competition for funds and staff resources

Early in the planning process a Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis was developed by engaging with MnDOT stakeholders in each of the eight Districts, Central and Technical Offices. The SWOT analysis was used to develop the vision, goals, strategies and performance measures for ITS in Minnesota.

APPENDIX B: ITS PLAN STAKEHOLDER INVOLVEMENT

This plan was developed between December 2014 and July 2015. It was guided by a stakeholder process which included a project management team and numerous stakeholder engagement sessions. The Project Management Team will continue as the implementers of this plan.

PROJECT MANAGEMENT TEAM

- Sue Groth, State Traffic Engineer
- Ray Starr, Assistant State Traffic Engineer
- Jim Kranig, RTMC Manager
- Brian Kary, Freeway Operations Engineer
- Steve Misgen, Metro Traffic Engineer
- Cory Johnson, ITS Research and Development Engineer
- Mark Nelson, Program Manager, Statewide Planning and Transportation Data Analysis
- Steve Lund, State Maintenance Engineer
- Mike Schweyen, District 6 Traffic Engineer

STAKEHOLDER ENGAGEMENT SESSIONS INCLUDED MEETINGS WITH:

- District Management Team and Traffic Engineers for Each District
- Staff from Offices of Maintenance, Transportation Data Analysis, RTMC
- Planning Management Group
- State MPO staff