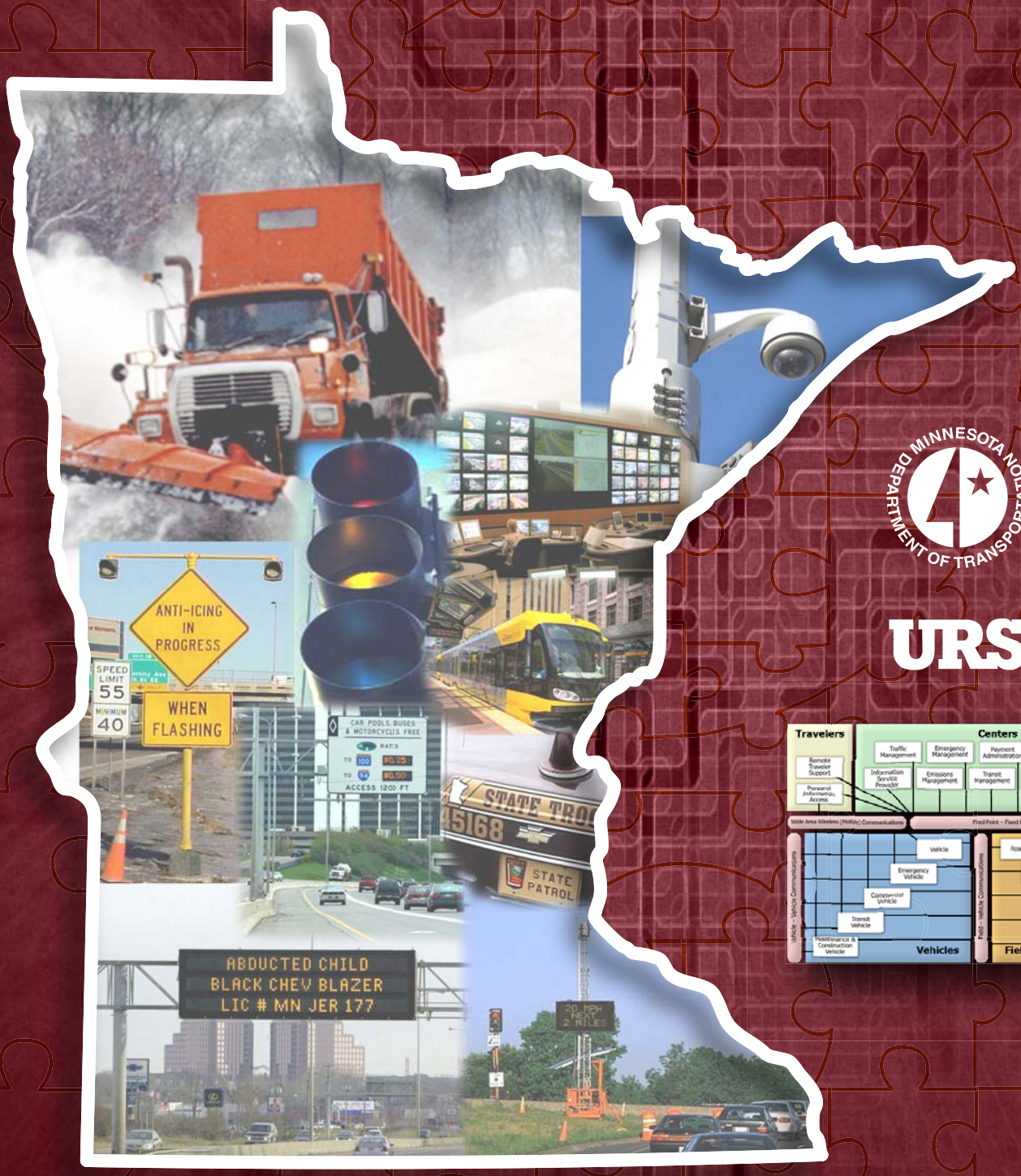
Minnesota Statewide Regional ITS Architecture

Version 2014

Volume 7:
Maintenance and Construction Management Service Package Bundle



MINNESOTA DEPARTMENT OF TRANSPORTATION

URS

Minnesota Statewide Regional ITS Architecture
Version 2014

Volume 7: Maintenance and Construction Management Service Package Bundle

Prepared by

URS Corporation

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ACRONYMS

AD	Archived Data Management
ADMS	Archived Data Management System
AMBER	America's Missing: Broadcast Emergency Response
APTS	Advanced Public Transportation System
ATIS	Advanced Traveler Information System
ATMS	Advanced Traffic Management System
AVL	Automatic Vehicle Location
AVSS	Advanced Vehicle Safety System
AWOS	Automated Weather Observation System
CAD	Computer Aided Dispatch
CARS	Condition Acquisition and Reporting System
CCTV	Closed Circuit Television
CVO	Commercial Vehicle Operations
DMS	Dynamic Message Sign
DTN	Data Transmission Network
EM	Emergency Management
EOC	Emergency Operations Center
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
GIS	Geographic Information System
GPS	Global Positioning System
HAR	Highway Advisory Radio
ICS	Incident Command Structure
ITS	Intelligent Transportation Systems
IWZ	Intelligent Work Zone
LED	Light-Emitting Diode
LOS	Level of Service
MCM	Maintenance and Construction Management
MDSS	Maintenance Decision Support System
MDT	Mobile Data Terminal
MnDOT	Minnesota Department of Transportation
MSP	Minnesota State Patrol
NADIN	National Airspace Data Interchange Network
NIMS	National Incident Management System
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
RCA	Resource Consumption Application
RTMC	Regional Transportation Management Center
RTMS	Remote Traffic Microwave Sensor
RWIS	Road Weather Information System
TDA	Office of Transportation Data & Analysis (MnDOT)
TDRL	Transportation Data Research Laboratory
TIS	Traveler Information System
TMC	Transportation/Traffic Management Center
TOCC	Transportation Operation and Communications Center
VMT	Vehicle-Miles Traveled

1. Introduction

1.1 Statewide Regional ITS Architecture Update

The Minnesota Statewide Regional Intelligent Transportation Systems (ITS) Architecture Version 2014 is an update of the previous version that was developed in 2009. It conforms with the National ITS Architecture and the Federal Highway Administration (FHWA) Final Rule 940 and Federal Transit Administration (FTA) Final Policy on ITS Architecture and Standards. The Final Rule and the Final Policy ensure that ITS projects carried out using funds from the Highway Trust Fund including the Mass Transit Account conform to the National ITS Architecture and applicable ITS standards.

The Minnesota Statewide Regional ITS Architecture represents a shared vision of how each agency's systems work together by sharing information and resources to enhance transportation safety, efficiency, capacity, mobility and security. The information exchange among the many transportation stakeholders helps illustrate various integration options, gain consensus on cost-effective ITS technologies and systems to be considered prior to investing in design, development and deployment of ITS.

The Minnesota Statewide Regional ITS Architecture is a living document and will evolve as needs, technology, stakeholders and funding change. The National ITS Architecture is a resource to the Minnesota Statewide Regional Architecture providing framework for planning, defining and integrating ITS.

The Minnesota Statewide Regional ITS Architecture promotes deployment and integration of ITS systems and services that are compatible and interoperable with other ITS systems and services across jurisdictional boundaries. It facilitates coordination, cooperation, and information and resource sharing among State and local agencies. It guides systematic deployment and integration of regional ITS to improve the safety, efficiency, dependability, and cost effectiveness of the transportation system in Minnesota.

The Minnesota Statewide Regional ITS Architecture is organized as follows:

- **Overview:** The Overview document identifies the purpose/need, a general description of the region, development objectives, and performance measures for the Minnesota Statewide Regional ITS Architecture.

- **Volumes 1 thru 8 – Development and Documentation of Service Package Bundles:** Each volume is specific to the corresponding Service Package Bundle and includes: a description of the Service Package Bundle, ITS development objectives, a summary of needs and services, and a detailed description of needs and services (consisting of the operational concept, inventory, specific service packages to address needs and services, interconnects and architecture flows, and research and development needs).

- **Volume 9 – ITS Initiatives and Project Concepts for Implementation:** This volume serves as long-range guidance to systematically and cost-effectively implement the ITS initiatives and project concepts for the next 15 to 20 years in Minnesota based on funding availability. It lists specific ITS needs that are further prioritized into ITS initiatives and project concepts. It also provides the corresponding details for each

initiative or project concept which include project concept descriptions, agency involved, champion, implementation timeframe, technology readiness, dependencies, benefits, service packages, estimated costs, and agreements needed.

- **Volume 10 – Turbo Architecture Outputs of the Regional ITS Architecture:** Volume 10 consists of a Turbo Architecture generated report for the Minnesota Statewide Regional ITS Architecture.

The purpose for developing Volumes 1 through 8 was to identify and prioritize stakeholder needs; gather information on existing infrastructure, components and technology; and define stakeholder roles and responsibilities in planning, deploying, operating and maintaining existing and future ITS systems.

Data collection activities were conducted early in the study process and focused on two primary tasks:

1. The assemblage of an inventory of existing and planned transportation infrastructure and, facilities and services.
2. The assessment of statewide needs and opportunities for further deployment of ITS needs.

Previously published transportation plans were the main source of data about characteristics of the existing transportation system, planned improvements, transportation system needs and goals. Strategic and long-range planning studies, ITS deployment and safety plans, transit studies and transportation planning and policy documents were reviewed.

1.2 Volume 7 – Maintenance and Construction Management

Maintenance and Construction Management (MCM) activities include monitoring, operating, maintaining, improving, and managing the physical condition of the roadway. MCM includes the management and coordination of maintenance and construction resources (personnel, equipment, materials, vehicle fleets, roadway maintenance activities (winter treatment and routine maintenance), and work zone activities; collection of road conditions, weather, and environmental data; and dissemination of work plans, road condition and environmental information.

Development of Volume 7 - MCM entailed the Project Consultant to work closely with MnDOT and stakeholders to identify and prioritize stakeholder needs; gather information on existing and future ITS infrastructure, components and technology; and define the stakeholders roles and responsibilities in planning, deploying, operating and maintaining existing and future ITS systems.

Volume 7 summarizes the findings of data collection and analysis activities conducted to support development of the MCM Service Package Bundle. Volume 7 is organized with the following sections:

- ***Section 1: Introduction*** provides a brief project overview and the purpose of this volume.
- ***Section 2: Identification of Existing MCM Systems*** provides a brief overview of statewide MCM system deployments with a detailed listing of existing/planned systems in *Appendix A*.

- ***Section 3: Development Objectives*** provides an overview of the Minnesota ITS Development Objectives specific to MCM. These objectives are used to identify needs and gaps, which will then be used to identify services to address those needs.
- ***Section 4: Identification of Needs and Services*** Based on the ITS Development Objectives, needs were identified and prioritized by the stakeholders. Services were identified to address those prioritized needs.
- ***Section 5: Detail of MCM Needs and Services*** describes, for each identified Need/Service, the following information:
    - **Operational Concept** - who is currently using the service and how they are using it. Users include both managers of a system and other users, like the traveling public, who use an end service.
    - **Existing Capabilities** - what systems are currently in place that are used to provide this service and who operates these services.
    - **Gaps and Planned Enhancements** - enhancements that can be made to better provide the service and address needs, who will use these enhancements, and what they will be used for. These enhancements can include expanding systems to geographic areas that currently do not have access to the service, enhancing an existing service to provide greater functionality or use by more groups, or implementing a new system to address a gap.
    - **Roles and Responsibilities** - what roles stakeholders need to fulfill to make the service operate successfully throughout a system's lifecycle (planning, design, implementation, operations, and maintenance).
    - **Interconnects** - the communications linkages between subsystems or stakeholders to provide the service.
    - **Data Archive Needs** - what data is generated for the service that should be archived, who is responsible for archiving, and any special needs or requirements for such archiving.
    - **Associated Service Packages** - other Service Packages that the service falls under. This includes both Service Packages within the MCM Service Package Bundle and those in other Service Package Bundles.
- ***Section 6: MCM Research and Development Needs*** describes general research that can be performed to help implement the identified services.

2. Identification of Existing Maintenance and Construction Management Systems

MCM systems are utilized throughout Minnesota and have aided transportation agencies to safely and efficiently maintain and enhance transportation infrastructure. Using those systems has increased efficiency and capacity, improved safety, enhanced mobility, and increased economic productivity of the Minnesota's transportation systems.

MCM systems can be used to assist in the maintenance and/or construction of roadway infrastructure. Work zone monitoring systems can gather information about roadway and traffic conditions and provide information to travelers to alert them of queues or traffic speeds as they approach the work zone. Roadside weather monitoring stations can gather road and weather data and send it to maintenance centers, providing information for maintenance decision to adjust their operations to make roadways safe for travelers. Tracking systems can also allow maintenance managers to monitor maintenance vehicles and resources to utilize those assets more efficiently.

An inventory of existing and planned MCM ITS systems (e.g. centers, vehicles, devices and infrastructure) in Minnesota is described in *Appendix A*. This inventory summarizes a list of existing and programmed ITS systems in the state, their general description, associated stakeholder that are involved with their operations and management, and their current deployment. The systems described in *Appendix A* are Minnesota-specific implementations of subsystems from the National ITS Architecture.

3. Development Objectives

Transportation needs identify the transportation problems that can be solved by ITS services. They also represent a link to transportation planning efforts that define the strategies and solutions to address various challenges. These strategies involve capital improvements as well as operational improvements. MCM ITS solutions involve services that improve the effectiveness and safety of maintenance and construction operations.

MCM includes the management and coordination of maintenance and construction resources; personnel, equipment, materials, vehicle fleets, roadway maintenance activities (winter treatment and routine maintenance), work zone activities, collection of road conditions and environmental data, and dissemination of work plans, road condition and environmental information. The goal of MCM is to provide effective and timely maintenance and construction operations, coordinate with other transportation agencies to maximize efficiency and minimize risk of incidents and traffic disruption. The Minnesota ITS Development Objectives in Table 3-1, specific to MCM, are steps to determine and/or measure whether or not MCM goals are being achieved. A complete list of Minnesota ITS Development Objectives is included in *Appendix B*.

Table 3-1. MCM Specific Minnesota ITS Development Objectives

A. Improve the Safety of the State's Transportation System

A-1 Reduce crash frequency *(ATIS, ATMS, APTS, CVO, EM, MCM & AVSS)*

- A-1-01 Reduce number of vehicle crashes
- A-1-02 Reduce number of vehicle crashes per VMT
- A-1-04 Reduce number of crashes due to unexpected congestion
- A-1-14 Reduce number of crashes related to driver inattention and distraction
- A-1-17 Reduce number of crashes due to roadway/geometric restrictions

A-2 Reduce fatalities and life changing injuries *(ATIS, ATMS, APTS, CVO, EM, MCM & AVSS)*

- A-2-01 Reduce number of roadway fatalities
- A-2-02 Reduce number of roadway fatalities per VMT
- A-2-04 Reduce number of fatalities due to unexpected congestion
- A-2-15 Reduce number of fatalities related to driver inattention and distraction
- A-2-18 Reduce number of fatalities due to roadway/geometric restrictions
- A-2-22 Reduce number of roadway injuries
- A-2-23 Reduce number of roadway injuries per VMT
- A-2-25 Reduce number of injuries due to unexpected congestion
- A-2-36 Reduce number of injuries related to driver inattention and distraction
- A-2-39 Reduce number of injuries due to roadway/geometric restrictions

Table 3-1. (Continued)

A-3 Reduce crashes in work zones *(ATIS, ATMS, EM, MCM & AVSS)*
- A-3-01 Reduce number of crashes in work zones
- A-3-02 Reduce number of fatalities in work zones
- A-3-03 Reduce number of motorist injuries in work zones
- A-3-04 Reduce number of workers injured by vehicles in work zones

B. Increase Operational Efficiency and Reliability of the Transportation System

B-1 Reduce overall delay associated with congestion *(ATIS, ATMS, MCM & AVSS)*
- B-1-10 Reduce hours of delay per capita
- B-1-11 Reduce hours of delay per driver
- B-1-12 Reduce the average of the 90th (or 95th) percentile travel times for (a group of specific travel routes or trips in the region)
- B-1-13 Reduce the 90th (or 95th) percentile travel times for each route selected
- B-1-14 Reduce the variability of travel time on specified routes during peak and off-peak periods

B-3 Reduce delays due to work zones *(ATIS, ATMS, EM, MCM & AVSS)*
- B-3-01 Reduce total vehicle hours of delay by time period (peak, off-peak) caused by work zones
- B-3-02 Reduce the percentage of vehicles traveling through work zones that are queued
- B-3-03 Reduce the average and maximum length of queues, when present,
- B-3-04 Reduce the average time duration (in minutes) of queue length greater than some threshold (e.g., 0.5 mile)
- B-3-05 Reduce the variability of travel time in work zones during peak and off-peak periods

C. Enhance Mobility, Convenience, and Comfort for Transportation System Users

C-4 Reduce stress caused by transportation *(ATIS, ATMS, APTS, EM, MCM & AVSS)*
- A-2-43 Reduce number of speed violations
- A-2-44 Reduce number of traffic law violations
- B-1-10 Reduce hours of delay per capita
- B-1-11 Reduce hours of delay per driver
- B-1-12 Reduce the average of the 90th (or 95th) percentile travel times for (a group of specific travel routes or trips in the region)
- B-1-13 Reduce the 90th (or 95th) percentile travel times for each route selected
- B-1-14 Reduce the variability of travel time on specified routes during peak and off-peak periods
- C-3-11 Increase number of 511 calls per year
- C-3-12 Increase number of visitors to traveler information website per year
- C-3-13 Increase number of users of notifications for traveler information (e.g., e-mail, text message)
- C-3-15 Increase the number of specifically tailored traveler information messages provided

Table 3-1. (Continued)

D. Improve the Security of the Transportation System

D-2 Safeguard the motoring public from homeland security and/or Hazmat incidents *(ATIS, ATMS, APTS, CVO, EM, MCM & AVSS)*

- C-3-09 Increase the percent of the transportation system in which travel conditions can be detected remotely via CCTV, speed detectors, etc.
- D-1-03 Increase customer service and personal safety ratings
- D-1-04 Reduce the number of reported personal safety incidents
- D-1-05 Decrease the number of security incidents on roadways
- D-1-06 Increase the percent of major and minor arterials are equipped with and operating with closed circuit television (CCTV) cameras
- D-1-07 Increase the number of critical sites with security surveillance
- D-1-08 Reduce the number of security incidents on transportation infrastructure
- D-1-09 Increase the number of critical sites with hardened security enhancements

E. Support Regional Economic Productivity and Development

E-4 Increase agency efficiency *(ADMS, ATMS, APTS, CVO, EM & MCM)*

- E-4-01 Increase the number of ITS-related assets tracked
- E-4-03 Increase the rate of on-time completion of construction projects
- E-4-04 Increase the rate at which equipment is utilized
- E-4-05 Increase the percentage of fleet/equipment within its lifecycle
- E-4-06 Increase the number of fleet vehicles with maintenance diagnostic equipment
- E-4-07 Increase the number of vehicles operating under CAD

E-6 Enhance efficiency at borders *(ATIS & CVO)*

- E-2-04 Increase the use of electronic credentialing at weigh stations and border crossings
- E-3-11 Reduce average crossing times at international borders

F. Preserve the Transportation System

F-1 Safeguard existing infrastructure *(ATMS, CVO, EM & MCM)*

- C-3-09 Increase the percent of the transportation system in which travel conditions can be detected remotely via CCTV, speed detectors, etc.
- D-1-06 Increase the percent of major and minor arterials are equipped with and operating with closed circuit television (CCTV) cameras
- D-1-07 Increase the number of critical sites with security surveillance
- D-1-08 Reduce the number of security incidents on transportation infrastructure
- D-1-09 Increase the number of critical sites with hardened security enhancements
- E-4-03 Increase the rate of on-time completion of construction projects

G. Enhance the Integration and Connectivity of the Transportation System

G-1 Aid in transportation infrastructure and operations planning *(ALL)*

- G-1-01 Increase the amount of data gathered from ITS enhancements used in infrastructure and operations planning
- G-1-02 Increase the number of planning activities using data from ITS systems
- G-1-03 Increase the number of years of data in database that is easily searchable and extractable
- G-1-04 Reduce project schedule deviation
- G-1-05 Reduce project cost deviation
- G-1-06 Reduce operations cost deviation

Table 3-1. (Continued)

G-1-07 Reduce administrative support rate (as part of overall project budget)

G-2 Reduce need for new facilities *(ATMS, CVO, MCM & AVSS)*
- B-1-10 Reduce hours of delay per capita
- B-1-11 Reduce hours of delay per driver
- B-1-12 Reduce the average of the 90th (or 95th) percentile travel times for (a group of specific travel routes or trips in the region)
- B-1-13 Reduce the 90th (or 95th) percentile travel times for each route selected
- B-1-14 Reduce the variability of travel time on specified routes during peak and off-peak periods

H. Reduce Environmental Impacts

H-2 Reduce negative impacts of the transportation system on communities *(ATMS, APTS, EM & MCM)*
- A-2-44 Reduce number of traffic law violations
- H-2-02 Increase the amount of environmentally friendly de-icing material used

4. Needs and Services

Stakeholder outreach has been a key component for updating the Minnesota Statewide Regional ITS Architecture. A stakeholder survey was conducted in early 2013 to capture the following changes since the last update of the Architecture in 2009:

- Additional ITS needs and services have been identified and added
- New technologies have come on-line
- New technologies have replaced out-of-date technology.

The survey asked each survey participant to review and provide priority ranking to each of the ITS functional/informational needs as well as research and technology development needs that were identified previously in the 2009 Minnesota Statewide Regional ITS Architecture. Survey participants were also asked to identify additional needs and provide information on the status of current projects/initiatives and plans for future projects/initiatives.

Between March and May 2013, a series of stakeholder workshops were conducted. The purpose of those workshops was to obtain feedback on the Minnesota ITS Goals and Objectives, discuss the results of the stakeholder survey, and gather additional feedback on needs and priority rankings. Stakeholders reviewed the ITS functional/informational needs as well as discussed the research and technology development needs. Subsequently, the highest priority needs that would benefit the traveling public were identified.

Table 4-1 displays the Specific Functional/Informational Needs/Services as potential solutions and enhancements. Priority is indicated in the Priority Points column, with each point representing one vote from responders through the stakeholder survey. The ITS Development Objectives and ITS Architecture Service Packages corresponding with the potential solutions are also listed in Table 4-1. The potential solutions and enhancements identified in Table 4-1 will provide the required service(s) to fill the gaps summarized in *Appendix C*. This appendix will

take the MCM Needs and associated MCM Solutions and define what and how the system will be used, who will use it and who is responsible for planning, design, implementation, operation and maintenance of the system.

Table 4-1. MCM Needs and Potential Solutions

Notes:

[a] *Priority point scoring system: 0 point for "no need"; 1 point for "low"; 2 points for "low to moderate"; 3 points for "moderate"; 4 points for "moderate to high"; and 5 points for "high".*

[b] *Discussions on needs/solutions fall under other service package bundles can be found in corresponding Service Package Bundle documents.*

[c] *Priority point is calculated based on limited votes (3 or less).*

ID	Need/Potential Solution	Priority Point[a]	ITS Development Objective	National ITS Architecture Reference[b]
WZ01	Track locations of maintenance fleet and personnel and usage of materials	3.29	E-4-01, E-4-04, E-4-07	MC01, MC06
WZ02	Coordinate construction and maintenance project schedules within and between agencies	3.71	C-3-10	MC10
WZ03	Warn work crews of errant vehicles	4.29	A-3-04	MC09
WZ04	Provide automated monitoring of road weather conditions	3.43	A-1-03, A-2-03, A-2-24, C-3-09	MC03, MC04
WZ05	Warn travelers about trucks entering/exiting work zones	3.43	A-3-01, A-3-02, A-3-03, A-3-04	MC09
WZ06	Provide queue detection and advisory to warn traffic of a stopped queue at work zone	4.00	A-3-01, A-3-02, A-3-03	MC08, ATMS01
WZ07	Provide roadway automated treatment with stationary units	2.29	A-1-03, A-2-03, A-2-24	MC05
WZ08	Provide maintenance decision support	2.57	A-1-03, A-2-03, A-2-24, E-4-01, E-4-04, E-4-07, H-2-02	MC06
WZ09	Provide dynamic late merge systems for construction/maintenance activities	3.23	B-3-01, B-3-02, B-3-03, B-3-04, B-3-05	MC08
WZ10	Use GPS/GIS data to target and record replacement and repair of infrastructure	3.71	G-1-01	MC07
WZ11	Provide work zone information to travelers	4.00	B-3-01, B-3-02, B-3-03, B-3-04, B-3-05, C-3-10, C-3-11, C-3-13, C-3-15	MC08
WZ12	Notify travelers of delays or travel times through work zones	3.57	B-3-01, B-3-02, B-3-03, B-3-04, B-3-05, C-3-10, C-3-11, C-3-13, C-3-15	MC08
WZ13	Provide cameras/sensors on bridges to assist for inspection and continual monitoring	2.00	C-3-09, D-1-06	MC12
WZ14	Provide automated flagging in stationary work zones	3.00	A-3-01, A-3-02, A-3-03, A-3-04	MC08
WZ15	Provide dynamic speed display	3.29	A-3-01, A-3-02, A-3-03, A-3-04	MC08, ATMS19, ATMS24

Table 4-1. (Continued)

ID	Need/Potential Solution	Priority Point[a]	ITS Development Objective	National ITS Architecture Reference[b]
WZ16	Provide additional warning on back of snowplow	5.00*	A-1-03, A-2-03, A-2-24	MC06, MC08
WZ17	Alert distracted motorists near work zones	5.00*	A-1-14, A-2-15, A-2-36, A-3-01, A-3-02, A-3-03, A-3-04	MC08, MC09
WZ18	Enforce timely sign changes in construction zones	5.00[c]	B-3-01, B-3-02, B-3-03, B-3-04, B-3-05	MC07, MC08
WZ19	Open up lane closures when not in use	5.00[c]	B-3-01, B-3-02, B-3-03, B-3-04, B-3-05	MC08
TI05	Provide information on roadway construction and maintenance activities	4.07	A-1-17, A-3-01, A-3-02, A-3-03, A-3-04, B-3-01, B-3-02, B-3-03, B-2-04, B-2-05, C-3-09, C-3-10, C-3-11, C-3-12, C-3-13, C-3-15	ATIS01, ATIS02, MC08
TM08	Provide enhanced manual or automated speed enforcement to improve safety	2.33	A-1-12, A-2-13, A-2-34, A-2-43, C-4-01	ATMS19, MC08
TM18	Provide dynamic speed feedback to drivers and enforcement agencies	2.69	A-1-12, A-2-13, A-2-34, A-2-43, C-4-01	ATMS19, MC08
TM29	Provide automated/ remote control gate systems	2.50	A-1-03, A-2-03, A-2-24	ATMS21
TM34	Provide roadway flood warnings	2.00	A-1-03, A-1-17, A-2-03, A-2-18, A-2-24, A-2-39	ATMS24, MC12
TM39	Monitor queue length at ramps, incident scenes and work zones	2.83	A-1-04, A-2-04, A-2-25, A-3-01, A-3-02, A-3-03, B-1-17, B-1-18, B-3-01, B-3-02, B-3-03, B-3-04	ATMS01, ATMS24, MC08
TM40	Enhance enforcement in work zones	3.50	A-3-01, A-3-02, A-3-03, A-3-04	ATMS19, MC08
TM43	Notify travelers of snowplow operations and cleanup using DMS	2.59	A-1-03, A-2-03, A-2-24, C-3-15	ATMS06, MC06

5. Detail of MCM Needs and Services

A detailed description of each MCM Needs and Services for Minnesota is found in *Appendix C. Appendix C* contains a table, listing the services sorted by Service Package and details for the service. The details described in the table include:

- **Operational Concept:** Describes who is currently using the service and how they are using it. Users of the service include both managers and operators of a system and other users who may be impacted and/or benefit from such a service, such as other agencies and the traveling public.
- **Existing Capabilities:** Describes what systems are currently in place that are used to provide this service and who operates these systems and provides such services.
- **Gaps and Planned Enhancements:** Summarizes enhancements that can be made to better provide the service and address needs, who will use these enhancements, and what they will be used for. These enhancements include expanding current systems to geographic areas that presently do not have access to the service, enhancing an existing service to fill identified gaps or use by more groups, or implementing a new system to address a need.
- **Roles and Responsibilities:** Describes the roles and responsibility of involving stakeholders to make the service operate successfully throughout a system's lifecycle (planning, design, implementation, operations, and maintenance).
- **Interconnects:** Presents the communications linkages between subsystems or stakeholders to provide the service.
- **Data Archive Needs:** Summarizes what data is generated for the service that should be archived, who is responsible for archiving, and any special needs or requirements for such archiving.
- **Associated Service Packages:** Describes other Service Package(s) required to deliver the desired service. This includes both Service Packages within the MCM Service Package Bundle and those in other Service Package Bundles.

6. MCM Research and Development Needs

In order to fill gaps and meet the needs for technology advancement in MCM services, some research must be performed to test solutions and gain a greater understanding of what can effectively address identified needs, gaps, and opportunities. Opportunities for MCM Research and Development Needs are as follows:

<u>Fleet Management</u>

- Develop a generalized life-cycle costing model that can be used for estimating the optimum life of various MnDOT assets
- Improve fleet management by integrating automated vehicle system data acquisition into its fleet information system
- Improve vehicle safety systems
- Test new applications of AVL data in maintenance decision making

<u>Road Weather Condition Monitoring</u>

- Test non-intrusive pavement sensors for data accuracy and reliability against in-place RWIS sensors, vehicle mounted sensors and visual observations.

- Develop procedures for real-time malfunction detection in RWIS to improve accuracy in forecasting roadway weather-related data

Infrastructure Monitoring and Maintenance

- Test GIS database for infrastructure inventory, status, and maintenance history and schedule
- Test systems to share maintenance schedule/closure information between agencies
- Develop rapid in-place testing techniques for bridges
- Test sensor use for bridge inspections
- Research location of camera placement for infrastructure inspection

Roadway Automated Treatment

- Test mobile roadway automated anti-icing systems
- Test maintenance vehicle anti-icing units

Work Zone Safety Monitoring

- Test work zone intrusion devices to increase work zone safety
- Test enhancements to intelligent work zone systems
- Maintain and review Intelligent Work Zone (IWZ) toolbox
- Test truck-entering alert system
- Test integration of real-time work zone information into HAR

Appendix A: Existing/Planned MCM Elements

System	Service Package(s)	Description	Stakeholder	Status
Advanced Pavement Condition and Visibility Warning System Roadside Equipment	MC03, ATMS06	The element represents the roadside equipment of the proposed automated warning system. The roadside equipment would consist of pavement sensors, visibility sensors, and either changeable message signs or static warning signs with flashing beacons located upstream from the problem area.	MnDOT	Planned
AWOS Central Control System	MC03, MC04	MnDOT Office of Aeronautics has installed and currently maintains Automated Weather Observation Systems (AWOS) throughout the state. AWOS data is gathered and re-distributed over the Federal Aviation Administration (FAA) National Airspace Data Interchange Network (NADIN), allowing these reports to become available through computer weather systems. Current weather information can be obtained by telephoning the AWOS site, where a computer generated voice relays up-to-the-minute observations. The AWOS data is visually displayed on a remote computer monitor at local airports, and is simultaneously broadcast over the local radio navigation aid or a VHF transmitter for in-flight use.	MnDOT Office of Aeronautics	Existing
AWOS Roadside Equipment	MC03	This element represents the roadside equipment of AWOS.	MnDOT Office of Aeronautics	Existing
Bridge Inspection/ Structural Monitoring Roadside Equipment	MC12	This element represents roadside cameras and sensors that are planned to be utilized for maintenance inspections of key bridges in Minnesota. Roadside equipment is planned to be controlled by MnDOT RTMC, TOCCs, and Maintenance and Construction Management Centers for maintenance inspections. Data on inspection activity can be archived to indicate dates of inspection and exactly what was inspected.	MnDOT	Planned
CCTV Roadside Equipment	MC08	This represents CCTV cameras deployed along the roadside by various agencies and municipalities throughout Minnesota. Images are received and monitored by transportation agencies.	MnDOT, Local Agencies	Existing

System	Service Package(s)	Description	Stakeholder	Status
Clarus Weather System	MC03, MC04	The Clarus Weather System is an FHWA-led initiative that plans to collect atmospheric and surface weather data from environmental sensor stations throughout the US and Canada and share the data with the general public and private information service providers. Eight U.S. states, including Minnesota and three Canadian territories, currently upload information to a map interface on the Clarus Initiative project website.	FHWA	Existing
Dynamic Late Merge Roadside Equipment	MC07, MC08	The Dynamic Late Merge System is placed in advance of lane closures due to roadway maintenance and construction. The roadside equipment consists of three portable Dynamic Message Signs (DMS) and a Remote Traffic Microwave Sensor (RTMS) detector.	MnDOT	Existing
Dynamic Message Sign Roadside Equipment	MC08	This element represents portable and permanent Dynamic Message Signs (DMS) operated throughout the state used to convey driver information on special events, maintenance and construction activity, incident management, AMBER Alerts, and transportation and national emergencies.	MnDOT, Local Agencies	Existing
Highway Advisory Radio Roadside Equipment	MC08	This represents roadside equipment that facilitates the operations of highway advisory radio (HAR) throughout Minnesota. HAR is controlled by MnDOT District Offices and city and county transportation agencies.	MnDOT, Local Agencies	Existing
Intelligent Work Zone System Roadside Equipment	MC07, MC08	This element represents an automated system of devices that provides motorists and/or workers real-time information for improved safety and mobility through a work zone. The information is categorized into 3 levels: (1) Conflict Warning - high priority information to warn motorists of eminent traffic and roadway hazards; (2) Traffic Control - provides important driving information such as advisory speeds, merging instructions, and lane control directions; and (3) Travel Information - provides information which the motorist may use to make route decisions, such as travel times, alternate route info, incident warnings and work zone staging information. Each system can be monitored and controlled as necessary by the MnDOT RTMC or TOCC operator.	MnDOT	Existing

System	Service Package(s)	Description	Stakeholder	Status
Lane/Ramp Access Control Roadside Equipment	MC08, ATMS21	This represents existing and planned automated gate closure systems along interstate highways. Existing system located on I-90 in Jackson, MN is activated during severe weather events and other severe incidents requiring freeway closures for winter roadway maintenance and snow plowing. The system includes automated gates, CCTV cameras that monitor each direction of travel at the intersection, and automated signs that warn drivers that the road ahead is closed. All components of this system are monitored and controlled by the MnDOT District 7B Office in Windom, MN. A planned gate system will be installed along I-35W at 46th St. S. in Minneapolis for a Bus Rapid Transit station. Buses will be able to activate the system with on-board equipment for automated entry and exit into and out of the station.	MnDOT	Existing
Maintenance and Construction Management Center	MC01, MC04, MC05, MC06, MC07, MC08, MC09, MC10, MC12	This element represents maintenance office, truck stations and garages of transportation agencies that perform the maintenance and construction activity including planned activities (road maintenance, snow plowing, etc.) and unplanned incidents within the jurisdiction area, and communicate maintenance and construction schedules and other related information to other agencies.	MnDOT, Local Agencies	Existing

System	Service Package(s)	Description	Stakeholder	Status
Maintenance and Construction Vehicle Equipment	MC01, MC06, MC07, MC08	This element represents maintenance vehicles that are utilized by the MnDOT and City and County Public Works/Highway Departments to support road maintenance. Automatic Vehicle Location (AVL) systems deployed on snow removal/highway maintenance vehicles within the metro area and several MnDOT Districts assist in overall snow fighting techniques, decision support systems, and area-wide highway maintenance issues for winter and summer operations. It is planned to expand the deployment of AVL systems statewide. Pilot projects conducted by MnDOT Office of Maintenance include vehicle-mounted electro-luminescence signs (Metro Area), full-matrix LED vehicle-mounted DMS (District 1/Virginia), Mold Board Lights (District 2/Crookston), and Guidance Lasers (District 7/Mankato).	MnDOT, Local Agencies	Existing
Maintenance Decision Support System	MC06	Maintenance Decision Support System (MDSS) is a server- and Client-side hardware and software package that provides winter maintenance support. MDSS offers visualizations of the real time maintenance data integrated from many sources and reports actual road conditions to establish appropriate maintenance treatments. It enables weather and roadway conditions predictions and identifies an optimal maintenance plan given user-configurable resources. Road and weather conditions, location of snowplows, and recommended chemical type and application rate are available to supervisors and dispatchers on desk-top computers. The same information is available to snow plow operators via on-board equipment.	MnDOT, MDSS Pooled Fund Study	Existing
National Weather Service	MC04, MC06, MC07	The National Oceanic and Atmospheric Administration's (NOAA) National Weather Service (NWS) provides weather, hydrologic, and climate forecasts and warnings for the United States, its territories, adjacent waters and ocean areas.	NOAA	Existing

System	Service Package(s)	Description	Stakeholder	Status
Roadway Automated Treatment System Roadside Equipment	MC05	This system remotely applies roadway chemicals due to ice conditions that may form on bridges, bridge approaches, or curves. Treatment systems exist in the metro area and MnDOT Districts 1 (Duluth), 6, (Rochester and Winona) and 7 (Cities of Worthington and Beaver Creek). Similar systems are planned for MnDOT Districts 2 and 4. Treatment systems in the metro area are connected to Advanced Warning Flashers to alert drivers of system operation. Further deployment is planned in District 6 on I-35 on the Albert Lea Lake Bridge. Mobile anti-icing systems are being tested in the metro area.	MnDOT, Local Agencies	Existing
RTMC	MC01, MC03, MC04, MC05, MC06, MC07, MC08, MC09, MC10, MC12	The RTMC is a unified communications center that houses State Patrol Dispatch, MnDOT Metro Maintenance Dispatch and MnDOT Traffic Operations. The Metro Maintenance Dispatch serves as a point of contact for incoming information. Staff handles phone calls and monitor electronic communications and the bridge de-icier system, roadway surface and sub-surface systems. Maintenance Dispatch coordinates and initiates traffic management systems with the RTMC, traffic management personnel and the State Patrol.	MnDOT	Existing
RWIS Central Control System	MC03, MC04	MnDOT RWIS Central Server collects, verifies, processes, and formats environmental and road pavement surface condition data. Data is then made available to maintenance personnel, law enforcement, vendors providing value-added services, and the general public via the 511 information system. It is planned to send RWIS data to the Condition Acquisition and Reporting System (CARS) database.	MnDOT Office of Maintenance, Local Agencies	Existing

System	Service Package(s)	Description	Stakeholder	Status
RWIS Roadside Equipment	MC03	MnDOT's RWIS Stations include 96 environmental sensor sites, designed to measure environmental conditions and road pavement surface conditions, and over 50 airport sites, designed just to measure environmental conditions, connected via statewide network. Environmental sensors are planned to be equipped with pan/tilt cameras to provide maintenance crews with additional road condition data. All data is communicated to the MnDOT RWIS Central Control System for verification, processing, and formatting. It is planned to upload camera images from RWIS stations to the MnDOT 511 Traveler Information Website (www.511mn.org).	MnDOT Office of Maintenance, Local Agencies	Existing
Surface Transportation Weather Service Providers	MC04, MC06, MC07	Providers of value-added sector specific meteorological services. These providers utilize National Weather Service data and predictions, road condition information and local environmental data to provide weather observations and forecasts. Examples include the Data Transmission Network (DTN).	Private Information Service Providers	Existing
TOCCs	MC01, MC03, MC04, MC05, MC06, MC07, MC08, MC09, MC10, MC12	The individual TOCCs are regional centers for 24-hour incident and emergency response, multi-agency dispatching and fleet management, interagency communications, collection and dissemination of road conditions and closures, traffic management, and, potentially, integrated transit operations. The roadside systems interfaced with TOCCs include CCTV, traffic detectors, DMS, variable speed limit signs, traffic signals, RWIS stations, and ice detectors. TOCCs are also equipped with CAD and CARS.	MnDOT	Existing

Appendix B: Minnesota ITS Development Objectives

General Purpose: Create a system that enhances transportation through the safe and efficient movement of people, goods, and information, with greater mobility and fuel efficiency, less pollution, and increased operating efficiency in Minnesota.

A. Improve the Safety of the State's Transportation System

A-1 Reduce crash frequency *(ATIS, ATMS, APTS, CVO, EM, MCM & AVSS)*

- A-1-01 Reduce number of vehicle crashes
- A-1-02 Reduce number of vehicle crashes per VMT
- A-1-03 Reduce number of crashes due to road weather conditions
- A-1-04 Reduce number of crashes due to unexpected congestion
- A-1-05 Reduce number of crashes due to red-light running
- A-1-06 Reduce number of crashes involving large trucks and buses
- A-1-07 Reduce number of crashes due to commercial vehicle safety violations
- A-1-08 Reduce number of crashes due to inappropriate lane departure, crossing and merging
- A-1-09 Reduce number of crashes at railroad crossings
- A-1-10 Reduce number of crashes at signalized intersections
- A-1-11 Reduce number of crashes at un-signalized intersections
- A-1-12 Reduce number of crashes due to excessive speeding
- A-1-13 Reduce number of crashes related to driving while intoxicated
- A-1-14 Reduce number of crashes related to driver inattention and distraction
- A-1-15 Reduce number of crashes involving pedestrians and non-motorized vehicles
- A-1-16 Reduce number of crashes at intersections due to inappropriate crossing
- A-1-17 Reduce number of crashes due to roadway/geometric restrictions
- A-1-18 Reduce number of crashes involving younger drivers (under 21)
- A-1-19 Reduce number of all secondary crashes

A-2 Reduce fatalities and life changing injuries *(ATIS, ATMS, APTS, CVO, EM, MCM & AVSS)*

- A-2-01 Reduce number of roadway fatalities
- A-2-02 Reduce number of roadway fatalities per VMT
- A-2-03 Reduce number of fatalities due to road weather conditions
- A-2-04 Reduce number of fatalities due to unexpected congestion
- A-2-05 Reduce number of fatalities due to red-light running
- A-2-06 Reduce number of fatalities involving large trucks and buses
- A-2-07 Reduce number of fatalities due to commercial vehicle safety violations
- A-2-08 Reduce number of transit fatalities
- A-2-09 Reduce number of fatalities due to inappropriate lane departure, crossing and merging
- A-2-10 Reduce number of fatalities at railroad crossings
- A-2-11 Reduce number of fatalities at signalized intersections
- A-2-12 Reduce number of fatalities at un-signalized intersections
- A-2-13 Reduce number of fatalities due to excessive speeding
- A-2-14 Reduce number of fatalities related to driving while intoxicated
- A-2-15 Reduce number of fatalities related to driver inattention and distraction
- A-2-16 Reduce number of fatalities involving pedestrians and non-motorized vehicles
- A-2-17 Reduce number of fatalities at intersections due to inappropriate crossing
- A-2-18 Reduce number of fatalities due to roadway/geometric restrictions
- A-2-19 Reduce number of fatalities involving younger drivers (under 21)

A-2-20 Reduce number of fatalities involving unbelted vehicle occupants
A-2-21 Reduce number of hazardous materials transportation incidents involving fatalities
A-2-22 Reduce number of roadway injuries
A-2-23 Reduce number of roadway injuries per VMT
A-2-24 Reduce number of injuries due to road weather conditions
A-2-25 Reduce number of injuries due to unexpected congestion
A-2-26 Reduce number of injuries due to red-light running
A-2-27 Reduce number of injuries involving large trucks and buses
A-2-28 Reduce number of injuries due to commercial vehicle safety violations
A-2-29 Reduce number of transit injuries
A-2-30 Reduce number of injuries due to inappropriate lane departure, crossing and merging
A-2-31 Reduce number of injuries at railroad crossings
A-2-32 Reduce number of injuries at signalized intersections
A-2-33 Reduce number of injuries at un-signalized intersections
A-2-34 Reduce number of injuries due to excessive speeding
A-2-35 Reduce number of injuries related to driving while intoxicated
A-2-36 Reduce number of injuries related to driver inattention and distraction
A-2-37 Reduce number of injuries involving pedestrians and non-motorized vehicles
A-2-38 Reduce number of injuries at intersections due to inappropriate crossing
A-2-39 Reduce number of injuries due to roadway/geometric restrictions
A-2-40 Reduce number of injuries involving younger drivers (under 21)
A-2-41 Reduce number of injuries involving unbelted vehicle occupants
A-2-42 Reduce number of hazardous materials transportation incidents involving injuries
A-2-43 Reduce number of speed violations
A-2-44 Reduce number of traffic law violations

A-3 Reduce crashes in work zones *(ATIS, ATMS, EM, MCM & AVSS)*
A-3-01 Reduce number of crashes in work zones
A-3-02 Reduce number of fatalities in work zones
A-3-03 Reduce number of motorist injuries in work zones
A-3-04 Reduce number of workers injured by vehicles in work zones

B. Increase Operational Efficiency and Reliability of the Transportation System

B-1 Reduce overall delay associated with congestion *(ATIS, ATMS, MCM & AVSS)*
B-1-01 Reduce the percentage of facility miles (highway, arterial, rail, etc.) experiencing recurring congestion during the peak period
B-1-02 Reduce the percentage of Twin Cities freeway miles congested in weekday peak periods
B-1-03 Reduce the share of major intersections operating at LOS F
B-1-04 Maintain the rate of growth in facility miles experiencing recurring congestion as less than the population growth rate (or employment growth rate)
B-1-05 Reduce the daily hours of recurring congestion on major freeways
B-1-06 Reduce the number of hours per day that the top 20 most congested roadways experience recurring congestion
B-1-07 Reduce the regional average travel time index
B-1-08 Annual rate of change in regional average commute travel time will not exceed regional rate of population growth
B-1-09 Improve average travel time during peak periods

- B-1-10 Reduce hours of delay per capita
- B-1-11 Reduce hours of delay per driver
- B-1-12 Reduce the average of the 90th (or 95th) percentile travel times for (a group of specific travel routes or trips in the region)
- B-1-13 Reduce the 90th (or 95th) percentile travel times for each route selected
- B-1-14 Reduce the variability of travel time on specified routes during peak and off-peak periods
- B-1-15 Reduce mean incident notification time
- B-1-16 Reduce mean time for needed responders to arrive on-scene after notification
- B-1-17 Reduce mean incident clearance time per incident
- B-1-18 Reduce mean incident clearance time for Twin Cities urban freeway incidents

B-2 Increase average vehicle occupancy and facility throughput *(ATMS & APTS)*

- B-2-01 Increase annual transit ridership
- B-2-02 Increase annual express bus ridership
- B-2-03 Increase annual light rail ridership
- B-2-04 Increase annual commuter rail ridership
- B-2-05 Maintain agency pre-defined performance targets for rides per hour of transit service
- B-2-06 Maintain transit passengers per capita rate for service types
- B-2-07 Maintain the cost efficiency of the statewide public transit network
- B-2-08 Maintain the service effectiveness of the statewide public transit network in terms of passengers/service hour and passengers/mile
- B-2-09 Maintain the cost effectiveness of the statewide public transit network in terms of cost per service hour, cost per passenger trip, and revenue recovery percentage
- B-2-10 Maintain the availability of the statewide public transit network in terms of hours (span) of service and frequency
- B-2-11 Reduce per capita single occupancy vehicle commute trip rate
- B-2-12 Increase the percentage of major employers actively participating in transportation demand management programs
- B-2-13 Reduce commuter vehicle miles traveled (VMT) per regional job
- B-2-14 Create a transportation access guide, which provides concise directions to reach destinations by alternative modes (transit, walking, bike, etc.)
- B-2-15 Improve average on-time performance for specified transit routes/facilities
- B-2-16 Increase use of automated fare collection system per year
- B-2-17 Increase the percent of transfers performed with automated fare cards
- B-2-18 Increase the miles of bus-only shoulder lanes in the metro area
- B-2-19 Increase the number of carpools
- B-2-20 Increase use of vanpools
- B-2-21 Provide carpool/vanpool matching and ridesharing information services
- B-2-22 Reduce trips per year in region through carpools/vanpools
- B-2-23 Increase vehicle throughput on specified routes
- B-2-24 Increase AM/PM peak hour vehicle throughput on specified routes
- B-2-25 Increase AM/PM peak hour person throughput on specified routes

B-3 Reduce delays due to work zones *(ATIS, ATMS, EM, MCM & AVSS)*

- B-3-01 Reduce total vehicle hours of delay by time period (peak, off-peak) caused by work zones
- B-3-02 Reduce the percentage of vehicles traveling through work zones that are queued

B-3-03 Reduce the average and maximum length of queues, when present,
B-3-04 Reduce the average time duration (in minutes) of queue length greater than some threshold (e.g., 0.5 mile)
B-3-05 Reduce the variability of travel time in work zones during peak and off-peak periods

B-4 Reduce traffic delays during evacuation from homeland security and Hazmat incidents *(ATIS, ATMS, APTS, CVO, EM, MCM & AVSS)*
B-4-01 Reduce vehicle hours of delay per capita during evacuation from homeland security and Hazmat incidents

C. Enhance Mobility, Convenience, and Comfort for Transportation System Users

C-1 Reduce congestion and incident-related delay for travelers *(ATIS, ATMS, APTS, EM & AVSS)*
B-1-01 Reduce the percentage of facility miles (highway, arterial, rail, etc.) experiencing recurring congestion during the peak period
B-1-02 Reduce the percentage of Twin Cities freeway miles congested in weekday peak periods
B-1-03 Reduce the share of major intersections operating at LOS F
B-1-04 Maintain the rate of growth in facility miles experiencing recurring congestion as less than the population growth rate (or employment growth rate)
B-1-05 Reduce the daily hours of recurring congestion on major freeways
B-1-06 Reduce the number of hours per day that the top 20 most congested roadways experience recurring congestion
B-1-07 Reduce the regional average travel time index
B-1-08 Annual rate of change in regional average commute travel time will not exceed regional rate of population growth
B-1-09 Improve average travel time during peak periods
B-1-10 Reduce hours of delay per capita
B-1-11 Reduce hours of delay per driver
B-1-12 Reduce the average of the 90th (or 95th) percentile travel times for (a group of specific travel routes or trips in the region)
B-1-13 Reduce the 90th (or 95th) percentile travel times for each route selected
B-1-14 Reduce the variability of travel time on specified routes during peak and off-peak periods
B-1-15 Reduce mean incident notification time
B-1-16 Reduce mean time for needed responders to arrive on-scene after notification
B-1-17 Reduce mean incident clearance time per incident
B-1-18 Reduce mean incident clearance time for Twin Cities urban freeway incidents
C-1-01 Reduce the vehicle hours of total delay associated with traffic incidents during peak and off-peak periods
C-1-02 Increase percentage of incident management agencies in the region that participate in a multi-modal information exchange network
C-1-03 Increase percentage of incident management agencies in the region that use interoperable voice communications
C-1-04 Increase percentage of incident management agencies in the region that participate in a regional coordinated incident response team
C-1-05 Increase the number of corridors in the region covered by regional coordinated incident response teams
C-1-06 Maintain a percentage of transportation operating agencies have a plan in place for a representative to be at the local or State Emergency Operations

Center (EOC) to coordinate strategic activities and response planning for transportation during emergencies
- C-1-07 Conduct joint training exercises among operators and emergency responders in the region
- C-1-08 Maintain a percentage of staff in region with incident management responsibilities who have completed the National Incident Management System (NIMS) Training and a percentage of transportation responders in the region are familiar with the incident command structure (ICS)
- C-1-09 Increase number of regional road miles covered by ITS-related assets (e.g., roadside cameras, dynamic message signs, vehicle speed detectors) in use for incident detection/response
- C-1-10 Increase number of traffic signals equipped with emergency vehicle preemption

C-2 Improve travel time reliability *(ATIS, ATMS, APTS & AVSS)*
- B-1-07 Reduce the regional average travel time index
- B-1-12 Reduce the average of the 90th (or 95th) percentile travel times for (a group of specific travel routes or trips in the region)
- B-1-14 Reduce the variability of travel time on specified routes during peak and off-peak periods
- B-2-15 Improve average on-time performance for specified transit routes/facilities
- B-2-16 Increase use of automated fare collection system per year
- B-2-17 Increase the percent of transfers performed with automated fare cards
- C-2-01 Decrease the average buffer index for multiple routes or trips
- C-2-02 Reduce the average planning time index for specific routes in region
- C-2-03 Increase the miles of bus-only shoulder lanes in the metro area

C-3 Increase choice of travel modes *(ATIS, ATMS & APTS)*
- B-2-01 Increase annual transit ridership
- B-2-11 Reduce per capita single occupancy vehicle commute trip rate
- B-2-12 Increase the percentage of major employers actively participating in transportation demand management programs
- B-2-13 Reduce commuter vehicle miles traveled (VMT) per regional job
- B-2-14 Create a transportation access guide, which provides concise directions to reach destinations by alternative modes (transit, walking, bike, etc.)
- C-3-01 Increase active (bicycle/pedestrian) mode share
- C-3-02 Reduce single occupancy vehicle trips through travel demand management strategies (e.g., employer or residential rideshare)
- C-3-03 Increase the percent of alternative (non-single occupancy vehicle) mode share in transit station communities (or other areas)
- C-3-04 Increase transit mode share
- C-3-05 Increase transit mode share during peak periods
- C-3-06 Increase average transit load factor
- C-3-07 Increase passenger miles traveled per capita on transit
- C-3-08 Reduce the travel time differential between transit and auto during peak periods per year
- C-3-09 Increase the percent of the transportation system in which travel conditions can be detected remotely via CCTV, speed detectors, etc.
- C-3-10 Increase the percent of transportation facilities whose owners share their traveler information with other agencies in the region
- C-3-11 Increase number of 511 calls per year

C-3-12 Increase number of visitors to traveler information website per year
C-3-13 Increase number of users of notifications for traveler information (e.g., e-mail, text message)
C-3-14 Increase the number of transit routes with information being provided by ATIS
C-3-15 Increase the number of specifically tailored traveler information messages provided
C-3-16 Increase annual transit ridership reported by urbanized area transit providers
C-3-17 Increase annual transit ridership reported by rural area transit providers

C-4 Reduce stress caused by transportation *(ATIS, ATMS, APTS, EM, MCM & AVSS)*
A-2-43 Reduce number of speed violations
A-2-44 Reduce number of traffic law violations
B-1-01 Reduce the percentage of facility miles (highway, arterial, rail, etc.) experiencing recurring congestion during the peak period
B-1-02 Reduce the percentage of Twin Cities freeway miles congested in weekday peak periods
B-1-03 Reduce the share of major intersections operating at LOS F
B-1-04 Maintain the rate of growth in facility miles experiencing recurring congestion as less than the population growth rate (or employment growth rate)
B-1-05 Reduce the daily hours of recurring congestion on major freeways
B-1-06 Reduce the number of hours per day that the top 20 most congested roadways experience recurring congestion
B-1-07 Reduce the regional average travel time index
B-1-08 Annual rate of change in regional average commute travel time will not exceed regional rate of population growth
B-1-09 Improve average travel time during peak periods
B-1-10 Reduce hours of delay per capita
B-1-11 Reduce hours of delay per driver
B-1-12 Reduce the average of the 90th (or 95th) percentile travel times for (a group of specific travel routes or trips in the region)
B-1-13 Reduce the 90th (or 95th) percentile travel times for each route selected
B-1-14 Reduce the variability of travel time on specified routes during peak and off-peak periods
B-1-15 Reduce mean incident notification time
B-1-16 Reduce mean time for needed responders to arrive on-scene after notification
C-3-11 Increase number of 511 calls per year
C-3-12 Increase number of visitors to traveler information website per year
C-3-13 Increase number of users of notifications for traveler information (e.g., e-mail, text message)
C-3-14 Increase the number of transit routes with information being provided by ATIS
C-3-15 Increase the number of specifically tailored traveler information messages provided
C-4-01 Reduce the speed differential between lanes of traffic on multi-lane highways
C-4-02 Increase the number of users aware of park-and-ride lots in their region
C-4-03 Increase the number parking facilities with electronic fee collection
C-4-04 Increase the number of parking facilities with automated occupancy counting and space management
C-4-05 Increase the number of parking facilities with advanced parking information to customers
C-4-06 Increase the number of parking facilities with coordinated electronic payment systems

C-4-07 Increase the number of parking facilities with coordinated availability information

D. Improve the Security of the Transportation System

D-1 Enhance traveler security *(APTS & EM)*

C-3-09 Increase the percent of the transportation system in which travel conditions can be detected remotely via CCTV, speed detectors, etc.
D-1-01 Reduce on an annual basis the number of complaints per 1,000 boarding passengers
D-1-02 Increase the number of closed circuit television (CCTV) cameras installed on platforms, park-n-ride lots, vehicles, and other transit facilities
D-1-03 Increase customer service and personal safety ratings
D-1-04 Reduce the number of reported personal safety incidents
D-1-05 Decrease the number of security incidents on roadways
D-1-06 Increase the percent of major and minor arterials are equipped with and operating with closed circuit television (CCTV) cameras
D-1-07 Increase the number of critical sites with security surveillance
D-1-08 Reduce the number of security incidents on transportation infrastructure
D-1-09 Increase the number of critical sites with hardened security enhancements

D-2 Safeguard the motoring public from homeland security and/or Hazmat incidents *(ATIS, ATMS, APTS, CVO, EM, MCM & AVSS)*

B-1-16 Reduce mean time for needed responders to arrive on-scene after notification
C-3-09 Increase the percent of the transportation system in which travel conditions can be detected remotely via CCTV, speed detectors, etc.
D-1-01 Reduce on an annual basis the number of complaints per 1,000 boarding passengers
D-1-02 Increase the number of closed circuit television (CCTV) cameras installed on platforms, park-n-ride lots, vehicles, and other transit facilities
D-1-03 Increase customer service and personal safety ratings
D-1-04 Reduce the number of reported personal safety incidents
D-1-05 Decrease the number of security incidents on roadways
D-1-06 Increase the percent of major and minor arterials are equipped with and operating with closed circuit television (CCTV) cameras
D-1-07 Increase the number of critical sites with security surveillance
D-1-08 Reduce the number of security incidents on transportation infrastructure
D-1-09 Increase the number of critical sites with hardened security enhancements
D-2-01 Reduce the number of Hazmat incidents
D-2-02 Reduce the number of homeland security incidents
D-2-03 Increase the number of travelers routed around Hazmat incidents
D-2-04 Increase the number of travelers routed around homeland security incidents
D-2-05 Reduce the Hazmat incident response time
D-2-06 Reduce the homeland security incident response time
D-2-07 Increase the number of Hazmat shipments tracked in real-time

E. Support Regional Economic Productivity and Development

E-1 Reduce travel time for freight, transit and businesses *(ATIS, ATMS, APTS, CVO & AVSS)*

B-1-14 Reduce the variability of travel time on specified routes during peak and off-peak periods
B-2-15 Improve average on-time performance for specified transit routes/facilities

B-2-16 Increase use of automated fare collection system per year
B-2-17 Increase the percent of transfers performed with automated fare cards
C-2-09 Increase the miles of bus-only shoulder lanes in the metro area
C-3-08 Reduce the travel time differential between transit and auto during peak periods per year
E-1-01 Maintain a travel time differential between transit and auto during peak periods
E-1-02 Improve average transit travel time compared to auto in major corridors
E-1-03 Decrease the annual average travel time index for selected freight-significant highways
E-1-04 Decrease point-to-point travel times on selected freight-significant highways
E-1-05 Decrease hours of delay per 1,000 vehicle miles traveled on selected freight-significant highways

E-2 Improve the efficiency of freight movement, permitting and credentials process *(ATIS & CVO)*
E-2-01 Increase the percent (or number) of commercial vehicles tracked by trucking companies
E-2-02 Increase the percent (or number) of freight shipment tracked
E-2-03 Increase the percent of agencies involved in CVO inspection, administration, enforcement, and emergency management in the region with interoperable communications
E-2-04 Increase the use of electronic credentialing at weigh stations and border crossings
E-2-05 Increase the number of automated permits/credentials issued
E-2-06 Reduce the frequency of delays per month at intermodal facilities
E-2-07 Reduce the average duration of delays per month at intermodal facilities

E-3 Improve travel time reliability for freight, transit and businesses *(ATMS, APTS, CVO & AVSS)*
B-1-14 Reduce the variability of travel time on specified routes during peak and off-peak periods
B-2-15 Improve average on-time performance for specified transit routes/facilities
B-2-16 Increase use of automated fare collection system per year
B-2-17 Increase the percent of transfers performed with automated fare cards
C-1-06 Increase percentage of incident management agencies in the region that participate in a multi-modal information exchange network
C-2-09 Increase the miles of bus-only shoulder lanes in the metro area
C-3-09 Increase the percent of the transportation system in which travel conditions can be detected remotely via CCTV, speed detectors, etc.
C-3-10 Increase the percent of transportation facilities whose owners share their traveler information with other agencies in the region
C-3-13 Increase number of users of notifications for traveler information (e.g., e-mail, text message)
E-1-08 Decrease the annual average travel time index for selected freight-significant highways
E-2-04 Increase the use of electronic credentialing at weigh stations and border crossings
E-3-01 Reduce average crossing times at international borders

E-4 Increase agency efficiency *(ADMS, ATMS, APTS, CVO, EM & MCM)*

- B-2-15 Improve average on-time performance for specified transit routes/facilities
- B-2-16 Increase use of automated fare collection system per year
- B-2-17 Increase the percent of transfers performed with automated fare cards
- C-2-09 Increase the miles of bus-only shoulder lanes in the metro area
- E-2-01 Increase the percent (or number) of commercial vehicles tracked by trucking companies
- E-2-03 Increase the percent of agencies involved in CVO inspection, administration, enforcement, and emergency management in the region with interoperable communications
- E-4-01 Increase the number of ITS-related assets tracked
- E-4-02 Reduce the number of pavement miles damaged by commercial vehicles
- E-4-03 Increase the rate of on-time completion of construction projects
- E-4-04 Increase the rate at which equipment is utilized
- E-4-05 Increase the percentage of fleet/equipment within its lifecycle
- E-4-06 Increase the number of fleet vehicles with maintenance diagnostic equipment
- E-4-07 Increase the number of vehicles operating under CAD

E-5 Reduce vehicle operating costs *(ATMS, APTS, CVO & AVSS)*

- B-1-01 Reduce the percentage of facility miles (highway, arterial, rail, etc.) experiencing recurring congestion during the peak period
- B-1-02 Reduce the percentage of Twin Cities freeway miles congested in weekday peak periods
- B-1-03 Reduce the share of major intersections operating at LOS F
- B-1-04 Maintain the rate of growth in facility miles experiencing recurring congestion as less than the population growth rate (or employment growth rate)
- B-1-05 Reduce the daily hours of recurring congestion on major freeways
- B-1-06 Reduce the number of hours per day that the top 20 most congested roadways experience recurring congestion
- B-1-07 Reduce the regional average travel time index
- B-1-08 Annual rate of change in regional average commute travel time will not exceed regional rate of population growth
- B-1-09 Improve average travel time during peak periods
- B-1-10 Reduce hours of delay per capita
- B-1-11 Reduce hours of delay per driver
- B-1-12 Reduce the average of the 90th (or 95th) percentile travel times for (a group of specific travel routes or trips in the region)
- B-1-13 Reduce the 90th (or 95th) percentile travel times for each route selected
- B-1-14 Reduce the variability of travel time on specified routes during peak and off-peak periods

E-6 Enhance efficiency at borders *(ATIS & CVO)*

- E-2-04 Increase the use of electronic credentialing at weigh stations and border crossings
- E-3-11 Reduce average crossing times at international borders

F. Preserve the Transportation System

F-1 Safeguard existing infrastructure *(ATMS, CVO, EM & MCM)*

- C-3-09 Increase the percent of the transportation system in which travel conditions can be detected remotely via CCTV, speed detectors, etc.

D-1-06 Increase the percent of major and minor arterials are equipped with and operating with closed circuit television (CCTV) cameras
D-1-07 Increase the number of critical sites with security surveillance
D-1-08 Reduce the number of security incidents on transportation infrastructure
D-1-09 Increase the number of critical sites with hardened security enhancements
E-2-03 Increase the percent of agencies involved in CVO inspection, administration, enforcement, and emergency management in the region with interoperable communications
E-4-03 Increase the rate of on-time completion of construction projects
F-1-01 Decrease the number of pavement miles damaged by commercial vehicles
F-1-02 Decrease the number of size and weight violations

G. Enhance the Integration and Connectivity of the Transportation System

G-1 Aid in transportation infrastructure and operations planning *(ALL)*

G-1-01 Increase the amount of data gathered from ITS enhancements used in infrastructure and operations planning
G-1-02 Increase the number of planning activities using data from ITS systems
G-1-03 Increase the number of years of data in database that is easily searchable and extractable
G-1-04 Reduce project schedule deviation
G-1-05 Reduce project cost deviation
G-1-06 Reduce operations cost deviation
G-1-07 Reduce administrative support rate (as part of overall project budget)

G-2 Reduce need for new facilities *(ATMS, CVO, MCM & AVSS)*

B-1-01 Reduce the percentage of facility miles (highway, arterial, rail, etc.) experiencing recurring congestion during the peak period
B-1-02 Reduce the percentage of Twin Cities freeway miles congested in weekday peak periods
B-1-03 Reduce the share of major intersections operating at LOS F
B-1-04 Maintain the rate of growth in facility miles experiencing recurring congestion as less than the population growth rate (or employment growth rate)
B-1-05 Reduce the daily hours of recurring congestion on major freeways
B-1-06 Reduce the number of hours per day that the top 20 most congested roadways experience recurring congestion
B-1-07 Reduce the regional average travel time index
B-1-08 Annual rate of change in regional average commute travel time will not exceed regional rate of population growth
B-1-09 Improve average travel time during peak periods
B-1-10 Reduce hours of delay per capita
B-1-11 Reduce hours of delay per driver
B-1-12 Reduce the average of the 90th (or 95th) percentile travel times for (a group of specific travel routes or trips in the region)
B-1-13 Reduce the 90th (or 95th) percentile travel times for each route selected
B-1-14 Reduce the variability of travel time on specified routes during peak and off-peak periods
E-2-04 Increase the use of electronic credentialing at weigh stations and border crossings
E-2-05 Increase the number of automated permits/credentials issued
E-3-11 Reduce average crossing times at international borders

H. Reduce Environmental Impacts

H-1 Reduce emissions/energy impacts and use associated with congestion *(ATIS, ATMS, CVO & AVSS)*

- B-1-01 Reduce the percentage of facility miles (highway, arterial, rail, etc.) experiencing recurring congestion during the peak period
- B-1-02 Reduce the percentage of Twin Cities freeway miles congested in weekday peak periods
- B-1-03 Reduce the share of major intersections operating at LOS F
- B-1-04 Maintain the rate of growth in facility miles experiencing recurring congestion as less than the population growth rate (or employment growth rate)
- B-1-05 Reduce the daily hours of recurring congestion on major freeways
- B-1-06 Reduce the number of hours per day that the top 20 most congested roadways experience recurring congestion
- B-1-07 Reduce the regional average travel time index
- B-1-08 Annual rate of change in regional average commute travel time will not exceed regional rate of population growth
- B-1-09 Improve average travel time during peak periods
- B-1-10 Reduce hours of delay per capita
- B-1-11 Reduce hours of delay per driver
- B-1-12 Reduce the average of the 90th (or 95th) percentile travel times for (a group of specific travel routes or trips in the region)
- B-1-13 Reduce the 90th (or 95th) percentile travel times for each route selected
- B-1-14 Reduce the variability of travel time on specified routes during peak and off-peak periods
- H-1-01 Reduce excess fuel consumed due to congestion
- H-1-02 Reduce total fuel consumed per capita for transportation
- H-1-03 Reduce vehicle miles traveled per capita
- H-1-04 Reduce MnDOT fleet gasoline use
- H-1-05 Reduce MnDOT fleet diesel use
- H-1-06 Reduce the amount of all emissions in the atmosphere
- H-1-07 Reduce the amount of carbon dioxide emissions measured

H-2 Reduce negative impacts of the transportation system on communities *(ATMS, APTS, EM & MCM)*

- A-2-44 Reduce number of traffic law violations
- B-2-01 Increase annual transit ridership
- B-2-12 Increase the percentage of major employers actively participating in transportation demand management programs
- B-2-13 Reduce commuter vehicle miles traveled (VMT) per regional job
- B-2-14 Create a transportation access guide, which provides concise directions to reach destinations by alternative modes (transit, walking, bike, etc.)
- B-2-19 Increase the number of carpools
- B-2-20 Increase use of vanpools
- B-2-21 Provide carpool/vanpool matching and ridesharing information services
- B-2-22 Reduce trips per year in region through carpools/vanpools
- H-2-01 Increase the average vehicle occupancy rate in HOV lanes
- H-2-02 Increase the amount of environmentally friendly de-icing material used

Appendix C: Needs and Services Detail

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Archive Need	Associated Service Package
Service Package MC01 - Maintenance and Construction Vehicle and Equipment Tracking								
WZ01	Track locations of maintenance fleet and personnel and usage of materials	• MnDOT maintenance, RTMC in the metro area and MnDOT Districts as well as local agencies use AVL systems, sensors, and equipment on snow removal/ maintenance vehicles to assist in snow fighting techniques, decision support systems, and area-wide highway maintenance issues for winter and summer operations. • Vehicle and equipment tracking also assists with personnel management • Data on winter maintenance activities can be used for traveler information.	• AVL systems on snow removal/ maintenance vehicles are used to report vehicle location. • On-board sensors and equipment are used to report material usage and equipment status. • Striper vehicles have a pavement marking management tool that allows them to see where pavement markings have been installed.	• MnDOT plans to expand the deployment of AVL systems to other Districts. • Counties will deploy AVL on their fleets of winter maintenance vehicles. • Information on snow plow activities will be shared with the public in Hennepin County. • Material information from trucks automatically fed to RCA for material usage. • GIS could be better used to understand where field equipment is and when it can be utilized.	• MnDOT maintenance and local agencies are responsible to plan, design, construct, operate, and maintain AVL systems for their fleet.	• AVL systems include interconnects between maintenance vehicles and RTMC/TOCC/ local maintenance and construction management centers. • AVL systems also include interconnects with traveler information systems (such as CARS) for travel information about which roads have been plowed.	• Data on maintenance material usage is archived for future analysis and planning. • Data on vehicle location archived for tort claims and personnel issues. • Automation of collected information into a database (e.g. salt usage, road conditions, current pavement conditions, chemical usage, etc.)	• MC06

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Archive Need	Associated Service Package
Service Package MC02 - Maintenance and Construction Vehicle Maintenance								
While there are maintenance and construction vehicle maintenance systems in Minnesota, no needs or services under this service package were identified by stakeholders.								

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Archive Need	Associated Service Package
Service Package MC03 – Road Weather Data Collection								
WZ04	Provide automated monitoring of road weather conditions	• MnDOT, NWS and local agencies use RWIS and AWOS to measure environmental and pavement surface conditions to assist in decisions on snow plowing schedules and chemical applications. • Law enforcement and local maintenance agencies access the data to dispatch and manage fleets. • Vendors use data to combine with value-added services, and offer information to the public. • The public uses the information to make travel decisions. • Data is shared with the Clarus system to out-of-state travelers.	• MnDOT uses over 90 RWIS sites, and over 50 airport sites, connected via a statewide network to measure road pavement and environmental conditions and over 80 MnDOT maintenance vehicles equipped with sensors. • Data is currently being downloaded from the RWIS Central Server by UM Duluth's Transportation Data Research Laboratory (TDRL) for archiving.	• Equip RWIS Stations with pan/tilt cameras to provide maintenance crews with additional road condition data • Upload camera images to the 511 website. • Transmit RWIS data from the central server to the CARS database. • Plan to obtain data from 700+ MnDOT maintenance vehicles (i.e. pavement and environmental conditions). • Limitations to how long the road weather condition data is stored.	• MnDOT Maintenance is responsible to plan, design, construct, operate and maintain the statewide RWIS system. • TDRL is responsible for data archiving.	• Automated monitoring systems include interconnects between roadside RWIS stations and the central RWIS server. The central RWIS server includes connections to RTMC/TOCCs/ local MCM centers as well as traveler information services. • This service also includes interconnects between the central RWIS server and the national Clarus database.	• RWIS data and MDSS should be archived for identifying trends and aiding in snow removal strategy planning as well as pavement condition modeling.	• MC04

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Archive Need	Associated Service Package
Service Package MC04 - Weather Information Processing and Distribution								
WZ04	Provide automated monitoring of road weather conditions	• See information under MC03						
Service Package MC05 – Roadway Automated Treatment								
WZ07	Provide roadway automated treatment with stationary units	• MnDOT Maintenance and local agencies use roadway automated treatment systems to apply anti-icing chemicals to bridges and roadway segments with recurring icing issues.	• Roadway automated treatment systems are currently in place in MnDOT Districts 1, 4, 6, 7, and the metro area. • Systems have connections to Advance Warning Flashers in the Twin Cities metro area to alert drivers of system operation.	• Deployment of similar systems is planned in other MnDOT Districts. • Portable anti-icing systems are being tested in the metro area. • Systems are planned for the Cities of Moorhead and East Grand Forks.	• MnDOT Maintenance and local agencies are responsible to plan, design, construct, operate and maintain systems on their roadways.	• Automated treatment systems include interconnects between roadside detection equipment and roadside treatment equipment • They also include interconnects between roadside equipment and RTMC/TOCCs/ local MCM centers.	• Data on system operation time, chemical amounts, and usage will be archived for maintenance decision making and resource allocation analysis.	
Service Package MC06 – Winter Maintenance								
WZ01	Track locations of maintenance fleet and personnel and usage of materials	See information under MC01						

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Archive Need	Associated Service Package
WZ08	Provide maintenance decision support	• MnDOT Metro Maintenance, district offices, use MDSS (Maintenance and Decision Support System) to view real-time maintenance data integrated from many sources, as well as, reports on road conditions to establish appropriate maintenance treatments.	• MnDOT Districts 1, 2, 3, 4, and 6 have begun the deployment of MDSS. • MDSS is used at the truck station level.	• Expand the use of MDSS system to other Districts.	• MnDOT is responsible for implementation, operations, and maintenance of MDSS system.	• Decision support systems includes interconnects between vehicles and the RTMC/TOCCs as well as roadside detection equipment and the RTMC/TOCCs.	• Maintenance support recommendations will be archived for future analysis, resource allocation, and treatment planning.	
WZ16	Provide additional warning on back of snowplow	• MnDOT Maintenance and local agencies install highly visible warning devices on the back of snowplows to provide added warnings to travelers.	• MnDOT maintenance is conducting a pilot study to install LED signs on the back of snowplows to provide warnings.	• Analyze and evaluate the pilot study results. • Research other methods and systems for providing warnings. • Implement LED signs or other proven effective warning systems.	• MnDOT is responsible for the research, development, evaluation, implementation, operations, and maintenance of the warning system.	• None.	• None.	• MC08

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Archive Need	Associated Service Package
Service Package MC07 – Roadway Maintenance and Construction								
WZ10	Use GPS/GIS data to target and record replacement and repair of infrastructure	• MnDOT Maintenance and local agencies use GIS databases to track maintenance work, determine when roadway infrastructure needs repair or replacement, and generate reports.	• MnDOT Maintenance and some local agencies currently maintain limited GPS/GIS based infrastructure data.	• Upgrade GIS and data management systems to incorporate GIS data of transportation infrastructure and ITS devices. • Gather GPS data for infrastructure inventory.	• MnDOT Maintenance and local agencies are responsible to plan, design, construct, operate, and maintain their systems.	• The MnDOT infrastructure data management system has interconnects between RTMC/TOCCs and the central server that houses the database. • Local agency infrastructure databases are self-contained.	• Infrastructure GPS/GIS data will be saved and archived for future analysis and planning.	
WZ18	Enforce timely sign changes in construction zones	• MnDOT Maintenance, local agencies and construction contractors changes the contents and placements of signs in and around work zones in a timely fashion to minimize traveler inconvenience and confusion and delay through work zones.	• MnDOT Maintenance, local agencies and construction contractors set up signage in accordance with the construction plans but may not change and/or remove signage in a timely fashion.	• Develop a policy or guidelines, provide training to agency and contractor staff, and enforcement the policy through field visits, inspections and contractor incentives and penalties in the construction contracts for timely sign changes and removals.	• MnDOT Maintenance and local agencies are responsible to develop a policy or guidelines, develop and provide training, and enforcement the policy and guidelines.	• None.	• None.	• MC08

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Archive Need	Associated Service Package
Service Package MC08 -Work Zone Management								
WZ06	Provide queue detection and advisory to warn traffic of a stopped queue at work zone	• MnDOT and local agencies responsible for traffic control and management at and near work zones use vehicle queue detection systems and dynamic message signs to alert drivers of stopped vehicle queue within a work zone, reducing number of crashes. • Drivers use this system to determine whether to take an alternate route or to slow down when approaching a work zone.	• Portable queue detection and advisory systems and dynamic message signs have been used by MnDOT maintenance crews and construction crews on freeway construction projects as an IWZ application.	• Deploy portable queue detection and advisory IWZ systems at construction projects in smaller urban and rural centers and throughout MnDOT Districts. • Establishing queue lengths that warrant advisory to traffic about stopped or slow moving queues. • Storing queue length system data for later analysis.	• MnDOT and local agencies are responsible to plan, design, construct, operate, and maintain the queue detection and advisory system.	• The queue detection and advisory system includes interconnects between roadside detection/monitoring equipment and portable roadside DMS/HAR.	• None. No data is archived from the queue detection and advisory system.	• ATMS01

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Archive Need	Associated Service Package
WZ09	Provide dynamic late merge systems for construction/ maintenance activities	• MnDOT Construction and local agencies use dynamic late merge systems to help drivers merge in an orderly fashion when entering a work zone, reducing delays and crashes. • Drivers use this system to inform them when they should safely merge into a queue entering a work zone. • Systems are utilized for major maintenance and construction projects that occur over long-term periods.	• Dynamic late merge systems have become known as Active Zipper Merge systems. • Systems are an application of IWZ systems. • Portable systems have been used on freeway construction projects in the Twin Cities metro area.	• Systems will be deployed at construction projects in smaller urban and rural centers.	• MnDOT Pre-Design and Construction are responsible to plan, design, construct, and operate the dynamic late merge system.	• Systems include interconnects between roadside detection equipment and roadside signage equipment. They also include interconnects to RTMC/TOCCs/ local maintenance and construction centers for operator override.	• None. No data is archived from the dynamic late merge system.	

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Archive Need	Associated Service Package
WZ11	Provide work zone information to travelers	• Real-time reporting systems in combination with en route and pre-trip services disseminate instant and accurate information to travelers through various traveler information systems (511, DMS, HAR, media, etc.) as well as to MnDOT Maintenance, MSP, and local agencies on road conditions, construction, incidents, special events, and over dimension vehicle restrictions.	• MnDOT District maintenance and Minnesota State Patrol use CARS to enter roadway and work zone information. • In MnDOT District 7, data entry occurs via web-enabled cell phones with approximately 75 users, primarily snow plow operators. • HAR provides detailed information about road construction prior to the project start and as work is underway. • Travel time, delay, and route management information are metro applications of IWZ systems. • MnDOT uses social media to provide work zone information. • DMS in District 3 warn drivers about snow plows on roadway ahead.	• Improve accuracy of data entry on work zones. • Provide real-time work zone information to travelers. • MnDOT District 6 plans for data entry via web-enabled cell phones. • Institutionalize remote data entry capabilities (similar to District 7). • Integrate CARS with Minnesota State Patrol CAD system. • Improve the level of detail of the reporting system. • Simplify the data entry system. • Automating lane closures with field ITS devices used for lane closures. • Automating work zone information on field devices. • Allowing contractors to update information on 511 system.	• CARS is maintained by MnDOT Maintenance. • MnDOT staff at District Offices and TOCC's, as well as Minnesota State Patrol staff, enters data into CARS. • MnDOT Construction, Maintenance and local agencies are responsible to plan, design, construct, operate, and maintain the IWZ traveler information systems.	• CARS includes interconnects between roadside or vehicle reporting equipment and the central server. CARS also includes interconnects between the central server to the 511 system. • IWZ systems include interconnects between roadside detection equipment and roadside signage. • IWZ systems also include interconnects between roadside equipment and RTMC/TOCCs/ local maintenance and construction centers.	• Maintenance and construction data is archived by MnDOT TDA Traveler Information System (TIS). • Traveler information from IWZ systems is not archived.	

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Archive Need	Associated Service Package
WZ12	Notify travelers of delays or travel times through work zones	• MnDOT and local agencies use detection or surveillance equipment to determine delay/ travel time through a work zone and disseminate the information in real-time to motorists via DMS and/or HAR upstream of the work zone. • Drivers use the information to anticipate delays, decide whether to change routes, and notify others of their estimated arrival time. • Real-time travel time and delay information is provided to RTMC, TOCCs, MnDOT Maintenance, MSP, and local agencies for coordinated traffic control strategies and emergency vehicle routing.	• Work zone travel time and delay information is metro applications of IWZ systems.	• Expand this service to areas outside of RTMC coverage area. • Effort is underway in metro area to notify travelers of delays/travel times through work zones.	• MnDOT Construction, Maintenance and local agencies are responsible to plan, design, construct, operate and maintain the IWZ traveler information systems.	• This service includes interconnects between roadside detection equipment and roadside travel information dissemination equipment. • This service also includes interconnects between roadside equipment and RTMC/TOCCs/ local maintenance and construction centers.	• None.	

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Archive Need	Associated Service Package
WZ14	Provide automated flagging in stationary work zones	• MnDOT and local agency crews use portable, temporary traffic control devices to control both ends of stationary work zones from a safe, centralized location. • Drivers use the system to take appropriate precautions and determine when they must stop and when they may approach the work zone.	• Autoflagger system is currently used by MnDOT construction and maintenance crews at some work zones. • MnDOT District 3 purchased three systems recently for flagging in work zones	• Deploy Autoflagger at more work zones to enhance safety for work zone personnel. • Develop a system for non-stationary work zones (i.e. M&O projects with a pilot vehicle). • Gap exists in traveling through an intersection in a work zone.	• MnDOT Planning, Pre-Design, are responsible to plan and design, Autoflagger systems. • MnDOT Construction, Maintenance, and local agencies are responsible to operate and maintain the systems.	• None.	• System activations will be logged and archived for diagnostics analysis and tort claims.	

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Archive Need	Associated Service Package
WZ15	Provide dynamic speed display	• MnDOT construction and maintenance and local agencies use this service to show drivers their actual speed and the advisory speed for the work zone. • Dynamic speed displays could also be provided by MnDOT and local agencies in permanent, non-work zone locations with fixed or portable trailer mounted signs. • Drivers adjust their speed appropriately according the advisory speed.	• Dynamic speed displays are widely used as an application of IWZ systems. • Dynamic speed displays are also widely used on trailer-mounted, truck-mounted, and stand-alone signs.	• Deploy dynamic speed displays at more work zones to enhance safety. • Expand use of permanent dynamic speed display to additional locations. • Gap exists in putting speed display in mobile trailer applications. District 4 is testing mobile speed display in summer 2013.	• MnDOT Construction and Maintenance and local agencies are responsible to plan, design, construct, operate and maintain dynamic speed display systems. • Private contractors are also responsible for operating dynamic advisory speed systems.	• Dynamic speed display systems include interconnects between roadside detection and roadside message equipment and between roadside message equipment and remote server for system control.	• Log sign message and detector data for evaluating system effectiveness	• ATMS19
WZ16	Provide additional warning on back of snowplow	See information under MC06.						

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Archive Need	Associated Service Package
WZ17	Alert distracted motorists near work zones	• MnDOT and local agencies use systems providing visual, haptic, and/or audio warnings to drivers when approach to work zone.	• Static signs and dynamic message signs are widely used to notify drivers when approaching to work zones.	• Use graphics, audio and haptic warnings to attract drivers attention. • Communicate and educate the driving public regarding distracted driving and safety near and within work zones.	• MnDOT Maintenance and local agencies are responsible to use warning devices to warn drivers approaching to work zones.	• This service includes interconnects between roadside detection and roadside message/ warning equipment and between roadside message/ warning equipment and remote server for system control.	• Log types of warnings and messages used, drivers behavior, and safety records for evaluating the effectiveness of the warning systems.	• MC09
WZ18	Enforce timely sign changes in construction zones	See information under MC07						
WZ19	Open up lane closures when not in use	• MnDOT construction and maintenance and local agencies monitor work zone status and open up lane closures when not in use to reduce delays due to work zones.	• Construction crew set up lane closures according to work to be performed.	• Actively monitor work progress in work zones and timely remove lane closure restrictions when not needed,	• MnDOT Maintenance and local agencies are responsible for monitoring the work progress and lane closures in work zones.	• None.	• None.	

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Archive Need	Associated Service Package
Service Package MC09 – Work Zone Safety Monitoring								
WZ03	Warn work crews of errant vehicles	• Construction and maintenance crews utilize Work Zone Intrusion Alarm to alert them to take appropriate actions whenever the work zone has been entered by a vehicle or when workers cross the work zone boundary as they are working.	• A pilot project is being conducted in MnDOT District 3. • An application of this is described in the IWZ Toolbox.	• Upon successful demonstration of the pilot project, future deployment of Work Zone Intrusion Alarm system is planned. • Additional research into system design is needed to improve system effectiveness. • Development of action plan for how work crews could be alerted when errant vehicles enter work zones • Addition of cameras to work zones to determine how widespread errant vehicles are within work zones.	• MnDOT Construction and Maintenance and local agencies are responsible to plan, design, construct, operate and maintain the alarm system. • Private contractors are also responsible for operating dynamic advisory speed systems.	• The Work Zone Intrusion Alarm system includes interconnects between roadside detection equipment and roadside alarm equipment.	• System activations will be logged and archived for diagnostic analysis and tort claims.	

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Archive Need	Associated Service Package
WZ05	Warn travelers about trucks entering/exiting work zones	• Construction and maintenance crews utilize work zone entrance/ exit alarms to alert motorists of trucks entering and exiting work zones. • Truck drivers utilize the system to alert motorists not to follow a truck into the work zone. • Drivers use the system to alert them to when to look for trucks entering or exiting the work zone and to react appropriately.	• Truck entering/ exiting warning systems are applications of IWZ Work Intrusion Warning, Truck Merging Traffic Warning, Truck Crossing Traffic Warning, and Truck Existing Warning Systems. • Static signs or flaggers are used at some work zones to alert drivers of construction trucks entrance/exit points.	• Develop and deploy vehicle warning system applications of IWZ at select work zones.	• MnDOT construction, private contractors and local agencies are responsible to plan, design, construct, operate and maintain the alarm system.	• This service includes interconnects between roadside detection equipment and roadside sign equipment. • This service also includes interconnects between in-vehicle equipment and roadside sign equipment.	• None. No data is archived from the alarm system.	
WZ17	Alert distracted motorists near work zones	See information under MC08.						

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Archive Need	Associated Service Package
Service Package MC10 – Maintenance and Construction Activity Coordination								
WZ02	Coordinate construction and maintenance project schedules within and between agencies	• MnDOT construction and maintenance and local agencies use a dynamic schedule incorporating multiple projects to coordinate construction and maintenance projects and utility work, access roadway closure information, and to communicate information to the public.	• MnDOT maintenance and local agencies release project schedules of construction and maintenance activity via website and media outlets and communicates with local stakeholders as appropriate.	• Develop dynamic graphical-based tool for communication of construction and maintenance activity. • Investigate staff requirements to enter data into the dynamic schedule tool.	• MnDOT construction is responsible to plan, design, construct, operate and maintain the construction coordination system. • MnDOT maintenance and local agencies are responsible for entering construction and maintenance data into the system.	• This coordination system includes interconnects between RTMC/TOCCs/ local MCM centers and agency planning offices to allow agencies to update their information and view schedules.	• Construction and maintenance project schedules may be archived for future studies.	
Service Package MC11 – Environmental Probe Surveillance								
While there is research into using vehicles as environmental probes in Minnesota, no needs or services under this service package were identified by stakeholders.								

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Archive Need	Associated Service Package
Service Package MC12 – Infrastructure Monitoring								
WZ13	Provide cameras/ sensors on bridges to assist for inspection and continual monitoring	• MnDOT and local agency inspectors use cameras and sensors to assist in the inspection of bridges by recording key structural measures that indicate when maintenance is needed.	• MnDOT and local agencies manually inspect bridges on a regular basis. • Infrastructure inspection equipment is available for use.	• Implement pilot project to utilize cameras and sensors for maintenance inspections of key bridges.	• MnDOT maintenance staff and local agencies are responsible to procure, maintain, and operate cameras and sensors and train staff.	• This service includes interconnects between camera/sensor roadside equipment and the center monitoring systems.	• Data on inspection activity can be archived to indicate dates of inspection and exactly what was inspected. • Video snapshots from the inspections should be archived in inspection files.	

Appendix D: MCM Service Packages and Descriptions

The descriptions of MCM service packages are taken directly from the National ITS Architecture version 7.0.

MC01 Maintenance and Construction Vehicle and Equipment Tracking
This service package will track the location of maintenance and construction vehicles and other equipment to ascertain the progress of their activities. These activities can include ensuring the correct roads are being plowed and work activity is being performed at the correct locations.

MC02 Maintenance and Construction Vehicle Maintenance
This service package performs vehicle maintenance scheduling and manages both routine and corrective maintenance activities on vehicles and other maintenance and construction equipment. It includes on-board sensors capable of automatically performing diagnostics for maintenance and construction vehicles, and the systems that collect this diagnostic information and use it to schedule and manage vehicle maintenance.

MC03 Road Weather Data Collection
This service package collects current road and weather conditions using data collected from environmental sensors deployed on and about the roadway (or guideway in the case of transit related rail systems). In addition to fixed sensor stations at the roadside, sensing of the roadway environment can also occur from sensor systems located on Maintenance and Construction Vehicles. The collected environmental data is used by the Weather Information Processing and Distribution service package to process the information and make decisions on operations. The collected environmental data may be aggregated, combined with data attributes and sent to meteorological systems for data qualification and further data consolidation. The service package may also request and receive qualified data sets from meteorological systems.

MC04 Weather Information Processing and Distribution
This service package processes and distributes the environmental information collected from the Road Weather Data Collection service package. This service package uses the environmental data to detect environmental hazards such as icy road conditions, high winds, dense fog, etc. so system operators and decision support systems can make decision on corrective actions to take. The continuing updates of road condition information and current temperatures can be used by system operators to more effectively deploy road maintenance resources, issue general traveler advisories, issue location specific warnings to drivers using the Traffic Information Dissemination service package, and aid operators in scheduling work activity.

MC05 Roadway Automated Treatment
This service package automatically treats a roadway section based on environmental or atmospheric conditions. Treatments include fog dispersion, anti-icing chemicals, etc. The service package includes the environmental sensors that detect adverse conditions, the automated treatment system itself, and driver information systems (e.g., dynamic message signs) that warn drivers when the treatment system is activated.

MC06 Winter Maintenance
This service package supports winter road maintenance including snow plow operations, roadway treatments (e.g., salt spraying and other anti-icing material applications), and other

snow and ice control activities. This package monitors environmental conditions and weather forecasts and uses the information to schedule winter maintenance activities, determine the appropriate snow and ice control response, and track and manage response operations.

MC07 Roadway Maintenance and Construction
This service package supports numerous services for scheduled and unscheduled maintenance and construction on a roadway system or right-of-way. Maintenance services would include landscape maintenance, hazard removal (roadway debris, dead animals), routine maintenance activities (roadway cleaning, grass cutting), and repair and maintenance of both ITS and non-ITS equipment on the roadway (e.g., signs, traffic controllers, traffic detectors, dynamic message signs, traffic signals, CCTV, etc.). Environmental conditions information is also received from various weather sources to aid in scheduling maintenance and construction activities.

MC08 Work Zone Management
This service package manages work zones, controlling traffic in areas of the roadway where maintenance, construction, and utility work activities are underway. Traffic conditions are monitored using CCTV cameras and controlled using dynamic message signs (DMS), Highway Advisory Radio (HAR), gates and barriers. Work zone information is coordinated with other groups (e.g., ISP, traffic management, other maintenance and construction centers). Work zone speeds and delays are provided to the motorist prior to the work zones. This service package provides control of field equipment in all maintenance and construction areas, including fixed, portable, and truck-mounted devices supporting both stationary and mobile work zones.

MC09 Work Zone Safety Monitoring
This service package includes systems that improve work crew safety and reduce collisions between the motoring public and maintenance and construction vehicles. This service package detects vehicle intrusions in work zones and warns crew workers and drivers of imminent encroachment or other potential safety hazards. Crew movements are also monitored so that the crew can be warned of movement beyond the designated safe zone. The service package supports both stationary and mobile work zones. The intrusion detection and alarm systems may be collocated or distributed, allowing systems that detect safety issues far upstream from a work zone (e.g., detection of over dimension vehicles before they enter the work zone).

MC10 Maintenance and Construction Activity Coordination
This service package supports the dissemination of maintenance and construction activity to centers that can utilize it as part of their operations, or to the Information Service Providers who can provide the information to travelers.

MC11 Environmental Probe Surveillance
This service package collects data from vehicles in the road network that can be used to directly measure or infer current environmental conditions. It leverages vehicle on-board systems that measure temperature, sense current weather conditions (rain and sun sensors) and also can monitor aspects of the vehicle operational status (e.g., use of headlights, wipers, and traction control system) to gather information about local environmental conditions. It includes the on-board vehicle systems that collect and report environmental probe data, the infrastructure equipment that collects the probe data and the centers that aggregate and share the collected probe data.

MC12 Infrastructure Monitoring

This service package monitors the condition of pavement, bridges, tunnels, associated hardware, and other transportation-related infrastructure (e.g., culverts) using both fixed and vehicle-based infrastructure monitoring sensors. Fixed sensors monitor vibration, stress, temperature, continuity, and other parameters and mobile sensors and data logging devices collect information on current infrastructure condition. This service package also monitors vehicle probes for vertical acceleration data and other probe data that may be used to determine current pavement condition.