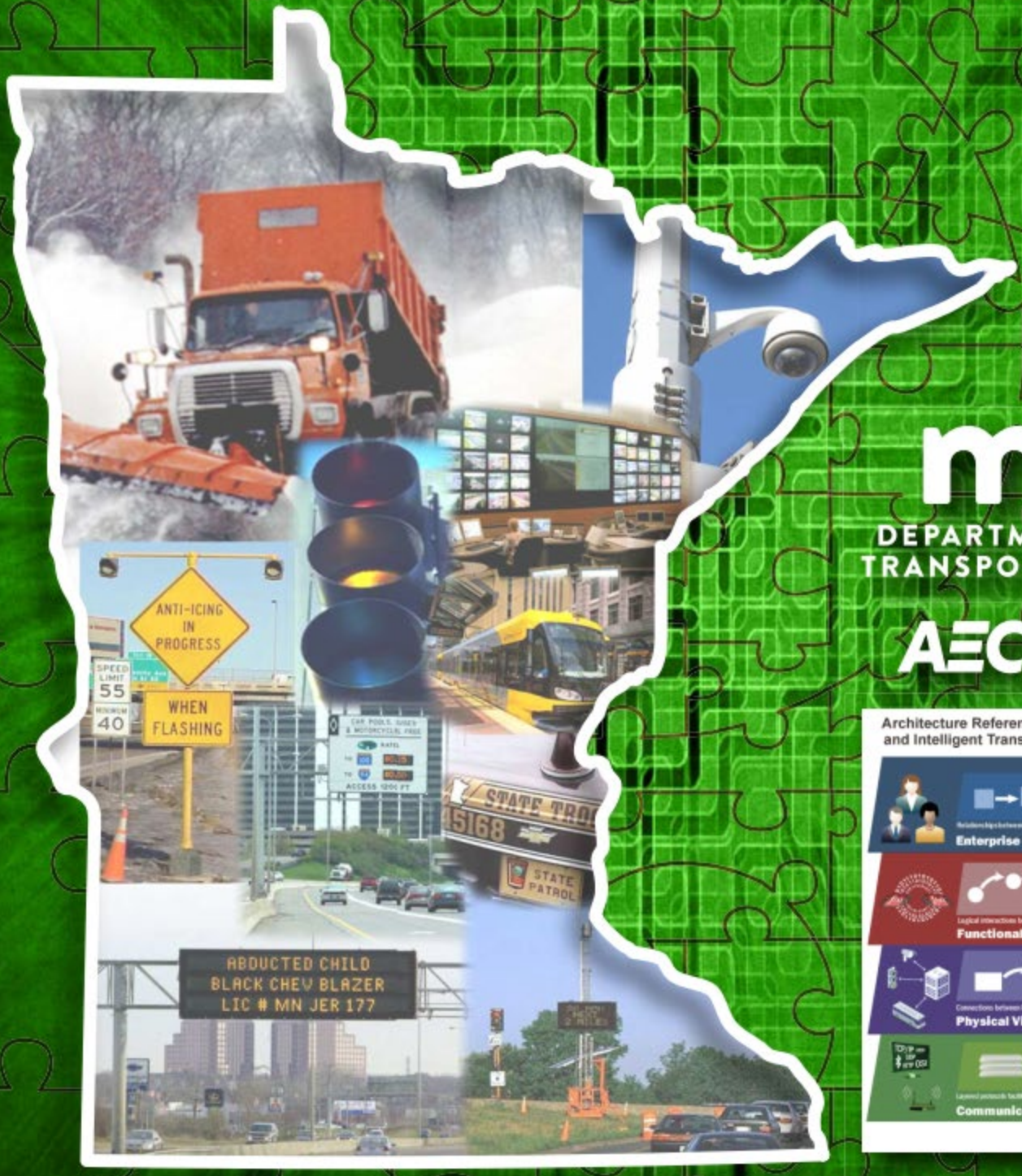
Minnesota Statewide Regional ITS Architecture

Version 2018

Volume 7:
Maintenance and Construction Service Package Area



DEPARTMENT OF TRANSPORTATION

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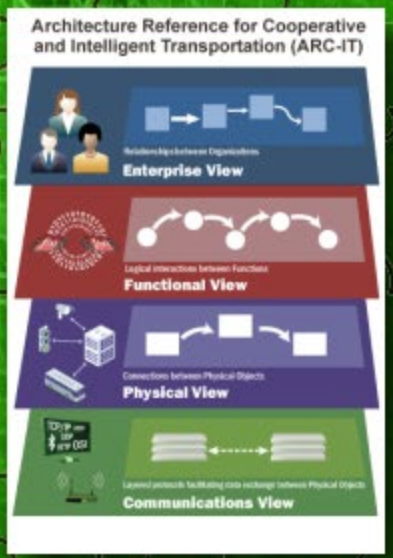

Minnesota Statewide Regional ITS Architecture
Version 2018

Volume 7: Maintenance and Construction Service Package Area

Prepared by

AECOM

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ACRONYMS

AMBER	America's Missing: Broadcast Emergency Response
ARC-IT	Architecture Reference for Cooperative and Intelligent Transportation
ATIS	Advanced Traveler Information System
ATMS	Advanced Traffic Management System
AVL	Automatic Vehicle Location
CAD	Computer Aided Dispatch
CARS	Condition Acquisition and Reporting System
CVO	Commercial Vehicle Operations
DM	Data Management
DMS	Dynamic Message Sign
DTN	Data Transmission Network
EOC	Emergency Operations Center
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
MC	Maintenance and Construction
MDSS	Maintenance Decision Support System
MnDOT	Minnesota Department of Transportation
MSP	Minnesota State Patrol
NIMS	National Incident Management System
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
PM	Parking Management
PS	Public Safety
PT	Public Transportation
RAD-IT	Regional Architecture Development for Intelligent Transportation
RCA	Resource Consumption Application
RTMC	Regional Transportation Management Center
RTMS	Remote Traffic Microwave Sensor
RWIS	Road Weather Information System
ST	Sustainable Travel
SU	Support
TDA	Office of Transportation Data & Analysis (MnDOT)
TI	Traveler Information
TIS	Traveler Information System
TM	Traffic Management
TMC	Transportation/Traffic Management Center
SRCC	Southern Regional Communications Center
VMT	Vehicle-Miles Traveled
VS	Vehicle Safety
WX	Weather
WZARD	Work Zone Accident Reduction Deployment

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 2014. It conforms with the National ITS Architecture (the Architecture Reference for Cooperative and Intelligent Transportation, or ARC-IT, Version 8.2) 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. ARC-IT 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.

- **Implementation Volume – 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.

- **Volumes 1 thru 12 – Development and Documentation of Service Package Areas:** Each volume is specific to the corresponding Service Package Area and includes: a description of the Service Package Area, 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 13 – RAD-IT Outputs of the Regional ITS Architecture:** Volume 13 consists of a report generated by the Regional Architecture Development for Intelligent Transportation (RAD-IT) software, formerly known as Turbo Architecture, for the Minnesota Statewide Regional ITS Architecture.

The purpose for developing Volumes 1 through 12 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 Service Package Area

Maintenance and Construction (MC) activities include monitoring, operating, maintaining, improving, and managing the physical condition of the roadway. MC 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 - MC Service Package Area entailed the Project Consultant working 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 MC Service Package Area. 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 Maintenance and Construction Management Systems*** provides a brief overview of statewide MC management 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 MC. 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 MC 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 MC Service Package Area and those in other Service Package Areas.
- ***Section 6: MC 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

MC management 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.

MC management 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 MC 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 ARC-IT.

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. MC ITS solutions involve services that improve the effectiveness and safety of maintenance and construction operations.

MC 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 MC management 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 1, specific to MC, are steps to determine and/or measure whether or not MC goals are being achieved. A complete list of Minnesota ITS Development Objectives is included in *Appendix B*.

Table 1. MC Specific Minnesota ITS Development Objectives

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

A-1 Reduce crash frequency
- 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
- 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

A-3 Reduce crashes in work zones
- 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
- 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
- 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

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

D. Improve the Security of the Transportation System

D-2 Safeguard the motoring public from homeland security and/or Hazmat incidents
C-3-09 Increase the percent of the transportation system in which travel conditions can be detected remotely via video monitoring cameras, 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 video monitoring cameras
D-1-07 Increase the number of critical sites with security monitoring
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
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

F. Preserve the Transportation System

F-1 Safeguard existing infrastructure
C-3-09 Increase the percent of the transportation system in which travel conditions can be detected remotely via video monitoring cameras, speed detectors, etc.
D-1-06 Increase the percent of major and minor arterials are equipped with and operating with video monitoring cameras
D-1-07 Increase the number of critical sites with security monitoring
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

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
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
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 2017 to capture the following changes since the last update of the Architecture in 2014:

- 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 2014 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 July 2017 and April 2018, 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 2 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 2. The potential solutions and enhancements identified in Table 2 will provide the required service(s) to fill the gaps summarized in *Appendix C*. This appendix will take the MC Needs and associated MC 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 2. MC 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 areas can be found in corresponding Service Package Area documents.*

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

ID	Need/Potential Solution	Priority Point[a]	ITS Development Objective	ARC-IT Reference[b]
MCM 01	Track locations of maintenance fleet and personnel and usage of materials	3.00	E-4-01, E-4-04, E-4-07	MC01, MC04
MCM 02	Coordinate construction and maintenance project schedules within and between agencies	3.67	C-3-10	MC08
MCM 03	Warn work crews of errant vehicles	4.33	A-3-04	MC07
MCM 04	Warn travelers about trucks entering/exiting work zones	3.20	A-3-01, A-3-02, A-3-03, A-3-04	MC06
MCM 05	Provide queue detection and advisory to warn traffic of a stopped queue at work zone	4.10	A-3-01, A-3-02, A-3-03	MC06, TM12
MCM 06	Provide roadway automated treatment with stationary units	1.80	A-1-03, A-2-03, A-2-24	MC03
MCM 07	Provide maintenance decision support	3.67	A-1-03, A-2-03, A-2-24, E-4-01, E-4-04, E-4-07, H-2-02	MC04
MCM 08	Provide dynamic late merge systems for construction/maintenance activities	3.07	B-3-01, B-3-02, B-3-03, B-3-04, B-3-05	MC06
MCM 09	Use GPS/GIS data to target and record replacement and repair of infrastructure	3.50	G-1-01	MC05
MCM 10	Provide work zone information to travelers	3.90	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	MC06
MCM 11	Notify travelers of delays or travel times through work zones	3.70	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	MC06
MCM 12	Provide cameras/sensors on bridges to assist for inspection and continual monitoring	3.17	C-3-09, D-1-06	MC09
MCM 13	Provide automated flagging in stationary work zones	2.88	A-3-01, A-3-02, A-3-03, A-3-04	MC06

ID	Need/Potential Solution	Priority Point[a]	ITS Development Objective	ARC-IT Reference[b]
MCM 14	Provide dynamic speed display	3.11	A-3-01, A-3-02, A-3-03, A-3-04	MC06, TM12, TM17
MCM 15	Provide additional warning on back of snowplow	3.14	A-1-03, A-2-03, A-2-24	MC04
MCM 16	Alert distracted motorists near work zones	4.67	A-1-14, A-2-15, A-2-36, A-3-01, A-3-02, A-3-03, A-3-04	MC06, MC07
MCM 17	Enforce timely sign changes in construction zones	4.20	B-3-01, B-3-02, B-3-03, B-3-04, B-3-05	MC05, MC06
MCM 18	Open up lane closures when not in use	4.20	B-3-01, B-3-02, B-3-03, B-3-04, B-3-05	MC06
MCM 19	Proper notification of changes in work zone traffic control	5.00[c]	B-3-01, B-3-02, B-3-03, B-3-04, B-3-05, C-3-15	MC06
MCM 20	Snow plow priority at traffic signals and ramp meters	5.00[c]	E-4-04, E-4-05, G-1-06, H-1-05, H-1-06, H-1-07	TM04, SU01, SU02
MCM 21	Spreading chemicals more evenly at intersections	4.00[c]	E-4-04	MC04
ATIS05	Provide information on roadway construction and maintenance activities	4.00	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	TI01, TI02, MC06
ATMS 08	Provide enhanced manual or automated speed enforcement to improve safety	3.57	A-1-12, A-2-13, A-2-34, A-2-43, C-4-01	TM17, MC06
ATMS 18	Provide dynamic speed feedback to drivers and enforcement agencies	2.77	A-1-12, A-2-13, A-2-34, A-2-43, C-4-01	TM17, MC06
ATMS 34	Provide roadway flood warnings	2.29	A-1-03, A-1-17, A-2-03, A-2-18, A-2-24, A-2-39	TM12, MC09, WX03
ATMS 39	Monitor queue length at ramps, incident scenes, and work zones	2.63	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	TM05, TM12, MC06
ATMS 40	Enhance enforcement in work zones	3.70	A-3-01, A-3-02, A-3-03, A-3-04	TM17, MC06
ATMS 43	Notify travelers of snowplow operations and cleanup using DMS	2.91	A-1-03, A-2-03, A-2-24, C-3-15	TM06, MC04
AVCV 01	Better moving roadwork information to vehicles - DMS sign information to vehicles	4.00[c]	A-3-01, A-3-02, A-3-03, A-3-04, B-3-01, B-3-02, B-3-03, B-3-04, B-3-05, C-3-15	MC06, VS09, TM06
AVCV 02	Better moving roadwork information to vehicles – WZARD signs	4.00[c]	A-3-01, A-3-02, A-3-03, A-3-04, B-3-01, B-3-02, B-3-03, B-3-04, B-3-05, C-3-15	MC06, VS09, TM06
AVCV 04	Reduce rear end crashes with DOT maintenance vehicles	2.00[c]	A-1-03, A-1-06, A-2-03, A-2-06, A-2-27, A-3-01, A-3-02, A-3-03, A-3-04	MC06, VS04

5. Detail of MC Needs and Services

A detailed description of each MC 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 MC Service Package Area and those in other Service Package Areas.

6. MC Research and Development Needs

In order to fill gaps and meet the needs for technology advancement in MC 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 MC 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

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 portable, 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 traveler information delivery systems
- Monitoring actual operations of different zipper merge treatments, before and after
- Investigate methods to differentiate “local” traffic for road closures/detours

Appendix A: Existing/Planned MC Elements

System	Service Package(s)	Description	Stakeholder	Status
Arrow Board Reporting System	MC06, TM06	The Arrow Board Reporting System consists of the arrow board devices and the arrow board server. The arrow board devices are equipped with automated reporting functionality. Upon activation, the Arrow Board System will assemble an initial message that includes the arrow board device ID, latitude/longitude, display status, device status, and orientation to the arrow board server. The server will poll the system every two minutes for new data. MnDOT RTMC via IRIS will access the data from the system server and will make arrow board-related lane closure incident event data available for CARS.	MnDOT	Planned
Bridge Inspection/ Structural Monitoring Roadside Equipment	MC09	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 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
Video Monitoring Roadside Equipment	MC06, TM01	This represents video monitoring cameras deployed along the roadside by various agencies and municipalities throughout Minnesota. Images are received and monitored by transportation agencies.	MnDOT, Local Agencies	Existing
Dynamic Late Merge Roadside Equipment	MC06	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	MC06, TM06	This element represents portable and permanent 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	MC06, TM06	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	MC06	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 SRCC operator.	MnDOT	Existing
Lane/Ramp Access Control Roadside Equipment	MC06, TM19	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, video monitoring 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, MC02, MC03, MC04, MC05, MC06, MC07, MC08, MC09, SU11	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
Maintenance and Construction Vehicle Equipment	MC01, MC02, MC04, MC05, MC06, SU11	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	MC04	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, MC05, WX01, WX02	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
Roadway Automated Treatment System Roadside Equipment	MC03	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, WX01, WX02	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
Surface Transportation Weather Service Providers	MC04, MC05, WX01, WX02	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

SRCC	MC01, MC03, MC04, MC05, MC06, MC07, MC08, MC09, WX01, WX02	SRCC is the regional center for the Rochester area for 24-hour incident and emergency response, multi-agency dispatching, interagency communications, collection and dissemination of road conditions and closures, and traffic management and operations. The roadside systems interfaced with SRCC include video monitoring cameras, traffic detectors, DMS, traffic signals, RWIS stations, and ice detectors.	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.

DM:	Data Management	VS:	Vehicle Safety
PT:	Public Transportation	CVO:	Commercial Vehicle Operations
TI:	Traveler Information	PS:	Public Safety
TM:	Traffic Management	MC:	Maintenance and Construction
PM:	Parking Management	WX:	Weather
SU:	Support	ST:	Sustainable Travel

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

A-1 Reduce crash frequency *(TI, TM, PT, CVO, PS, MC, VS & WX)*

- 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 *(TI, TM, PT, CVO, PS, MC, VS & WX)*

- 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 *(TI, TM, PS, MC & VS)*
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 *(TI, TM, MC & VS)*
B-1-01 Reduce the percentage of facility miles (highway, arterial, rail, etc.) experiencing recurring congestion during peak periods
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 passenger occupancy and facility throughput *(TM, PT & ST)*
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 *(TI, TM, PS, MC & VS)*
- 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 *(TI, TM, PT, CVO, PS & VS)*
- 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 *(TI, TM, PT, PS & VS)*
- B-1-01 Reduce the percentage of facility miles (highway, arterial, rail, etc.) experiencing recurring congestion during peak periods
- 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 *(TI, TM, PT & VS)*
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 *(TI, TM, PT & ST)*
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 video monitoring cameras, 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 *(TI, TM, PT, PM, PS, MC & VS)*
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 peak periods
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 *(PT & PS)*

C-3-09 Increase the percent of the transportation system in which travel conditions can be detected remotely via video monitoring cameras, 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 video monitoring 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 video monitoring cameras
D-1-07 Increase the number of critical sites with security monitoring
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 *(TI, TM, PT, CVO, PS, MC & VS)*

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 video monitoring cameras, 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 video monitoring 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 video monitoring cameras
D-1-07 Increase the number of critical sites with security monitoring
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 *(TI, TM, PT, CVO & VS)*

- 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 *(TI & 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 *(TM, PT, CVO & VS)*

- 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 video monitoring cameras, 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 *(DM, TM, PT, CVO, PS, MC & SU)*
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 *(TM, PT, CVO & VS)*
B-1-01 Reduce the percentage of facility miles (highway, arterial, rail, etc.) experiencing recurring congestion during peak periods
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 *(TI & 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 *(TM, CVO, PS & MC)*

- C-3-09 Increase the percent of the transportation system in which travel conditions can be detected remotely via video monitoring cameras, speed detectors, etc.
- D-1-06 Increase the percent of major and minor arterials are equipped with and operating with video monitoring cameras
- D-1-07 Increase the number of critical sites with security monitoring
- 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 *(TM, CVO, MC & VS)*

- B-1-01 Reduce the percentage of facility miles (highway, arterial, rail, etc.) experiencing recurring congestion during peak periods
- 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 *(ST, TI, TM, CVO & VS)*

B-1-01 Reduce the percentage of facility miles (highway, arterial, rail, etc.) experiencing recurring congestion during peak periods
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 *(TM, PT, PS, ST & MC)*

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 passenger occupancy rate in HOV lanes
H-2-02 Increase the amount of environmentally friendly de-icing material used

Appendix C: Needs and Services Detail

Service Package MC01 - Maintenance and Construction Vehicle and Equipment Tracking

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Archive Need	Associated Service Package
MCM 01	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 / 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.)	• MC04

Service Package MC02 - Maintenance and Construction Vehicle Maintenance

While there are fleet management and maintenance systems for maintenance and construction vehicles in Minnesota, no needs or services under this service package were identified by stakeholders.

Service Package MC03 – Roadway Automated Treatment

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Archive Need	Associated Service Package
MCM 06	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/SRCC/ 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 MC04 – Winter Maintenance

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Archive Need	Associated Service Package
MCM 01	Track locations of maintenance fleet and personnel and usage of materials	See information under MC01.						
MCM 07	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 and enhance the use of MDSS statewide.	• MnDOT is responsible for implementation, operations, and maintenance of MDSS system.	• Decision support systems includes interconnects between vehicles and MDSS.	• Maintenance support recommendations will be archived for future analysis, resource allocation, and treatment planning.	
MCM 15	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.	

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Archive Need	Associated Service Package
MCM 21	Spreading chemicals more evenly at intersections	• The application of chemicals in multiple directions of travel at an intersection can provide a more even spread of the chemicals across the intersection.	• MnDOT Maintenance and local agencies operate winter maintenance vehicles spread materials to prevent snow and ice from forming on roadways	• Enhancement to snow removal and chemical application procedures that results in a more even spread of material at an intersection.	• Each agency is responsible for the planning, design, construction, operations, and monitoring of the enhancement to winter maintenance operations.	• Includes interconnects between winter maintenance vehicles and central monitoring software to confirm chemical application to intersections	• None	
ATM S43	Notify travelers of snowplow operations and cleanup using DMS	• MnDOT and local agencies track snowplow locations and activities and use DMS to provide snowplow location notices and snow cleanup maintenance information to travelers. • Travelers observe information on DMS and take precaution as approaching and passing snowplows in operation.	• Many snowplows are equipped with AVL to assist maintenance and traffic management staff to track snowplow locations. • MnDOT Metro has over 85 DMS, and more are deployed in other districts. • Operations of DMS are capable of being shared between agencies.	• Expand AVL capability to additional MnDOT and local agencies' snowplow and maintenance vehicles. • Expand DMS deployment. Deploy additional DMS at key decision points throughout Minnesota.	• Each agency is responsible for the planning, design, construction, operations, and maintenance of their DMS and AVL systems.	• DMS systems include interconnects between roadside DMS equipment and TMCs and other agencies controlling DMS operation. • This service also includes interconnects between in-vehicle equipment and maintenance dispatch centers. • Interconnects are also needed between maintenance dispatch centers and TMCs.	• None	• TM06

Service Package MC05 – Roadway Maintenance and Construction

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Archive Need	Associated Service Package
MCM 09	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 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.	
MCM 17	Enforce timely sign changes in construction zones	• MnDOT Construction, 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 Construction, 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.	• Continue enhancing policy and guidelines, providing training to agency and contractor staff. • Improve enforcement of the policy through field visits, inspections and contractor incentives and penalties in the construction contracts for timely sign changes and removals.	• MnDOT Construction and local agencies are responsible to develop a policy or guidelines, develop and provide training, and enforcement the policy and guidelines.	• None.	• None.	• MC06

Service Package MC06 -Work Zone Management

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Archive Need	Associated Service Package
MCM 04	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.	

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Archive Need	Associated Service Package
MCM 05	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. • MnDOT is conducting a pilot project on I-94 in the East Metro area.	• 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. • Deploy portable, lite version of the system for temporary work zones. • Provide notifications to project staff when queue lengths get passed certain points.	• 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.	• Data from the queue detection and advisory system should be archived.	• TM12

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Archive Need	Associated Service Package
MCM 08	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/SRCC/ 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
MCM 10	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. • MnDOT provides detailed information via 511 website, mobile app, and email 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 also uses social media to provide work zone information. • DMS (WZARD sings) 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. • Institutionalize remote data entry capabilities. • 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, 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/SRCC/ 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
MCM 11	Notify travelers of delays or travel times through work zones	• MnDOT and local agencies use detection or video monitoring 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, SRCC, 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/SRCC/ local maintenance and construction centers.	• None.	

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Archive Need	Associated Service Package
MCM 13	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
MCM 14	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	• TM12 • TM17

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Archive Need	Associated Service Package
MCM 16	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. • MnDOT has conducted research in providing visual and audible alerts and/or vibration to drivers, including a long range acoustic alert system.	• Use graphics, audio and haptic warnings to attract driver's 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.	• MC07
MCM 17	Enforce timely sign changes in construction zones	See information under MC05.						
MCM 18	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. • Utilize MnDOT innovative contracting method of Lane Rental.	• MnDOT Maintenance and Construction 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
MCM 19	Proper notification of changes in work zone traffic control	• Communication with general public to allow for proper advanced planning by all.	• Transportation Management Plans (TMPs) are designed to document when changes in traffic control will be needed.	• No current automated method of notifying the general public about changes in work zone traffic control. • Metro's current enhancements to the TMP are aimed at improving notification of changes in traffic control.	• MnDOT Maintenance and local agencies are responsible for communicating the updates on changes in work zone traffic control	• None	• None	

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Archive Need	Associated Service Package
ATIS 05	Provide information on roadway construction and maintenance activities	• MnDOT and local agencies provide information on roadway construction and maintenance activities through the 511 Traveler Information website, local agency websites, telephone information services, and media outlets. • ISPs utilize the data feed provided by MnDOT via CARS to provide roadway construction and maintenance activity information to travelers.	• The 511 website, phone service, KBEM, local media outlets, and social media (e.g. Twitter and Facebook) provides information roadwork and maintenance activities by month. • Shoulder mounted DMS are used for longer term construction projects. • MnDOT provides a data feed to private ISPs and travelers through CARS that includes road construction and maintenance activity information.	• Provide information on alternate routes and detours on the 511 telephone information service, website, DMS, and other services. • Provide information on roadway construction and maintenance activities outside of the metro area in suburban areas.	• MnDOT is responsible to plan, design, operate and maintain the traveler information systems. • Local agencies are responsible to plan, design, operate and maintain systems providing information on closures, alternate routes and detours.	• Interconnects are required between CARS and the 511 system. • Interconnects are required between CARS and ISPs.	• None	• TI01 • TI02

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Archive Need	Associated Service Package
ATM S08	Provide enhanced manual or automated speed enforcement to improve safety	• State Patrol and local agencies perform speed enforcement at locations experiencing frequent speeding as a deterrent to improve travel safety • State Patrol and local agencies use automated speed monitoring and enforcement to reduce crashes • Drivers comply with speed limits and travel with safe speeds.	• State Patrol and local enforcement agencies patrol roadways regularly to enforce and enhance speed compliance. • Target speed enforcement at locations with frequent speeding and/or high incidents due to speeding. • Provide extraordinary enforcement to increase presence at work zones.	• Increase automated speed enforcement is not permissible under current statute. Legislation must be passed to authorize it. • Conduct operational tests and move toward full legislative approval. • Perform automated speed enforcement in work zones when possible. • MnDOT is conducting a pilot project of enhanced speed compliance for work zones.	• State patrol and local agencies are responsible for performing speed enforcement.	• Speed enforcement does not include any interconnects. • Automated speed enforcement systems include interconnects between roadway detection equipment and in-vehicle equipment in the enforcement vehicles.	• Speeding and enforcement data should be archived.	• TM17

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Archive Need	Associated Service Package
ATM S18	Provide dynamic speed feedback to drivers and enforcement agencies	• MnDOT and local agencies use dynamic speed feedback to alert drivers of their speeds. • MnDOT Construction and Maintenance and local agencies advise drivers on the speed to safely travel through a work zone. • Drivers view the speed information and make adjustment as appropriate.	• MnDOT and local agencies use dynamic feedback systems. • Speed Advisory Information is an application of the Intelligent Work Zone (IWZ) systems. • MnDOT uses these systems for maintenance and construction activities.	• Deploy dynamic advisory speed systems at more work zones to provide smooth traffic flow through work zones. • Deploy dynamic advisory speed systems at more permanent non-work zone locations.	• Each agency is responsible to plan, design, construct, operate, and maintain their own dynamic speed feedback systems. • Private contractors are also responsible for operating dynamic advisory speed systems in work zones.	• This service includes interconnects between roadway detection equipment and roadway signing equipment. • This service also includes interconnects between roadside signing equipment and remote server for system control.	• Speed feedback activation data should be archived for future analysis to determine how well the systems work. • Data collection options include local storage and real-time communica-tion.	• TM17

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Archive Need	Associated Service Package
ATM S39	Monitor queue length at ramps, incident scenes and work zones	• MnDOT RTMC monitors traffic backups on ramps and adjusts ramp meter timing. • RTMC, SRCC, MnDOT maintenance and local agencies monitor backups approaching work zones and activate counter measures. • RTMC, SRCC, and local agencies monitor backups caused by incidents.	• The RTMC uses video monitoring cameras and queue detectors to monitor queues on some ramps. • Queue monitoring has been used in some construction projects and has been incorporated into the dynamic late merge system. • RTMC and SRCC use video monitoring cameras to monitor queues approaching work zones and incidents.	• Implement queue detection at more ramp locations with meters. • Improve queue detection technology. • Implement queue detection systems at work zones. • Video monitoring capability is being added to TH 13 arterial for monitoring of corridor.	• MnDOT and local agencies are responsible to plan, design, construct, operate, and maintain their own queue detection and monitoring systems. • MnDOT Construction & Maintenance is responsible to plan, design, deploy, operate, and maintain their portable detection system for work zones.	• Queue monitoring systems include interconnects between the roadside detection/ monitoring equipment and TMCs. • Detection/monitoring systems for work zones include interconnects between roadside detection/monitoring equipment and permanent or portable traffic management systems as well as between roadside detection/monitoring equipment and portable roadside DMS/HAR.	• Queue detection data should be routinely saved for use in performance measures and future traffic management planning.	• TM05 • TM12

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Archive Need	Associated Service Package
ATM S40	Enhance enforcement in work zones	• MnDOT and local agencies use speed monitoring equipment to assist enforcement agencies with detecting speed violations in work zone. • MnDOT, State Patrol, and local agencies use automated speed enforcement as a deterrent to improve travel safety in work zones.	• MnDOT uses dynamic speed feedback signs to inform drivers of their current speeds compared to the posted speed limits. • State Patrol and local agencies perform manual enforcement in work zones.	• Increase manual enforcement in work zones and gradually move toward automated enforcement through operational tests and enabling legislation. • Automated speed enforcement is not permissible under current statute. Legislation must be passed to authorize it. • MnDOT is conducting a pilot project of enhanced speed compliance for work zones.	• State patrol and local agencies are responsible to perform enforcement in work zones. • Each agency is responsible to plan, design, construct, operate, and maintain their automated speed enforcement systems.	• Speed enforcement systems may include interconnects between roadway detection equipment, centers, and in-vehicle equipment.	• Speed enforcement data should be archived to study the potential effects of automated enforcement on speed limit compliance.	• TM17

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Archive Need	Associated Service Package
AVC V01	Better moving roadwork information to vehicles – DMS and arrow board sign information to vehicles	• MnDOT uses arrow boards in advance of active work zones. Arrow boards automatically report the location and operation of the boards to RTMC and CARS. • MnDOT posts/updates work zone/lane closure information on DMS, the 511 website and mobile app. • Travelers use the information to safely travel through work zones.	• MnDOT, working with the ENTERPRISE pooled fund program, is conducting a pilot project "Real-Time Integration of Arrow Board Messages into Traveler Information Systems."	• Upon successful pilot demonstration, deploy the system to multiple work zones and conduct a larger scale of evaluation.	• MnDOT is responsible to research, test, plan, construct, operate and maintain the system.	• Includes interconnects between RTMC and arrow boards/DMS roadside equipment; between RTMC and CARS; and between CARS and 511 traveler information website/mobile app.	• Activation and performance data will be archived for future analysis.	• VS09 • TM06

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Archive Need	Associated Service Package
AVC V02	Better moving roadwork information to vehicles – WZARD signs	• WZARD system establishes communication between different types of detection and display devices to detect the presence of maintenance and construction vehicles, and provide information to DMS and arrow board signs located within the area. • The information presented through DMS and arrow board signs alert drivers beforehand about the maintenance and construction operations.	• MnDOT has tested the system along eastbound I-94, between TH 15 in St. Cloud to TH 101 in Rogers, to alert drivers about the presence of snow plow using DMS within that area.	• Expand the utilization of the system to other areas. • Evaluate the performance and benefits of the system. • Expand the system to include State Patrol and/or other emergency vehicles equipped with AVL/GPS systems.	• MnDOT is responsible to plan, construct, operate and maintain the WZARD system.	• WZARD system include interconnects between maintenance vehicle equipment and WZARD software system, and maintenance vehicle equipment and DMS roadside equipment.	• System generated data should be archived for further analysis and evaluation of the system.	• VS09 • TM06

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Archive Need	Associated Service Package
AVC V04	Reduce rear end crashes with DOT maintenance vehicles	• WZARD system detects the presence of maintenance and construction vehicles, and provides information to DMS and arrow board signs located within the area to alert drivers beforehand about the maintenance and construction operations.	• MnDOT has tested the WZARD system along eastbound I-94, between TH 15 in St. Cloud to TH 101 in Rogers, to alert drivers about the presence of snow plow using DMS within that area.	• Expand the utilization of the system to other areas. • Evaluate the performance and benefits of the system. • Expand the system to include State Patrol and/or other emergency vehicles equipped with AVL/GPS systems. • Test connected vehicle V2V and V2I technology.	• MnDOT is responsible to plan, construct, operate and maintain the WZARD system. • MnDOT, in coordination with USDOT, vehicle manufacturers and private sectors, is responsible to research and test V2V and V2I safety applications.	• WZARD system include interconnects between maintenance vehicle equipment and WZARD software system, and maintenance vehicle equipment and DMS roadside equipment. • This service also includes interconnects between connected vehicles and interconnects between CV roadside equipment and connected vehicles.	• System generated data should be archived for further analysis and evaluation of the system.	• VS07

Service Package MC07 – Work Zone Safety Monitoring

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Archive Need	Associated Service Package
MCM 03	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.	• Pilot projects are being conducted in MnDOT Districts 1 and 3. The pilots include using cameras to monitor work zones and detect work zone intrusion. • An application of this is described in the IWZ Toolbox. • Several research projects are underway.	• Upon successful demonstration of the pilot projects, develop action plans for how work crews could be alerted when errant vehicles enter work zones. • Upon successful pilot demonstration, deploy Work Zone Intrusion Alarm system. • Additional research into system design is needed to improve system effectiveness. • 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.	
MCM 16	Alert distracted motorists near work zones	See information under MC06.						

Service Package MC08 – Maintenance and Construction Activity Coordination

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Archive Need	Associated Service Package
MCM 02	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. • MnDOT uses Georilla for coordinating project schedule in the Metro area. The program has an auto-script to look for conflicts.	• Develop dynamic graphical-based tool for communication of construction and maintenance activity. • Investigate staff requirements to enter data into the dynamic schedule tool. • Work with local agencies in the Metro area to enhance the use of Georilla. • Work with MnDOT staff and local agencies in Greater Minnesota to identify needs.	• 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/SRCC/ 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 MC09 – Infrastructure Monitoring

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Archive Need	Associated Service Package
MCM 12	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.	

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Archive Need	Associated Service Package
ATM S34	Provide roadway flood warnings	• MnDOT and local agencies use these systems to detect potential and actual flooding affecting roadways, alert state and local enforcement, and provide warnings to travelers and information on alternate routes through various means (DMS, HAR, 511). • Drivers use these systems to avoid flooded roadways and reroute to their destination.	• Flood warning systems are planned in Austin. • Hazardous roadway warnings are an application of Intelligent Work Zones (IWZ) Systems.	• Deploy flood warning systems at locations with a history of flooding. • Develop automated data entry into 511 system.	• Each agency is responsible for the planning, design, construction, operations, and maintenance of its flood warning systems.	• Flood warning systems include interconnects between roadside detection equipment and roadside signs. • Systems also include interconnects between roadside equipment and TMCs, MCM centers, law enforcement, and emergency management.	• Need for archiving system activation logs.	• TM12 • WX03

Service Package TM04 – Connected Vehicle Traffic Signal System[1]

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Archive Need	Associated Service Package
MCM 20	Snow plow priority at traffic signals and ramp meters	• MnDOT uses connected vehicle technology to enable snow plows to receive priority at traffic signals and ramp meters.	• As part of the Connected Corridor Program, MnDOT is currently in the planning stage to implement connected vehicle technology for snow plow signal priority.	• Implement the Connected Corridor system to enable snow plows to request and receive priority at signalized intersections and ramp meters.	• MnDOT is responsible to plan, design, construct, operate and maintain the snow plow signal priority system.	• This service includes interconnects between connected vehicle roadside equipment and snow plow on-board equipment.	• Data collected through the system should be archived for research and operational analysis.	• SU01 • SU02

Service Package VS04 – V2V Special Vehicle Alert[2]

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Archive Need	Associated Service Package
AVC V04	Reduce rear end crashes with DOT maintenance vehicles	See information under MC06.						

[1] See Volume 3 – Traffic Management Service Package Area for the description of TM04 – Connected Vehicle Traffic Signal System.
[2] See Volume 8 – Vehicle Safety Service Package Area for the description of VS04 – V2V Special Vehicle Alert.

Service Package VS09 – Reduced Speed Zone Warning / Lane Closure[3]

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Archive Need	Associated Service Package
AVC V01	Better moving roadwork information to vehicles – DMS sign information to vehicles	See information under MC06.						
AVC V02	Better moving roadwork information to vehicles – WZARD signs	See information under MC06.						

[3] See Volume 8 – Vehicle Safety Service Package Area for the description of VS09 – Reduced Speed Zone Warning / Lane Closure.

Appendix D: Maintenance and Construction Service Packages and Descriptions

The descriptions of Maintenance and Construction (MC) Service packages are taken directly from ARC-IT version 8.2.

MC01 Maintenance and Construction Vehicle and Equipment Tracking
This service package tracks the location of maintenance and construction vehicles and other equipment to ascertain the progress of their activities. Checks 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 and equipment maintenance.

MC03 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.

MC04 Weather 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.

MC05 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 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.

MC06 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., TIC, 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.

MC07 Work Zone Safety Monitoring
This service package provides warnings to maintenance personnel within a work zone about potential hazards within the work zone. It enables vehicles or the infrastructure to provide warnings to workers in a work zone when a vehicle is moving in a manner that appears to create an unsafe condition (e.g., moving at high speed or entering the work zone).

MC08 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 Transportation Information Centers who can provide the information to travelers. Center to center coordination of work plans supports adjustments to reduce disruption to regional transportation operations.

MC09 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.