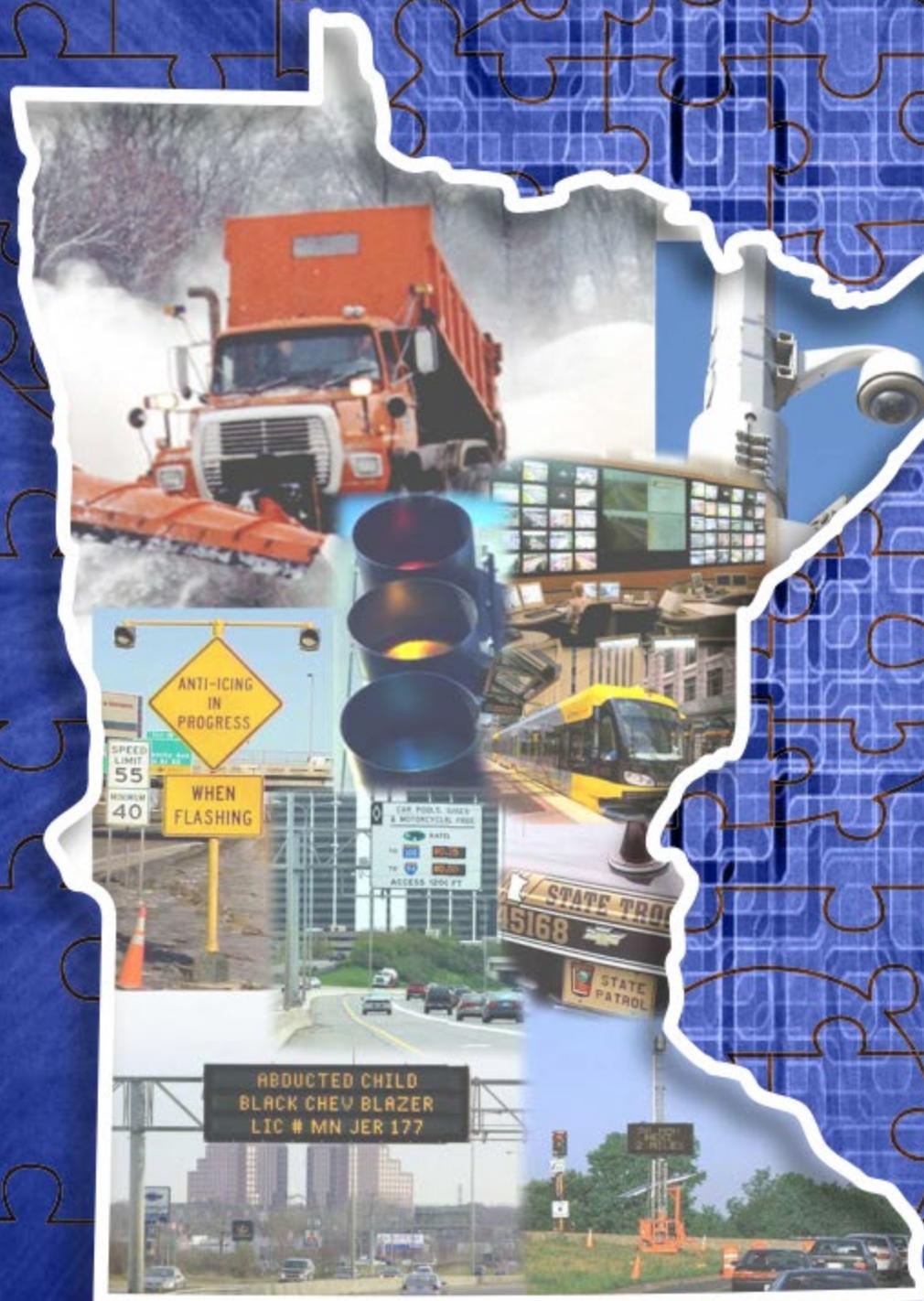# Minnesota Statewide Regional ITS Architecture

Version 2018

Volume 10:
Weather Service Package Area

m1
DEPARTMENT OF TRANSPORTATION

AECOM

Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT)

Relationships between Organizations
Enterprise View

Logical interactions between Functions
Functional View

Connections between Physical Objects
Physical View

Layered protocols facilitating data exchange between Physical Objects
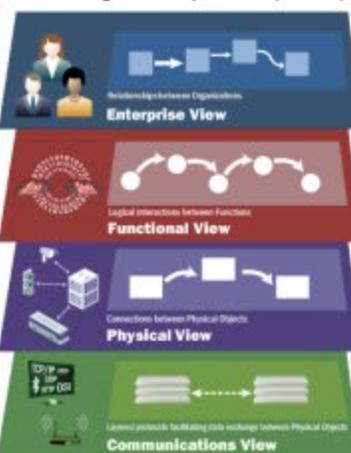**Communications View**

Minnesota Statewide Regional ITS Architecture Version 2018

Volume 10: Weather Service Package Area

Prepared by

AECOM

December 2018

TABLE OF CONTENTS

ACRONYMS

ARC-IT	Architecture Reference for Cooperative and Intelligent Transportation
ATIS	Advanced Traveler Information System
AVL	Automatic Vehicle Location
AWOS	Automated Weather Observation System
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
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
HAR	Highway Advisory Radio
HOV	High-Occupancy Vehicle
ICS	Incident Command Structure
ITS	Intelligent Transportation Systems
IWZ	Intelligent Work Zone
LOS	Level of Service
MC	Maintenance and Construction
MCM	Maintenance and Construction Management
MnDOT	Minnesota Department of Transportation
MSP	Minnesota State Patrol
NADIN	National Airspace Data Interchange Network
NIMS	National Incident Management System
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
PM	Parking Management
PS	Public Safety
PT	Public Transportation
RAD-IT	Regional Architecture Development for Intelligent Transportation
RTMC	Regional Transportation Management Center (MnDOT)
RWIS	Road Weather Information System
SRCC	Southern Region Communication Center
ST	Sustainable Travel
SU	Support
TDRL	Transportation Data Research Laboratory (University of Minnesota)
TI	Traveler Information
TM	Traffic Management
TMC	Transportation/Traffic Management Center
VHF	Very High Frequency
VMT	Vehicle-Miles Traveled
VS	Vehicle Safety
WX	Weather
XML	Extensible Markup Language

1. Introduction

1.1 Statewide Regional ITS Architecture Update

The Minnesota Statewide Regional Intelligent Transportation Systems (ITS) Architecture Version 2018 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:

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

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 10 – Weather Service Package Area

Weather (WX) Service Package Area includes collecting environmental data corresponding to current road and weather conditions, processing that environmental data to detect/forecast environmental hazards, road and weather conditions (which impact travel conditions and, maintenance and construction operations), and collectively use the environmental data to disseminate appropriate information about road and weather conditions to alert travelers and also to manage maintenance and construction operations.

Development of Volume 10 – WX 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 10 summarizes the findings of data collection and analysis activities conducted to support development of the WX Service Package Area. Volume 10 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 Weather Systems* provides a brief overview of statewide WX system deployments with a detailed listing of existing and planned systems in *Appendix A*.

- ➢ **Section 3: Development Objectives** provides an overview of the Minnesota ITS Development Objectives specific to WX. 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 WX Needs and Services** describes, for each identified Need/Service, the following information:
  - o **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.
  - o **Existing Capabilities** - what systems are currently in place that are used to provide this service and who operates these services.
  - o **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.
  - o **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).
  - o **Interconnects** - the communications linkages between subsystems or stakeholders to provide the service.
  - o **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.
  - o **Associated Service Packages** - other Service Packages that the service falls under. This includes both Service Packages within the Service Package Bundle and those in other Service Package Bundles.
- ➢ **Section 6: WX Research and Development Needs** describes general research that can be performed to help implement the identified services.

2.   Identification of Existing Weather Systems

WX systems are deployed throughout Minnesota and have aided transportation agencies to gather, process and provide environmental information that impacts mobility, safety and transportation infrastructure. Using that environmental information has improved the overall performance of Minnesota's transportation systems including increased efficiency, improved safety and enhanced mobility.

WX systems can be used to alert travelers about unsafe driving conditions and to manage maintenance and construction of roadway infrastructure. WX systems collect data from environmental sensors, vehicle on-board systems and other systems that directly/indirectly measure different parameters that aid in determining current environmental conditions. The collected environmental data is processed and used by transportation management systems to determine current and/or forecast road conditions, weather conditions and environmental hazards. Maintenance and construction management centers use the environmental data in deciding modifications to resources, materials and operations to increase performance, safety

and efficiency of different types of maintenance activities and roadway infrastructure construction. During the winter maintenance, the environmental data including vehicle operational status can be used by winter maintenance supervisors to determine current road condition and provide necessary instructions to maintenance vehicle operators to make adjustments to snow removal and roadway treatment strategies. Maintenance and construction staff also use the environmental data during the construction of roadway infrastructure in deciding modifications for scheduling construction activities. The environmental data is used by different transportation management and information centers to issue advisories/alerts to travelers about unsafe driving conditions or road closures at particular locations caused by inclement weather or other weather-related impacts.

An inventory of existing and planned WX systems 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. WX ITS solutions involve services that improve the overall performance of transportation systems, including safety, mobility, transportation infrastructure, travel time, and travel time reliability.

WX Service Package Area includes collecting environmental data corresponding to current road and weather conditions, processing that environmental data to detect/forecast environmental hazards, road and weather conditions (which impact travel conditions and, maintenance and construction operations), and collectively use the environmental data to disseminate appropriate information about road and weather conditions to alert travelers and also to manage maintenance and construction operations. The goal of WX systems is to improve safety, mobility, and performance of transportation systems and operations through the use of advanced data collection techniques, information management, communication systems, and system integration between multiple jurisdictions. The Minnesota ITS Development Objectives in Table 1, specific to WX, are steps to determine and/or measure whether or not WX goals are being achieved. A complete list of Minnesota ITS Development Objectives is included in *Appendix B*.

Table 1. WX 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-1-03   Reduce number of crashes due to road weather conditions
    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-2-03   Reduce number of fatalities due to road weather conditions
    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-2-24   Reduce number of injuries due to road weather conditions
    A-2-39   Reduce number of injuries due to roadway/geometric restrictions

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

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 WX Needs and associated 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. WX Needs and Potential Solutions

Notes:
  [a] *Priority point scoring system: 0 point for "no need"; 1 point for "low"; 2 points for "low to moderate"; 3 points for "moderate"; 4 points for "moderate to high"; and 5 points for "high".*
  [b] *Discussions on needs/solutions fall under other service package bundles can be found in corresponding Service Package Bundle documents.*

ID	Need/Potential Solution	Priority Point[a]	ITS Development Objective	ARC-IT Reference[b]
WTR01	Provide automated monitoring of road weather conditions	3.67	A-1-03, A-2-03, A-2-24, C-3-09	WX01, WX02
ATIS04	Provide current and forecast road and weather condition information	4.14	A-1-03, A-2-03, A-2-24, C-3-09, C-3-10, C-3-11, C-3-12, C-3-13, C-3-15	WX02, TI01, TI02
ATMS34	Provide roadway flood warnings	2.29	A-1-03, A-1-17, A-2-03, A-2-18, A-2-24, A-2-39	WX03, TM12, MC09

5.   Detail of WX Needs and Services

A detailed description of each WX 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 DM Service Package Bundle and those in other Service Package Bundles.

6.   WX Research and Development Needs

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

- Test non-intrusive pavement sensors for data accuracy and reliability against in-place RWIS sensors, vehicle mounted sensors and visual observations.
- Develop procedures for real-time malfunction detection in RWIS to improve accuracy in forecasting roadway weather-related data.
- Investigate methods and processes to improve data latency, quality and consistency.
- Develop more reliable methods for forecasting road conditions to share via traveler information (vs. forecasting done today for maintenance operations).
- Develop improved means of using current and forecasted weather data to inform drivers of poor conditions or to recommend no travel or to provide travel times in poor roadway surface conditions.

Appendix A: Existing/Planned WX Elements

System	Service Package	Description	Stakeholder	Status
Advanced Pavement Condition and Visibility Warning System Roadside Equipment	WX01, WX03	The element represents the roadside equipment of the proposed automated warning system. The roadside equipment would consist of pavement sensors, visibility sensors, and either changeable message signs or static warning signs with flashing beacons located upstream from the problem area.	MnDOT	Planned
AWOS Central Control System	WX01, WX02	MnDOT Office of Aeronautics has installed and currently maintains Automated Weather Observation Systems (AWOS) throughout the state. AWOS data is gathered and re-distributed over the Federal Aviation Administration (FAA) National Airspace Data Interchange Network (NADIN), allowing these reports to become available through computer weather systems. Current weather information can be obtained by telephoning the AWOS site, where a computer generated voice relays up-to-the-minute observations. The AWOS data is visually displayed on a remote computer monitor at local airports, and is simultaneously broadcast over the local radio navigation aid or a VHF transmitter for in-flight use.	MnDOT Office of Aeronautics	Existing
AWOS Roadside Equipment	WX01	This element represents the roadside equipment of AWOS.	MnDOT Office of Aeronautics	Existing
Condition Acquisition and Reporting System (CARS)	WX02	This system represents a central source of roadway event information for both the management and dissemination of traffic-related information to the traveling public. The system is maintained by the MnDOT and data is input throughout MnDOT at District Offices. Minnesota State Patrol users also enter information to CARS on road conditions and incidents each day. CARS also manages automated data entry for congestion in the Twin Cities metro area based on information from loop detector roadside equipment. Data entered into CARS is available to the public to use for traveler information services through an XML feed. In MnDOT District 7, data entry occurs via web-enabled cellular telephones with approximately 75 users, primarily snow plow operators. Similar deployment is planned for MnDOT District 6.	MnDOT Office of Maintenance	Existing

System	Service Package	Description	Stakeholder	Status
Clarus Weather System	WX01, WX02	The Clarus Weather System is an FHWA-led initiative that plans to collect atmospheric and surface weather data from environmental sensor stations throughout the US and Canada and share the data with the general public and private information service providers. Eight U.S. states, including Minnesota and three Canadian territories, currently upload information to a map interface on the Clarus Initiative project website.	FHWA	Existing
Maintenance and Construction Management Center	WX01, WX02	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	WX01	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 and other technology (including air/pavement temperature sensors) 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. Other municipalities utilize vehicle ITS equipment to varying extents that provides the processing, sensory, storage, and communications functions necessary to support road maintenance and construction.	MnDOT, Local Agencies	Existing
National Weather Service	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

System	Service Package	Description	Stakeholder	Status
RTMC	WX01, WX02, WX03	The RTMC is a unified communications center that houses State Patrol Dispatch, MnDOT Metro Maintenance Dispatch and MnDOT Traffic Operations. The Metro Maintenance Dispatch serves as a point of contact for incoming information. Staff handles phone calls and monitor electronic communications and the bridge de-icier system, roadway surface and sub-surface systems. Maintenance Dispatch coordinates and initiates traffic management systems with the RTMC, traffic management personnel and the State Patrol.	MnDOT	Existing
RWIS Central Control System	WX01, WX02	MnDOT RWIS Central Server collects, verifies, processes, and formats environmental and road pavement surface condition data. Data is then made available to the Condition Acquisition and Reporting System (CARS) database, maintenance personnel, law enforcement, vendors providing value-added services, and the general public via the 511 information system.	MnDOT Office of Maintenance, Local Agencies	Existing
RWIS Roadside Equipment	WX01	MnDOT's RWIS Stations include 96 environmental sensor sites, designed to measure environmental conditions and road pavement surface conditions, and over 50 airport sites, designed just to measure environmental conditions, connected via statewide network. Environmental sensors are planned to be equipped with pan/tilt cameras to provide maintenance crews with additional road condition data. All data is communicated to the MnDOT RWIS Central Control System for verification, processing, and formatting. It is planned to upload camera images from RWIS stations to the MnDOT 511 Traveler Information Website (www.511mn.org).	MnDOT Office of Maintenance, Local Agencies	Existing
SRCC	WX01, WX02, WX03	MnDOT Southern Regional Communication Center (SRCC) is a regional center in the Rochester area for 24-hour incident and emergency response, multi-agency dispatching and fleet management, interagency communications, and collection and dissemination of road conditions.	MnDOT	Existing

System	Service Package	Description	Stakeholder	Status
Surface Transportation Weather Service Providers	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

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   <u>Enhance traveler security</u> *(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   <u>Safeguard the motoring public from homeland security and/or Hazmat incidents *(TI, TM, PT, CVO, PS, MC & VS)*</u>

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 <u>Reduce travel time for freight, transit and businesses</u> *(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 <u>Improve the efficiency of freight movement, permitting and credentials process</u> *(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 <u>Improve travel time reliability for freight, transit and businesses</u> *(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 Packages WX01 – Weather Data Collection

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Data Archive Need	Associated Service Package
WTR 01	Provide automated monitoring of road weather conditions	• MnDOT and local agencies use RWIS and AWOS to measure environmental and pavement surface conditions to assist in decisions on snow plowing schedules and chemical applications. • Law enforcement and local maintenance agencies access the data to dispatch and manage fleets. • The public uses the information to make travel decisions. • Data is shared with the Clarus system to out-of-state travelers.	• MnDOT uses RWIS sites and airport sites, connected via a statewide network to measure road pavement and environmental conditions and MnDOT maintenance vehicles equipped with sensors. • RWIS Stations are equipped with pan/tilt cameras to provide additional road condition data. • Camera images are available on the 511 website. • RWIS data are transmitted from the central server to the CARS database.	• Plan to obtain data from MnDOT maintenance vehicles (i.e. pavement and environmental conditions). • Limitations to how long the road weather condition data is stored.	• MnDOT Maintenance is responsible to plan, design, construct, operate and maintain the statewide RWIS system. • TDRL is responsible for data archiving.	• Automated monitoring systems include interconnects between roadside RWIS stations and the central RWIS server. The central RWIS server includes connections to RTMC/local MCM centers as well as traveler information services. • This service also includes interconnects between the central RWIS server and the national Clarus database.	• RWIS data and MDSS should be archived for identifying trends and aiding in snow removal strategy planning as well as pavement condition modeling. •	• WX02

Service Package WX02 – Weather Information Processing and Distribution

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Data Archive Need	Associated Service Package
WTR 01	Provide automated monitoring of road weather conditions	See information under WX01.						
ATIS 04	Provide current and forecast road and weather condition information	• MnDOT and local agencies collect road and weather conditions information using observations from MSP troopers and field personnel or RWIS sensors. • MnDOT and local agencies receive current and forecast weather information from the National Weather Service and private weather information providers. • MnDOT and local agencies process and provide information to travelers via various traveler information systems.	• MnDOT provides a statewide traffic map that includes driving condition information (good, fair, difficult) • The 511 website and phone services provide current conditions and forecasted weather information from the National Weather Service. • MDSS is also used for road and weather condition information. • Some roadways are segmented in the 511 system to identify road conditions more specifically. • Automated RWIS data entry into CARS and 511 systems.	• Include road condition information for major arterials in urbanized areas. • Evolve from county-wide condition reports to route-specific reports. • Include forecasting roadway conditions is an area to evolve in improving condition reports and route-specific reports. • Use of data from bridge anti-icing systems. • Use of data from MDSS to let people know when specific roads have been plowed	• MnDOT is responsible to plan, design, operate and maintain the 511 and RWIS systems. • Local agencies are responsible to plan, design, operate and maintain their own traveler information systems.	• Interconnects are required between roadside equipment (RWIS) and CARS/central processing systems for road weather conditions information. • Interconnects are required between weather information providers and CARS/central processing systems. • Interconnects exist between CARS/ center processing systems and 511 traveler information system.	• Weather and road condition information is archived for future analysis and planning efforts.	• TI01 • TI02

Service Package WX03 – Spot Weather Impact Warning

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Data 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 Zone (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 • MC09

Appendix D: Weather Service Packages and Descriptions

The descriptions of Weather (WX) service packages are taken directly from the ARC-IT version 8.2.

WX01 Weather Data Collection
This service package collects current road and weather conditions using data collected from environmental sensors deployed on and about the roadway. It also collects data from vehicles in the road network that can be used to directly measure or infer current environmental conditions. It leverages vehicle on-board systems that measure temperature, sense current weather conditions (rain and sun sensors) and also can monitor aspects of the vehicle operational status (e.g., use of headlights, wipers, and traction control system) to gather information about local environmental conditions. In addition, environmental sensor systems located on Maintenance and Construction Vehicles are also potential data sources. The collected environmental data is used by the Weather Information Processing and Distribution service package to process the information and make decisions on operations. The collected environmental data may be aggregated, combined with data attributes and sent to meteorological systems for data qualification and further data consolidation. The service package may also request and receive qualified data sets from meteorological systems.

WX02 Weather Information Processing and Distribution
This service package processes and distributes the environmental information collected from the Weather Data Collection service package. This service package uses the environmental data to detect environmental hazards such as icy road conditions, high winds, dense fog, etc. so operational centers and decision support systems can make decision on corrective actions to take. The continuing updates of road condition information and current temperatures can be used to more effectively deploy road maintenance resources, issue general traveler advisories, issue location specific warnings to drivers using the Traffic Information Dissemination service package, and aid operators in scheduling work activity.

WX03 Spot Weather Impact Warning
This service package will alert drivers to unsafe conditions or road closure at specific points on the downstream roadway as a result of weather-related impacts, which include, but are not limited to high winds, flood conditions, ice, or fog. The service packages is designed to use standalone weather systems to warn drivers about inclement weather conditions that may impact travel conditions. Real time weather information is collected from fixed environmental sensor stations and vehicle based sensors. The information is processed to determine the nature of the alert or warning to be delivered and then communicated to connected vehicles. If the warning includes road closure then diversion information can be provided. For non-equipped vehicles the alerts or warnings will be provided via roadway signage. In addition, the roadway equipment may calculate the appropriate speed for current weather conditions and provide this information to the connected vehicle or on roadway signage.