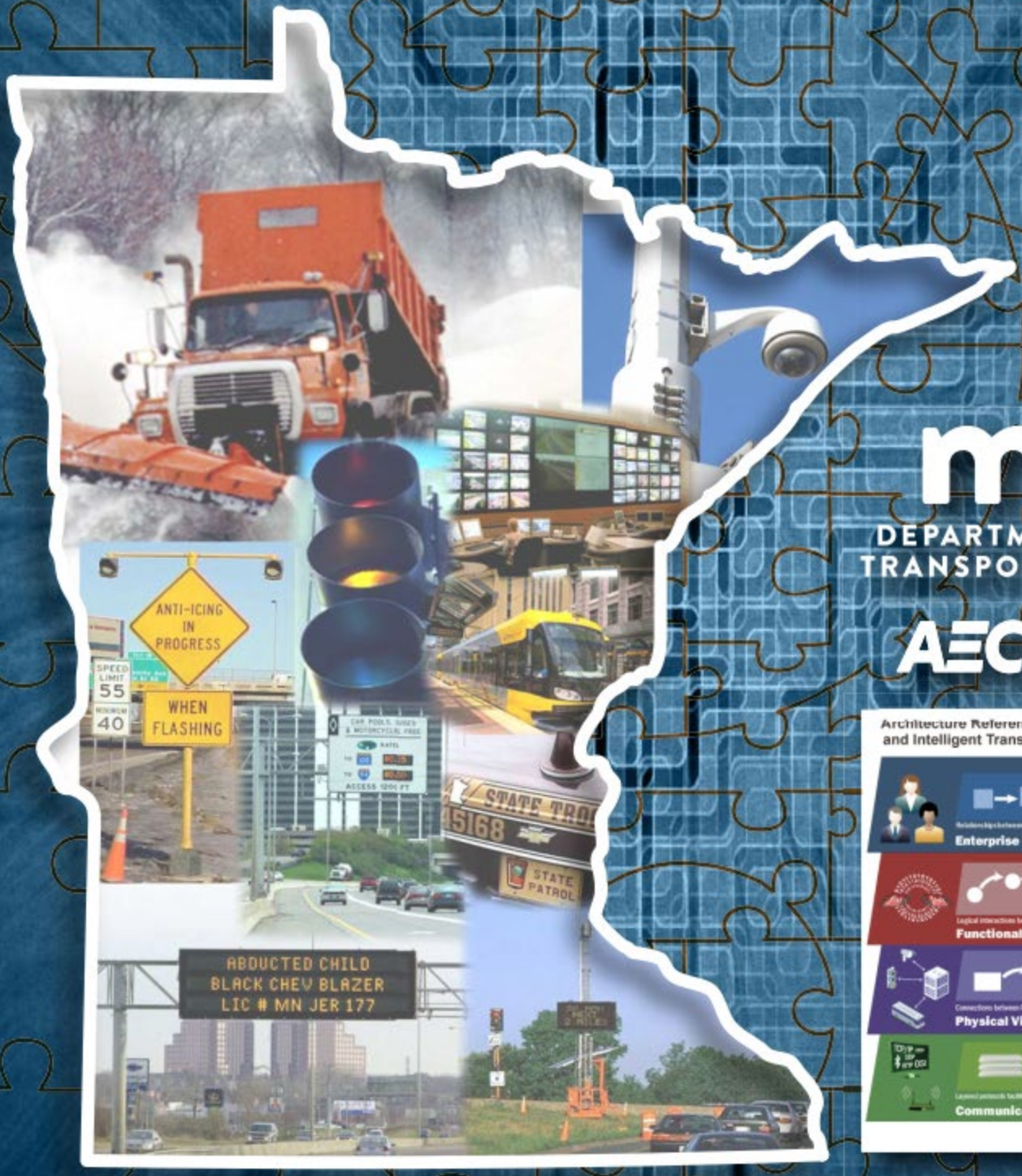
Minnesota Statewide Regional ITS Architecture

Version 2018

Volume 11:
Support Service Package Area



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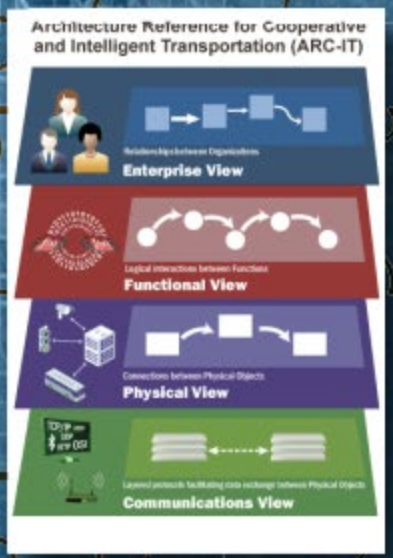

Minnesota Statewide Regional ITS Architecture
Version 2018

Volume 11: Support Service Package Area

Prepared by

AECOM

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ACRONYMS

APTS	Advanced Public Transportation System
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
DOT	Department of Transportation
EM	Emergency Management
EMS	Emergency Medical Services
EOC	Emergency Operations Center
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
GPS	Global Positioning System
HOV	High-Occupancy Vehicle
ICS	Incident Command Structure
ITS	Intelligent Transportation Systems
LOS	Level of Service
MC	Maintenance and Construction
MCM	Maintenance and Construction Management
MCMIS	Motor Carrier Management Information System
MnDOT	Minnesota Department of Transportation
MSP	Minnesota State Patrol
NIMS	National Incident Management System
PM	Parking Management
PS	Public Safety
PT	Public Transportation
RAD-IT	Regional Architecture Development for Intelligent Transportation
RTMC	Regional Transportation Management Center (MnDOT)
SRCC	Southern Regional Communications Center
ST	Sustainable Travel
SU	Support
TI	Traveler Information
TM	Traffic Management
TMC	Transportation/Traffic Management Center
VMT	Vehicle-Miles Traveled
VS	Vehicle Safety
WX	Weather

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 Architecture Outputs of the Regional ITS Architecture:** Volume 14 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 11 – Support Service Package Area

Support (SU) Service Package Area includes applications that support and make other ITS and connected/automated vehicle (CAV) applications work in a real world. SU services include:

- Managing distribution of ITS data from data providers to consumers and protecting the data from unauthorized access
- Defining interfaces for downloading and updating all types of map data used to support ITS
- Identifying and interfacing with external systems to obtain accurate location and time to ITS devices and systems
- Supporting maintenance of ITS technology, devices and systems within centers, on vehicles and in the field.
- Enabling the secured management and operations of CAV applications.

Some of the SU services are essential for any CAV deployment to work. The two highest priority SU services for any CAV project are: Security Credential Management and System Monitoring.

If a project is going to involve more than Vehicle to Vehicle (V2V) applications, then the following Support services will be needed:

- Data Distribution
- Object Registration and Discovery
- Infrastructure Management

Development of Volume 11 – SU 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 11 summarizes the findings of data collection and analysis activities conducted to support development of the SU Service Package Area. Volume 11 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 Support Systems*** provides a brief overview of statewide SU 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 SU. 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 SU 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 Service Package Bundle and those in other Service Package Bundles.
- ***Section 6: SU Research and Development Needs*** describes general research that can be performed to help implement the identified services.

2. Identification of Existing Support Systems

Support (SU) services and systems have been implemented to support data distribution as well as management and operations of various ITS devices and systems throughout Minnesota. For example, MnDOT and Metro Transit have implemented systems enabling them to remotely interface with vehicles and download vehicle diagnostic data. Those data are used for monitoring vehicle health, troubleshooting and scheduling for repairs or preventive maintenance. Additional SU systems, in particular those support CAV applications, are being planned and will be deployed over time.

An inventory of existing and planned SU 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. SU solutions involve services that improve the overall information and data management, distribution and security functions. They have direct influences on improving the security and performance of transportation systems, including safety, mobility and environment.

SU systems include use of data and systems that support operations for all ITS as well as for specific CAV services (e.g. cooperative ITS credentials management). SU services provide the crucial linkages between the sources of ITS data and data users. SU systems offer valuable tools that support a variety of purposes, such as enabling data distribution, enabling various ITS services and CAV applications, supporting maintenance of ITS devices and systems, supporting data security and privacy issues, etc. The Minnesota ITS Development Objectives in Table 1, specific to SU, are steps to determine and/or measure whether or not SU goals are being achieved. A complete list of Minnesota ITS Development Objectives is included in *Appendix B*.

Table 1. SU Specific Minnesota ITS Development Objectives

E. Support Regional Economic Productivity and Development

E-4 Increase agency efficiency

- E-4-01 Increase the number of ITS-related assets tracked
- E-4-04 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

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

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 SU 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. SU Needs and Potential Solutions

Notes:

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

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

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

ID	Need/Potential Solution	Priority Point[a]	ITS Development Objective	ARC-IT Reference[b]
SUP01	CAD-to-CAD sharing among public safety and transportation agencies	5.00[c]	B-1-15, B-1-16, B-1-17, B-1-18, C-1-01, C-1-02	TM08, PS12, SU03
SUP02	Managing and sharing transportation data	5.00[c]	C-3-10, G-1-01, G-1-02, G-1-03	DM01, SU03
ATIS02	Provide traveler information across state borders	3.00	C-3-10, C-3-12, C-3-15	TI01, TM06, SU03
ATIS12	Share/integrate public safety CAD data with CARS	3.25	C-1-01, C-1-02, C-3-10, D-2-03, D-2-04	SU03
ATIS21	Make real-time transportation operations data available to other transportation system operators (i.e. interagency data sharing)	2.57	C-3-10	SU03
ATMS36	Implement Integrated Corridor Management (ICM) strategies	2.63	B-1-01, B-1-02, B-1-03, B-1-04, B-1-05, B-1-06, B-1-07, B-1-08, B-1-09, B-1-10, B-1-11, B-1-12, B-1-13, B-1-14, B-2-23, B-2-24, B-2-25, C-3-02, C-3-03, C-3-04, C-3-05, C-3-08, H-2-01	TM01, TM03, TM05, ST06, TM07, TM09, TM10, TM16, SU03
ATMS54	Import of WAZE and other crowd sourced data to mine for incidents	5.00[c]	B-1-15, B-1-16, B-1-17, B-1-18, C-1-09, G-1-01, G-1-03	TM08, SU03
APTS08	Support vehicle diagnostics and maintenance	3.63	E-4-05, E-4-06	PT06, SU11
APTS32	Create connections with other public agencies and third parties to share real-time and historical transit data both ways	2.67[c]	C-3-10, G-1-01, G-1-02	SU03, DM01, DM02
MCM20	Snow plow priority at traffic signals and ramp meters	4.00[c]	E-4-04, E-4-05, G-1-06, H-1-05, H-1-06, H-1-07,	TM04, SU01, SU02

5. Detail of SU Needs and Services

A detailed description of each SU 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. SU Research and Development Needs

SU systems support the operations and maintenance of ITS devices, systems and specific CAV services. Given their supporting roles, research and development needs for SU systems are embedded in those in other service package areas. As such, research and development needs specific to SU service package area are not identified separately.

Appendix A: Existing/Planned SU Elements

System	Service Package	Description	Stakeholder	Status
911 Dispatch Center	SU03	This element represents the dispatch centers that receives 911 calls and dispatch the appropriate sheriff, police, fire and EMS for traffic incidents. Some centers are equipped with computer aided dispatch (CAD) systems. Dispatch centers coordinate traffic incident responses and exchange mutual aid and incident information with agencies as necessary.	Minnesota State Patrol, Local EM Agencies	Existing
CARS	SU03	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. CARS is integrated with the MSP Computer Aided Dispatch System at RTMC.	MnDOT	Existing
CV Roadside Equipment	SU01, SU02, SU08	This element represents the Connected Vehicle roadside devices that are used to send messages to, and receive messages from, nearby vehicles using Dedicated Short Range Communications (DSRC) or other alternative wireless communications technologies. Communications with adjacent field equipment and back office centers that monitor and control the RSE are also supported. This device operates from a fixed position and may be permanently deployed or a portable device that is located temporarily in the vicinity of a traffic incident, road construction, or a special event. It includes a processor, data storage, and communications capabilities that support secure communications with passing vehicles, other field equipment, and centers.	MnDOT	Planned

System	Service Package	Description	Stakeholder	Status
Maintenance and Construction Management Center	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	SU01, SU02, SU08	This element represents maintenance vehicles that are utilized by the MnDOT and City and County Public Works/Highway Departments to support road maintenance. As part of the Connected Corridor Initiative, MnDOT will equip snow plows with connected vehicle equipment and V2I communications for signal priority at traffic signals and ramp meters.	MnDOT	Existing

System	Service Package	Description	Stakeholder	Status
Metro Area Transit Management Centers	SU03	This element represents transit management centers operating within the Twin Cities metropolitan area that operate fixed route and demand responsive public transit services. This includes the Metro Transit Control Center and Suburban Transit Provider Operations Centers, independent of Metro Transit, that connect outer-ring metro-area suburbs with Minneapolis and St. Paul metro areas. Metro Transit Control Center utilizes Global Position System (GPS) technology to identify the location of all transit vehicles and also uses an 800-megahertz regional radio system, which allows Metro Transit to interact with police and fire departments and emergency response teams. Metro Transit also utilizes an automated transit fleet maintenance system (TxBase). Within the metro area, door-to-door demand response transit service is provided by Metro Mobility (serving Minneapolis, St. Paul and many surrounding suburbs), Anoka County Traveler (serving Anoka County), DARTS (serving Dakota County), Scott County (Scott County) and H.S.I. (serving Washington County). Transit fare coordination exists between Metro Transit and all Suburban Transit Providers. As a suburban transit provider, Minnesota Valley Transit Authority plans to implement Bus Rapid Transit components, such as transit signal priority and transit kiosks at transit stations along the Cedar Avenue/I-35W Corridor. Other Suburban Transit Providers include Maple Grove Transit, Southwest Metro Transit Commission, Prior Lake Laker Lines, Plymouth Transit, and Scott County Transit.	Metro Area Transit Providers	Existing

System	Service Package	Description	Stakeholder	Status
Minnesota State Patrol District Office	SU03	This element represents the 12 State Patrol district offices that manage resources and communicate incident data and resource requests to other public and private agencies. Emergency vehicle components are connected to and operated by the State Patrol Dispatch Center. Central office in St. Paul coordinates alert notifications and emergency plans with the NDDES SOC and also coordinates incident response and threat information with the North Dakota State Radio. It is planned to monitor information received from the Minnesota State Patrol Computer Aided Dispatching (CAD) System and process the transmission of this information to the MnDOT 511 Telephone Information Service and Traveler Information Website (511mn.org).	Minnesota State Patrol	Existing
Ramp Meter Roadside Equipment	SU02	This element represents signal controllers at ramp meters capable of broadcasting messages and receiving messages via DSRC or other V2I communications from vehicles for signal priority request.	MnDOT	Planned
RTMC	SU01, SU02, SU03, SU08	MnDOT RTMC is located in the Waters Edge Building in Roseville. The RTMC is where State Patrol, MnDOT Maintenance, and MnDOT Freeway Operations work together to quickly detect, respond to and remove incidents off of the freeway systems. The RTMC is responsible for managing traffic on the Twin Cities metro freeways with the use of ramp meters, variable message signs, lane control signals and loop detectors. Additional RTMC components include the HOV system, MnPASS, and airborne monitoring systems. The RTMC monitors traffic conditions, assists in incident management and provides traveler information. Traffic Operations staff also continually perform systems analysis of field equipment, the ramp meter algorithm and Operations Center equipment. They also analyze and research traffic flow trends, new technologies and other issues that affect congestion.	MnDOT	Existing
Traffic Signal Roadside Equipment	SU02	This element represents traffic signal controllers capable of broadcasting messages and receiving messages via DSRC or other V2I communications from vehicles for signal priority requests.	MnDOT	Planned

System	Service Package	Description	Stakeholder	Status
Transit Vehicle Equipment	SU01, SU08, SU11	This element represents transit vehicles and on-board ITS equipment operated by transit service providers. On-board ITS equipment may include AVL, MDT, radio communications, TSP, passenger counter, electronic fare collection equipment, security monitoring devices, and traveler information annunciation. TSP exists on vehicles serving St. Cloud and East Grand Forks. TSP is planned for vehicles serving Minneapolis, Rochester, Duluth, and Moorhead. Transit vehicles for Metro Transit, MTC, and DTA are equipped with on-board monitoring cameras. Transit vehicles for Metro Transit, MTC, and DTA have Automated Vehicle Location (AVL) devices installed. Transit vehicles for Metro Transit, MTC, DTA, MAT, CAT, and Rochester support electronic fare collection devices. Transit vehicles for Metro Transit and DTA support automated passenger counting. Light Rail transit vehicles support automated next stop annunciation. MVTA and Metro Transit plan to deploy transit vehicle lateral and longitudinal vehicle safety warning systems as well as advanced vehicle lateral control for shoulder-running buses to improve transit travel safety. Future plans include installation of pedestrian and bicyclist detection/warning systems to provide warnings to transit operators.	Metro Area Transit Providers, Local Transit Providers, Intercity Transit Providers, NCDA	Existing
Transit Vehicle Maintenance Facilities	SU11	This element represents maintenance facilities for transit vehicles (including buses for fixed-route, BRT and demand-responsive services, and LRT vehicles). These facilities support transit maintenance scheduling and monitoring. On-board condition sensors monitor system status and transmit critical status information to these maintenance facilities. The maintenance facilities process the data and schedule preventative and corrective maintenance. The maintenance facilities may collect vehicle diagnostic information from vehicles and provide service options for vehicle drivers.	Metro Area Transit Providers, Local Transit Providers, Intercity Transit 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 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 Packages SU01 – Connected Vehicle System Monitoring and Management

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Data 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.	• TM04 • SU02

Service Packages SU02 – Core Authorization

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Data Archive Need	Associated Service Package
MCM 20	Snow plow priority at traffic signals and ramp meters	See information under SU01.						

Service Package SU03 – Data Distribution

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Data Archive Need	Associated Service Package
SUP01	CAD-to-CAD sharing among public safety and transportation agencies	• MSP, local public safety agencies, and other emergency responders share data among their CAD systems to increase situational awareness as well as better coordinate incident/ emergency response and provide appropriate resources.	• Agencies and PSAPs currently have separate, non-integrated CAD systems. Coordination with different dispatch centers by communicating each other on the same radio frequency during an incident. • Hennepin County uses FATPOT and is upgrading to newer server in 2019.	• Promote data sharing among CAD systems. • Integrate MSP CAD system with that of other emergency responders. • Integrate CAD and/or allow data sharing among systems within the same region. • Additional gaps could be identified as a result of PSAP consolidation.	• MSP and local public safety agencies are responsible to coordinate for data sharing, develop common standards, integrate, and maintain their CAD systems.	• CAD data sharing and integration includes interconnects between CAD systems at dispatch centers.	• None. Individual CAD systems already have archiving guidelines and storage protocols.	• TM08 • PS12

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Data Archive Need	Associated Service Package
SUP02	Managing and sharing transportation data	• MnDOT, MSP, local agencies and transit agencies collect and manage data from their perspective systems to aid in real-time monitoring, situational awareness and for operational analysis and performance management. • MnDOT, MSP, local agencies and transit agencies share their data with others to facilitate transportation management and incident response and management.	• Individual agencies operate own data collection systems and manage own databases. • Sharing of real-time and historical transportation data occurs between few agencies, mainly in the Twin Cities area.	• Broaden the types of data collected and shared among agencies. • Enhance the capabilities of data management to support planning, performance monitoring, safety analysis, operational analysis, and research. • Enhance the ability to share real-time transportation data among operating agencies.	• Each agency is responsible to plan, design, construct, operate and maintain its own data collection and management system. • Agencies are responsible to coordinate and collaborate with others to establish policies and agreements and to plan, design, construct, operate and maintain systems and components to allow for data sharing.	• This service includes interconnects among participating agencies' databases.	• Data archive needs are determined by individual agency and system.	• DM01

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Data Archive Need	Associated Service Package
ATIS 02	Provide traveler information across state borders	• MnDOT and neighboring state DOTs share regional traveler information across state borders. • MnDOT and neighboring state DOTs provide consistent and reliable traveler information via various traveler information delivery systems to travelers in the region.	• Minnesota's 511 website provides indirect links (through FHWA) to neighboring states' traffic information websites and intercity bus services. • North/West Passage traveler information website provide traveler information for states participate in the study.	• Provide a link on 511 website to North/West Passage traveler information website. • Provide direct links to neighboring states' traveler information systems. • Share regional traveler information data with neighboring states.	• MnDOT is responsible to maintain links to and provide relevant information to neighboring states' traveler information systems. • Neighboring states are responsible to maintain web page links and provide traveler information to MnDOT	• Interconnects are required between MnDOT 511 and other regional 511/ traveler information systems.	• None	• TI01 • TM06
ATIS 12	Share/integrate public safety CAD data with CARS	• MnDOT CARS automatically incorporates data from the public safety agencies' CAD systems, increasing the timeliness and accuracy of information in CARS • General public uses 511 system to receive incident information	• MSP's CAD is integrated with MnDOT's CARS. • Other public safety agencies' CAD systems and MnDOT's CARS systems currently operate independently of each other.	• Continue Enhance the integration between CARS and MSP CAD system. • Establish more frequent updates (such as every 30 seconds) than just every 5 minutes. • Integrate more CAD systems with CARS beyond the state patrol.	• MnDOT is responsible to plan, design, operate and maintain CARS • MnDOT and each public safety agency are responsible to plan, design, operate, and maintain interfaces between its CAD systems and CARS.	• Interconnects are required between public safety CAD systems and CARS.	• None	

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Data Archive Need	Associated Service Package
ATIS 21	Make real-time transportation operations data available to other transportation system operators (i.e. interagency data sharing)	• MnDOT and local agencies collect real-time transportation operations data. • MnDOT and local agencies provides relevant real-time operations data to other transportation agencies upon request. • Transit vehicles collect real-time operations data and send to transit control center for dissemination to other agencies	• IRIS is a data distribution system used at the MnDOT RTMC from which data is shared with other agencies. • Third-party access to MnDOT CARS data is made available to outside vendors and universities • Camera feeds in District 4 are shared with other agencies. • MnDOT and Wisconsin DOT share control of DMS and camera images in Duluth, La Crosse and Metro regions.	• Provide real-time transportation operations data outside the Twin Cities area to other transportation agencies.	• MnDOT is responsible to plan, design, operate, and maintain IRIS, RTMC, and CARS. • MnDOT and other transit/ transportation agencies are responsible to coordinate with each other to plan, design, operate and maintain interfaces necessary for real-time data sharing. • MnDOT and other transit/ transportation agencies are responsible to establish agreements for interagency data sharing.	• Interconnects are required between RTMC and other TMCs.	• None	

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Data Archive Need	Associated Service Package
ATM S36	Implement Integrated Corridor Management (ICM) strategies	• Transportation agencies would coordinate transportation management and transit operations on their systems to optimize overall traffic flow in a corridor by accessing underused capacity. • The public would use this service to determine which route and/or mode they use for their trips.	• RTMC and Minneapolis TMC operate transportation management systems on their roadways. • Transit authorities operate their own transit systems.	• MnDOT and ICM Project Partners applied for federal funds to implement its ICM strategies on the I-394 corridor. • Effectiveness of strategies will be modeled. • Communications links and policies between partners will be enhanced. • One agency managing regional traffic operations and principal arterial operations in multiple jurisdictions in the region.	• RTMC and the City of Minneapolis are responsible to plan, design, construct, operate, and maintain their transportation management systems. • Metro Transit is responsible to plan, design, construct, operate, and maintain their transit system • RTMC, Hennepin County TMC, Minneapolis TMC, and Metro Transit will be responsible for collecting and archiving network-specific data.	• An ICM system includes interconnects between roadside equipment and the RTMC and Minneapolis TMC. • An ICM system also includes interconnects between transit centers and transit vehicles. • An ICM system in the Twin Cities includes interconnects between the RTMC, Minneapolis TMC, and Metro Transit centers.	• Data on network and roadway/ bus route performance from use of ICM strategies should be archived for evaluation and analysis.	• TM01 • TM03 • TM05 • TM07 • TM09 • TM10 • TM16 • ST06

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Data Archive Need	Associated Service Package
ATM S54	Import of WAZE and other crowd sourced data to mine for incidents	• MnDOT imports and integrates traffic incident data from WAZE and other crowd sourced data with data reported by MSP and MnDOT • MnDOT develops and uses tools to verify and validate incident data from WAZE and other crowd sourced database. • MnDOT uses the valid and fused data mine for traffic incidents.	• MnDOT currently uses third party speed and travel time data to supplement MnDOT detector data for generating traffic flow/congestion maps. • MnDOT uses incident reports from MSP along with detectors and CCTV cameras for incident detection and verification.	• Investigate and develop filtering techniques for assessing incident reports and alert notifications from WAZE and other crowd sourced data. • Develop and improve techniques to mine for incidents using WAZE and crowd sourced data.	• MnDOT is responsible to work with WAZE and other crowd sourced data providers to establish partnerships. • MnDOT is responsible to plan, develop, implement, operate, and maintain a data mining system for incident detection and verification.	• This service includes interconnects between MnDOT RTMC/SRCC and private third party data providers; and interconnects between MnDOT RTMC/SRCC and MSP.	• Verified incidents should be archived.	• TM08

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Data Archive Need	Associated Service Package
APTS 32	Create connections with other public agencies and third parties to share real-time and historical transit data both ways	• Transit agencies work with other transit, traffic and public safety agencies to share real-time and historical data. • Transit agencies work with third party data/ information providers to share information to improve services and customer satisfaction. • Transit agencies uses real-time and historical data for performance monitoring, planning, analysis and research.	• Information sharing among transit, traffic and public safety agencies occurs on limited basis. • MnDOT shares Metro area congestion, detour and incident information with transit providers in the Metro area. • Minneapolis and St. Paul shares roadway closures with transit providers in the Metro area.	• Coordinate with traffic and public safety agencies and third party providers to identify data sharing needs. • Develop and implement plans for establishing connects with traffic and public safety agencies and third parties to share data both ways.	• Public agencies are responsible to coordinate with each other to plan and implement two-way data sharing. • Transit agencies are responsible to coordinate with third party data providers to enable two-way data sharing.	• Interconnects between transit management centers, other transit management centers, traffic management centers, public safety agencies and third party providers.	• None.	• DM01 • DM02

Service Packages SU04 – Map Management

While there are systems in Minnesota have map management functions, no needs or services under this service package were identified by stakeholders.

Service Packages SU05 – Location and Time

While there are systems utilizing this service in Minnesota, no needs or services under this service package were identified by stakeholders.

Service Packages SU06 – Object Registration and Discovery

While Minnesota is conducting research and pilot deployment on Connected and Automated Vehicle technologies, specific needs or services under this service package were not identified by stakeholders.

Service Packages SU07 – Privacy Protection
While Minnesota is conducting research and pilot deployment on Connected and Automated Vehicle technologies, specific needs or services under this service package were not identified by stakeholders.

Service Packages SU08 – Security and Credentials Management
While Minnesota is conducting research and pilot deployment on Connected and Automated Vehicle technologies, specific needs or services under this service package were not identified by stakeholders.

Service Packages SU09 – Center Maintenance
While there are various centers for ITS in Minnesota, no needs or services under this service package were identified by stakeholders.

Service Packages SU10 – Field Equipment Maintenance
While there are various ITS field devices in Minnesota, no needs or services under this service package were identified by stakeholders.

Service Packages SU11 – Vehicle Maintenance

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Data Archive Need	Associated Service Package
APTS 08	Support vehicle diagnostics and maintenance	• Transit agencies use sensors to monitor vehicle usage and conditions and transmit data to fleet management systems to issue diagnostic reports and maintenance requests. • Fleet management systems process data and schedule preventative and corrective maintenance. • The systems also provide personnel with vehicle diagnostic and historical maintenance data for use during preventative maintenance and for roadside assistance calls.	• Metro Transit uses TxBase interface to generate work orders when some error codes are received. • Metro Transit is updating its AVL system to gather vehicle diagnostics through the AVL system. • St. Cloud enters all diagnostic data into its fleet management system. • (DTA uses AVL system for diagnostic data reporting and on-board sensors for preventative maintenance. • Transit agencies have integrated vehicle monitoring equipment with automated diagnostic systems.	• Expand implementation of fleet management systems with automated diagnostic and scheduling capabilities to other transit agencies.	• Transit agencies are responsible to plan, design, construct, integrate, operate and maintain their vehicle monitoring and diagnostic systems.	• This service includes interconnects between in-vehicle monitoring equipment and fleet management/ diagnostic systems.	• Diagnostic and maintenance history will be archived for use in future vehicle maintenance and fleet maintenance analysis.	• PT06

Service Packages SU12 – Traveler Device Maintenance

While there are public traveler devices in Minnesota, no needs or services under this service package were identified by stakeholders.

Appendix D: Support Service Packages and Descriptions

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

SU01 Connected Vehicle System Monitoring and Management
This service package provides monitoring, management and control services necessary to other applications and/or devices operating within the Connected Vehicle Environment. This service package maintains and monitors the performance and configuration of the connected vehicle system. This includes tracking and management of the infrastructure configuration as well as detection, isolation, and correction of infrastructure service problems. It also includes monitoring of performance of the infrastructure and mobile equipment, which includes RSEs, OBEs, the back office applications, as well as the communication links that connect the system.

SU02 Core Authorization
This service package manages the authorization mechanisms to define roles, responsibilities and permissions for connected vehicle applications. This allows system administrators to establish operational environments where different connected vehicle system users may have different capabilities. For instance, some Mobile elements may be authorized to request signal priority, or some Centers may be permitted to use the geographic broadcast service, while those without those permissions would not.

SU03 Data Distribution
This service package manages the distribution of data from data providers to data consumers and protects those data from unauthorized access. It informs data providers of how to provide data, manages data subscriptions, and provides data forwarding capabilities. The service package also maintains a directory of System Users that want data and supports multiple distribution mechanisms including publish-subscribe and directly from data provider to data consumer. It allows data consumers to specify (and change the specification of) data they wish to receive.

SU04 Map Management
This service package defines interfaces that can be used download or update all types of map data used to support intelligent transportation systems. This map data will be accessed by centers, field, and vehicle physical objects. The service package can also be used to harness the Connected Vehicle Environment to provide rich source data that can be used to verify, refine, and enhance geographic map data.

SU05 Location and Time
This service package identifies the external systems and interfaces that provide accurate location and time to intelligent transportation system devices and systems.

SU06 Object Registration and Discovery
This service package provides registration and lookup services necessary to allow objects to locate other objects operating within the Connected Vehicle Environment. An object registry is like a phone book for all the connected centers, systems, and equipment in the transportation system (the “objects”). In this service package, each object registers itself with the ORDS and tells the registry where it lives in the communication network (e.g., host, port, node name) and information about the services it provides - information that other objects can use to determine the type of service, the geographic scope of the service, and other information that helps users

of the registry to make informed decisions about which object(s) support a needed service or information stream. This is the “Discovery” part of the service. Connected objects can use the registry to find (discover) objects that can be used to get needed information or services.

SU07 Privacy Protection
This service package provides the privacy protection essential to the operation of connected vehicle applications. Privacy Protection obscures the network identifiers of mobile devices in order to allow communications with credentials management and other centers.

SU08 Security and Credentials Management
This service package is used to ensure trusted communications between mobile devices and other mobile devices or roadside devices and protect data they handle from unauthorized access. The service package grants trust credentials to qualified mobile devices and infrastructure devices in the Connected Vehicle Environment so that those devices may be considered trusted by other devices that receive trust credentials from the SCM service package. The service package allows credentials to be requested and revoked and secures the exchange of trust credentials between parties, so that no other party can intercept and use those credentials illegitimately. The service package provides security to the transmissions between connected devices, ensuring authenticity and integrity of the transmissions. Additional security features include privacy protection, authorization and privilege class definition, as well as non-repudiation of origin.

SU09 Center Maintenance
This service package supports maintenance of the computers, networks, video walls, and other information technology assets that are installed in a center to support center operations. Like other support service packages, this SP is drawn at a high level of abstraction so the basic interfaces and functionality associated with maintaining center IT assets can be applied to any center.

SU10 Field Equipment Maintenance
This service package supports maintenance of ITS devices that are installed in the field. Like other support service packages, this SP is drawn at a high level of abstraction so the basic interfaces and functionality associated with maintaining field ITS assets can be applied to any field equipment. In particular, this service package supports maintenance of field subsystems like ITS Payment Equipment, Parking Management Systems, and Commercial Vehicle Check Equipment where maintenance is not covered by a more specific Service Package. Two Field subsystems have more specific service packages associated with their maintenance: See MC05 for maintenance of ITS Roadway Equipment and SU01 for more specific interfaces associated with maintaining Connected Vehicle Roadside Equipment.

SU11 Vehicle Maintenance
This service package identifies the interfaces and functionality that support vehicle maintenance, including maintenance of ITS equipment on board the vehicle. An interface with a Vehicle Service Center supports vehicle monitoring to support timely, effective maintenance. It also supports software configuration management and updates as part of maintenance of the software-based on-board systems. While this service package covers only maintenance of the Vehicle OBE, it is defined at the highest level of abstraction so that any center that is contemplating advanced maintenance concepts for its fleet vehicles can use this service package. Other service packages that provide maintenance support for fleet vehicles include CVO01, MC02, and PT06.

SU12 Traveler Device Maintenance

This service package supports maintenance of ITS personal devices and public devices that are installed in traveler environments like transit stations and other public areas frequented by travelers. Like other device maintenance service packages, this SP is drawn at a high level of abstraction to cover the basic interfaces and functionality associated with maintaining traveler-oriented personal and public devices. For personal devices, the focus is on devices that are used by transportation professionals. The maintenance of smart phones, tablets, laptops, and other general purpose devices that are used by travelers is coordinated between the travelers and the providers of the devices and communications services, which is beyond the scope of the architecture.