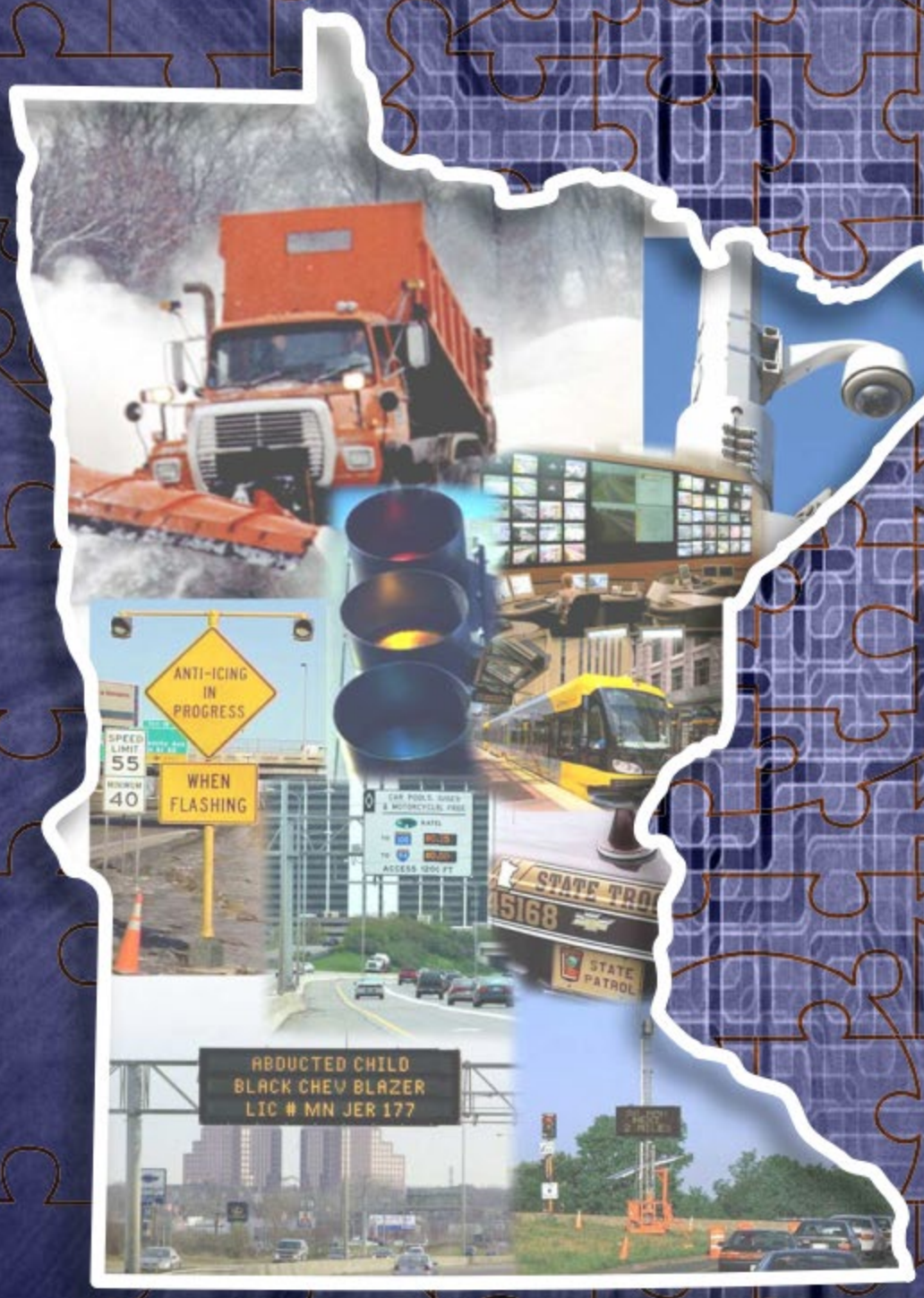
Minnesota Statewide Regional ITS Architecture

Version 2018

Volume 12:
Sustainable Travel Service Package Area



DEPARTMENT OF TRANSPORTATION

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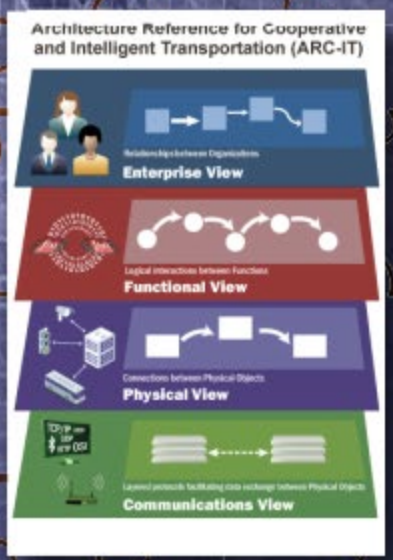

Minnesota Statewide Regional ITS Architecture
Version 2018

Volume 12: Sustainable Travel Service Package Area

Prepared by

AECOM

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ACRONYMS

ARC-IT	Architecture Reference for Cooperative and Intelligent Transportation
ATIS	Advanced Traveler Information System
ATMS	Advanced Traffic Management System
CAD	Computer Aided Dispatch
CV	Connected Vehicle
CVO	Commercial Vehicle Operations
DM	Data Management
DMS	Dynamic Message Sign
DOT	Department of Transportation
EOC	Emergency Operations Center
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
HOT	High-Occupancy Toll
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
MPAC	Minnesota Pollution Control Agency
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
RSE	Roadside Equipment
RTMC	Regional Transportation Management Center (MnDOT)
ST	Sustainable Travel
SU	Support
TDM	Travel Demand Management
TI	Traveler Information
TM	Traffic Management
TMC	Transportation/Traffic Management Center
V2I	Vehicle to Infrastructure
V2V	Vehicle to Vehicle
V2X	Vehicle to Vehicle, Infrastructure, or other Devices
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 12 – Sustainable Travel Service Package Area

Sustainable Travel (ST) Service Package Area includes ITS and connected vehicle applications and strategies that aid overall transportation systems to function in fuel/energy efficient and environmental friendly manner, reduce emissions, use renewable energy sources, support eco-friendly transportation system and infrastructure, and, develop sustainable ecosystem which gives flexibility to meet future transportation demand with current needs.

Development of Volume 12 – ST 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 12 summarizes the findings of data collection and analysis activities conducted to support development of the ST Service Package Area. Volume 12 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 Sustainable Travel Systems*** provides a brief overview of statewide ST 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 ST. 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 ST 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: ST Research and Development Needs*** describes general research that can be performed to help implement the identified services.

2. Identification of Existing Sustainable Travel Systems

ST systems are applications and strategies that utilize ITS and connected vehicle technologies to facilitate a more sustainable relationship between transportation and the environment. ST systems facilitate and incentivize "green choices" by all transportation service consumers, including system users, system operators, policy decision makers, etc. They provide environmental benefits via reductions in fuel use and efficiency as well as emissions.

ST systems include in-vehicle technology that monitors individual vehicle emissions and field technology that monitors general air quality and collects data for a region. ST systems also include connected vehicle technologies that enable traffic management strategies optimized for the environment. ST strategies and applications include: eco-traffic signal timing, eco-traffic metering, HOV/HOT lane management, eco-lanes management, eco-approach and departure at signalized intersections, and low emission zone management. Those strategies are aimed to reduce fuel consumption and overall emissions at intersections, along a corridor, or for a region.

An inventory of existing and planned ST 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. ST solutions involve services that reduce negative environmental impacts and improve the overall fuel and energy efficiency and air quality.

The goal of ST systems is to increase fuel and energy efficiency and reduce emissions through the use of in-vehicle and roadside sensing technology, advanced data collection techniques, information management, communication systems, and system integration. The Minnesota ITS Development Objectives in Table 1, specific to ST, are steps to determine and/or measure whether or not ST goals are being achieved. A complete list of Minnesota ITS Development Objectives is included in *Appendix B*.

Table 1. ST Specific Minnesota ITS Development Objectives

B. Increase Operational Efficiency and Reliability of the Transportation System

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-2-11 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-2-19 Increase the number of carpools
- B-2-20 Increase use of vanpools
- B-2-22 Reduce trips per year in region through carpools/vanpools

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

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
- C-3-02 Reduce single occupancy vehicle 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-3-16 Increase annual transit ridership reported by urbanized area transit providers
C-3-17 Increase annual transit ridership reported by rural area transit providers

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

H. Reduce Environmental Impacts

H-1 Reduce emissions/energy impacts and use associated with congestion

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

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-2-19 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

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 ST 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. ST 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]
ATMS20	Operate dynamic shoulders	1.38	B-1-01, B-1-02, B-1-04, B-1-05, B-1-09, B-1-10, B-1-11, B-1-12, B-1-13, B-1-14, B-2-11, B-2-19, B-2-22, B-2-23, B-2-24, B-2-25, C-2-01, C-2-02	ST06, TM10, TM22
ATMS26	Operate and enforce MnPASS lanes	1.67	B-1-01, B-1-02, B-1-04, B-1-05, B-1-09, B-1-10, B-1-11, B-1-12, B-1-13, B-1-14, B-2-11, B-2-19, B-2-22, B-2-23, B-2-24, B-2-25	ST06, TM10, TM16, TM22
ATMS27	Provide HOV bypass lanes at ramp meter locations	1.92	B-2-01, B-2-02, B-2-19, B-2-20, B-2-22	ST06

ID	Need/Potential Solution	Priority Point[a]	ITS Development Objective	ARC-IT Reference[b]
ATMS31	Monitor and collect air quality data	2.38	H-1-01, H-1-02, H-1-03, H-1-04, H-1-05, H-1-06, H-1-07	ST01
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	ST06, TM01, TM03, TM05, TM07, TM09, TM10, TM16, SU03
ATMS48	Increase enforcement/presence of enforcement	5.00[c]	A-2-43, A-2-44, C-1-09, C-3-09, D-1-01, D-1-02, D-1-04, D-1-05, D-1-06, D-1-07, D-1-08, D-1-09, E-2-03, F-1-02	ST06, TM17, TM22
AVCV03	SPaT Information to vehicles	5.00[c]	A-1-05, A-1-10, A-1-16, A-2-05, A-2-11, A-2-17, A-2-26, A-2-32, A-2-38, B-1-03, G-1-02	TM04, ST08, VS13

5. Detail of ST Needs and Services

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

In order to fill gaps and meet the needs for technology advancement in ST 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 ST are as follows:

- Develop automated vehicle passenger occupancy detection system as assistance in counting vehicle passenger occupancy
- Continue refining ramp metering algorithms
- Test HOT/parking payment integration
- Investigate methods and technologies for improving traffic signal operations
- Investigate local street intersection treatments to reduce bike stops

Appendix A: Existing/Planned ST Elements

System	Service Package	Description	Stakeholder	Status
CV Roadside Equipment	ST08	This element represents the Connected Vehicle (CV) 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
Minnesota State Patrol District Office	ST06	Enforcement of MnPASS lanes in the Twin Cities area is performed by the Minnesota State Patrol, along with local enforcement agencies.	Minnesota State Patrol	Existing
MnPASS Roadside Equipment	ST06	Roadside equipment includes variable message signs to display toll amounts that vary by time of day and/or levels of traffic congestion on toll facility and flashing roadside beacons to indicate that proper toll amounts have been paid for use of the HOT (High-Occupancy Toll) Lane facility. Equipment also includes ramp access controls to prevent drivers from entering the HOT Lane facility. MnPASS is designed to improve roadway efficiency by increasing person and vehicle-carrying capabilities in the MnPASS lanes. HOT lane tolls are priced dynamically based on the level of demand for the HOT lanes.	MnDOT	Existing
MnPASS Service Center	ST06	This element represents the center that performs administrative functions relating to MnPASS operations.	MnDOT	Existing
MnPASS Vehicle Equipment	ST06	This element represents the transponder that supports automated payment of tolls along MnPASS Lanes.	Travelers	Existing

System	Service Package	Description	Stakeholder	Status
Roadway Lighting Management Central Monitoring System	ST04	This element represents the central location at which Roadway Lighting Management Roadside Equipment is monitored.	City of Minneapolis	Planned
Roadway Lighting Management Roadside Equipment	ST04	This represents roadside equipment that will apply an optimal amount of roadway lighting based on current road and weather conditions. System is planned in the City of Minneapolis, which will allow operational control of the City's street lighting system from a central location, delivering light intelligently based upon real-time conditions. Through a wireless network and existing power and cable lines, the user can efficiently and effectively control the operation of all street lights maintained by the City of Minneapolis from one central location, mobile or stationary.	City of Minneapolis	Planned
RTMC	ST06, ST08	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
Tunnel Emissions Roadside Equipment	ST01	This represents the Tunnel Alarm Monitoring System is currently operated by MnDOT District 1 and the State Patrol dispatchers and includes the monitoring of the Lief Erickson Tunnel within Segment 10 and the Silver Creek and Lafayette Bluff tunnels along Highway 61 north of Duluth (along the North Shore). Roadside equipment monitors for carbon monoxide (CO) levels, fire, fan and generator operation and communications and power.	MnDOT	Existing

System	Service Package	Description	Stakeholder	Status
Vehicle Passenger Occupancy Monitoring/ Enforcement Roadside Equipment	ST06	This element represents roadside equipment that is planned to monitor vehicle passenger occupancies along designated HOV/MnPASS lanes and signal for enforcement when violations are detected.	MnDOT	Planned

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 ST01 – Emissions Monitoring

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Data Archive Need	Associated Service Package
ATMS 31	Monitor and collect air quality data	• Federal, state, and local agencies collect air quality data in selected areas to measure emissions and air pollution levels. • MnDOT Environmental Services and the Minnesota Pollution Control Agency (MPCA) use data to monitor and analyze air quality in the Twin Cities metro area. • MnDOT informs travelers of ozone and air quality information. • Travelers use air quality information to make travel and modal choices.	• Air quality sensors are installed on I-394 and the Lowry Tunnel in Minneapolis.	• Install additional air quality sensors at strategic locations. • Refine air quality analysis algorithms • Develop future strategies to reduce greenhouse gases.	• Federal, state (i.e. MnDOT), and local agencies are responsible to plan, design, construct, and maintain the air quality monitoring system. • MnDOT Planning is responsible for analysis of data for long term planning purposes.	• Air quality monitoring systems include interconnects from roadside equipment to the RTMC.	• Monitoring center should archive air quality data for future environmental study and analysis.	

Service Package ST02 – Eco-Traffic Signal Timing
No needs or services under this service package were identified by stakeholders.

Service Package ST03 – Eco-Traffic Metering
No needs or services under this service package were identified by stakeholders.

Service Package ST04 – Roadside Lighting
No needs or services under this service package were identified by stakeholders.

Service Package ST05 – Electric Charging Stations Management
No needs or services under this service package were identified by stakeholders.

Service Package ST06 – HOV/HOT Lane Management

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Data Archive Need	Associated Service Package
ATMS 20	Operate dynamic shoulders	• MnDOT operates dynamic shoulders to allow single occupancy vehicles (SOV) to use shoulders in order to reduce overall congestion and divert traffic from other lanes during traffic incidents. • Transit, HOV, and motorcycles can use the lanes free of charge. SOV drivers can enter the lanes for a fee based on the level of congestion. • Tolls for SOV are collected electronically using MnPASS transponders. • Toll rates are displayed via dynamic message signs prior to access points. • MSP and local law enforcement agencies monitor lane users and enforce compliance.	• There are currently no priced dynamic shoulder lanes in Minnesota. They are planned to be deployed on I-35W in Minneapolis between 46th Street and downtown. • Bus-only shoulders are utilized throughout the metro area for transit vehicles.	• Priced and un-priced dynamic shoulder lanes are planned for I-35W in Minneapolis between 46th Street and downtown. • Pricing algorithm will be further refined. • Electronic overhead lane control signs will be used to operate the shoulder lanes.	• MnDOT is responsible to plan, design, implement, operate, and maintain the dynamic shoulders in the metro area. • MSP and local law enforcement agencies are responsible to enforce appropriate usage of lanes.	• Dynamic shoulder systems include interconnects between vehicles and roadside equipment for toll collection. • Systems also include interconnects between roadside toll equipment and the toll collection center for account monitoring. • Systems also include interconnects between roadside detection, lane control equipment, DMS, and the RTMC. • Systems include interconnects between toll collection center and the RTMC.	• MnPASS data including volume, speed, revenue, and violations should be archived. This data will be used for performance monitoring and reporting. • MnPASS user account transactions should also be archived for back-office account management.	• TM10 • TM22

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Data Archive Need	Associated Service Package
ATMS 26	Operate and enforce MnPASS lanes	• MnDOT RTMC operates the dynamically priced MnPASS lanes to allow SOV to use the facility to reduce overall congestion. • Transit, HOV, and motorcycles use the lanes free of charge. SOV drivers can enter the lanes for a fee based on the level of congestion. • Tolls for SOVs are collected electronically using MnPASS transponders. • Toll rates are displayed via overhead electronic signs prior to access points. • MSP and local law enforcement agencies monitor lane users and enforce compliance.	• MnPASS lanes are currently operational on I-394, I-35E and I-35W in the Twin Cities Metro Area. • Priced dynamic shoulder lanes, similar to the I-394 MnPASS, have been implemented on I-35W from 46th Street to downtown Minneapolis, as well as on I-94 between Minneapolis and St. Paul. • Minnesota State Patrol (MSP) is primarily being utilized as enforcement on MnPASS lanes.	• Implement additional MnPASS lanes in the Metro area. • Develop an automated vehicle passenger occupancy detection system to assist enforcement. • Integration of MnPASS with other toll systems (part of MAP-21 legislation).	• MnDOT will plan, design, implement, operate, and maintain MnPASS lanes in the Twin Cities metro area. • MSP and local law enforcement agencies are responsible to enforce appropriate usage of lanes.	• MnPASS systems include interconnects between vehicles and roadside equipment for toll collection. • Systems also include interconnects between roadside toll equipment and the toll collection center for account monitoring. • Systems also include interconnects between roadside detection, lane control equipment, DMS, and the RTMC. • Systems include interconnects between toll collection center and the RTMC.	• MnPASS data including volume, speed, revenue, and violations is archived. This data is used for performance monitoring and reporting. MnPASS user account transactions should also be archived for back-office account management.	• TM10 • TM16 • TM22

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Data Archive Need	Associated Service Package
ATMS 27	Provide HOV bypass lanes at ramp meter locations	• MnDOT provides HOV bypass at ramp metering locations to encourage carpooling and use of transit by allowing preferred access. • HOVs and transit vehicles use this service to bypass vehicle queues at on-ramp locations. • MSP and local law enforcement agencies enforce HOV requirements.	• Some metro area ramp meters currently have HOV bypass lanes.	• Construct HOV bypasses at additional metered ramp locations when requested by transit agencies • Develop automated vehicle passenger occupancy verification system for effective enforcement.	• MnDOT is responsible for the planning, design, construction, operations, and maintenance of HOV bypasses. • MSP and local law enforcement agencies are responsible to enforce occupancy compliance.	• Interconnect from HOV bypass ramp detection systems to RTMC. • Vehicle occupancy verification systems include interconnects between roadside detection equipment and in-vehicle enforcement alert equipment.	• Vehicle occupancy verification enforcement will be archived for performance measures analysis and citation use. • Vehicle detection data also needs to be archived.	

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Data Archive Need	Associated Service Package
ATMS 36	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 • SU03

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Data Archive Need	Associated Service Package
ATMS 48	Increase enforcement / presence of enforcement	• State Patrol and local enforcement agencies increase their presence and visibility on the road to the general public.	• MnDOT and local agencies use dynamic speed feedback signs to inform drivers of their current speeds compared to the posted speed limits. • MSP and local enforcement agencies enforce traffic law violations on the road, including work zones and MnPASS lanes.	• Increase manual enforcement and gradually move toward automated enforcement through operational tests and enabling legislation. • Automated speed enforcement is not permissible under current statute. Legislation must be passed to authorize it.	• State patrol and local agencies are responsible to perform enforcement on the road. • Each agency is responsible to plan, design, construct, operate, and maintain their automated enforcement systems.	• Automated enforcement systems include interconnects between roadway detection equipment and in-vehicle equipment in the enforcement vehicles.	• Enforcement/ violation data should be archived to study the potential effects of automated enforcement.	• TM17 • TM22

Service Package ST07 – Eco-Lanes Management

No needs or services under this service package were identified by stakeholders.

Service Package ST08 – Eco-Approach and Departure at Signalized Intersections

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Data Archive Need	Associated Service Package
AVCV 03	SPaT Information to vehicles	• SPaT information assists drivers in, making right-turns, detecting pedestrian and bike activity, making trip decisions, adjusting driving behavior based on traffic signal timings, and to support other safety, mobility and environmental related V2X applications.	• MnDOT has deployed SPaT information dissemination system for the TH-55 corridor between downtown Minneapolis and I-494, and ramp intersections along the parallel of I-394, as part of the Connected Corridor project.	• MnDOT continues to fine-tune the deployment of SPaT information dissemination system for the TH-55 corridor. • MnDOT plans to expand the Connected Corridor concept to other corridors.	• MnDOT/Local Agencies are responsible to develop, test, deploy, operate, and maintain infrastructure and data management systems to support various applications of V2X.	• This service includes interconnects between TMCs and MCM centers, traffic control device, roadside equipment and in-vehicle equipment.	• Data related to traffic signal phasing and timing is stored to improve efficiency of system and corridor management, and also to support other V2X applications.	• TM04 • VS13

Service Package ST09 – Connected Eco-Driving

No needs or services under this service package were identified by stakeholders.

Service Package ST10 – Low Emissions Zone Management

No needs or services under this service package were identified by stakeholders.

Appendix D: Sustainable Travel Service Packages and Descriptions

The descriptions of Sustainable Travel (ST) service packages are taken directly from the ARC-IT version 8.2.

ST01 Emissions Monitoring
This service package monitors individual vehicle emissions and provides general air quality monitoring using distributed sensors to collect the data. The collected information is transmitted to the Emissions Management Center for processing. Both area wide air quality monitoring and point emissions monitoring are supported by this service package. For area wide monitoring, this service package measures air quality, identifies sectors that are non-compliant with air quality standards, and collects, stores and reports supporting statistical data. For point emissions monitoring, this service package collects data from on-board diagnostic systems and measures tail pipe emissions to identify vehicles that exceed emissions standards and/or clean vehicles that could be released from standard emissions tests, depending on policy and regulations. Summary emissions information or warnings can also be displayed to drivers. The gathered information can be used to implement environmentally sensitive travel demand management (TDM) programs, policies, and regulations.

ST02 Eco-Traffic Signal Timing
The Eco-Traffic Signal Timing service package is similar to current adaptive traffic signal control systems; however, the service package's objective is explicitly to optimize traffic signals for the environment rather than the current adaptive systems' objective, which is to enhance the intersection level of service or throughput, which might improve the intersection's environmental performance. The Eco-Traffic Signal Timing service package processes real-time and historical connected vehicle data at signalized intersections to reduce fuel consumption and overall emissions at the intersection, along a corridor, or for a region. It evaluates traffic and environmental parameters at each intersection in real time and adapts so that the traffic network is optimized using available green time to serve the actual traffic demands while minimizing the environmental impact.

ST03 Eco-Traffic Metering
The Eco-Traffic Metering service package determines the most environmentally efficient operation of traffic signals at freeway on-ramps to manage the rate of entering automobiles. This service package collects traffic and environmental data from roadside sensors and connected vehicles to allow on-ramp merge operations that minimize overall emissions, including traffic and environmental conditions on the ramp and on the freeway upstream and downstream of the ramp. Using this information, the service package determines a timing plan for the ramp meter based on current and predicted traffic and environmental conditions.

ST04 Roadside Lighting
The Roadside Lighting service package is a connected vehicle version of the automated roadside lighting systems that uses the presence of vehicles based on V2I communications as an input to control of roadside lighting systems. The service package can use the presence of vehicles to alter roadside lighting levels, and can use environmental data obtained from the vehicles as an input to support adjustment of the lighting based on adverse weather conditions such as fog, rain, or snow.

ST05 Electric Charging Stations Management
The Electric Charging Station Management service package provides an exchange of information between the electric vehicle and charging station to manage the charging operation. The agency or company operating the charging station can use vehicle information such as the capability of the vehicle (e.g. operational status of the electrical system, how many amps can the vehicle handle, and % charge complete) to determine that the charge is being properly applied and determine an estimated time to complete charging.

ST06 HOV/HOT Lane Management
This service package manages high-occupancy vehicle (HOV) and high-occupancy toll (HOT) lanes by coordinating freeway ramp meters and connector signals with HOV lane usage signals. Preferential treatment is given to HOV lanes using special bypasses, reserved lanes, and exclusive rights-of-way that may vary by time of day. Vehicle occupancy can be detected to verify HOV compliance and to notify enforcement agencies of violations. For HOT lane configurations, tolls are collected for vehicles that do not meet the high-occupancy criteria for the lane.

ST07 Eco-Lanes Management
The Eco-Lanes Management service package supports the operations of eco-lanes – dedicated lanes similar to high-occupancy vehicle (HOV) or high-occupancy toll (HOT) lanes, but optimized for the environment. The service package employs communication technology to gather traffic and environmental information from multiple sources including infrastructure, vehicles, and other systems. The service package then processes these data and determines whether an eco-lane should be created or decommissioned along a roadway. These decisions would be in response to real-time traffic and environmental conditions. While the eco-lanes would have the capability to be flexible and more dynamic, it is envisioned that these parameters would change only as needed to ensure that travelers do not become confused by a system that is too dynamic in nature. Travelers would need to assume some level of consistency with their trip and should not be surprised by constant changing of the eco-lane's parameters. The Eco-Lanes Management service package establishes parameters and defines or geo-fences the eco-lanes boundaries. Eco-lanes parameters may include the types of vehicles allowed in the eco-lanes, emissions parameters for entering the eco-lanes, the number of lanes, and the start and end of the eco-lanes. The service package also conveys this information about eco-lanes to traveler information centers so those centers can provide the information to travelers.

ST08 Eco-Approach and Departure at Signalized Intersections
The Eco-Approach and Departure at Signalized Intersections service package uses wireless data communications sent from a connected vehicle roadside equipment (RSE) unit to connected vehicles to encourage "green" approaches to and departures from signalized intersections. The vehicle collects intersection geometry information and signal phase movement information using V2I communications and data from nearby vehicles using V2V communications. Upon receiving this information, the service package performs calculations to provide speed advice to the driver, allowing the driver to adapt the vehicle's speed to pass the next traffic signal on green or to decelerate to a stop in the most eco-friendly manner. The service package also considers a vehicle's acceleration as it departs from a signalized intersection. Finally, the service package may perform engine adjustments that provide increased fuel efficiency.

ST09 Connected Eco-Driving

The Connected Eco-Driving service package provides customized real-time driving advice to drivers so that they can adjust their driving behavior to save fuel and reduce emissions. Eco-driving advice includes recommended driving speeds, optimal acceleration, and optimal deceleration profiles based on prevailing traffic conditions, interactions with nearby vehicles, and upcoming road grades. The service package also provides feedback to drivers on their driving behavior to encourage drivers to drive in a more environmentally efficient manner. Finally, the service package may include vehicle-assisted strategies where the vehicle automatically implements the eco-driving strategy (e.g., changes gears, switches power sources, or reduces its speed in an eco-friendly manner).

ST10 Low Emissions Zone Management

The Low Emissions Zone Management service package supports the operation of a low emissions zone that is responsive to real-time traffic and environmental conditions. Low emissions zones are geographic areas that seek to restrict or deter access by specific categories of high-polluting vehicles into the area to improve the air quality within the geographic area. The service package uses data collected from vehicles using connected vehicle technologies and from roadside equipment as input to the system. The Low Emissions Zone Management service package supports the geo-fencing of a cordon that may be scalable and moveable (e.g., created for a day, removable, flexible in its boundaries) and would be less dependent on conventional ITS infrastructure. The service package would establish parameters including the types of vehicles permitted to enter the zone, exemptions for transit vehicles, emissions criteria for entering the zone, fees or incentives for vehicles based on emissions data collected from the vehicle, and geographic boundaries for the low emissions zone. The service package would also include electronic toll collection functions that support payments of fees or collection of incentives for registered vehicles using connected vehicle technologies. Finally, this service package provides information about the low emissions zone to traveler information centers, including information about criteria for entering the zone, expected fees and incentives, current and predicted traffic conditions, and geographic boundaries of the zone.