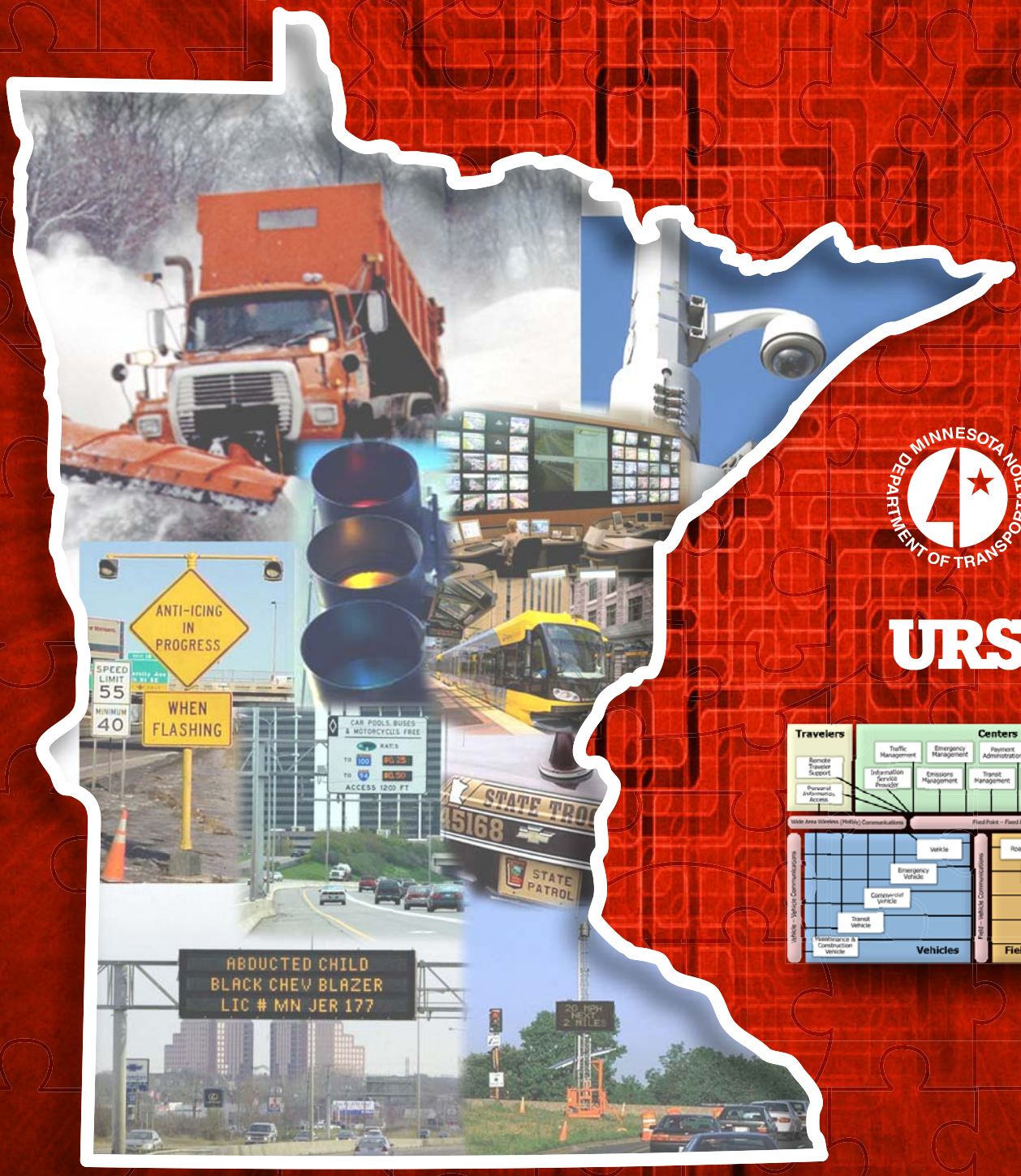
Minnesota Statewide Regional ITS Architecture

Version 2014

Volume 8:
Advanced Vehicle Safety Systems Service Package Bundle



MINNESOTA DEPARTMENT OF TRANSPORTATION

URS

Minnesota Statewide Regional ITS Architecture
Version 2014

Volume 8: Advanced Vehicle Safety Systems Service Package Bundle

Prepared by

URS Corporation

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ACRONYMS

ADMS	Archived Data Management System
APTS	Advanced Public Transportation System
ATIS	Advanced Traveler Information System
ATMS	Advanced Traffic Management System
AVSS	Advanced Vehicle Safety System
CAD	Computer Aided Dispatch
CCTV	Closed Circuit Television
CICAS	Cooperative Intersection Collision Avoidance Systems
CICAS-SSA	CICAS-Stop Sign Assist
CVO	Commercial Vehicle Operations
DOT	Department of Transportation
EM	Emergency Management
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
MBUF	Mileage-Based User Fee
MCM	Maintenance and Construction Management
MnDOT	Minnesota Department of Transportation
MVTA	Minnesota Valley Transit Authority
NIMS	National Incident Management System
PDA	Personal Digital Assistant
USDOT	United States Department of Transportation
V2I	Vehicle-to-Infrastructure
V2V	Vehicle-to-Vehicle
VMT	Vehicle Miles Traveled

1. Introduction

1.1 Statewide Regional ITS Architecture Update

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

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

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

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

The Minnesota Statewide Regional ITS Architecture is organized as follows:

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

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

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

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

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

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

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

- 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 8 – Advanced Vehicle Safety Systems

Advanced Vehicle Safety Systems (AVSS) use intelligent safety technology that detect and warn of potential dangerous situations and can indirectly reduce congestion and associated fuel consumption and pollution. AVSS improve driver behavior in risky situations by changing vehicle speed and direction, either automatically or through visual and auditory warnings. Examples of AVSS technology include adaptive cruise control, vision enhancement systems, collision avoidance systems, intelligent stability and handling systems, and drowsy driver sensors. Much of the AVSS is related to connected vehicle technology. Connected vehicle technology provides a starting point for transportation connectivity that will potentially enable countless applications. Connected vehicle applications provide connectivity:

- Among vehicles to enable crash prevention;
- Between vehicles and the infrastructure to enable safety, mobility, and environmental benefits; and
- Among vehicles, infrastructure, and wireless devices to provide continuous real-time connectivity to all system users.

AVSS technology consists of vehicle-based systems, infrastructure or roadside elements, interfaces between vehicles (vehicle-to-vehicle or V2V), and interfaces between vehicles and infrastructure elements (vehicle-to-infrastructure or V2I).

Vehicle-based systems include on-board sensors that will determine the vehicle's condition, performance, and on-board safety data; and visual and audial systems that will display information and warn the driver of potential dangers. On-board safety sensors and collision

sensors will monitor the areas in front of, behind and to the sides of the vehicle and present warnings to the driver about potential hazards.

The V2V application area covers the interface between vehicles that are equipped with a short range communications device. Each vehicle broadcasts to other vehicles its own location, vehicle speed, heading, acceleration/deceleration, anticipated lane and movement, status of systems onboard the vehicle (anti-lock brake activation, stability control system activation), and basic vehicle characteristics (length, width). In turn, the vehicle receives similar data from other vehicles. By using this collected data while monitoring its own speed and trajectory, environmental and roadway conditions, the vehicle could determine the likelihood of a collision and deploy a pre-crash safety system either to avoid or reduce the incident.

The V2I application area covers the interface between roadside equipment and vehicles that are equipped with a short range communications device. Vehicle location, vehicle speed, heading, acceleration/deceleration, anticipated lane and movement, vehicle control (anti-lock brake activation, stability control system activation), and basic vehicle characteristics (length, width) are collected by the field equipment. Safety related data collected by the field equipment from other sources are also transmitted to the vehicle. This collected data could be used to warn the driver of potential conflicts with other vehicles approaching an intersection, stalled vehicles, wrong way drivers, debris, standing water, or other safety hazards.

Development of Volume 8 – AVSS entailed the project Consultant to work closely with MnDOT and stakeholders to identify and prioritize stakeholder needs; gather information on existing and future ITS infrastructure, components and technology; and define the stakeholders roles and responsibilities in planning, deploying, operating and maintaining existing and future ITS systems.

Volume 8 summarizes the findings of data collection and analysis activities conducted to support development of the AVSS Service Package Bundle. Volume 8 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 Archived Data Management Systems*** provides a brief overview of statewide AVSS 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 AVSS. 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 AVSS 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: AVSS Research and Development Needs*** describes general research that can be performed to help implement the identified services.

2. Identification of Existing Advanced Vehicle Safety Systems

Since early 2000, the United States Department of Transportation (USDOT) has been engaged in research and development of AVSS and connected vehicle technology with automotive manufacturers. Partnering with the USDOT, state DOTs also involved in the pilot studies and test beds for the technology development.

MnDOT participates in the FHWA's Cooperative Intersection Collision Avoidance Systems (CICAS) under the connected vehicle initiative. The CICAS initiative focuses on determining the optimal combination of infrastructure and in-vehicle systems needed to address a full range of intersection crash problems. MnDOT, in collaboration with the University of Minnesota, focused on warning drivers of unsafe gaps at rural thru-stop intersections in the CICAS-SSA (Stop Sign Assist) project.

In 2007, the Minnesota Legislature appropriated $5 million for MnDOT to conduct a technology research project exploring mileage-based user fees (MBUF). The project developed technology as the means for assessing user fees based on mileage driven. It also combined this technology with other safety and mobility technologies and applications in support of the connected vehicle and CICAS initiatives. These applications included localized in-vehicle signing for improving safety, especially for rural areas, providing location-specific traveler information, and collecting vehicle probe data.

The University of Minnesota works with Minnesota Valley Transit Authority (MVTA) to deploy a high-accuracy GPS system on ten MVTA buses. This system will help bus drivers navigate narrow shoulder lanes on Cedar Avenue and I-35W, both into and out of downtown Minneapolis. Based on the success of and lessons learned from the study, assistance systems will be deployed by Metro Transit and other regional transit providers.

An inventory of existing and planned AVSS in Minnesota is described in *Appendix A*. This inventory summarizes a list of existing and programmed ITS systems in the state, their general description, associated stakeholder that are involved with their operations and management,

and their current deployment. The systems described in *Appendix A* are Minnesota-specific implementations of subsystems from the National ITS Architecture.

3. Development Objectives

Transportation needs identify the transportation problems that can be solved by ITS services. They also represent a link to transportation planning efforts that define the strategies and solutions to address various challenges. These strategies involve capital improvements as well as operational improvements. AVSS solutions involve services that improve safety of the transportation system and have influences on improving performance and efficiency of transportation systems, including congestion, travel time, travel time reliability, and fuel consumption.

The Minnesota ITS Development Objectives in Table 3-1, specific to AVSS, are steps to determine and/or measure whether or not AVSS goals are being achieved. A complete list of Minnesota ITS Development Objectives is included in *Appendix B*.

Table 3-1. AVSS Specific Minnesota ITS Development Objectives

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

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

- A-1-01 Reduce number of vehicle crashes
- A-1-02 Reduce number of vehicle crashes per VMT
- A-1-03 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-1-08 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-2 Reduce fatalities and life changing injuries *(ATIS, ATMS, APTS, CVO, EM, MCM & AVSS)*

- A-2-01 Reduce number of roadway fatalities
- A-2-02 Reduce number of roadway fatalities per VMT
- A-2-03 Reduce number of fatalities due to road weather conditions
- A-2-04 Reduce number of fatalities due to unexpected congestion
- A-2-05 Reduce number of fatalities due to red-light running
- A-2-06 Reduce number of fatalities involving large trucks and buses
- A-2-09 Reduce number of fatalities due to inappropriate lane departure, crossing and merging

Table 3-1. (Continued)

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-2-22 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-2-30 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-2-43 Reduce number of speed violations

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

B. Increase Operational Efficiency and Reliability of the Transportation System

B-1 Reduce overall delay associated with congestion *(ATIS, ATMS & MCM)*
B-1-01 Reduce the percentage of facility miles (highway, arterial, rail, etc.) experiencing recurring congestion during the peak period
B-1-02 Reduce the percentage of Twin Cities freeway miles congested in weekday peak periods
B-1-03 Reduce the share of major intersections operating at LOS F
B-1-05 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

Table 3-1. (Continued)

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-3 Reduce delays due to work zones *(ATIS, ATMS, EM, MCM & AVSS)*
B-3-01 Reduce total vehicle hours of delay by time period (peak, off-peak) caused by work zones
B-3-05 Reduce the variability of travel time in work zones during peak and off-peak periods

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

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

C-1 Reduce congestion and incident-related delay for travelers *(ATIS, ATMS, APTS, EM & AVSS)*
B-1-01 Reduce the percentage of facility miles (highway, arterial, rail, etc.) experiencing recurring congestion during the peak period
B-1-02 Reduce the percentage of Twin Cities freeway miles congested in weekday peak periods
B-1-03 Reduce the share of major intersections operating at LOS F
B-1-05 Reduce the daily hours of recurring congestion on major freeways
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-1-09 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

C-2 Improve travel time reliability *(ATIS, ATMS, APTS & AVSS)*
B-1-07 Reduce the regional average travel time index
B-1-12 Reduce the average of the 90th (or 95th) percentile travel times for (a group of specific travel routes or trips in the region)
B-1-14 Reduce the variability of travel time on specified routes during peak and off-peak periods
C-2-01 Decrease the average buffer index for multiple routes or trips

Table 3-1. (Continued)

C-2-02 Reduce the average planning time index for specific routes in region

C-4 Reduce stress caused by transportation *(ATIS, ATMS, APTS, EM, MCM & AVSS)*

A-2-43 Reduce number of speed violations
B-1-01 Reduce the percentage of facility miles (highway, arterial, rail, etc.) experiencing recurring congestion during the peak period
B-1-02 Reduce the percentage of Twin Cities freeway miles congested in weekday peak periods
B-1-03 Reduce the share of major intersections operating at LOS F
B-1-05 Reduce the daily hours of recurring congestion on major freeways
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-1-09 Improve average travel time during peak periods
B-1-10 Reduce hours of delay per capita
B-1-10 Reduce hours of delay per driver
B-1-12 Reduce the average of the 90th (or 95th) percentile travel times for (a group of specific travel routes or trips in the region)
B-1-13 Reduce the 90th (or 95th) percentile travel times for each route selected
B-1-14 Reduce the variability of travel time on specified routes during peak and off-peak periods
C-4-01 Reduce the speed differential between lanes of traffic on multi-lane highways

E. Support Regional Economic Productivity and Development

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

B-1-14 Reduce the variability of travel time on specified routes during peak and off-peak periods
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-3 Improve travel time reliability for freight, transit and businesses *(ATMS, APTS, CVO & AVSS)*

B-1-14 Reduce the variability of travel time on specified routes during peak and off-peak periods
E-1-08 Decrease the annual average travel time index for selected freight-significant highways

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

B-1-01 Reduce the percentage of facility miles (highway, arterial, rail, etc.) experiencing recurring congestion during the peak period
B-1-02 Reduce the percentage of Twin Cities freeway miles congested in weekday peak periods
B-1-03 Reduce the share of major intersections operating at LOS F
B-1-05 Reduce the daily hours of recurring congestion on major freeways

Table 3-1. (Continued)

- 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-1-09 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

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

- B-1-01 Reduce the percentage of facility miles (highway, arterial, rail, etc.) experiencing recurring congestion during the peak period
- B-1-02 Reduce the percentage of Twin Cities freeway miles congested in weekday peak periods
- B-1-03 Reduce the share of major intersections operating at LOS F
- B-1-05 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-1-09 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. Reduce Environmental Impacts

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

- B-1-01 Reduce the percentage of facility miles (highway, arterial, rail, etc.) experiencing recurring congestion during the peak period
- B-1-02 Reduce the percentage of Twin Cities freeway miles congested in weekday peak periods
- B-1-03 Reduce the share of major intersections operating at LOS F
- B-1-05 Reduce the daily hours of recurring congestion on major freeways

Table 3-1. (Continued)

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-1-09	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

4. Needs and Services

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

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

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

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

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

ID	Need/Potential Solution	Priority Point[a]	ITS Development Objective	National ITS Architecture Reference
TR13	Provide collision avoidance assistance for transit vehicles	3.00	A-1-06, A-2-06, A-2-08, A-2-27, A-2-29	AVSS03, AVSS04
TR18	Install pedestrian detection/warning system to reduce incidents	2.71	A-1-06, A-1-15, A-2-06, A-2-08, A-2-16, A-2-27, A-2-29, A-2-37	AVSS03
CF08	Provide collision avoidance assistance for commercial vehicles	2.50	A-1-01, A-1-02, A-1-06, A-1-07, A-1-08, A-1-12, A-1-13, A-1-14	AVSS03, AVSS04, AVSS10
TM02	Implement red-light running technology	3.20	A-1-05, A-1-10, A-2-05, A-2-11, A-2-26, A-2-32	ATMS03, AVSS05
TM33	Provide intersection collision avoidance systems	3.67	A-1-01, A-1-08, A-1-10, A-1-11, A-1-16, A-2-01, A-2-09, A-2-11, A-2-12, A-2-17, A-2-22, A-2-30, A-2-32, A-2-33, A-2-38	AVSS05, AVSS10

5. Detail of AVSS Needs and Services

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

6. AVSS Research and Development Needs

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

- Investigate new technologies for obtaining real-time traffic data primarily in rural areas where traditional detection methods are not feasible or economical
- Investigate impact of traveler information on drivers when they receive it while driving (via PDA, in-vehicle navigation, cell phone, etc.)
- Explore technologies for monitoring traffic and travel conditions in rural areas
- Develop automated vehicle passenger occupancy detection system as assistance in counting vehicle passenger occupancy
- Vehicle to infrastructure communications
- Individual data communications to DOT
- Test effective engineering and enforcement countermeasures for red-light running
- Develop automated incident warning systems for intersections
- Test intersection collision avoidance systems
- Test lane departure systems
- Test traffic calming/driver warning system
- Improve vehicle safety systems

Appendix A: Existing/Planned AVSS Elements

System	Service Package	Description	Stakeholder	Status
Intersection Collision Warning Roadside Equipment	AVSS05	MnDOT and local agencies are participating in FHWA's Cooperative Intersection Collision Avoidance System (CICAS) initiative. This element represents roadside equipment that provides drivers on rural roadways with advance warning information, indicating when entry into an intersection is not safe. Roadside equipment is designed to detect vehicles within a specified zone and send messages to other roadside equipment located upstream of the detection zone, which alerts oncoming motorists of vehicle presence that cannot be seen by the driver on the roadway.	MnDOT	Existing
Transit Vehicle Equipment	AVSS03, AVSS04	Minnesota Valley Transit Authority (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. The University of Minnesota is currently working with MVTA to deploy a high-accuracy GPS system on 10 MVTA buses. This system will help drivers navigate narrow shoulder lanes on Cedar Avenue, the Cross-town Freeway, and I-35W, both into and out of downtown Minneapolis. Based on the success of and lessons learned from the project, assistance systems will be deployed by Metro Transit and other regional transit providers.	Metro Transit, Metro Area Transit Providers	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.

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

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

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

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

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

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

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

B. Increase Operational Efficiency and Reliability of the Transportation System

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

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

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

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

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

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

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

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

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

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

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

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

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

C-3-13 Increase number of users of notifications for traveler information (e.g., e-mail, text message)
C-3-14 Increase the number of transit routes with information being provided by ATIS
C-3-15 Increase the number of specifically tailored traveler information messages provided
C-3-16 Increase annual transit ridership
C-3-17 Increase annual transit ridership reported by urbanized area transit providers
C-3-18 Increase annual transit ridership reported by rural area transit providers

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

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

D. Improve the Security of the Transportation System

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

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

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

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

E. Support Regional Economic Productivity and Development

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

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

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

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

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

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

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

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

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

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

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

F. Preserve the Transportation System

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

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

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

G. Enhance the Integration and Connectivity of the Transportation System

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

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

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

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

H. Reduce Environmental Impacts

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

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

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

- A-2-44 Reduce number of traffic law violations
- B-2-12 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
- C-3-17 Increase annual transit ridership
- H-2-01 Increase the average vehicle occupancy rate in HOV lanes
- H-2-02 Increase the amount of environmentally friendly de-icing material used

Appendix C: Needs and Services Detail

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Data Archive Need	Associated Service Package
Service Package AVSS03 – Longitudinal Safety Warning								
TR13	Provide collision avoidance assistance for transit vehicles	• Transit vehicle drivers use collision avoidance systems to monitor the areas around the vehicles, detect potential hazards, and receive warnings when hazardous conditions are present. • Transit drivers use on-board safety sensors and collision sensors to monitor the areas to the sides of vehicles as buses are merging into and out of shoulder lanes and bus stops. • Warnings about potential hazards are presented to transit drivers.	• Vehicle collision warning systems have been tested in several states, including Minnesota. • MTVA has an avoidance system installed on 10 vehicles and will expand the system to more vehicles in the near future.	• Test and deploy GPS system for bus-only shoulder lane use driver assistance. • Test and deploy lateral safety detection and warning systems to improve safety of buses merging. • Test and deploy collision warning/ avoidance systems on buses.	• Transit agencies are responsible to plan, design, construct, operate and maintain their collision warning/ avoidance systems on their fleet vehicles. • Transit agencies are responsible to plan, design, construct, operate and maintain their lateral safety detection and warning systems on their fleet vehicles.	• Lateral safety detection and warning systems as well as collision warning/ avoidance systems include interconnects between in-vehicle safety and collision detection equipment and in-vehicle warning equipment. • Interconnects between in-vehicle detection equipment and in-vehicle driver feedback equipment.	• None.	• AVSS04

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Data Archive Need	Associated Service Package
TR18	Install pedestrian detection/ warning system to reduce incidents	• The detection and warning system detects pedestrians in obstructed view area. • Transit drivers receive alerts of pedestrians in obstructed view areas.	• Some garage and transit station entry/exit ways have static and dynamic pedestrian warning systems. • No current systems provide in-vehicle warnings to drivers.	• Test and deploy on-board pedestrian detection/warning systems. • Test and deploy roadside pedestrian warning systems at areas with high pedestrian accident rates.	• Transit agencies are responsible to plan, design, construct, operate and maintain their on-board pedestrian detection and warning systems. • Local traffic agencies are responsible to plan, design, construct, operate and maintain roadside signage.	• Pedestrian detection and warning systems include interconnects between in-vehicle detection equipment and in-vehicle warning equipment. • Interconnects between roadside detection and warning equipment and in-vehicle warning equipment.	• Warnings activation data will be archived for future system analysis and tort claims.	

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Data Archive Need	Associated Service Package
CF08	Provide collision avoidance assistance for commercial vehicles	• Intersection collision warning systems alert drivers of potential collisions. • Truck drivers use on-board safety and collision sensors to provide warnings to drivers about potential hazards around the vehicle or in its path.	• MnDOT is currently testing the FHWA's Cooperative Intersection Collision Avoidance System (CICAS) under the Connected Vehicle Initiative. • Individual trucking companies are investigating the use of on-board safety and collision sensors.	• Investigate the use of on-board safety and collision sensors to aid drivers in avoiding collisions.	• MnDOT is responsible to investigate and test appropriate sensors and related equipment, and maintain roadside equipment. • Private trucking companies and fleet managers are responsible to procure, operate, and maintain on-board equipment.	• Interconnects are required between roadside, on-board, and in-vehicle equipment.	• Warnings and driver/vehicle responses are archived for studies of effectiveness or accident investigations.	• AVSS04 • AVSS10
Service Package AVSS04 – Lateral Safety Warning								
TR13	Provide collision avoidance assistance for transit vehicles	See information under AVSS03						
CF08	Provide collision avoidance assistance for commercial vehicles	See information under AVSS03						

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Data Archive Need	Associated Service Package
Service Packages AVSS05-Intersection Safety Warning								
TM02	Implement red-light running technology	• Local law enforcement agencies use systems to automatically detect red light violators at signalized intersections and manage photographic evidence of violations in real-time.	• MnDOT and local agencies are currently testing a collision prevention system that automatically detects red-light violators. Data is then used to develop engineering and enforcement (but not automated citations) counter measures to reduce violations.	• Automated red-light running enforcement is not permissible under current statute. Legislation must be passed to authorize it. • Deploy system at signalized intersections with highest crash and near miss rates around Minnesota.	• Local law enforcement agencies and other local agencies are responsible to plan, design, construct, operate, and maintain their own red-light running systems.	• Red-light running systems include interconnect between roadside detection equipment and roadside traffic signal systems. • Each red-light running system includes interconnects from roadside equipment to the law enforcement agency.	• Violation data including vehicle detection, time, date, and violation will be archived for performance measures and/or citation use.	• ATMS03

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Data Archive Need	Associated Service Package
TM33	Provide intersection collision avoidance systems	• MnDOT/Local Agencies use this service to alert drivers of unsafe gaps to avoid collisions at intersections. • Drivers use this service to take appropriate action to avoid collisions.	• MnDOT/Local Agencies are participating in FHWA's Cooperative Intersection Collision Avoidance System (CICAS) initiative.	• Test and deploy intersection warning systems at rural and suburban intersections. • Research, develop and test intersection collision avoidance systems.	• MnDOT/Local Agencies are responsible to develop, test, deploy, operate, and maintain intersection warning systems. • FHWA in conjunction with state DOTs, automobile manufactures, and research institutes are responsible for developing and testing intersection collision avoidance systems.	• Intersection warning systems include interconnects between roadside detection equipment and roadside warning systems. • Intersection collision avoidance systems include interconnects between roadside equipment and in-vehicle equipment.	• Activation and performance data will be archived for future analysis.	• AVSS10
Service Package AVSS10 – Intersection Collision Avoidance								
CF08	Provide collision avoidance assistance for commercial vehicles	See information under AVSS03						
TM23	Provide intersection collision avoidance systems	See information under AVSS05						

Appendix D: AVSS Service Packages and Descriptions

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

AVSS01 Vehicle Safety Monitoring
This service package will diagnose critical components of the vehicle and warn the driver of potential dangers. On-board sensors will determine the vehicle's condition, performance, on-board safety data, and display information.

AVSS02 Driver Safety Monitoring
This service package will determine the driver's condition, and warn the driver of potential dangers. On-board sensors will determine the driver's condition, performance, on-board safety data, and display information.

AVSS03 Longitudinal Safety Warning
This service package allows for longitudinal warning. It utilizes safety sensors and collision sensors. It requires on-board sensors to monitor the areas in front of and behind the vehicle and present warnings to the driver about potential hazards.

AVSS04 Lateral Safety Warning
This service package allows for lateral warning. It utilizes safety sensors and collision sensors. It requires on-board sensors to monitor the areas to the sides of the vehicle and present warnings to the driver about potential hazards.

AVSS05 Intersection Safety Warning
This service package monitors vehicles approaching an intersection and warns drivers when hazardous conditions are detected. The service package detects impending violations (e.g., red-light violations) and potential conflicts between vehicles occupying or approaching the intersection (e.g., situations where a left turn would be unsafe because of approaching traffic). When a potentially hazardous condition is detected, a warning is communicated to the involved vehicles using short range communications and/or signs/signals in the intersection.

AVSS06 Pre-Crash Restraint Deployment
This service package provides in-vehicle sensors and on-board communications to monitor the vehicle's local environment, determine collision probability and deploy a pre-crash safety system. It will include on-board sensors to measure lateral and longitudinal gaps and together with weather and roadway conditions will determine lateral and longitudinal collision probability. It will exchange messages with other equipped vehicles to determine the precise location of surrounding vehicles. It will deploy a pre-crash safety system when a crash is imminent.

AVSS07 Driver Visibility Improvement
This service package will enhance driver visibility using an enhanced vision system. On-board display hardware is needed.

AVSS08 Advanced Vehicle Longitudinal Control
This service package automates the speed and headway control functions on board the vehicle. It utilizes safety sensors and collision sensors combined with vehicle dynamics processing to control the throttle and brakes. It requires on-board sensors to measure longitudinal gaps and a processor for controlling the vehicle speed.

AVSS09 Advanced Vehicle Lateral Control
This service package automates the steering control on board the vehicle. It utilizes safety sensors and collision sensors combined with vehicle dynamics processing to control the steering. It requires on-board sensors to measure lane position and lateral deviations and a processor for controlling the vehicle steering.

AVSS10 Intersection Collision Avoidance
This service package will determine the probability of an intersection collision and provide timely warnings to approaching vehicles so that avoidance actions can be taken. This service package builds on the Intersection Safety Warning field and in-vehicle equipment and adds equipment in the vehicle that can take control of the vehicle to avoid intersection violations and potential collisions. The same sensors and communications equipment in the roadway infrastructure are used to assess vehicle locations and speeds near an intersection. This information is determined and communicated to the approaching vehicle using a short range communications system. The vehicle uses this information to develop control actions which alter the vehicle's speed and steering control and potentially activate its pre-crash safety system.

AVSS11 Automated Vehicle Operations
This service package enables "hands-off" operation of the vehicle on automated portions of the highway system. Implementation requires lateral lane holding, vehicle speed and steering control. Communications between vehicles and between the vehicles and supporting infrastructure equipment supports cooperative check-in to the automated portion of the system and transition to automated mode, coordination of maneuvers between vehicles in automated mode, and checkout from the automated system as the driver resumes control of the vehicle.

AVSS12 Cooperative Vehicle Safety Systems
This service package enhances the on-board longitudinal and lateral warning stand-alone systems by exchanging messages with other surrounding vehicles and roadside equipment. Vehicles send out information concerning their location, speed, and direction to surrounding vehicles. The roadside equipment provides information about potential safety hazards in the vehicle path such as stalled (unequipped) vehicles, wrong-way drivers, debris, or water hazards. The on-board systems can then process this information and present warnings to the driver including headway warnings, merge warnings, unsafe passing warnings, and warnings about hazards detected in the vehicle path. Special messages from approaching emergency vehicles may also be received and processed.