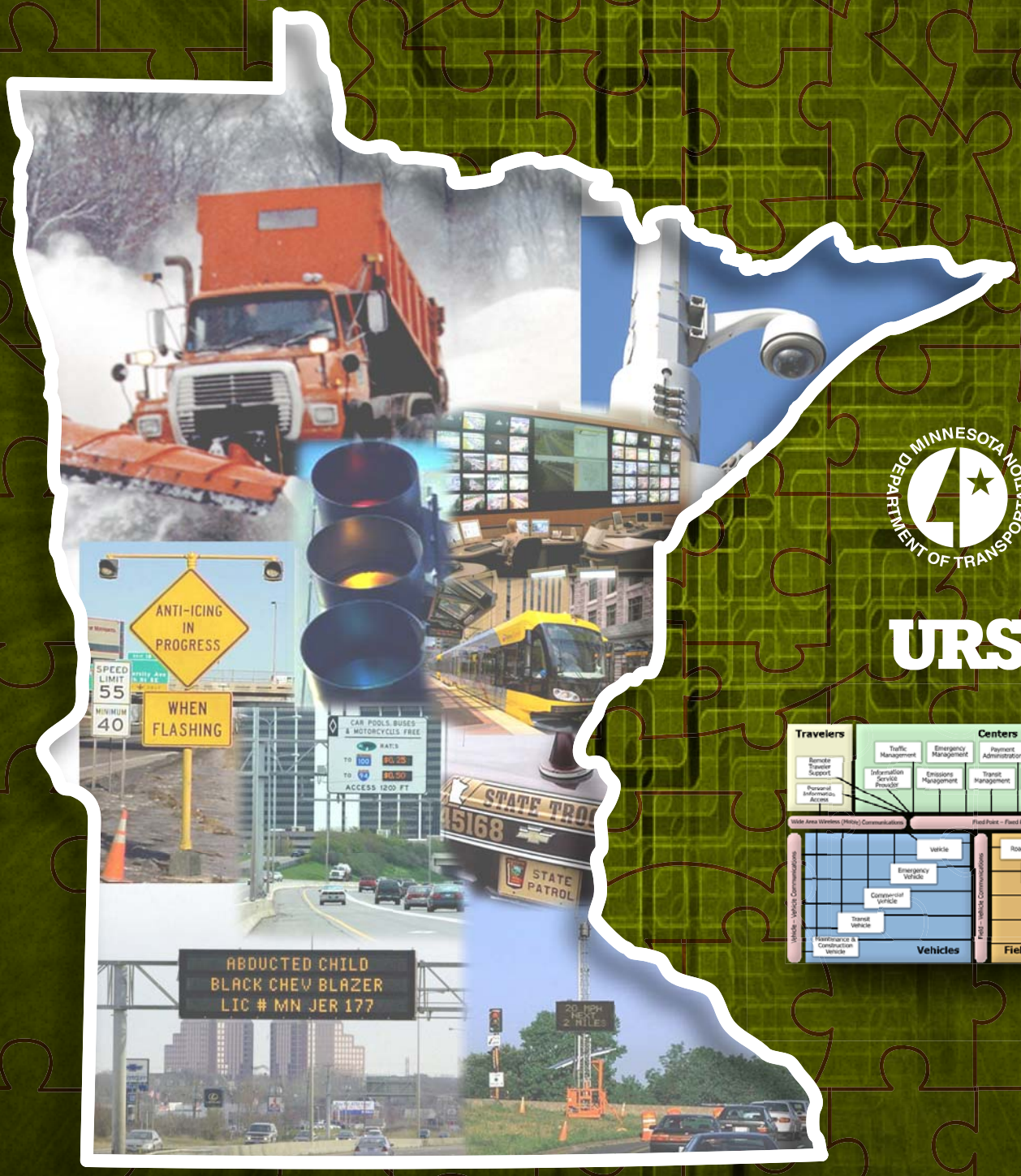
Minnesota Statewide Regional ITS Architecture

Version 2014

Volume 4:
Advanced Public Transportation Systems Service Package Bundle



MINNESOTA DEPARTMENT OF TRANSPORTATION

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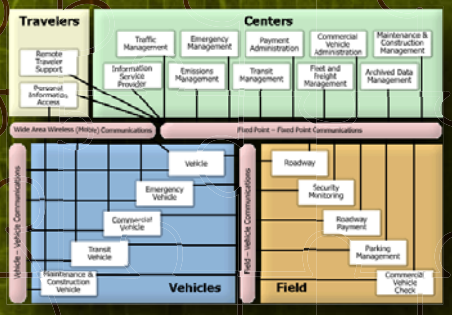

Minnesota Statewide Regional ITS Architecture
Version 2014

Volume 4: Advanced Public Transportation Systems Service Package Bundle

Prepared by

URS Corporation

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ACRONYMS

AD	Archived Data Management
ADMS	Archived Data Management System
ADA	Americans with Disabilities Act
APTS	Advanced Public Transportation System
ATIS	Advanced Traveler Information System
ATMS	Advanced Traffic Management System
AVL	Automatic Vehicle Location
AVSS	Advanced Vehicle Safety System
BRT	Bus Rapid Transit
CAD	Computer Aided Dispatch
CAT	Cities Area Transit (East Grand Forks)
CCTV	Closed Circuit Television
CVO	Commercial Vehicle Operations
DARTS	Dakota Area Resources and Transportation for Seniors
DOT	Department of Transportation
DTA	Duluth Transit Authority
EM	Emergency Management
EOC	Emergency Operations Center
EVP	Emergency Vehicle Preemption
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
GIS	Geographic Information System
GPS	Global Positioning System
HiSPARC	High Speed, Accuracy, Reliability, and Capacity
HOV	High-Occupancy Vehicle
HSI	Human Services Inc.
ICS	Incident Command Structure
ITS	Intelligent Transportation Systems
IVR	Interactive Voice Response
LCD	Liquid-Crystal Display
LED	Light-Emitting Diode
LOS	Level of Service
MAT	Metro Area Transit (Moorhead)
MCM	Maintenance and Construction Management
MDT	Mobile Data Terminal
MnDOT	Minnesota Department of Transportation
MTC	Metropolitan Transit Commission (St. Cloud)
MVTA	Minnesota Valley Transit Authority
NIMS	National Incident Management System
PD	Police Department
PDA	Personal Digital Assistant
RTMC	Regional Transportation Management Center
TSP	Transit Signal Priority
U of M	University of Minnesota
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:

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

Previously published transportation plans were the main source of data about characteristics of the existing transportation system, planned improvements, transportation system needs and goals. Strategic and long-range planning studies, ITS deployment and safety plans, transit studies and transportation planning and policy documents were reviewed.

1.2 Volume 4 – Advanced Public Transportation Systems

Advanced Public Transportation Systems (APTS) are intended to enhance public transportation choices, safety and efficiency with a goal towards increased transit ridership.

Development of Volume 4 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 4 summarizes the findings of data collection and analysis activities conducted to support development of the APTS Service Package Bundle. Volume 4 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 Advanced Public Transportation Systems*** provides a brief overview of statewide APTS 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 APTS. 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 APTS 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 APTS Service Package Bundle and those in other Service Package Bundles.
- ***Section 6: APTS Research and Development Needs*** describes general research that can be performed to help implement the identified services.

2. Identification of Existing APTS

APTS systems are utilized throughout Minnesota to assist in transit operations and enhance services to transit users. Using those systems has improved schedule adherence, transit security, backroom operations, and availability of information about modal choices.

APTS can be used to assist in the operations, security, and fleet management, of a transit system as well as coordinate services provided by different transit providers. Transit users can access schedule information through telephone systems, Internet sites or electronic displays, quickly pay with electronic payment cards, and easily transfer to another transit vehicle or mode of travel. APTS also allow transit vehicles to operate more efficiently and stay on schedule through implementations such as scheduling software, bus signal priority, computer-aided dispatch (CAD), automated vehicle location (AVL), and mobile data terminals (MDT). Operations managers can use services such as automated passenger counting, vehicle tracking, fare management, and dispatch and response logs to enhance operational planning and make back-office activities more efficient. Security enhancements such as transit platform monitoring, in-vehicle surveillance and driver alert systems are used to improve the safety of passengers as well as vehicle operators.

An inventory of existing and planned APTS (e.g. control centers, vehicles, devices and infrastructure) in Minnesota is described in *Appendix A*. This inventory summarizes a list of existing and programmed ITS systems in the state, their general description, associated stakeholder that are involved with their operations and management, and their current deployment. The systems described in *Appendix A* are Minnesota-specific implementations of subsystems from 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. APTS solutions involve services that improve the schedule adherence, safety, and operations of the transit system as well as the safety and experience of the transit user.

APTS are intended to enhance public transportation choices, safety and efficiency with a goal towards increased transit ridership. The vision for APTS is that it will enable travelers in Minnesota to have reliable public transportation choices for a safe, efficient and satisfying trip. The Minnesota ITS Development Objectives in Table 3-1, specific to APTS, are steps to determine and/or measure whether or not APTS goals are being achieved. A complete list of Minnesota ITS Development Objectives is included in *Appendix B*.

Table 3-1. APTS 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-1-06 Reduce number of crashes involving large trucks and buses
- A-1-15 Reduce number of crashes involving pedestrians and non-motorized vehicles

A-2 Reduce fatalities and life changing injuries *(ATIS, ATMS, APTS, CVO, EM, MCM & AVSS)*
- A-2-06 Reduce number of fatalities involving large trucks and buses
- A-2-08 Reduce number of transit fatalities
- A-2-16 Reduce number of fatalities involving pedestrians and non-motorized vehicles
- A-2-27 Reduce number of injuries involving large trucks and buses
- A-2-29 Reduce number of transit injuries
- A-2-37 Reduce number of injuries involving pedestrians and non-motorized vehicles

B. Increase Operational Efficiency and Reliability of the Transportation System

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

Table 3-1. (Continued)

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-2-14 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-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-2 Improve travel time reliability *(ATIS, ATMS, APTS & AVSS)*
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-2-03 Increase the miles of bus-only shoulder lanes in the metro area

C-3 Increase choice of travel modes *(ATIS, ATMS & APTS)*
B-2-14 Create a transportation access guide, which provides concise directions to reach destinations by alternative modes (transit, walking, bike, etc.)
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-3-14 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)*
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

Table 3-1. (Continued)

C-4-02 Increase the number of users aware of park-and-ride lots in their region
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-4-07 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)*
- 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-1-07 Increase the number of critical sites with security surveillance
- 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)*
- 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-1-06 Increase the percent of major and minor arterials are equipped with and operating with closed circuit television (CCTV) cameras
- D-1-08 Increase the number of critical sites with security surveillance
- D-1-10 Increase the number of critical sites with hardened security enhancements

E. Support Regional Economic Productivity and Development

E-1 Reduce travel time for freight, transit and businesses *(ATIS, ATMS, APTS, CVO & AVSS)*
- 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-3 Improve travel time reliability for freight, transit and businesses *(ATMS, APTS, CVO & AVSS)*
- 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

Table 3-1. (Continued)

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

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

H. Reduce Environmental Impacts

H-2 Reduce negative impacts of the transportation system on communities *(ATMS, APTS, EM & MCM)*
B-2-14 Create a transportation access guide, which provides concise directions to reach destinations by alternative modes (transit, walking, bike, etc.)
C-3-17 Increase annual transit ridership

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.

A workshop with APTS stakeholders was conducted in March 2013. The purpose of the workshop 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 Needs and associated APTS 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. APTS 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	National ITS Architecture Reference[b]
TR01	Provide transit route, schedule, and fare information	4.14	B-2-01, B-2-02, B-2-03, B-2-04, C-3-04, C-3-05, C-3-06, C-3-07, C-3-14, C-3-16, C-3-17	APTS08
TR02	Provide real-time transit vehicle arrival/departure information	4.43	B-2-01, B-2-02, B-2-03, B-2-04, C-3-04, C-3-05, C-3-06, C-3-07, C-3-14, C-3-16, C-3-17	APTS01, APTS08, ATMS06
TR03	Provide simple and flexible fare payment systems	4.14	B-2-16, B-2-17	APTS04
TR04	Coordinate timed transfers between route segments, providers & modes	3.71	B-2-01, B-2-08, C-3-10	APTS07, APTS11
TR05	Manage transit fleet and personnel operations	3.71	B-2-15, E-4-01, E-4-04, E-4-05, E-4-06, E-4-07	APTS01
TR06	Provide surveillance and enforcement on transit vehicles and transit facilities	4.14	D-1-02, D-1-03, D-1-04, D-1-07, D-1-08, D-1-09	APTS05
TR07	Provide electronic fare payment card	4.29	B-2-16, B-2-17	APTS04
TR08	Support vehicle diagnostics and maintenance	3.71	E-4-05, E-4-06	APTS06
TR10	Provide on-board automated enunciators	3.43	C-3-14, C-3-15	APTS08
TR11	Provide information to the ADA community	3.86	C-3-14, C-3-15	APTS08

Table 4-1. (Continued)

ID	Need/Potential Solution	Priority Point[a]	ITS Development Objective	National ITS Architecture Reference[b]
TR12	Optimize garage operations	2.86	E-4-04, E-4-05, E-4-06	APTS06
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
TR14	Provide security at park and ride lots	2.57	D-1-02, D-1-03, D-1-04	APTS05
TR15	Optimize schedule efficiency	3.71	B-2-15, E-4-01, E-4-07	APTS02
TR16	Provide information on ridesharing opportunities	2.71	B-2-11, B-2-12, B-2-19, B-2-20, B-2-21, B-2-22, B-2-23, B-2-23, B-2-25, C-3-02, C-3-03	APTS08, ATIS08
TR17	Coordinate transit vehicle movements with traffic control devices	2.57	B-2-15, C-3-08, E-1-01, E-1-02	APTS09
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
TR19	Provide queue jumping	1.57	B-2-15, B-2-18, C-3-08, E-1-01, E-1-02	APTS09
TR20	Provide real-time transfer information to travelers en route	3.71	B-2-01, B-2-08, C-3-14	APTS08
TR21	Provide on-line reservation system for demand-responsive transit	2.86	B-2-01, B-2-06, B-2-07, B-2-08, B-2-09, B-2-10	APTS03, ATIS02
TR22	IT support consistently with mission critical operations systems	3.00[c]	B-2-01, B-2-06, B-2-07	APTS06
TR23	Provide multi-communication mode hub/ infrastructure on buses to transmit/ receive high speed data in the most efficient and cost-effective manner	5.00[c]	B-2-01, B-2-06, B-2-07	APTS06
TR24	Metro Transit Police records integration with other PD's	3.00[c]	B-1-16, G-1-01, G-1-02, G-1-03	AD1, AD2
TR25	Wireless access for transit customers	3.00[c]	C-3-04, C-3-05	APTS08
TR26	Additional GIS systems integration	3.00[c]	G-1-01, G-1-02, G-1-03	APTS02, APTS03, AD1
TI19	Provide different alternatives to travelers for the most appropriate route/mode/time of travel	3.09	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-2-11, B-2-14, B-3-01, B-3-02, B-3-03, B-3-04, B-3-05, C-2-01, C-2-02, C-3-01, C-3-02, C-3-03, C-3-04, C-3-05, C-3-08	ATIS01, ATIS05, APTS08

5. Detail of APTS Needs and Services

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

6. APTS Research and Development Needs

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

<u>Communications</u>

- Analyze technologies and policies to transmit and record real-time operations data
- Research, develop, and test new methods to integrate existing systems to gain operational efficiencies and leverage agency investment in technology systems

<u>Data</u>

- Enhance route performance analysis tools
- Refine/enhance transit scheduling software
- Enhance archived data search tools
- Test coordination of different agency scheduling software for mixed mode/provider schedule coordination

- Test use of transit vehicles as traffic probes

Operations
- Test smart/electronic fare cards
- Enhance carpool rideshare finding systems
- Test transit signal priority technologies and systems
- Develop bus stop occupancy alert system for drivers

Maintenance
- Enhance vehicle performance monitoring/diagnostic equipment
- Test in-garage transit vehicle bus finder system

Transit Information
- Enhance trip planning systems
- Test transit information distribution to PDAs/handheld wireless devices
- Enhance interactive transit information systems
- Develop and test next bus arrival time systems
- Test bus arrival announcement systems at bus stops
- Test traveler information distribution methods for ADA and elderly communities
- Develop/enhance on-line transit reservation systems

Safety
- Test collision avoidance systems
- Test pedestrian warning systems
- Test lane departure warning/shoulder driving assistance systems

Security
- Enhance automated surveillance monitoring/alert systems

Appendix A: Existing/Planned APTS Elements

Element	Service Package	Description	Stakeholder	Status
Commuter Rail Operations Center	APTS02, APTS04, APTS07, APTS11	This element represents the Northstar Commuter Rail operations center that operates and maintains commuter rail vehicles between downtown Minneapolis and Big Lake. Commuter rail vehicle maintenance facility is located in Big Lake. Stations are located in Minneapolis, Fridley, Coon Rapids, Anoka, Elk River, and Big Lake. Future plans are to expand the commuter rail line northwest to downtown Saint Cloud and the VA Medical Center.	Northstar Corridor Development Authority	Existing
Dynamic Message Sign Roadside Equipment	APTS08, ATMS06	Real-time information on transit travel times as compared passenger-vehicle travel times is displayed to passengers via dynamic message signs prior to arriving at selected park-and-ride locations in the Twin Cities metro area.	MnDOT, Metro Transit	Existing
Intercity Transit Management Centers	APTS02, APTS04	This element represents transit management centers that operate intercity fixed routes traveling long distances. These centers include the Northstar Commuter Coach traveling between Elk River and Minneapolis and Greyhound and Jefferson Lines buses traveling throughout the state.	Intercity Transit Providers	Existing
Light Rail Operations Center	APTS02, APTS06, APTS09	This element represents the Metro Transit light rail transit management center. This center dispatches and maintains all light rail transit vehicles running between downtown Minneapolis and the Mall of America (Blue Line) and along University Avenue between Minneapolis and Saint Paul (Green Line). Other light rail transit lines connecting suburbs with Minneapolis and Saint Paul are in early planning stages.	Metro Transit	Existing

Element	Service Package	Description	Stakeholder	Status
Local Transit Management Centers	APTS01, APTS02, APTS03, APTS04, APTS05, APTS06, APTS08, APTS09, APTS10	This element represents local transit management centers operating outside of the Twin Cities metropolitan area that operate fixed route and demand responsive public transit services. These centers include the St. Cloud Metropolitan Transit Commission (MTC), Duluth Transit Authority (DTA), City of Rochester Public Transit, Metro Area Transit (MAT -- serving Moorhead), Cities Area Transit (CAT -- serving East Grand Forks), and various county and city-level transit management centers. St. Cloud MTC uses ITS applications such as transit signal priority (TSP), electronic fare collection, on-board surveillance systems, and automated transit fleet management system. DTA disseminates real-time bus arrival information at bus stops, via the internet, and via on-board enunciators. DTA manages electronic fare collection with smart "touch" cards that are integrated with U of M student ID cards. DTA also operates surveillance systems on-board all buses and at transit centers/garages. City of Rochester manages electronic fare collection and plans to operate TSP at all signalized intersections that serve emergency vehicles with traffic signal preemption within the City. MAT currently operates electronic fare collection and plans to operate TSP at intersections where traffic signals are operated by MnDOT. CAT currently operates TSP at intersections where traffic signals are operated by MnDOT. Various other counties and cities throughout the state are in the process of deploying AVL equipment.	Local Transit Providers	Existing

Element	Service Package	Description	Stakeholder	Status
Metro Area Transit Management Centers	APTS01, APTS02, APTS03, APTS04, APTS05, APTS06, APTS07, APTS08, APTS09, APTS10, APTS11	This element represents transit management centers operating within the Twin Cities metropolitan area that operate fixed route and demand responsive public transit services. This includes the Metro Transit Control Center and Suburban Transit Provider Operations Centers, independent of Metro Transit, that connect outer-ring metro-area suburbs with Minneapolis and St. Paul metro areas. Metro Transit Control Center utilizes Global Position System (GPS) technology to identify the location of all transit vehicles and also uses an 800-megahertz regional radio system, which allows Metro Transit to interact with police and fire departments and emergency response teams. Metro Transit also utilizes an automated transit fleet maintenance system (TxBase). Within the metro area, door-to-door demand response transit service is provided by Metro Mobility (serving Minneapolis, St. Paul and many surrounding suburbs), Anoka County Traveler (serving Anoka County), DARTS (serving Dakota County), Scott County (Scott County) and H.S.I. (serving Washington County). Transit fare coordination exists between Metro Transit and all Suburban Transit Providers. As a suburban transit provider, Minnesota Valley Transit Authority plans to implement Bus Rapid Transit components, such as transit signal priority and transit kiosks at transit stations along the Cedar Avenue/I-35W Corridor. Other Suburban Transit Providers include Maple Grove Transit, Southwest Metro Transit Commission, Prior Lake Laker Lines, Plymouth Transit, and Scott County Transit.	Metro Area Transit Providers	Existing
Park-and-Ride Parking Information System Roadside Equipment	APTS08, ATMS16	Real-time information on availability of parking spaces at transit park-and-ride facilities is provided to drivers via electronic message signs at selected park-and-ride locations in the Twin Cities metro area.	Metro Transit	Existing
Real-Time Bus Arrival Time Display Roadside Equipment	APTS08	Real-time information on bus and light rail arrival/departure times is provided to passengers via electronic message signs at bus stops and light rail stations in the Twin Cities metro area. Signs are installed at key decision points for drivers along arterial roads and freeways prior to entrances to park-and-ride facilities. Commuter rail arrival/departure times could also be displayed to travelers in the future.	Metro Transit	Existing

Element	Service Package	Description	Stakeholder	Status
Traffic Signal Roadside Equipment	APTS09	This element represents traffic signals on all Minnesota roads and highways that are controlled by Traffic Signal Central Control and monitored by Traffic Signal Central Monitoring. Transit Signal Priority (TSP) capability has been implemented in the Twin Cities metro area for Metro Transit.	MnDOT, Local Agencies	Existing
Transit Center and Station Surveillance System Roadside Equipment	APTS05	These systems represent surveillance and security monitoring at transit centers, garages, stations, and park and ride lots. The systems have been implemented at centers and garages for the Saint Cloud Metropolitan Transit Commission, Duluth Transit Authority, and Metro Transit. Park and ride surveillance system and light rail boarding area surveillance systems are deployed by Metro Transit.	Metro Area Transit Providers, Local Transit Providers	Existing
Transit Information Websites	APTS08, ATIS01, ATIS07, ATIS08	This element represents websites that provide general route and schedule information to travelers. Metro Transit, Duluth Transit Authority, and Cities Area Transit websites support transit trip planner functions. Metro Transit website also provides real-time bus arrival information and supports trip planning and dynamic ridesharing functions. DARTS is considering an on-line ride reservation system.	Metro Area Transit Providers, Local Transit Providers	Existing
Transit Kiosks	APTS04, APTS08	This element represents transit kiosks that manage electronic fare payment and provide real-time stop arrival notifications. Kiosks are currently in operation along the Metro Transit Light Rail lines. Kiosks are also deployed as part of the Minnesota Valley Transit Authority Bus Rapid Transit project along Cedar Avenue and I-35W.	Metro Area Transit Providers	Existing

Element	Service Package	Description	Stakeholder	Status
Transit Vehicle Equipment	APTS01, APTS02, APTS03, APTS04, APTS05, APTS06, APTS08, APTS09, APTS10, AVSS03, AVSS04, AVSS09	This element represents transit vehicles and on-board ITS equipment operated by transit service providers. On-board ITS equipment may include AVL, MDT, radio communications, TSP, passenger counter, electronic fare collection equipment, surveillance and security monitoring devices, and traveler information annunciation. TSP exists on vehicles serving St. Cloud and East Grand Forks. TSP is planned for vehicles serving Minneapolis, Rochester, Duluth, and Moorhead. Transit vehicles for Metro Transit, MTC, and DTA are equipped with on-board surveillance cameras. Transit vehicles for Metro Transit, MTC, and DTA have Automated Vehicle Location (AVL) devices installed. Transit vehicles for Metro Transit, MTC, DTA, MAT, CAT, and Rochester support electronic fare collection devices. Transit vehicles for Metro Transit and DTA support automated passenger counting. Light Rail transit vehicles support automated next stop annunciation. MVTA and Metro Transit plan to deploy transit vehicle lateral and longitudinal vehicle safety warning systems as well as advanced vehicle lateral control for shoulder-running buses to improve transit travel safety.	Metro Area Transit Providers, Local Transit Providers, Intercity Transit Providers, NCDA	Existing
TransitLine Phone System	APTS08	This system allows users to utilize a touchtone phone to access transit schedule information. TransitLine also gives other transit related information such as State Fair transit information, and Snow Reroute information when applicable. TransitLine provides visually impaired customers with equal access to schedules. It is planned to upgrade the system with limited voice response technology and real-time bus arrival and departure information.	Metro Transit	Existing

Appendix B: Minnesota ITS Development Objectives

General Purpose: Create a system that enhances transportation through the safe and efficient movement of people, goods, and information, with greater mobility and fuel efficiency, less pollution, and increased operating efficiency in Minnesota.

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-1-05 Reduce the daily hours of recurring congestion on major freeways
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-1-10 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
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-1-05 Reduce the daily hours of recurring congestion on major freeways
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-1-10 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
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-3-10 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-3-10 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-1-08 Increase the number of critical sites with security surveillance
D-1-09 Reduce the number of security incidents on transportation infrastructure
D-1-10 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-3-10 Increase the percent of the transportation system in which travel conditions can be detected remotely via CCTV, speed detectors, etc.
C-3-11 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-1-05 Reduce the daily hours of recurring congestion on major freeways
- 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-1-10 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

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-3-10 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-1-08 Increase the number of critical sites with security surveillance
D-1-09 Reduce the number of security incidents on transportation infrastructure
D-1-10 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-1-05 Reduce the daily hours of recurring congestion on major freeways
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-1-10 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
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-1-05 Reduce the daily hours of recurring congestion on major freeways
- 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-1-10 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
- 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 APTS01-Transit Vehicle Tracking								
TR02	Provide real-time transit vehicle arrival/ departure information	• Transit agencies provide real-time vehicle arrival/ departure information to customers via travel information systems to assist with their travel decisions. • Customers use real-time arrival/ departure information to make mode and route choices.	• Metro Transit provides real-time information on LED signs and LCD monitors at around 60 to 70 locations. Information is also provided via phone, internet, and mobile phone as well as through the NexTrip. • Metro Transit also provides LRT arrival information for the Hiawatha and Central Corridor LRT lines at stations. • Duluth Transit Authority (DTA) currently provides real-time arrival information at 7 locations with dynamic message signs. DTA will add 14 locations in the coming year. • DTA also has an email	• Expand real-time transit arrival time and transit travel-time information. • Integrate Metro Transit CAD/AVL system and RTMC to generate and provide real-time transit information. • Expand the capabilities of providing real-time transit information via mobile devices. • Make information systems more interactive and customer-driven. • Display real-time information consistently between agencies and systems to avoid confusion. • Integrate real-time transit information into a Transit Trip Planning System. • Display real-time	• Transit agencies are responsible to plan, design, construct, operate and maintain their information systems.	• Real-time vehicle arrival systems include interconnects between in-vehicle GPS/AVL equipment and transit management centers. • Interconnects between transit management centers and traveler information systems.	• Vehicle travel time and schedule adherence data should be archived for performance evaluation and analysis.	• APTS08 • ATMS06

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Data Archive Need	Associated Service Package
			notification/text message system that notified riders 15 minutes prior to departure for selected stops.	transit arrival/ departure information via DMS and web service. • Provide real-time information of transit transfer connections and connections to other modes on board of transit vehicles. • Address data latency issues with real-time information.				
TR05	Manage transit fleet and personnel operations	• Transit agencies monitor vehicle locations to manage operations and schedule adherence and to optimize future operations.	• Most transit agencies use automated vehicle location (AVL) systems on transit fleet vehicles and computer aided dispatch (CAD) to manage resources.	• Expand AVL deployments. • Integrate transit resources and/or information between agencies.	• Transit agencies are responsible to plan, design, construct, operate and maintain their AVL systems.	• AVL systems include interconnects between in-vehicle equipment, transit operational devices, and transit management centers.	• AVL data is archived for future analysis to improve operations.	

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Data Archive Need	Associated Service Package
TR09	Measure historical transit route performance	• Transit agencies measure and analyze route performance to identify areas to enhance service and improve operations.	• Many metro area and local transit agencies already track route performance and use in analysis of transit operations.	• Refine data analysis tools to evaluate route performance based on archived data. • Refine tools to manage archived transit performance data.	• Transit agencies are responsible to gather, manage, archive, and analyze route performance for their system.	• This service includes interconnects between in-vehicle equipment and transit management centers. • Interconnects between transit management centers and transit data archives.	• Key measures of route performance have already been archived for future analysis and comparison.	• AD1

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Data Archive Need	Associated Service Package
Service Package APTS02-Transit Fixed-Route Operations								
TR15	Optimize schedule efficiency	• Transit agencies track route performance and analyze schedule efficiency. • Transit agencies use performance analysis results and scheduling software to improve schedule efficiency to provide better service at a lower cost.	• Many agencies already use scheduling software to improve operations efficiency. • Other services that support schedule adherence also have a secondary effect of improving schedule efficiency.	• Enhance scheduling software. • Coordinate implementation of related services such as TR02 – provide real-time transit vehicle arrival/departure information, TR04 – coordinate time transfer, TR09 – measure historical route performance, and TR17 – coordinate transit vehicle movements with traffic control devices.	• Transit agencies are responsible to plan, design, construct, integrate, operate and maintain their systems to optimize schedules.	• Scheduling optimization systems includes interconnects between historic route databases and scheduling software systems.	• None. This service uses key historic travel information already archived.	
TR26	Additional GIS systems integration	• Transit police and transit agencies use GIS systems for collecting incident data and performing incident investigation.	• Transit agencies use GIS for operations and management. • Transit police uses GIS to an extent for incident data collection.	• Integrate transit agencies GIS systems with city/ county law enforcement systems for enhanced data collection and investigation capabilities.	• Transit agencies are responsible to coordinate with law enforcement agencies and to plan, procure, integrate, operate and maintain their systems.	• None.	• Transit service data and incident data are already archived.	• APTS03 • AD1

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Data Archive Need	Associated Service Package
Service Package APTS03-Demand Response Transit Operations								
TR21	Provide on-line reservation system for demand-responsive transit	• Demand-responsive transit agencies provide on-line services to allow customers to schedule pick-up and drop-off. • Demand-response transit riders use on-line services to schedule pick-ups and drop-offs.	• Many demand-responsive transit agencies schedule services via phone and web.	• Implement on-line reservation systems on agency web-sites and integrate them with fleet scheduling systems. • Dakota Area Resources and Transportation for Seniors (DARTS) plans to implement an on-line reservation system. • Integrate with fixed route trip planning system.	• Demand-responsive transit agencies are responsible to plan, design, construct, integrate, operate and maintain on-line reservation systems.	• Interconnects between on-line reservation web sites and scheduling systems.	• Service requests will be archived for schedule analysis and request tracking.	
TR26	Additional GIS systems integration	See information under APTS02						

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Data Archive Need	Associated Service Package
Service Package APTS04-Transit Fare Collection Management								
TR03	Provide simple and flexible fare payment systems	• Transit agencies use simple electronic fare payment systems to make it easier for customers to pay. • Transit agencies in the same region integrate their fare payment systems to allow customers to use a single fare card to ride on transit services provided by different agencies. • Transit customers pay fare using electronic fare cards.	• Metro Transit is coordinating fare payment between bus and rail services and with Suburban Transit Providers. • U of M, Metro Transit, and Duluth Transit Authority (DTA) have integrated transit smart cards and Student ID cards for U of M students and faculty. • St. Cloud MTC is examining using the smart card capability. • Businesses and Metro Transit have integrated transit smart card and MetroPass. • Metro Transit has implemented Go-To Card customer check balance and add value capability to fare payment systems	• Coordinate payment integration between transit systems. • Too many fares between peak, off-peak, etc. Met Council is developing a policy to simplify those fares across agencies. • Allow credit card payment to simplify payment system and easily allow charges for additional services. • Integrate existing dial-a-ride fare payment service with existing bus and rail payment systems in the Twin Cities area. • Implement new technology for fare payment to replace older systems and maintain simplicity.	• Transit agencies are responsible to plan, design, construct, integrate, operate and maintain their payment systems.	• This service includes interconnects between transit traveler cards and in-vehicle electronic fare boxes. • Interconnects between in-vehicle electronic fare boxes and transit operations centers. • Interconnects between fare payment system and credit card processing center. • Interconnects between fare payment system and IVR phone system.	• Transit customer account transactions should be archived for back-office account management.	

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Data Archive Need	Associated Service Package
TR07	Provide electronic fare payment card	• Transit agencies provide electronic fare card to simplify fare collection and reduce boarding time. • Customers use electronic fare system to quickly pay and board vehicle. • Transit agencies use electronic fare card as employee security cards/timecards.	• Metro Transit has implemented Go-To Card for electronic fare payment. • St. Cloud MTC is examining using the smart card capability. • Metro Transit and Duluth Transit Authority (DTA) uses transit smart card for employee security and door access in addition to transit usage.	• DTA is planning to use transit smart card for employee time clock management. • Regional transit providers plan to use electronic fare cards in same capacity as Metro Transit. • Investigate the use of electronic fare card to pay for parking • Investigate the use of electronic fare card for paratransit.	• Transit agencies are responsible to plan, design, construct, integrate, operate and maintain their fare payment system.	• This service includes interconnects between transit traveler cards and in-vehicle electronic fare boxes. • Interconnects between in-vehicle electronic fare boxes and transit operations centers.	• Transit customer account transactions should be archived for back-office account management. • Archive electronic fare card usage and bad list data. • Need central database to allow fare management across regional providers.	

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Data Archive Need	Associated Service Package
Service Package APTS05-Transit Security								
TR06	Provide surveillance and enforcement on transit vehicles and transit facilities	• Transit agencies use surveillance to monitor and/or detect suspicious activities, threats or incidents on transit vehicles, outside transit vehicles, and in and around transit facilities. • Transit agencies share surveillance and information of suspicious activities, threats, and incidents with enforcement agencies.	• St. Cloud MTC, Metro Transit, and DTA have video surveillance on their buses. • St. Cloud MTC is planning an operational test to enhance its security features. • Metro Transit has surveillance systems installed at transit centers and garages. • DTA operates surveillance systems at transit centers and garages. • Silent, driver activated security alert buttons in vehicles.	• Enhance automated surveillance monitoring with alarms. • Install secure, high capacity, wireless communications between surveillance equipment and operations centers (video download to garage, center, and supervisor personnel • Multi-agency integration of surveillance video (police, DOT, etc.). • Upgrade analog cameras to digital cameras.	• Transit agencies are responsible to plan, design, construct, operate and maintain their surveillance systems.	• This service includes interconnects between in-vehicle surveillance equipment/ roadside surveillance equipment and transit management center/ enforcement agency (DOT, other transit agencies). • Interconnects between transit management center and enforcement agency (DOT, other transit agencies).	• Live video should be "buffered" for a period of time to allow saving video of interest after the fact. • Video of interest should be permanently saved and cataloged for training, post incident briefing, and tort cases.	

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Data Archive Need	Associated Service Package
TR14	Provide security at park and ride lots	• Transit agencies use surveillance to monitor and record suspicious activity at park-and-ride lots to improve the safety and security of customers and vehicle operators.	• Some transit agencies already use cameras for surveillance at park-and-ride lots. • Panic buttons and emergency phones also exist at select park-and-ride facilities.	• Deploy surveillance cameras at more park-and-ride lots. • Integrate monitoring alert systems with surveillance systems to automatically alert agencies of suspicious activities. • Upgrade analog cameras to digital cameras.	• Transit agencies are responsible to plan, design, construct, operate and maintain their surveillance systems.	• This service includes interconnects between roadside surveillance equipment and transit management centers.	• Live video should be "buffered" for a period of time to allow saving video of interest after the fact. • Video of interest should be permanently saved and cataloged for training, post incident briefing, and tort cases.	

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Data Archive Need	Associated Service Package
Service Package APTS06-Transit Fleet Management								
TR08	Support vehicle diagnostics and maintenance	• Transit agencies use sensors to monitor vehicle usage and conditions and transmit data to fleet management systems to issue diagnostic reports and maintenance requests. • Fleet management systems process data and schedule preventative and corrective maintenance. • The systems also provide personnel with vehicle diagnostic and historical maintenance data for use during preventative maintenance and for roadside assistance calls.	• Metro Transit uses TxBase interface to generate work orders when some error codes are received. • Metro Transit is updating its AVL system to gather vehicle diagnostics through the AVL system. • St. Cloud enters all diagnostic data into its fleet management system. • Duluth Transit Authority (DTA) uses AVL system for diagnostic data reporting and on-board sensors for preventative maintenance. • Transit agencies have integrated vehicle monitoring equipment with automated diagnostic systems.	• Expand implementation of fleet management systems with automated diagnostic and scheduling capabilities to other transit agencies.	• Transit agencies are responsible to plan, design, construct, integrate, operate and maintain their vehicle monitoring and diagnostic systems.	• This service includes interconnects between in-vehicle monitoring equipment and fleet management/ diagnostic systems.	• Diagnostic and maintenance history will be archived for use in future vehicle maintenance and fleet maintenance analysis.	

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Data Archive Need	Associated Service Package
TR12	Optimize garage operations	• Transit agencies use fleet/garage management systems to improve efficiency in vehicle storage, finding, and maintenance.	• Metro Transit employees perform bus "markup" by walking the aisles in bus garages and recording the position of each bus in the garage area. • Duluth Transit Authority (DTA) staff assigns transit vehicles to drivers. DTA is setting up a parking grid and notification system that will inform drivers where their buses are parked. • Metro Transit has a garage bus locator system to locate buses while they are parked in garages. Upgrade is underway to install LED signage to direct information to bus drivers on where to park when they enter the garage.	• Some transit agencies plan to deploy a garage bus locator system to locate buses primarily while they are parked on transit agency property.	• Transit agencies are responsible to plan, design, deploy, integrate, operate and maintain their fleet/garage management systems.	• The fleet management systems and garage bus locator systems include interconnects between in-vehicles equipment and garage operations centers • Interconnects between garage operations centers and transit management centers.	• None.	

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Data Archive Need	Associated Service Package
TR22	IT support consistently with mission critical operations systems	• Transit agencies' IT departments support real-time operations and mission-critical operations consistently	• IT support in general is focused on administrative support and cannot support real-time and mission-critical operations in the same fashion.	• IT departments provide needed support for real-time and mission-critical operations at a level that is consistent with the administrative support.	• Transit agencies are responsible for identifying IT support needed for real-time and mission critical operations and coordinating with their IT departments for the support.	• None.	• None.	
TR23	Provide multi-communication mode hub/ infrastructure on buses to transmit/ receive high speed data in the most efficient and cost-effective manner	• Transit agencies use a high speed communications network for transit control staff to send and receive data to/from data systems on-board transit vehicles to improve safety and operations. • On-board equipment and data systems include Automated Vehicle Locator technology, Security Cameras, Transit Signal Priority, and Automated Passenger Counter equipment.	• Metro Transit vehicles are equipped with multiple on-board data systems, such as Automated Vehicle Locator technology, Security Cameras, Transit Signal Priority, and Automated Passenger Counter equipment. • Metro Transit is improving current radio communications and implementing software upgrades.	• Implement the High Speed, Accuracy Reliability, and Capacity (HiSPARC) program to increase the ability of transit vehicles to send and receive data at a higher speed. • Upgrade hardware on vehicles and investigate hardware options to allow high speed data communications between buses and the Metro Transit Control Center.	• Transit agencies are responsible to plan, design, deploy, integrate, operate and maintain their HiSPARC systems.	• This service includes interconnects between transit vehicles, their on-board equipment, transit management centers, and agencies.	• None.	

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Data Archive Need	Associated Service Package
Service Package APTS07-Multi-modal Coordination								
TR04	Coordinate timed transfers between route segments, providers & modes	• Transit agencies share and coordinate vehicle routes and schedules to minimize wait times and missed transfers at transfer points. • Transit agencies coordinate with providers of other modes to improve service coordination and operating efficiency.	• Metro Transit uses software to provide internal timed transfers. • Three transit agencies are coordinating services in common regional centers in southwest and west central Minnesota • Duluth Transit Authority (DTA) uses AVL system to coordinate transfers between DTA routes. • DTA uses Google Transit Trip Planning. Metro Transit and Regional Transit Providers will also use Google in Sept. 2008.	• Improve automated coordination among transit providers to expand service and prevent duplicating trips • Alert transit drivers/dispatchers whether passengers are waiting at a bus stop. • Reduce duplication of routes between fixed route and demand-response • Deploy GPS/AVL technology for transit agencies in greater MN transit.	• Transit agencies are responsible to communicate and coordinate with each other to improve service coordination. • Coordination between regional transit providers, county, and transit planning stakeholders for greater MN.	• This service includes interconnects between transit vehicles, transit management centers, and agencies. • Interconnects between different transit management centers.	• Historic route performance and schedule adherence data should be archived to assist in analyzing vehicles arrive/depart times at transfer points and trip patterns/ trends.	• APTS11

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Data Archive Need	Associated Service Package
Service Package APTS08-Transit Traveler Information								
TR01	Provide transit route and schedule information	• Transit agencies use various travel information systems to provide route, schedule, and fare information to the public. • Transit customers use route, schedule, and fare information to make time/route/mode travel decisions.	• Many transit agencies provide route, schedule and fare information via websites or phone systems as well as printed schedules at stops. • Metro Transit provides a trip planner service on its website. • Duluth Transit Authority (DTA) uses WebWatch software that informs customers via the Internet of the planned transit departures from bus stops. • Several transit agencies use Google Transit to disseminate route information.	• Enhance voice recognition for automated trip planning. • Implement route planning systems for agencies that do not have them (regional transit and county providers). • Provide WiFi Internet access points on trains. • Install kiosks at key transit stops/centers to provide information and for trip planning.	• Transit agencies are responsible to plan, design, construct, operate and maintain their travel information systems.	• Transit traveler information systems include interconnects between transit scheduling systems and websites, phone systems, kiosks and other information distribution equipment.	• Service usage should be tracked and archived.	
TR02	Provide real-time transit vehicle arrival/ departure information	See information under APTS01						

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Data Archive Need	Associated Service Package
TR10	Provide on-board automated enunciators	• Transit agencies use on-board enunciators to automatically announce stops based on vehicle locations. • Customer use enunciators to determine what stop the vehicle is at and whether they should get off.	• Metro Transit's light rail system uses on-board automated enunciators to announce next stops/routes and safety messages. Enunciators at LRT stations also provide safety messages. Metro Transit will have 75% of its bus fleet equipped with enunciators by the spring of 2014. • Duluth Transit Authority (DTA) utilizes on-board enunciators to announce next stops/routes and safety messages on the interior and exterior of transit vehicles. Drivers can also activate a set of pre-defined messages to address transit customers. • St. Cloud MTC has on-board enunciators on all its fixed route fleet.	• Deploy on-board enunciators/visual display systems and integrate them with AVL systems. Southwest Transit is planning on deploying the technology in a few years.	• Transit agencies are responsible to plan, design, construct, operate and maintain their automated enunciator systems/visual display systems.	• Enunciator systems include interconnects between in vehicle enunciators and in-vehicle AVL equipment.	• None.	

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Data Archive Need	Associated Service Package
TR11	Provide information to the ADA community	• Transit agencies use websites, telephone services, printed materials, media, and other means to provide transit service and fare information to ADA communities. • The traveler information systems provided by transit agencies shall meet Section 508 of the U.S. Rehabilitation Act of 1973. • ADA communities obtain information on transit availability, routes, schedule, fare, vehicle types, and accessibility options.	• Transit agencies currently provide vehicle wheelchair accessibility information via public websites and brochures. • Provision of on-board enunciators by Metro Transit and DTA provide automated information to ADA community. • Metro Transit has push-button annunciators at stops equipped with LED real-time signs and LCD monitors.	• Develop/update transit agency websites to meet accessibility requirements as required by Section 508. • Coordinate with solutions to address needs/services of TR01 – provide transit route, schedule and fare information and TR11 – provide on-board automated enunciators.	• Transit agencies are responsible to plan, design, construct, operate and maintain their travel information systems.	• Transit travel information systems include interconnects between transit management centers and websites, phone systems, kiosks and other information distribution equipment.	• None.	

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Data Archive Need	Associated Service Package
TR16	Provide information on ridesharing opportunities	• Transit agencies provide transit and ridesharing information to customers to assist them with travel decisions and interagency trip coordination. • Customers use this information to obtain rideshare information and form carpools.	• Agencies provide information on transit and carpooling opportunities on their websites or phone information systems. • Metro Transit provides rideshare information on its web site and has on-line carpool and vanpool matching capabilities.	• Enhance carpool and vanpool ridematching system. • Opportunities for coordination of existing transit services in greater Minnesota with city/county/ regional transit providers.	• Transit agencies are responsible to plan, design, construct, operate and maintain their carpool/vanpool ridematching systems.	• None.	• None.	• ATIS08

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Data Archive Need	Associated Service Package
TR20	Provide real-time transfer information to travelers en route	• Transit agencies provide real-time transfer information to customers “en route” to assist with their travel decisions, regardless of travel mode. • Customers use real-time arrival information to make transfer decisions.	• Metro Transit has real-time next bus arrival signs at 3 locations. • Duluth Transit Authority (DTA) currently provides real-time arrival information at 7 locations with dynamic message signs. DTA will add 14 locations in the coming year. • Beta testing of NexTrip on Metro Transit website, phone, and PDA.	• Integrate Metro Transit CAD/AVL system with RTMC to generate real-time information. • Provide real-time next bus arrival and transfer information at transit centers and transfer points. • Provide next bus arrival time at decision points on freeways and major arterials. • Provide real-time information to customers en route. • Add rail mode information to NexTrip. • Integrate St. Cloud transit information into NexTrip.	• Transit agencies are responsible to plan, design, construct, operate and maintain their AVL and real-time information systems.	• Transfer information systems include interconnects between in-vehicle AVL systems and transit management centers. • Interconnects between operations centers and roadside and portable traveler information equipment.	• None. Transit arrival archive data is archived as part of the CAD/AVL service.	

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Data Archive Need	Associated Service Package
TR25	Wireless access for transit customers	• Transit agencies provide wireless access at transit stations and on transit vehicles.	• Southwest Transit provides wireless access to its customers at major transit centers/stations and on many of its buses.	• Metro Transit plans to provide wireless access to its customers on-board transit vehicles as well as key transit centers.	• Transit agencies are responsible to plan, design, construct, operate and maintain their systems.	• None.	• None.	
Service Package APTS09-Transit Signal Priority								
TR17	Coordinate transit vehicle movements with traffic control devices	• Transit agencies will use transit signal priority (TSP) to increase schedule adherence and improve transit speed and trip time reliability for customers.	• Many signalized intersections in many cities are equipped with emergency vehicle preemption (EVP) • St. Cloud MTC currently operates TSP at all intersections where MTC buses travel through. • Metro Transit deployed TSP along two north-south arterial corridors and near park-and-ride locations along I-35W corridor.	• Expand TSP along other key transit corridors.	• Transit agencies are responsible to plan, design, construct, operate and maintain their TSP systems. • Local traffic control agencies are responsible to operate and maintain traffic signals. • Transit agencies are responsible to coordinate with local traffic control and law enforcement agencies.	• TSP systems includes interconnects between transit vehicles, roadside signal control equipment, and a transit management center.	• Vehicle travel time and schedule adherence data should be archived as part of CAD/AVL service for performance evaluation and analysis.	

ID	Need/Service	Operational Concept	Existing Capability	Gap/Planned Enhancement	Role/ Responsibility	Interconnect	Data Archive Need	Associated Service Package
TR19	Provide queue jumping	• Transit agencies use queue jumping to allow transit vehicles preferred access to reduce travel time and enhance schedule adherence.	• Buses currently have access to HOV bypass lanes at some ramp locations in the metro area and have an exception for turn lanes.	• Investigate queue jumping for future BRT projects. • Test and implement queue jump systems at selected bottle necked areas. • Implement queue jumps along with TSP to improve operations efficiency.	• Transit agencies are responsible to coordinate with MnDOT and local agencies to plan, design, construct, operate and maintain their queue jump systems.	• None.	• None.	
Service Package APTS10-Transit Passenger Counting								
Many transit agencies have automated passenger counters installed in their transit vehicles. No additional needs or services in this area were identified by stakeholders.								
Service Package APTS11-Multimodal Connection Protection								
TR04	Coordinate timed transfers between route segments, providers & modes	See information under APTS07						

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[1]								
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. • MVTA 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

[1] See Volume 8 – AVSS Service Package Bundle for the description of AVSS03 – Longitudinal Safety Warning.

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.	
Service Package AVSS04-Lateral Safety Warning[2]								
TR13	Provide collision avoidance assistance for transit vehicles	See information under AVSS03						

[2] See Volume 8 – AVSS Service Package Bundle for the description of AVSS04 – Lateral Safety Warning.

Appendix D: APTS Service Packages and Descriptions

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

APTS01 Transit Vehicle Tracking
This service package monitors current transit vehicle location using an Automated Vehicle Location System. The location data may be used to determine real time schedule adherence and update the transit system's schedule in real-time. Vehicle position may be determined either by the vehicle (e.g., through GPS) and relayed to the infrastructure or may be determined directly by the communications infrastructure. A two-way wireless communication link with the Transit Management Subsystem is used for relaying vehicle position and control measures. Fixed route transit systems may also employ beacons along the route to enable position determination and facilitate communications with each vehicle at fixed intervals. The Transit Management Subsystem processes this information, updates the transit schedule and makes real-time schedule information available to the Information Service Provider.

APTS02 Transit Fixed-Route Operations
This service package performs automated dispatch and system monitoring for fixed-route and flexible-route transit services. This service performs scheduling activities including the creation of schedules, blocks and runs, as well as operator assignment. This service determines the transit vehicle trip performance against the schedule using AVL data and provides information displays at the Transit Management Subsystem. Static and real time transit data is exchanged with Information Service Providers where it is integrated with that from other transportation modes (e.g. rail, ferry, air) to provide the public with integrated and personalized dynamic schedules.

APTS03 Demand Response Transit Operations
This service package performs automated dispatch and system monitoring for demand responsive transit services. This service performs scheduling activities as well as operator assignment. In addition, this service package performs similar functions to support dynamic features of flexible-route transit services. This package monitors the current status of the transit fleet and supports allocation of these fleet resources to service incoming requests for transit service while also considering traffic conditions. The Transit Management Subsystem provides the necessary data processing and information display to assist the transit operator in making optimal use of the transit fleet. This service includes the capability for a traveler request for personalized transit services to be made through the Information Service Provider (ISP) Subsystem. The ISP may either be operated by a transit management center or be independently owned and operated by a separate service provider. In the first scenario, the traveler makes a direct request to a specific paratransit service. In the second scenario, a third party service provider determines that the paratransit service is a viable means of satisfying a traveler request and makes a reservation for the traveler.

APTS04 Transit Fare Collection Management
This service package manages transit fare collection on-board transit vehicles and at transit stops using electronic means. It allows transit users to use a traveler card or other electronic payment device. Readers located either in the infrastructure or on-board the transit vehicles enable electronic fare payment. Data is processed, stored, and displayed on the transit vehicle and communicated as needed to the Transit Management Subsystem. Two other service packages, ATMS10: Electronic Toll Collection and ATMS16: Parking Facility Management,

also provide electronic payment services. These three service packages in combination provide an integrated electronic payment system for transportation services.

APTS05 Transit Security

This service package provides for the physical security of transit passengers and transit vehicle operators. On-board equipment is deployed to perform surveillance and sensor monitoring in order to warn of potentially hazardous situations. The surveillance equipment includes video (e.g., CCTV cameras), audio systems and/or event recorder systems. The sensor equipment includes threat sensors (e.g., chemical agent, toxic industrial chemical, biological, explosives, and radiological sensors) and object detection sensors (e.g., metal detectors). Transit user or transit vehicle operator activated alarms are provided on-board. Public areas (e.g., transit stops, park and ride lots, stations) are also monitored with similar surveillance and sensor equipment and provided with transit user activated alarms. In addition this service package provides surveillance and sensor monitoring of non-public areas of transit facilities (e.g., transit yards) and transit infrastructure such as bridges, tunnels, and transit railways or bus rapid transit (BRT) guideways. The surveillance equipment includes video and/or audio systems. The sensor equipment includes threat sensors and object detection sensors as described above as well as, intrusion or motion detection sensors and infrastructure integrity monitoring (e.g., rail track continuity checking or bridge structural integrity monitoring).

The surveillance and sensor information is transmitted to the Emergency Management Subsystem, as are transit user activated alarms in public secure areas. On-board alarms, activated by transit users or transit vehicle operators are transmitted to both the Emergency Management Subsystem and the Transit Management Subsystem, indicating two possible approaches to implementing this service package.

In addition the service package supports remote transit vehicle disabling by the Transit Management Subsystem and transit vehicle operator authentication.

APTS06 Transit Fleet Management

This service package supports automatic transit maintenance scheduling and monitoring. On-board condition sensors monitor system status and transmit critical status information to the Transit Management Subsystem. Hardware and software in the Transit Management Subsystem processes this data and schedules preventative and corrective maintenance. The service package also supports the day to day management of the transit fleet inventory, including the assignment of specific transit vehicles to blocks.

APTS07 Multi-modal Coordination

This service package establishes two way communications between multiple transit and traffic agencies to improve service coordination. Multimodal coordination between transit agencies can increase traveler convenience at transit transfer points and clusters (a collection of stops, stations, or terminals where transfers can be made conveniently) and also improve operating efficiency. Transit transfer information is shared between Multimodal Transportation Service Providers and Transit Agencies.

APTS08 Transit Traveler Information

This service package provides transit users at transit stops and on-board transit vehicles with ready access to transit information. The information services include transit stop annunciation, imminent arrival signs, and real-time transit schedule displays that are of general interest to transit users. Systems that provide custom transit trip itineraries and other tailored transit information services are also represented by this service package.

APTS09 Transit Signal Priority
This service package determines the need for transit priority on routes and at certain intersections and requests transit vehicle priority at these locations. The signal priority may result from limited local coordination between the transit vehicle and the individual intersection for signal priority or may result from coordination between transit management and traffic management centers. Coordination between traffic and transit management is intended to improve on-time performance of the transit system to the extent that this can be accommodated without degrading overall performance of the traffic network.

APTS10 Transit Passenger Counting
This service package counts the number of passengers entering and exiting a transit vehicle using sensors mounted on the vehicle and communicates the collected passenger data back to the management center. The collected data can be used to calculate reliable ridership figures and measure passenger load information at particular stops.

APTS11 Multimodal Connection Protection
This service package supports the coordination of multimodal services to optimize the travel time of travelers as they move from mode to mode (or to different routes within a single mode). A near term function supported by this service package would be for a single transit agency to coordinate crossing routes so that passengers on one route would have the opportunity to transfer with minimum wait time to another route within the same transit system. The next level of complexity of this service package would be for this coordination to occur across transit agencies, or between transit agencies and other modes of transportation. The most advanced functions of this service package would be to track the route of an individual traveler and ensure that connections are properly scheduled on an individual basis. This final capability represents a long-term functionality, which could be managed either through an Information Serviced Provider or through a Transit Management subsystem.