Analysis, Modeling, and Simulation (AMS) Testbed Development and Evaluation to Support Dynamic Mobility Applications (DMA) and Active Transportation and Demand Management (ATDM) Programs

AMS Testbed Detailed Requirements

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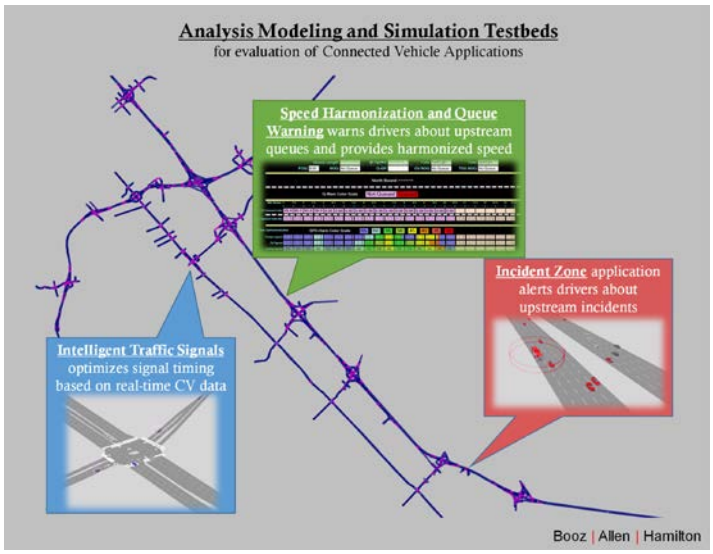

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16. Abstract

The primary objective of this project is to develop multiple simulation Testbeds/transportation models to evaluate the impacts of DMA connected vehicle applications and the active and dynamic transportation management (ATDM) strategies. The outputs (modeling results) from this project will help USDOT prioritize their investment decisions for DMA and ATDM programs.

The primary purpose of this report is to document the detailed requirements developed for AMS Testbeds. Detailed AMS requirements developed under this task will serve as the basis for the AMS Testbed selection and Testbed development activities. The document enlists the following types of requirements: (1) System User Requirements, (2) Connected Vehicles and Connected Traveler Devices Requirements, (3) Communications Systems Requirements, (4) Operational Data Environment Requirements, (5) System Manager Requirements, (6) Data and Information Flows Requirements, (7) Operational Condition and System performance Measurement Requirements, and (8) DMA Applications and ATDM Strategies Requirements.

17. Key Words ATDM, DMA, AMS, Selection criteria, Testbeds, active transportation demand managements, modeling, dynamic mobility application,	**18. Distribution Statement**

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Chapter 1. Introduction

The United States Department of Transportation (USDOT) initiated the Active Transportation and Demand Management (ATDM) and Dynamic Mobility Applications (DMA) Programs to seek transformative mobility, safety, and environmental impacts through enhanced, performance-driven operational practices in surface transportation systems management. In order to explore a potential transformation in transportation systems performance, both programs require an Analysis, Modeling and Simulation (AMS) capability. AMS tools and methodologies offer a cost-effective approach to addressing complex questions on optimization of longer-range investments, shorter-term operational practices, and overall system performance. A capable, reliable AMS Testbed provides a valuable mechanism to address this shared need by providing a laboratory for the refinement and integration of research concepts in a virtual computer-based simulation environment prior to field deployment. A joint DMA-ATDM AMS Testbed can make significant contributions in identifying the benefits of more effective, more active systems management, resulting from integrating transformative applications enabled by new data from wirelessly connected vehicles, travelers, and infrastructure.

The primary purpose of this report is to document the detailed AMS requirements that were developed from the high-level AMS Testbed requirements document developed by Noblis for USDOT, and other related DMA and ATDM documents. Detailed AMS requirements developed under this task will serve as the basis for the AMS Testbed selection and Testbed development activities. The Table 1 summarizes numbers of detailed requirement developed under each requirement group:

Table 1. High-level Grouping of the AMS Testbed Detailed Requirements

High-Level Functional Requirement Group	Numbers of Detailed Requirement Developed
System User Requirements	101
Connected Vehicles and Connected Traveler Devices Requirements	105
Communications Systems Requirements	29
Operational Data Environment Requirements	12
System Manager Requirements	18
Data and Information Flows Requirements	5
Operational Condition and System performance Measurement Requirements	10
DMA Applications and ATDM Strategies Requirements	45
TOTAL	**325**

Detailed AMS requirements listed in the following sections are derived and developed from the following references:

- *AMS Testbed Requirements for DMA and ATDM Programs*, Final Report, Version 4, USDOT, April 5, 2013
- *AMS Framework for DMA and ATDM Programs*, Draft Report, Version 1.4, USDOT, May 2, 2013
- *ATDM Foundational Research – Analysis Plan*, Final Report, USDOT, June 27, 2013
- *AMS Preliminary Evaluation Plan for DMA Applications, Draft Report, Version 1.1, USDOT, October, 2, 2013*

As far as the layout of this report is concerned, this chapter provides a high-level overview of the detailed AMS Testbed requirements that were developed to assist in Testbed selection, development and evaluation of DMA applications and ATDM strategies. Chapters 2 through 8 provide the detailed requirements pertaining to different categories:

- Chapter 2 provides the detailed requirements pertaining to System Users.
- Chapter 3 provides the detailed requirements pertaining to Connected Vehicles and Connected Traveler Devices.
- Chapter 4 enlists the detailed requirements for developing Operational Data Environments.
- Chapter 5 provides detailed System Manager Requirements.
- Chapter 6 provides detailed requirements for Data and Information Flow.
- Chapter 7 provides detailed requirements for Operational Conditions and measurement of system performance.
- Chapter 8 provides detailed requirements for the different DMA applications and ATDM strategies used in the project.

Chapter 2. System User Requirements

System Users are humans, who make a range of strategic and tactical decisions regarding their travel. These decisions may be whether to travel, what mode of travel to use, when to take a trip, what route to travel on within a mode, where to park, and finally, how a collection of trips (tour) within a day will meet a variety of obligations and desired outcomes.

Table 2 below shows the System User Requirements to be fulfilled by AMS Testbed.

Table 2. System User Requirements

ID	Requirement
SU-1	**The AMS Testbed shall emulate[1] and track each Traveler's time-referenced geographic location (position) as he/she plans, executes, and completes a trip within the transportation system.**
SU-1-1	The A MS Testbed shall track **all pertinent** Travelers' location/ time during the **planning** state of the trip/tour.
SU-1-2	The AMS Testbed shall track **all pertinent** Travelers' location on a continuous basis[2] **during the trip execution** including origin location, destination location, and **en-route**.
SU-1-3	The AMS Testbed shall track **all pertinent** Travelers' location and time for each intermediate **stop** location.
SU-2	**The AMS Testbed shall emulate and track each Travelers' time-referenced state and transition among various potential states (pre-trip, Pedestrian, Non-motorized Traveler, light vehicle driver, light vehicle passenger, and transit rider) as they plan, execute, and complete trips within the transportation system.**
SU-2-1	The AMS Testbed shall track individual Travelers at **pre-trip** state when they plan their travel including *mode of travel, origin location, destination location, time of travel and tour pattern including transition between different states*
SU-2-2	The AMS Testbed shall track individual **Pedestrian and Non-Motorized Traveler movements** execute and complete the trips within the Transportation System on a continuous basis
SU-2-3	The AMS Testbed shall track individual **Light vehicle driver and Light vehicle passenger** movements as they execute and complete the trips within the Transportation System on a continuous basis
SU-2-4	The AMS Testbed shall track individual **Transit Riders** as they execute and complete the trips within the Transportation System on a continuous basis
SU-2-5	The AMS Testbed shall be able to consider all potential states and travel modes (pre-trip, Pedestrian, Non-motorized Traveler, light vehicle driver, light vehicle passenger, and transit rider) in a **combined manner** and track any transitions between states and/or modes on a continuous basis as the traveler **plans** the trip or tour.

[1] See Glossary for definition of *emulate*.
[2] See Glossary for o*n a continuous basis*.

ID	Requirement
SU-2-6	The AMS Testbed shall be able to consider all potential states and travel modes (pre-trip, Pedestrian, Non-motorized Traveler, light vehicle driver, light vehicle passenger, and transit rider) in a **combined manner** and track any transitions between states **en route** or during trip execution.
SU-3	**The AMS Testbed shall emulate each Traveler's time-delimited tour planning, both in the pre-trip as well as en route states, subject to the nature and accuracy of available data on travel cost (parking fee, toll, fuel consumption, and transit fare), expected trip duration, trip travel time reliability, safety and environmental impact.**
SU-3-1	The AMS Testbed shall emulate the impact of **travel cost** (parking fee, toll, fuel consumption, and transit fare) data on Travelers time-dependent tour planning/decision making (e.g. mode, time of travel, route, and destination) during **pre-trip** state.
SU-3-2	The AMS Testbed shall emulate the impact of **travel cost** (parking fee, toll, fuel consumption, and transit fare) data on Travelers time-dependent tour planning/decision making (e.g. mode, time of travel, route, and destination) during **en route** state.
SU-3-3	The AMS Testbed shall emulate impact of **expected trip duration** on Travelers time-dependent tour planning/decision making (e.g. mode, time of travel, route, and destination) during **pre-trip** state.
SU-3-4	The AMS Testbed shall emulate impact of **expected trip duration** on Travelers time-dependent tour planning/decision making (e.g. mode, time of travel, route, and destination) during **en route** state.
SU-3-5	The AMS Testbed shall emulate impact of estimated **travel time reliability** on Travelers time-dependent tour planning/decision (e.g. mode, time of travel, route, and destination) making during pre-trip state.
SU-3-6	The AMS Testbed shall emulate impact of estimated **travel time reliability** on Travelers time-dependent tour planning/decision making (e.g. mode, time of travel, route, and destination) during **en route** state.
SU-3-7	The AMS Testbed shall emulate impact of **safety considerations** (e.g. crash probability) on Travelers time-dependent tour planning/decision making (e.g. mode, time of travel, route, and destination) during pre-trip state.
SU-3-8	The AMS Testbed shall emulate impact of **safety considerations** (e.g. crash probability) on Travelers time-dependent tour planning/decision making (e.g. mode, time of travel, route, and destination) during en route state.
SU-3-9	The AMS Testbed shall emulate impact of **environmental considerations** (fuel consumed, GHG emission) on Travelers time-dependent tour planning/decision making (e.g. mode, time of travel, route, and destination) during pre-trip state.
SU-3-10	The AMS Testbed shall emulate impact of **environmental considerations** (fuel consumed, GHG emission) on Travelers time-dependent tour planning/decision making (e.g. mode, time of travel, route, and destination) during **en route** state.
SU-4	**The AMS Testbed shall emulate decision making by Pedestrians and Travelers in Non-motorized Modes of travel in the absence and presence of Mobile Devices, subject to the nature and accuracy of data available to support decision making.**
SU-4-1	The AMS Testbed shall emulate **Pedestrians' movements and their decision-making** process on street crossing and mode choice in response to information received on the Mobile Devices
SU-4-2	The AMS Testbed shall emulate Pedestrians decision-making in response to the different types and accuracy of data available to support decision making
SU-4-3	The AMS Testbed shall emulate **Non-motorized (bicycle)** Travelers' movements and their decision-making (e.g. travel lane, speed) in the presence of Mobile Devices

ID	Requirement
SU-4-4	The AMS Testbed shall emulate Non-motorized (bicycle) Travelers' decision-making in response to the different types and accuracy of data available to support decision making
SU-5	**The AMS Testbed shall emulate decision making by Light Vehicle Drivers[3] in the absence and presence of Mobile Devices, Carry-in Devices, Integrated Devices, and message signs subject to the nature and accuracy of data available to support decision making.**
SU-5-1	The AMS Testbed shall emulate **Light Vehicle Drivers' movements and decision-making** (e.g. travel speed, acceleration/deceleration rates, following distance, lane choice, route choice) in response to the type and accuracy of data available to support decision making
SU-5-2	The AMS Testbed shall emulate **Light Vehicle Drivers' decision-making** (e.g. travel speed, lane choice, route choice) in **the presence and absence of Mobile Devices, Carry-In Devices, and Integrated Devices**
SU-5-3	The AMS Testbed shall emulate **Light Vehicle Drivers' decision-making and compliance** (e.g. travel speed, acceleration/deceleration rates, following distance, lane choice, route choice) in the **presence and absence of message signs within the transportation network**
SU-5-4	The AMS Testbed shall distinctly emulate the differences in **Light Vehicle Drivers' decision-making and compliance** (e.g. travel speed, acceleration/deceleration rates, following distance, lane choice, route choice) in response to providing information via **Mobile Devices, Carry-In Devices, and Integrated Devices vs. message signs within the transportation network**
SU-6	**The AMS Testbed shall emulate decision making by Light Vehicle Passengers in the absence and presence of Mobile Devices subject to the nature and accuracy of data available to support decision making.**
SU-6-1	The AMS Testbed shall explicitly **consider Passengers** in the Light Vehicle and whether they carry Mobile Devices
SU-6-1-1	The AMS Testbed shall emulate **Light Vehicle Passengers**' decision-making in response to the type and accuracy of data available (e.g. Traveler information on route choice) to support decision making in the presence and absence of Mobile Devices
SU-6-2	The AMS Testbed shall emulate **differences in decision making** if data/information is provided to Light Vehicle Passengers' vs. data/information provided to the Light Vehicle Driver
SU-7	**The AMS Testbed shall emulate decision making by Transit Riders in the absence and presence of Mobile Devices subject to the nature and accuracy of data available to support decision making.**
SU-7-1	The AMS Testbed shall emulate **Transit Riders'** movements and decision making (e.g. take an alternative bus instead of planned bus, change time of departure or destination either **pre-trip or en route**) in response to the type and accuracy of data available (e.g. real-time transit schedule, anticipated delays in train/bus arrival times) in presence and absence of Mobile devices
SU-8	**The AMS Testbed shall emulate tactical driving decisions made by Light Vehicle Drivers with respect to lane selection, lane changing, gap acceptance, following headway, speed, acceleration, deceleration, stopping, braking, hard braking, yielding, and merging subject to the nature and accuracy of data available to support decision making.**

[3] See Glossary for definition of *Light Vehicle Driver*

ID	Requirement
SU-8-1	The AMS Testbed shall emulate **Light Vehicle Drivers'** real-time tactical driving decisions at a **microscopic level** subject to the type and the accuracy of the data available to support the tactical driving decisions.
SU-8-1-1	The AMS Testbed shall emulate **Light Vehicle Drivers' lane selection** including decisions based on time-of-day lane use restrictions with or without relevant real-time information to the Driver
SU-8-1-2	The AMS Testbed shall emulate **Light Vehicle Drivers' lane changing** decisions with or without relevant real-time information to the Driver
SU-8-1-3	The AMS Testbed shall emulate **Light Vehicle Drivers' gap acceptance** decisions with or without relevant real-time information to the Driver
SU-8-1-4	The AMS Testbed shall emulate **Light Vehicle Drivers' following headway decisions** with or without relevant real-time information to the Driver
SU-8-1-5	The AMS Testbed shall emulate **Light Vehicle Drivers' speed selection decisions** with or without relevant real-time information to the Driver
SU-8-1-6	The AMS Testbed shall emulate **Light Vehicle Drivers' acceleration and deceleration** restrictions with or without relevant real-time information to the Driver
SU-8-1-7	The AMS Testbed shall emulate **Light Vehicle Drivers' stopping decisions** with or without relevant real-time information to the Driver
SU-8-1-8	The AMS Testbed shall emulate **Light Vehicle Drivers' braking and hard braking** decisions with or without relevant real-time information to the Driver
SU-8-1-9	The AMS Testbed shall emulate **Light Vehicle Drivers' yielding and merging behavior** with or without relevant real-time information to the Driver
SU-9	**The AMS Testbed shall emulate and track each Transit Driver and associated transit vehicle's time-referenced geographic location (position) within the transportation system.**
SU-9-1	The AMS Testbed shall emulate and track **Transit Drivers' locations** along with time.
SU-9-2	The AMS Testbed shall emulate and track **Transit Vehicles' location**, including transit stops and dwell times within the transportation system in real-time on a continuous basis
SU-9-3	The AMS Testbed shall track **transit vehicle location** along with time when it is in or off service
SU-10	**The AMS Testbed shall emulate tactical driving decisions made by Transit Drivers with respect to lane selection, lane changing, gap acceptance, following headway, speed, acceleration, deceleration, stopping, braking, hard braking, yielding, and merging subject to the nature and accuracy of data available to support decision making.**
SU-10-1	The AMS Testbed shall emulate **Transit Drivers' tactical driving decisions** at a microscopic level subject to the nature and accuracy of data available to support decision making.
SU-10-1-1	The AMS Testbed shall emulate **Transit Drivers' lane selection decisions** with or without relevant real-time information to the Driver.
SU-10-1-2	The AMS Testbed shall emulate **Transit Drivers' lane changing decisions** with or without relevant real-time information to the Driver.
SU-10-1-3	The AMS Testbed shall emulate **Transit Drivers' gap acceptance decisions** with or without relevant real-time information to the Driver.
SU-10-1-4	The AMS Testbed shall emulate **Transit Drivers' following headway decisions** with or without relevant real-time information to the Driver
SU-10-1-5	The AMS Testbed shall emulate **Transit Drivers' speed selection** with or without relevant real-time information to the Driver
SU-10-1-6	The AMS Testbed shall emulate **Transit Drivers' acceleration and deceleration** decisions with or without relevant real-time information to the Driver

ID	Requirement
SU-10-1-7	The AMS Testbed shall emulate **Transit Drivers' stopping decisions** with or without relevant real-time information to the Driver
SU-10-1-8	The AMS Testbed shall emulate **Transit Drivers' braking and hard braking decisions** with or without relevant real-time information to the Driver.
SU-10-1-9	The AMS Testbed shall emulate **Transit Drivers' yielding and merging behavior** with or without relevant real-time information to the Driver
SU-11	**The AMS Testbed shall emulate fixed route/fixed schedule transit, flexible route bus, rail transit and paratransit.**
SU-11-1	The AMS Testbed shall emulate **fixed route/ fixed schedule** bus service vehicles' movements (e.g. schedule, routes, fixed stops, a vehicle type, dwell times, an operator and passenger service (on/off) within the transportation network and track the movement of the buses/passengers in the network on a continuous basis.
SU-11-2	The AMS Testbed shall **emulate flexible route bus service** vehicles' movements (e.g. schedule, routes, flexible stops, a vehicle type, an operator and passenger service (on/off)) within the transportation network and track the movement of the flexible route buses/passengers in the network on a continuous basis.
SU-11-3	The AMS Testbed shall **emulate rail transit service vehicles'** movements (e.g. schedule, routes, stop locations, operation speed along with dwell times, an operator and passenger service (on/off)) within the transportation network and track the movement of trains/passengers in the network on a continuous basis.
SU-11-4	The AMS Testbed shall **emulate on-demand transit service** from any origin to any destination within the transportation network and track the movements of the paratransit service within the transportation system on a continuous basis.
SU-12	**The AMS Testbed shall emulate a Transit Driver's adherence to dynamic transit dispatch plans (e.g., to counteract bus bunching) when received subject to the nature and accuracy of data available to support decision making.**
SU-12-1	The AMS Testbed shall emulate the **dynamic transit dispatch** process and its impact on transit operations
SU-12-2	The AMS Testbed shall emulate a **Transit Drivers' adherence** to dynamic transit dispatch plan upon receipt of dynamic transit dispatch plans.
SU-13	**The AMS Testbed shall emulate decision making by Transit Drivers in the absence and presence of Mobile Devices, Carry-in Devices, Integrated Devices, and message signs subject to the nature and accuracy of data available to support decision making.**
SU-13-1	The AMS Testbed shall emulate Transit Drivers' real-time decision making (e.g. route choice, dwell times, lane usage) subject to the nature and accuracy of data available to support decision making.
SU-13-2	The AMS Testbed shall emulate Transit Drivers' decision making in the presence and absence of Mobile Devices, Carry-In Devices, and Integrated Devices
SU-13-3	The AMS Testbed shall emulate Transit Drivers' decision making in the presence and absence of message signs
SU-14	**The AMS Testbed shall emulate and track each Truck Driver and associated freight vehicle's time-referenced geographic location (position) within the transportation system.**
SU-15	**The AMS Testbed shall emulate tactical driving decisions made by Truck Drivers with respect to lane selection, lane changing, gap acceptance, following headway, speed, acceleration, deceleration, stopping, braking, hard braking, yielding, and merging subject to the nature and accuracy of data available to support decision making.**

ID	Requirement
SU-15-1	The AMS Testbed shall emulate **real-time Truck Drivers' tactical driving** decisions merging subject to the nature and accuracy of data available to support decision making.
SU-15-1-1	The AMS Testbed shall emulate **Truck Drivers' lane selection decisions** including based on time-of-day lane use restrictions with or without relevant real-time information to the Driver
SU-15-1-2	The AMS Testbed shall emulate **Truck Drivers' lane changing decisions** with or without relevant real-time information to the Driver
SU-15-1-3	The AMS Testbed shall emulate **Truck Drivers' gap acceptance decisions** with or without relevant real-time information to the Driver
SU-15-1-4	The AMS Testbed shall emulate **Truck Drivers' following headway decisions** with or without relevant real-time information to the Driver
SU-15-1-5	The AMS Testbed shall emulate **Truck Drivers' speed selection** with or without relevant real-time information to the Driver
SU-15-1-6	The AMS Testbed shall emulate **Truck Drivers' acceleration and deceleration** decisions with or without relevant real-time information to the Driver
SU-15-1-7	The AMS Testbed shall emulate **Truck Drivers' stopping decisions** with or without relevant real-time information to the Driver
SU-15-1-8	The AMS Testbed shall emulate **Truck Drivers' braking and hard braking** decisions with or without relevant real-time information to the Driver
SU-15-1-9	The AMS Testbed shall emulate **Truck Drivers' yielding and merging behavior** with or without relevant real-time information to the Driver
SU-16	**The AMS Testbed shall emulate a Truck Driver's adherence to plans when received on dynamic routing, tours, and actions at waypoints subject to the nature and accuracy of data available to support decision making.**
SU-16-1	The AMS Testbed shall emulate Truck Driver's adherence to plans upon receipt of a **dynamic routing request**
SU-16-2	The AMS Testbed shall emulate Truck Driver's adherence to plans upon receipt of **dynamic tours request**
SU-16-3	The AMS Testbed shall emulate **Truck Drivers' actions at waypoints**
SU-16-4	The AMS Testbed shall emulate **Truck Drivers' decisions making on plan adherence** based on the type and accuracy of data available.
SU-17	**The AMS Testbed shall emulate decision making by Truck Drivers in the absence and presence of Mobile Devices, Carry-in Devices, Integrated Devices, and message signs subject to the nature and accuracy of data available to support decision making.**
SU-17-1	The AMS Testbed shall emulate **Truck Drivers' decision making** subject to the nature and accuracy of data available to support decision making.
SU-17-1-1	The AMS Testbed shall emulate **Truck Drivers' decision making** in the presence and absence of Mobile Devices, Carry-In Devices, and Integrated Devices
SU-17-1-2	The AMS Testbed shall emulate **Truck Drivers' decision making** in the presence and absence of message signs
SU-18	**The AMS Testbed shall emulate and track each Public Safety Worker and public safety vehicle's time-referenced geographic location (position) within the transportation system, including in an active incident zone.**
SU-18-1	The AMS Testbed shall **emulate active incident zone and Public Safety Vehicles'** movements within the incident zone
SU-18-2	The AMS Testbed shall **track Public Safety Worker's and vehicles location** on a continuous basis.

ID	Requirement
SU-19	**The AMS Testbed shall emulate tactical driving decisions made by Public Safety Vehicle Drivers with respect to lane selection, lane changing, gap acceptance, following headway, speed, acceleration, deceleration, stopping, braking, hard braking, yielding, and merging subject to the nature and accuracy of data available to support decision making.**
SU-19-1	The AMS Testbed shall emulate **Public Safety Vehicle Drivers' tactical driving** decisions subject to the nature and accuracy of data available to support decision making.
SU-19-1-1	The AMS Testbed shall **emulate Public Safety Vehicle Drivers' lane selection** decisions with or without relevant real-time information to the Driver
SU-19-1-2	The AMS Testbed shall emulate **Public Safety Vehicle Drivers' lane changing** decisions.
SU-19-1-3	The AMS Testbed shall emulate **Public Safety Vehicle Drivers' gap acceptance** decisions
SU-19-1-4	The AMS Testbed shall emulate **Public Safety Vehicle Drivers' following headway** decisions.
SU-19-1-5	The AMS Testbed shall emulate **Public Safety Vehicle Drivers' speed selection**.
SU-19-1-6	The AMS Testbed shall emulate **Public Safety Vehicle Drivers' acceleration and deceleration** decisions.
SU-19-1-7	The AMS Testbed shall emulate **Public Safety Vehicle Drivers' stopping decisions**.
SU-19-1-8	The AMS Testbed shall emulate **Public Safety Vehicle Drivers' braking and hard braking decisions**
SU-19-2	The AMS Testbed shall emulate impact of **Light Vehicle Drivers' driving behavior** (e.g. slow down) **due to presence** of Public Safety Vehicles with flash lights on.
SU-20	**The AMS Testbed shall emulate a Public Safety Vehicle Driver's adherence to plans when received on dynamic routing and response staging subject to the nature and accuracy of data available to support decision making.**
SU-20-1	The AMS Testbed shall emulate **Public Safety Vehicles' dynamic routing process**
SU-20-2	The AMS Testbed shall emulate **Public Safety Vehicle Driver's adherence to plans** when in receipt of dynamic routing plans
SU-20-3	The AMS Testbed shall emulate **Public Safety Vehicles' response staging process.**
SU-20-4	The AMS Testbed shall emulate **Public Safety Vehicle Driver's adherence upon receipt** of response staging request
SU-21	**The AMS Testbed shall emulate the time-referenced geographic location of Public Safety Workers acting as emergency response personnel within an active incident zone in the absence and presence of Mobile Devices subject to the nature and accuracy of data available to support decision making.**
SU-22	**The AMS Testbed shall emulate decision making by Public Safety Vehicle Drivers in the absence and presence of Mobile Devices, Carry-in Devices, Integrated Devices, and message signs subject to the nature and accuracy of data available to support decision making.**
SU-23	**The AMS Testbed shall emulate adherence by Drivers of light, transit, and freight vehicles with directions when received on presence of emergency response personnel subject to the nature and accuracy of data available to support decision making.**

ID	Requirement
SU-24	**The AMS Testbed shall emulate various compliance rates of System Users (drivers, Pedestrians, bicyclists, light vehicle passengers, transit riders, transit drivers, truck drivers, and public safety vehicle driver) when presented with advisory and regulatory information.**
SU-24-1	The AMS Testbed shall emulate the process of **transmitting advisory information**.[4] (e.g. speed advisories, lane advisories, route advisories) to different system users
SU-24-2	The AMS Testbed shall emulate the process of **transmitting regulatory information**.[5] (e.g. speed advisories, lane advisories, route advisories) to different system users
SU-24-3	The AMS Testbed shall emulate different **System Users' compliance to advisories** (e.g. speed advisories, lane advisories, route advisories)
SU-24-4	The AMS Testbed shall emulate different **System Users' compliance to regulatory information** (e.g. speed regulations, lane regulations)

[4] See Glossary for definition of *advisories*
[5] See Glossary for definition of *regulatory information*

Chapter 3. Connected Vehicles and Connected Traveler Devices Requirements

Mobile Devices include smartphones, tablets, and other hand-held devices that have their own power source and are capable of hosting one or more Applications. Mobile devices can communicate using either DSRC or cellular communications systems (or both), and are carried by a System User throughout a trip. **Carry-In Devices** are specially-designed mobile devices that can be carried into a vehicle and may be safely utilized by the driver of a vehicle while en route (e.g., aftermarket navigation systems). **Integrated Devices** are permanently located within a specific vehicle and may be safely utilized by the driver of a vehicle while en route. A **Connected Vehicle** is a vehicle equipped with one or more **Carry-In** or **Integrated Devices**.

Table 3 below shows the Connected Vehicle and Connected Traveler Devices Requirements to be fulfilled by AMS Testbed.

Table 3. Connected Vehicle/Traveler Device Requirements

ID	Requirement
CV-1	**The AMS Testbed shall emulate Mobile Devices that are capable of transmitting messages via cellular or DSRC or both.**
CV-1-1	The AMS Testbed shall emulate **Mobile Devices that communicate** via Dedicated Short Range Communications (**DSRC**).[6]
CV-1-2	The AMS Testbed shall emulate **Mobile Devices that communicate via cellular** communications.[7]
CV-1-3	The AMS Testbed shall emulate **Mobile Devices that communicate via both DSRC and cellular** communications.
CV-1-4	The AMS Testbed shall **emulate cellular network coverage** areas.
CV-1-5	The AMS Testbed shall identify if a Mobile Device is within cellular coverage
CV-1-6	The AMS Testbed shall emulate message transmission by a cellular-capable Mobile Device.
CV-1-7	The AMS Testbed shall emulate message receipt by a cellular-capable Mobile Device.
CV-1-8	The AMS Testbed shall identify if a DSRC-capable Mobile Device is within range of DSRC-capable Road-Side Equipment (RSE).[8]
CV-1-9	The AMS Testbed shall emulate message transmission by a DSRC-capable Mobile Device.
CV-1-10	The AMS Testbed shall emulate message receipt by a DSRC-capable Mobile Device.

[6] See Glossary for description of DSRC.
[7] See Glossary for description of the cellular communications mechanisms.
[8] See Glossary for a description of RSE.

ID	Requirement
CV-2	**The AMS Testbed shall emulate the time-referenced geographic location, operational status (ON, OFF, NOT FUNCTIONING), and power status of a Mobile Device, and the state of the device (in use and connected to the vehicle, not in use but within a vehicle, outside a vehicle, etc.).**
CV-2-1	The AMS Testbed shall emulate Mobile Device location along with the time
CV-2-2	The AMS Testbed shall emulate Mobile Device operational status.
CV-2-2-1	The AMS Testbed shall emulate mutually exclusive Mobile Device statuses.
CV-2-2-2	The AMS Testbed shall emulate the Mobile Device Status 'ON', "OFF' or "NOT FUNCTIONING"
CV-2-3	The AMS Testbed shall indicate if a Mobile Device is inside or outside a vehicle.
CV-2-4	The AMS Testbed shall indicate if a Mobile Device is connected or not connected to a vehicle.
CV-2-5	The AMS Testbed shall indicate if a Mobile Device is in use or not in use
CV-3	**The AMS Testbed shall emulate Carry-in Devices that are capable of transmitting messages via cellular or DSRC or both.**
CV-3-1	The AMS Testbed shall **emulate Carry-In Devices that communicate** via Dedicated Short Range Communications (**DSRC**).
CV-3-2	The AMS Testbed shall **emulate Carry-In Devices that communicate via cellular** communications.
CV-3-3	The AMS Testbed shall emulate Carry-In Devices that communicate via **both** DSRC and cellular communications.
CV-3-4	The AMS Testbed shall identify if a Carry-In Device is within cellular coverage
CV-3-5	The AMS Testbed shall emulate message transmission by a cellular-capable Carry-In Device.
CV-3-6	The AMS Testbed shall emulate message receipt by a cellular-capable Carry-In Device.
CV-3-7	The AMS Testbed shall identify if a DSRC-capable Carry-In Device is within range of DSRC-capable Road-Side Equipment (RSE).
CV-3-8	The AMS Testbed shall emulate message transmission by a DSRC-capable Carry-In Device.
CV-3-9	The AMS Testbed shall emulate message receipt by a DSRC-capable Carry-In Device.
CV-4	**The AMS Testbed shall emulate the time-referenced geographic location, and operational status (ON, OFF, NOT FUNCTIONING) of Carry-In Devices.**
CV-4-1	The AMS Testbed shall emulate location and associated time of Carry-In Device.
CV-4-2	The AMS Testbed shall emulate Carry-In Device operational status.
CV-4-2-1	The AMS Testbed shall emulate mutually exclusive Carry-In Device statuses.
CV-4-2-2	The AMS Testbed shall emulate the Carry-In Device Status 'ON', "OFF' or "NOT FUNCTIONING"
CV-5	**The AMS Testbed shall emulate Integrated Devices that are capable of Transmitting message via cellular or DSRC or both**
CV-5-1	The AMS Testbed shall emulate Integrated Devices that communicate via Dedicated Short Range Communications (DSRC).
CV-5-2	The AMS Testbed shall emulate Integrated Devices that communicate via cellular communications.
CV-5-3	The AMS Testbed shall emulate Integrated Devices that communicate via both DSRC and cellular communications.
CV-5-4	The AMS Testbed shall identify if an Integrated Device is within cellular coverage
CV-5-5	The AMS Testbed shall emulate message transmission by a cellular-capable Integrated Device.
CV-5-6	The AMS Testbed shall emulate message receipt by a cellular-capable Integrated Device.

ID	Requirement
CV-5-7	The AMS Testbed shall identify if a DSRC-capable Integrated Device is within range of DSRC-capable Road-Side Equipment (RSE).
CV-5-8	The AMS Testbed shall emulate message transmission by a DSRC-capable Integrated Device.
CV-5-9	The AMS Testbed shall emulate message receipt by a DSRC-capable Integrated Device.
CV-6	**The AMS Testbed shall emulate the time-referenced geographic location, and operational status (ON, OFF, NOT FUNCTIONING) of Integrated Devices.**
CV-6-1	The AMS Testbed shall emulate location and associated time of Integrated Device.
CV-6-2	The AMS Testbed shall emulate Integrated Device operational status.
CV-6-2-1	The AMS Testbed shall emulate mutually exclusive Integrated statuses.
CV-6-2-2	The AMS Testbed shall emulate the Integrated Device Status 'ON', "OFF' or "NOT FUNCTIONING"
CV-7	**The AMS Testbed shall emulate coordinated or independent transmission of messages from Mobile Devices, Carry-in Devices and Integrated Devices when co-located in a vehicle (light, transit, freight, public safety) via cellular or DSRC or both.**
CV-7-1	The AMS Testbed shall emulate **coordinated transmission of messages by Mobile Devices** located in a vehicle via cellular communications.
CV-7-2	The AMS Testbed shall emulate **coordinated transmission of messages by Carry-In Devices** located in a vehicle via cellular communications.
CV-7-3	The AMS Testbed shall emulate **coordinated transmission of messages by Integrated** Devices located in a vehicle via cellular communications.
CV-7-4	The AMS Testbed shall emulate coordinated transmission of messages by Mobile Devices located in a vehicle via DSRC.
CV-7-5	The AMS Testbed shall emulate coordinated transmission of messages by Carry-In Devices located in a vehicle via DSRC.
CV-7-6	The AMS Testbed shall emulate coordinated transmission of messages by Integrated Devices located in a vehicle via DSRC.
CV-7-7	The AMS Testbed shall emulate independent transmission of messages by Mobile Devices located in a vehicle via cellular communications.
CV-7-8	The AMS Testbed shall emulate independent transmission of messages by Carry-In Devices located in a vehicle via cellular communications.
CV-7-9	The AMS Testbed shall emulate independent transmission of messages by Integrated Devices located in a vehicle via cellular communications.
CV-7-10	The AMS Testbed shall emulate independent transmission of messages by Mobile Devices located in a vehicle via DSRC.
CV-7-11	The AMS Testbed shall emulate independent transmission of messages by Carry-In Devices located in a vehicle via DSRC.
CV-7-12	The AMS Testbed shall emulate independent transmission of messages by Integrated Devices located in a vehicle via DSRC.
CV-8	**The AMS Testbed shall emulate the reception of messages by DSRC-capable Mobile Devices, Carry-in Devices and Integrated Devices from other local DSRC-capable mobile, carry-in, and Integrated Devices.**
CV-8-1	The AMS Testbed shall emulate communication between multiple Mobile Devices via DSRC.
CV-8-2	The AMS Testbed shall emulate communication between Mobile Devices and Carry-In Devices via DSRC.
CV-8-3	The AMS Testbed shall emulate communication between Mobile Devices and Integrated Devices via DSRC.
CV-8-4	The AMS Testbed shall emulate communication between Mobile Devices and Roadside Device Networks via DSRC.

ID	Requirement
CV-8-5	The AMS Testbed shall emulate communication between multiple Carry-In Devices via DSRC.
CV-8-6	The AMS Testbed shall emulate communication between Carry-In Devices and Integrated Devices via DSRC.
CV-8-7	The AMS Testbed shall emulate communication between Carry-In Devices and Roadside Networks via DSRC.
CV-8-8	The AMS Testbed shall emulate communication between multiple Integrated Devices via DSRC.
CV-8-9	The AMS Testbed shall emulate communication between Integrated Devices and Roadside Networks via DSRC.
CV-9	**The AMS Testbed shall emulate the reliability of Mobile Devices, Carry-in Devices and Integrated Devices, specifically the reliability of a device to receive or send messages subject to local interference, device malfunction, or user error.**
CV-9-1	The AMS Testbed shall emulate Mobile Device availability.[9]
CV-9-1-1	The AMS Testbed shall emulate Mobile Device reliability.[10]
CV-9-1-2	The AMS Testbed shall emulate Mobile Device maintainability.[11]
CV-9-2	The AMS Testbed shall emulate Carry-In Device availability.
CV-9-2-1	The AMS Testbed shall emulate Carry-In Device reliability.
CV-9-2-2	The AMS Testbed shall emulate Carry-In Device maintainability.
CV-9-3	The AMS Testbed shall emulate Integrated Device availability.
CV-9-3-1	The AMS Testbed shall emulate Integrated Device reliability.
CV-9-3-2	The AMS Testbed shall emulate Integrated Device maintainability.
CV-9-4	The AMS Testbed shall emulate RSE availability.
CV-9-4-1	The AMS Testbed shall emulate RSE reliability.
CV-9-4-2	The AMS Testbed shall emulate RSE maintainability.
CV-9-5	The AMS Testbed shall emulate Radio Frequency (RF) interference.
CV-9-5-1	The AMS Testbed shall emulate naturally occurring RF interference.
CV-9-5-2	The AMS Testbed shall emulate man-made RF interference created without the intent to interfere with operations.
CV-9-5-3	The AMS Testbed shall emulate man-made RF interference created with the intent to interfere with operations.
CV-9-6	The AMS Testbed shall emulate human user error.
CV-9-6-1	The AMS Testbed shall emulate improper configuration or use of Mobile Devices.
CV-9-6-2	The AMS Testbed shall emulate improper configuration or use of Carry-In Devices.
CV-9-6-3	The AMS Testbed shall emulate improper configuration or use of Integrated Devices.
CV-9-6-4	The AMS Testbed shall emulate improper configuration or use of RSE Devices.
CV-10	**The AMS Testbed shall track the time-referenced geographic- location and emulate the movement of Connected and Unconnected Vehicles within the transportation system, including time parked between trips made as a part of a multi-trip tour.**
CV-10-1	The AMS Testbed shall track location and associated time of Connected Vehicles
CV-10-2	The AMS Testbed shall track location and associated time of Unconnected Vehicles

[9] Availability is the probability that a system or part of a system may be operational during any randomly selected instant of time

[10] Reliability is the ability of a system to perform as designed in an operational environment over time without failure.

[11] Maintainability is measured by an item's ability to be retained in a specified condition through scheduled maintenance, or restored to a specified condition through proper repair.

ID	Requirement
CV-10-3	The AMS Testbed shall emulate movement of Connected Vehicles within the transportation system
CV-10-3-1	The AMS Testbed shall emulate trip made by Connected Vehicles
CV-10-3-2	The AMS Testbed shall emulate tour consisting of multiple trips made by Connected Vehicles
CV-10-3-3	The AMS Testbed shall emulate time parked between trips made by Connected Vehicles
CV-10-4	The AMS Testbed shall emulate movement of Unconnected Vehicles with the transportation system
CV-10-4-1	The AMS Testbed shall emulate trip made by Unconnected Vehicles
CV-10-4-2	The AMS Testbed shall emulate tour consisting of multiple trips made by Unconnected Vehicles
CV-10-4-3	The AMS Testbed shall emulate time parked between trips made by Unconnected Vehicles
CV-11	**The AMS Testbed shall reflect differences in vehicle size and weight among Light Vehicles, Transit Vehicles, Trucks and Public Safety Vehicles and associated differences in vehicle performance.**
CV-11-1	The AMS Testbed shall emulate physical characteristics of vehicles.
CV-11-1-1	The AMS Testbed shall emulate vehicle dimensions.
CV-11-1-2	The AMS Testbed shall emulate vehicle weight.
CV-11-1-3	Vehicle physical characteristics emulated shall be configurable for each vehicle emulated.
CV-11-2	The AMS Testbed shall emulate performance characteristics for each vehicle emulated.
CV-11-2-1	The AMS Testbed shall emulate vehicle acceleration at different terrains.
CV-11-2-2	The AMS Testbed shall emulate vehicle deceleration at different terrains.
CV-11-2-3	The AMS Testbed shall emulate vehicle turning radius.
CV-11-2-4	Vehicle performance characteristics emulated shall be configurable for each vehicle emulated.
CV-11-3	The AMS Testbed shall emulate trucks' vehicle weight changes.

Chapter 4. Operational Data Environments Requirements

Operational Data Environments aggregate and enhance data passed from detection and communication systems to support System Manager decision-making.

Table 4 below shows the Operational Data Environment Requirements to be fulfilled by AMS Testbed.

Table 4. Operational Data Environments Requirements

ID	Requirement
OD-1	**The AMS Testbed shall emulate Data Quality Control (QC) and Aggregation processes, including the nature and effectiveness of quality checks and data performed for different data types.**
OD-1-1	The AMS Testbed shall be capable of performing different Data Quality Control and Aggregation processes on traffic data collected from transportation network on a continuous basis (e.g. volumes, speeds, queue lengths) to support System Manager decision making (e.g. change ramp meter plans, provide speed advisory on dynamic message signs)
OD-1-2	The AMS Testbed shall capture the impacts of the nature and effectiveness of quality checks on different types of data
OD-2	**The AMS Testbed shall emulate the processing time associated with performing Data Quality Control and Aggregation processes.**
OD-3	**The AMS Testbed shall emulate and differentiate between integrated and independent Data Quality Control and Aggregation processes in support of System Managers.**
OD-4	**The AMS Testbed shall emulate the capture and aggregation of data from Connected Vehicles, Mobile Devices, and Detection Systems into Private Sector Data Services.**
OD-4-1	The AMS Testbed shall emulate the capture of data from Mobile Devices, Carry-In Devices, and Integrated devices on a continuous basis
OD-4-2	The AMS Testbed shall be capable of aggregating data collected from Mobile Devices, Carry-In Devices, and Integrated devices, and be able to emulate the processing time required to carry out these tasks.
OD-5	**The AMS Testbed shall account for the processing time associated with performing Data Quality Control and Aggregation processes within Private Sector Data Services.**
OD-6	**The AMS Testbed shall emulate the provision of aggregated and quality controlled data products from Private Sector Data Services into Data QC and Aggregation processes supporting System Managers.**
OD-6-1	The AMS Testbed shall be able to generate aggregated and quality controlled data collected by Private Sector Data Services.
OD-6-2	The AMS Testbed shall emulate the process of transmitting aggregated and quality controlled data from the Private Sector Data Services to the Data Quality Control and Aggregation processes.

OD-7	**The AMS Testbed shall emulate the use of Predictive Tools within an Operational Data Environment, dependent on the flow of data from Data QC and Aggregation processes.**
OD-7-1	The AMS Testbed shall contain and be able to use of different parametric Predictive Tools or specific prediction methods within an Operational Data Environment to anticipate network performance (e.g. speeds, volumes, queue lengths) based on current and historical data
OD-8	**The AMS Testbed shall emulate and differentiate among alternative forms of Predictive Tools, including their prediction horizon, accuracy, scope, and processing time.**
OD-8-1	The AMS Testbed shall be able to differentiate and use alternative forms of parametric Predictive Tools or specific prediction method based on prediction horizon needs.
OD-8-2	The AMS Testbed shall be able to differentiate and use alternative forms of parametric Predictive Tools or specific prediction method based on prediction accuracy needs to support System Managers decision making
OD-8-3	The AMS Testbed shall be able to differentiate and use alternative forms of parametric Predictive Tools or specific prediction method based on geographic scope of prediction needed to support System Managers decision making
OD-8-4	The AMS Testbed shall be able to differentiate and use alternative forms of parametric Predictive Tools or specific prediction method based on prediction processing time needs.

Chapter 5. System Manager Requirements

System Managers control a particular aspect of the system and are responsible for ensuring the safe and efficient operation of their element of the transportation system.

Table 5 below shows the System Manager Requirements to be fulfilled by AMS Testbed.

Table 5. System Manager Requirements

ID	Requirement
SM-1	**The AMS Testbed shall emulate the duration and outcomes of decision-making by Freeway System and Tollway Managers, subject to the latency, accuracy, reliability and nature of Operational Data Environments available to support this decision-making.**
SM-1-1	The AMS Testbed shall have a freeway system and infrastructure details that can be used to emulate the outcomes of decision-making by Freeway System managers based on available data (real-time and archived)
SM-1-2	The AMS Testbed shall be able to emulate duration and outcomes of dynamic decision-making of Freeway System Managers to freeway operations (e.g. access control to freeway facilities such as HOV lanes, ramp meter operations) subject to latency, accuracy and type of data available to support decision-making.
SM-1-3	The AMS Testbed shall have a tollway system that has infrastructure details that can be used to emulate the outcomes of decision-making by Tollway managers based on available data (real-time and archived)
SM-1-4	The AMS Testbed shall be able to emulate duration and outcomes of dynamic decision-making of Tollway System Managers to toll road operations (e.g. dynamic change of policies related to the price and speed) subject to latency, accuracy and type of data available to support decision-making.
SM-2	**The AMS Testbed shall emulate the duration and outcomes of decision-making by Arterial System Managers, subject to the latency, accuracy, reliability and nature of Operational Data Environments available to support this decision-making.**
SM-2-1	The AMS Testbed shall have an Arterial system and infrastructure details that can be used to emulate the outcomes of decision-making by Arterial System managers based on available data (real-time and archived)
SM-2-2	The AMS Testbed shall be able to emulate duration and outcomes of dynamic decision-making of Arterial System Managers to arterial operations (e.g. changes to signal timings, granting signal priority based on vehicle types) subject to latency, accuracy and type of data available to support decision-making.
SM-3	**The AMS Testbed shall emulate the duration and outcomes of decision-making by Road-Weather System Managers, subject to the latency, accuracy, reliability and nature of Operational Data Environments available to support this decision-making.**
SM-3-1	The AMS Testbed shall have ability to emulate the outcomes of decision-making by Road-Weather System Managers based on road-weather available data (real-time and archived)

ID	Requirement
SM-3-2	The AMS Testbed shall be able to emulate duration and outcomes of dynamic decision-making of Road-Weather System Managers to transportation operations (e.g. response to snow or heavy rain) subject to latency, accuracy and type of data available to support decision-making.
SM-4	**The AMS Testbed shall emulate the duration and outcomes of decision-making by Transit System Managers, subject to the latency, accuracy, reliability and nature of Operational Data Environments available to support this decision-making.**
SM-4-1	The AMS Testbed shall have Transit system and infrastructure details that can be used to emulate the outcomes of decision-making by Transit System Managers based on available transit data (e.g. real-time and archived transit ridership, planned and actual schedule, anticipated demand)
SM-4-2	The AMS Testbed shall be able to emulate duration and outcomes of dynamic decision-making of Transit System Managers to transit operations (e.g. changes to transit schedule based on real-time and anticipated ridership, adherence to planned schedule) subject to latency, accuracy and type of data available to support decision-making.
SM-5	**The AMS Testbed shall emulate the duration and outcomes of decision-making by Parking System Managers, subject to the latency, accuracy, reliability and nature of Operational Data Environments available to support this decision-making.**
SM-5-1	The AMS Testbed shall have detailed information on the Parking System (both on-street and off-street) within the transportation system that can be used to emulate the outcomes of decision-making by Parking System Managers based on available data (e.g. real-time and archived data on Parking availability, Parking cost, anticipated parking demand)
SM-5-2	The AMS Testbed shall be able to emulate duration and outcomes of dynamic decision-making of Parking System Managers to parking operations (e.g. dynamic change of policies related to the price and speed) subject to latency, accuracy, and type of data available to support decision-making.
SM-6	**The AMS Testbed shall emulate the duration and outcomes of decision-making by Freight System Managers, subject to the latency, accuracy, reliability and nature of Operational Data Environments available to support this decision-making.**
SM-6-1	The AMS Testbed shall have Freight data and information (e.g. access to facilities for freight vehicles, pricing) that can be used to emulate the outcomes of decision-making by Freight System Managers
SM-6-2	The AMS Testbed shall be able to emulate duration and outcomes of dynamic decision-making of Freight System Managers subject to latency, accuracy, and type of data available to support decision-making.
SM-7	**The AMS Testbed shall emulate the duration and outcomes of decision-making by Public Safety Managers, subject to the latency, accuracy, reliability and nature of Operational Data Environments available to support this decision-making.**
SM-7-1	The AMS Testbed shall be capable of emulating Public Safety Managers decision-making in response to real-time incidents (e.g. the staging of emergency response vehicles and personnel, and the closure of lanes and facilities required as a part of the incident response)
SM-7-2	The AMS Testbed shall be able to emulate duration and outcomes of dynamic decision-making of Public Safety Managers subject to latency, accuracy, and type of data available to support decision-making.

ID	Requirement
SM-8	**The AMS Testbed shall emulate the duration and outcomes of decision-making by Information Service Providers, subject to the latency, accuracy, reliability and nature of Operational Data Environments available to support this decision-making.**
SM-8-1	The AMS Testbed shall emulate the presence of Information Service Providers' who generate and either broadcast or provide information (e.g. congestion related, weather related) to the system users (travelers)
SM-8-2	The AMS Testbed shall emulate the duration and outcomes of decision-making by Information Service Providers, subject to the latency, accuracy, reliability and nature of information available to support this decision-making**.**
SM-9	**The AMS Testbed shall emulate and differentiate the duration and outcomes of integrated versus independent decision-making among System Managers, including Freeway and Tollway System Managers, Signal System Mangers, Road-Weather System Managers, Parking System Managers, Freight System Managers, Public Safety Managers, and Information Service Providers.**
SM-10	**The AMS Testbed shall emulate the forms, scope and limitations of system control exerted by Freeway System and Tollway Managers, including messages passed through Broadcast Media, Traffic Control Systems, the DSRC Roadside Network or Wide-Area Wireless Networks to control or influence System User decision-making.**
SM-11	**The AMS Testbed shall emulate the forms, scope and limitations of system control exerted by Arterial System Managers, including messages passed through Traffic Control Systems, the DSRC Roadside Network or Wide-Area Wireless Networks to control or influence System User decision-making.**
SM-12	**The AMS Testbed shall emulate the forms, scope and limitations of system control exerted by Road-Weather System Managers, including messages passed through Broadcast Media, Traffic Control Systems, the DSRC Roadside Network or Wide-Area Wireless Networks to control or influence System User decision-making.**
SM-13	**The AMS Testbed shall emulate the forms, scope and limitations of system control exerted by Transit System Managers, including messages passed through Broadcast Media, Traffic Control Systems, the DSRC Roadside Network or Wide-Area Wireless Networks to control or influence System User decision-making.**
SM-14	**The AMS Testbed shall emulate the forms, scope and limitations of system control exerted by Parking System Managers, including messages passed through Broadcast Media, Traffic Control Systems, the DSRC Roadside Network or Wide-Area Wireless Networks to control or influence System User decision-making.**
SM-15	**The AMS Testbed shall emulate the forms, scope and limitations of system control exerted by Freight System Managers, including messages passed through Broadcast Media, Traffic Control Systems, the DSRC Roadside Network or Wide-Area Wireless Networks to control or influence System User decision-making.**
SM-16	**The AMS Testbed shall emulate the forms, scope and limitations of system control exerted by Public Safety Managers, including messages passed through Broadcast Media, Traffic Control Systems, the DSRC Roadside Network or Wide-Area Wireless Networks to control or influence System User decision-making.**
SM-17	**The AMS Testbed shall emulate the forms, scope and limitations of system control exerted by Information Service Providers, including messages passed through Broadcast Media, the DSRC Roadside Network or Wide-Area Wireless Networks to influence System User decision-making.**

ID	Requirement
SM-18	**The AMS Testbed shall emulate the utilization of Automated Control by one or more System Managers who delegate specific forms of routine decision-making and control message generation.**

Chapter 6. Data and Information Flow Requirements

Data and Information Flows are represented by directed arcs (arrows) for direct entity-to-entity communications. Each flow represents a message within the system. Individual data and information flows are associated with a specific communications system. Each message represents a collection of data elements from one *System Entity* to one or more other *System Entities.*

Table 6 below shows the Data and Information Flow Requirements to be fulfilled by AMS Testbed.

Table 6. Data and Information Flow Requirements

ID	Requirement
DI-1	**The AMS Testbed shall emulate the transmission and reception of Information and Data Flows between System Entities over a specific communications system, whether broadcast or point-to-point in nature, the interval at which the data flow occurs, and the content of the message contained in the data flow.**
DI-1-1	The AMS Testbed shall support easy interfacing with communication models/methods to emulate the transmission and reception of Information (e.g. location of the device, vehicle data) and Data Flows between System Entities over a specific communications system (cellular, Wide-area wireless system) whether broadcast (BSM) or point-to-point (BMM) in nature, the interval at which the data flow occurs, and the content of the message contained in the data flow.
DI-2	**The AMS Testbed shall emulate the transmission and reception of Basic Safety Messages (BSM) among *Connected Vehicles, Mobile Devices,* and the *DSRC Roadside Network*.**
DI-2-1	The AMS Testbed shall have the capability to track Connected Vehicles, Mobile Devices and the DSRC Roadside Network within the transportation system on a continuous basis and emulate the transmission and reception of BSM at every tenth (0.1) second Basic Safety Message.
DI-2-2	The AMS Testbed shall emulate BSM message transmission and reception using DSRC-capable Mobile Devices, Carry-In Devices and Integrated Devices
DI-3	**The AMS Testbed shall emulate the transmission of Basic Mobility Messages (BMM) from *Connected Vehicles* and *Mobile Devices* to the *System Entity* tasked with managing BMM messaging (either a *Private Sector Data Services* or a *Data QC and Aggregation* process)**
DI-3-1	The AMS Testbed shall emulate the transmission of BMM from Connected Vehicles and Mobile Devices (at 0.1 seconds latency) on a continuous basis and perform data QC and aggregation process
DI-4	**The AMS Testbed shall emulate the transmission of Signal, Phase and Timing (SPaT) Messages from the DSRC Roadside Device Network to DSRC-capable Connected Vehicles.**
DI-4-1	The AMS Testbed shall emulate the transmission of SPaT messages from the DSRC Roadside Device Network to DSRC capable connected vehicles on a continuous basis (in real time)

Chapter 7. Operational Condition and System Performance Measurement Requirements

Operational Conditions describe different realizations of natural variation in travel demand and incident patters, and variation in weather conditions. Each operational condition has a probability of occurrence. **System Performance Measures** characterize the mobility, safety and environmental impacts of a particular system alternative that connect the various elements of the system together in a particular way. These impacts can be quantified and monetized in a consistent and systematic way for comparison with total cost of system to determine cost-effectiveness, and must be assessed over the full range of identified operational conditions.

Table 7 below shows the Operational Condition and System Performance Measurement Requirements

Table 7. Operational Condition/Performance Measurement Requirements

ID	Requirement
OC-1	**The AMS Testbed shall emulate a range of Operational Conditions, including variations in travel demand, weather, and incident patterns.**
OC-1-1	The AMS Testbed shall emulate operational conditions with required data that reflect variations on travel demand (including day-to-day fluctuations)
OC-1-1-1	The AMS Testbed shall emulate operational condition with required data that reflect weather events (e.g. heavy snow or rain)
OC-1-1-2	The AMS Testbed shall emulate operational condition with required data that reflect incidents
OC-2	**The AMS Testbed shall be capable of calculating a consistent set of Performance Measures describing mobility, safety, and environmental impacts, over all Operational Conditions and subject to multiple alternative systems linking System Users and System Managers.**
OC-2-1	The AMS Testbed shall be able to calculate traditional transportation network performance including travel times and travel delays on a continuous (second-by-second) basis
OC-2-2	The AMS Testbed shall be able to calculate network and individual traveler's travel time reliability in the network
OC-2-3	The AMS Testbed shall be able to calculate queue lengths both at freeway and arterial segments on a continuous (second-by-second) basis
OC-2-4	The AMS Testbed shall be capable of calculating a consistent set of safety Performance (e.g. crash rates) at network level
OC-2-5	The AMS Testbed shall be capable of calculating a consistent set of environmental Performance Measures (e.g. Fuel Savings, GHG and other emission estimates) both at network and individual traveler level
OC-3	**The AMS Testbed shall be capable of being calibrated and validated using relevant Performance Measures against real-world conditions, both in terms of the representation of Operational Conditions and Alternative Systems, where such data are available from actual surface transportation systems.**

OC-3-1	The AMS Testbed shall have historical data (archived) that can be used to calibrate and validate the performance measures generated by the AMS Testbed
OC-3-2	The AMS Testbed shall have abundant data Performance Measures data that correspond to different Operational Conditions (typical week day, special event, weather event, and incident) of interest.

Chapter 8. DMA Applications and ATDM Strategies Requirements

ATDM Strategies and DMA Applications enhance decision-making or enable new forms of decision-making by System Users or System Managers. These strategies and application may also provide new forms of system control for System Managers. ATDM Strategies are defined in the ATDM Concept of Operations in three categories: Active Demand Management Strategies, Active Traffic Management Strategies, and Active Parking Management Strategies. Thirty DMA s have been defined in six bundles: Freight Traveler Information Systems (FRATIS), Intelligent Dynamic Transit Operations (IDTO), Enabling Advanced Traveler Information (EnableATIS), Next Generation Integrated Corridor Management (ICM), Response, Emergency Staging and Communications, Uniform Management, and Evacuation(R.E.S.C.U.M.E), Multi-Modal Intelligent Signal Systems (M-ISIG), and Intelligent Network Flow Optimization (INFLO). Complete Concepts of Operation and System Requirements have developed for all of the DMA bundles with the exception of EnableATIS and Next-Generation ICM. ATDM Strategies and DMA Applications have been developed separately in the two programs, and there are some overlaps and differences between the defined set of applications.

Table 8 below shows the DMA Applications and ATDM Strategies Requirements to be fulfilled by AMS Testbed.

Table 8. Application/Strategy Requirements

ID	Requirement
AP-1	**The AMS Testbed shall emulate Dynamic Shoulder Lanes.**
AP-1-1	The AMS Testbed shall emulate the dynamic operation (e.g. open/close, posted speed) of the Shoulder lanes to reflect System Managers real-time decision making based on current and/or predicted network conditions.
AP-1-2	The AMS Testbed shall capture the network performance, lane flows and lane changing behavior on both regular and shoulder lanes on a continuous basis.
AP-2	**The AMS Testbed shall emulate driver behaviors in Dynamic Shoulder Lanes that are distinct from behaviors on regular lanes.**
AP-2-1	The AMS Testbed shall distinctly emulate driver behavior (e.g. acceleration rates, deceleration, gap acceptance) on Dynamic Shoulder Lanes
AP-2-2	The AMS Testbed shall distinctly emulate driver behavior on regular lanes (e.g. acceleration rates, deceleration, gap acceptance)
AP-3	**The AMS Testbed shall emulate restriction of access to Dynamic Shoulder Lanes by vehicle type (e.g., transit) and vehicle occupancy (e.g., HOV 2+, HOV 3+).**
AP-3-1	The AMS Testbed shall track vehicle types (e.g. transit) and vehicle occupancy (e.g., HOV 2+, HOV 3+) in real-time and emulate restriction of access to Dynamic Shoulder Lanes by vehicle type and/or occupancy in response to real-time change in operations imposed by System Manager.
AP-4	**The AMS Testbed shall emulate Dynamic Lane Use Control, including shoulder lanes.**

ID	Requirement
AP-4-1	The AMS testbed shall emulate Lane Use operations on regular and shoulder lanes that are controlled by System Manager in response to current and/or predicted network conditions.
AP-5	**The AMS Testbed shall emulate Dynamic HOV/Managed Lanes.**
AP-5-1	The AMS Testbed shall emulate the dynamic operation of HOV/Managed lanes (e.g. occupancy rules, tools, operation hours) to reflect System Managers real-time decision making based on current and/or predicted network and demand conditions.
AP-5-2	The AMS Testbed shall capture the network performance and lane flows on HOV/Managed Lanes and generate data needed for real-time monitoring.
AP-6	**The AMS Testbed shall emulate detection of position, start time, duration, and length of queues on freeways and arterials in support of a Queue Warning DMA or Queue Warning strategy supporting System Manager decision-making.**
AP-6-1	In support of Queue Warning DMA, the AMS Testbed shall emulate detection of position, start time, duration, and length of queues on freeways based on data generated from connected vehicles on freeways and arterials along other data sources and transmit the information to support System Manager Decision making on implementation of Queue Warning application
AP-6-2	The AMS Testbed shall support easy integration/implementation of Queue Warning DMA
AP-6-3	In support of ATDM Queue Warning strategy, the AMS Testbed shall emulate detection of position, start time, duration, and length of queues on freeways based on data generated on freeways and arterials facilities and transmit the information to support System Manager Decision making on implementation of Queue Warning strategy in real-time based on current and anticipated network conditions
AP-6-4	The AMS Testbed shall support easy integration/implementation traffic responsive and adaptive Ramp Meter algorithms that emulate the implementation of ATDM Queue Warning Strategy in response to current and anticipated network performance
AP-7	**The AMS Testbed shall emulate altered driving behavior in response to Queue Warning messages generated by the Q-WARN DMA and delivered to Carry In or Integrated Devices within Connected Vehicles or through local signage within the Traffic Control System.**
AP-7-1	The AMS Testbed shall emulate altered driving behavior (e.g. speed of travel, acceleration, deceleration, braking) in response to Queue warning messages generated by the Q-WARN application on a continuous basis and delivered to Carry-In of Integrated Devices within Connected Vehicles along with the regional network impacts associated with the change in driving behavior
AP-7-2	The AMS Testbed shall distinctly emulate altered driving behavior in response warning messages generated by the Q-WARN application on a continuous basis and delivered through local signage and the regional network impacts associated with the change in driving behavior
AP-8	**The AMS Testbed shall emulate the estimation of dynamic target speed recommendations by roadway section and lane made by the SPD-HARM application or the Dynamic Speed Limits strategy deployed in support of System Managers.**
AP-8-1	The AMS Testbed shall emulate the estimation of dynamic target speed recommendations by roadway section and by lane made by the SPD-HARM application using real-time traffic and anticipated traffic conditions
AP-8-2	The AMS Testbed shall emulate the estimation of dynamic target speed recommendations by roadway section and by lane suggested by the Dynamic Speed Limits strategy using real-time traffic and predicted traffic conditions

ID	Requirement
AP-9	**The AMS Testbed shall emulate transmission of SPD-HARM enhanced target speed recommendations via message signs; or directly to Carry-In or Integrated Devices running the SPD-HARM application within a Connected Vehicle.**
AP-9-1	The AMS Testbed shall emulate the estimation of SPD-HARM enhanced target speed recommendations using real-time traffic and predicted traffic conditions generated using connected vehicle data
AP-9-2	The AMS Testbed shall emulate the transmission of SPD-HARM enhanced target speed recommendations directly to Carry-In Devices running the SPD-HARM application within a Connected Vehicle and capture the driving behaviors changes (e.g. speed reductions, deceleration, acceleration)
AP-10	**The AMS Testbed shall emulate driver decision-making in response to target speed recommendations made by the SPD-HARM application running on a Carry-In or Integrated Device within a Connected Vehicle.**
AP-10-1	The AMS Testbed shall emulate driver decision-making (e.g. speed reductions, deceleration, and acceleration) in response to target speed recommendations made by the SPD-HARM application running on a Carry-In Device or Integrated Device within a Connected Vehicle.
AP-11	**The AMS Testbed shall emulate altered driving behavior in response to combined queue warning and target speed recommendations made by a combined Q-WARN/SPD-HARM application.**
AP-12	**The AMS Testbed shall emulate the creation, movement, and dispersion of a platoon of Connected Vehicles utilizing Coordinated Adaptive Cruise Control (CACC) application, traveling at the same speed and maintaining the same gap with their respective leaders in the platoon.**
AP-12-1	The AMS Testbed shall emulate Vehicle-to-Vehicle communication between connected vehicles and capture the impact of e creation, movement, and dispersion of a platoon of Connected Vehicles utilizing Coordinated Adaptive Cruise Control (CACC) application, traveling at the same speed and maintaining the same gap with their respective leaders in the platoon.
AP-13	**The AMS Testbed shall emulate the identification and implementation of altered signal control settings enhanced by the M-ISIG DMA bundle or the ATDM Adaptive Traffic Signal Control and Adaptive Ramp Metering strategies.**
AP-13-1	The AMS Testbed shall emulate the identification and implementation of altered signal control settings enhanced by the M-ISIG DMA bundle using connected vehicle data
AP-13-2	The AMS Testbed shall emulate the identification and implementation of altered signal control settings enhanced by the ATDM Adaptive Traffic Signal Control using current and anticipated traffic conditions.
AP-13-3	The AMS Testbed shall emulate the identification and implementation of altered signal control settings enhanced by Adaptive Ramp Metering strategies using current and anticipated traffic conditions.
AP-14	**The AMS Testbed shall emulate the identification and implementation of signal control settings optimized to allow for the rapid and safe movement of Public Safety Vehicles (PREEMPT), Trucks (FSIG), Transit Vehicles (TSP), and Pedestrians (PED-SIG).**
AP-14-1	The AMS Testbed shall emulate the identification and implementation of signal control settings optimized to allow for the rapid and safe movement of Public Safety Vehicles (PREEMPT)
AP-14-2	The AMS Testbed shall emulate the identification and implementation of signal control settings optimized to allow for the rapid and safe movement of Trucks (FSIG)
AP-14-3	The AMS Testbed shall emulate the identification and implementation of signal control settings optimized to allow for the rapid and safe movement of Transit Vehicles (TSP)

ID	Requirement
AP-14-4	The AMS Testbed shall emulate the identification and implementation of signal control settings optimized to allow for the rapid and safe movement of Pedestrians (PED-SIG)
AP-15	**The AMS Testbed shall emulate the dynamic creation of high-occupancy vehicles through the DRIDE application running on Mobile Devices or through other Dynamic Ridesharing services supporting informal ridesharing.**
AP-16	**The AMS Testbed shall emulate multi-modal forms of Traveler information services that include cost, reliability and parking delivered pre-trip through Broadcast Media or pre-trip and en route through Mobile Devices, Carry-in Devices, and Integrated Devices.**
AP-16-1	The AMS Testbed shall emulate multi-modal Traveler information services pertaining to travel cost and capture the demand changes when delivered pre-trip through Broadcast Media or pre-trip
AP-16-2	The AMS Testbed shall emulate multi-modal Traveler information services pertaining to travel cost and capture the demand changes when delivered en route through Mobile Devices, Carry-in Devices, and Integrated Devices.
AP-16-3	The AMS Testbed shall emulate multi-modal Traveler information services pertaining to travel time reliability and capture the demand changes when delivered pre-trip through Broadcast Media or pre-trip
AP-16-4	The AMS Testbed shall emulate multi-modal Traveler information services pertaining to travel time reliability and capture the demand changes when delivered en route through Mobile Devices, Carry-in Devices, and Integrated Devices.
AP-16-5	The AMS Testbed shall emulate multi-modal Traveler information services pertaining to parking and capture the demand changes when delivered pre-trip through Broadcast Media or pre-trip
AP-16-6	The AMS Testbed shall emulate multi-modal Traveler information services pertaining to parking and capture the demand changes when delivered en route through Mobile Devices, Carry-in Devices, and Integrated Devices.
AP-17	**The AMS Testbed shall emulate Active Parking Management Strategies employed to support decision-making by Parking System Managers, including Dynamic Wayfinding, Dynamic Overflow Transit Parking, Dynamic Parking Reservation, and Dynamic Priced Parking**
AP-17-1	The AMS Testbed shall emulate demand/ network impacts (both current and anticipated) in real-time of Dynamic Wayfinding Strategy employed to provide real-time parking availability and routing information to the parking space.
AP-17-2	The AMS Testbed shall emulate demand/ network impacts (both current and anticipated) of Dynamic Overflow Transit Parking strategy employed to monitor parking demand near Transit facilities in real-time and make determinations if overflow parking is needed.
AP-17-3	The AMS Testbed shall emulate demand/ network impacts (both current and anticipated) of Dynamic Parking Reservation strategy employed to make real-time parking reservations.
AP-17-4	The AMS Testbed shall emulate demand/ network impacts (both current and anticipated) of Dynamic Priced Parking strategy employed as a means to influence travel and parking choices and dynamically manage the traffic demand.
AP-18	**The AMS Testbed shall emulate Dynamic HOV Lane Conversion, including dynamic alterations to access policy (e.g., HOV-2 to HOV-3) and price.**
AP-18-1	The AMS Testbed shall emulate demand/ network impacts resulting from decision making of System Managers (based on current and anticipated traffic and demand conditions) on Dynamic HOV Lane Conversion, including dynamic alterations to access policy (e.g., HOV-2 to HOV-3) and price.
AP-19	**The AMS Testbed shall emulate Intelligent Dynamic Transit Operations (IDTO), including transit connection protection and dynamic dispatch.**

ID	Requirement
AP-19-1	The AMS Testbed shall emulate transition connection protection application and capture the demand and associated network impacts
AP-19-2	The AMS Testbed shall emulate dynamic transit dispatch application and capture the demand and associated network impacts
AP-20	**The AMS Testbed shall emulate Incident Management practices, including the management of local incident zones, the staging of emergency response vehicles and personnel, and the closure of lanes and facilities required as a part of the incident response.**
AP-21	**The AMS Testbed shall emulate Dynamic Pricing and Dynamic Fare Reduction strategies, including dynamic changes to roadway tolls or transit fares.**
AP-21-1	The AMS Testbed shall continuously emulate behavior changes (e.g. route choice, mode choice changes) and network impacts associated with real-time changes to roadway tolls.
AP-21-2	The AMS Testbed shall continuously emulate behavior changes (e.g. increase in mode share) and network impacts associated with real-time changes to transit fares.
AP-22	**The AMS Testbed shall emulate the concurrent deployment of two or more DMAs or ATDM strategies, including synergies or conflicts arising from this interaction.**
AP-23	**The AMS Testbed shall emulate Dynamic Junction Control**
AP-23-1	The AMS Testbed shall continuously emulate Systems Managers real-time decision making to continuously monitor lane volumes and allocate lane access on mainline and ramp lanes in interchange.
AP-24	**The AMS Testbed shall emulate Dynamic Merge Control**
AP-24-1	The AMS Testbed shall capture the impact of System Manager continuously monitoring the traffic conditions on the mainline lanes and ramps approaching merge areas are continuously monitored and activate Dynamic Merge Control based on real-time and anticipated congestion conditions.
AP-25	**The AMS Testbed shall emulate Dynamic Lane Reversal or Contraflow lanes, including dynamically adjusting the lane directionality in response to real-time traffic conditions.**
AP-25-1	The AMS Testbed shall capture the impact of System Manager continuously monitoring the traffic conditions and activate Dynamic Lane Reversal or Contraflow lanes based on real-time and anticipated congestion conditions.
AP-26	**The AMS Testbed shall emulate freight operations, including drayage optimization and freight Traveler information**

References

1. AMS Testbed Requirements for DMA and ATDM Programs, Final Report, Version 4, USDOT, April 5, 2013
2. AMS Framework for DMA and ATDM Programs, Draft Report, Version 1.4, USDOT, May 2, 2013
3. ATDM Foundational Research – Analysis Plan, Final Report, USDOT, June 27, 2013
4. AMS Preliminary Evaluation Plan for DMA Applications, Draft Report, Version 1.1, USDOT, October, 2, 2013

APPENDIX A. Glossary

TERM	Definition
ACTIVE INCIDENT ZONE	Incident scenes, traffic stops, and work zones are areas where vehicle incident responders, crash victims, travelers and other emergency personnel may be present, actively trying to resolve traffic related incidents.
ACTUAL START TIME	Actual start time of a trip is the logged time at which a trip begins from an origin.
ADVISORIES	Advisories are messages issued by traffic management agencies to inform travelers of events, incidents or weather that might potentially affect travel. Advisories are not enforced by law.
ADVISORY INFORMATION	Advisory information provides travelers with details of events, incidents or weather that might potentially affect travel.
ARRIVAL TIME AT DESTINATION	Arrival time is the logged time at which a trip ends at a destination.
AUTOMATED CONTROL	Automated control is the regulation of a process without direct human intervention.
AVAILABILITY	Availability is the probability that a system or part of a system may be operational during any randomly selected instant of time
CARRY-IN DEVICES	Carry-In Devices are specially-designed mobile devices that can be carried into a vehicle and may be safely utilized by the driver of a vehicle while en route (e.g., aftermarket navigation systems).Carry-in devices may host one or more Applications, and may be capable of communicating using either DSRC or cellular communications systems (or both). Carry-In Devices are not intended to support System User decision making outside of a vehicle, but may be transferred between vehicles as a part of a trip or tour. These devices may or may not communicate or otherwise obtain or infer vehicle status data from a host vehicle. These devices are assumed to be powered whenever they are placed within the vehicle.
CELLULAR-COMMUNICATIONS MECHANISMS	Cellular communications mechanisms are wide area communications technologies that can carry either voice or data.
DATA FLOWS	Data flows are the intermediate processes in a network that communicate by sending data over specified channels connecting the network
DEPARTURE TIME	Departure time is the time at which a trip is designated to begin from an origin.
DESTINATION	Destination is the location at which a trip ends
DSRC	Dedicated short-range communications were one-way or two-way short- to medium-range wireless communication channels specifically designed for automotive use and a corresponding set of protocols and standards
DURATION OF DECISION MAKING	Duration of decision making is the time elapsed between the reception of information and the action carried out in response to the information.
EMERGENCY RESPONSE PERSONNEL	“emergency response personnel” means personnel responsible for mitigation activities in a medical emergency, fire emergency, hazardous material emergency, or natural disaster
EMULATE	Emulation of traffic/transportation entities is to represent their behavior using a model with as much detail as deemed reasonable.
INCIDENT ZONES	Incident scenes, traffic stops, and work zones are areas where a traffic related incident has taken place. These zones are restricted to traffic in order to resolve the incident.

TERM	Definition
INTEGRATED DEVICES	Integrated Devices are permanently located within a specific vehicle and may be safely utilized by the driver of a vehicle while en route. Integrated devices may host one or more Applications, and may be capable of communicating using either DSRC or cellular communications systems (or both). These devices can obtain or infer a specific set of vehicle status data from a host vehicle.
LIGHT VEHICLE DRIVER	Light vehicle driver is a driver of a vehicle of maximum Gross Vehicle Weight Rating (GVWR) < 8,500 lbs.
LIGHT VEHICLE PASSENGER	Light vehicle passenger is a person in a vehicle of maximum Gross Vehicle Weight Rating (GVWR) < 8,500 lbs., who is not driving the vehicle.
MAINTAINABILITY	Maintainability is measured by an item's ability to be retained in a specified condition through scheduled maintenance, or restored to a specified condition through proper repair.
MESSAGE RELIABILITY	Message reliability is establishing communication of messages that are guaranteed to reach their destination complete and uncorrupted and in the order they were sent.
MESSAGE SIGNS	Message signs are static or dynamic displaying messages that provide regulatory or advisory information to travelers.
NON-MOTORIZED TRAVELER	Non-motorized traveler is a state where one walks or uses a bicycle or other non-motorized mode to complete a leg of a trip.
OBE	On-board Equipment is a carry-in device or an integrated device that enables a vehicle to establish V2V or V2I communications.
ON A CONTINUOUS BASIS	Term "on a continuous basis" is generally used to indicate second-by-second basis for tactical decision making
OPERATIONAL DATA ENVIRONMENTS	Operational Data Environments aggregate and enhance data passed from detection and communication systems to support System Manager decision-making. Operational Data Environments comprise a mix of data with different sources, reliability and latency. For example, a Signal System Manager may have data on intersection turning movements collected manually once a year plus data on approach flows to the same intersections aggregated over 15 minute intervals and a smaller collection of point-to-point travel time estimates updated every 10 minutes when available from processed automated vehicle location data. An Operational Data Environment does not contain every form of data desired or useful to System Managers, and by definition is the sum of all the data available to System Managers together with all of its inherent attributes, limitations, and potential flaws.
ORIGIN	Origin is the location of a traveler at the beginning of a trip.
PARAMETRIC PREDICTIVE ANALYSIS	Predictive analytics encompasses a variety of techniques from statistics, modeling, machine learning, and data mining that analyze current and historical facts to make predictions about future or unknown, events.
PEDESTRIAN	Pedestrian is a traveler state where the traveler walks to complete a leg of a trip.
REGULATORY INFORMATION	Regulatory information is that which is enforced by law. System users are to abide by the information.
RELIABILITY	Reliability is the ability of a system to perform as designed in an operational environment over time without failure.
ROADSIDE NETWORK	Roadside network or DSRC Roadside Device Network may receive or transmit messages broadcast over the designated DSRC communications frequency (5.9 GHz). Mobile Devices and Connected Vehicles may broadcast messages via DSRC that can be received by the DSRC Roadside Network when the devices and vehicles are within communication range. The DSRC Roadside Network

TERM	Definition
	may receive and transmit messages from System Managers or the Traffic Control System to broadcast to devices and vehicles within range.
ROUTE	A path chosen by a traveler to travel from an Origin to Destination.
RSE	Roadside Equipment is the equipment on the transportation network that is installed to receive or transmit messages broadcast over the designated DSRC communications frequency (5.9 GHz). Mobile Devices and Connected Vehicles may broadcast messages via DSRC that can be received by the DSRC Roadside Network when the devices and vehicles are within communication range. The DSRC Roadside Network may receive and transmit messages from System Managers or the Traffic Control System to broadcast to devices and vehicles within range.
RESPONSE STAGING	Response staging is to resolve an incident at a location that is safe for responders, their vehicles and equipment, and victims along with other personnel. The staging area should cause minimum disruption to the traffic.
STATE	State refers to the travelers distinct states of existence namely Pre-trip (i.e. the traveler is at home or other activity location and is yet to enter the transportation network) and en-route (i.e. the traveler is on the transportation network using a particular mode of travel)
SYSTEM ENTITIES	System Entities comprise of System Users, Connected Vehicles/Devices, Communications Systems, Operational Data Environments, and System Managers.
SYSTEM MANAGERS	System Managers control a particular aspect of the system and are responsible for ensuring the safe and efficient operation of their element of the transportation system. Note that while System Managers are humans, some aspects of system management may be automated and do not require human intervention or decision-making on a regular basis. A System Manager, without any technological assistance, has a limited view of system performance or the actions of the System Users. System Managers are dependent on the nature, accuracy and reliability of Operational Data Environments created to provide insight into the state of the system and the effectiveness of potential changes to controls at their direction. Likewise, the nature of controls possible in a surface transportation system are also limited to a set of authorized alterations in traffic control systems, information provided through broadcast media, and the adjustment of policies related to the price and nature of access to elements of the transportation system. Their actions are constrained by the in the forms, scope and limitations of their control systems. Note that some elements of this control are intended to influence short-term behavior of System Users currently on the transportation system, depending on the nature of current conditions, such as the modification of target speeds on selected roadway sections. Other elements of control are intended to influence longer-term behavior of System Users, including High-Occupancy Vehicle (HOV) facility access or the cost of utilizing the facility (in the case of tolled facility).
TIME DELIMITED TOUR PLANNING	Time delimited tour planning is the traveler's itinerary of travel to carry out a set of activities that occur at fixed times. The tour planning involves planning to use certain modes of transport at specific times to carry out a set of activities that occur at fixed times.
TRAFFIC DETECTION SYSTEMS	Traffic Detection Systems include loop detectors, Bluetooth readers and other roadside devices that have their own power source and are capable of passively detecting and classifying attributes of vehicle or pedestrian movement within a specific range of the location of the device. The detection system includes supporting roadside/wayside communications systems that aggregate, prepare,

TERM	Definition
	or otherwise process local data prior to transmission to Operational Data Environments supporting System Managers.
TRANSIT RIDER	A traveler using a transit mode that transports many people or goods at a time.
TRAVEL DATA	Travel data represents a collection of data elements transmitted from one System Entity to one or more other System Entities (System Users, Connected Vehicles/Devices, Communications Systems, Operational Data Environments, and System Managers).
TRAVEL TIME	Travel time is the time taken by a traveler to complete a leg of a trip. The sum of travel times of all legs of the trip is the total trip travel time.
TRAVELER	A Traveler may transition between one or more mutually exclusive states while planning and executing travel, starting from a Pre-Trip Traveler state and passing through one or more combinations of Pedestrian, Non-Motorized Traveler, Light Vehicle Passenger, Light Vehicle Driver, or Transit Rider states prior to completing a trip.
TRAVELER INFORMATION	Information received by a traveler on a network by message signs, wireless or cellular devices, and other broadcast media that is intended to inform them of events, incidents or agency decisions that may affect their travel.
TRIP CHAIN	Trip chain is a set of consecutive trips that may occur in sequence to carry out a set of activities.
TRIP START TIME	The time at which a traveler leaves an origin.

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