

VEHICLE INFRASTRUCTURE INTEGRATION (VII)

RAMP METERING POC APPLICATION REQUIREMENTS



Research and Innovative Technology Administration

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1 Introduction

Freeway operators use ramp metering systems to moderate the flow of traffic onto freeways. This can help the keep traffic flowing on the mainline while still providing access to the freeway. Dynamic modification of ramp metering rates is difficult, as it requires knowledge of freeway performance, queue length on the ramp, and arterial performance. With VII, the potential exists to gather a more robust and richer data set describing the freeway, ramp and arterial conditions, leading to more frequent evaluation of ramp metering rates.

The Ramp Metering application is geared toward proving the viability of using VII to support enhanced ramp metering applications in the future. The POC efforts concentrate on determining what traffic measures with potential applicability to ramp metering can reliably be determined from VII probe data.

The POC Ramp Metering application does not attempt to perform adaptive ramp control or integrated control across multiple ramps, but rather assess the ability of VII to obtain the ramp performance metrics necessary to implement these features in the future.

2 Requirements Guide

2.1 Precedence and Criticality of Requirements

The following terms are used to qualify the requirements (shall), expectations (should) and assumptions (will) contained in this document and are based on RFC 2119.

WORD	MEANING
SHALL	This word means that the definition is an absolute requirement of the application.
SHOULD	This word means that valid reasons may exist for not meeting the specific expectation, but the full implications of this must be understood carefully.
WILL	This word indicates functionality that the operational environment surrounding the application is to provide.

2.2 Requirements Identification

All articles in this document will be categorized as follows:

- Assumption – assumption about the operation of entities external to the application.
- Constraint – constraint specifies behaviors or characteristics levied on the application by external entities.
- Functional Requirements – functional requirements specify actionable behaviors of the application.
- Performance Requirements – performance requirements specify quantifiable characteristics of application operations.
- Security Requirements – security requirements specify mechanisms to prevent the application from compromising connected resources.
- Performance Expectations – end-to-end performance expected for each application.
- External Interface Requirements – external interface requirements define application interfaces with VII and non-VII Systems.

All articles in this document are identified by a tag of the form: **ST-Category-Number**. The definitions for the tags are listed below:

“S” stands for **Scope**, single character in the 1st position with the following value list

“A”	for Application
”V”	for VII System
“X”	for External Entity

“**T**” stands for **Type**, a single character in the 2nd position with the following value list

“A”	for “Assumptions”
“C”	for “Constraint”
“F”	for “Functional Requirement”
“S”	for “Security Requirement”
“P”	for “Performance Requirement”
“X”	for “External” Application Interface
“N”	for “End-to-End Performance Expectation”

Category is a variable length text string, usually a defined VII acronym, which will identify a group of requirements.

“TI”	for Traveler Information
“WI”	for Weather Information
“CMLB”	for Corridor Management Load Balancing
“CMPA”	for Corridor Management Planning Assistance
“STO”	for Signal Timing Optimization
“RM”	for Ramp Metering
“PD”	for Pothole Detection

Number is a two digit numerical value which identifies the specific requirement. Child requirements are numbered using a hierarchical decimal system of numerical values.

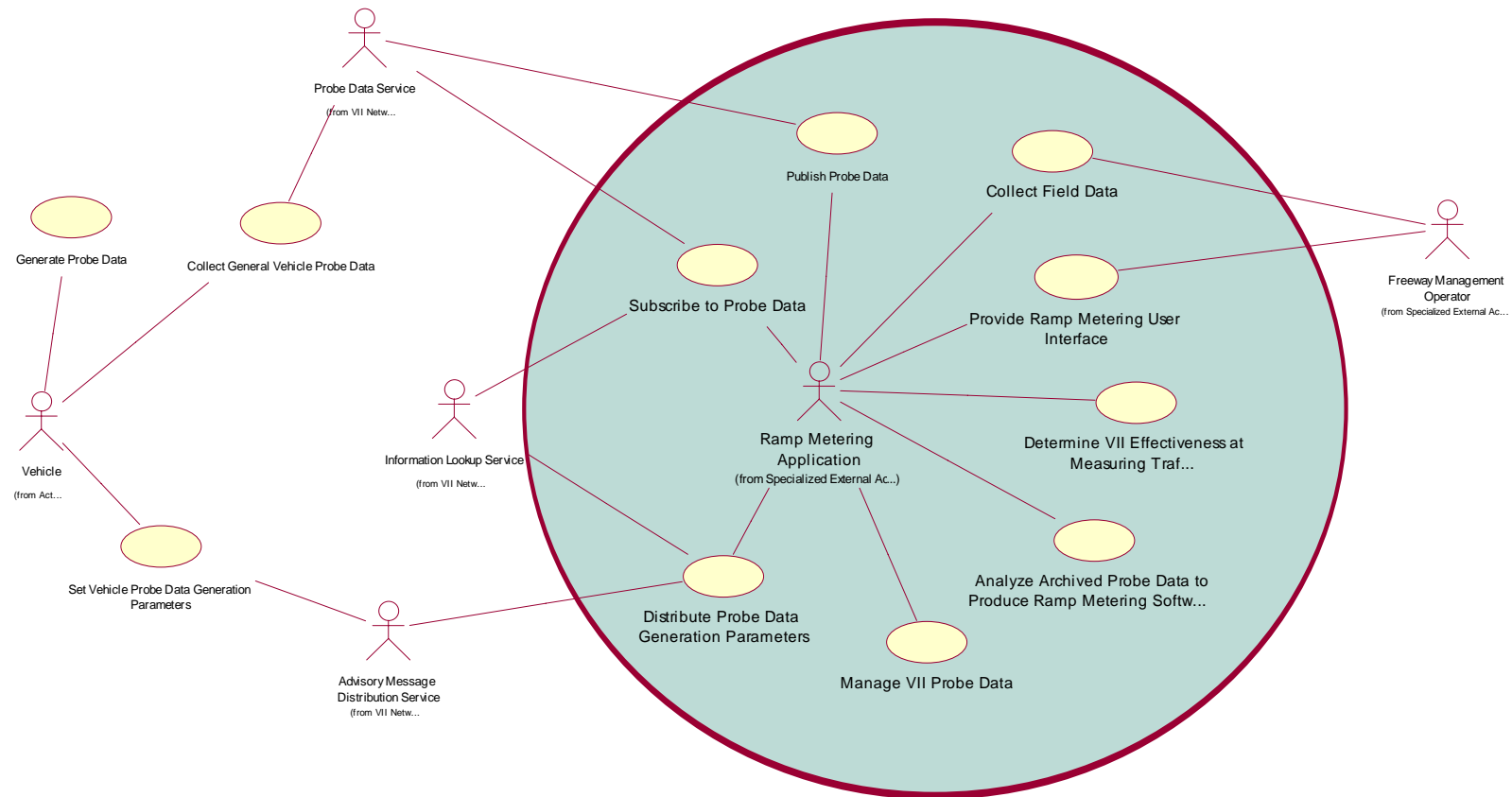
2.3 Requirements Relationship

The requirements have been developed as “parent-child” requirements and should be tested as such. In other words, verification of all “child” requirements automatically implies verification of their “parent” requirement.

3 Application Boundary Definition

The following POC use case diagram identifies the actors and basic functions involved in implementing the Ramp Metering Application. This diagram was taken from the VII POC Applications Concept of Operations document version 1.4¹. The shaded portion of the diagram represents the boundary of the Ramp Metering Application for POC.

Figure 3.1 – POC Ramp Metering Application Use Case Diagram



¹ This is the most recent version of the Ramp Metering POC Use Case diagram. Version 1.4 of the VII Applications Concept of Operations will eventually be updated with this edition of the diagram. The changes included in this diagram are critical to the writing of the functional requirements for the Ramp Metering application, as they better identify the role of the Freeway Management Operator than the officially published version.

The following table maps the actors in the use case to the VII System Architecture, as defined within the VII National System Requirements v1.2.1.

Table 3.2 - POC Ramp Metering Application Actors

Actor	System Boundary
Vehicle	Vehicle
Probe Data Service	VII System
Information Lookup Service	VII System
Advisory Message Distribution Service	VII System
Ramp Metering Application	Network User
Freeway Management Operator	Network User External Entity

As shown in the above table, the Ramp Metering Application “lives” on the Network User side, outside of the VII System. However, in order for the application to function as intended, it requires all the other actors identified in the use case to perform appropriate actions.

The requirements in the following sections are developed around the basic functions identified within the shaded portion of the use case diagram. The actors in the use case diagram are used as “nouns” to describe the requirements. These requirements are levied on the POC implementation only, and may or may not apply to the Day-1 Ramp Metering Application.

4 Assumptions and Constraints

4.1 Assumptions

Identifier	VII System Assumptions
VA-RM-01	The Vehicle will generate probe data snapshots in accordance with SAE J2735 version 15 and the POC Additions and Exceptions to J2735 (APP190-02).
VA-RM-01.1	All probe data snapshots generated by the Vehicle will include latitude and longitude of the vehicle location.
VA-RM-01.2	All probe data snapshots generated by the Vehicle will include elevation of the vehicle location.
VA-RM-01.3	All probe data snapshots generated by the Vehicle will include time (hour, minute and seconds) that the snapshot was generated.
VA-RM-01.4	All probe data snapshots generated by the Vehicle will include date (month, day, year) that the snapshot was generated.
VA-RM-01.5	All probe data snapshots generated by the Vehicle will include vehicle heading.
VA-RM-01.6	All probe data snapshots generated by the Vehicle will include vehicle brake application status.
VA-RM-01.7	All probe data snapshots generated by the Vehicle will include vehicle speed.
VA-RM-01.8	All probe data snapshots generated by the Vehicle will include vehicle wiper status.
VA-RM-01.9	All probe data snapshots generated by the Vehicle will include the probe segment number.
VA-RM-01.10	The Vehicle's probe snapshot generation parameters will be configurable within the vehicle.
VA-RM-02	The Vehicle will buffer probe data snapshots in accordance with SAE J2735 version 15 and the POC Additions and Exceptions to J2735 (APP190-02).
VA-RM-02.1	The Vehicle's probe snapshot buffering parameters will be configurable within the vehicle.
VA-RM-03	The Vehicle will provide probe data snapshots to the Probe Data Service, when available, as part of Probe Data Messages in accordance with the process outlined in SAE J2735 version 15 and the POC Additions and Exceptions to J2735 (APP190-02).
VA-RM-04	The Vehicle will log information related to probe data generation and Probe Data Service interactions.
VA-RM-04.1	The Vehicle will log all probe data snapshots generated within the previous 24-hour period.
VA-RM-04.1.1	For each snapshot logged by the Vehicle, the snapshot type (periodic, start, stop, or event including the event trigger) will be recorded.
VA-RM-04.1.2	For each snapshot logged by the Vehicle, the time and type of buffer state changes will be recorded.

Identifier	VII System Assumptions
VA-RM-04.1.3	For each snapshot logged by the Vehicle, the probe data management scheme at time of each snapshot generation will be recorded.
VA-RM-04.1.4	Each snapshot logged by the Vehicle will be uniquely identifiable.
VA-RM-04.2	The Vehicle will log all of the locations and times at which the probe segment number changes.
VA-RM-04.3	The Vehicle will log the location and times at which the snapshot buffer overflows.
VA-RM-04.4	The Vehicle will log the times at which the vehicle location information is not available.
VA-RM-04.5	The Vehicle will log the location and times at which the vehicle operational data used for probe data generation is not available.
VA-RM-04.6	The Vehicle will log probe messages provided to the Probe Data Service within the previous 24-hour period.
VA-RM-04.6.1	For each message logged, the Vehicle will record information necessary to identify the specific probe snapshots included in each message.
VA-RM-04.6.2	For each message logged, the Vehicle will record the location and time of transmission of the message to the Probe Data Service.
VA-RM-04.6.3	For each message logged, the Vehicle will record information necessary to identify which infrastructure component (i.e. which RSE) of the Probe Data Service the message was transmitted to.
VA-RM-04.6.4	For each message logged, the Vehicle will record the probe data management scheme at the time the message was transmitted to the Probe Data Service.
VA-RM-05	The Probe Data Service will accept a subscription from the Ramp Metering Application as specified in Network User to Service Delivery Node (SDN) Subsystem Software Interface Requirements Specification - Version 1.1 (or latest), using the X-031 interface.
VA-RM-06	The Probe Data Service will attempt to deliver all Probe Data Snapshots received from Vehicles to the Ramp Metering Application, if the snapshot parameters meet the Ramp Metering Application's probe data subscription profile.
VA-RM-07	The Advisory Message Distribution Service will accept advisory message delivery requests from the Ramp Metering Application as specified in Network User to Service Delivery Node (SDN) Subsystem Software Interface Requirements Specification - Version 1.1 (or latest), using the X-032 interface.
VA-RM-08	The Advisory Message Distribution Service will forward the Ramp Metering Application-provided advisory messages to vehicles, as specified in SDN to RSE Subsystem Software Interface Requirements Specification - Version 1.1 (or latest) and RSE to OBE Subsystem Software Interface Requirements Specification.
VA-RM-09	The Vehicle shall set its probe snapshot generation parameters to the values specified in a Probe Generation Message as defined in POC Additions and Exceptions to J2735 (APP190-02) upon receipt of a Probe Generation Message.
VA-RM-10	The Vehicle shall reset its probe snapshot generation rate to its

Identifier	VII System Assumptions
	original value according to the mechanism described in POC Additions and Exceptions to J2735 (APP190-02).
VA-RM-11	The Information Lookup Service will respond to a request from the Ramp Metering Application with the information necessary for the Ramp Metering Application to subscribe to probe data within a specified geographic boundary.
VA-RM-12	The Information Lookup Service will respond to a request from the Ramp Metering Application with the information necessary for the Ramp Metering Application to deliver an advisory message within a specified geographic boundary.
VA-RM-13	The Information Lookup Service will respond to a request from the Ramp Metering Application with the information necessary for the Ramp Metering Application to submit advisory messages within a specified geographic boundary.

Identifier	Non-VII External Entity Assumptions
XA-RM-01	Noblis, as part of USDOT's "VII Data Characteristics for Traffic Management" study, will provide algorithms for calculating travel times using probe data.
XA-RM-02	Noblis, as part of USDOT's "VII Data Characteristics for Traffic Management" study, will provide algorithms for calculating freeway average speed using probe data.
XA-RM-03	Noblis, as part of USDOT's "VII Data Characteristics for Traffic Management" study, will provide algorithms for calculating ramp queue length using probe data.
XA-RM-04	Noblis, as part of USDOT's "VII Data Characteristics for Traffic Management" study, will provide algorithms for detecting queue overflow events using probe data.
XA-RM-05	Noblis, as part of USDOT's "VII Data Characteristics for Traffic Management" study, will provide algorithms for calculating time in queue using probe data.
XA-RM-06	Noblis, as part of USDOT's "VII Data Characteristics for Traffic Management" study, will provide algorithms for calculating delay using probe data.

Identifier	Non-VII External Entity Assumptions
XA-RM-07	The Freeway Management Operator will collect field data on a per-ramp basis.
XA-RM-07.1	The Freeway Management Operator will determine and record link travel times on adjoining freeway segments at 5 minute intervals.
XA-RM-07.2	The Freeway Management Operator will determine and record speeds on adjoining freeway segments at 5 minute intervals.
XA-RM-07.3	The Freeway Management Operator will determine and record ramp queue length at 5 minute intervals.
XA-RM-07.4	The Freeway Management Operator will identify and record ramp queue overflow events.
XA-RM-07.5	The Freeway Management Operator will determine and average stop locations on the ramp at 5 minute intervals.
XA-RM-07.6	The Freeway Management Operator will determine and record average stop delay on the mainline at 5 minute intervals.
XA-RM-07.7	The Freeway Management Operator will determine and record average stop delay on the ramp at 5 minute intervals.
XA-RM-07.8	The Freeway Management Operator will determine and record average time in queue on the ramp at 5 minute intervals.
XA-RM-07.9	The Freeway Management Operator will determine and record vehicle trajectories through the ramp merge area.
XA-RM-07.10	The Freeway Management Operator will determine and record ramp metering rates in effect during data collection activities.
XA-RM-07.11	The Freeway Management Operator will determine and record the labor and total cost of data collection activities.
XA-RM-08	The Freeway Management Operator will compare the costs of obtaining the measures needed to generate a ramp metering plan from field data versus the costs needed to compute using VII probe data.
XA-RM-09	The Freeway Management Operator will compare the costs of obtaining the measures of ramp performance from field data versus the costs needed to compute using VII probe data.

4.2 Constraints

Identifier	Constraints
AC-RM-01	The geographic extent of the Ramp Metering Application is limited to a single ramp and the adjoining freeway and arterial upstream and downstream links in the Detroit POC Development and Test Environment.

5 Functional Requirements

5.1 Subscribe to Probe Data

Identifier	Functional Requirements
AF-RM-01	The Ramp Metering Application shall subscribe to probe data from the Probe Data Service.
AF-RM-01.1	The Ramp Metering Application shall have the ability to obtain information about the availability of Probe Data Service. .
AF-RM-01.1.1	The Ramp Metering Application shall send a Probe Data Service availability lookup request to the Information Lookup Service, when directed by the Freeway Management Operator.
AF-RM-01.1.2	The Ramp Metering Application shall receive information from the Information Lookup Service about the availability of the Probe Data Service.
AF-RM-01.2	The Ramp Metering Application shall include a probe data subscription profile.
AF-RM-01.2.1	The Ramp Metering Application's probe data subscription profile shall include a geographic boundary defined by the Freeway Management Operator.
AF-RM-01.2.2	The Ramp Metering Application's probe data subscription profile shall include a start time (month, day, year, hour, and minute) of the subscription defined by the Freeway Management Operator.
AF-RM-01.2.3	The Ramp Metering Application's probe data subscription profile shall include an end time (month, day, year, hour, and minute) of the subscription defined by the Freeway Management Operator.
AF-RM-01.2.4	The Ramp Metering Application's probe data subscription profile shall include probe data elements defined by the Freeway Management Operator.
AF-RM-01.3	The Ramp Metering Application shall update the probe data subscription profile when directed by the Freeway Management Operator.
AF-RM-01.4	The Ramp Metering Application shall send a subscription request based on the subscription profile to the Probe Data Service, when directed by the Freeway Management Operator.
AF-RM-01.5	The Ramp Metering Application shall cancel a subscription to the Probe Data Service when directed by the Freeway Management Operator.

5.2 Publish Probe Data

Identifier	Functional Requirements
AF-RM-02	The Ramp Metering Application shall receive probe data snapshots from the Probe Data Service.

5.3 Manage VII Probe Data

Identifier	Functional Requirements
AF-RM-03	The Ramp Metering Application shall manage probe data snapshots received from the Probe Data Service.
AF-RM-03.1	The Ramp Metering Application shall store all probe data snapshots received from the Probe Data Service.
AF-RM-03.1.1	The Ramp Metering Application shall store all probe data snapshots received from the Probe Data Service in received form.
AF-RM-03.1.2	The Ramp Metering Application shall append the time the snapshot was received by the Ramp Metering Application for all probe data snapshots received from the Probe Data Service.
AF-RM-03.1.3	The Ramp Metering Application shall have a mechanism to access stored probe data snapshots based on the value of any parameter included within the snapshots.
AF-RM-03.2	The Ramp Metering Application shall verify the contents of probe data snapshots received from the Probe Data Service.
AF-RM-03.2.1	The Ramp Metering Application shall verify that the contents of probe data snapshots received from the Probe Data Service match with the corresponding subscription requests.
AF-RM-03.2.2	The Ramp Metering Application shall store the result of the verification for all probe data snapshots.

5.4 Analyze Archived Probe Data to Produce Ramp Metering Software Inputs

Identifier	Functional Requirements
AF-RM-04	The Ramp Metering Application shall analyze probe data to compute measures needed for generating ramp metering plans.
AF-RM-04.1	The Ramp Metering Application shall compute link travel times on freeway segments adjoining the freeway ramp.
AF-RM-04.1.1	The Ramp Metering Application shall have up-to-date geographic information data covering the geographic extent of the Ramp Metering Application, to geo-locate travel times.
AF-RM-04.1.2	The Ramp Metering Application's geographic information data shall include information describing boundaries of each freeway and ramp lane.
AF-RM-04.1.3	The Ramp Metering Application shall define the freeways adjoining the ramps included in the geographic information data into travel time estimation links with.
AF-RM-04.1.4	The Ramp Metering Application shall define the start and end points of the travel time estimation links using freeway interchanges, arterial intersections, or pre-defined landmarks.
AF-RM-04.1.5	When enabled by the Freeway Management Operator, the Ramp Metering Application shall utilize the stored probe data to compute the freeway mainline link travel times adjoining the ramp using algorithms developed by Noblis as part of USDOT's "VII Data Characteristics for Traffic Management" study.
AF-RM-04.1.6	The Ramp Metering Application shall store computed link travel

Identifier	Functional Requirements
	times.
AF-RM-04.1.7	The Ramp Metering Application shall verify that all computed link travel times are within threshold values defined by the Freeway Management Operator.
AF-RM-04.1.8	The Ramp Metering Application shall store the result of the verification for all computed travel times.
AF-RM-04.2	The Ramp Metering Application shall compute mainline speed on freeway segments adjoining the freeway ramp.
AF-RM-04.2.1	The Ramp Metering Application shall have up-to-date geographic information data covering the geographic extent of the Ramp Metering Application, to geo-locate mainline speed data.
AF-RM-04.2.2	The Ramp Metering geographic information data shall include information describing boundaries of each freeway and ramp lane.
AF-RM-04.2.3	The Ramp Metering Application shall define the freeways adjoining the ramps included in the geographic information data into speed estimation links.
AF-RM-04.2.4	The Ramp Metering Application shall define the start and end points of the speed estimation links using freeway interchanges, arterial intersections, or pre-defined landmarks.
AF-RM-04.2.5	When enabled by the Freeway Management Operator, the Ramp Metering Application shall utilize the stored probe data to compute the mainline (freeway) speeds adjoining the ramp using algorithms developed by Noblis as part of USDOT's "VII Data Characteristics for Traffic Management" study.
AF-RM-04.2.6	The Ramp Metering Application shall store computed mainline speeds.
AF-RM-04.2.7	The Ramp Metering Application shall verify that all computed mainline speeds are within threshold values defined by the Freeway Management Operator.
AF-RM-04.2.8	The Ramp Metering Application shall store the result of the verification for all computed mainline speeds.
AF-RM-04.3	The Ramp Metering Application shall compute ramp queue length on freeway ramps.
AF-RM-04.3.1	The Ramp Metering Application shall have up-to-date geographic information data covering the geographic extent of the Ramp Metering Application, to geo-locate ramp queues.
AF-RM-04.3.2	The Ramp Metering geographic information data shall include information describing boundaries of each adjoining arterial, freeway and ramp lane.
AF-RM-04.3.3	When enabled by the Freeway Management Operator, the Ramp Metering Application shall utilize the stored probe data to compute ramp queue length using algorithms developed by Noblis as part of USDOT's "VII Data Characteristics for Traffic Management" study.
AF-RM-04.3.4	The Ramp Metering Application shall store computed ramp queue length.
AF-RM-04.3.5	The Ramp Metering Application shall verify that all computed ramp queue lengths are within threshold values defined by the

Identifier	Functional Requirements
	Freeway Management Operator.
AF-RM-04.3.6	The Ramp Metering Application shall store the result of the verification for all computed ramp queue lengths.
AF-RM-04.4	The Ramp Metering Application shall compute queue overflow on ramps.
AF-RM-04.4.1	The Ramp Metering Application shall have up-to-date geographic information data covering the geographic extent of the Ramp Metering Application, to geo-locate ramp queues.
AF-RM-04.4.2	The Ramp Metering geographic information data shall include information describing boundaries of each freeway, arterial and ramp lane.
AF-RM-04.4.3	When enabled by the Freeway Management Operator, the Ramp Metering Application shall utilize the stored probe data to compute ramp queue overflow using algorithms developed by Noblis as part of USDOT's "VII Data Characteristics for Traffic Management" study.
AF-RM-04.4.4	The Ramp Metering Application shall store computed ramp queue overflow.
AF-RM-04.4.5	The Ramp Metering Application shall verify that all computed ramp queue overflows are within threshold values defined by the Freeway Management Operator.
AF-RM-04.4.6	The Ramp Metering Application shall store the result of the verification for all computed ramp queue overflows.
AF-RM-04.5	The Ramp Metering Application shall compute the number of vehicle stops on ramps.
AF-RM-04.5.1	The Ramp Metering Application shall have up-to-date geographic information data covering the geographic extent of the Ramp Metering Application, to geo-locate vehicle stops.
AF-RM-04.5.2	The Ramp Metering geographic information data shall include information describing boundaries of the ramp lanes.
AF-RM-04.5.3	When enabled by the Freeway Management Operator, the Ramp Metering Application shall utilize the stored probe data to compute the number of vehicle stops per lane on the ramp.
AF-RM-04.5.4	The Ramp Metering Application shall store computed numbers of vehicle stops.
AF-RM-04.5.5	The Ramp Metering Application shall verify that all computed numbers of vehicle stops are within threshold values defined by the Freeway Management Operator.
AF-RM-04.5.6	The Ramp Metering Application shall store the result of the verification for all computed numbers of vehicle stops.
AF-RM-04.6	The Ramp Metering Application shall compute the number of vehicle stops on freeway mainlines adjoining the ramp.
AF-RM-04.6.1	The Ramp Metering Application shall have up-to-date geographic information data covering the geographic extent of the Ramp Metering Application, to geo-locate vehicle stops.
AF-RM-04.6.2	The Ramp Metering geographic information data shall include information describing boundaries of the ramp and adjoining freeway mainline lanes.
AF-RM-04.6.3	The Ramp Metering Application shall define the freeways

Identifier	Functional Requirements
	adjoining the ramps included in the geographic information data into links with specific start and end points.
AF-RM-04.6.4	When enabled by the Freeway Management Operator, the Ramp Metering Application shall utilize the stored probe data to compute the number of vehicle stops per lane on the freeway mainlines adjoining the ramp.
AF-RM-04.6.5	The Ramp Metering Application shall store computed mainline number of vehicle stops.
AF-RM-04.6.6	The Ramp Metering Application shall verify that all computed mainline numbers of vehicle stops are within threshold values defined by the Freeway Management Operator.
AF-RM-04.6.7	The Ramp Metering Application shall store the result of the verification for all computed numbers of vehicle stops.
AF-RM-04.7	The Ramp Metering Application shall compute mainline average stop delay on freeway segments adjoining freeway ramps.
AF-RM-04.7.1	The Ramp Metering Application shall have up-to-date geographic information data covering the geographic extent of the Ramp Metering Application, to geo-locate vehicle stops.
AF-RM-04.7.2	The Ramp Metering geographic information data shall include information describing boundaries of each freeway and ramp lane.
AF-RM-04.7.3	The Ramp Metering Application shall define the freeways adjoining the ramps included in the geographic information data into links with specific start and end points.
AF-RM-04.7.4	When enabled by the Freeway Management Operator, the Ramp Metering Application shall utilize the stored probe data to compute average stop delay on the freeway mainlines adjoining the ramp.
AF-RM-04.7.5	The Ramp Metering Application shall store computed mainline average stop delay.
AF-RM-04.7.6	The Ramp Metering Application shall verify that all computed mainline average stop delays are within threshold values defined by the Freeway Management Operator.
AF-RM-04.7.7	The Ramp Metering Application shall store the result of the verification for all computed mainline average stop delays.
AF-RM-04.8	The Ramp Metering Application shall compute average stop delay on ramps.
AF-RM-04.8.1	The Ramp Metering Application shall have up-to-date geographic information data covering the geographic extent of the Ramp Metering Application, to geo-locate vehicle stops.
AF-RM-04.8.2	The Ramp Metering geographic information data shall include information describing boundaries of each freeway and ramp lane.
AF-RM-04.8.3	When enabled by the Freeway Management Operator, the Ramp Metering Application shall utilize the stored probe data to compute average stop delay on the ramp.
AF-RM-04.8.4	The Ramp Metering Application shall store computed ramp average stop delay.
AF-RM-04.8.5	The Ramp Metering Application shall verify that all computed ramp average stop delays are within threshold values defined by

Identifier	Functional Requirements
	the Freeway Management Operator.
AF-RM-04.8.6	The Ramp Metering Application shall store the result of the verification for all computed ramp average stop delays.
AF-RM-04.9	The Ramp Metering Application shall compute time in queue on ramps.
AF-RM-04.9.1	The Ramp Metering Application shall have up-to-date geographic information data covering the geographic extent of the Ramp Metering Application, to geo-locate queues.
AF-RM-04.9.2	The Ramp Metering geographic information data shall include information describing boundaries of each freeway and ramp lane.
AF-RM-04.9.3	When enabled by the Freeway Management Operator, the Ramp Metering Application shall utilize the stored probe data to compute time in queue on the ramp using algorithms developed by Noblis as part of USDOT's "VII Data Characteristics for Traffic Management" study.
AF-RM-04.9.4	The Ramp Metering Application shall store computed time in queue.
AF-RM-04.9.5	The Ramp Metering Application shall verify that all computed time in queues are within threshold values defined by the Freeway Management Operator.
AF-RM-04.9.6	The Ramp Metering Application shall store the result of the verification for all computed time in queues.

5.5 Collect Field Data

Identifier	Functional Requirements
AF-RM-05	The Ramp Metering Application shall manage collected field data.
AF-RM-05.1	The Ramp Metering Application shall provide a mechanism for importing field-collected data.
AF-RM-05.1.1	The Ramp Metering Application shall provide a mechanism for importing mainline link travel times.
AF-RM-05.1.2	The Ramp Metering Application shall provide a mechanism for importing mainline speeds.
AF-RM-05.1.3	The Ramp Metering Application shall provide a mechanism for importing ramp queue lengths.
AF-RM-05.1.4	The Ramp Metering Application shall provide a mechanism for the importing time of ramp queue overflow events.
AF-RM-05.1.5	The Ramp Metering Application shall provide a mechanism for importing ramp delay.
AF-RM-05.1.6	The Ramp Metering Application shall provide a mechanism for importing mainline delay.
AF-RM-05.1.7	The Ramp Metering Application shall provide a mechanism for importing average stop locations on the mainline.
AF-RM-05.1.8	The Ramp Metering Application shall provide a mechanism for importing average stop delay on the mainline.
AF-RM-05.1.9	The Ramp Metering Application shall provide a mechanism for

Identifier	Functional Requirements
	importing average stop delay on ramps.
AF-RM-05.1.10	The Ramp Metering Application shall provide a mechanism for importing time in queue on ramps.
AF-RM-05.1.11	The Ramp Metering Application shall provide a mechanism for importing vehicle time and position trajectories.
AF-RM-05.1.12	The Ramp Metering Application shall provide a mechanism for importing ramp metering rates.
AF-RM-05.1.13	The Ramp Metering Application shall provide a mechanism for importing labor and cost of data collection for ramp data collection activities.
AF-RM-05.2	The Ramp Metering Application shall store imported field data organized by location and time of data collection.

5.6 Determine VII Effectiveness at Measuring Traffic Characteristics

Identifier	Functional Requirements
AF-RM-06	The Ramp Metering Application shall analyze probe data to compute measures to determine the effectiveness of VII Probe data at measuring traffic characteristics.
AF-RM-06.1	The Ramp Metering Application shall determine the variance between field-collected ramp queue length and computed ramp queue length.
AF-RM-06.1.1	The Ramp Metering Application shall have up-to-date geographic information data covering the geographic extent of the Ramp Metering Application, to geo-locate ramp queues.
AF-RM-06.1.2	The Ramp Metering geographic information data shall include information describing boundaries of each freeway and ramp lane.
AF-RM-06.1.3	The Ramp Metering Application shall define the freeways adjoining the ramps included in the geographic information data into links with specific start and end points.
AF-RM-06.1.4	When enabled by the Freeway Management Operator, the Ramp Metering Application shall utilize the stored probe data to compute average ramp queue length per lane using algorithms developed by Noblis as part of USDOT's "VII Data Characteristics for Traffic Management" study for the same geographic location and time as the field-collected average ramp queue length.
AF-RM-06.1.5	The Ramp Metering Application shall calculate the variance between the stored field-collected average ramp queue length per lane and computed average ramp queue length per lane.
AF-RM-06.1.6	The Ramp Metering Application shall store the computed ramp queue length and variance from field-collected ramp queue length.
AF-RM-06.2	The Ramp Metering Application shall determine the variance between field-collected average stop locations per lane on the mainline and computed average stop locations per lane.
AF-RM-06.2.1	The Ramp Metering Application shall have up-to-date geographic

	information data covering the geographic extent of the Ramp Metering Application, to geo-locate mainline stop locations.
AF-RM-06.2.2	The Ramp Metering geographic information data shall include information describing boundaries of each freeway and ramp lane.
AF-RM-06.2.3	The Ramp Metering Application shall define the freeways adjoining the ramps included in the geographic information data into links with specific start and end points.
AF-RM-06.2.4	When enabled by the Freeway Management Operator, the Ramp Metering Application shall utilize the stored probe data to compute stop locations per lane on the mainline for the same geographic location and time as the field-collected stop locations per lane on the mainline.
AF-RM-06.2.5	The Ramp Metering Application shall calculate the variance between the stored field-collected stop locations per lane and computed stop locations per lane.
AF-RM-06.2.6	The Ramp Metering Application shall store the computed average stop locations per lane and variance from field-collected average stop locations per lane.
AF-RM-06.3	The Ramp Metering Application shall determine the variance between field-collected average stop delay per lane on the mainline with computed average stop delay per lane on the mainline.
AF-RM-06.3.1	The Ramp Metering Application shall have up-to-date geographic information data covering the geographic extent of the Ramp Metering Application, to geo-locate mainline stop delay.
AF-RM-06.3.2	The Ramp Metering geographic information data shall include information describing boundaries of each freeway and ramp lane.
AF-RM-06.3.3	The Ramp Metering Application shall define the freeways adjoining the ramps included in the geographic information data into links with specific start and end points.
AF-RM-06.3.4	When enabled by the Freeway Management Operator, the Ramp Metering Application shall utilize the stored probe data to compute average stop delay per lane on the mainline for the same geographic location and time as the field-collected average stop delay per lane on the mainline.
AF-RM-06.3.5	The Ramp Metering Application shall calculate the variance between the stored field-collected mainline average stop delay per lane and computed mainline average stop delay per lane.
AF-RM-06.3.6	The Ramp Metering Application shall store the computed average stop delay per lane and variance from field-collected average stop delay per lane.
AF-RM-06.4	The Ramp Metering Application shall determine the variance between field-collected link travel times on the mainline with computed link travel times.
AF-RM-06.4.1	The Ramp Metering Application shall have up-to-date geographic information data covering the geographic extent of the Ramp Metering Application, to geo-locate freeway link travel times.
AF-RM-06.4.2	The Ramp Metering geographic information data shall include information describing boundaries of each freeway and ramp lane.
AF-RM-06.4.3	The Ramp Metering Application shall define the freeways

	adjoining the ramps included in the geographic information data into links with specific start and end points.
AF-RM-06.4.4	When enabled by the Freeway Management Operator, the Ramp Metering Application shall utilize the stored probe data to compute average link travel times per lane on the mainline for the same geographic location and time as the field-collected average link travel times per lane on the mainline.
AF-RM-06.4.5	The Ramp Metering Application shall calculate the variance between the stored field-collected mainline average link travel times per lane and computed mainline average link travel times per lane.
AF-RM-06.4.6	The Ramp Metering Application shall store the computed mainline link travel times and variances from field-collected mainline link travel time.
AF-RM-06.5	The Ramp Metering Application shall determine the variance between field-collected average time in ramp queue with computed average time in ramp queue.
AF-RM-06.5.1	The Ramp Metering Application shall have up-to-date geographic information data covering the geographic extent of the Ramp Metering Application, to geo-locate vehicle ramp queues.
AF-RM-06.5.2	The Ramp Metering geographic information data shall include information describing boundaries of each freeway and ramp lane.
AF-RM-06.5.3	The Ramp Metering Application shall define the freeways adjoining the ramps included in the geographic information data into links with specific start and end points.
AF-RM-06.5.4	The Ramp Metering Application shall utilize the stored probe data to compute the average time in ramp queue using algorithms developed by Noblis as part of USDOT's "VII Data Characteristics for Traffic Management" study for the same geographic location and time as the field-collected average time in ramp queue.
AF-RM-06.5.5	The Ramp Metering Application shall calculate the variance between the stored field-collected average time in ramp queue and computed average time in ramp queue.
AF-RM-06.5.6	The Ramp Metering Application shall store the computed average time in ramp queue and variance from field-collected average time in ramp queue.
AF-RM-06.6	The Ramp Metering Application shall determine the variance between field-collected average ramp delay with computed average ramp delay.
AF-RM-06.6.1	The Ramp Metering Application shall have up-to-date geographic information data covering the geographic extent of the Ramp Metering Application, to geo-locate vehicle ramp queues.
AF-RM-06.6.2	The Ramp Metering geographic information data shall include information describing boundaries of each freeway and ramp lane.
AF-RM-06.6.3	The Ramp Metering Application shall define the freeways adjoining the ramps included in the geographic information data into links with specific start and end points.
AF-RM-06.6.4	The Ramp Metering Application shall utilize the stored probe data to compute the average ramp delay using algorithms developed by Noblis as part of USDOT's "VII Data Characteristics for Traffic

	Management” study for the same geographic location and time as the field-collected ramp delay.
AF-RM-06.6.5	The Ramp Metering Application shall calculate the variance between the stored field-collected average ramp delay and computed average ramp delay.
AF-RM-06.6.6	The Ramp Metering Application shall store the computed average ramp delay and variance from field-collected average ramp delay.
AF-RM-06.7	The Ramp Metering Application shall determine the variance between field-collected average mainline delay with computed average mainline delay.
AF-RM-06.7.1	The Ramp Metering Application shall have up-to-date geographic information data covering the geographic extent of the Ramp Metering Application, to geo-locate vehicle mainline delay.
AF-RM-06.7.2	The Ramp Metering geographic information data shall include information describing boundaries of each freeway and ramp lane.
AF-RM-06.7.3	The Ramp Metering Application shall define the freeways adjoining the ramps included in the geographic information data into links with specific start and end points.
AF-RM-06.7.4	The Ramp Metering Application shall utilize the stored probe data to compute average mainline delay using algorithms developed by Noblis as part of USDOT’s “VII Data Characteristics for Traffic Management” study for the same geographic location and time as the field-collected mainline delay.
AF-RM-06.7.5	The Ramp Metering Application shall calculate the variance between the stored field-collected average mainline delay and computed average mainline delay.
AF-RM-06.7.6	The Ramp Metering Application shall store the computed average mainline delay and variance from field-collected average mainline delay.
AF-RM-06.8	The Ramp Metering Application shall determine the variance between field-collected average mainline speed with computed average mainline speed.
AF-RM-06.8.1	The Ramp Metering Application shall have up-to-date geographic information data covering the geographic extent of the Ramp Metering Application, to geo-locate vehicle mainline speed.
AF-RM-06.8.2	The Ramp Metering geographic information data shall include information describing boundaries of each freeway and ramp lane.
AF-RM-06.8.3	The Ramp Metering Application shall define the freeways adjoining the ramps included in the geographic information data into links with specific start and end points.
AF-RM-06.8.4	The Ramp Metering Application shall utilize the stored probe data to compute the average mainline speed using algorithms developed by Noblis as part of USDOT’s “VII Data Characteristics for Traffic Management” study for the same geographic location and time as the field-collected mainline speeds.
AF-RM-06.8.5	The Ramp Metering Application shall calculate the variance between the stored field-collected average mainline speed and computed average mainline speed.
AF-RM-06.8.6	The Ramp Metering Application shall store the computed average mainline speed and variance from field-collected average mainline

	speed.
AF-RM-06.9	The Ramp Metering Application shall determine the variance between the field-collected start time of any queue overflow events with the computed start time of queue overflow events.
AF-RM-06.9.1	The Ramp Metering Application shall have up-to-date geographic information data covering the geographic extent of the Ramp Metering Application, to geo-locate vehicle mainline speed.
AF-RM-06.9.2	The Ramp Metering geographic information data shall include information describing boundaries of each freeway and ramp lane.
AF-RM-06.9.3	The Ramp Metering Application shall define the freeways adjoining the ramps included in the geographic information data into links with specific start and end points.
AF-RM-06.9.4	The Ramp Metering Application shall utilize the stored probe data to compute the start time of any queue overflow events using algorithms developed by Noblis as part of USDOT's "VII Data Characteristics for Traffic Management" study for the same geographic location and time as the field-collected queue overflow events.
AF-RM-06.9.5	The Ramp Metering Application shall calculate the variance between the stored field-collected the start time of any queue overflow events and computed the start time of any queue overflow events.
AF-RM-06.9.6	The Ramp Metering Application shall store the computed queue overflow event start times and variance from field-collected queue overflow event start times.

5.7 Distribute Probe Data Generation Parameters

Identifier	Functional Requirements
AF-RM-07	The Ramp Metering Application shall send a Probe Management Message, as defined in POC Additions and Exceptions to J2735 (APP190-02), to the Advisory Message Distribution Service when directed by the Freeway Management Operator.

5.8 Provide Ramp Metering Application User Interface

Identifier	Functional Requirements
AF-RM-08	The Ramp Metering Application shall provide a User Interface (UI) for the Freeway Management Operator to manage the Ramp Metering Application.
AF-RM-08.1	The Ramp Metering Application shall provide a User Interface (UI) for the Freeway Management Operator to manage the probe data subscription.
AF-RM-08.1.1	The Ramp Metering Application UI shall provide the Freeway Management Operator the ability to add and modify the probe data elements of the probe data subscription profile.

Identifier	Functional Requirements
AF-RM-08.1.2	The Ramp Metering Application UI shall provide the Freeway Management Operator the ability to add and modify the geographic boundary of the probe data subscription profile.
AF-RM-08.1.3	The Ramp Metering Application UI shall provide the Freeway Management Operator the ability to add and modify the start and end times of the probe data subscription profile.
AF-STO-08.1.4	The Ramp Metering Application UI shall provide the Freeway Management Operator the ability to send a probe data subscription request
AF-STO-08.1.5	The Ramp Metering Application UI shall provide the Freeway Management Operator the ability to cancel a probe data subscription request
AF-RM-08.2	The Ramp Metering Application shall provide a UI to allow the Freeway Management Operator to manage probe data.
AF-RM-08.2.1	The Ramp Metering Application UI shall provide the Freeway Management Operator the ability to view, in a tabular form, probe data stored by the Ramp Metering Application.
AF-RM-08.2.2	The Ramp Metering Application UI shall provide the Freeway Management Operator the ability to select a subset of stored probe data for viewing, based on the value of any parameter of the probe data snapshot.
AF-RM-08.2.3	The Ramp Metering Application UI shall provide the Freeway Management Operator the ability to select a subset of stored probe data for viewing, based on the time the probe data snapshot was received from the Probe Data Service.
AF-RM-08.2.4	The Ramp Metering Application UI shall provide the Freeway Management Operator the ability to view the most recently received probe data snapshots.
AF-RM-08.2.5	The Ramp Metering Application UI shall provide the Freeway Management Operator the ability to view any probe data verification errors generated by the Ramp Metering Application.
AF-RM-08.3	The Ramp Metering Application shall provide a UI to allow the Freeway Management Operator to set parameters for the algorithms used to compute ramp queue length, stop locations on the mainline, stop delay on the mainline, mainline link travel time, time in ramp queue, average ramp delay, average mainline delay, mainline speed and the start time of queue overflow events.
AF-RM-08.4	The Ramp Metering Application UI shall provide the Freeway Management Operator the ability to specify the geographic boundaries of the ramp, freeway, and arterials within the geographic extent of the Ramp Metering Application.
AF-RM-08.5	The Ramp Metering Application UI shall provide the Freeway Management Operator the ability to view computed ramp queue length, stop locations on the mainline, stop delay on the mainline, mainline link travel time, time in ramp queue, average ramp delay, average mainline delay, mainline speed and the start time of queue overflow events.
AF-RM-08.6	The Ramp Metering Application UI shall provide the Freeway

Identifier	Functional Requirements
	Management Operator the ability to view the variances between computed and field collected ramp queue length, stop locations on the mainline, stop delay on the mainline, mainline link travel time, time in ramp queue, average ramp delay, average mainline delay, mainline speed and the start time of queue overflow events..
AF-RM-08.7	The Ramp Metering Application UI shall provide the Freeway Management Operator the ability to define values of the parameters of a Probe Management Message as defined in SAE J2735 version 15 and the POC Additions and Exceptions to J2735 (APP190-02).
AF-RM-08.8	The Ramp Metering Application UI shall provide the Freeway Management Operator the ability to choose to broadcast a Probe Management Message as an advisory message delivery request to the Advisory Message Delivery Service.
AF-RM+8.9	The Ramp Metering Application UI shall provide the Freeway Management Operator the ability to view advisory message delivery requests.
AF-RM+8.9.1	The Ramp Metering Application UI shall provide the Freeway Management Operator the ability to view the active, scheduled, and expired advisory message delivery requests in a tabular format, using one row for each delivery request.
AF-RM+8.9.2	The Ramp Metering Application UI shall update the view with the latest advisory message delivery requests generated by the Ramp Metering Application.
AF-RM+8.9.3	The Ramp Metering Application UI shall provide the Freeway Management Operator the ability to view any delivery request related errors reported by the Advisory Message Distribution Service.
AF-RM+8.10	The Ramp Metering Application UI shall provide the Freeway Management Operator the ability to cancel an advisory message delivery request.
AF-RM+8.11	The Ramp Metering Application UI shall provide the Freeway Management Operator the ability to create lookup requests to the Information Lookup Service about VII System managed entities (i.e., RSEs, Probe Data Service Availability, and Advisory Message Distribution Service availability).
AF-RM+8.12	The Ramp Metering Application UI shall provide the Freeway Management Operator the ability to view information about VII System managed entities (i.e., RSEs, Probe Data Service Availability, and Advisory Message Distribution Service availability).
AF-RM+8.13	The Ramp Metering Application UI shall provide the Freeway Management Operator the ability to enable or disable, either separately or together, the analysis of probe data for computing ramp queue length, stop locations on the mainline, stop delay on the mainline, mainline link travel time, time in ramp queue, average ramp delay, average mainline delay, mainline speed and the start time of queue overflow events.

6 Security Requirements

Identifier	Security Requirements
AS-RM-01	The Ramp Metering Application shall be coded to ensure that adequate security measures are in place to prevent it from compromising connected system resources both within the host computing and VII infrastructure environments.
AS-RM-02	The Ramp Metering Application shall be subject to a code security assessment to ensure it complies with safe coding practices.
AS-RM-03	The Ramp Metering Application shall validate all user input to prevent maliciously entered data from being accepted.
AS-RM-04	The Ramp Metering Application shall enforce access policies associated with specific user roles.
AS-RM-05	Upon detection of any security event, the Ramp Metering Application shall isolate the compromised component in order to render it harmless to the rest of the network.
AS-RM-06	The Ramp Metering Application shall prevent known message-based attacks from inbound XML formatted data.
AS-RM-07	The Ramp Metering Application shall only use FIPS 140-2 compliant crypto algorithms wherever encryption is needed.
AS-RM-08	The Ramp Metering Application shall encrypt a user's ID and password while performing authentication.
AS-RM-09	The Ramp Metering Application shall encrypt it's own user ID and password used to establish connectivity to the DBMS.
AS-RM-10	The Ramp Metering Application shall store all user ID's and password's in the DBMS in either encrypted or hashed format.
AS-RM-11	The Ramp Metering Application shall be designed with user roles which employ the concept of least privileges.
AS-RM-12	The Ramp Metering Application shall be designed to connect to the DBMS with an account that is consistent with the concept of least privileges.
AS-RM-13	The Ramp Metering application shall only communicate with the VII CA Subsystem via a private, or virtual private communications link.
AS-RM-14	The Ramp Metering application shall only communicate with Managed Entities via a private, or virtual private communications link.

7 External Interface Requirements

Identifier	External Interface Requirements
AX-RM-01	The Ramp Metering Application shall utilize the X-034 interface, as defined in the Network User to Service Delivery Node (SDN) Subsystem Software Interface Requirements Specification - Version 1.1 (or latest), when communicating with the Information Lookup Service .
AX-RM-02	The Ramp Metering Application shall utilize the X-031 interface, as defined in the Network User to Service Delivery Node (SDN) Subsystem Software Interface Requirements Specification - Version 1.1 (or latest), when communicating with the Probe Data Service .
AX-RM-03	The Ramp Metering Application shall utilize the X-032 interface, as defined in the Network User to Service Delivery Node (SDN) Subsystem Software Interface Requirements Specification - Version 1.1 (or latest), when communicating with the Advisory Message Distribution Service.

8 Performance Requirements

Identifier	Performance Requirement
AP-RM-01	The Ramp Metering Application shall take no longer than ten seconds to retrieve all of the probe data snapshots for a given freeway/ramp analysis section over a fifteen (15) minute period.
AP-RM-02	The Ramp Metering Application shall take no longer than one (1) minute to produce the ramp metering measures of effectiveness for a single freeway/ramp interchange.

9 End-to-End Performance Expectations

Identifier	Expectation
AN-RM-01	Computed ramp queue length, stop locations on the mainline, stop delay on the mainline, mainline link travel time, time in ramp queue, average ramp delay, average mainline delay, mainline speed and the start time of queue overflow events should be within 10% of field-collected measures.
AN-RM-02	Vehicle snapshots provided to the Ramp Metering application should be of sufficient frequency and accuracy to allow the determination of vehicle time and position trajectory through ramp/freeway merge area with lane resolution.
AN-RM-03	Latitude and longitude included in Probe Data Snapshots should be sufficiently accurate to determine a vehicle's horizontal position within one (1) meter.
AN-RM-04	Elevation included in Probe Data Snapshots should be sufficiently accurate to determine a vehicle's vertical position within three (3) meters.
AN-RM-05	Time associated with vehicle position included in Probe Data Snapshots should be accurate to within one (1) second.
AN-RM-06	Speed associated with a vehicle position included in Probe Data Snapshots should be accurate to within two (2) kph.
AN-RM-07	Vehicle snapshots should be provided to the Ramp Metering application within fifteen (15) minutes of their generation by the Vehicle.
AN-RM-08	The Ramp Metering Application's subscription to probe data should commence distribution of probe data snapshots within one (1) minute of subscription.
AN-RM-09	The Advisory Message Distribution Service should commence distribution of Probe Data Management Messages within one (1) minute of the advisory message broadcast start time for all advisory message delivery requests received from the Ramp Metering Application.
AN-RM-10	Vehicles should set their probe generation parameters in accordance with a Probe Management Message within one (1) second of receipt of a Probe Management Message.
AN-RM-11	Probe Management Messages should be distributed to Vehicles at least seven hundred (700) feet prior to the beginning of the ramp/freeway interchange.
AN-RM-12	Vehicles should reset their probe generation parameters to those values in place prior to receipt of a Probe Management Message within one (1) second after the Vehicle has determined that the Probe Management Message no longer applies, as defined in SAE J2735 version 15 and the POC Additions and Exceptions to J2735 (APP190-02).

Appendix A. List of Acronyms

AAM	Alliance of Automobile Manufacturers
AASHTO	American Association of State and Highway Transportation Officials
ABS	Antilock Braking System
AMDS	Advisory Message Distribution Service
AMI-C	Automotive Multimedia Interface Collaboration
ASTM	American Society for Testing and Materials
CA	Certification Authority
CAMP	Crash Collision Avoidance Metrics Partnership
CICAS	Cooperative Intersection Collision Avoidance Systems
CSP	Content Service Provider
DIC	DSRC Industry Consortium
DiD	Defense In Depth
DOT	Departments of Transportation
DSRC	Dedicated Short Range Communications
DTE	Development and Test Environment
EDMap	Enhanced Digital Map
ENOC	Enterprise Network Operations Center
ENS	Event Notification System
ESS	Environmental Sensor Stations
FAA	Federal Aviation Administration
FCC	Federal Communications Commission
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FTA	Federal Transit Administration
GHz	Gigahertz
GPS	Global Positioning System
GSA	General Services Administration
HMI	Human Machine Interface
IdAM	Identity and Access Management
IEEE	Institute of Electrical and Electronic Engineers
ILS	Information Lookup Service
ISTEA	Intermodal Surface Transportation Efficiency Act
IT	Information Technology
ITIL	Information Technology Infrastructure Library
ITS	Intelligent Transportation System
ITSM	Information Technology Service Management
IVHS	Intelligent Vehicle Highway Systems
IVI	Intelligent Vehicle Initiative
LBS	Location Based Services
MDSS	Maintenance Decision Support System
MPO	Metropolitan Planning Organization
NAP	Network Access Point
NHS	National Highway System
NHTSA	National Highway Traffic Safety Administration
NMS	Network Management System

NOC	Network Operations Center
NWS	National Weather Service
O&M	Operations and Maintenance
OBE	On Board Equipment
OBU	On Board Unit
OEM	Original Equipment Manufacturer
OSI	Open Systems Interconnection
PATH	Partners for Advanced Transit and Highways
PDS	Probe Data Service
PSAP	Public Service Answering Point
QoS	Quality of Service
RSE	Road Side Equipment
RSU	Road Side Unit
RWIS	Road Weather Information System
SAE	Society of Automotive Engineers
SDLC	System Development Life Cycle
SDN	Service Delivery Node
SNMP	Simple Network Management Protocol
SOC	Security Operations Center
SSL	Secure Sockets Layer
TEA-21	Transportation Equity Act for the 21 st Century
TMC	Traffic Management Center
TOC	Traffic Operations Center
VII	Vehicle Infrastructure Integration
VPN	Virtual Private Network
VSC	Vehicle Safety Communications
U.S. DOT	U.S. Department of Transportation

Appendix B. References

REF #	REFERENCE	VERSION
1	VII POC Applications Concept of Operations	Version 1.4
2	VII National System Requirements	Version 1.2.1
3	Road Side Equipment (RSE) Subsystem Specification	Version 1.0
4	Enterprise Network Operations Center (ENOC) Subsystem Specification	Version 1.1
5	Certificate Authority (CA) Subsystem Specification	Version 1.1
6	ENOC to Administrative User Subsystem Software IRS [X-011]	Version 1.1
7	Network User to SDN Subsystem Software IRS [X-031, X-032, X-033]	Version 1.1
8	ENOC to Managed Entity Subsystem Software IRS	Version 1.1
9	ENOC to Managed Network Element Software IRS	Version 1.1
10	SDN to RSE Subsystem Software IRS [I-06]	Version 1.1
11	ENOC to CA Subsystem Software IRS [I-13]	Version 1.1
12	ENOC to SDN Subsystem Software IRS [I-11]	Version 1.1
13	VII USDOT Day-1 Use Case Descriptions (May 2006)	Version 1.0
14	Network Subsystem Specification	Version 1.0
15	VII Concept of Operations	Draft 1.2
16	VII Systems Security Plan	Version 2.1
17	SDN Subsystem Specification (SSS)	Version 1.1
18	VII Infrastructure Lexicon	Version 1.0
19	Draft SAE J2735 Dedicated Short Range Communications (DSRC) Message Set Dictionary	Rev. 15
20	APP190-02 POC Additions & Exceptions to the POC Version of SAE J2735	R00
21	VII x.509 Certificate Authority Certificate Practice Statement (CPS)	TBD