

**VEHICLE INFRASTRUCTURE INTEGRATION
(VII)**

**CORRIDOR MANAGEMENT
LOAD BALANCING
POC APPLICATION REQUIREMENTS**



Research and Innovative Technology Administration

April 2007

VERSION 1.2

Booz | Allen | Hamilton

REVISION HISTORY

Date	Version	Description
March 1, 2007	1.0	Draft for Review
March 26, 2007	1.1	Revised per Comments and SRR
April 11, 2007	1.2	Revised per additional comments

Table of Contents

1	Introduction.....	3
2	Requirements Guide	4
2.1	Precedence And Criticality Of Requirements.....	4
2.2	Requirements Identification.....	4
2.3	Requirements Relationship	5
3	Application Boundary Definition	6
4	Assumptions and Constraints	8
4.1	Assumptions.....	8
4.2	Constraints	10
5	Functional Requirements	11
5.1	Subscribe to Probe Data.....	11
5.2	Publish Probe Data.....	13
5.3	Manage VII Probe Data	13
5.4	Analyze Real-Time Data to Determine Roadway Travel Conditions	13
5.5	Collect Field Data	16
5.6	Determine VII Effectiveness at Measuring Traffic Characteristics.....	16
5.7	Construct Traveler Information Messages.....	17
5.8	Provide Traveler Information Messages.....	17
5.9	Provide CMLB Application User Interface	18
6	Security Requirements	23
7	External Interface Requirements	24
8	Performance Requirements	25
9	End-to-End Performance Expectations	26
	Appendix A. List of Acronyms	27
	Appendix B. References.....	29

1 Introduction

Traffic managers work with freeway operators, signal system operators, transit system operators to help move travelers and goods in the most economical fashion. This requires extensive coordination between agencies with traditionally disparate goals, operating procedures and data collection methods. VII presents the possibility for wide area data collection that these agencies typically do not have access to, and further provide the potential for information dissemination that bridges the gaps between operational entities.

Corridor Management Load Balancing (CMLB) is principally concerned with making the best use of the roadway infrastructure through the redistribution of traffic. For POC, the CMLB application will concentrate on determining the practicality of achieving performance measurement of roadway resources using VII data.

The process for development of this application concept was to take the Day-1 Use Case definition of CMLB, and determine what aspects of the Day-1 Use Case warranted a proof-of-concept and were practical to develop in that POC timeframe. The requirements for this subset of the Day-1 Use Case is presented in this document.

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.
- Security Requirements – security requirements specify mechanisms to prevent the application from compromising connected resources.
- Performance Requirements – performance requirements specify quantifiable characteristics of application operations.
- 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 “Assumption”
“C”	for “Constraint”
“F”	for “Functional Requirement”
“S”	for “Security Requirement”
“P”	for “Performance Requirement”
“X”	for “External Application Interface Requirement”
“N”	for “End-to-End Performance Expectation”

Category is a variable length text string, usually a defined VII acronym, which will identify a specific application.

“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.

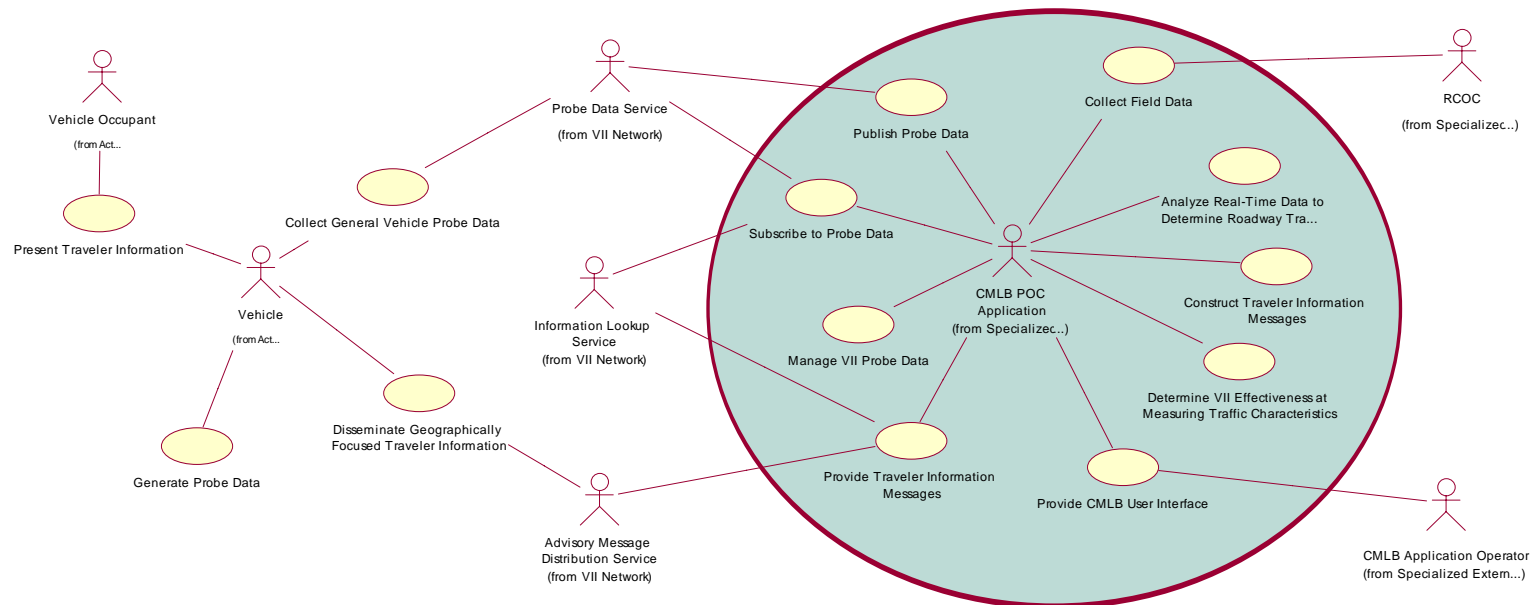
2.3 Requirements Relationship

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 CMLB 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 CMLB Application for POC.

Figure 3.1 – POC CMLB Application Use Case Diagram



¹ This is the most recent version of the Corridor Management Load Balancing POC Use Case diagram. Version 1.4 of the VII Applications Concept of Operations (current officially published version) 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 Corridor Management Load Balancing application, as they better identify the role of the Corridor Management Load Balancing Application 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 Version 1.2.1.

Table 3.1 – CMLB Application Actors

Actor	VII System Architecture Entities
Vehicle Occupant	Vehicle External Entity
Vehicle	Vehicle
Probe Data Service	VII System
Information Lookup Service	VII System
Advisory Message Distribution Service	VII System
CMLB Application	Network User
CMLB Application Operator	Network User External Entity
RCOC	Network User External Entity

As shown in the above table, the CMLB 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 CMLB Application².

² For more information about the mapping of Day-1 application capabilities to the POC implementation, see the POC Applications Concept of Operations v1.4, Chapter 13.

4 Assumptions and Constraints

4.1 Assumptions

Identifier	VII System Assumptions
VA-CMLB-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-CMLB-01.1	All probe data snapshots generated by the Vehicle will include latitude and longitude of the vehicle location.
VA-CMLB-01.2	All probe data snapshots generated by the Vehicle will include elevation of the vehicle location.
VA-CMLB-01.3	All probe data snapshots generated by the Vehicle will include time (hour, minute and seconds) that the snapshot was generated.
VA-CMLB-01.4	All probe data snapshots generated by the Vehicle will include date (month, day, year) that the snapshot was generated.
VA-CMLB-01.5	All probe data snapshots generated by the Vehicle will include vehicle heading.
VA-CMLB-01.6	All probe data snapshots generated by the Vehicle will include brake system status (brake applied).
VA-CMLB-01.7	All probe data snapshots generated by the Vehicle will include vehicle speed.
VA-CMLB-01.8	All probe data snapshots generated by the Vehicle will include the probe segment number.
VA-CMLB-01.9	The Vehicle's probe snapshot generation parameters will be configurable within the vehicle.
VA-CMLB-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-CMLB-02.1	The Vehicle's probe snapshot buffering parameters will be configurable within the vehicle.
VA-CMLB-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-CMLB-04	The Vehicle will log information related to probe data generation and Probe Data Service interactions.
VA-CMLB-04.1	The Vehicle will log all probe data snapshots generated within the previous 24-hour period.
VA-CMLB-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-CMLB-04.1.2	For each snapshot logged by the Vehicle, the time and type of buffer state changes will be recorded.
VA-CMLB-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-CMLB-04.1.4	Each snapshot logged by the Vehicle will be uniquely identifiable.

Identifier	VII System Assumptions
VA-CMLB-04.2	The Vehicle will log all of the locations and times at which the probe segment number changes.
VA-CMLB-04.3	The Vehicle will log the location and times at which the snapshot buffer overflows.
VA-CMLB-04.4	The Vehicle will log the times at which the vehicle location information is not available.
VA-CMLB-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-CMLB-04.6	The Vehicle will log probe messages provided to the Probe Data Service within the previous 24-hour period.
VA-CMLB-04.6.1	For each message logged, the Vehicle will record information necessary to identify the specific probe snapshots included in each message.
VA-CMLB-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-CMLB-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-CMLB-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-CMLB-05	The Probe Data Service will accept a subscription from the CMLB 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-CMLB-06	The Probe Data Service will attempt to deliver all Probe Data Snapshots received from Vehicles to the CMLB Application, if the snapshot parameters meet the CMLB Application's probe data subscription profile.
VA-CMLB-07	The Advisory Message Distribution Service will accept advisory message delivery requests from the CMLB 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-CMLB-08	The Advisory Message Distribution Service will forward the CMLB 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-CMLB-09	The Vehicle will present the CMLB Application provided advisory messages to the Vehicle Occupant, as specified in APP110-01 POC In-Vehicle Signage Application SFPR – Version 1.0.
VA-CMLB-10	The Information Lookup Service will respond to a request from the CMLB Application with the information necessary for the CMLB Application to subscribe to probe data within a specified geographic boundary.
VA-CMLB-11	The Information Lookup Service will respond to a request from the CMLB Application with the information necessary for the CMLB Application to deliver an advisory message within a specified

Identifier	VII System Assumptions
	geographic boundary.
VA-CMLB-12	The Advisory Message Distribution Service will allow for creating, modifying, deleting, and querying advisory message delivery requests by the CMLB Application.
VA-CMLB-13	The Information Lookup Service will respond to a request from the CMLB Application with the information necessary for the CMLB Application to submit advisory messages within a specified geographic boundary.
VA-CMLB-14	The Advisory Message Distribution Service will accept advisory messages from the CMLB 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.

Identifier	Non-VII External Entity Assumptions
XA-CMLB-01	Noblis, as part of USDOT's "VII Data Characteristics for Traffic Management" study, will provide algorithms for estimating current travel times using probe data.
XA-CMLB-02	Noblis, as part of USDOT's "VII Data Characteristics for Traffic Management" study, will provide algorithms for generating speed profiles using probe data.
XA-CMLB-03	Noblis, as part of USDOT's "VII Data Characteristics for Traffic Management" study, will provide algorithms for estimating volumes using probe data.
XA-CMLB-04	The Road Commission for Oakland County (RCOC) will collect and provide CMLB related field data to the CMLB Application, including link travel times, speeds, volumes, stop locations and stop delays, and lane closures within the geographic extent of the CMLB Application.
XA-CMLB-05	The Road Commission for Oakland County (RCOC) will record and provide the labor hours and total cost required to collect the CMLB related field data including link travel times, speeds, volumes, stop locations and stop delays, and lane closures within the geographic extent of the CMLB Application.

4.2 Constraints

Identifier	Constraints
AC-CMLB-01	The geographic extent of the CMLB Application is limited to the Detroit POC Development and Test Environment.

5 Functional Requirements

5.1 Subscribe to Probe Data

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

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

Identifier	Functional Requirements
AF-CMLB-01.2.4	The CMLB Application's probe data subscription profile shall include probe data elements defined by the CMLB Application Operator.
AF-CMLB-01.3	The CMLB Application shall update the probe data subscription profile when directed by the CMLB Application Operator.
AF-CMLB-01.4	The CMLB Application shall send a subscription request based on the subscription profile to the Probe Data Service, when directed by the CMLB Application Operator.
AF-CMLB-01.5	The CMLB Application shall cancel a subscription to the Probe Data Service when directed by the CMLB Application Operator.

5.2 Publish Probe Data

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

5.3 Manage VII Probe Data

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

5.4 Analyze Real-Time Data to Determine Roadway Travel Conditions

Identifier	Functional Requirements
AF-CMLB-04	The CMLB Application shall analyze real-time probe data to determine roadway travel conditions.

Identifier	Functional Requirements
AF-CMLB-04.1	The CMLB Application shall estimate travel times.
AF-CMLB-04.1.1	The CMLB Application shall have up-to-date geographic information data covering the geographic extent of the CMLB Application, to geo-locate roadway travel times.
AF-CMLB-04.1.2	The CMLB Application shall define the freeways and arterials included in the geographic information data into travel time reporting links.
AF-CMLB-04.1.3	The CMLB Application shall define the start and end points of the travel time reporting links using freeway interchanges, arterial intersections, or pre-defined landmarks.
AF-CMLB-04.1.4	When enabled by the CMLB Application Operator, the CMLB Application shall utilize the stored probe data to estimate current travel times along the travel time reporting links using the algorithms developed by Noblis as part of USDOT's "VII Data Characteristics for Traffic Management" study.
AF-CMLB-04.1.5	The CMLB Application shall store estimated link travel times.
AF-CMLB-04.1.6	The CMLB Application shall verify that all estimated travel times are within threshold values defined by the CMLB Application Operator.
AF-CMLB-04.1.7	The CMLB Application shall store the result of the verification for all estimated travel times.
AF-CMLB-04.2	The CMLB Application shall detect lane closures.
AF-CMLB-04.2.1	The CMLB Application shall have up-to-date geographic information data covering the geographic extent of the CMLB Application, to geo-locate lane closures.
AF-CMLB-04.2.2	The CMLB Application shall define the freeways and arterials included in the geographic information data into lane closure detection links.
AF-CMLB-04.2.3	The CMLB Application shall define the start and end points of the lane closure detection links using freeway interchanges, arterial intersections, or pre-defined landmarks.
AF-CMLB-04.2.4	When enabled by the CMLB Application Operator,, the CMLB Application shall detect occurrence of lane closures, lane closure locations and lane closure detection times along the lane closure detection links.
AF-CMLB-04.2.5	The CMLB Application shall geo-locate lane closures, utilizing geographic information data.
AF-CMLB-04.2.6	The CMLB Application shall store lane closures information.
AF-CMLB-04.2.7	The CMLB Application shall require verification of lane closures by the CMLB Application Operator.
AF-CMLB-04.2.8	The CMLB Application shall log false lane closure alarms designated by the CMLB Application Operator.
AF-CMLB-04.3	The CMLB Application shall generate speed profiles.
AF-CMLB-04.3.1	The CMLB Application shall have up-to-date geographic information data covering the geographic extent of the CMLB Application, to geo-locate speed profiles.
AF-CMLB-04.3.2	The CMLB Application shall define the freeways and arterials included in the geographic information data into speed profile generation links.

Identifier	Functional Requirements
AF-CMLB-04.3.3	The CMLB Application shall define the start and end points of the speed profile generating links using freeway interchanges, arterial intersections, or pre-defined landmarks.
AF-CMLB-04.3.4	When enabled by the CMLB Application Operator, the CMLB Application shall generate speed profiles by lane at pre-defined locations along the speed profile generating links, using the algorithms developed by Noblis as part of USDOT's "VII Data Characteristics for Traffic Management" study.
AF-CMLB-04.3.5	The CMLB Application shall store estimated speeds.
AF-CMLB-04.3.6	The CMLB Application shall verify that all estimated speeds are within threshold values defined by the CMLB Application Operator.
AF-CMLB-04.3.7	The CMLB Application shall store the result of the verification for all estimated speeds.
AF-CMLB-04.4	The CMLB Application shall estimate volumes.
AF-CMLB-04.4.1	The CMLB Application shall have up-to-date geographic information data covering the geographic extent of the CMLB Application, to geo-locate volumes.
AF-CMLB-04.4.2	The CMLB Application shall define the freeways and arterials included in the geographic information data into volume estimation links.
AF-CMLB-04.4.3	The CMLB Application shall define the start and end points of the volume estimation links using freeway interchanges, arterial intersections, or pre-defined landmarks.
AF-CMLB-04.4.4	When enabled by the CMLB Application Operator, the CMLB Application shall utilize the stored probe data to estimate volumes by lane at pre-defined locations along the volume estimation links, using the algorithms developed by Noblis as part of USDOT's "VII Data Characteristics for Traffic Management" study.
AF-CMLB-04.4.5	The CMLB Application shall store estimated volumes.
AF-CMLB-04.4.6	The CMLB Application shall verify that all estimated volumes are within threshold values defined by the CMLB Application Operator.
AF-CMLB-04.4.7	The CMLB Application shall store the result of the verification for all estimated volumes.
AF-CMLB-04.5	The CMLB Application shall estimate stop locations and stop delays.
AF-CMLB-04.5.1	The CMLB Application shall have up-to-date geographic information data covering the geographic extent of the CMLB Application, to geo-locate stop locations and stop delays.
AF-CMLB-04.5.2	The CMLB Application shall define the freeways and arterials included in the geographic information data into stop locations and stop delays estimation links.
AF-CMLB-04.5.3	The CMLB Application shall define the start and end points of the stop locations and stop delays estimation links using freeway interchanges, arterial intersections, or pre-defined landmarks.
AF-CMLB-04.5.4	When enabled by the CMLB Application Operator, the CMLB Application shall utilize the stored probe data to estimate stop

Identifier	Functional Requirements
	locations and stop delays along the stop locations and stop delays estimation links.
AF-CMLB-04.5.5	The CMLB Application shall geo-locate stop locations, utilizing geographic information data.
AF-CMLB-04.5.6	The CMLB Application shall store estimated stop locations and stop delays.
AF-CMLB-04.5.7	The CMLB Application shall verify that all estimated stop delays are within threshold values defined by the CMLB Application Operator.
AF-CMLB-04.5.8	The CMLB Application shall store the result of the verification for all estimated stop delays.

5.5 Collect Field Data

Identifier	Functional Requirements
AF-CMLB-05	The CMLB Application shall process CMLB related field data received from RCOC.
AF-CMLB-05.1	The CMLB Application shall receive CMLB related field data, including link travel times, speeds per lane, volumes per lane, stop locations and stop delays, and lane closures, from RCOC.
AF-CMLB-05.2	The CMLB Application shall store CMLB related field data, including link travel times, speeds per lane, volumes per lane, stop locations and stop delays, and lane closures, received from RCOC.
AF-CMLB-05.3	The CMLB Application shall receive data about the labor hours and total cost required to collect the CMLB related field data, from RCOC.
AF-CMLB-05.4	The CMLB Application shall store the data received from RCOC for the labor hours and total cost required to collect the CMLB related field data.

5.6 Determine VII Effectiveness at Measuring Traffic Characteristics

Identifier	Functional Requirements
AF-CMLB-06	The CMLB Application shall compare traffic measures computed utilizing probe data with field collected data provided by RCOC to determine the effectiveness of measuring VII-based traffic characteristics.
AF-CMLB-06.1	The CMLB Application shall determine the variance between the field-collected link travel times and the computed link travel times.
AF-CMLB-06.2	The CMLB Application shall store the variance between computed and field-collected link travel times.
AF-CMLB-06.3	The CMLB Application shall determine the variance between the field-collected stop locations per lane and the computed stop locations per lane.

Identifier	Functional Requirements
AF-CMLB-06.4	The CMLB Application shall store the variance between computed and field-collected stop locations per lane.
AF-CMLB-06.5	The CMLB Application shall determine the variance between field-collected stop delays per lane and computed stop delays per lane.
AF-CMLB-06.6	The CMLB Application shall store the variance between computed and field-collected stop delays per lane.
AF-CMLB-06.7	The CMLB Application shall determine the variance between the field-collected speeds per lane and the computed speeds per lane.
AF-CMLB-06.8	The CMLB Application shall store the variance between computed and field-collected speeds per lane.
AF-CMLB-06.9	The CMLB Application shall determine the variance between the field-collected volumes per lane and the computed volumes per lane.
AF-CMLB-06.10	The CMLB Application shall store the variance between computed and field-collected volumes per lane.
AF-CMLB-06.11	The CMLB Application shall determine the variance between field-collected lane closures and computed lane closures.
AF-CMLB-06.12	The CMLB Application shall store the variance between computed and field-collected lane closures.

5.7 Construct Traveler Information Messages

Identifier	Functional Requirements
AF-CMLB-07	The CMLB Application shall construct traveler information messages.
AF-CMLB-07.1	The CMLB Application shall construct all traveler information messages using the Traffic Advisory Message format specified in APP190-02 POC Additions and Exceptions to the POC Version of SAE J2735.
AF-CMLB-07.2	The CMLB Application shall utilize estimated and RCOC provided travel times to construct travel time messages.
AF-CMLB-07.3	The CMLB Application shall store constructed travel time messages.
AF-CMLB-07.4	The CMLB Application shall utilize estimated and RCOC provided lane closures information to construct lane closure messages.
AF-CMLB-07.5	The CMLB Application shall store constructed lane closure messages.

5.8 Provide Traveler Information Messages

Identifier	Functional Requirements
AF-CMLB-08	The CMLB Application shall provide traveler information messages to the Advisory Message Distribution Service.

Identifier	Functional Requirements
AF-CMLB-08.1	The CMLB Application shall have the ability to obtain information about the availability of Advisory Message Distribution Service.
AF-CMLB-08.1.1	The CMLB Application shall send a Advisory Message Distribution Service availability lookup request to the Information Lookup Service, when directed by the CMLB Application Operator.
AF-CMLB-08.1.2	The CMLB Application shall receive information from the Information Lookup Service about the availability of the Advisory Message Distribution Service.
AF-CMLB-08.2	The CMLB Application shall provide the CMLB Application Operator the ability to construct broadcast strategies which identify the distribution parameters of advisory messages.
AF-CMLB-08.2.1	The CMLB Application broadcast strategies shall be for any given combination of traveler information message type (travel time, lane closure), location, duration, and priority.
AF-CMLB-08.2.2	The CMLB Application broadcast strategies shall include the distribution parameters specified in Network User to Service Delivery Node (SDN) Subsystem Software Interface Requirements Specification - Version 1.1 (or latest), using the X-032 interface.
AF-CMLB-08.2.3	The CMLB Application shall store broadcast strategies.
AF-CMLB-08.3	The CMLB Application shall generate advisory message delivery requests.
AF-CMLB-08.3.1	The CMLB Application shall generate an advisory message delivery request when a new advisory message is constructed, unless the CMLB Application Operator has chosen to broadcast only verified messages and the new advisory message has not been verified.
AF-CMLB-08.3.2	The CMLB Application shall include in the advisory message delivery request, a broadcast strategy based on the newly constructed advisory message's type, location, duration, and priority.
AF-CMLB-08.3.3	The CMLB Application shall include, as part of the advisory message delivery request, the newly constructed advisory message.
AF-CMLB-08.4	The CMLB Application shall send advisory message delivery requests to the Advisory Message Distribution Service.
AF-CMLB-08.5	The CMLB Application shall store advisory message delivery requests.
AF-CMLB-08.6	The CMLB Application shall cancel advisory message delivery requests to the Advisory Message Distribution Service, when directed by the CMLB Application Operator.

5.9 Provide CMLB Application User Interface

Identifier	Functional Requirements
AF-CMLB-9	The CMLB Application shall provide a User Interface (UI) for the CMLB Application Operator to manage the CMLB Application.

Identifier	Functional Requirements
AF-CMLB-9.1	The CMLB Application shall provide a User Interface (UI) for the CMLB Application Operator to manage the probe data subscription.
AF-CMLB-9.1.1	The CMLB Application UI shall provide the CMLB Application Operator the ability to add and modify the probe data elements of the probe data subscription profile.
AF-CMLB-9.1.2	The CMLB Application UI shall provide the CMLB Application Operator the ability to add and modify the geographic boundary of the probe data subscription profile.
AF-CMLB-9.1.3	The CMLB Application UI shall provide the CMLB Application Operator the ability to add and modify the start and end times of the probe data subscription profile.
AF-CMLB-9.1.4	The CMLB Application UI shall provide the CMLB Application Operator the ability to send a probe data subscription request.
AF-CMLB-9.1.5	The CMLB Application UI shall provide the CMLB Application Operator the ability to cancel a probe data subscription request.
AF-CMLB-9.2	The CMLB Application shall provide a UI for the CMLB Application Operator to manage probe data.
AF-CMLB-9.2.1	The CMLB Application UI shall provide the CMLB Application Operator the ability to view, in a tabular form, probe data stored by the CMLB Application.
AF-CMLB-9.2.2	The CMLB Application UI shall provide the CMLB Application 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-CMLB-9.2.3	The CMLB Application UI shall provide the CMLB Application 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-CMLB-9.2.4	The CMLB Application UI shall provide the CMLB Application Operator the ability to view the most recently received probe data snapshots.
AF-CMLB-9.2.5	The CMLB Application UI shall provide the CMLB Application Operator the ability to view any probe data verification errors generated by the CMLB Application.
AF-CMLB-9.3	The CMLB Application shall provide a UI for the CMLB Application Operator to manage travel time messages.
AF-CMLB-9.3.1	The CMLB Application UI shall provide the CMLB Application Operator the ability to define the active regions (i.e. region within which a link travel time message gets presented to the Vehicle Occupant) for each travel time reporting link.
AF-CMLB-9.3.2	The CMLB Application UI shall provide the CMLB Application Operator the ability to view travel time messages in a tabular format, using one row for each pre-defined travel time reporting link.
AF-CMLB-9.3.3	The CMLB Application UI shall provide the CMLB Application Operator the ability to view the most recently generated travel time messages.
AF-CMLB-9.3.4	The CMLB Application UI shall provide the CMLB Application

Identifier	Functional Requirements
	Operator the ability to view any travel times related errors generated by the CMLB Application.
AF-CMLB-9.4	The CMLB Application shall provide a UI for the CMLB Application Operator to manage lane closure messages.
AF-CMLB-9.4.1	The CMLB Application UI shall provide the CMLB Application Operator the ability to define the active regions (i.e. region within which a lane closure message gets presented to the Vehicle Occupant) for each lane closure message.
AF-CMLB-9.4.2	The CMLB Application UI shall provide the CMLB Application Operator the ability to view lane closure messages in a tabular format, using one row for each detected lane closure.
AF-CMLB-9.4.3	The CMLB Application UI shall provide the CMLB Application Operator the ability to view the most recently generated lane closure messages.
AF-CMLB-9.4.4	The CMLB Application UI shall provide the CMLB Application Operator the ability to view any lane closures related errors generated by the CMLB Application.
AF-CMLB-9.4.5	The CMLB Application UI shall provide the CMLB Application Operator the ability to designate a lane closure detected by the CMLB Application as a false alarm.
AF-CMLB-9.5	The CMLB Application shall provide a UI for the CMLB Application Operator to manage speed profiles.
AF-CMLB-9.5.1	The CMLB Application UI shall provide the CMLB Application Operator the ability to define the specific locations for generating speed profiles.
AF-CMLB-9.5.2	The CMLB Application UI shall provide the CMLB Application Operator the ability to view speed profiles in a graph format, using one graph for each pre-defined location.
AF-CMLB-9.5.3	The CMLB Application UI shall provide the CMLB Application Operator the ability to view the most recently generated speed profiles.
AF-CMLB-9.5.4	The CMLB Application UI shall provide the CMLB Application Operator the ability to view any speed profiles related errors generated by the CMLB Application.
AF-CMLB-9.6	The CMLB Application shall provide a UI for the CMLB Application Operator to manage volumes.
AF-CMLB-9.6.1	The CMLB Application UI shall provide the CMLB Application Operator the ability to define the specific locations for generating volumes.
AF-CMLB-9.6.2	The CMLB Application UI shall provide the CMLB Application Operator the ability to view volumes in a tabular format, using one row for each pre-defined location.
AF-CMLB-9.6.3	The CMLB Application UI shall provide the CMLB Application Operator the ability to view the most recently generated volumes.
AF-CMLB-9.6.4	The CMLB Application UI shall provide the CMLB Application Operator the ability to view any volumes related errors generated by the CMLB Application.
AF-CMLB-9.7	The CMLB Application shall provide a UI for the CMLB Application Operator to manage stop locations and stop delays.

Identifier	Functional Requirements
AF-CMLB-9.7.1	The CMLB Application UI shall provide the CMLB Application Operator the ability to define the links for estimating stop locations and stop delays.
AF-CMLB-9.7.2	The CMLB Application UI shall provide the CMLB Application Operator the ability to view stop locations and stop delays in a tabular format, using one row for each stop location and associated delay.
AF-CMLB-9.7.3	The CMLB Application UI shall provide the CMLB Application Operator the ability to view the most recently generated stop locations and stop delays.
AF-CMLB-9.7.4	The CMLB Application UI shall provide the CMLB Application Operator the ability to view any stop locations and stop delays related errors generated by the CMLB Application.
AF-CMLB-9.8	The CMLB Application shall provide a UI for the CMLB Application Operator to define travel time reporting links, lane closure detection links, speed profile generation links, volume estimation links, and stop locations and stop delays estimation links.
AF-CMLB-9.9	The CMLB Application UI shall provide the CMLB Application Operator the ability to input the labor hours and total cost required to collect the CMLB related field data including link travel times, speeds, volumes, stop locations and stop delays, and lane closures
AF-CMLB-9.10	The CMLB Application UI shall provide the CMLB Application Operator the ability to graphically compare the field data collected and provided by RCOG, with the traffic measures computed by the CMLB Application.
AF-CMLB-9.11	The CMLB Application shall provide a UI for the CMLB Application Operator to view in tabular form estimated travel times, detected lane closures, estimated speeds, estimated volumes, and estimated stop locations and stop delays stored by the CMLB Application.
AF-CMLB-9.12	The CMLB Application shall provide a UI for the CMLB Application Operator to view advisory message delivery requests.
AF-CMLB-9.12.1	The CMLB Application shall provide a UI for the CMLB Application Operator to view the active, scheduled, and expired advisory message delivery requests in a tabular format, using one row for each delivery request.
AF-CMLB-9.12.2	The CMLB Application UI shall update the view with the latest advisory message delivery requests generated by the CMLB Application.
AF-CMLB-9.12.3	The CMLB Application UI shall provide the CMLB Application Operator the ability to view any delivery request related errors reported by the Advisory Message Distribution Service.
AF-CMLB-9.13	The CMLB Application UI shall provide the CMLB Application Operator the ability to cancel an advisory message delivery request.
AF-CMLB-9.12	The CMLB Application shall provide a UI for the CMLB

Identifier	Functional Requirements
	Application Operator to view errors generated by the CMLB Application related to RCOC provided data.
AF-CMLB-9.13	The CMLB Application shall provide a UI for the CMLB Application Operator to create, view, modify, and delete broadcast strategies for broadcasting travel information messages at various RSEs within geographic extent of the CMLB Application.
AF-CMLB-9.14	The CMLB Application shall provide a UI for the CMLB Application Operator to choose to broadcast all travel time and lane closure messages, or only those that have been verified.
AF-CMLB-9.15	The CMLB Application shall provide a UI for the CMLB Application Operator to create lookup requests to the Information Lookup Service about information on VII System managed entities (i.e. RSEs, Probe Data Service availability, and Advisory Message Distribution Service availability).
AF-CMLB-9.16	The CMLB Application shall provide a UI for the CMLB Application Operator to view information about VII System managed entities (i.e. RSEs, Probe Data Service availability, and Advisory Message Distribution Service availability).
AF-CMLB-9.17	The CMLB Application shall provide a UI for the CMLB Application Operator to set parameters for the algorithms used to estimate travel times, detect lane closures, generate speed profiles, estimate volumes, and estimate stop locations and stop delays.
AF-CMLB-9.18	The CMLB Application shall provide a UI for the CMLB Application Operator to set threshold values for link travel times, speeds, volumes, and stop delays.
AF-CMLB-9.19	The CMLB Application shall provide a UI for the CMLB Application Operator to enable or disable, either separately or together, the analysis of probe data for estimating travel times, detecting lane closures, generating speed profiles, estimating volumes, and estimating stop locations and stop delays.

6 Security Requirements

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

7 External Interface Requirements

Identifier	External Interface Requirements
AX-CMLB-01	The CMLB 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-CMLB-02	The CMLB 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-CMLB-03	The CMLB 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.
AX-CMLB-04	The CMLB Application shall receive CMLB related field data, including link travel times , speeds, volumes, stop locations and stop delays, and lane closures from RCOC, using an interface specified by RCOC.

8 Performance Requirements

Identifier	Performance Requirements
AP-CMLB-01	It shall take no longer than five (5) seconds for the CMLB Application to obtain all stored probe data for a fifteen (15) minute period.
AP-CMLB-02	The CMLB Application shall generate a travel information message (travel time, lane closure) within two (2) minutes of obtaining stored probe data.

9 End-to-End Performance Expectations

Identifier	Performance Expectations
VN-CMLB-01	Vehicle snapshots provided to the CMLB Application should be of sufficient frequency and accuracy to allow the determination of vehicle lane changes.
VN-CMLB-02	Latitude and Longitude included in Probe Data Snapshots should be accurate to determine a vehicle's horizontal position to within one (1) meter.
VN-CMLB-03	Elevation included in Probe Data Snapshots should be sufficiently accurate to determine a vehicle's vertical position within three (3) meters.
VN-CMLB-04	Time associated with Vehicle position included in Probe Data Snapshots should be accurate to within one (1) second.
VN-CMLB-05	Speed associated with a Vehicle position included in Probe Data Snapshots should be accurate to within two (2) kmph.
VN-CMLB-06	Vehicle snapshots should be provided to the CMLB Application within two (2) minutes of their transmission by the Vehicle.
VN-CMLB-07	The Probe Data Service should provide probe data snapshots within one (1) minute of the subscription start time, if probe data snapshots are available and meet the subscription profile.
VN-CMLB-08	The Advisory Message Distribution Service should commence distribution of traveler information messages within one (1) minute of the accepting an advisory message broadcast start time, for all advisory message delivery requests received from the CMLB Application.

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