Infrastructure Connectivity Certification Test Procedures for Infrastructure-Based Connected Automated Vehicle Components

MAP – SAE J2735

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16. Abstract

The successful deployment and operation of connected vehicle systems will require that devices, systems, and applications developed by different providers are compatible, interoperable, non-interfering, and in some instances, perhaps, interchangeable. Some devices, systems, and applications, such as active safety applications, may be required to meet minimum operational performance standards. A list of questions was distributed to potential stakeholders to gather information on which aspects of the industry should be considered for certification. The results were compiled and consolidated into a list of recommendations that yielded three applications to be addressed under this project. This document contains the test plan for one of the three applications.

The scope of the test cases in this document is to evaluate the output of a MAP application which encodes elements of MAP data into a Society of Automotive Engineers (SAE) J2735 MAP message over available wireless technology. This test plan aims to evaluate the format, structure, and encoding of the MAP message. SAE J2735 standard governs the MAP message format and structure. The message is represented in the ASN.1 format, which is UPER Hex encoded for broadcast. The scope of testing includes various mandatory data elements and their corresponding values, and verification of the various format conversions. Various sources for the MAP information would be considered. This document will focus on the ingestion of the information to ASN.1 format and its eventual conversion to UPER Hex for broadcast.

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List of Acronyms

ASN.1	Abstract Syntax Notation One
CAV	connected automated vehicle
CV	connected vehicle
CV2X	cellular vehicle-to-everything
DSRC	dedicated short-range communication
DUT	device under test
FHWA	Federal Highway Administration
GPS	global positioning systems
HRDO	Office of Operations Research and Development
KML	Keyhole Markup Language
NTCIP	National Transportation Communications for Intelligent Transportation Systems Protocol
PC	personal computer
PoE	Power-over-Ethernet
RSE	roadside equipment
RSU	roadside unit
SAE	Society of Automotive Engineers
SSH	secure shell
TFHRC	Turner-Fairbank Highway Research Center
UDP	user datagram protocol
UPER	unaligned packet encoding rules
USDOT	United States Department of Transportation

Test Plan Approvals

Coordination and Approvals

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The signatures below constitute approval of this plan.

Deb Curtis ***Project Manager***	***(Date)***	*(Name)* ***(Title)***	***(Date)***

Chapter 1. Introduction

Background

The United States Department of Transportation's (USDOT) connected vehicle program aims to improve safety, enhance mobility, and reduce the environmental footprint of our transportation systems through connected vehicle technology. In support of that goal, the Federal Highway Administration (FHWA) Office of Operations Research and Development (HRDO) performs transportation operations and research and development (R&D) at the Saxton Transportation Operations Laboratory (STOL), established at the Turner-Fairbank Highway Research Center (TFHRC).

Connected transportation systems use connected vehicle (CV) technology to link vehicles and mobile devices to each other, to transportation infrastructure, and to the larger communication infrastructure requiring trusted communications and interoperability. USDOT is assessing services and applications that realize the full potential of connected vehicles, travelers and infrastructure to enhance current operational practices and transform future surface transportation systems. To realize this potential, connected vehicle equipment and applications must meet minimum performance requirements, conform to common technical standards, guidelines, specifications, and interoperate with one another. Certification testing provides a formal means of verifying that a device, application, or service conforms to these requirements.

The successful deployment and operation of connected vehicle systems requires that devices, systems, and applications developed by different providers are compatible, interoperable, non-interfering, and in some instances, perhaps, interchangeable. Some devices, systems, and, applications, such as active safety applications, may be required to meet minimum operational performance standards. A list of questions was distributed to potential stakeholders to gather information on which aspects of the industry should be considered for certification. The results were compiled and consolidated into a list of recommendations that yielded three applications to be addressed under this project. This document contains the test plan and test design for one of the three applications.

Test Scope

The scope of the test cases in this document is to evaluate the output of a MAP application, which encodes elements of MAP data into a Society of Automotive Engineers (SAE) J2735 MAP message over available wireless technology. This test plan is intended to outline the evaluation and testing of the format, structure, and encoding of the MAP message. SAE J2735 governs the MAP message format and structure. The message is represented in the Abstract Syntax Notation One (ASN.1) format, which is encoded according to unaligned packet encoding rules (UPER) Hex for broadcast. The scope of testing includes various mandatory data elements and their corresponding values along with verification of the various format conversions. Various sources for the MAP information would be considered. This document will focus on the ingestion of the information to ASN.1 format and its eventual conversion to UPER Hex for broadcast.

The test considers three major processes and data structures for effective testing:

1. Input: MAP data.
2. Processing: ASN.1 format.
3. Output: UPER Hex encoded payload.

Evaluations will be performed on the following functional areas:

1. Content verification for critical MAP data elements according to SAE J2735.
2. Format verification for generated ASN.1 MAP.
3. ASN.1 {J2735 (MAP) message format} to UPER Hex encoding verification.

Items and Features to Be Tested

1. The completeness of MAP elements.

   To successfully encode an SAE J2735 MAP message, it is necessary to obtain critical elements for this message. This test plan tests the completeness of MAP critical elements. These MAP elements could be generated from various sources (e.g., National Transportation Communications for Intelligent Transportation Systems Protocol [NTCIP] 1202 v03 data objects, Map Creation Tool, Keyhole Markup Language [KML] convertor, etc.).
2. MAP formatting verification according to SAE J2735.

   Interoperability is crucial for connected automated vehicle (CAV) deployment. One key approach to interoperability is to ensure that different CAV messages are correctly and uniformly encoded. After MAP elements are encoded to a SAE J2735 MAP message, the format of this message will be verified.

Analysis and Report Findings

The test conductors will analyze the test results and prepare a test report for each vendor and submit the report to the vendor. These reports provide guidance to vendors regarding implementations that either meet or partially meet the requirements evaluated as part of this test. These reports do not, in any way, serve as official approval, confirmation, or certification by USDOT.

Upon request, the test conductors may also support briefings with the vendor to explain the results. The test conductors may also support information exchange and collaboration on the recommended next steps.

Test Objective

The primary objective of this document is to describe the process for certifying and evaluating implementations of SAE J2735 MAP messages. The testing agency will be able to test the MAP messages through various stages of message creation. Certification will be used as a procurement tool for connected vehicle (CV) device deployers.

Chapter 2. Test Environment

Tests will be conducted at a certification test laboratory (CTL), such as OmniAir and its affiliates. This test is designed for MAP J2735 message set; it will include testing of various elements starting with the MAP data input to the unaligned packet encoding rules (UPER) Hex output by linking the various stages to the J2735 message set directory.

Test Environment Requirements

To conduct tests, each test environment must have the following configuration and equipment:

- A power source appropriate to the device under test (DUT).
- An optional global positioning system (GPS) signal to provide location and system time. GPS can be provided by:
    - Access to the open sky.
    - GPS repeater (license may be required).
    - GPS simulator (time synchronization is required across all testing devices for accuracy).
- Network backhaul to allow connection to a hardware that includes a MAP application.
- Laptop with internet protocol (IP) packet sniffer and UPER decoder.
- Test tool to log encoded packets over the available communication medium.
- An optional MAP data broadcasting device.

Qualification Criteria

Qualification is determined at the various stages of testing. This will determine that the message is converted in the correct format while maintaining the mandatory standards and fields. Each value will be checked that it is within the acceptable range, as stated in the standards documents. A CTL is expected to have sufficient resources (e.g., equipment; personnel with related expertise) to complete all tests identified in this test plan.

Chapter 3. Test Schedule, Personnel, and Documentation

This section contains a high-level test schedule, required personnel to execute tests, and a description of several documents to record test activities and results.

Test Schedule

Table 1 lists the anticipated activities for the evaluation process after a device is admitted to the certification testing process. These activities are required for each vendor under test.

Table 1. Test activities.

ID	Activity	Estimated Duration
1	Initial hardware inspection	1 day
2	Initial configuration to operate in the applicable test environment	1 day
3	Full evaluation	2 weeks
4	Document results and submit final report	1 week

Personnel

The required number and qualifications of staff to complete testing activities will depend on the organization. Table 2 lists the staff anticipated to complete the activities in the estimated duration shown in table 1.

Table 2. Test personnel.

Title	Minimum Number
Test director/manager	1
Test conductor	1
Test operator	1–2
Roadside equipment technology expert	1
Vendor representative	1 per vendor
Test observers	As desired

Test Director (Quality Assurance Manager)

The test director supervises and controls all tests, reviews and approves test procedures, has authority to direct test activities, and is responsible for communicating test status to all stakeholders. The test director notifies key stakeholders of the test schedule in advance of the scheduled start.

Test Conductor

The test conductor is responsible for running daily test activities and remains in contact with vendors, as needed, to communicate which tests are being run and receive support input during testing. The test conductor distributes test scripts, forms, and other pertinent information, and answers questions.

Throughout the test day, the test conductor verifies that entrance criteria have been met for each test run, verifies readiness of test participants and equipment, and announces the start and end of each testing period. The test conductor also ensures other participants execute tests according to procedures. At all times, the test conductor is responsible for judging how to proceed if incidents or exceptions occur and canceling and rescheduling tests in the event a failure prevents a test from being executed.

At the end of the test period, the test conductor writes up the results of various completed test runs and incidents or exceptions that occurred. The status report is emailed to relevant stakeholders.

Test Operator

The test operator defines and executes test procedures to evaluate each device and records the outputs and overall results of each test.

Roadside Equipment Technology Expert

The technology expert has extensive knowledge of the technology under test. This includes use cases, underlying and enabling technologies, communication protocols, data transfer mechanism(s), and security. The technology expert advises the test conductor, as needed.

Vendor Representative

The vendor representative supports the test conductors and test operators during all testing phases, as required. Support is provided in person or remotely. A representative of the vendor of each device being certified should be involved in the testing.

Test Observers

Test observers witness test runs at the certification test lab's (CTL) discretion.

Note: Some roles can be combined such that a single person assumes up to two roles (i.e., the test conductor can also be the test operator).

Documentation

Test Records

Specific test information, including test environment, test execution, attendees/participants/observers, are captured for each individual test. Each requirement evaluated will be marked with a P or an F, indicating success (pass) or failure (fail). All failures, work-arounds, and deviations from procedure are recorded in a comments section of the form. These entries are entered electronically during test execution.

Risks and Mitigation

Risks include product risks and project risks. Product risks include flaws in the content or structure of a message due to misunderstandings or errors in implementation; these may be expected. These risks may be mitigated by accepting from reputable manufacturers devices whose primary functionalities have gone through other qualification testing or have been used in the field. Project risks include lack of trained staff due to new and evolving test tools, rigid deadlines, and changing industry standards and requirements. Other risks include the possibility of using unknown MAP data formats as input. The MAP application under test may not be robust enough to handle subtle changes in the input data, which are caused by multiple options available. This may be mitigated by defining the standard set of input variables required for conversion. Early deployers must adhere to the specific MAP data input formats for successful testing and implementation.

Chapter 4. Test Case Specifications

This section contains information about individual test case specifications, which are used to certify and evaluate if roadside equipment (RSE) can provide critical and necessary Society of Automotive Engineers (SAE) J2735 MAP message objects for target connected vehicle (CV) applications.

General Test Environment Setup

Chapter 2 presented the minimum device requirements for executing the test cases. Figure 1 shows a general test environment setup. A physical or virtual wireless broadcasting device under test (DUT) needs to be compatible with the SAE J2735 standard messages. A personal computer (PC) is needed to conduct all test cases. A user-desired packet capture (.pcap decoder) tool, like Wireshark, is expected to be installed on this PC. (Note: this document uses Wireshark as an example to illustrate test procedures. This does not indicate the authors endorse Wireshark.)

The following steps are necessary to configure the wireless broadcasting device and logging computer before conducting test cases described in this document:

- Configure DUT:
    - Power on the device using Power-over-Ethernet (PoE) or other available power source.
    - Connect to the device under test using an Ethernet/Wi-Fi connection.
    - Use one of the following methods for data capture based on the functions available for the DUT:
        i. Configure the device to log the encoded SAE J2735 MAP messages on the DUT, to be accessed by the logging device.
        ii. Forward the MAP messages to the Ethernet interface pointing to the internet protocol (IP) address of the logging device.
        iii. Use a packet capture tool to capture and log the packets over the available wireless technology for further analysis on the device.
- Configure PC:
    - Power on the PC.
    - Configure the DUT using secure shell (SSH) or other available communication method to enable logging of encoded SAE J2735 MAP message packets using any of the three methods mentioned in the above section.
    - Configure a software package that can monitor and collect data on the target communication layer, or decode logged .pcap files for analysis (e.g., Wireshark).
- Decode message:
    - Decode the encoded SAE J2735 MAP message before checking for mandatory fields.
    - Use any of the below methods to decode the message:
        i. Configure the packet capture device to decode the SAE J2735 user datagram protocol (UDP) packet to unpack the various layers and decode the payload.

ii. Use an available Abstract Syntax Notation One (ASN.1), or other convertor, to convert the encoded payload to an object value defining output for analysis.

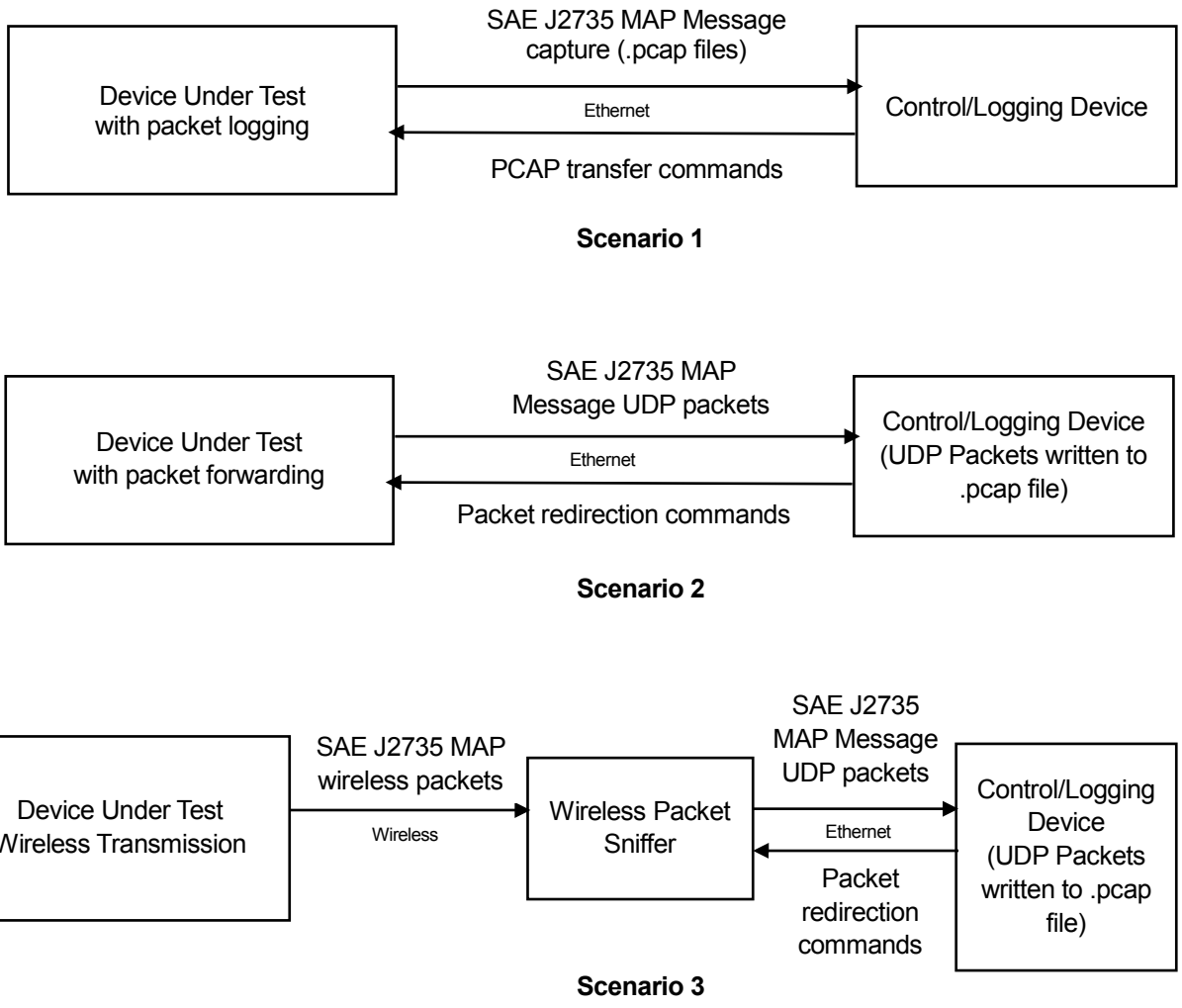

Figure 1. Diagram. Typical test environment setup.

Source: *Federal Highway Administration*

DUT can be any physical or virtual device that builds MAP messages according to the J2735 standard. After configuring the DUT, logging computer, and, alternatively, the wireless packet capture device, any two devices communicating through the Ethernet interface must be connected within a subnet by using an Ethernet cable or a network switch. The test operator must ensure communication between two devices are properly set up. The wireless interface of the device under test is the preferred method for collecting the output data.

Field Existence

The test cases listed in this section evaluate whether the mandatory fields exist in the MAP message broadcast from the RSE.

Table 3. MessageID and Message Type existence.

Test Case #	EXIST-01
Test Case	**MessageID and Message Type Existence**
Reference	*SAE J2735 2016: Section 7.40*
Objective	Users can verify MessageID and Message Type fields exist in the MAP message broadcast from the RSE
Entrance Criteria	RSE under test complies with SAE J2735 2016
Data Inputs	MAP message from the logging device and the IP address with listening port configured by the user
Data Outputs	MAP message contained in a .pcap file on the user's computer
Exit Criteria	MessageID and Message Type fields in the MAP message exist and the results are documented
Test Procedures	• The test operator configures the device under test to produce and transmit the encoded MAP message. • The test operator configures the test PC to receive the encoded MAP messages. • The test operator uses the converted SAE J2735 MAP Message in the ASN.1 or other human readable format to check the presence of MessageID and Message Type values. • Certain test tools may include MessageID and Message Type under "choice Index."

Table 4. msgIssueRevision (MsgCount) existence.

Test Case #	EXIST-02
Test Case	**msgIssueRevision (MsgCount) Existence**
Reference	*SAE J2735 2016: Section 7.104*
Objective	Users can verify msgIssueRevision field exists in the MAP message broadcast from the RSE
Entrance Criteria	RSE under test complies with SAE J2735 2016
Data Inputs	MAP message from the logging device and the IP address with listening port configured by the user
Data Outputs	MAP message contained in a .pcap file on the user's computer
Exit Criteria	msgIssueRevision exists in the MAP message broadcast and the results are documented
Test Procedures	• The test operator configures the device under test to produce and transmit the encoded MAP message.

Test Case #	EXIST-02
Test Case	**msgIssueRevision (MsgCount) Existence**
	• The test operator configures the test PC to receive the encoded MAP message. • The test operator uses the converted SAE J2735 MAP message in the ASN.1 or other human readable format to check for the presence of msgIssueRevision value. • Certain test tools may term msgIssueRevision as msgRevision.

Table 5. regionId existence.

Test Case #	EXIST-03
Test Case	**regionId Existence**
Reference	*SAE J2735 2016: Section 5.1, 7.151*
Objective	Users can verify regionId field exists in the MAP message broadcast from the RSE
Entrance Criteria	RSE under test complies with SAE J2735 2016
Data Inputs	MAP message from the logging device and the IP address with listening port configured by the user
Data Outputs	MAP message contained in a pcap file on the user's computer
Exit Criteria	regionId field exists in the MAP message broadcast and the results are documented

Test Procedures	• The test operator configures the device under test to produce and transmit the encoded MAP message.
	• The test operator configures the test PC to receive the encoded MAP message.
	• The test operator uses the converted SAE J2735 MAP message in the ASN.1 or other human readable format to check for the presence of regionId value.
	• The known regions are:
	  • RegionId 0: Default.
	  • RegionId 1: United States of America.
	  • RegionId 2: Japan.
	  • RegionId 3: European Union.

Table 6. id (IntersectionID) existence.

Test Case #	EXIST-04
Test Case	**id (IntersectionID) Existence**
Reference	*SAE J2735 2016: Section 6.36, 7.56*
Objective	Users can verify id field exists in the MAP message broadcast from the RSE

Test Case #	EXIST-04
Test Case	**id (IntersectionID) Existence**
Entrance Criteria	RSE under test complies with SAE J2735 2016
Data Inputs	MAP message from the logging device and the IP address with listening port configured by the user
Data Outputs	MAP message contained in a .pcap file on the user's computer
Exit Criteria	id field exists in the MAP message broadcast and the results are documented
Test Procedures	• The test operator configures the device under test to produce and transmit the encoded MAP message. • The test operator configures the test PC to receive the encoded MAP message. • The test operator uses the converted SAE J2735 MAP message in the ASN.1 or other human readable format to check for the presence of id.

Table 7. refPoint (Lat + Long) existence.

Test Case #	EXIST-05
Test Case	**refPoint (Lat + Long) Existence**
Reference	*SAE J2735 2016: Section 6.34*
Objective	Users can verify refPoint (Lat + Long) field exists in the MAP message broadcast from the RSE
Entrance Criteria	RSE under test complies with SAE J2735 2016
Data Inputs	MAP message from the logging device and the IP address with listening port configured by the user
Data Outputs	MAP message contained in a .pcap file on the user's computer
Exit Criteria	refPoint (Lat + Long) field exists in the MAP message broadcast and the results are documented
Test Procedures	• The test operator configures the DUT to produce and transmit the encoded MAP message. • The test operator configures the test PC to receive the encoded MAP message. • The test operator uses the converted SAE J2735 MAP message in the ASN.1 or other human readable format to check the presence of refPoint value.

Table 8. nodeList (x,y offset from refPoint) existence.

Test Case #	EXIST-06
Test Case	**nodeList (x,y offset from refPoint) Existence**
Reference	*SAE J2735 2016: Section 6.11, 6.29, 6.72, 6.75, 6.72*
Objective	Users can verify nodeList (x,y offset from refPoint) field exists for each lane in the MAP message broadcast from the RSE
Entrance Criteria	RSE under test complies with SAE J2735 2016
Data Inputs	MAP message from the logging device and the IP address with listening port configured by the user
Data Outputs	MAP message contained in a .pcap file on the user's computer
Exit Criteria	nodeList (x,y offset from refPoint) field exists for each lane in the MAP message broadcast and the results are documented
Test Procedures	• The test operator configures the DUT to produce and transmit the encoded MAP message. • The test operator configures the test PC to receive the encoded MAP message. • The test operator uses the converted SAE J2735 MAP message in the ASN.1 or other human readable format to check the presence of nodeList values for each lane in the MAP message.

Table 9. ingressApproach (ID) or egressApproach (ID) existence.

Test Case #	EXIST-07
Test Case	**ingressApproach (ID) or egressApproach (ID) Existence**
Reference	*SAE J2735 2016: Section 6.29, 7.11*
Objective	Users can verify ingressApproach or egressApproach field exists for each lane in the MAP message broadcast from the RSE; a lane must have only one or the other
Entrance Criteria	RSE under test complies with SAE J2735 2016
Data Inputs	MAP message from the logging device and the IP address with listening port configured by the user
Data Outputs	MAP message contained in a .pcap file on the user's computer
Exit Criteria	Either ingress ApproachID or egress ApproachID field exists for each lane in the MAP message broadcast and the results are documented
Test Procedures	• The test operator configures the DUT to produce and transmit the encoded MAP message. • The test operator configures the test PC to receive the encoded MAP message.

Test Case #	EXIST-07
Test Case	**ingressApproach (ID) or egressApproach (ID) Existence**
	• The test operator uses the converted SAE J2735 MAP message in the ASN.1 or other human readable format to check the presence of ingressApproach or egressApproach value for each lane in the MAP message.

Table 10. laneID existence.

Test Case #	EXIST-08
Test Case	**laneID Existence**
Reference	*SAE J2735 2016: Section 6.14, 7.86*
Objective	Users can verify laneID field exists under GenericLane for each lane in the MAP message broadcast from the RSE
Entrance Criteria	RSE under test complies with SAE J2735 2016
Data Inputs	MAP message from the logging device and the IP address with listening port configured by the user
Data Outputs	MAP message contained in a .pcap file on the user's computer
Exit Criteria	laneID field exists for each lane in the MAP message broadcast and the results are documented
Test Procedures	• The test operator configures the DUT to produce and transmit the encoded MAP message. • The test operator configures the test PC to receive the encoded MAP message. • The test operator uses the converted SAE J2735 MAP message in the ASN.1 or other human readable format to check for the presence of laneID values for each lane in the MAP message.

Table 11. directionalUse existence.

Test Case #	EXIST-10
Test Case	**directionalUse Existence**
Reference	*SAE J2735 2016: Section 7.87*
Objective	Users can verify directionalUse field exists for each lane in the MAP message broadcast from the RSE; a lane must have only one or the other
Entrance Criteria	RSE under test complies with SAE J2735 2016
Data Inputs	MAP message from the logging device and the IP address with listening port configured by the user
Data Outputs	MAP message contained in a .pcap file on the user's computer

Test Case #	EXIST-10
Test Case	**directionalUse Existence**
Exit Criteria	directionalUse field exists for each lane in the MAP message broadcast and the results are documented
Test Procedures	• The test operator configures the DUT to produce and transmit the encoded MAP message. • The test operator configures the test PC to receive the encoded MAP messages. • The test operator uses the converted SAE J2735 MAP message in the ASN.1 or other human readable format to check the presence of directionalUse value for each lane in the MAP message. • Certain test tools may show the value under "LaneDirection."

Table 12. connectingLane existence (only in case of ingress lane).

Test Case #	EXIST-11
Test Case	**connectingLane Existence (Only in Case of Ingress Lane)**
Reference	*SAE J2735 2016: Section 6.13*
Objective	Users can verify connectingLane field exists for each ingress lane in the MAP message broadcast from the RSE
Entrance Criteria	RSE under test complies with SAE J2735 2016
Data Inputs	MAP message from the logging device and the IP address with listening port configured by the user
Data Outputs	MAP message contained in a .pcap file on the user's computer
Exit Criteria	connectingLane field exists for each ingress lane in the MAP message broadcast and the results are documented
Test Procedures	• The test operator configures the DUT to produce and transmit the encoded MAP message. • The test operator configures the test PC to receive the encoded MAP messages. • The test operator uses the converted SAE J2735 MAP message in the ASN.1 or other human readable format to check the presence of connectingLane value for each ingress lane in the MAP message.

Table 13. maneuvers existence (only in case of ingress lane).

Test Case #	EXIST-12
Test Case	**maneuvers existence (Only in Case of Ingress Lane)**
Reference	*SAE J2735 2016: Section 6.29, 7.4*
Objective	Users can verify maneuvers field exists under GenericLane for each ingress lane in the MAP message broadcast from the RSE
Entrance Criteria	RSE under test complies with SAE J2735 2016
Data Inputs	MAP message from the logging device and the IP address with listening port configured by the user
Data Outputs	MAP message contained in a .pcap file on the user's computer
Exit Criteria	Maneuvers field exists for each ingress lane in the MAP message broadcast and the results are documented
Test Procedures	• The test operator configures the DUT to produce and transmit the encoded MAP message. • The test operator configures the test PC to receive the encoded MAP message. • The test operator uses the converted SAE J2735 MAP message in the ASN.1 or other human readable format to check the presence of maneuvers value for each ingress lane in the MAP message.

Input Verification

The test cases in this section evaluate if the mandatory fields in the MAP message broadcast from the RSE match with the input.

Table 14. messageID and Message Type input verification.

Test Case #	VERIFY-01
Test Case	**MessageID and Message Type Input Verification**
Reference	*SAE J2735 2016: Section 7.40*
Objective	Users can verify the MessageID and Message Type fields in the MAP message broadcast from the RSE match with the input source
Entrance Criteria	RSE under test complies with SAE J2735 2016 and the message id and Message Type fields exist
Data Inputs	Encoded MAP message and user-generated MAP input source
Data Outputs	Report verifying the value associated with MessageID and Message Type fields by comparing the encoded MAP message logs to the user-generated MAP input source
Exit Criteria	MessageID and Message Type data in the MAP message broadcast are verified with the input and the results are documented

Test Case #	VERIFY-01
Test Case	**MessageID and Message Type Input Verification**
Test Procedures	• The test operator configures the DUT to produce and transmit the encoded MAP message. • The test operator configures the test PC to receive the encoded MAP messages. • The test operator uses the converted SAE J2735 MAP message in the ASN.1 or other human readable format to compare the Message ID and Message Type values with the original MAP file used for store and repeat. • Certain test tools may include MessageID and Message Type under “choice Index.” • The acceptable values are: ○ DSRCmsgID and Message Type: 18 – MAP. • The test operator repeats the test with an invalid input, and verifies that an invalid output is not produced.

Table 15. msgIssueRevision (MsgCount) input verification.

Test Case #	VERIFY-02
Test Case	**msgIssueRevision (MsgCount) Input Verification**
Reference	*SAE J2735 2016: Section 7.104*
Objective	Users can verify the msgIssueRevision field in the MAP message broadcast from the RSE matches with the input
Entrance Criteria	RSE under test complies with SAE J2735 2016 and the msgIssueRevision field exists
Data Inputs	Encoded MAP message and user-generated MAP input source
Data Outputs	Report verifying the value associated with msgIssueRevision field by comparing the encoded MAP message logs to the user-generated MAP input source
Exit Criteria	msgIssueRevision data in the MAP message broadcast are verified with the input and the results are documented
Test Procedures	• The test operator configures the DUT to produce and transmit the encoded MAP message. • The test operator configures the test PC to receive at least 257 encoded MAP messages. • The test operator uses the converted SAE J2735 MAP message in the ASN.1 or other human readable format to verify that the value contained in the msgIssueRevision field is monotonically increasing, except when the value rolls over, and within the acceptable range. • Certain test tools may term msgIssueRevision as msgRevision. • The acceptable values are: • MsgCount: integer (0..127).

Table 16. regionId input verification.

Test Case #	**VERIFY-03**
Test Case	**regionId Input Verification**
Reference	*SAE J2735 2016: Section 5.1, 7.151*
Objective	Users can verify the regionId field in the MAP message broadcast from the RSE matches with the input
Entrance Criteria	RSE under test complies with SAE J2735 2016 and the regionId field exists
Data Inputs	Encoded MAP message and user-generated MAP input source
Data Outputs	Report verifying the value associated with regionId field by comparing the encoded MAP message logs to the user-generated MAP input source
Exit Criteria	regionId data in the MAP message broadcast are verified with the input and the results are documented

Test Procedures	• The test operator configures the DUT to produce and transmit the encoded MAP message.
	• The test operator configures the test PC to receive the encoded MAP messages.
	• The test operator uses the converted SAE J2735 MAP message in the ASN.1 or other human readable format to compare the regionId value with the original MAP file used for store and repeat.
	• The acceptable values are:
	  • RegionId: integer (0..255).
	• The test operator repeats the test with the following values:
	  • Lowest acceptable value.
	  • Highest acceptable value.
	  • Value within acceptable range.
	  • Value outside of range.
	A list of recommended values to be tested is available in appendix A.

Table 17. id (IntersectionID) input verification.

Test Case #	**VERIFY-04**
Test Case	**id (IntersectionID) Input Verification**
Reference	*SAE J2735 2016: Section 6.36, 7.56*
Objective	Users can verify the id field in the MAP message broadcast from the RSE matches with the input
Entrance Criteria	RSE under test complies with SAE J2735 2016 and the IntersectionID exists
Data Inputs	Encoded MAP message and user-generated MAP input source

Test Case #	VERIFY-04
Test Case	**id (IntersectionID) Input Verification**
Data Outputs	Report verifying the value associated with id field by comparing the encoded MAP message logs to the user-generated MAP input source
Exit Criteria	id data in the MAP message broadcast are verified with the input and the results are documented

Test Procedures	• The test operator configures the DUT to produce and transmit the encoded MAP message.
	• The test operator configures the test PC to receive the encoded MAP messages.
	• The test operator uses the converted SAE J2735 MAP message in the ASN.1 or other human readable format to compare the id value with the original MAP file used for store and repeat.
	• The acceptable values are:
	  • IntersectionID: integer (0..65535).
	• The test operator repeats the test with the following values:
	  • Lowest acceptable value.
	  • Highest acceptable value.
	  • Value within acceptable range.
	  • Value outside of range.
	A list of recommended values to be tested is available in appendix A.

Table 18. refPoint (Lat + Long) input verification.

Test Case #	**VERIFY-05**
Test Case	**refPoint (Lat + Long) Input Verification**
Reference	*SAE J2735 2016: Section 6.34*
Objective	Users can verify the refPoint (Lat + Long) field in the MAP message broadcast from the RSE matches with the input
Entrance Criteria	RSE under test complies with SAE J2735 2016 and the refPoint field exists
Data Inputs	Encoded MAP message and user-generated MAP input source
Data Outputs	Report verifying the value associated with refPoint (Lat + Long) field by comparing the encoded MAP message logs to the user-generated MAP input source
Exit Criteria	refPoint (Lat + Long) data in the MAP message broadcast are verified with the input and the results are documented

Test Procedures	• The test operator configures the DUT to produce and transmit the encoded MAP message.
	• The test operator configures the test PC to receive the encoded MAP messages.
	• The test operator uses the converted SAE J2735 MAP message in the ASN.1 or other human readable format to compare the refPoint value with the original MAP file used for store and repeat.
	• The acceptable values are:
	  ○ Latitude: integer (-900000000..900000001).
	  ○ Longitude: integer (-1799999999..1800000001).
	  ○ Elevation: integer (-4096..61439) [optional].
	• The test operator repeats the test with the following values:
	  ○ Lowest acceptable value.
	  ○ Highest acceptable value.
	  ○ Value within acceptable range.
	  ○ Value outside of range.
	A list of recommended values to be tested is available in appendix A.

Table 19. nodeList (x,y offset from refPoint) input verification.

Test Case #	**VERIFY-06**
Test Case	**nodeList (x,y offset from refPoint) Input Verification**
Reference	*SAE J2735 2016: Section 6.11, 6.29, 6.72, 6.75, 7.72*
Objective	Users can verify the nodeList (x,y offset from refPoint) field for each lane in the MAP message broadcast from the RSE matches with the input
Entrance Criteria	RSE under test complies with SAE J2735 2016 and the nodeList field exists

Test Case #	VERIFY-06
Test Case	**nodeList (x,y offset from refPoint) Input Verification**
Data Inputs	Encoded MAP message and user-generated MAP input file
Data Outputs	Report verifying the value associated with nodeList (x,y offset from refPoint) field by comparing the encoded MAP message logs to the user-generated MAP input source
Exit Criteria	nodeList (x,y offset from refPoint) data for each lane in the MAP message broadcast are verified with the input and the results are documented

Test Procedures	• The test operator configures the DUT to produce and transmit the encoded MAP message.
	• The test operator configures the test PC to receive the encoded MAP messages.
	• The test operator uses the converted SAE J2735 MAP message in the ASN.1 or other human readable format to compare the nodeList value for each lane with the original MAP file used for store and repeat.
	• The acceptable values are:
	  • nodeSetXY (a set of 20, 22, 24, 26, 28, 32, or 64-bit values).
	  • computedLane.
	• The test operator repeats the test with the following values:
	  • Lowest acceptable value.
	  • Highest acceptable value.
	  • Value within acceptable range.
	  • Value outside of range.
	A list of recommended values to be tested is available in appendix A.

Table 20. ingressApproach (ID) or egressApproach (ID) input verification.

Test Case #	VERIFY-07
Test Case	**ingressApproach (ID) or egressApproach (ID) Input Verification**
Reference	*SAE J2735 2016: Section 6.29, 7.11*
Objective	Users can verify the ingressApproach or egressApproach field for each lane in the MAP message broadcast from the RSE matches with the input; a lane must have only one or the other
Entrance Criteria	RSE under test complies with SAE J2735 2016 and the ingressApproach or egressApproach field exists
Data Inputs	Encoded MAP message and user-generated MAP input source
Data Outputs	Report verifying the value associated with ingressApproach or egressApproach field by comparing the encoded MAP message logs to the user-generated MAP input source
Exit Criteria	Either ingressApproach or egressApproach data for each lane in the MAP message broadcast are verified with the input and the results are documented

Test Case #	VERIFY-07
Test Case	**ingressApproach (ID) or egressApproach (ID) Input Verification**

Test Procedures	• The test operator configures the DUT to produce and transmit the encoded MAP message.
	• The test operator configures the test PC to receive the encoded MAP messages.
	• The test operator uses the converted SAE J2735 MAP message in the ASN.1 or other human readable format to compare the ingressApproach value for each lane with the original MAP file used for store and repeat.
	• The acceptable values are:
	  • ApproachID: integer (0..15) [0 to be used when valid value is unknown].
	• The test operator repeats the test with the following values:
	  • Lowest acceptable value.
	  • Highest acceptable value.
	  • Value within acceptable range.
	  • Value outside of range.
	A list of recommended values to be tested is available in appendix A.

Table 21. laneID input verification.

Test Case #	VERIFY-08
Test Case	**laneID Input Verification**
Reference	*SAE J2735 2016: Section 6.14, 7.86*
Objective	Users can verify the laneID field under GenericLane for each lane in the MAP message broadcast from the RSE matches with the input
Entrance Criteria	RSE under test complies with SAE J2735 2016 and the laneID field exists
Data Inputs	Encoded MAP message and user-generated MAP input source
Data Outputs	Report verifying the value associated with laneID field by comparing the encoded MAP message logs to the user-generated MAP input source
Exit Criteria	laneID data for each lane in the MAP message broadcast are verified with the input and the results are documented
Test Procedures	• The test operator configures the DUT to produce and transmit the encoded MAP message. • The test operator configures the test PC to receive the encoded MAP messages. • The test operator uses the converted SAE J2735 MAP message in the ASN.1 or other human readable format to compare the laneID value for each lane with the original MAP file used for store and repeat. • The acceptable values are:

Test Case #	VERIFY-08
Test Case	**laneID Input Verification**

	• LaneID: integer (0..255).
	• The test operator repeats the test with the following values:
	  • Lowest acceptable value.
	  • Highest acceptable value.
	  • Value within acceptable range.
	  • Value outside of range.
	A list of recommended values to be tested is available in appendix A.

Table 22. directionalUse input verification.

Test Case #	VERIFY-10
Test Case	**directionalUse Input Verification**
Reference	*SAE J2735 2016: Section 7.87*
Objective	Users can verify the directionalUse field for each lane in the MAP message broadcast from the RSE matches with the input; a lane must have only one or the other
Entrance Criteria	RSE under test complies with SAE J2735 2016 and the directionalUse field exists
Data Inputs	Encoded MAP message and user-generated MAP input source
Data Outputs	Report verifying the value associated with directionalUse field by comparing the encoded MAP message logs to the user-generated MAP input source
Exit Criteria	directionalUse data for each lane in the MAP message broadcast are verified with the input and the results are documented

Test Procedures	• The test operator configures the DUT to produce and transmit the encoded MAP message.
	• The test operator configures the test PC to receive the encoded MAP messages.
	• The test operator uses the converted SAE J2735 MAP message in the ASN.1 or other human readable format to compare the directionalUse value for each lane with the original MAP file used for store and repeat.
	• Certain test tools may show the value under “LaneDirection.”
	• The acceptable values are:
	  • LaneDirection: BitString (0..1)
	  ingressPath: bit 0.
	  egressPath: bit 1.
	• The test operator repeats the test with the following values:
	  • Lowest acceptable value.
	  • Highest acceptable value.

Test Case #	VERIFY-10
Test Case	**directionalUse Input Verification**
	• Value within acceptable range. • Value outside of range. A list of recommended values to be tested is available in appendix A.
	•

Table 23. connectingLane input verification (only in case of ingress lane).

Test Case #	VERIFY-11
Test Case	**connectingLane Input Verification (Only in Case of Ingress Lane)**
Reference	*SAE J2735 2016: Section 6.13*
Objective	Users can verify the connectingLane field for each ingress lane in the MAP message broadcast from the RSE matches with the input
Entrance Criteria	RSE under test complies with SAE J2735 2016 and the connectingLane field exists
Data Inputs	Encoded MAP message and user-generated MAP input source
Data Outputs	Report verifying the value associated with connectingLane field by comparing the encoded MAP message logs to the user-generated MAP input source
Exit Criteria	connectingLane data for each ingress lane in the MAP message broadcast is verified with the input and the results are documented

Test Procedures	• The test operator configures the DUT to produce and transmit the encoded MAP message.
	• The test operator configures the test PC to receive the encoded MAP messages.
	• The test operator uses the converted SAE J2735 MAP message in the ASN.1 or other human readable format to compare the connectingLane value for each ingress lane with the original MAP file used for store and repeat.
	• The acceptable values are:
	  • LaneID: integer (0..255).
	  • AllowedManeuvers: integer (0..12) [optional].
	• The test operator repeats the test with the following values:
	  • Lowest acceptable value.
	  • Highest acceptable value.
	  • Value within acceptable range.
	  • Value outside of range.
	A list of recommended values to be tested is available in appendix A.

Table 24. Maneuvers input verification (only in case of ingress lane).

Test Case #	**VERIFY-12**
Test Case	**Maneuvers Input Verification (Only in Case of Ingress Lane)**
Reference	*SAE J2735 2016: Section 7.4*
Objective	Users can verify the maneuvers field under GenericLane for each ingress lane in the MAP message broadcast from the RSE matches with the input
Entrance Criteria	RSE under test complies with SAE J2735 2016 and the maneuvers field exists
Data Inputs	Encoded MAP message and user-generated MAP input source
Data Outputs	Report verifying the value associated with maneuvers field by comparing the encoded MAP message logs to the user-generated MAP input source
Exit Criteria	Maneuvers data for each ingress lane in the MAP message broadcast is verified with the input and the results are documented

Test Procedures	• The test operator configures the DUT to produce and transmit the encoded MAP message.
	• The test operator configures the test PC to receive the encoded MAP messages.
	• The test operator uses the converted SAE J2735 MAP message in the ASN.1 or other human readable format to compare the maneuvers value for each ingress lane with the original MAP file used for store and repeat.
	• The acceptable values are:
	  • AllowedManeuvers: BitString (0..11) [optional].
	• The test operator repeats the test with the following values:
	  • Lowest acceptable value.
	  • Highest acceptable value.
	  • Value within acceptable range.
	  • Value outside of range.
	A list of recommended values to be tested is available in appendix A.

Multiple MAP File Verification

Table 25. Check if the roadside equipment can handle various intersection geometries.

Test Case #	**SAMPLE-01**
Test Case	**MAP File Sample Verification**
Reference	*SAE J2735 2016: Section 5.6*
Objective	Users can verify the RSE can broadcast various intersection geometries
Entrance Criteria	RSE under test complies with SAE J2735 2016

Test Case #	SAMPLE-01
Test Case	**MAP File Sample Verification**
Data Inputs	Encoded MAP messages and user-generated MAP input source
Data Outputs	Report verifying the RSE can broadcast various intersection geometries by comparing the encoded MAP message logs to the user-generated MAP input source
Exit Criteria	MAP messages broadcast are consistent with the input and the results are documented
Test Procedures	• The test operator configures the DUT to produce and transmit the encoded MAP messages. • The test operator configures the test PC to receive the encoded MAP messages. • The test operator uses the converted SAE J2735 MAP message in the ASN.1 or other human readable format to compare with the original MAP file used. • Any inconsistencies between the encoded MAP messages and the input map files are noted.

Appendix A. Test Values for MAP Fields

Field Under Test	Lowest Acceptable Value	Highest Acceptable Value	Within Acceptable Range	Positive Invalid Value	Negative Invalid Value
msgIssueRevision	0	127	64	129	-1
regionId	0	255	128	256	-1
id (IntersectionID)	0	65535	32768	65536	-1
refPoint (Lat)	-900000000	900000001	1	900000002	-900000001
refPoint (Long)	-1799999999	1800000001	1	1800000002	-1800000000
nodeList (x,y offset)	-32768	32767	32000	32768	-32769
nodeList (lat,lon)	-900000000, -1799999999	900000001, 1800000001	389564590, -771502970	900000002, 1800000002	-900000001, -1800000000
ingressApproach	0	15	7	16	-1
egressApproach	0	15	7	16	-1
laneID	0	255	128	256	-1
*laneSharing	0	511	257	512	-1
directionalUse	0	3	1	4	-1
laneID (ConnectingLane)	0	255	128	256	-1
*AllowedManeuvers (ConnectingLane)	0	4095	3840	4096	-1
*maneuvers	0	4095	129	4096	-1

* indicates field is optional

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