V2X Interoperability Test Plan

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Revision History

Date	Rev.	Section(s)	Description
8/13/24	-	-	Initial Outline of V2X Interoperability Test Plan
8/14/24	-	1, 13, 14	Drafted Test Cases and Intro
8/21/24	-	1, 2, 4, 5, 9, 10, 11, 13	Addressed Tony English' comments
8/27	-	-	General Updates
9/3	-	2.1, 2.2, 3	Test Equipment information
9/13	-	14	Test Procedures

1 Introduction

1.1 Overview

With the accelerating deployment of Vehicle-to-Everything (V2X) technologies there is the potential for different interpretations of key V2X standards to introduce interoperability issues between operational deployments. It is critical that Interoperability Tests be conducted with operational deployments now to either validate that V2X standards are being interpreted correctly or identify issues and address them in standards before there are millions of devices deployed. Interoperability Testing around traveler information messages (TIM), road safety messages (RSM), Secure Credential Management System (SCMS) providers and newer cellular technologies is critical to accomplish now when changes to these messages and capabilities can be accomplished without effecting millions of devices. The Interoperability Test Plan 1 will outline the test cases and procedures for the end-to-end interoperability testing process.

1.2 Objectives

The goal for the Interoperability Test Technical Support task order is to test TIM, RSM, SCMS, and newer cellular technologies with Infrastructure Owner Operators (IOOs). The Interoperability Test will be designed to validate that the operational configuration of V2X devices and V2X communications between different IOOs and deployment agencies are interoperable with each other and to find potential areas where there may be interoperability issues.

The operational configuration and communication will be tested between different site's OBUs and V2X interactions between selected OBUs and RSUs. RSUs should be able to transmit the correct TIM for the appropriate test case. OBUs should be able to receive the TIM and display it only in the valid direction and Geographic Validity Region.

1.3 Assumptions

To demonstrate interoperable connected vehicle applications, many supporting connected vehicle technology elements need to be included:

- OBUs and RSUs need to use credentials obtained from the same security credential management system (SCMS), as defined in IEEE 1609.2.1, to include signatures with messages and validate received messages as necessary.
- Positioning accuracy must satisfy SAE J2945/1. It was agreed that the tests and demonstration of I2V interoperability will take place in an "open sky" environment with no site-specific position augmentation. This test will focus on I2V TIMs. No V2V testing is planned.
- Although the focus of the Interoperability Test is on light-duty vehicle interoperability, the presence of optional data content in device messages designed for trucks or other vehicle classes should not affect basic interoperability of messages and credentials.

1.4 References

Table 1 provides documentation that was used in the creation of this test plan:

Table 1. References

Document	Title
Interoperability Test Cases.zip (Multiple files)	Wyoming Interoperability Test Cases
CVP Phase 2 Test Plan	Connected Vehicle Pilot Phase Interoperability Test – Test Plan
TIM Definitions PowerPoint	TIM Definitions for Interoperability Testing
TIM Standardization PowerPoint	TIM Standardization

1.5 Document Overview

This document identifies and describes the organization, resources, activities, methods, and procedures that will be used during V2X Interoperability Testing. Sections included in this Test Plan include:

- **Section 1: I**ntroduction – States the purpose of this test plan, provides references to other documents relevant to this project, and identifies the scope of this plan.
- **Section 2: Test Equipment** – Identifies the equipment that will be tested within the scope of this test plan.
- **Section 3: Features to Be Tested** – Identifies the features of the test items that will be tested.
- **Section 4: Features Not to Be Tested** – Identifies any features of the test items that will not be tested.
- **Section 5: Approach** – Provides the overall test strategy for V2X Interoperability Testing. It defines the overall rules and processes that will be used.
- **Section 6: Pass/Fail Criteria** – Identifies the completion criteria for the test items included in the test plan.
- **Section 7: Suspension Criteria and Resumption Requirements** – Specifies what constitutes stoppage for a test or series of tests.
- **Section 8: Test Environment** – Describes the environment that V2X Interoperability Testing will be conducted within.
- **Section 9: Roles and Responsibilities** – Identifies who the responsible party is for areas of the test.
- **Section 10: Testing Preconditions** – Identifies the key tasks that must be complete before V2X Interoperability Testing can be conducted.
- **Section 11: Schedule** – Identifies the timeline for the key tasks and test items included in the test plan.
- **Section 12: Risks and Contingencies** – Identifies the overall risks to the project with emphasis on the test processes.

- **Section 13: Test Cases** – Provides the test cases for each of the tests that will be accomplished during testing.
- **Section 14: Test Procedures** – Provides the detailed step-by-step procedures for each test case.

2 Test Equipment

2.1 Test Equipment OBU

Table 2. Test Equipment OBU

Device	Vendor	Model #	SW Version	Quantity
OBU	Commsignia	ITS-OB4 Qualcomm	-	1
OBU	Commsignia	ITS-OB4 Qualcomm	-	1
OBU	Cohda	MK6	-	1
OBU	Ficosa	TCU-CARCOM-G1	-	1

2.2 Test Environment RSU

Table 3. Test Environment RSU

Device	Vendor	Model #	SW Version	Quantity
RSU	Commsignia	ITS-RS4 Qualcomm	-	2
RSU	Yunex	RSU2X Autotalks	-	1
RSU	Danlaw	RouteLink	-	1
RSU	Kapsch	RIS-9260	-	1

2.3 Test Item Installation

V2X Interoperability Test site equipment expectations include:

- Equipment shall be delivered to Vince Garcia at WYDOT by September 30th to provide enough time for initial equipment installation.
    - Shipping address and contact info:

        CC: Vince Garcia

Wyoming Department of Transportation

5300 Bishop Blvd, Cheyenne, WY 82009

2.4 TIM Generation

The following are the data needs for TIMs to be used at the Archer Test Track:

- Identification of which RSUs should be used to broadcast the TIM.
- Identification of whether production certifications are okay to use.
- ASN.1 code to send to the RSU using SNMP per CTI 4001.
- The ASN.1 code should be built for the road at the Archer Test Track.
- The TIM shall be saved in the following tool so that TIM parameters can be edited day of testing: Connected Vehicle TIM Message Creator (connectedvcs.com).
- MUTCD graphics (PNG/JPG) shall be used for OBUs.
- The OBUs shall use an ITIS sentence (preference for ITIS codes only and no text) to identify the TIM to MUTCD graphic.
- Identification of directionality to drive for the expected driver alert in the geofence.
- Identification of directionality to drive and not expect the driver alert in the geofence (if applicable).
- The deployer shall be prepared to generate any updates and expiration that are needed to test for ASN.1.

2.5 Data Collection and Logging

Each testing group will need to have a way to log data on the OBU. The minimum data needed to provide to the test management group is:

1) Location and time for each received TIM, to include TIM.
2) Location, time and heading (using BSM at time of driver alert for example) of vehicle with each driver alert for each TIM, to include TIM.

This data log should be provided in a way that does not require any vendor tools to view and do data analytics with. The data should be provided on a shared cloud data system (Google Drive, OneDrive, S3 bucket, etc.). Flash drives should not be used to share with test management group.

3 Features to Be Tested

V2X Interoperability Testing will focus on demonstrating interoperability between different IOOs and deployment agencies. This test is designed to validate the operational configuration and communication between RSUs and OBUs for sending TIMs. Three test cases have been designed for common TIM warning formats—Weather, Work Zone, and Variable Speed. Additional TIMs may be tested if time permits. As a stretch goal each TIM test, in addition to PC5 (LTE-V2X), will also be tested with MEC (Network-V2X).

Table 4. Test Equipment Used for Interoperability Tests (X = Required, Y = Stretch Goal)

Deployer	Equipment	Baseline	Weather TIM	Work Zone TIM	Variable Speed TIM	Edge CaseTIM
WYDOT: Commsignia RSU	CDOT OBU – Commsignia	X	X	X	X	Y
WYDOT: Commsignia RSU	GDOT OBU – Cohda	X	X	X	X	Y
WYDOT: Commsignia RSU	UDOT OBU – Ficosa	X	X	X	X	Y
CDOT: Commsignia RSU	WYDOT OBU – Commsignia	X	X	X	X	Y
CDOT: Commsignia RSU	UDOT OBU – Ficosa	X	X	X	X	Y
CDOT: Commsignia RSU	GDOT OBU – Cohda	X	X	X	X	Y
GDOT: Danlaw RSU	WYDOT OBU – Commsignia	X	X	X	X	Y
GDOT: Danlaw RSU	CDOT OBU – Commsignia	X	X	X	X	Y
GDOT: Danlaw RSU	UDOT OBU – Ficosa	X	X	X	X	Y
UDOT/Panasonic: Kapsch RSU	WYDOT OBU – Commsignia	X	X	X	X	Y
UDOT/Panasonic: Kapsch RSU	CDOT OBU – Commsignia	X	X	X	X	Y
UDOT/Panasonic: Kapsch RSU	GDOT OBU – Cohda	X	X	X	X	Y

4 Features Not to Be Tested

This round of interoperability testing is the first of three or four rounds, so this test is limited to TIMs. Future rounds of testing will likely have an expanded scope and include other message types in addition to TIMs.

The following features are not within scope of this testing:

- Negative testing of any of the applications.
- Performance testing of any of the applications.
- Road Safety Messages.
- Forward Collision Warning.
- Electronic Emerging Brake Light.
- Signal Phase and Timing.
- Connected Intersections testing.

5 Approach

This section covers the approach for test planning as well as the approach for conducting the test itself.

5.1 V2X Interoperability Demonstration Planning

5.2 Test Readiness Review (TRR)

Prior to V2X Interoperability Testing, there will be a Test Readiness Review (TRR) to review key pre-conditions in Section 10 that must be met before the demonstration can be held and to officially approve of the Test Cases and Test Procedures. Participating deployments will send their devices to the Interoperability Testing Environment to be delivered by September 30th. Progress towards test readiness will be reviewed at the V2X Cohort meetings, however the TRR will be the formal meeting where all stakeholders agree that they are ready to conduct the Interoperability Testing.

5.3 Test Execution

The execution of V2X Interoperability Testing will last for four days and will be split into three phases: (i) Installation and Checkout, (ii) Test Case/Test Procedure Dry Runs, and (iii) Interoperability Demonstration Runs for Record. Throughout all three phases, a Test Director, whose role is described in Section 9, will be the final authority on test activities including confirming completion of each phase and initiation of the subsequent phase. Test workbooks will be developed and distributed for guidance and test recording.

5.3.1 Installation and Checkout

The first phase will be installation and checkout. This phase will be accomplished in accordance with Section 2.3 of this document. It is anticipated that participants will send devices to the Interoperability Test Environment to be received by WYDOT by September 30th.The contractor shall assist in the checkout of Test Equipment and Test Environmental setup. At the completion of the installation and checkout, each site must confirm their devices under test are installed and operating correctly with verified conformance to prerequisite lower layer communication standards and security.

5.3.2 Test Case/Test Procedure Dry Runs

The second phase of test execution includes a dry run of the test cases and test procedures that are demonstrated during the interoperability test. Once the tests have been successfully run and devices and procedures appear to work correctly and demonstrate the necessary functionality, test execution moves to the third phase. If there are any issues during the dry runs, Noblis works with USDOT and test participants to quickly triage and determine adjustments or revisions to the test cases/procedures and document for the record testing phase.

5.3.3 Interoperability Demonstration Runs for Record

The third phase of test execution includes the official interoperability testing runs for record. During the runs for record phase, all test cases are executed per a USDOT approved schedule. During testing, Noblis appoints personnel to track a master copy of the workbook, track the status of each test executed, officially record pass/fails, note any issues or discrepancies.

5.3.4 Interoperability Test Workbooks

Interoperability test workbooks in electronic form are prepared for key test participants and delivered 10 business days before the start of each test. Noblis creates at least 20 hard copies to be available on the test days. The workbooks include the following:

- List of key points of contact with contact numbers
- Test schedules
- Test procedures for participants to track steps during testing with a notes column to make notes on any issues or discrepancies found during testing
- Expected outcomes for each test

5.4 Test Reporting

After the successful conclusion of V2X Interoperability Testing, a Test Report will be developed that provides an overview of all of the tests executed and their results. The Test Report will also provide an overview of the data collected and how to request/receive access to that data. Finally, it will provide lessons learned from interoperability testing as well as any issues encountered and how those issues were resolved/will be resolved.

6 Pass/Fail Criteria

The Pass/Fail criteria for each test case is listed in Section 13: Test Cases. For a Test Case to pass, it must fulfill all Pass criteria in that test case, or all Threshold criteria in those test cases that have Threshold and Objective criteria. Partially meeting pass criteria will result in a failure for that test case, however retesting may only require retesting the failed functionality.

7 Suspension Criteria and Resumption Requirements

There are multiple possible events that could require suspension of testing. The most critical would be safety of life issues either associated with an issue with the devices or if conditions in the test environment become hazardous to the vehicles operating within it (e.g., inclement weather). Other events could be inoperable devices or multiple devices experiencing critical functional issues. The Test Director will make the final decision on whether to suspend or resume testing. For testing to resume, the issue(s) that caused the suspension of testing must be confirmed to be resolved by all stakeholders involved with the test as well as the Test Director.

8 Test Environment

Testing will be conducted at the Archer Complex in Cheyenne, Wyoming. Figure 1 depicts a map of the test facility including key infrastructure (e.g., location of TIM geofences, conference room, and rest rooms) currently located at the Test Facility.

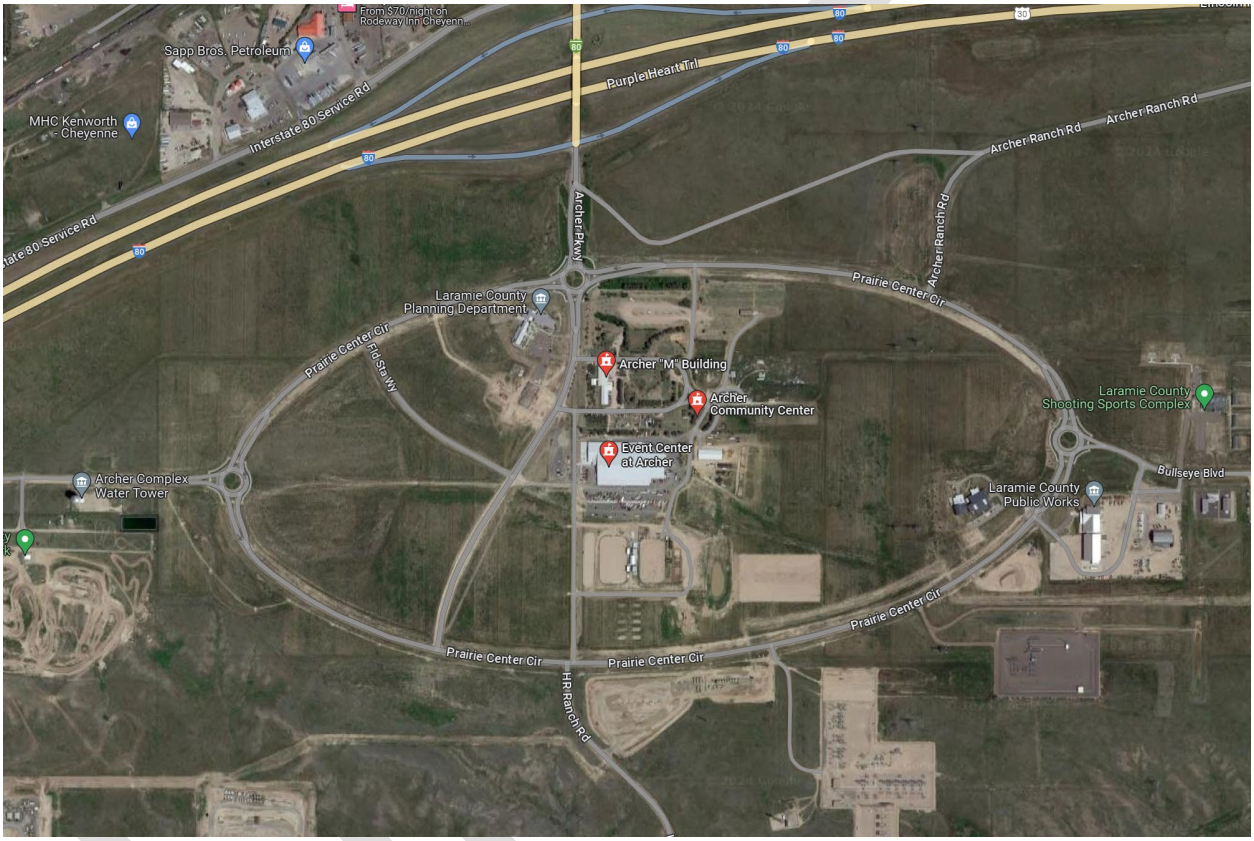

Figure 1. Map of the Test Facility

9 Roles and Responsibilities

The following roles are defined in this Test Plan.

Test Director – Tony English, Darren Weibler Assisting

The Test Director is responsible for managing the execution of testing. The Test Director is responsible for:

- Managing the execution of each Test Execution phase;
- Approving the completion of each test execution phase and will approve the initiation of the next phase;
- Suspending/resuming testing, as necessary, during test execution;
- Approving changes to the test schedule during the test execution phase; and
- Approving the end of testing.

Test Coordinator – Noblis

The Test Coordinator is responsible for:

- Maintaining and updating the V2X Interoperability Test Plan;
- Working with the applicable stakeholders to get inputs for gaps/updates to the test plan;
- Tracking the status of V2X Interoperability Test Planning/Test Readiness;
- Supporting the execution of interoperability testing by tracking progress of each deployer through each execution phase, tracking and redlining test procedures as they are run, and tracking and documenting issues and lessons learned; and
- Coordinating the development of V2X Interoperability Test Report.

Deployer Test Leads – Deployer 1: WYDOT Michael English, Deployer 2: CDOT Drew Johnston, Deployer 3: GDOT, and Deployer 4: UDOT/Panasonic

The Deployer Test Leads are responsible for:

- Providing site specific inputs to the V2X Interoperability Test Plan;
- Reviewing the V2X Interoperability Test Plan and providing comments;
- Providing site specific devices, installation kits, and other necessary equipment for the demonstration;
- Approving the installation and functional checkout of their site-specific devices;
- Troubleshooting issues found with site specific devices and/or identifying the subject matter experts necessary to troubleshoot their site-specific devices;
- Collecting data from site specific devices; and
- Providing site specific inputs to the V2X Interoperability Test Report; and
- Reviewing the V2X Interoperability Test Report and providing comments.

Test Support Personnel – Brandon Payne, Rick Smith and Daniel Stephenson to support TIM updates to RSUs for all devices.

The Test Team shall be responsible for:

- Providing inputs to the Interoperability Test Plan, specifically identifying the optimal locations to execute the Test Cases and Procedures in Sections 13 and 14 of this document;
- Preparing the test environment;
- Driving the vehicles through the test environment;
- Conducting test support roles such as Flagger and Manual Signal Operator; and
- Operating test environment specific devices/equipment.

USDOT Representative Team – Kate Hartman, Justin Anderson

The USDOT Representative Team shall be responsible for:

- Reviewing, commenting on and approving the V2X Interoperability Test Plan
- Witnessing the execution of the tests;
- Coordinating/Approving test support; and
- Reviewing, commenting on and approving the first V2X Interoperability Test Report.

V2X Device Vendors – Commsignia, Ficosa, Danlaw, Kapsch, Cohda

The V2X Device Vendors shall be responsible for:

- Providing test support and assistance to the Deployer Test Leads;
- Supporting device installation and checkout as necessary; and
- Supporting troubleshooting of issues found during testing as necessary.

10 Testing Preconditions

The following preconditions must be met before V2X Interoperability Testing can begin:

- All stakeholders must approve the Test Plan;
- All devices must be enrolled/have production certificates from the SCMS System;
- All devices must either have an OmniAir device certification or must be enrolled in the certification program and passed XXXX tests
- All devices must have demonstrated their required functionality within their respective deployments;
- Test environment is available and ready for V2X device installation.
    - Drivers are available and familiar with test cases and procedures;
    - Testing locations are available and have staff to help assist when necessary
        - Infrastructure is available and configured
            - Test Plan has been coordinated with facilities and neighbors
            - Flaggers have been identified and are available
    - Meeting rooms and other facilities are reserved;
    - Test Equipment is available and functional;
        - Wireless Packet Sniffers/
        - Vehicles
            - Potentially conflicting safety systems (e.g. automated steering) disabled
    - TIMs have been generated for each RSU location

11 Schedule

This section contains a detailed test schedule based on the deployment sites providing their OBUs and RSUs a minimum of two weeks before the start of formal testing. This schedule assumes using a single OBU installed in a single vehicle for each test run. A basic assumption of 10 minutes per test run is assumed for these schedules, however as Test Staff install devices and conduct dry runs, this assumption may be revised. The following is a more detailed breakout of the test schedule.

- **Test Readiness Review –**
    - Review Test Preconditions in Section 10 of this document and ensure all are either met or on track to be met before XXXX
    - All stakeholders approve the final test plan.
    - All Deployment programs confirm that they are still ready and able to participate in interoperability testing XXXX and that devices are received no later than XXXX.
- **Day 1: Monday**
    - 8:30 AM – 5:00 PM - Sites to Set-up Devices and Verify they are working properly
        - Note: V2X Interoperability Testing deployers to coordinate schedule with UDSDOT staff
- **Day 2: Tuesday**
    - 8:30 AM – 9:00 AM - Day 1 Welcome and Opening Remarks
    - 9:00 AM – 10:00 AM - Set-Up and Prep for Tests
    - 10:00 AM – 1:00 PM - Testing
    - 1:00 PM – 1:30 PM - Lunch
    - 1:30 PM – 5:00 PM - Testing
    - 5:00 PM – 5:30 PM - Wrap Up
- **Day 3: Wednesday**
    - 8:30 AM – 9:00 AM - Day 2 Kick-off and Prep for Tests
    - 9:00 AM – 1:00 PM - Testing
    - 1:00 PM – 1:30 PM - Lunch
    - 1:30 PM – 5:00 PM - Testing
    - 5:00 PM – 5:30 PM - Wrap Up
- **Day 4: Thursday**
    - 8:30 AM – 9:00 AM - Day 3 Kick-off and Prep for Tests
    - 9:00 AM – 1:00 PM - Testing
    - 1:00 PM – 1:30 PM - Lunch
    - ~~1:30 PM – 5:00 PM – Re-Testing/Ad Hoc Testing (as necessary)~~
    - ~~5:00 PM – 5:30 PM - Wrap Up~~

12 Risks and Contingencies

Table 5 provides the high-level risks and contingencies identified with conducting this Interoperability Test.

Table 5. Risks and Contingencies

Risk	Likelihood	Severity	Contingency
Foul Weather	Medium	Low	The most likely weather occurrence during the likely timeframe of the interoperability test is rain. The test team will monitor weather forecasts leading up to the interoperability test and the Test Director will make final decisions on if the weather conditions are safe enough to conduct testing.
GPS Accuracy	Medium	High	If sufficient GPS accuracy cannot be achieved (either through GPS satellite coverage or EMI interference) the V2V safety applications will not generate the proper warnings. This can be mitigated if the deployment programs can provide devices prior to testing so test staff can conduct early testing to characterize GPS coverage.
EMI Interference	Low	High	There is the possibility that neighboring facilities may conduct activities that could interfere with communications in the V2X spectrum. The Test Facility will coordinate this interoperability test with neighboring facilities to minimize the risk of this type of interference.
Test Vehicle Mechanical Breakdown	Low	Low	The Test Facility maintains a fleet of test vehicles and regularly conducts maintenance on them. If a test vehicle experiences mechanical issues the Test Facility will investigate the issue while testing can continue using the other vehicles with equipment installed. If the vehicle cannot be repaired in time, the Test Facility will determine the feasibility of installing the OBU in a different vehicle.

13 Test Cases

13.1 Baseline OBU Data Collection

13.1.1 Test Objective

The objective of the Baseline OBU Data Collection test is to collect data (Driver Alerts, BSMs, and TIMs) from OBUs from each deployer installed on a vehicle to create a baseline of how devices perform. If the deployer can provide their devices early, this testing may be accomplished prior to their arrival for testing. Otherwise, this test would be the first test accomplished and would be accomplished in conjunction with the Installation and Checkout Phase.

To collect baseline conditions, SCMS production certificates will be used for TIM generation on RSUs and OBUs. All broadcast TIMs will be signed unless testing receipt security on OBUs.

13.1.2 Test Description

Table 6 provides an overview of the OBUs installed in each test vehicle.

Table 6. OBUs Used for the Baseline OBU Data Collection Test

Vehicle	OBU 1	OBU 2
Vehicle #1	WYDOT Commsignia	CDOT Commsignia
Vehicle #2	UDOT Ficosa	GDOT Cohda

*** Note:** Vehicle will be rental cars used by each deployer.

Each vehicle travels the path shown in Figure 2. Baseline OBU Data Collection Path from Point A to Point B. The vehicle travels this path three times. The OBUs will collect driver alerts, BSMs, and TIMs that caused alert. All logs will include ms UTC time. At the conclusion, it is verified that TIMs were collected from each deployer. These logs will be uploaded to deployer selected cloud drive (OneDrive, Google Drive, S3 bucket or the like) for review by test admin team.

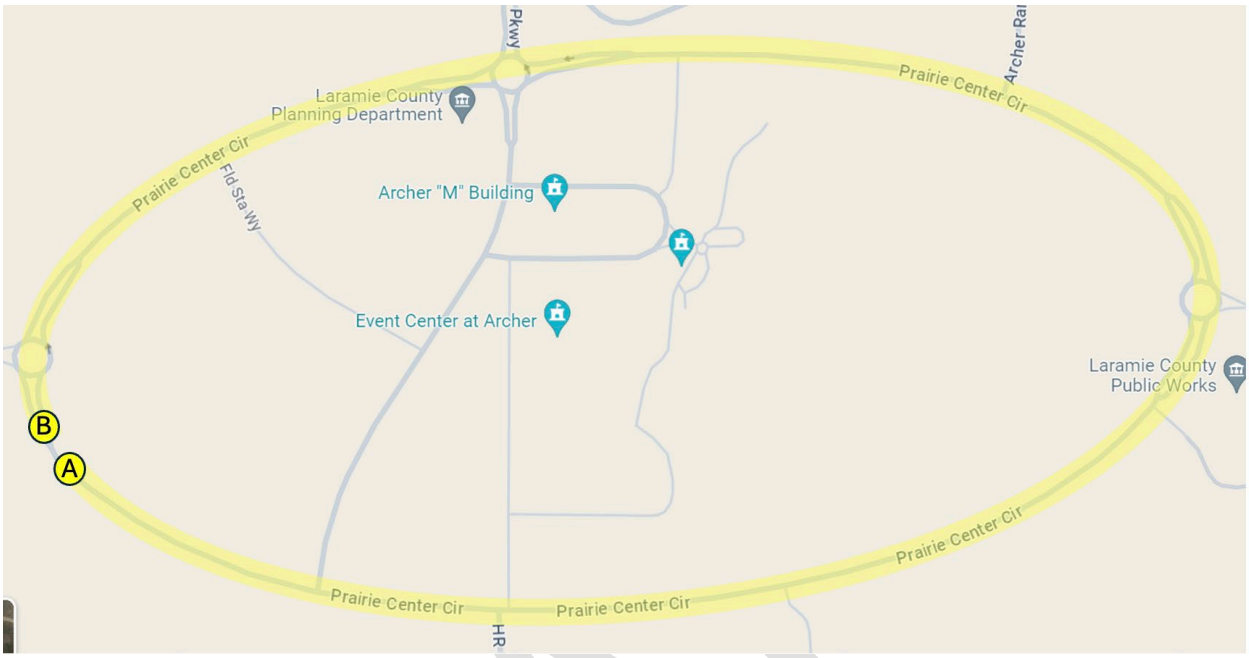

Figure 2. Baseline OBU Data Collection Path

13.2 Weather Warning TIM Test Cases

13.2.1 Weather Warning TIM Creation and Delivery

13.2.1.1 Test Objective

The objective of the Weather Warning TIM creation and delivery test case is for multiple deployments to generate a weather warning TIM for the same weather warning according to their operational processes, distribute that TIM to an RSU and have multiple different vendor OBUs drive past the RSU, store the TIM and then display the TIM only when it meets the criteria for display. The intent is to demonstrate that the TIM messages generated by each of the participating deployments can be received and displayed with the relevant information by each of the different OBU models. SCMS production certificates will be used for the generation of TIMs on RSUs and validated on the OBUs.

13.2.1.2 Test Description

The initial step of this test will be for all participating deployment agencies to generate a weather warning TIM as described below:

Figure 3. Weather Warning TIM location.

Value	Column 1	Column 2
msgCnt	1	-
packetID	8D442EF0010C6B1A01	-
dataframe	-	-
-	content	advisory
-	itis-codes	4868
Region	-	-
-	anchor	Lat: 41.153400 Lon: -104.657587
-	lane-width	50 m
-	directionality	3
-	closed-path	false
-	description	path
-	direction-mask	“1111000011110000”
suggested icon		-

The packetID and message count together uniquely identify the TIM. The provided packetID is an example value. For this initial TIM version, the message count is set to 1. Subsequent updates or revocations of this TIM will increment the message count. A depiction of the Geographic Validity Region of the TIM is shown in the figure above. The validity region geofence is defined as a path along the roadway with a 50-meter lane width. Note, the heading direction mask defines valid vehicle headings to provide this alert. In this case a driver alert for this TIM should be displayed in either direction of travel through the TIM geofence. A suggested driver display icon is provided; this is the suggested graphic to display for the driver if the OBU provides such a display.

The following hex string is a signed and encoded version of the initial Weather Warning TIM described above:

0381004003807b001f78701575588d442ef0010c6b1a010f775d9b0301c271635d816742b80ffff93f42baac
21c0a007f8da7bb7f74107963d197920a2c600000000271635d816742b809388de1e02110047671d088a0
d65048ed6d7824143342117657e409678b5e0476353fc26c52d781393d46b09fb2a7f8000004c10f775d9b

06001830002519767c5327f0002520c01ff120081010100030180c620fb90caad3b9c50820851142251286
5acbd396921000326e52b7883279c830101800348010100018381837 48c51728ff0d88dad3ecd5a87c471
e77fb53eb57db0dad64fe5c85dd5c59e5280805c022422a198a55df34d44d29a923feb3c22cf5e6326fdd01
0d8eedf67f1d55b7c3bad69cb4d46ea8eb928c9ccbb8445ef4084d92c65b1e3767e7943fddd343e

During the tests, the start time and duration will be configured for the broadcast TIMs to support a series of updates and revocations.

Each deployment will then either deploy the message directly to an RSU in the test environment or provide the message to the deployment agency that controls that RSU for deployment. The deployment agency will also detail whether:

- They sign their TIM messages at the TMC
- They sign their TIM messages at the RSU (expected way for most testing)
- They sign their TIM messages at the TMC, send to the RSU, RSU validates the signature on the TIM and then strips the certificate and signs with its certificate.

Vehicles with different OBU models will start driving at the top of the oval track from the north most roundabout, traveling counterclockwise around the oval. Observers will note that the Weather Warning TIM should appear on the HMI as the vehicle enters the geofence in the northwest quadrant of the oval track and should note the approximate time and location when the TIM appeared.

The vehicles will turn around through the east most roundabout and drive through the TIM geofence traveling clockwise around the oval. Observers will note that the Weather Warning TIM should appear on the HMI as the vehicle enters the geofence from the west side and should note the approximate time and location when the TIM appeared.

13.2.1.3 Pass/Fail Criteria

- RSUs correctly broadcast the Weather Warning TIM.
- OBUs receive the Weather Warning TIM and display it driving either way in the Geographic Validity Region.

13.2.2 Weather Warning TIM Revoke

13.2.2.1 Test Objective

The objective of the Weather Warning TIM Revoke test case is for deployments to revoke their original Weather Warning TIM message and verify that the OBU updates the TIM message that resides in their devices. Revoking a TIM message means updating the TIM message and setting the expiration time to within 5 minutes of the current time.

13.2.2.2 Test Description

To revoke the Weather Warning TIM deployments will update the originally generated Weather Warning TIM to change its validity time so that it becomes invalid within 5 minutes of the current time. The packetID of the TIM should remain the same as the original Weather Warning TIM, but the message count must be incremented to indicate that this newly generated TIM supersedes the original Weather Warning TIM.

Deployments will update their Weather Warning TIM with this validity time change and resend that TIM to the test environment RSUs. Vehicles may need to remain running between the original test and this revoke test to ensure the original TIM remains on the OBU and that the revocation TIM supersedes the original version. The vehicles will then travel the same pattern as described in Section 13.2.1.2, however in this case, a message should never appear on the HMI since the current time is outside the validity of the TIM. As an additional check, inspection of the OBU logs should show the TIM was updated internally to the latest version.

13.2.2.3 Pass/Fail Criteria

- RSUs correctly broadcast the updated Weather Warning TIM.
- OBUs receive the Weather Warning TIM and do not display it.
- OBUs update their internal saved version of the Weather Warning TIM.

13.3 Variable Speed Limit TIM

13.3.1 Variable Speed Limit TIM Creation and Delivery

13.3.1.1 Test Objective

The objective of the Variable Speed Limit TIM creation and delivery test case is for multiple deployments to generate a variable speed warning TIM for the same speed limit warning according to their operational processes, distribute that TIM to an RSU and have multiple different vendor OBUs drive past the RSU, store the TIM and then display the TIM only when it meets the criteria for a Driver Alert. The intent is to demonstrate that the TIM messages generated by each of the participating deployments can be received and displayed with the relevant information by each of the different OBU models.

13.3.1.2 Test Description

The initial step of this test will be for all participating deployment agencies to generate a Variable Speed Limit TIM as described below:

Figure 4. Variable Speed Limit TIM location.

Value	Column 1	Column 2
msgCnt	1	-
packetID	8D442EF002FC6B1B01	-
dataframe	-	-
-	content	speedLimit
-	itis-codes	268, 12599, 8720
region		
-	anchor	Lat: 41.1513384 Lon: -104.6444217
-	lane-width	50 m
-	directionality	3
-	closed-path	false
-	description	path
-	direction-mask	“0000000000001111”
region		
-	anchor	Lat: 41.15315006 Lon: -104.64710095

Value	Column 1	Column 2
-	lane-width	50 m
-	directionality	3
-	closed-path	false
-	description	path
-	direction-mask	“0000000000001111”
suggested icon		-

The packetID and message count together uniquely identify the TIM. The provided packetID is an example value. For this initial TIM version, the message count is set to 1. Subsequent updates or revocations of this TIM will increment the message count. A depiction of the Geographic Validity Region of the TIM is shown in the figure above. The validity region geofence for this TIM consists of two sequential regions as indicated in the parameters listed above. To get the exact path definition the encoded TIM included below can be decoded. The validity region geofence is defined as a path along the roadway with a 50-meter lane width. Note, the heading direction mask defines valid vehicle headings to provide this alert. In this case a driver alert for this TIM should be displayed while traveling in a northwest direction through the TIM geofence (counterclockwise direction around the test oval). A suggested driver display icon is provided; this is the suggested graphic to display for the driver if the OBU provides such a display.

The following hex string is a signed and encoded version of the initial Variable Speed Limit TIM described above:

03810040038081ce001f80ca701575588d442ef002fc6b1b010f775d9b0301c27160d9416752ca37fff93f42
baac21c0a017f98a7c32e5c9334edd3d10356a820f2c7a32f24145a2e6300000000138b06ca0b3a965189c
46000f1087033d5e9817e3a0405d7f4e15f7e8cc0a8a340485040a4b826db525c134d286a091434973fcc5
3e1972e499a76e9e881ab54107963d197920a2d17328000000009c58c3da59d3e13a4e23000788428492
3a0244bdf50e8a25aea85bd128e2c24b895d6e07a821c6c18810c2e000001900430626e22103ddd766c06
00183000251a824822ff40002520c01ff120081010100030180c620fb90caad3b9c508208511422512865ac
bd396921000326e52b7883279c830101800348010100001838183748c51728ff0d88dad3ecd5a87c471e77f
b53eb57db0dad64fe5c85dd5c59e52808045321cb9c97bb27a57de5c5732d970930c24ae1071977839e3e
6bd1f47b151f1b4f9be2fd7c9ad3d3f809dee0fdf6eb6e64bffc059e2c65cadf07ed0b51937c9

During the tests, the start time and duration will be configured for the broadcast TIMs to support a series of updates and revocations.

Each deployment will then either deploy the message directly to an RSU in the test environment or provide the message to the deployment agency that controls that RSU for deployment. The deployment agency will also detail whether:

- They sign their TIM messages at the TMC.
- They sign their TIM messages at the RSU (expected way for most testing).
- They sign their TIM messages at the TMC, send to the RSU, RSU validates the signature on the TIM and then strips the certificate and signs with its certificate.

Vehicles with different OBU models will start driving at the eastern side of the oval track at the eastern most roundabout, traveling counterclockwise around the oval. Observers will note that the Speed Limit TIM should appear on the HMI as the vehicle enters the geofence in the northeast quadrant of the oval track and should note the approximate time and location when the TIM appeared.

The vehicles will turn around through the north most roundabout and drive through the TIM geofence traveling clockwise around the oval. Observers should note that the Variable Speed Limit TIM does not appear on the HMI as the vehicle is traveling in the opposite direction of the defined valid heading mask.

13.3.1.3 Pass/Fail Criteria

- RSUs correctly broadcast the Variable Speed Limit TIM.
- OBUs receive the Variable Speed Limit TIM and display it only in the valid direction and Geographic Validity Region.

13.3.2 Variable Speed Limit TIM Update

13.3.2.1 Test Objective

The objective of the Variable Speed Limit TIM Update test case is for deployments to update their original Variable Speed Limit TIM message and verify that the OBUs update the TIM message that resides in their devices.

13.3.2.2 Test Description

The update to the Variable Speed Limit TIM will change the defined speed limit from 55 mph down to 45 mph. This represents a typical update that might be made in an area where changing conditions warrant a speed limit reduction. The updated TIM will retain the same packetID as the original, but will increment the message count to indicate this updated TIM supersedes the original TIM. In addition to the incremented message count, the ITIS codes will be updated to reflect the speed limit change. The previous version will remain broadcasting to ensure the OBUs are checking the message count and only displaying the latest TIM. These changes are indicated in the TIM parameters in the table below.

Value	Column 1	Column 2
msgCnt	2	-
packetID	8D442EF002FC6B1B01	-
dataframe	-	-
-	content	speedLimit
-	itis-codes	268, 12589, 8720
region	-	-
region	-	-
-	-	-
suggested icon		-

The following hex string is a signed and encoded version of the updated Variable Speed Limit TIM described above:

03810040038081ce001f80ca702575588d442ef002fc6b1b010f775d9b0301c27160d9416752ca37fff93f42baac21c0a017f98a7c32e5c9334edd3d10346a820f2c7a32f24145a2e6300000000138b06ca0b3a965189c46000f1087033d5e9817e3a0405d7f4e15f7e8cc0a8a340485040a4b826db525c134d286a091434973fcc53e1972e499a76e9e881a354107963d197920a2d17328000000009c58c3da59d3e13a4e230007884284923a0244bdf50e8a25aea85bd128e2c24b895d6e07a821c6c18810c2e000001900430625a22103ddd766c0600183000251a91999162b0002520c01ff120081010100030180c620fb90caad3b9c508208511422512865acbd396921000326e52b7883279c830101800348010100001838183748c51728ff0d88dad3ecd5a87c471e77fb53eb57db0dad64fe5c85dd5c59e52808090ceef9121f40e0b80de326440362522d60938bcb749b2f1c135a7429633aaa46f71709484567d0e5666bca6c344cf81db5716160f0af0e088a55fab74528639

Deployments will update their Speed Limit TIM with this speed limit change and resend that TIM to the test environment RSUs. Vehicles may need to remain running between the original test and this update test to ensure the original TIM remains on the OBU and that the updated TIM supersedes the original version. The vehicles will then travel the same pattern as described in Section 13.3.1.2, however in this case, the displayed message should reflect the updated speed limit. As an additional check, inspection of the OBU logs should show the TIM was updated internally to the latest version.

13.3.2.3 Pass/Fail Criteria

- RSUs correctly broadcast the updated Variable Speed Limit TIM.
- OBUs receive the updated Variable Speed Limit TIM and display it only in the valid direction and Geographic Validity Region.
- OBUs update their internal saved version of the Variable Speed Limit TIM with the updated TIM.

13.4 Work Zone TIM

13.4.1 Work Zone TIM Creation and Delivery

13.4.1.1 Test Objective

The objective of the Work Zone TIM Creation and Delivery test case is for multiple deployments to generate a work zone TIM for work zone warning according to their operational processes, distribute that TIM to an RSU and have multiple different vendor OBUs drive past the RSU, store the TIM and then display the TIM only when it meets the criteria for display. The intent is to demonstrate that the TIM messages generated by each of the participating deployments can be received and displayed with the relevant information by each of the different OBU models.

TIMs for a roadway work zone are typically assembled as a combination of TIMs, each one providing information about different elements of a road construction zone. The TIMs assembled for the Work Zone TIM test include a regulatory reduced speed zone, a lane closure warning, and a construction site location.

13.4.1.2 Test Description

The initial step of this test will be for all participating deployment agencies to generate TIMs for a work zone as described below:

Figure 5 Work Zone TIM location

13.4.1.2.1 Reduced Speed Zone

The first TIM for the work zone defines the reduced regulatory speed limit imposed for the work zone. This TIM includes two data frames, the first contains the area where the new speed limit is in effect and the second is an upstream warning for motorists about the upcoming reduced speed limit.

Value	Column 1	Column 2
msgCnt	1	-
packetID	8D442EF011020B1C01	-
dataframe	-	-
-	content	speedLimit
-	itis-codes	268, 12589, 8720
region	-	-
-	anchor	Lat: 41.1472587 Lon: -104.6513098
-	lane-width	50 m
-	directionality	3
-	closed-path	false
-	description	path
-	direction-mask	“0111000000000000”
suggested icon		-
dataframe	-	-
-	content	speedLimit
-	itis-codes	268, 12302, 12589, 8720, 13569
region	-	-
-	anchor	Lat: 41.14899435 Lon: -104.6633312
-	lane-width	50 m
-	directionality	3
-	closed-path	false
-	description	path
-	direction-mask	“0011111000000000”
suggested icon		-

The packetID and message count together uniquely identify the TIM. The provided packetID is an example value. For this initial TIM version, the message count is set to 1. Subsequent updates or revocations of this TIM will increment the message count. A depiction of the Geographic Validity Region of the TIM is shown in the figure above. This TIM includes two dataframes, one for the speed limit and the second for the speed reduction warning. Each dataframe contains the ITIS codes and the validity region geofence for their respective messages. Within each region definition, the direction mask defines valid vehicle headings for this alert. For these reduced speed warnings, driver alerts should be displayed while traveling in an easterly direction through the TIM geofence (counterclockwise direction around the test oval). A suggested driver display icon is provided; this is the suggested graphic to display for the driver if the OBU provides such a display.

The following hex string is a signed and encoded version of the Work Zone reduced speed limit TIM described above:

0381004003808201 1a001f8116701575588d442ef011020b1c010f775d9b0b01c2715bde59674a61affff93f
42baac21c0a007f98afbf96bf5bf765414f865cb91041e58f465e4828b26700000000138adef2cb3a530d49c
4670001088067d4a3077388e383dc64bda2a9b6897b153ad45c707994a84c3cfcd7b41d9bad560dc5757b
86b059ed00064010c189688840f775d9b180e138aefe60b39dda7ffffc9fa15d5610e05003fd057dfcb5fadfbb
2a0a7c32e5c882965c9d71e5c8820f2c7a32f241459338000000009c577f3059ceed3e4e231f0008458296
9000387625541e0052aa0f3f2a1307d1f57b454868ebda2ab4977b4156d33ded0abe75f55456976fed02b8
46817b1566e42390aa22215540068010c18070c4b4442035013ddd766c0600183000251bd1b9ece01000
2520c01ff120081010100030180c620fb90caad3b9c508208511422512865acbd396921000326e52b78832
79c830101800348010100018381837 48c51728ff0d88dad3ecd5a87c471e77fb53eb57db0dad64fe5c85dd
5c59e5280805f6c1e7293fa8efeeb6e9cbaa990b013f400e8f0bf971373f6850c0c3387083ad2c7eb7f2ed29
d923115dcefa4bf07c8752cd77d4ff362bf9b6dd03e76d3397c

13.4.1.2.2 Right Lane Closed Ahead

The second TIM for the work zone is a lane closure warning. It provides a warning for oncoming motorists that the right lane is closed ahead of them.

Value	**Column 1**	**Column 2**
msgCnt	1	-
packetID	8D442EF0010D5C1C01	-
dataframe	-	-
-	content	workZone
-	itis-codes	8196, 771
region	-	-

Value	Column 1	Column 2
-	anchor	Lat: 41.147205668 Lon: -104.6590462
-	lane-width	50 m
-	directionality	3
-	closed-path	false
-	description	path
-	direction-mask	“0011110000000000”
suggested icon		-

The packetID and message count together uniquely identify the TIM. The provided packetID is an example value. For this initial TIM version, the message count is set to 1. Subsequent updates or revocations of this TIM will increment the message count. A depiction of the Geographic Validity Region of the TIM is shown in the figure above. To get the exact path definition the encoded TIM included below can be decoded. The validity region geofence is defined as a path along the roadway with a 50-meter lane width. Note, the heading direction mask defines valid vehicle headings to provide this alert. In this case a driver alert for this TIM should be displayed while traveling in an eastbound direction through the TIM geofence (counterclockwise direction around the test oval). A suggested driver display icon is provided; this is the suggested graphic to display for the driver if the OBU provides such a display.

The following hex string is a signed and encoded version of the Work Zone lane closure warning TIM described above:

03--
8100400380818d001f8089701575588d442ef0010d5c1c010f775d9b0301c2715bcdc96740f00ffff93f42baa
c21c0a007f9aa5a73e8e9330eeca821ecdfcf2e44107963d197920a2c99c000000004e2b79b92ce81e0127
118f000422013eeed02b3287b42158cabeaa8adacdfda054ac501302a434825f1527ec2390ab37215543e5
d497c1f60e5ed00088801006067bbaecd80600183000251bf4a8a8dc50002520c01ff12008101010003018
0c620fb90caad3b9c508208511422512865acbd396921000326e52b7883279c8301018003480101000183
8183748c51728ff0d88dad3ecd5a87c471e77fb53eb57db0dad64fe5c85dd5c59e52808020b4d340483417
07c2963bd6f050b20364824bfc4a7487604b52767d954688f8a833c460c2308bd18552c980f5d4935fab93e
3905bc2b34afc30307842cb162c

13.4.1.2.3 Work Zone

The third work zone TIM identifies the exact area of the work zone.

Value	Column 1	Column 2
msgCnt	1	-
packetID	8D442EF0F00E5C1C01	-
dataframe	-	-
-	content	workZone
-	itis-codes	1025
region	-	-
-	anchor	Lat: 41.1476001 Lon: -104.6494760
-	lane-width	50 m
-	directionality	3
-	closed-path	false
-	description	path
-	direction-mask	“0111000000000000”

Value	Column 1	Column 2
suggested icon		-

The packetID and message count together uniquely identify the TIM. The provided packetID is an example value. For this initial TIM version, the message count is set to 1. Subsequent updates or revocations of this TIM will increment the message count. A depiction of the Geographic Validity Region of the TIM is shown in the figure above. To get the exact path definition the encoded TIM included below can be decoded. The validity region geofence is defined as a path along the roadway with a 50-meter lane width. Note, the heading direction mask defines valid vehicle headings to provide this alert. In this case a driver alert for this TIM should be displayed while traveling in an eastbound direction through the TIM geofence (counterclockwise direction around the test oval). A suggested driver display icon is provided; this is the suggested graphic to display for the driver if the OBU provides such a display.

The following hex string is a signed and encoded version of the Work Zone warning TIM described above:

0381004003806e001f6b701575588d442ef0f00e5c1c010f775d9b0301c2715c4911674c9eb7fff93f42baac
21c0a007f91afbf96bf5bf7654107963d197920a2ce000000002715c4911674c9eb1388ce00021080993800
0eda72d087d1fa2603c97d1c81f2eac720e36b4bd8004008027bbaecd80600183000251bf4a985e0a00025
20c01ff120081010100030180c620fb90caad3b9c50820851142251286 5acbd396921000326e52b7883279
c830101800348010100018381837 48c51728ff0d88dad3ecd5a87c471e77fb53eb57db0dad64fe5c85dd5c
59e528080421ffc5d12daeb410ec5cb5cf2abbe8ae729672e7e0643f00c87b59f198ebd95843ab35ade3d36
ff5035f782e4695367c72863b06b81845a4be13044fb46b892

During the tests, the start time and duration will be configured for the broadcast TIMs to support a series of updates and revocations.

Each deployment will then either deploy the message directly to an RSU in the test environment or provide the message to the deployment agency that controls that RSU for deployment. The deployment agency will also detail whether:

- They sign their TIM messages at the TMC.
- They sign their TIM messages at the RSU (expected way for most testing).
- They sign their TIM messages at the TMC, send to the RSU, RSU validates the signature on the TIM and then strips the certificate and signs with its certificate.

Vehicles with different OBU models will start driving at the western side of the oval track at the western most roundabout, traveling counterclockwise around the oval. Observers should note the approximate time and location for each of the work zone related TIMs that appear on the HMI as the vehicle traverses the full work zone section.

The vehicles will turn around through the eastern most roundabout and drive through the TIM geofence traveling clockwise around the oval. Observers should note that none of the work zone related TIMs should appear on the HMI as the vehicle is traveling in the opposite direction of the defined valid heading masks.

13.4.1.3 Pass/Fail Criteria

- RSUs correctly broadcast the Work Zone TIMs.
- OBUs receive the Work Zone TIMs and display them only in their valid direction and Geographic Validity Region.

13.5 End of Ramp Deceleration Warning (ERDW) TIM

13.5.1 ERDW TIM Creation and Delivery

For this interoperability testing, the ERDW lane geometry of the THEA REL is adapted to the red circled location of the Wyoming test site.

Figure 6: Wyoming ERDW Lane Geometry Adaptation

Short queue operation on the Wyoming track is shown in Figure 7. Queue length is set manually, and the ACM test procedure is repeated for short queue.

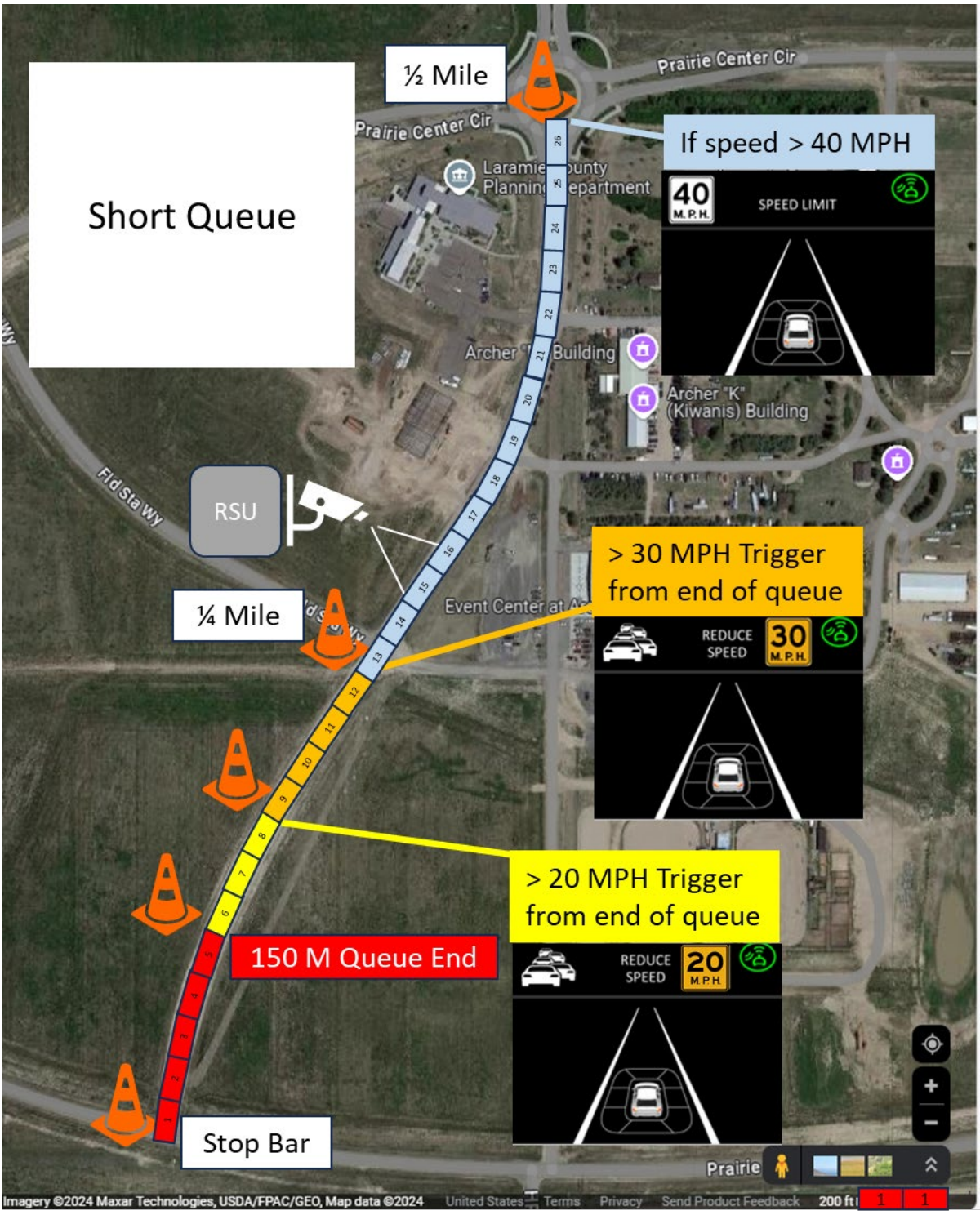
Short Queue
½ Mile
Prairie Center Cir
Prairie Center Cir
If speed > 40 MPH
40 M.P.H.
SPEED LIMIT
Archer "K" (Kiwanis) Building
RSU
¼ Mile
> 30 MPH Trigger from end of queue
REDUCE SPEED
30 M.P.H.
> 20 MPH Trigger from end of queue
REDUCE SPEED
20 M.P.H.
150 M Queue End
Stop Bar
Prairie
Imagery ©2024 Maxar Technologies, USDA/FPAC/GEO, Map data ©2024
United States
Terms
Privacy
Send Product Feedback

Figure 7: Wyoming ERDW Lane Geometry Adaptation for Short Queue

Long queue operation on the Wyoming track is shown in Figure 8. Queue length is set manually, and the ACM test procedure is repeated for long queue. Once long and short queues are set and verified manually, the camera is enabled to sense stopped cars within its field of view that automatically triggers long queue.

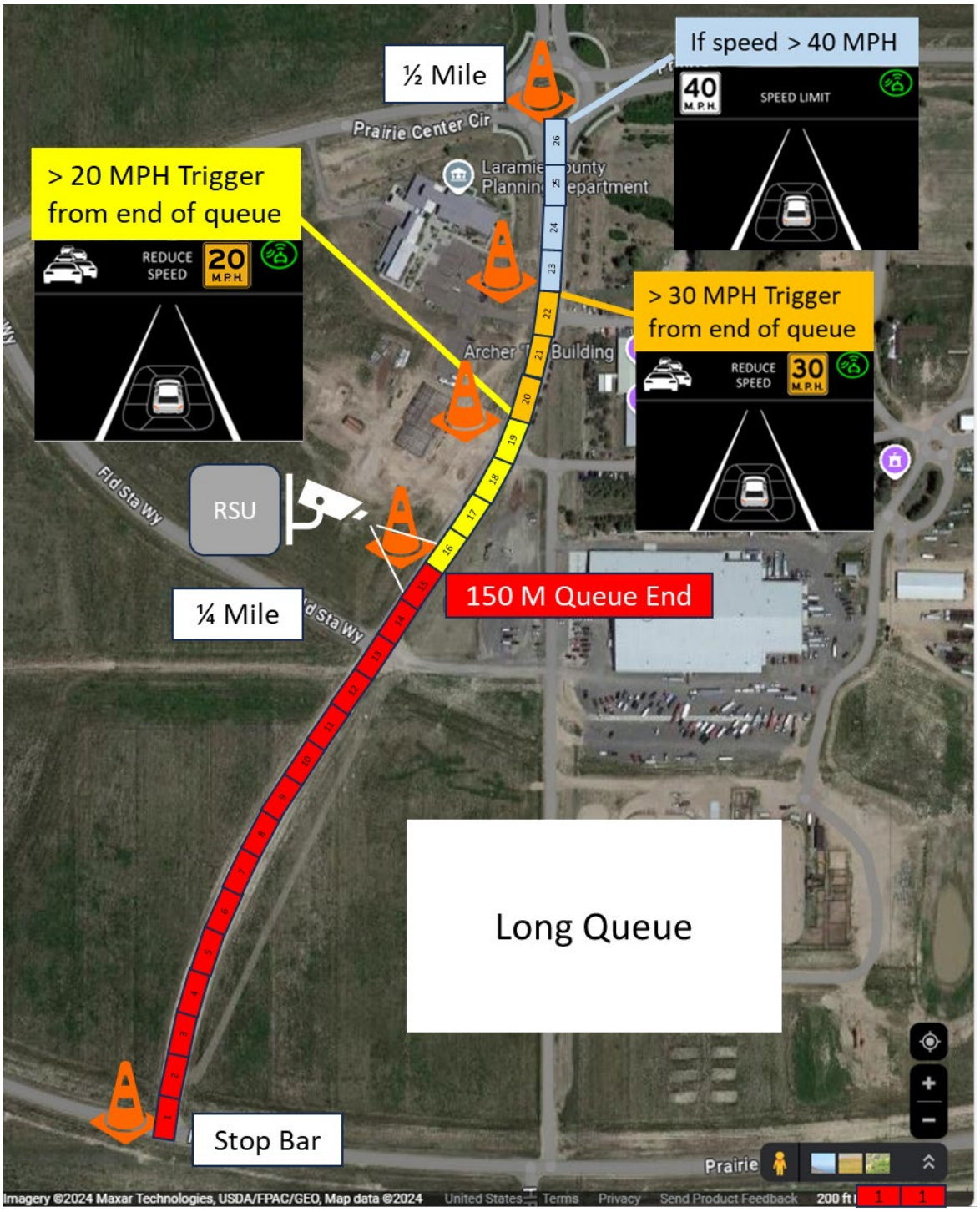

Figure 8: Wyoming ERDW Lane Geometry Adaptation for Long Queue

13.5.1.1 Test Objective

The objective of the ERDW TIM Creation and Delivery test case is for multiple deployments to generate a ERDW TIM for vehicles approaching a variable length queue extending from an imaginary signalized intersection at the end of an expressway exit ramp. Multiple different vendor OBUs/ASDs drive past the RSU, store the TIM and then display the TIM only when it meets the criteria for display. The intent is to demonstrate that the TIM messages generated by each of the participating deployments can be received and displayed with the relevant information by each of the different OBU/ASD models.

13.5.1.2 Test Description

The initial step of this test will be for an RSU to transmit an ERDW TIM with the parameters of Figure 7 and Figure 8. Marker cones are placed at the roadside at the end of queue location, plus at each trigger point shown in Figure 7 and Figure 8.

Vehicles with different OBU/ASD models will start driving at the top of the oval track from the Laramie County Planning Department building, traveling counterclockwise around the oval. Observers will note that the ERDW TIM should appear on the HMI as the vehicle enters the geofence in the upper left quadrant of the oval track and should note the approximate time and location when the TIM appeared as compared to the cones placed at the roadside. The test is repeated for both long queue and short queue lengths as well as traveling at speeds above and below the speed advice.

13.5.1.3 Pass/Fail Criteria

- RSUs correctly broadcast the ERDW TIM
- OBUs/ASDs receive the ERDW TIM and display it correctly between trigger points only when exceeding the deceleration speed advice.

13.6 Pedestrian Crash Warning (PCW) TIM

13.6.1 PCW TIM Creation and Delivery

For this interoperability testing, the PCW lane geometry is adapted to the red circled location of the Wyoming test site of Figure 9, configured as shown in Figure 10.

Figure 9: Wyoming PCW Lane Geometry Adaptation

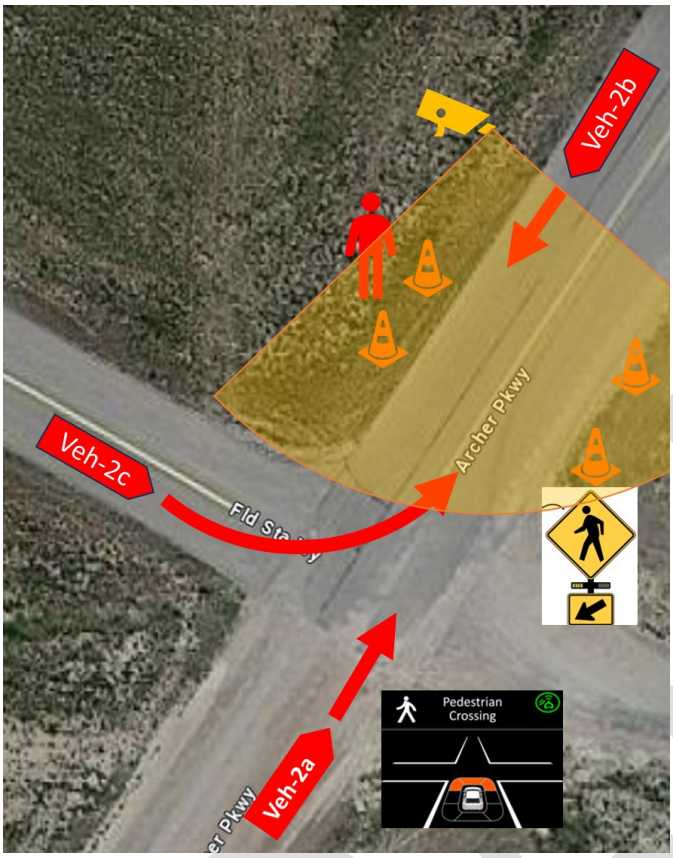

Figure 10: WY PCW Test Site Configuration

RSU and sensor are installed at the TEE intersection, with vehicle approaches and pedestrian approaches matching those of the Tampa midblock crossing, with the crosswalk here located by four cones. Additionally, a crosswalk sign is also installed. RSU sends TIM for the MUTCD crosswalk sign continually, plus transmits PSM for pedestrians within the sensor field of view. RSU is also capable of activating Rectangular Rapid Flashing Beacon (RRFB) when the crosswalk is occupied but excluded from this test.

13.6.1.1 Test Objectives

The objective of the test cases is threefold:

1. Verify crosswalk TIM in vehicle when approaching crosswalk for different OBU/ASD models.
2. Verify PCW display when vehicle is on crash trajectory with VRU for different OBU/ASD models.
3. Verify activation of RRFB when crosswalk is occupied.

13.6.1.2 Test Description

Test sequences are conducted on the site of Figure 10. For each test sequence, display of crosswalk TIM is verified for each vehicle approach. Verify that the RRFB is activated when the crosswalk is occupied.

13.6.1.3 Pass/Fail Criteria

- RSUs correctly broadcast the Crosswalk TIM
- OBUs/ASDs receive the Crosswalk TIM and display it correctly on each approach.
- OBUs/ASDs receive PSMs.
- OBUs/ASDs display PCW when on crash trajectory.
- RRFB is activated when crosswalk is occupied.

13.7 Test Case Prioritization

Due to time constraints, it may not be possible to conduct all of the test cases listed above. Table 7 lists the test cases in order of priority. The execution of test cases will focus on the higher priority test cases first and accomplish the others as time permits.

Table 7. Test Case Prioritization

Priority	Test Case
1	Weather Warning TIM
2	Variable Speed Limit TIM
3	Work Zone TIM
4	End of Ramp Deceleration Warning TIM
5	Pedestrian Crash Warning TIM

14 Test Procedures

14.1 Baseline OBU Data Collection

The path for the Baseline OBU Data Collection Tool is depicted in the figure below.

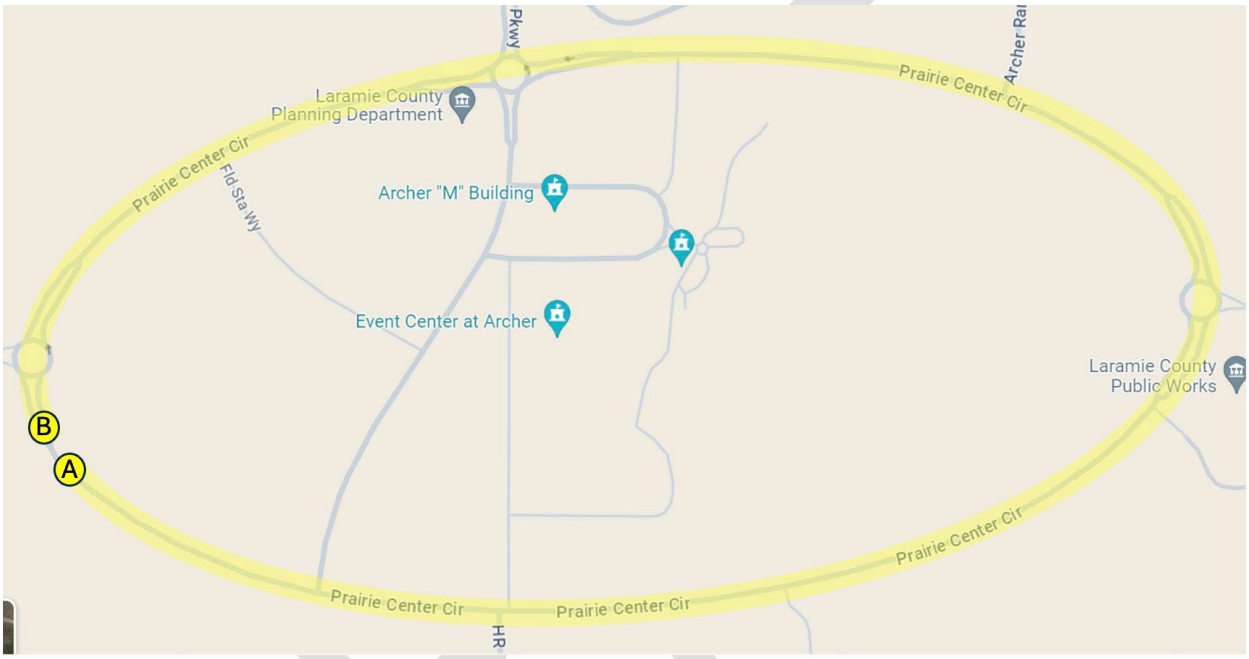

Figure 11. Baseline OBU Data Collection Path 1

Table 8 includes the Test Procedures for the Baseline OBU Data Collection Test.Table 8 includes the Test Procedures for the Baseline OBU Data Collection Test.

Table 8. Baseline OBU Data Collection Test Procedures Path

ID	Step	Action	Expected Result	Pass/Investigate/ Fail
1.	Verify Readiness	WYDOT OBU is installed in Vehicle and operating	-	Pass/Fail
2.	Verify Readiness	CDOT OBU is installed in Vehicle and operating	-	Pass/Fail
3.	Verify Readiness	GDOT OBU is installed and operating	-	Pass/Fail
4.	Verify Readiness	UDOT OBU is installed and operating	-	Pass/Fail
5.	Test Vehicle	Travel to the beginning of the Test path (Point A) as shown in Figure 6	-	-

ID	Step	Action	Expected Result	Pass/Investigate/ Fail
6.	Test Vehicle	Travel along Prairie Center Circle	-	-
7.	Test Vehicle	Continue straight until reaching Point B in Figure 6	-	-
8.	Test Vehicle	Repeat Steps 5-7 three more times	-	-
9.	Verify Data Collection	Verify that data was collected by each of the OBUs installed on the Test Vehicle	-	Pass/Fail

14.2 Weather Warning TIM Procedures

Table 9. Weather Warning TIM Test Procedures

ID	Step	Action	Expected Result	Pass/Investigate/ Fail
1.	Verify TIM readiness	Verify that start time and duration has been configured to broadcast the TIMs	-	-
2.	Deploy TIM	The first deployer will either deploy the message directly to an RSU in the test environment or provide the message to the deployment agency that controls that RSU for deployment	-	-
3.	Sign TIM	The deployment agency will sign the TIM using their protocol	RSUs correctly broadcast the Weather Warning TIM	Pass/Fail
4.	Begin driving	The deployer vehicles will start driving at the top of the oval track from the north most roundabout, traveling counterclockwise around the oval	-	-
5.	Observe TIM	Observers will note the Weather Warning TIM as it appears on the HMI as the vehicle enters the geofence by taking a picture or screenshot of the TIM image	OBUs receive the Weather Warning TIM and display the correct TIM image	Pass/Fail
6.	Note TIM time and location	Observers will note the approximate time and location when the TIM appears	-	-
7.	Continue driving to next TIM	The vehicles will proceed on the oval track through the next two TIM geofences (Work Zone and Variable Speed Limit)	-	-
8.	Vehicle turn around and drive clockwise	The vehicles will turn around through the north most roundabout and drive through the two TIM geofences traveling clockwise around the oval	-	-
9.	Observe TIM on secondary pass through geofence	Observers will note that the Weather Warning TIM as it appears on the HMI as the vehicle enters the geofence from the west side by taking a picture or screenshot of the TIM image	RSUs correctly broadcast the Weather Warning TIM	Pass/Fail
10.	Note time and location	Observers will note the approximate time and location when the TIM appears on the secondary pass through the geofence	-	-
11.	Return to Laramie County Office	The vehicles will return to the office to download data and prepare for the next portion of the test	-	-
12.	Increment original TIM	The deployers will increment the newly generated TIM to change its validity time so that it becomes invalid within 5 minutes of the current time	-	-
13.	Update TIM to revoke	Deployer will update the TIM with the validity time change	-	-
14.	Resend TIM	Deployer will resend the TIM to the RSUs	-	-

15.	*Note*	*Vehicles may need to remain running to ensure the original TIM remains on the OBU and that the revocation TIM supersedes the original version*	-	-
16.	Begin driving	The vehicles will drive the same path as in Step 4	-	-
17.	Observe no TIM	The observer should note no TIM while passing through the geofence	OBUs do not receive a Variable Speed Limit TIM	Pass/Fail
18.	Repeat	Repeat Steps 4-17 for the following deployer	-	-

14.2.1 Test Combinations Matrix

Weather Warning TIM	**Deployer RSUs**	WYDOT Commsignia	CDOT Commsignia	GDOT Danlaw	UDOT/ Panasonic Kapsch	THEA	Denso
Deployer OBUs	-	-	-	-	-	-	-
WYDOT Commsignia	-	-	-	-	-	-	-
CDOT Commsignia	-	-	-	-	-	-	-
GDOT Cohda	-	-	-	-	-	-	-
UDOT/Panasonic Ficosa	-	-	-	-	-	-	-
THEA	-	-	-	-	-	-	-
Denso	-	-	-	-	-	-	-

14.3 Variable Speed Limit TIM

Table 10. Incident TIM Test Procedures

ID	Step	Action	Expected Result	Pass/Investigate/ Fail
1.	Verify TIM readiness	Verify that start time and duration has been configured to broadcast the TIMs	-	-

2.	Deploy TIM	The first deployer will either deploy the message directly to an RSU in the test environment or provide the message to the deployment agency that controls that RSU for deployment	-	-
3.	Sign TIM	The deployment agency will sign the TIM using their protocol	RSUs correctly broadcast the Variable Speed Limit TIM	Pass/Fail
4.	Begin driving	The deployer vehicles will start driving at the top of the oval track from the north most roundabout, traveling counterclockwise around the oval	-	-
5.	Observe TIM	After passing through the Work Zone TIM, observers will note the Variable Speed Limit TIM as it appears on the HMI as the vehicle enters the geofence by taking a picture or screenshot of the TIM image	OBUs receive the Variable Speed Limit TIM and display the correct TIM image	Pass/Fail
6.	Note TIM time and location	Observers will note the approximate time and location when the TIM appears	-	-
7.	Vehicle turn around and drive clockwise	The vehicle will turn around through the north most roundabout and drive through the TIM geofence traveling clockwise around the oval	-	-
8.	Observe no TIM when passing though geofence in opposite direction	Observers will note that the Variable Speed Limit TIM does not appear on the HMI as the vehicle enters the geofence from the opposite direction	OBUs do not receive a Variable Speed Limit TIM	Pass/Fail
9.	Return to Laramie County Office	The vehicles will continue around the oval loop, returning to the office to download data and prepare for the next portion of the test	-	-
10.	Update original TIM	The deployer will change the speed limit from 55 mph to 45 mph	-	-
11.	Resend TIM	Deployer will resend the TIM to the RSUs	-	-
12.	*Note*	*Vehicles may need to remain running to ensure the original TIM remains on the OBU and that the revocation TIM supersedes the original version*	-	-
13.	Begin driving	The vehicles will drive the same path as in Step 4	-	-
14.	Observe updated TIM	After passing through the Work Zone TIM, observers will note the TIM with new speed limit and take a picture or screenshot of the TIM image	OBUs receive the updated Variable Speed Limit TIM and display the correct TIM image	Pass/Fail
15.	Note TIM time and location	Observer will note the approximate time and location when the TIM appears	-	-
16.	Repeat	Repeat Steps 4-15 for the following deployers	-	-

14.3.1 Test Combinations Matrix

Weather Warning TIM	**Deployer RSUs**	WYDOT Commsignia	CDOT Commsignia	GDOT Danlaw	UDOT/ Panasonic Kapsch	THEA	Denso
Deployer OBUs	-	-	-	-	-	-	-
WYDOT Commsignia	-	-	-	-	-	-	-
CDOT Commsignia	-	-	-	-	-	-	-
GDOT Cohda	-	-	-	-	-	-	-
UDOT/Panasonic Ficosa	-	-	-	-	-	-	-
THEA	-	-	-	-	-	-	-
Denso	-	-	-	-	-	-	-

14.4 Work Zone TIM Test Procedures

Table 11. Work Zone TIM Test Procedures

ID	Step	Action	Expected Result	Pass/Investigate/ Fail
1.	Verify TIM Readiness	Verify that start time and duration has been configured to broadcast the TIMs	-	-
2.	Deploy TIM	The first deployer will either deploy the message directly to an RSU in the test environment or provide the message to the deployment agency that controls that RSU for deployment	-	-
3.	Sign TIM	The deployment agency will sign the TIM using their protocol	RSUs correctly broadcast the Weather Warning TIM	-
4.	Begin Driving	The deployer vehicles will start driving at the top of the oval track from the north most roundabout, traveling counterclockwise around the oval	-	-
5.	Observe Reduced Speed Zone TIM	After passing through the Weather Warning TIM, observers will note that the Reduced Speed Zone TIM as it appears on the HMI as the vehicle enters the geofence by taking a picture or screenshot of the warning image	OBUs receive the Reduced Speed Zone TIM and display the correct TIM image	Pass/Fail
6.	Note TIM time and location	Observers will note the approximate time and location when the TIM appears	-	-
7.	Observe Right Lane Closed Ahead TIM	Observers will note the Right Lane Closed Ahead TIM as it appears on the HMI as the vehicle enters the geofence by taking a picture or screenshot of the warning image	OBUs receive the Right Lane Closed Ahead TIM and display the correct TIM image	Pass/Fail
8.	Note TIM time and location	Observers will note the approximate time and location when the TIM appears	-	-
9.	Observe Work Zone TIM	Observers will note the Work Zone TIM as it appears on the HMI as the vehicle enters the geofence by taking a picture or screenshot of the warning image	OBUs receive the Work Zone TIM and display the correct TIM image	Pass/Fail
10.	Note TIM time and location	Observers will note the approximate time and location when the TIM appears	-	-
11.	Vehicle Turn Around and Drive Clockwise	The vehicles will turn around through the north most roundabout and drive through the TIM geofence traveling clockwise around the oval	-	-
12.	Observe no TIM when passing though Geofence in opposite direction	Observers will note that the sequence of three Work Zone related TIMs do not appear on the HMI as the vehicle enters the geofence from the opposite direction	OBUs do not receive any of the Work Zone TIMs	Pass/Fail
13.	Return to Laramie County Office	The vehicles will continue around the oval loop, returning to the office to download data and prepare for the next test	-	-

14.	Repeat	Repeat Steps 4-13 for the following deployers	-

14.4.1 Test Combinations Matrix

Weather Warning TIM	**Deployer RSUs**	WYDOT Commsignia	CDOT Commsignia	GDOT Danlaw	UDOT/ Panasonic Kapsch	THEA	Denso
Deployer OBUs	-	-	-	-	-	-	-
WYDOT Commsignia	-	-	-	-	-	-	-
CDOT Commsignia	-	-	-	-	-	-	-
GDOT Cohda	-	-	-	-	-	-	-
UDOT/Panasonic Ficosa	-	-	-	-	-	-	-
THEA	-	-	-	-	-	-	-
Denso	-	-	-	-	-	-	-

14.5 End of Ramp Crash Warning (ERDW) TIM Test Procedures

ID	Step	Action	Expected Result	Pass/Investigate/Fail
1.	Verify TIM Readiness	Verify that start time and duration has been configured to broadcast the TIMs	-	-

ID	Step	Action	Expected Result	Pass/Investigate/Fail
2.	Deploy TIM	Each deployment will either deploy the message directly to an RSU in the test environment or provide the message to the deployment agency that controls that RSU for deployment	-	-
3.	Sign TIM	The deployment agency will sign the TIM using their protocol	RSUs correctly broadcast the ERDW TIM	-
4.	Place Marker Cones	Marker cones will be placed at the roadside at the end of queue location, plus at each trigger point	-	-
5.	Begin Driving	The first deployer vehicle will start driving at the top of the oval track from the Laramie County Planning Department building, traveling counterclockwise around the oval	-	-
6.	Observe ERDW TIM	Observers will note the ERDW TIM as it appears on the HMI as the vehicle enters the geofence in the upper left quadrant of the oval track	OBUs receive the ERDW TIM and display it driving in the Geographic Validity Region	Pass/Fail
7.	Note TIM time and location	Observer will note the approximate time and location when the TIM appears	-	-
8.	Vehicles Returns to Start	Vehicle will take a right on to Prairie Center Cir when reaching the end of Archer Pkwy. Vehicles will travel clockwise returning to Laramie County Planning Department	-	-
9.	-	-	-	-
10.	-	-	-	-
11.	-	-	-	-
12.	-	-	-	-
13.	-	-	-	-
14.	-	-	-	-
15.	-	-	-	-
16.	-	-	-	-

14.5.1 Test Combinations Matrix

Weather Warning TIM	**Deployer RSUs**	WYDOT Commsign ia	CDOT Commsign ia	GDOT Danlaw	UDOT/ Panasonic Kapsch	THEA	Denso
Deployer OBUs	-	-	-	-	-	-	-

Weather Warning TIM	**Deployer RSUs**	WYDOT Commsignia	CDOT Commsignia	GDOT Danlaw	UDOT/ Panasonic Kapsch	THEA	Denso
WYDOT Commsignia	-	-	-	-	-	-	-
CDOT Commsignia	-	-	-	-	-	-	-
GDOT Cohda	-	-	-	-	-	-	-
UDOT/Panasonic Ficosa	-	-	-	-	-	-	-
THEA	-	-	-	-	-	-	-
Denso	-	-	-	-	-	-	-

14.6 Pedestrian Crossing Warning (PCW) TIM Test Procedures

ID	Step	Action	Expected Result	Pass/Investigate/Fail
1.	Verify TIM Readiness	Verify that start time and duration has been configured to broadcast the TIMs	-	-
2.	Deploy TIM	Each deployment will either deploy the message directly to an RSU in the test environment or provide the message to the deployment agency that controls that RSU for deployment	-	-
3.	Sign TIM	The deployment agency will sign the TIM using their protocol	RSUs correctly broadcast the PCW TIM	-
4.	Begin Driving	The first deployer vehicle will start driving…	-	-
5.	-	-	-	-
6.	-	-	-	-
7.	-	-	-	-
8.	-	-	-	-
9.	-	-	-	-
10.	-	-	-	-
11.	-	-	-	-
12.	-	-	-	-
13.	-	-	-	-
14.	-	-	-	-
15.	-	-	-	-
16.	-	-	-	-

14.6.1 Test Combinations Matrix

Weather Warning TIM	**Deployer RSUs**	WYDOT Commsignia	CDOT Commsignia	GDOT Danlaw	UDOT/ Panasonic Kapsch	THEA	Denso
Deployer OBUs	-	-	-	-	-	-	-

Weather Warning TIM	**Deployer RSUs**	WYDOT Commsignia	CDOT Commsignia	GDOT Danlaw	UDOT/ Panasonic Kapsch	THEA	Denso
WYDOT Commsignia	-	-	-	-	-	-	-
CDOT Commsignia	-	-	-	-	-	-	-
GDOT Cohda	-	-	-	-	-	-	-
UDOT/Panasonic Ficosa	-	-	-	-	-	-	-
THEA	-	-	-	-	-	-	-
Denso	-	-	-	-	-	-	-

15 Modifications Made to Test Plans and Procedures

During the execution of testing, there is the possibility that the details of some aspects of the test plan might have to be changed. This section will document what those changes were and the reasons for the changes.

16 Post Test Analysis

Analysis will be conducted after testing to review the OBU log files. Log files will be analyzed to validate the reception of each TIM. The time and location will be noted from the log files as part of the analysis. Section 2.5 provides the minimum requirements for data collection and logging.

Appendix A. Acronyms

Acronym	Definition
ASD	Aftermarket Safety Device
BSM	Basic Safety Message
CV	Connected Vehicle
CVP	Connected Vehicle Pilot
DN	Distress Notification
DSRC	Dedicated Short Range Communication
EEBL	Electronic Emergency Brake Light
EIRP	Effective Isotropic Radiated Power
FCW	Forward Collision Warning
GPS	Global Positioning System
I2V	Infrastructure to Vehicle
IMA	Intersection Movement Assist
ISS	Integrity Security Services
NHTSA	National Highway Traffic Safety Administration
NYC	New York City
OBU	On-Board Unit
OTA	Over-the-Air
PII	Personally Identifiable Information
PSM	Personal Safety Messages
RLVW	Red-Light Violation Warning
RSU	Roadside Unit
RTCM	Radio Technical Commission for Martime Services
SAE	Society of Automotive Engineers
SCMS	Security Credential Management System
SPAT	Signal, Phase, and Timing
SRM	Signal Request Message
SSM	Signal Status Message
STOL	Saxton Transportation Operations Laboratory
TFHRC	Turner-Fairbank Highway Research Center
THEA	Tampa Hillsborough Expressway Authority
TIM	Traffic Incident Management
TRR	Test Readiness Review
USDOT	United States Department of Transportation

Acronym	Definition
V2I	Vehicle to Infrastructure
V2V	Vehicle to Vehicle
V2V-MD	Vehicle-to-Vehicle Model Deployment
VAD	Vehicle Awareness Devices
WAVE	Wireless Access in Vehicular Environments
WSA	WAVE Service Advertisement Message
WYDOT	Wyoming Department of Transportation

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