Connected Vehicle Pilots Phase 2 Interoperability Test

Test Plan

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Final Report – August 13, 2018
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16. Abstract

Task 3-C in Phase 3 of the Connected Vehicle Pilot Deployment Program Cooperative Agreement calls for a Stakeholder Outreach activity that includes an interoperability activity showing successful interaction between the local Connected Vehicle Pilot Deployment site and in-vehicle devices from one or more other Connected Vehicle Pilot site. The US Department of Transportation (USDOT) and the three Connected Vehicle Pilot sites—New York City (NYC), Tampa, and Wyoming—have engaged in multiple discussions about the definition of interoperability and approaches to conduct a limited demonstration of interoperability during Phase 2 that is supportive of the future Task 3-C activity.

This document is the official planning document for Connected Vehicle Pilots Phase 2 Interoperability Test. The purpose of the test was to test vehicle-to-vehicle (V2V) interactions between different site's OBUs and vehicle-to-infrastructure (V2I) interactions between selected OBUs and RSUs. The Connected Vehicle Pilot Deployment Program's definition of interoperability is: "A vehicle with an Onboard Unit (OBU) from one of the three CV Pilot sites is able to interact with OBUs and Roadside Units (RSUs) from each of the other sites in accordance with the key connected vehicle interfaces and standards."

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1. Introduction

1.1 Overview

Task 3-C in Phase 3 of the Connected Vehicle Pilot Deployment Program Cooperative Agreement calls for a Stakeholder Outreach activity that includes an interoperability activity showing successful interaction between the local Connected Vehicle Pilot Deployment site and in-vehicle devices from one or more other Connected Vehicle Pilot site. The US Department of Transportation (USDOT) and the three Connected Vehicle Pilot sites—New York City (NYC), Tampa, and Wyoming—have engaged in multiple discussions about the definition of interoperability and approaches to conduct a limited demonstration of interoperability during Phase 2 that is supportive of the future Task 3-C activity.

This document summarizes the path forward based on the previous discussions and input solicited from each stakeholder. The intent is for this document to be kept up-to-date to capture the collective understanding of the planned steps and progress being made over time during Phase 2. The document serves as a Test Plan for the Connected Vehicle Pilots Phase 2 Interoperability Test.

1.2 Objectives

The Connected Vehicle Pilot Deployment Program's definition of interoperability is:

> *"A vehicle with an Onboard Unit (OBU) from one of the three CV Pilot sites is able to interact with OBUs and Roadside Units (RSUs) from each of the other sites in accordance with the key connected vehicle interfaces and standards."*

The Connected Vehicle Pilots Phase 2 Interoperability Test goals consist of testing vehicle-to-vehicle (V2V) interactions between different site's OBUs and vehicle-to-infrastructure (V2I) interactions between selected OBUs and RSUs. OBUs from all sites should be able to:

- Receive SAE J2735 Basic Safety Messages (BSMs) transmitted by each of the other sites' OBUs over-the-air via dedicated short-range communications (DSRC),
- Authenticate messages as needed (i.e., when acting on the data or hearing a device for the first time),
- Parse messages (i.e., decode J2735 message to individual data element level), and
- Process them (i.e., use the data as an input to applications, triggering responses according to the device's own application) in accordance with SAE J2945/1 (potentially augmented as necessary for trucks to specify treatment of trailers/articulation, etc.).

Specific V2V testing will include:

- The Forward Collision Warning (FCW) application hosted by OBU equipped vehicles (i.e., Turner Fairbank Highway Research Center [TFHRC] owned vehicles, each equipped with a different Connected Vehicle Pilot site's OBU/vehicle-based equipment) from each site will be able to interact with equipped lead vehicles from each of the other sites in an "open-sky" environment, and demonstrate a response (e.g., alert). Open sky is understood to be conditions where the OBU will not require global positioning system (GPS) corrections or other refinements for location accuracy and precision. The Connected Vehicle Pilot sites will determine whether their FCW application (as the following vehicle) needs tuning beyond their own deployment configuration, based on the test cases in Section 10, which will need to consider each FCW application's trigger conditions.

- As a stretch goal, the V2V Electronic Emergency Brake Light (EEBL) and V2V Intersection Movement Assist (IMA) applications on OBUs from Tampa and NYC will be able to interact with equipped vehicles from the other site in an open-sky environment to demonstrate a response.

Specific V2I testing will include:

- Interactions between selected OBUs and RSUs from NYC and Tampa, and
- V2I testing focused on applications that utilize Signal Phase and Timing (SPaT) and MAP (e.g., the red-light violation warning application).

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)—with common root—to include signatures with messages and validate received messages as necessary. The Connected Vehicle Pilot sites will use the commercial Green Hills/ISS Test SCMS system for the interoperability test.
- Positioning accuracy must satisfy SAE J2945/1 for V2V. It was agreed that the tests and demonstration of V2V interoperability will take place in an "open sky" environment with no site-specific position augmentation.
- Although the focus of the Phase 2 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 **(Source: ITS JPO, 2018)**

Document	Title
4s12_V2I Interoperability Level Test Procedure_Sys-v3	Level Test Procedure 4S12_Interoperability_V2I_SY (Siemens)
121617 – Interoperability Demo Playbook	Joint Connected Vehicle Pilot / USDOT Playbook for Interoperability Demonstration
Interoperability Test Cases.zip (Multiple files)	Wyoming Interoperability Test Cases

Document	Title
Technical Report – Plan and Test Procedures for Vehicle Awareness Devices (VADs) and Aftermarket Safety Devices.pdf	Vehicle-to-Vehicle Safety System Light Vehicle Builds and Model Deployment Support (V2V-MD) Test Plan and Test Procedures for Vehicle Awareness Devices and Aftermarket Safety Devices (NHTSA)

1.5 Document Overview

This document identifies and describes the organization, resources, activities, methods, and procedures that will be used during Connected Vehicle Pilots Phase 2 Interoperability Test. Sections included in this Test Plan include:

- **Section 1: Introduction** – 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 for Testing** – Identifies the features of the test items that will be tested. It also identifies any features of the test items that will not be tested.
- **Section 4: Approach** – Provides the overall test strategy for Connected Vehicle Pilots Phase 2 Interoperability Testing. It defines the overall rules and processes that will be used. It also identifies the completion criteria for the test items included in the Test Plan; and specifies on what constitutes stoppage for a test or series of tests.
- **Section 5: Test Environment** – Describes the environment that Connected Vehicle Pilots Phase 2 Interoperability Testing will be conducted within.
- **Section 6: Roles and Responsibilities** – Identifies who the responsible party is for areas of the test.
- **Section 7: Testing Preconditions** – Identifies the key tasks that must be complete before Connected Vehicle Pilots Phase 2 Interoperability Testing can be conducted.
- **Section 8: Schedule** – Identifies the timeline for the key tasks and test items included in the test plan.
- **Section 9: Risks and Contingencies** – Identifies the overall risks to the project with emphasis on the test processes.
- **Section 10: Test Cases** – Provides the test cases for each of the tests that will be accomplished at during the Interoperability Demonstration.
- **Section 11: Test Procedures** – Provides the detailed step-by-step procedures for each test case.
- **Section 12: Modifications Made to Test Cases / Test Procedures** – Provides information on modifications made to the test cases and test procedures when the test was executed.

2 Test Equipment

The Connected Vehicle Pilots Phase 2 Interoperability Test focuses on demonstrating interoperability between the different connected vehicle devices and applications covered by this test plan procured by each of the Connected Vehicle Pilot sites—NYC, Tampa, and Wyoming. Devices provided by the USDOT's Saxton Transportation Operational Laboratory (STOL) at TFHRC will also be used. The tables below list the primary connected vehicle devices that will be under test during this demonstration.

2.1 NYC Test Equipment

Table 2 identifies the NYC equipment that will be used for the CV Pilots Phase 2 Interoperability Test.

Table 2. NYC Test Equipment **(Source: ITS JPO, 2018)**

Device	Vendor	Model #	Quantity
OBU	Danlaw	Danlaw v1.8	1
OBU	Savari	MobiWAVE 1000 MW1210-QO0	1
OBU	Siemens	Sitraffic ESCoS Roadside Unit V1.0	1

2.2 Tampa Test Equipment

Table 3 identifies the Tampa equipment that will be used for the CV Pilots Phase 2 Interoperability Test.

Table 3. Tampa Test Equipment **(Source: ITS JPO, 2018)**

Device	Vendor	Model #	Quantity
OBU	Commsignia	ITS-OB4	1
OBU	Savari	MW1220-QO0	1
OBU	SiriusXM	Auriga SX-7800-0369	1
RSU	Siemens	Sitraffic ESCoS Roadside Unit V1.0	1

2.3 Wyoming Test Equipment

Table 4 identifies the Wyoming equipment that will be used for the CV Pilots Phase 2 Interoperability Test.

Table 4. Wyoming Test Equipment (Source: ITS JPO, 2018)

Device	Vendor	Model #	Quantity
OBU	Lear	Roadstar	1 (1 Spare)

2.4 TFHRC Test Equipment

Table 5 identifies the TFHRC equipment that will be used for the CV Pilots Phase 2 Interoperability Test.

Table 5. TFHRC Test Equipment (Source: ITS JPO, 2018)

Device	Vendor	Model #	Quantity
RSU	Siemens	Sitraffic ESCoS Roadside Unit V1.0	2
Signal Controller	McCain	ATC eX 2070	2
Vehicle	Chevrolet	Equinox	1
Vehicle	2011 Buick	Lacrosse	
Vehicle	2011 Toyota	Venza	2
Vehicle	2012 Infiniti	M37	2

2.5 Test Item Installation

Connected Vehicle Pilot site equipment expectations include:

- Each Connected Vehicle Pilot site will work with STOL personnel to equip a TFHRC-owned vehicle with the site's OBU (one or more) configured and installed including Human Machine Interface (e.g., FCW alert), enrolled with Green Hills/ISS SCMS Test certificates (not production), vehicle size parameters, etc. Each site will work with the STOL personnel who will drive the vehicles based on predefined scenarios reviewed in advance of the Phase 2 Interoperability Test.
- NYC and Tampa will work with STOL personnel to establish TFHRC infrastructure equipment configuration (e.g., RSU broadcasting WSA, SPAT, MAP, BSM ingestion, channel plan, intersection and crosswalk configurations, network access, etc.) in advance.
- Each Connected Vehicle Pilot site will discuss with other sites and TFHRC staff what data (logging) capabilities and formats are available for each device. Presumption is that data from the demonstration does not contain personally identifiable information (PII) and will be shared with the USDOT and all three sites. No additional device capabilities (e.g., logging software) will be provided beyond the device design as of the October 2017 virtual meeting. External logging may be considered by sites to verify successful demonstration execution.

- The sites and TFHRC staff will agree on a common time reference to ensure that all recordings/logs (roadside and vehicle) can be tracked together.

2.6 RSU Channel Plan

The RSU channel assignments will follow the guidance jointly developed by the Connected Vehicle Pilot Sites. Table 6 is the latest version of the Connected Vehicle Pilot DSRC Channel Assignments and is not likely to change prior to the Interoperability Test.

Table 6. Connected Vehicle Pilot DSRC Channel Assignments **(Source: ITS JPO, 2018)**

Radio	Channel	Size	Timeslot [0|1|B]	Message	Reasoning	Site / Scenario
0	172	10	0,1	BSM, Distress Notification (DN)	Commercial Fleets / Snow Plows OBU / Highway Patrol (Lear)	Wyoming
0	172	10	0,1	BSM	COTS Radio (SiriusXM)	Wyoming
0	172	10	0,1	BSM, MAP, SPaT, RTCM	Safety Channel - Continuous	NYC
1	174	10	0,1	SCMS (IPv6), I2V Download	Over-the-Air (OTA) Firmware Updates, OTA Parameter Updates, SCMS Services	NYC
1	176	10	-,1	SCMS (IPv6), V2I Upload, PVD	Commercial OBY and COTS OBU SCMS Communications, log file upload to TMC	Wyoming
1	176	10	0,1	V2I Upload	Operational and Maintenance Uploads, Event Uploads	NYC
1	178	10	0,-	WSA, TIM	Advertisement for OTA Firmware Updates, OTA Parameter Updates, Operational and Maintenance Upload Services, SCMS Services	NYC
1	178	19	0,-	WSA, TIM	Commercial OBU and COTS OBU	Wyoming
1	180	10	0,1	V2I Upload	Operation and Maintenance Uploads, Event Uploads	NYC
1	182	10	0,1	SCMS (IPv6), I2V Download	OTA Firmware Updates, OTA Parameter Updates, SCMS Services	NYC
0	172	10	0,1	BSM, MAP, SPaT, RTCM	Operate Radio 0 in Continuous Mode on Safety Channel 172	Tampa

Radio	Channel	Size	Timeslot [0|1|B]	Message	Reasoning	Site / Scenario
1	176	10	-,1	PSM, SCMS, SRM, SSM, Data Log	Use 176 for PSM as recommended by J2945/0. Move signal request message (SRM), and SSM messages to 176 as well, SSM would have limited range due to max EIRP of 20 for this channel. Use this channel for Data Log Transfer in the downtown area.	Tampa
1	178	10	0,-	WSA, TIM, RSA	Standard Control Channel Usage	Tampa
0	180	10	0,1	Data Log	Data Log Transfer on RSU along REL	Tampa
1	182	10	-,1	OTA	OTA File Broadcast (Software and Parameter Update)	Tampa

2.7 MAP Message Generation

MAP messages will be created by STOL/TFHRC staff and reviewed by the NYC and Tampa Connected Vehicle Pilot staff. Each RSU owner will be responsible for loading the messages on their respective units.

2.8 Data Collection and Logging

NYC's two ASD's will collect DSRC message traffic using their native logging mechanisms. All DSRC message traffic will exist in the single log and be correlated to individual test cases by the start time-of-day for the test as recorded in the day's test log. Specific details for how data is collected off of the ASDs can be found in Section 11.7 of this document.

Tampa RSUs will provide data collection mechanisms via laptop connected via Ethernet to the RSU. Specific details for how data is collected off of the ASDs can be found in Section 11.8 of this document.

The Wyoming Connected Vehicle Pilot site will collect logs based on the Host and Remote vehicle adequate to demonstrate time to collision, forward collision warnings, and BSMs signature validation. These logs will be generated entirely within the Wyoming Connected Vehicle Pilot site's OBU. Details on data collection procedures can be found in Section 11.9 Wyoming Device Procedures.

3 Features for Testing

3.1 Features to Be Tested

The Connected Vehicle Pilots Phase 2 Interoperability Test will focus on demonstrating interoperability between NYC, Tampa, and Wyoming OBUs/ASDs by utilizing the FCW application. The first feature that will be tested consists of OBUs/ASDs from different Connected Vehicle Pilot sites operating in an FCW scenario (i.e., a Remote Vehicle stopped with Host Vehicle approaching from behind at the FCW triggering speed). The criteria for passing this test is the Host Vehicle's ability to receive and process BSMs from the Remote Vehicle and provide the driver a forward collision warning.

As a stretch goal and as time permits, the NYC and Tampa Connected Vehicle Pilot sites will demonstrate the IMA and EEBL applications. As with FCW, NYC and Tampa OBUs/ASDs will operate in IMA and EEBL scenarios to generate IMA and EEBL warnings. These scenarios are more complicated than the FCW scenarios. An overview of these tests can be found in Section 10 of this document.

The last feature that will be included in this Interoperability Test will be demonstrated between NYC and Tampa RSUs and their respective OBUs/ASDs for reception of SPAT and MAP messages. The goal of this test is for NYC and Tampa OBUs/ASDs to receive SPaT and MAP messages from an RSU that is not part of their deployment. As a stretch goal testing may include a Host Vehicle initiating a Red-Light Violation Warning (RLVW) scenario and the driver receiving a warning.

Table 7. Test Equipment Used for Interoperability Tests **(Source: ITS JPO, 2018)**

Connected Vehicle Pilot Site	Equipment	Baseline	FCW	IMA	EEBL	V2I / RLVW
NYC	OBU – Danlaw	●	●	+	+	●
NYC	OBU – Savari	●	●	+	+	●
NYC	RSU – Siemens					●
Tampa	OBU – Commsignia	●	●	+	+	●
Tampa	OBU – Savari	●	●	+	+	●
Tampa	OBU – SiriusXM	●	●	+	+	●
Tampa	RSU – Siemens					●
Wyoming	OBU – Lear	●	●			
TFHRC	RSU - Lear					●

● = Required, **+** = Stretch Goal

3.2 Features Not to Be Tested

The following features are not within scope of this testing:

- Negative testing of any of the applications. All Connected Vehicle Pilot sites are still required to conduct negative testing of applications within their own test programs prior to the start of deployment operations. Negative testing, in this context, includes how applications handle malformed messages, messages with bad/illogical contents, messages without certificates, etc.
- Performance testing of any of the applications. All Connected Vehicle Pilot sites are still required to conduct performance testing of these applications within their own test programs prior to the start of deployment operations. Performance testing, in this context, includes how accurately OBUs are reporting their positioning, how quickly applications alert drivers after receiving a triggering event, etc.

4 Approach

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

4.1 Connected Vehicle Pilot Interoperability Demonstration Planning

This document is the official planning document for Connected Vehicle Pilots Phase 2 Interoperability Test. The initial draft of this document was created using the testing inputs from Tampa and Wyoming; NHTSA V2V safety test procedure; as well as the Interoperability Demo Playbook (12/16/2017) which was created to help define the scope for Phase 2 Interoperability Testing. After the initial draft was compiled, gaps were identified and assigned to specific stakeholders. Those assignments are tracked by the USDOT and its technical support contractor (Noblis). The status of the action items was reported during bi-weekly Connected Vehicle Pilot Technical Roundtable Meetings. Each Connected Vehicle Pilot site was responsible for reviewing this document and providing comments/corrections. Noblis maintained configuration control of the document and updated the document based on Connected Vehicle Pilot sites and STOL/TFHRC staff inputs. This Test Plan must be approved by all stakeholders before scheduling the Interoperability Test.

4.2 Test Readiness Review (TRR)

Prior to the Connected Vehicle Pilots Phase 2 Interoperability Test, a Test Readiness Review (TRR) will be conducted to review key preconditions in Section 7 that must be met before the demonstration can be held and to officially approve of the Test Cases and Test Procedures. Progress towards test readiness will be reviewed at the Connected Vehicle Pilot Technical Roundtable Meetings, however the TRR will be the formal meeting where all stakeholders agree that they are ready to conduct the Phase 2 Interoperability Test.

4.3 Test Execution

The execution of the Connected Vehicle Pilots Phase 2 Interoperability Test will be split into three phases:

1. Installation and Checkout,
2. Test Case/Test Procedure Dry Runs, and
3. Interoperability Demonstration Runs for Record.

Throughout all three phases, a Test Director, whose role is described in Section 6.1, will be the final authority on test activities including confirming completion of each phase and initiation of the subsequent phase.

4.3.1 Installation and Checkout

The first phase will be installation and checkout. This phase will be accomplished in accordance with Section 2.5 of this document. At the completion of the installation and checkout phase each Connected Vehicle Pilot site must confirm that their connected vehicle devices have been installed and are operating correctly before moving to the second phase and TFHRC support staff must confirm that the TFHRC environment and equipment is configured and ready to begin testing. This phase will start 2 weeks before the beginning of testing and include the baseline data collection tests in Section 10.1.

4.3.2 Test Case/Test Procedure Dry Runs

Phase 2 of test execution will be a dry run of the test cases and test procedures that will be accomplished during the interoperability test. This phase is crucial because it will be the first opportunity to run through the tests with all stakeholder’s present and able to help determine if any issues found during the dry run are due to issues with the devices or with the design of the test. Once the tests have been successfully dry run and devices and procedures appear to work correctly and demonstrate the necessary functionality, test execution will move to the third and final phase.

4.3.3 Interoperability Demonstration Runs for Record

Phase 3 of test execution will be the official Connected Vehicle Pilots Phase 2 Interoperability Test runs for record. During the runs for record phase, all test cases will be executed in accordance with the schedule provided in Section 8. At the Test Director’s discretion, the schedule can be changed if issues are encountered to best maximize the available testing time.

4.4 Test Reporting

After successful conclusion of the Connected Vehicle Pilots Phase 2 Interoperability Test, 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.

4.5 Pass/Fail Criteria

The Pass/Fail criteria for each test case is listed in Section 10. 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.

4.6 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.

5 Test Environment

Testing will be conducted at the USDOT's TFHRC—located in McLean, Virginia. Figure 1 depicts a map of the test facility including key infrastructure (e.g., location of traffic signals and cabinets) currently located at TFHRC. The test bed includes three traffic signal cabinets near the first intersection and one near the second intersection as shown by the blue boxes on the map. The RSUs used for the interoperability test were mounted on Poles D and F (shown with green dots). Traffic sensors are installed throughout the FHWA Cirgulation Road with a GPS station located near the second intersection to the left of North Driveway and denoted by a green box. Four pedestal poles (shown with red dots) and a gantry (shown with two orange boxes with connecter line) are also shown on the map.

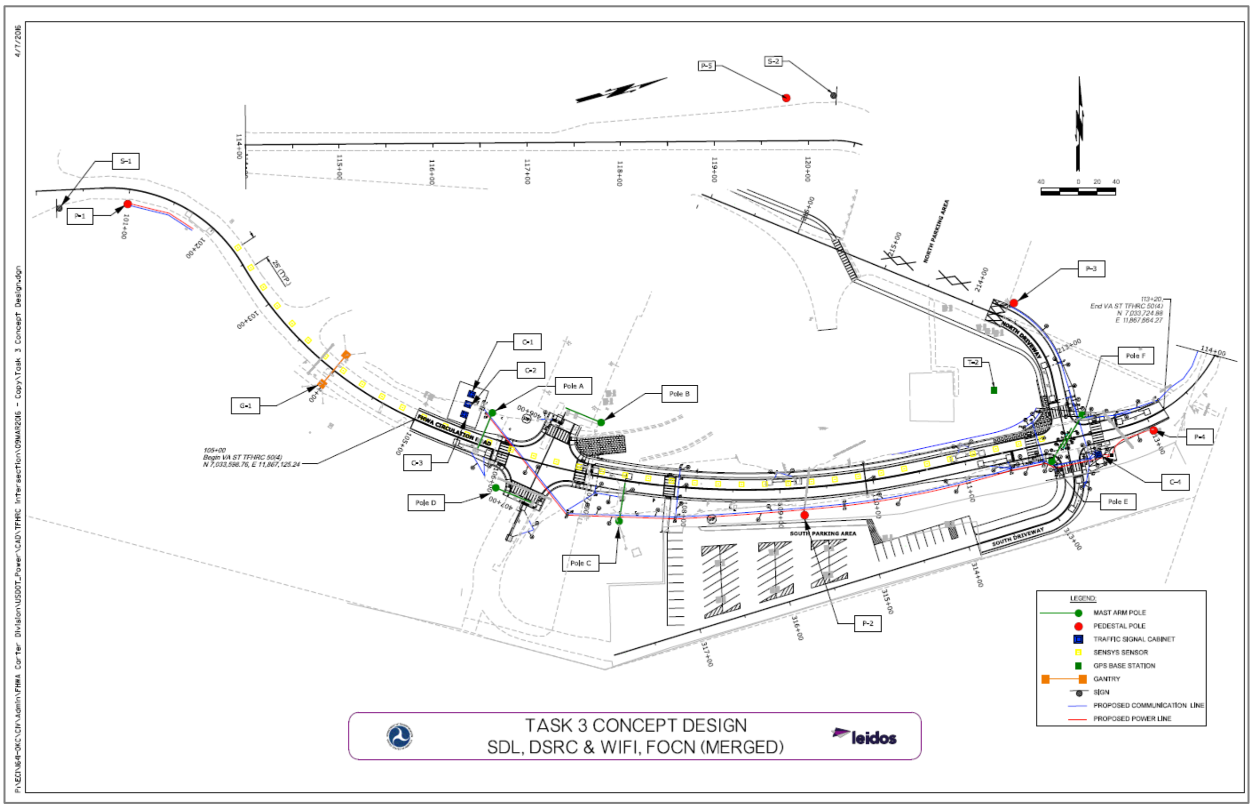

Figure 1. Map of the TFHRC Facility **(Source: FHWA, 2018)**

6 Roles and Responsibilities

This section defines the various roles and responsibilities for the Connected Vehicle Pilots Phase 2 Interoperability Test.

6.1 Test Director

Deb Curtis (FHWA) will serve as the Test Director for the Interoperability Test. 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.

6.2 Test Coordinator

Justin Anderson (Noblis) will serve as the Test Coordinator for the Interoperability Test. The Test Coordinator is responsible for:

- Maintaining and updating the Connected Vehicle Pilots Phase 2 Interoperability Testing Test Plan;
- Working with the applicable stakeholders to get inputs for gaps/updates to the test plan;
- Tracking the status of Connected Vehicle Pilots Phase 2 Interoperability Testing Test Planning/Test Readiness;
- Supporting the execution of interoperability testing by tracking progress of each Connected Vehicle Pilot 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 Connected Vehicle Pilots Phase 2 Interoperability Testing Test Report.

6.3 Connected Vehicle Pilot Site Test Leads

The Connected Vehicle Pilot Site Test Leads will be: Hisham Khanzada (NYC), Steve Novosad (Tampa), and Tony English (Wyoming). The Connected Vehicle Pilot Site Test Leads are responsible for:

- Providing site specific inputs to the Test Plan for the Connected Vehicle Pilots Phase 2 Interoperability Test;

- Reviewing the Test Plan for the Connected Vehicle Pilots Phase 2 Interoperability Test 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 Test Report for the Connected Vehicle Pilots Phase 2 Interoperability Test; and
- Reviewing the Test Report for the Connected Vehicle Pilots Phase 2 Interoperability Test and providing comments.

6.4 Test Support Personnel

The STOL Contractor—Leidos— will provide test support personnel. Test Support Personnel 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 10 and 11 of this document, respectively;
- Preparing the test environment (Note: Tampa will send an installer to install equipment in the vehicles in advance of the Interoperability Test);
- 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.

6.5 USDOT Representative Team

The USDOT Representative Team will include Jonathan Walker (NYC Site Representative), Ed Fok (filling in for Govind Vadakpat and the Tampa Site Representative), and Kate Hartman (Wyoming Site Representative). The USDOT Representative Team shall be responsible for:

- Reviewing, commenting on and approving the Test Plan for the Connected Vehicle Pilots Phase 2 Interoperability Test;
- Witnessing the execution of the tests;
- Coordinating/Approving test support; and
- Reviewing, commenting on and approving the Test Report for the Connected Vehicle Pilots Phase 2 Interoperability Test.

6.6 Independent Evaluator

Texas A&M Transportation Institute (TTI) will serve as the Independent Evaluator. The Independent Evaluator shall be responsible for:

- Witnessing the execution of the tests;
- Recording observations and lessons learned based on what they witnessed;
- Interviewing key test stakeholders to get their input on what was successful and what didn't work during the interoperability test;
- Developing an independent evaluation of the interoperability of devices based on the testing and interviews, including highlighting what worked well, what couldn't be tested and what doesn't work and needs further definition; and
- Reviewing, commenting and providing input for the Test Report for the Connected Vehicle Pilots Phase 2 Interoperability Test.

6.7 Connected Vehicle Device Vendors

Connected Vehicle Device Vendors include Commsignia, Danlaw, Lear, Savari, Siemens, and SiriusXM. The Connected Vehicle Device Vendors shall be responsible for:

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

7 Testing Preconditions

The following preconditions must be met before the Connected Vehicle Pilots Phase 2 Interoperability Test can begin:

- All stakeholders must approve the Test Plan;
- All devices must be enrolled/have certificates from Green Hills/ISS Commercial Test SCMS System;
- All devices must have demonstrated their required functionality during their respective Connected Vehicle Pilot project testing;
- Test environment is available and ready for Connected Vehicle Pilot site 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
            - Manual Signal Switcher has been identified and is available
    - Meeting rooms and other facilities are reserved;
    - TFHRC Test Equipment is available and functional;
        - Signal Controllers
        - Fiber Backhaul
        - V2I Hub
        - DSRC Packet Sniffers
        - Vehicles
            - Potentially conflicting safety systems (e.g. automated steering) disabled
    - MAP Messages have been generated for each RSU location

8 Schedule

This section contains the test schedule based on the Connected Vehicle Pilot 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 for both the Host and Remote Vehicles and tests with only OBUs from the other Connected Vehicle Pilot sites (e.g. – Tampa and NYC do not execute interoperability tests with the other devices in their programs). A basic assumption of 10 minutes per test run is assumed. A detailed test schedule is included in Appendix B.

- **Test Readiness Review – May 25, 2018**
  - Review Test Preconditions in Section 7 of this document and ensure all are either met or on track to be met before June 26th.
  - All stakeholders approve the final test plan.
  - All Connected Vehicle Pilot sites confirm that they are still ready and able to participate in interoperability testing June 26-28 and that TFHRC receives devices prior to June 11th.
- **Day 1: Monday June 25, 2018**
  - 8:30 AM – 5:00 PM - Sites to Set-up Devices and Verify they are working properly
    - Note: Connected Vehicle Pilot Sites to coordinate schedule with STOL staff; The Connected Vehicle Pilot Sites are not required to attend the entire time, but by the end of the day should verify that all their devices are working properly.
- **Day 2: Tuesday June 26, 2018**
  - 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 – 12:00 PM - Test Case 10.2: FCW Stationary Remote Vehicle Same Lane
  - 12:00 PM – 12:30 PM - Lunch
  - 12:30 PM – 2:30 PM - Test Case 10.2: FCW Stationary Remote Vehicle Same Lane
  - 2:30 PM – 4:30 PM - Test Case 10.5: IMA Host Vehicle Stopped
  - 4:30 PM – 5:00 PM - Wrap Up
- **Day 3: Wednesday June 27, 2018**
  - 8:30 AM – 9:00 AM - Day 2 Kick-off and Prep for Tests
  - 9:00 PM – 10:00 PM - Test Case 10.6: V2I / RLVW
  - 10:00 AM – 1:00 PM - Test Case 10.4 FCW Moving Remote Vehicle and EEBL
  - 1:00 PM – 1:30 PM - Lunch
  - 1:30 PM – 5:10 PM - Test Case 10.3 FCW Stationary Remote Vehicle Adjacent Lane
  - 5:10 PM – 5:30 PM - Wrap Up
- **Day 4: Thursday June 28, 2018**
  - 8:30 AM – 10:30 AM - Complete Re-Tests (as needed)
  - 10:30 AM – 12:00 PM - Face-to-Face Meeting: Independent Evaluator Focus Group

9 Risks and Contingencies

Table 8 provides the high-level risks and contingencies identified with conducting the Interoperability Test.

Table 8. Risks and Contingencies **(Source: ITS JPO, 2018)**

Risk	Likelihood	Severity	Contingency
Inclement 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 Electromagnetic Interference (EMI) the V2V safety applications will not generate the proper warnings. This can be mitigated if the Connected Vehicle Pilot programs can provide devices to TFHRC prior to testing so TFHRC 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 DSRC spectrum. TFHRC will coordinate this interoperability test with neighboring facilities to minimize the risk of this type of interference.
Test Vehicle Mechanical Breakdown	Low	Low	TFHRC maintains a fleet of test vehicles and regularly conducts maintenance on them. If a test vehicle experiences mechanical issues TFHRC staff will investigate the issue while testing can continue using the other vehicles with equipment installed. If the vehicle cannot be repaired in time, TFHRC will determine the feasibility of installing the OBU in a different vehicle.

10 Test Cases

10.1 Baseline OBU/ASD Data Collection

10.1.1 Test Objective

The objective of the Baseline OBU/ASD Data Collection test is to collect data from OBUs/ASDs from each site installed on a vehicle simultaneously to create a baseline of how devices perform in relation to each other. If the Connected Vehicle Pilot sites 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.

10.1.2 Test Description

Table 9 provides an overview of the OBUs installed in each test vehicle. TFHRC and STOL staff will conduct the installation of the OBUs in these vehicles utilizing guidance provided by the Connected Vehicle Pilot sites.

Table 9. OBUs Used for the Baseline OBU/ASD Data Collection Test (Source: ITS JPO, 2018)

Vehicle	OBU 1	OBU 2	OBU 3
Vehicle #1	Wyoming Lear	Tampa Commsignia	NYC Savari
Vehicle #2	Tampa Savari	Tampa SiriusXM	NYC Danlaw

Note: Both vehicle need to be GM vehicles since NYC OBUs need to connect to the CAN-BUS.

Each vehicle will travels Path 1 (Figure 2) from Point A to Point B, turns around and travels from Point B to Point C. The vehicle travels this path three times. As the vehicle travels these paths a DSRC Packet Sniffer collects BSMs from all three OBUs/ASDs. At the conclusion, it is verified that BSMs were collected from all three OBUs/ASDs and that they show the path that the vehicle traveled.

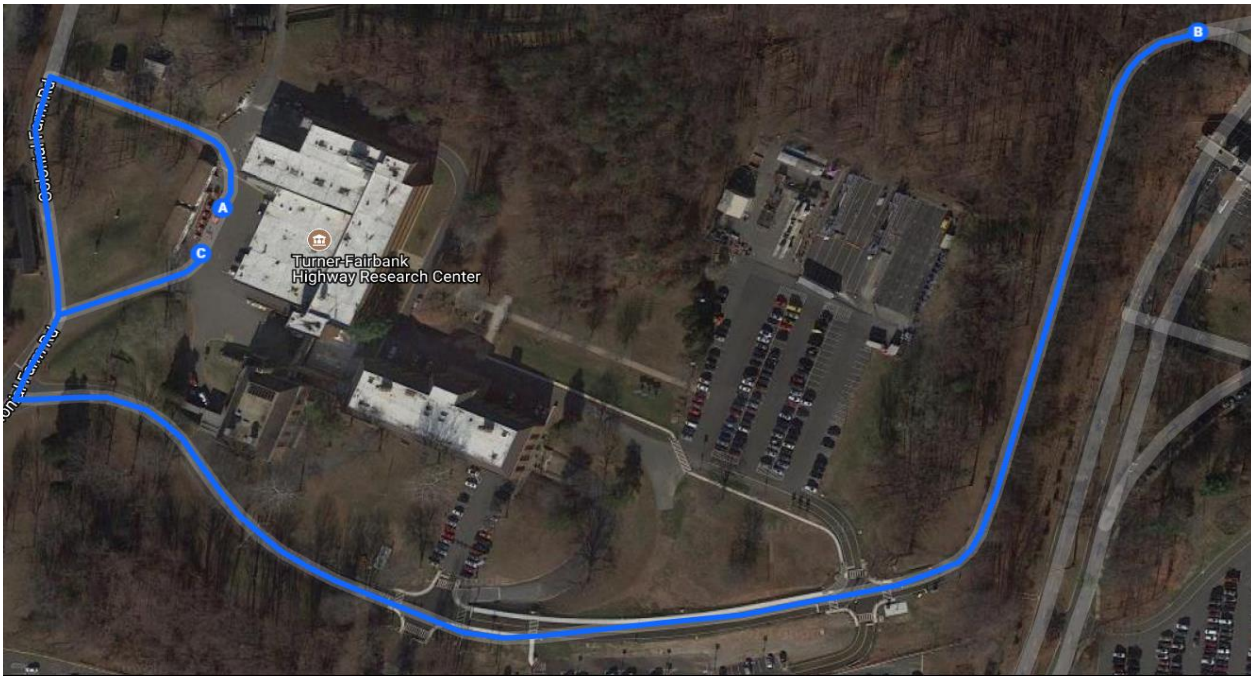

Figure 2. Baseline OBU/ASD Data Collection - Path 1 **(Source: ITS JPO, 2018)**

If data collected shows OBUs/ASDs are operating nominally, each vehicle will travel Path 2 (Figure 3). As the vehicles travel these paths a DSRC Packet Sniffer collects BSMs from all three OBUs/ASDs. At the conclusion, it is verified that BSMs were collected from all three OBUs/ASDs and that they show the path that the vehicle traveled.

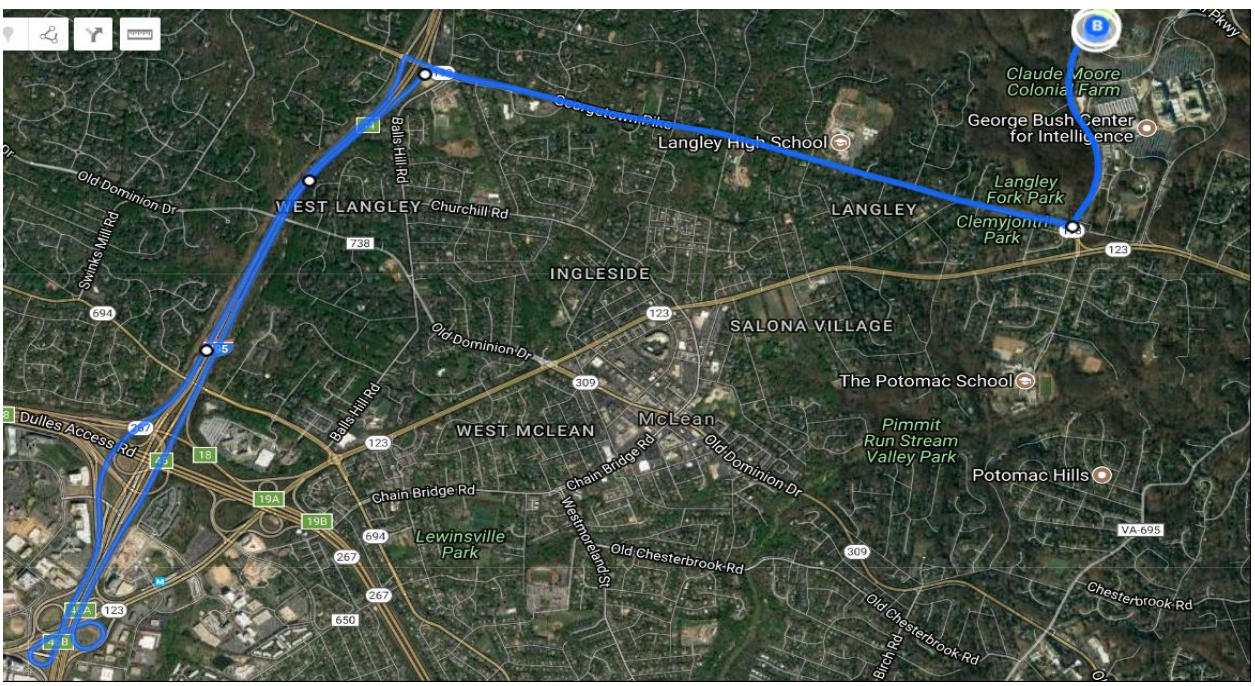

Figure 3. Baseline OBU/ASD Data Collection - Path 2 **(Source: ITS JPO, 2018)**

10.2 FCW Stationary Remote Vehicle Same Lane

10.2.1 Test Objective

The objective of FCW Stationary Remote Vehicle Same Lane test is to have each model of OBU/ASD from each Connected Vehicle Pilot site demonstrate that they can produce an FCW warning to a driver when receiving BSMs from one of the other Connected Vehicle Pilot site devices and with the Host Vehicle approaching a stationary Remote Vehicle in the same lane.

10.2.2 Test Description

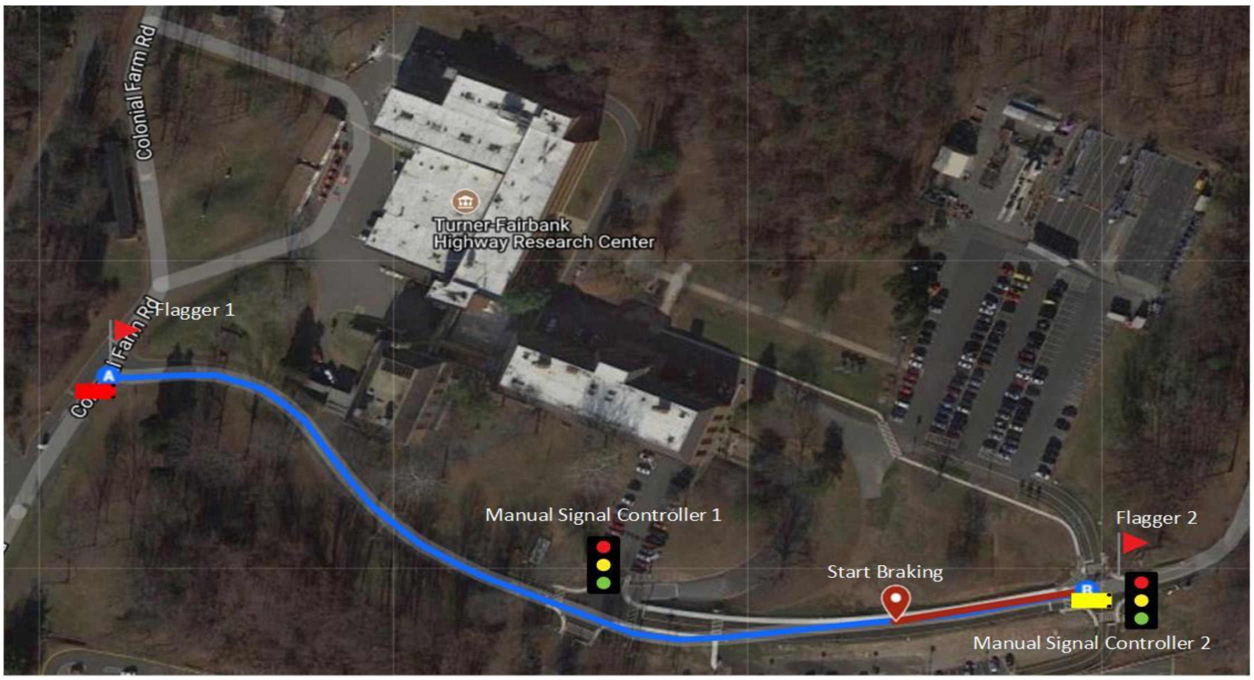

Figure 4. FCW Stationary Remote Vehicle Same Lane **(Source: ITS JPO, 2018)**

The device under test will be the Host Vehicle (depicted in Figure 4 as a red box), with a one OBU installed on it and a Remote Vehicle (depicted in Figure 4 as a yellow box) with an OBU from a different Connected Vehicle Pilot site. The Remote Vehicle will drive to location B in Figure 4 below and stop there. The Host Vehicle will drive to location A in Figure 4 below and stop there. The Host Vehicle will accelerate to the 35 mph and approach the Remote Vehicle at location B. When the Host Vehicle gets to the Start Braking Point (approximately 150 feet from the Remote Vehicle and marked by a flag or cone) a warning is provided to the Host Vehicle driver that a forward collision is imminent. The Host Vehicle either stops behind the Remote Vehicle or drives around the Remote Vehicle. If the test is successful, the Host Vehicle returns to location A and a vehicle with a different device installed drives to location B and the test is run again. The test is re-executed for all combinations of Host and Remote Vehicles. Flaggers (depicted in Figure 4 as red triangles) will be positioned at each end of this run to ensure no other vehicles enter the roadway. Additionally, the signals at each intersection will be put into manual mode with a person controlling each intersection to ensure they maintain the correct signal phase throughout the test.

10.2.3 Pass/Fail Criteria

The following criteria must be met for this test to pass:

- The Host Vehicle must receive and process BSMs from the Remote Vehicle,
- The Host Vehicle must authenticate the BSMs from the Remote Vehicle triggering the alert, and
- The Host Vehicle driver must receive a forward collision warning.

10.3 FCW Stationary Remote Vehicle Adjacent Lane

10.3.1 Test Objective

The objective of the FCW Stationary Remote Vehicle Adjacent Lane test is to have each model of OBU/ASD from each Connected Vehicle Pilot site demonstrate that they do not produce an FCW warning when approaching another vehicle producing BSMs in an adjacent lane.

10.3.2 Test Description

Figure 5: FCW Stationary Remote Vehicle Adjacent Lane (Source: ITS JPO, 2018)

The device(s) under test will be in the Host Vehicle (depicted in Figure 5 as a red box), with a different device from one of the other Connected Vehicle Pilot sites installed in the Remote Vehicle (depicted in Figure 5 as a yellow box). The Remote Vehicle will drive to location C in Figure 5 below and stop in the cutaway area facing east as if it were in a lane adjacent to the normal road. The Host Vehicle will drive to location A in Figure 5 below and stop there. The Host Vehicle will accelerate to 35 mph and approach the Remote Vehicle at location B. The Host Vehicle will continue traveling past the Remote Vehicle to Location B. The Host Vehicle driver should not receive a forward collision warning when approaching or passing the Remote Vehicle. If the test is successful, the Host Vehicle returns to location A and a vehicle with a different device installed drives to location C and the test is run again. The test is re-executed for all combinations of Host and Remote Vehicles. Flaggers (depicted in Figure 5 as red triangles) will be positioned at each end of this run to ensure no other vehicles enter the roadway. Additionally, the signals at each intersection will be put into manual mode with a person controlling each intersection to ensure they maintain the correct signal phase throughout the test.

10.3.3 Pass/Fail Criteria

The following criteria must be met for this test to pass:

- The Host Vehicle must receive and process BSMs from the Remote Vehicle,
- The Host Vehicle must authenticate the BSMs from the Remote Vehicle and not trigger the alert, and
- The Host Vehicle driver does not receive a forward collision warning.

10.4 FCW Moving Remote Vehicle and Electronic Emergency Brake Light (EEBL)

10.4.1 Test Objective

The objective of the FCW Moving Remote Vehicle and EEBL test is to have each model of OBU/ASD and demonstrate that the NYC and Tampa devices can produce an EEBL warning to a driver when receiving BSMs from one of the other Connected Vehicle Pilot site devices and participating in an EEBL scenario while demonstrating that Wyoming, NYC and Tampa devices can produce FCW warning as they get within FCW range of the Remote Vehicle.

10.4.2 Test Description

Figure 6: FCW Moving Remote Vehicle and EEBL (Source: ITS JPO, 2018)

The device(s) under test will be the Host Vehicle (depicted in Figure 6 as a red box), with a different device from one of the other Connected Vehicle Pilot Sites installed in the Remote Vehicle (depicted in Figure 6 as a yellow box). The Host Vehicle will drive to Location A in Figure 6 and the Remote Vehicle will position itself 150 feet in front of the Host Vehicle. Both the Host and Remote Vehicles accelerate to 35 mph and maintain 150 feet distance between each other. At the Start Braking Point the Remote Vehicle will start braking and come to a complete stop. The Host Vehicle driver confirms that they received the electronic emergency brake light warning and/or forward collision warning. As the Host Vehicle continues forward, the Host Vehicle driver confirms that they receive a forward collision warning after receiving the electronic emergency brake light warning. If the test is successful, then the test is repeated for all combinations of connected vehicle devices. Flaggers (depicted in Figure 6 as red triangles) will be positioned at each end of this run to ensure no other vehicles enter the roadway.

Additionally, the signals at each intersection will be put into manual mode with a person controlling each intersection to ensure they maintain the correct signal phase throughout the test.

10.4.3 Pass/Fail Criteria

The following criteria must be met for this test to pass:

- The Host Vehicle must receive and process BSMs from the Remote Vehicle,
- The Host Vehicle must authenticate the BSMs from the Remote Vehicle triggering the alert, and
- The Host Vehicle driver must receive an electronic emergency brake light warning followed by a forward collision warning.

10.5 Intersection Movement Assist (IMA) Host Vehicle Stopped

10.5.1 Test Objective

The objective of IMA Host Vehicle Stopped test is to have each model of OBU/ASD from the NYC and Tampa Connected Vehicle Pilot sites demonstrate that they can produce an IMA warning to a driver when receiving BSMs from one of the other Connected Vehicle Pilot deployment project with the Host Vehicle stopped and an intersection and then starts slowly moving as the Remote Vehicle traverses the intersection.

10.5.2 Test Description

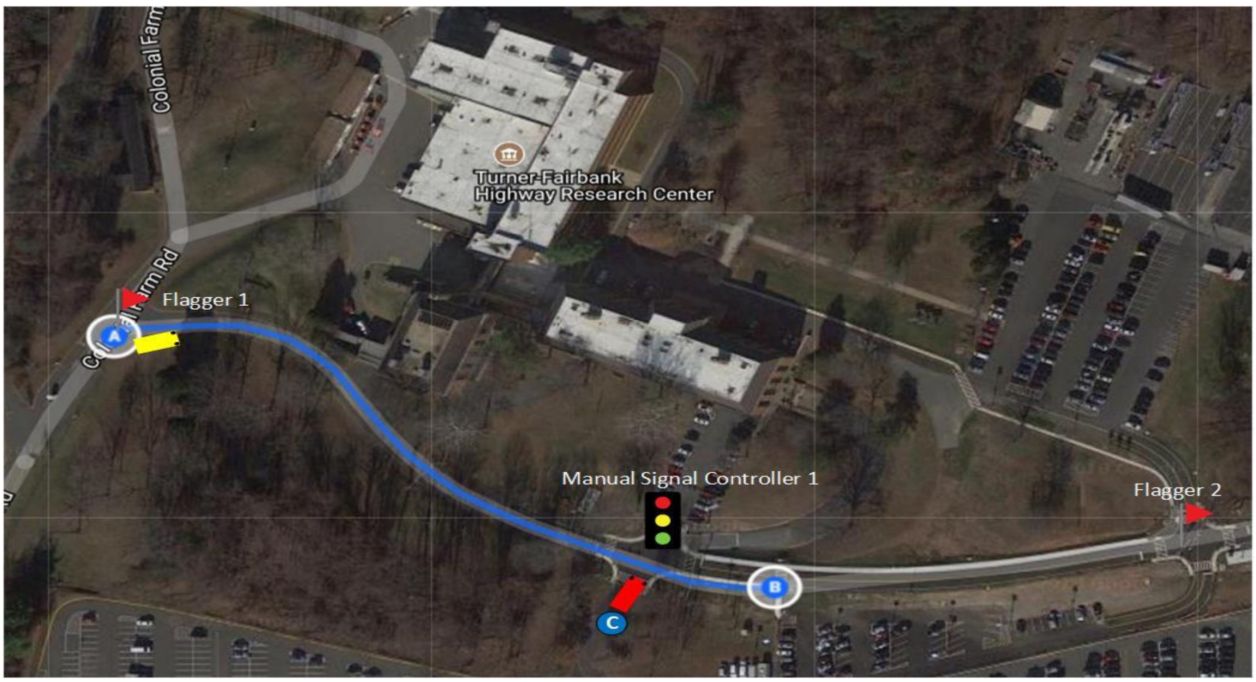

Figure 7: IMA Host Vehicle Stopped **(Source: ITS JPO, 2018)**

The device under test will be the Host Vehicle (depicted in Figure 7 as a red box), with a different device from one of the other Connected Vehicle Pilot sites installed in the Remote Vehicle (depicted in Figure 7 as a yellow box). The Remote Vehicle will drive to location A in Figure 7 below and stop there. The Host Vehicle drives to Location C in Figure 7 below and stops there. The Remote Vehicle accelerates to 35 mph, maintains that speed and travels along the path shown in Figure 7 toward Location C. The Host Vehicle remains stopped at Location F. When the Remote Vehicle is within 25 feet of the intersection (which will be marked by flags or a cone) the Host Vehicle releases the brake and the driver confirms they have received an intersection movement assist warning. If the test is successful, then the test is repeated for all combinations of connected vehicle devices.

10.5.3 Pass/Fail Criteria

The following criteria must be met for this test to pass:

- The Host Vehicle must receive and process BSMs from the Remote Vehicle,
- The Host Vehicle must authenticate the BSMs from the Remote Vehicle triggering the alert, and
- The Host Vehicle driver must receive an intersection movement assist warning.

10.6 Vehicle to Infrastructure (V2I)/Red Light Violation Warning (RLVW)

10.6.1 Test Objective

The objective of V2I / RLVW test is to have each model of OBU/ASD from the NYC and Tampa Connected Vehicle Pilot sites demonstrate that they can receive SPAT and MAP messages from the other Connected Vehicle Pilot deployments RSUs. As a stretch goal, each model of OBU/ASD would provide a red-light violation warning (RLVW) to the driver when participating in an RLVW Scenario.

10.6.2 Test Description

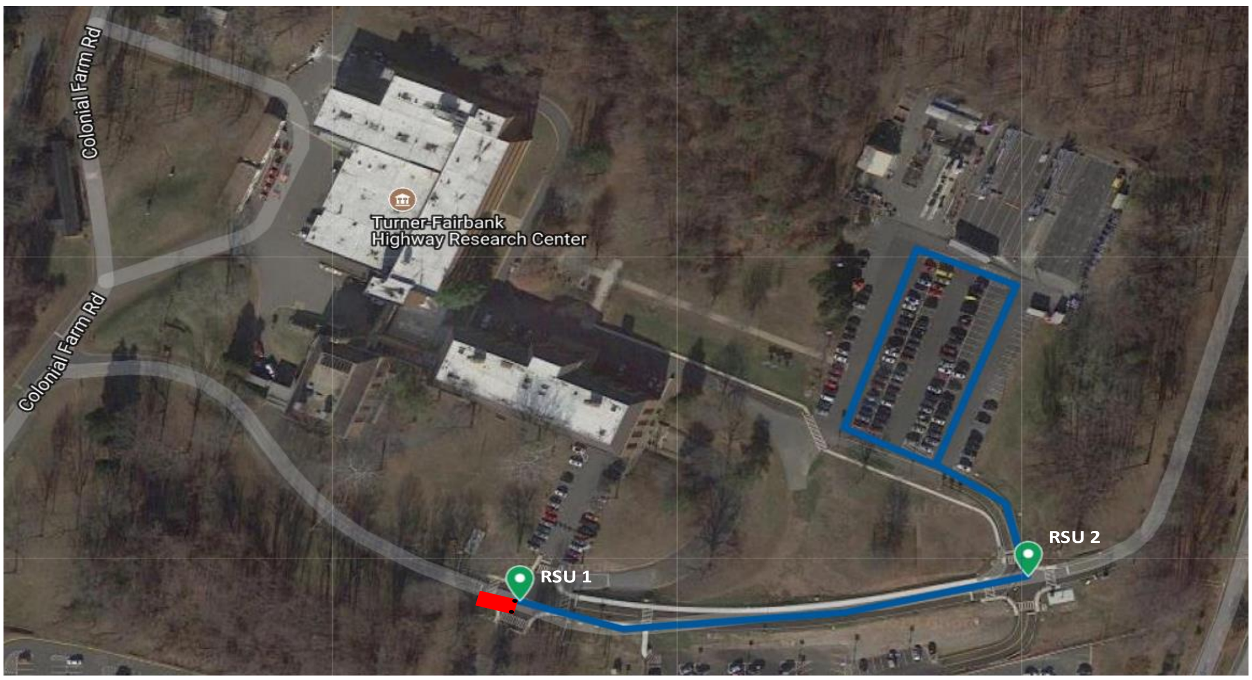

Figure 8: V2I / RLVW **(Source: ITS JPO, 2018)**

Three RSUs are installed at locations RSU 1, RSU 2 and RSU 3. Table 10 shows the RSU model and Signal Controller model used at each location.

Table 10. V2I / RLVW RSUs and Traffic Signal Controllers **(Source: ITS JPO, 2018)**

Location	RSU Model	Signal Controller Model
RSU 1	Siemens	Sitraffic ESCoS Roadside Unit V 1.0
RSU 2	Siemens	Sitraffic ESCoS Roadside Unit V 1.0

The Host Vehicle (depicted in Figure 8 as a red box), travels to the Location of RSU 1 and stops. The Host travels along the path show in Figure 8 below to RSU 2, makes a left turn into the parking lot, turns around and travels long the same path in reverse.

10.6.3 Pass/Fail Criteria

10.6.3.1 Threshold Criteria

The following is the threshold criteria for passing the test:

- The Host Vehicle must receive, and process SPAT and MAP messages from the RSU, and
- The Host Vehicle must authenticate the SPAT and MAP messages from the RSU.

10.6.3.2 Objective Criteria

The following is the objective criteria for the test:

- The Host Vehicle provides a red-light violation warning to the driver when entering an RLVW scenario.

10.7 Test Case Prioritization

Due to time constraints it may not be possible to conduct all of the test cases listed above. Table 11 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 11. Test Case Prioritization **(Source: ITS JPO, 2018)**

Priority	Test Case
1	10.2 FCW Stationary Remote Vehicle
2	10.6 V2I / RLVW
3	10.1 Baseline OBU/ASD Data Collection
4	10.5 IMA Host Vehicle Stopped
5	10.4 FCW Moving Remote Vehicle and EEBL
6	10.3 FCW Stationary Remote Vehicle Opposite Lane

11 Test Procedures

11.1 Baseline OBU/ASD Data Collection

Path 1 for the Baseline OBU/ASD Data Collection Test is depicted in the figure below.

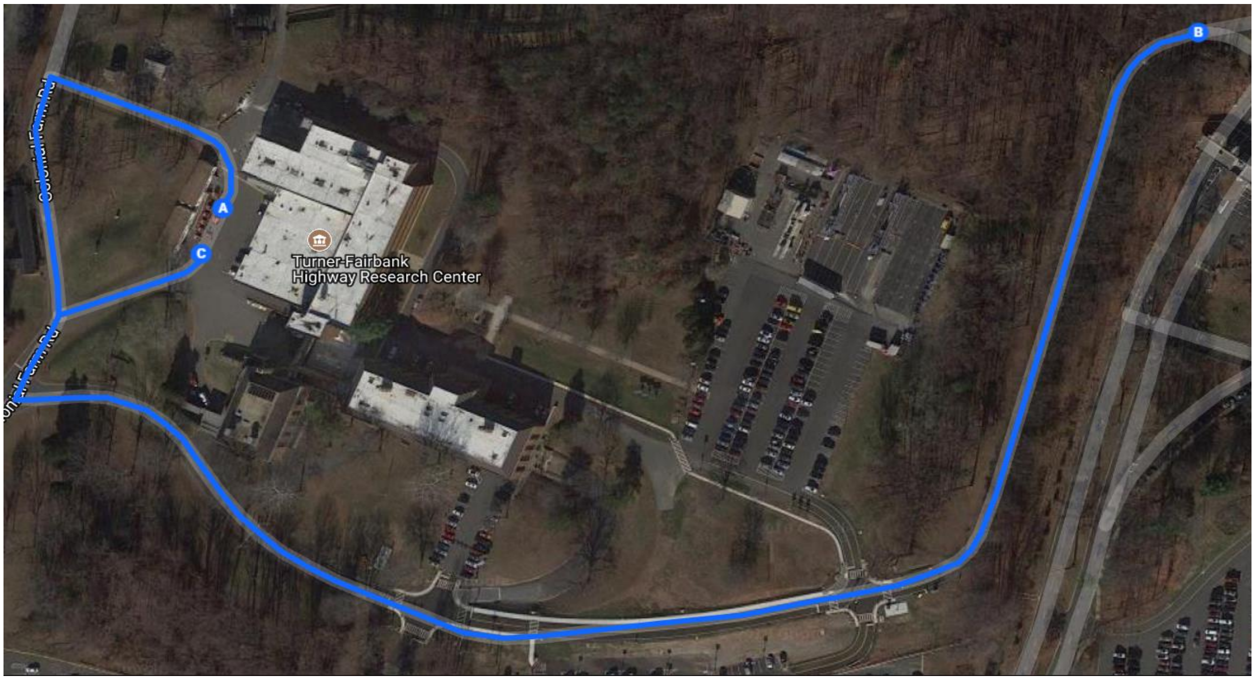

Figure 9. Baseline OBU/ASD Data Collection Path 1 (Source: ITS JPO, 2018)

Table 12 includes the Test Procedures for the Baseline OBU/ASD Data Collection Test – Path 1.

Table 12. Baseline OBU/ASD Data Collection Test Procedures – Path 1 (Source: ITS JPO)

ID	Step	Action	Expected Result	Pass / Investigate / Fail
1.	Verify Readiness	NYC OBU is installed and operating according to procedures in Section 11.7.		Pass / Fail
2.	Verify Readiness	Tampa OBU is installed and operating according to procedures in Section 11.8.		Pass / Fail
3.	Verify Readiness	Wyoming OBU is installed and operating according to procedures in Section 11.9.		Pass / Fail
4.	Test Vehicle	Travel to Point A in Figure 9.		

ID	Step	Action	Expected Result	Pass / Investigate / Fail
5.	Test Vehicle	Travel up the hill and turn left on Colonial Farm Rd.		
6.	Test Vehicle	Travel along Colonial Farm Rd. and turn left onto the test bed.		
7.	Test Vehicle	Continue straight until reaching Point B in Figure 9.		
8.	Test Vehicle	Turn vehicle around and travel back along making a right turn onto Colonial Farm Rd.		
9.	Test Vehicle	Continue to Point C in Figure 9.		
10.	Test Vehicle	Repeat Steps 4-9 two more times.		
11.	Verify Data Collection	Verify that data was collected by all three OBUs installed on the Test Vehicle.		Pass / Fail
12.	Test Vehicle	If data was successfully collected, continue to Step 13.		

Path 2 for the Baseline OBU/ASD Data Collection Test is depicted in the figure below.

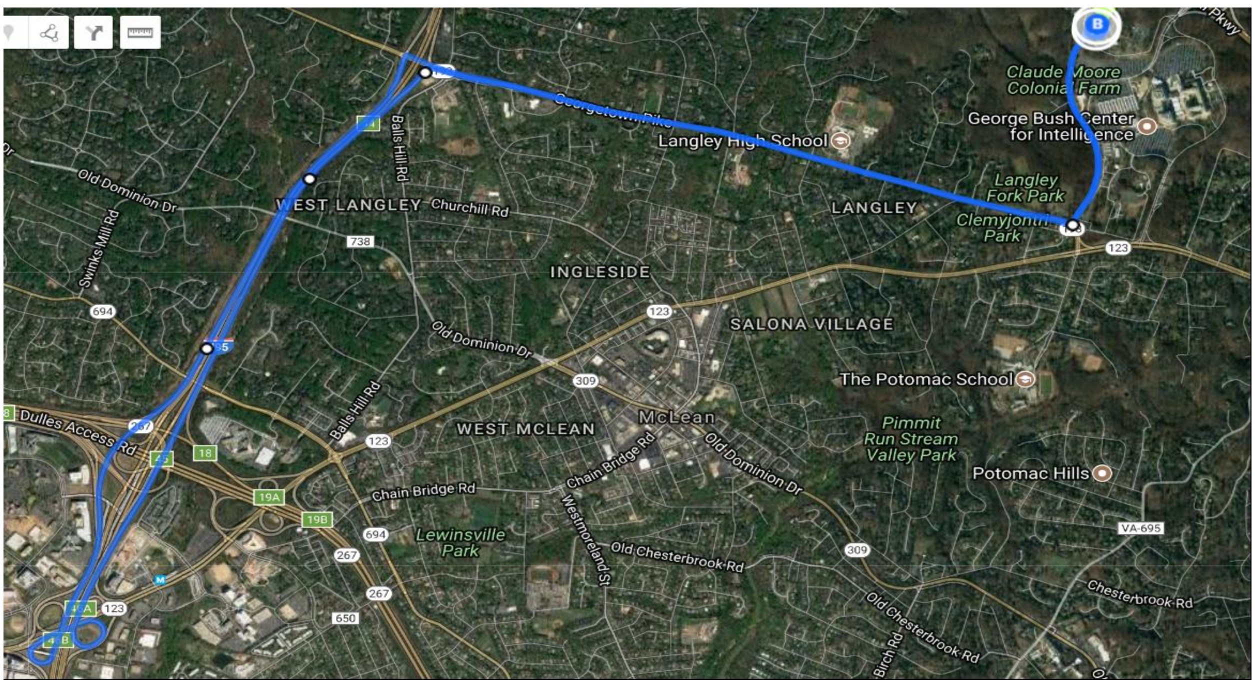

Figure 10. Baseline OBU/ASD Data Collection Path 2 (Source: ITS JPO, 2018)

Table 13 includes the Test Procedures for the Baseline OBU/ASD Data Collection Test – Path 2.

Table 13. Baseline OBU/ASD Data Collection Test Procedures – Path 2 (Source: ITS JPO, 2018)

ID	Step	Action	Expected Result	Pass/Investigate/ Fail
1.	Test Vehicle	Travel to Point A in Figure 10.		
2.	Test Vehicle	Travel up the hill and turn left on Colonial Farm Rd.		
3.	Test Vehicle	Travel 0.819 mi along Colonial Farm Rd and turn right onto Georgetown Pike.		
4.	Test Vehicle	Travel 2.4 mi along Georgetown Pike and turn left onto the Interstate I-495 S ramp.		
5.	Test Vehicle	Travel 0.951 mi along I-495 S and keep to the right at the fork in the road to stay on I-495 S.		
6.	Test Vehicle	Travel 1.77 mi along I-495 S and take exit 46B State Route 123/Chain Br Rd toward McLean.		
7.	Test Vehicle	Merge onto Chain Bridge Rd/Dolley Madison Blvd and travel for 0.3 mi taking the Interstate 495 N ramp to Rockville/Baltimore.		
8.	Test Vehicle	Merge onto I-495 N and travel 2.33 mi taking exit 44 for VA-193/Georgetown Pike.		
9.	Test Vehicle	Turn right onto Georgetown Pike and travel 2.32 mi.		
10.	Test Vehicle	Turn left onto Colonial Farm Rd and travel 0.826 mi stopping at Location B in Figure 10.		
11.	Verify Data Collection	Verify that data was collected by all three OBUs installed on the Test Vehicle.		Pass / Fail

11.2 Forward Collision Warning (FCW) Stationary Remote Vehicle – Same Lane

The path for the FCW Stationary Remote Vehicle – Same Lane Test is depicted in the figure below.

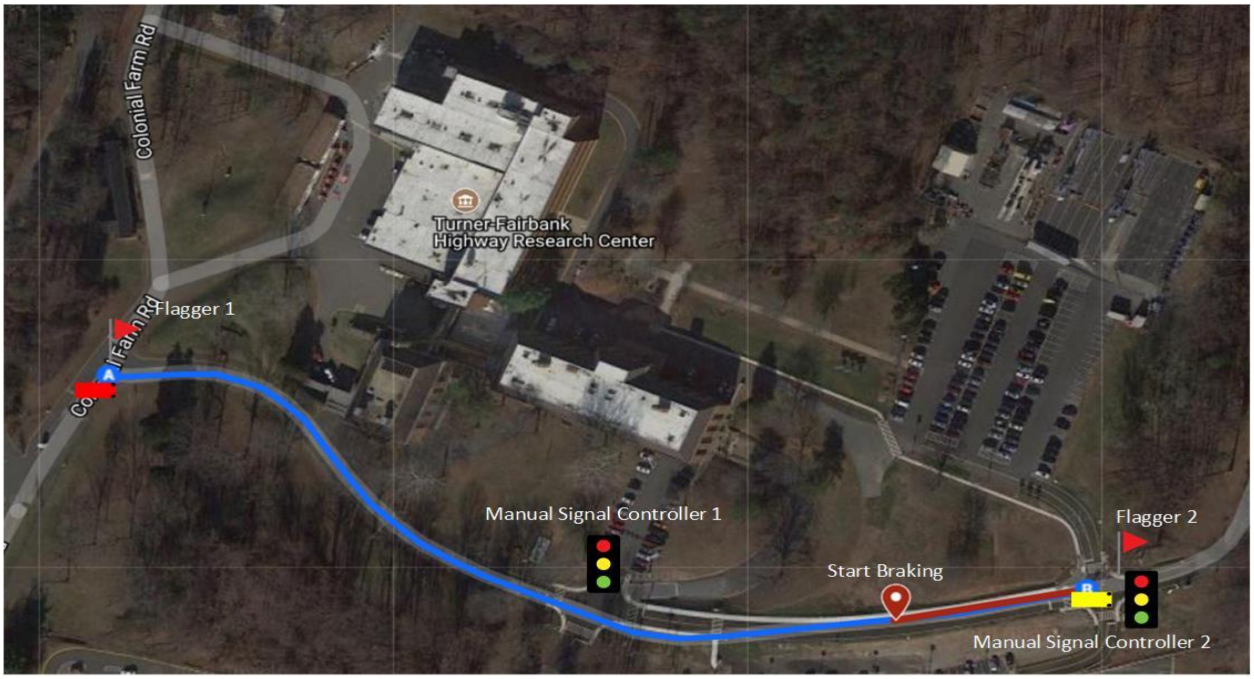

Figure 11. FCW Stationary Remote Vehicle Same Lane Path (Source: ITS JPO, 2018)

Table 14 includes the Test Procedures for the FCW Stationary Remote Vehicle – Same Lane Test.

Table 14. FCW Stationary Remote Vehicle Same Lane Test Procedures (Source: ITS JPO, 2018)

ID	Step	Action	Expected Result	Pass / Investigate / Fail
1.	Verify Readiness	Verify OBUs in Host and Remote Vehicle are operating and collecting data in accordance with the specific device instructions found in Sections 11.7 – 11.9.		Pass / Fail
2.	Verify Readiness	Verify no connected vehicle devices are broadcasting messages conformant with the SAE J2735 2009 standard.		
3.	Verify Readiness	Verify flaggers are at their required positions and ready to stop traffic along the vehicle paths in Figure 11.		
4.	Verify Readiness	Verify Manual Signal Controllers are ready set the signals to the correct phase.		

ID	Step	Action	Expected Result	Pass / Investigate / Fail
5.	Test Set-up, Host Vehicle	Drive to Location A in Figure 11 and stop.		
6.	Test Set-up, Remote Vehicle	Drive to Location B in Figure 11 and stop at that location in the right lane of the road. Apply the brake but do not put the vehicle in park.		
7.	Flaggers	Stop traffic from entering the vehicle paths show in Figure 11.		
8.	Manual Signal Controller 1	Set the light to Green for Eastbound/Westbound Traffic.		
9.	Manual Signal Controller 2	Set the light to Red for Eastbound/Westbound Traffic.		
10.	Test Director	Records the time of the test		
11.	Host Vehicle	Accelerate to 35 mph and maintain that speed traveling along the path shown in Figure 11.		
12.	Host Vehicle	When the Host Vehicle is within 150 feet (marked by a flag or cone) of the Remote Vehicle it receives a forward collision warning and then either come to a stop behind the Remote Vehicle or drive around it.	Driver receives Forward Collision Warning.	Pass / Investigate / Fail
13.	Host Vehicle	Host Vehicle driver manually records the forward collision warnings they received (e.g. – audio only, audio and visual, etc.)		
14.	Host Vehicle	If Host Vehicle driver received the proper forward collision warnings notify Test Director for recording the result.		
15.	Remote Vehicle	If Host Vehicle driver received the proper forward collision warnings, switch the Remote Vehicle to a vehicle with a different OBU/ASD.		
16.		Repeat Steps 1-15 for all OBU combinations. Then switch the Host Vehicle with a vehicle with a different OBU repeating Steps 1-15 until all combinations of Host and Remote Vehicle combinations have been accomplished.		Pass / Investigate / Fail

11.2.1 Test Combinations Matrix

Table 15 include the test combinations for the FCW Stationary Remote Vehicle – Same Lane Test

Table 15. FCW Stationary Remote Vehicle – Same Lane Test Combinations Matrix **(Source: ITS JPO, 2018)**

FCW Stationary Remote Vehicle – Same Lane	Remote Device	Wyoming - Lear	NYC - Danlaw	NYC - Savari	Tampa - Commsignia	Tampa - Savari	Tampa - SiriusXM
Host Device							
Wyoming - Lear							
NYC - Danlaw							
NYC - Savari							
Tampa - Commsignia							
Tampa - Savari							
Tampa - SiriusXM							

11.3 FCW Stationary Remote Vehicle – Adjacent Lane

The path for the FCW Stationary Remote Vehicle – Adjacent Lane Test is depicted in the figure below.

Figure 12. FCW Stationary Remote Vehicle – Adjacent Lane Path (Source: ITS JPO, 2018)

Table 16 includes the Test Procedures for the FCW Stationary Remote Vehicle – Adjacent Lane Test.

Table 16. FCW Stationary Remote Vehicle Adjacent Lane Test Procedures (Source: ITS JPO, 2018)

ID	Step	Action	Expected Result	Pass / Investigate / Fail
1.	Verify Readiness	Verify OBUs in Host and Remote Vehicle are operating and collecting data in accordance with the specific device instructions found in Sections 11.7 – 11.9.		Pass / Fail
2.	Verify Readiness	Verify no connected vehicle devices are broadcasting messages conformant with the SAE J2735 2009 standard.		
3.	Verify Readiness	Verify flaggers are at their required positions and ready to stop traffic along the vehicle paths in Figure 12.		
4.	Verify Readiness	Verify Manual Signal Controller is ready set the signal to the correct phase.		
5.	Test Set-up, Host Vehicle	Drive to Location A in Figure 12 and stop.		

ID	Step	Action	Expected Result	Pass / Investigate / Fail
6.	Test Set-up, Remote Vehicle	Drive to Location C in Figure 12 and stop facing east in the cutaway area as if you are in a right lane adjacent to the normal roadway. Apply the brake but do not put the vehicle in park.		
7.	Flaggers	Stop traffic from entering the vehicle paths show in Figure 12.		
8.	Manual Signal Controller 1	Set the light to Green for Eastbound/Westbound Traffic.		
9.	Test Director	Records the time of the test		
10.	Host Vehicle	Accelerate to 35 mph and maintain that speed traveling along the path shown in Figure 12.		
11.	Host Vehicle	Proceed through the intersection to Location B. The driver **should not** receive a forward collision warning.	Driver **does not** receive Forward Collision Warning.	Pass / Fail
12.	Host Vehicle	Host Vehicle driver acknowledges that they did not receive a warning.		
13.	Host Vehicle	If Host Vehicle driver did not receive a forward collision warning notify Test Director.		
14.	Remote Vehicle	If Host Vehicle driver did not receive a forward collision warning, switch the Remote Vehicle to a vehicle with a different OBU/ASD.		
15.		Repeat Steps 1-14 for all OBU combinations. Then switch the Host Vehicle with a vehicle with a different OBU repeating Steps 1-14 until all combinations of Host and Remote Vehicle combinations have been accomplished.		Pass / Fail

11.3.1 Test Combinations Matrix

Table 17 include the test combinations for the FCW Stationary Remote Vehicle – Adjacent Lane Test

Table 17. FCW Stationary Remote Vehicle – Adjacent Lane Test Combinations Matrix (Source: ITS JPO, 2018)

FCW Stationary Remote Vehicle Adjacent Lane	**Remote Device**	Wyoming - Lear	NYC - Danlaw	NYC - Savari	Tampa - Commsignia	Tampa - Savari	Tampa - SiriusXM
Host Device							
Wyoming - Lear							
NYC - Danlaw							
NYC - Savari							
Tampa - Commsignia							
Tampa - Savari							
Tampa - SiriusXM							

11.4 FCW Moving Remote Vehicle and Electronic Emergency Brake Light (EEBL)

The path for the FCW Moving Remote Vehicle Same Lane and EEBL Test is depicted in the figure below.

Figure 13. FCW Moving Remote Vehicle and EEBL Path **(Source: ITS JPO)**

Table 18 includes the Test Procedures for the FCW Moving Remote Vehicle Same Lane and EEBL Test.

Table 18. FCW Moving Remote Vehicle and EEBL Test Procedures **(Source: ITS JPO, 2018)**

ID	Step	Action	Expected Result	Pass / Investigate / Fail
1.	Verify Readiness	Verify OBUs in Host and Remote Vehicle are operating and collecting data in accordance with the specific device instructions found in Sections 11.7 – 11.9.		Pass / Fail
2.	Verify Readiness	Verify no connected vehicle devices are broadcasting messages conformant with the SAE J2735 2009 standard.		
3.	Verify Readiness	Verify flaggers are at their required positions and ready to stop traffic along the vehicle paths in Figure 13.		
4.	Verify Readiness	Verify Manual Signal Controllers are ready set the signals to the correct phase.		

ID	Step	Action	Expected Result	Pass / Investigate / Fail
5.	Test Set-up, Host Vehicle	Drive to Location A in Figure 13 and stop.		
6.	Test Set-up, Remote Vehicle	Drive to Location A in Figure 13 and stop 150 feet in front of the Host Vehicle.		
7.	Flaggers	Stop traffic from entering the vehicle paths show in Figure 13.		
8.	Manual Signal Controller 1	Set the light to Green for Eastbound/Westbound Traffic.		
9.	Manual Signal Controller 2	Set the light to Red for Eastbound/Westbound Traffic.		
10.	Test Director	Records the time of the test		
11.	Host Vehicle & Remote Vehicle	Both vehicles accelerate to 35 mph and maintain 150 feet distance.		
12.	Remote Vehicle	When the Remote Vehicle reaches the braking, point shown in Figure 13 (This should be marked with a sign or cone) it starts to brake coming to a full stop.		
13.	Host Vehicle	When the Host Vehicle is within 150 feet of the Remote Vehicle it receives an emergency brake light warning.	Driver receives Emergency Electronic Brake Light Warning	Pass / Investigate / Fail
14.	Host Vehicle	When the Host Vehicle is within 150 feet of the Remote Vehicle, and after receiving the emergency brake light warning, it receives a forward collision warning and then either come to a stop behind the Remote Vehicle or drive around it.	Driver receives Forward Collision Warning	Pass / Investigate / Fail
15.	Host Vehicle	Host Vehicle driver manually records the emergency brake light warnings they received (e.g. – audio only, audio and visual, etc.)		
16.	Host Vehicle	Host Vehicle driver manually records the forward collision warnings they received (e.g. – audio only, audio and visual, etc.)		
17.	Host Vehicle	If Host Vehicle driver received the proper emergency brake light and forward collision warnings notify Test Director.		
18.	Remote Vehicle	If Host Vehicle driver received the proper emergency brake light warnings, switch the Remote Vehicle to a vehicle with a different OBU/ASD.		
19.		Repeat Steps 1-18 for all OBU combinations. Then switch the Host Vehicle with a vehicle with a different OBU repeating Steps 1-18 until all combinations of Host and Remote Vehicle combinations have been accomplished.		Pass /Fail

11.4.1 Test Combinations Matrix

Table 19 include the test combinations for the FCW Moving Remote Vehicle Same Lane and EEBL Test.

Table 19. FCW Moving Remote Vehicle Same Lane and EEBL Test Combinations Matrix

(Source: ITS JPO, 2018)

FCW Moving Remote Vehicle Same Lane and EEBL	**Remote Device**	Wyoming - Lear	NYC - Danlaw	NYC - Savari	Tampa - Commsignia	Tampa - Savari	Tampa - SiriusXM
Host Device							
Wyoming - Lear			FCW Only	FCW Only	FCW Only	FCW Only	FCW Only
NYC - Danlaw							
NYC - Savari							
Tampa - Commsignia							
Tampa - Savari							
Tampa - SiriusXM							

11.5 Intersection Movement Assist (IMA) – Host Vehicle Stopped

The path for the IMA – Host Vehicle Stopped Test is depicted in the figure below.

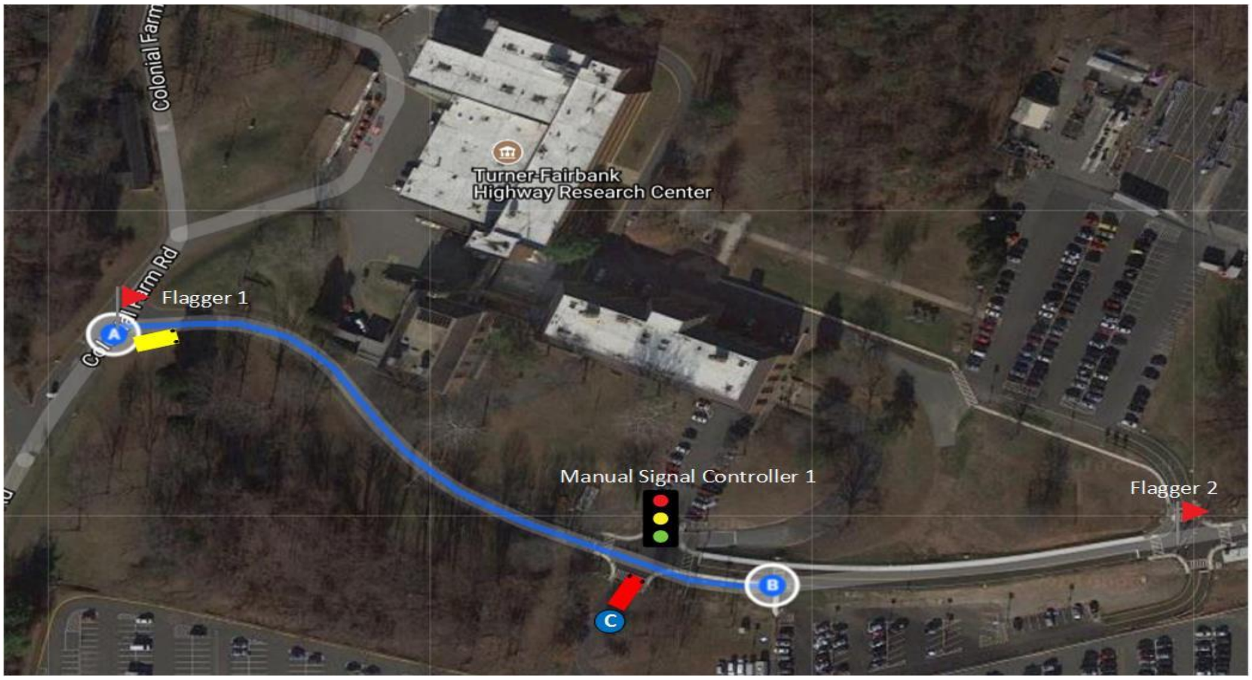

Figure 14. IMA – Host Vehicle Stopped Path (Source: ITS JPO, 2018)

Table 20 includes the Test Procedures for the IMA – Host Vehicle Stopped Test.

Table 20. IMA Host Vehicle Stopped Test Procedures (Source: ITS JPO, 2018)

ID	Step	Action	Expected Result	Pass / Investigate / Fail
1.	Verify Readiness	Verify OBUs in Host and Remote Vehicle are operating and collecting data in accordance with the specific device instructions found in Sections 11.7 – 11.8.		Pass / Fail
2.	Verify Readiness	Verify no connected vehicle devices are broadcasting messages conformant with the SAE J2735 2009 standard.		
3.	Verify Readiness	Verify flaggers are at their required positions and ready to stop traffic along the vehicle paths in Figure 14.		
4.	Verify Readiness	Verify Manual Signal Controllers are ready set the signals to the correct phase.		

ID	Step	Action	Expected Result	Pass / Investigate / Fail
5.	Test Set-up, Remote Vehicle	Drive to Location A in Figure 14 and stop.		
6.	Test Set-up, Host Vehicle	Drive to Location C in Figure 14 and stop, applying the brake but not putting the vehicle in park.		
7.	Flaggers	Stop traffic from entering the vehicle paths show in Figure 14.		
8.	Manual Signal Controller 1	Set the light to Green for Eastbound/Westbound Traffic.		
9.	Test Director	Records the time of the test		
10.	Remote Vehicle	Accelerate to 35 mph and maintain that speed along the path to Location B.		
11.	Host Vehicle	When the Remote Vehicle is within 25 feet of the intersection, release the brake. Host Vehicle driver should get an IMA warning.	Driver receives IMA Warning	Pass / Investigate / Fail
12.	Remote Vehicle	Stop when you have reached Location B.		
13.	Host Vehicle	Host Vehicle driver manually records the IMA warnings they received (e.g. – audio only, audio and visual, etc.)		
14.	Host Vehicle	If Host Vehicle driver received the proper IMA warnings notify Test Director.		
15.	Remote Vehicle	If Host Vehicle driver received the proper IMA warnings, switch the Remote Vehicle to a vehicle with a different OBU/ASD.		
16.		Repeat Steps 1-15 for all OBU combinations. Then switch the Host Vehicle with a vehicle with a different OBU repeating Steps 1-15 until all combinations of Host and Remote Vehicle combinations have been accomplished.		Pass / Investigate / Fail

11.5.1 Test Combinations Matrix

Table 21 include the test combinations for the IMA – Host Vehicle Stopped Test.

Table 21. IMA – Host Vehicle Stopped Test Combinations Matrix **(Source: ITS JPO, 2018)**

IMA – Host Vehicle Stopped	**Remote Device**	NYC - Danlaw	NYC - Savari	Tampa - Commsignia	Tampa - Savari	Tampa - SiriusXM
Host Device						
NYC - Danlaw						
NYC - Savari						
Tampa - Commsignia						
Tampa - Savari						
Tampa - SiriusXM						

11.6 Vehicle to Infrastructure (V2I) / Red Light Violation Warning (RLVW)

The path for the V2I / RLVW Test is depicted in the figure below.

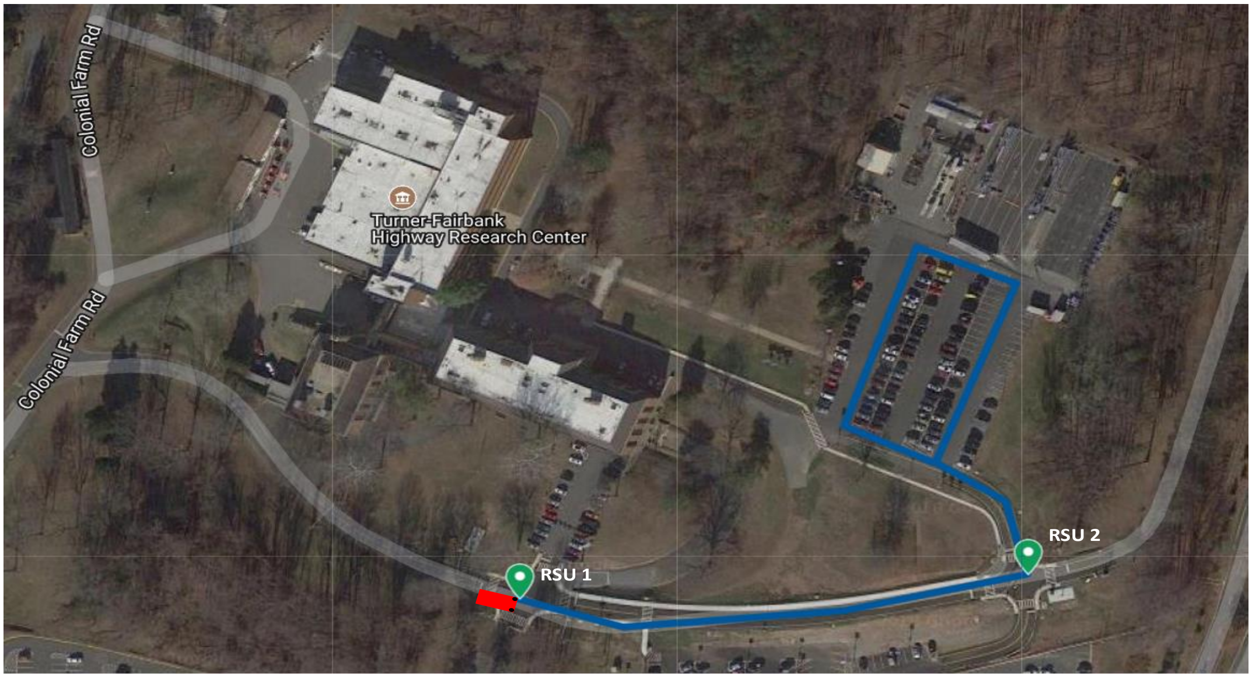

Figure 15. V2I / RLVW Path (Source: ITS JPO, 2018)

Table 22 includes the Test Procedures for the V2I / RLVW Test.

Table 22. V2I / RLVW Test Procedures (Source: ITS JPO, 2018)

ID	Step	Action	Expected Result	Pass / Investigate / Fail
1.	Verify Readiness	Verify OBUs in Host and Remote Vehicle are operating and collecting data in accordance with the specific device instructions found in Sections 11.7 – 11.8.		Pass / Fail
2.	Verify Readiness	Verify RSUs and Signal Controllers are operating and collecting data in accordance with the specific device instructions found in Sections 11.7 – 11.8.		Pass / Fail
3.	Verify Readiness	Verify no connected vehicle devices are broadcasting messages conformant with the SAE J2735 2009 standard.		

ID	Step	Action	Expected Result	Pass / Investigate / Fail
4.	Test Set-up, Host Vehicle	Travel to RSU 1 location in Figure 15 and stop.		
5.	Host Vehicle	Accelerate to the speed limit and travel along the path shown in Figure 15 until reaching RSU 2 location.		
6.	Host Vehicle	Turn Left into the Parking lot and follow the Parking Lot around to RSU 3 making a loop to end back at the intersection with RSU 2.		
7.	Host Vehicle	Turn Right at the RSU 2 intersection and travel along the path back to RSU 1 and come to a stop.		
8.	Verify Results	Verify that the OBU received SPAT and MAP messages while in range of each RSU shown in Figure 15.		Pass / Fail
9.		If successful Repeat Steps 1-8 for all OBUs.		Pass / Fail

11.6.1 Test Combinations Matrix

Table 21 include the test combinations for the V2I / RLVW Test.

Table 23. V2I / RLVW Combinations Matrix **(Source: ITS JPO, 2018)**

V2I / RLVW	**Device**	Tampa – Siemens RSU	NYC – Siemens RSU	NYC – Siemens RSU	TFHRC – Lear RSU
Host Device					
NYC – Danlaw					
NYC – Savari					
Tampa – Commsignia					
Tampa – Savari					
Tampa - SiriusXM					

11.7 NYC Device Procedures

The following procedures are used to set up, configure and/or collect data from the NYC OBUs and RSUs.

Table 24. NYC Device Procedures(Source: ITS JPO, 2018)

ID	Step	Action	Expected Result	Pass / Investigate / Fail
1.	Verify Readiness, NYC Savari OBU	Confirm Host Vehicle has Savari OBU, antenna and HMI installed and configured according to the NYC Connected Vehicle Pilot OBU Configuration.		
2.	Test Set-up, NYC Savari OBU	Launch MWRIG software.		
3.	Test Set-up, NYC Savari OBU	Login to ASD with MWRIG via the Ethernet Cable on ASD.		
4.	Test Set-up, NYC Savari OBU	Click on “Edit Files” button.		
5.	Test Set-up, NYC Savari OBU	Click on “V2V Config”.		
6.	Test Set-up, NYC Savari OBU	Click “Edit” button, then scroll to Logging Configuration Items.		
7.	Test Set-up, NYC Savari OBU	Click “Yes” to overwrite changes.		
8.	Test Set-up, NYC Savari OBU	When prompted reboot the device.		
9.	Data Collection, NYC Savari OBU	Launch MWRIG software.		
10.	Data Collection, NYC Savari OBU	Login to ASD with MWRIG via the Ethernet Cable on ASD.		
11.	Data Collection, NYC Savari OBU	Click on “Download Logs” button.		
12.	Data Collection, NYC Savari OBU	Click on “/nojournal/bsmlogs/”.		
13.	Data Collection, NYC Savari OBU	Click “Download”.		
14.	Data Collection, NYC Savari OBU	Open WinSCP Editor Software.		
15.	Data Collection, NYC Savari OBU	In WinSCP, choose File protocol: SCP. Click “Login” button		

ID	Step	Action	Expected Result	Pass / Investigate / Fail
16.	Data Collection, NYC Savari OBU	In the right window that shows the ASD folders: • Open “root” folder • Open “nojournal” folder • Open “bsmlogs” folder • Select the file with the following format: ○ interop_Year_Mo_DY_Hr_Mn_Sc.csv Drag and drop this file to the left window that shows the laptop folders.		
17.	Verify Readiness, NYC Danlaw OBU	Confirm Host Vehicle has Danlaw OBU, antenna and HMI installed and configured according to the NYC Connected Vehicle Pilot OBU Configuration.		
18.	Data Collection, NYC Danlaw OBU	Connect to the ASD with an Ethernet cable using an USB to Ethernet Adapter.		
19.	Data Collection, NYC Danlaw OBU	Ensure your laptop is on the same subnet.		
20.	Data Collection, NYC Danlaw OBU	Open WinSCP application and login to the device.		
21.	Data Collection, NYC Danlaw OBU	Navigate to the folder on the device.		
22.	Data Collection, NYC Danlaw OBU	Logs are created as timestamped folders. Copy over the relevant folder to desired location on your Windows PC.		

11.8 Tampa Device Procedures

The following procedures are used to set up, configure and/or collect data from the Tampa OBUs and RSUs.

Table 25. Tampa Device Procedures **(Source: ITS JPO, 2018)**

ID	Step	Action	Expected Result	Pass / Investigate / Fail
1.	Verify Readiness	Confirm Host Vehicle has OBU, antenna and HMI installed and configured according to the Tampa Connected Vehicle Pilot OBU Configuration.		
2.	Data Collection, Tampa	Confirm test laptop has Wireshark and Java installed and Siemen’s remote-sniffer.jar in local folder.		
3.	Data Collection, Tampa	Connect laptop via Ethernet to ETH1 port on RSU.		
4.	Data Collection, Tampa	Open a command prompt window and execute a command.		
5.	Data Collection, Tampa	Wireshark collects messages in a packet capture data (PCAP) file. When data collection is done, save PCAP file.		

11.9 Wyoming Device Procedures

The following procedures are used to set up, configure and/or collect data from the Wyoming OBU.

Table 26. Wyoming Device Procedures (Source: ITS JPO, 2018)

ID	Step	Action	Expected Result	Pass / Investigate / Fail
1.	Verify Readiness	Confirm Host Vehicle has Lear LocoMate 300 OBU, antenna and HMI installed and configured according to the Wyoming Connected Vehicle Pilot OBU Configuration.		
2.	Test Set-up, Wyoming OBU	Power up Host Vehicle OBU and verify it is operating and linked to the HMI. Confirm this by driving a short distance and validating that the vehicle speed and location are updated on the HMI to reflect the short drive.		
3.	Test Set-up, Wyoming OBU	Connect laptop to the OBU via Ethernet.		
4.	Test Set-up, Wyoming OBU	From the system shell confirm that log files are being generated.		
5.	Test Set-up, Wyoming OBU	Confirm that all files are incrementing and when reached the appropriate size the files should automatically be moved to directories.		
6.	Test Set-up, Wyoming OBU	Clear pre-existing logs on the OBU		
7.	Data Collection, Wyoming OBU	After all tests are complete, turn off all OBU's to avoid gathering any extraneous test data.		
8.	Data Collection, Wyoming OBU	2. Grab all log and copy files into a .tar file.		
9.	Data Collection, Wyoming OBU	# On the OBU session control protocol (SCP) the .tar file to local.		
10.	Data Collection, Wyoming OBU	Log into VPN to ODE server.		
11.	Data Collection, Wyoming OBU	Copy the .tar file from the User machine to ODE server and un-tar the file.		
12.	Data Collection, Wyoming OBU	Manually run the script that will un-parse and place log files in specific directories (script will run automatically every 5 minutes).		

ID	Step	Action	Expected Result	Pass / Investigate / Fail
13.	Data Collection, Wyoming OBU	Execute a set of queries on the DW to extract bsm and driver alert log records for the period of time around each FCW test run. These queries are implemented in a script that generates a keyhole markup language (KML) file for display in Google Earth. This allows each bsm and driver alert record from each test vehicle to be plotted in the Google Earth application. The follow example command line runs the query script to generate the KML file for a test at testing location 07 Dec 2017 03:15:10 pm mountain standard time (MST) and ended at 03:16:00 pm MST. python create_kml.py circle --lat 38.870339 --long -77.048138 --distance 1000 --beginTime '2017-12-07 22:15:10' --endTime '2017-12-07 22:16:00'		
14.	Data Collection, Wyoming OBU	Open the resulting KML file in Google Earth. The BSM records and driver alert records for each vehicle will be visible along the paths they traveled at the test site location. BSM records from each vehicle will be in a different color. Driver alert records will be shown as white arrows at each point in the vehicle trajectory that the driver alert was issued. Adjust the time slider so that appropriate BSM and driver alerts around the FCW test are visible.		
15.	Data Collection, Wyoming OBU	Using the Google Earth ruler tool, measure the distance in meters from the first advisory FCW (stationary vehicle alert) to the location of the stationary Remote Vehicle. Record the Host Vehicle speed in mph that is associated with this first advisory FCW.		
16.	Data Collection, Wyoming OBU	Calculate the time to collision (ttc) at the point where the advisory FCW is issued. The constant 0.44704 converts speed from mph to m/s. Time to collision (sec) ttc = distance /(speed(mph) * 0.44704)		
17.	Data Collection, Wyoming OBU	Confirm that this ttc is close to the standards for FCW advisory time.		
18.	Data Collection, Wyoming OBU	Using the Google Earth ruler tool, measure the distance in meters from the second imminent FCW alert to the location of the		

ID	Step	Action	Expected Result	Pass / Investigate / Fail
		stationary Remote Vehicle. Record the Host Vehicle speed in mph that is associated with this first advisory FCW.		
19.	Data Collection, Wyoming OBU	Calculate the time to collision (ttc) at the point where the advisory FCW is issued. The constant 0.44704 converts speed from mph to m/s. Time to collision (sec) ttc = distance /(speed(mph) * 0.44704)		
20.	Data Collection, Wyoming OBU	Confirm that this ttc is close to the standards for FCW imminent alert time.		

12 Modifications Made to Test Cases / Test Procedures

While dry running the test cases and procedures on Day 1 of the Interoperability Test, the Connected Vehicle Pilot sites proposed changes to the Test Plan that needed to be made to have reliable and meaningful results. In addition, on the morning of Day 4, additional test cases were developed to leverage the extra time made available due to early completion of original tests. This section provides an overview of the changes to the test plan as they were implemented as well as the reasoning behind those changes.

12.1 FCW Stationary Remote Vehicle in the Adjacent Lane

The objective of the FCW Stationary Remote Vehicle in the Adjacent Lane test was to have each model of OBU/ASD from each Connected Vehicle Pilot site demonstrate that they do not produce an FCW warning when approaching another vehicle producing BSMs in an adjacent lane. The geographic layout of the TFHRC testbed created an obstacle that forced the original test plan to get modified. The original location of the Remote Vehicle (yellow vehicle at location C) as shown in Figure 16, was too close to a curve that had the Host Vehicle pointing at Remote Vehicle, which triggered a false FCW. The test plan was modified to accommodate the new proposed location for the Remote Vehicle at location B as shown in Figure 17. Pilots were able to receive true warnings at the new location. In addition, pilot sites updated lane width settings to providing reliable results.

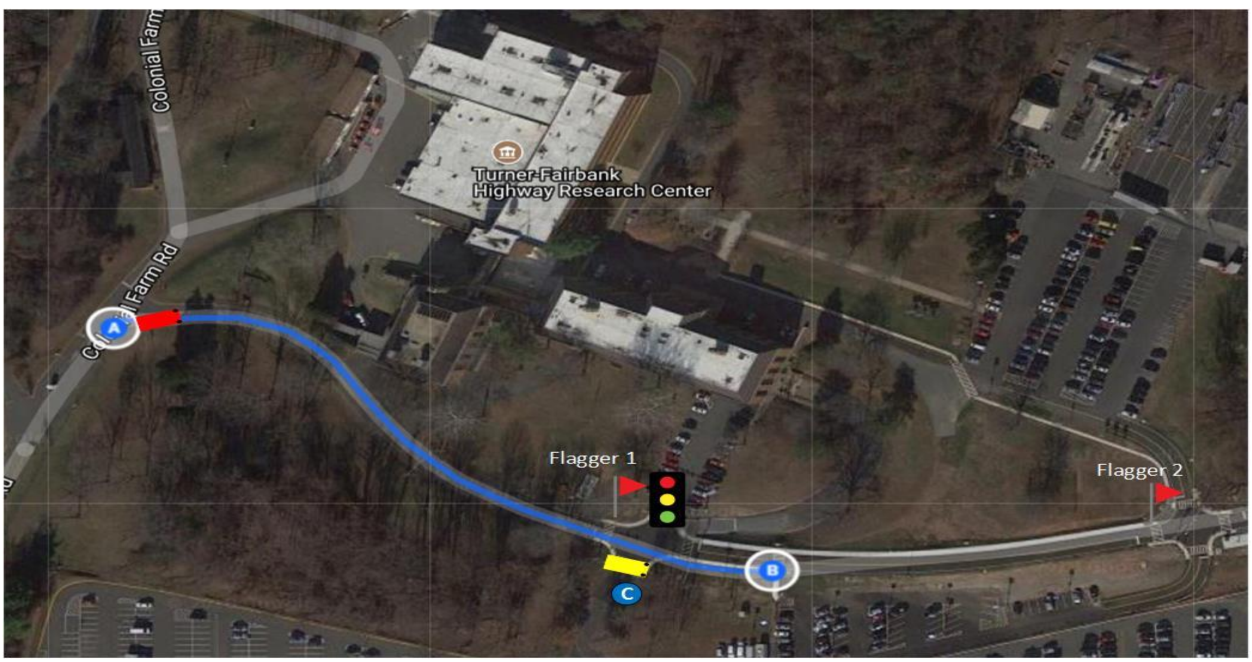

Figure 16. Original FCW Stationary Remote Vehicle in the Adjacent Lane (Source: ITS JPO, 2018)

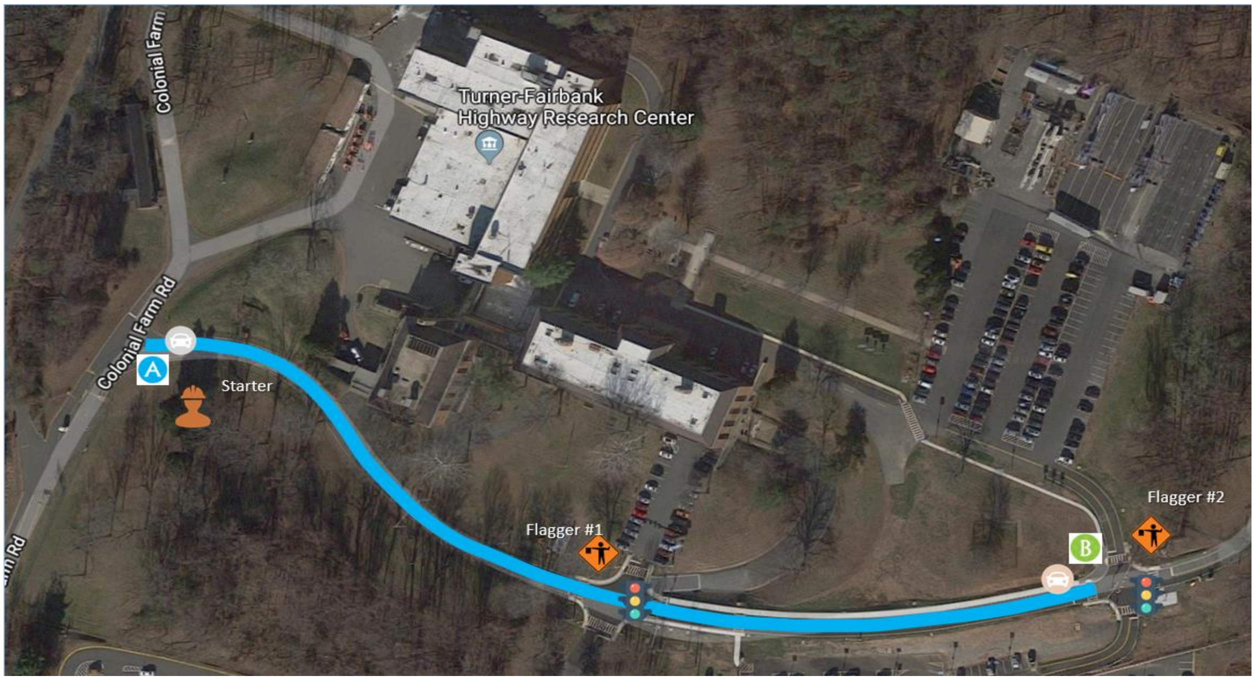

Figure 17. Modified FCW Stationary Remote Vehicle in the Adjacent Lane **(Source: ITS JPO, 2018)**

12.2 IMA – Host Vehicle Stopped

The objective of the IMA – Host Vehicle Stopped test was to have each model of OBU/ASD from the NYC and Tampa Connected Vehicle Pilot sites demonstrate that they can produce an IMA to a driver when receiving BSMs from one of the other Connected Vehicle Pilot site vehicles with the Host Vehicle stopped at an intersection and then starts slowly moving as the Remote Vehicle traverses the intersection. The original test called for the Host Vehicle's driver to release the brake, however the modification called for the Host Vehicle to be moving at a slow speed. To accommodate the change, the Host Vehicle was moved further back from the intersection (as seen in Figure 18) and then accelerated towards the intersection when the Remote Vehicle was in range (crossing the gantry).

Figure 18. Original IMA Host Vehicle Stopped (Source: ITS JPO, 2018)

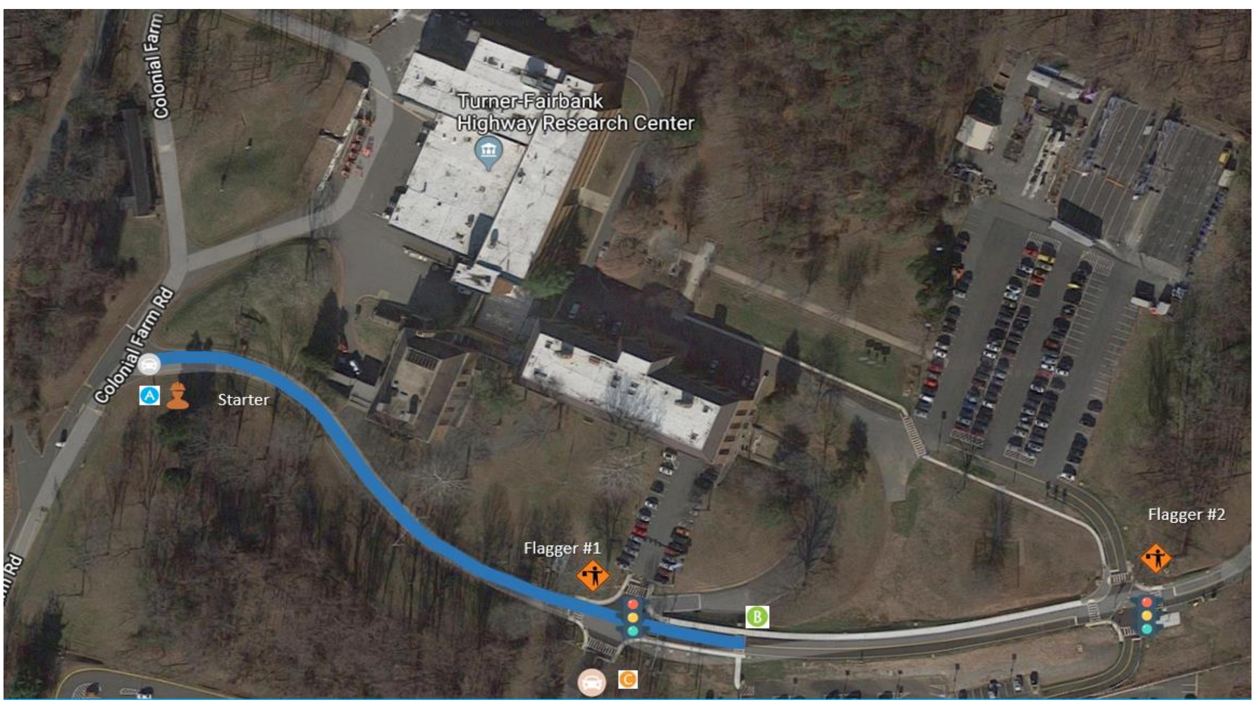

Figure 19. Modified IMA Host Vehicle Stopped (Source: ITS JPO, 2018)

12.3 FCW Stationary Remote Vehicle Same Lane with Parallel Platoon

Due to testing being completed early, an additional test was run on Day 4—the FCW Stationary Remote Vehicle Same Lane with Parallel Platoon test. The objective of this test was to have each model of the OBU/ASD from each Connected Vehicle Pilot deployment site that they can produce an FCW warning to a driver when receiving BSMs from one of the other Connected Vehicle Pilot deployment project devices, and with the Host Vehicle approaching a stationary Remote Vehicle in the same lane in addition to four Connected Vehicle Pilot site vehicles platooned on the adjacent lane (see Figure 20). The test procedures for this test were similar to those used for the FCW tests identified in this test plan; however, the platoon of vehicles traveled with the Host and Remote Vehicles.

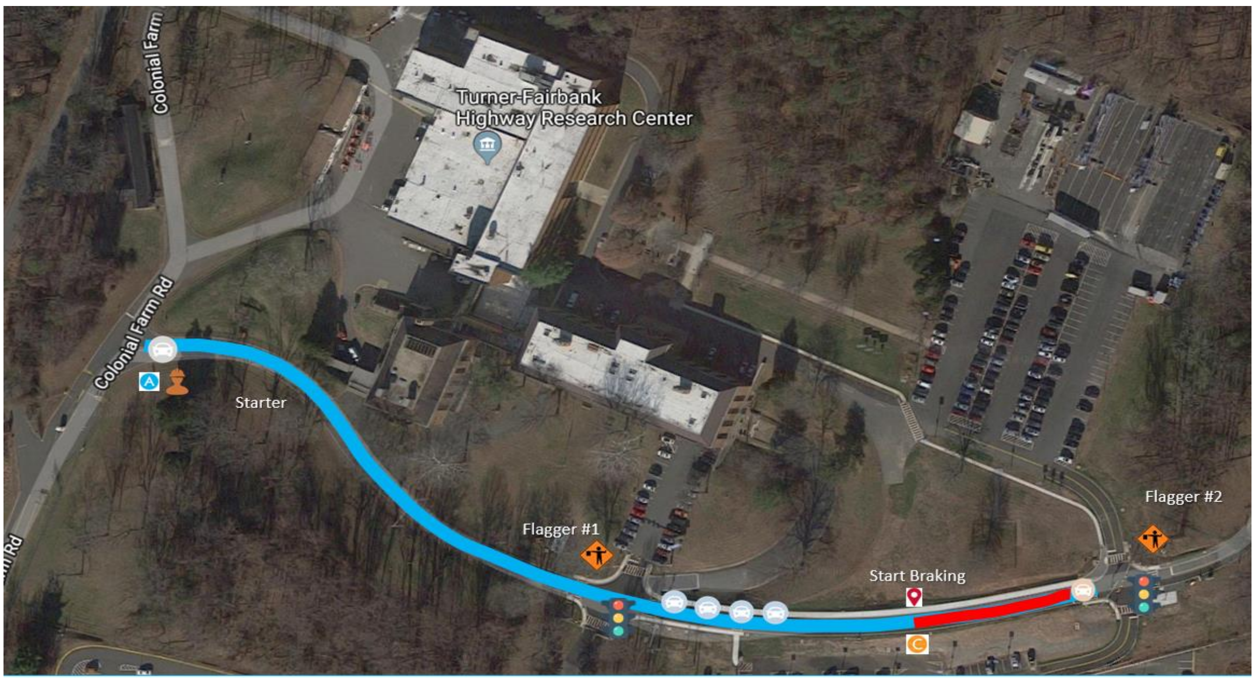

Figure 20. FCW Stationary Remote Vehicle Same Lane with Parallel Platoon **(Source: ITS JPO, 2018)**

Appendix A. Acronyms

(Source: ITS JPO)

Acronym	Definition
ASD	Aftermarket Safety Device
ATC	Air Traffic Control
BSM	Basic Safety Message
COTS	Commercial Off-the-Shelf
CV	Connected Vehicle
DN	Distress Notification
DSRC	Dedicated Short Range Communication
EEBL	Electronic Emergency Brake Light
EIRP	Effective Isotropic Radiated Power
EMI	Electromagnetic Interference
FCW	Forward Collision Warning
GPS	Global Positioning System
I2V	Infrastructure to Vehicle
I-495	Interstate 495
IMA	Intersection Movement Assist
ISS	Integrity Security Services
ITS-OB4	ITS V2X Onboard Unit
KML	Keyhole Markup Language
MST	Mountain Standard Time
NHTSA	National Highway Traffic Safety Administration
NYC	New York City
OBU	On-Board Unit
ODE	Orchestration Director Engine
OTA	Over-the-Air
PCAP	Packet Capture Data
PII	Personally Identifiable Information
PSM	Personal Safety Messages
PVD	ParaView Data

Acronym	Definition
RLVW	Red-Light Violation Warning
RSU	Roadside Unit
RTCM	Radio Technical Commission for Maritime Services
SAE	Society of Automotive Engineers
SCMS	Security Credential Management System
SCP	Session Control Protocol
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
TTI	Texas A&M Transportation Institute
USDOT	United States Department of Transportation
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

Appendix B. Detailed Test Case Schedules

Day 2: Tuesday June 26, 2018

10:00 AM – 12:00 PM: Test Case 13.2: FCW Stationary Remote Vehicle Same Lane

Table 27. Schedule for FCW Stationary Remote Vehicle Same Lane (Source: ITS JPO, 2018)

ID	Host Vehicle	Remote Vehicle	Time
1	Tampa - Commsignia	NYC - Savari	10:00 AM – 10:10 AM
2	NYC - Danlaw	Tampa - Savari	10:10 AM – 10:20 AM
3	Tampa - SiriusXM	Wyoming - Lear	10:20 AM – 10:30 AM
4	NYC - Savari	Tampa - Commsignia	10:30 AM – 10:40 AM
5	Wyoming - Lear	NYC - Danlaw	10:40 AM – 10:50 AM
6	Tampa - Savari	NYC - Savari	10:50 AM – 11:00 AM
7	Wyoming - Lear	Tampa - SiriusXM	11:10 AM – 11:20 AM
8	NYC - Savari	Tampa - Savari	11:20 AM – 11:30 AM
9	Wyoming - Lear	Tampa - Commsignia	11:30 AM – 11:40 AM
10	Tampa - Savari	NYC - Danlaw	11:40 AM – 11:50 AM
11	NYC - Savari	Tampa - SiriusXM	11:50 AM – 12:00 PM
12	NYC - Danlaw	Wyoming - Lear	12:30 PM – 12:40 PM
13	Tampa - SiriusXM	NYC - Savari	12:40 PM – 12:50 PM
14	Tampa - Savari	Wyoming - Lear	12:50 PM – 1:00 PM
15	NYC - Danlaw	Tampa - Commsignia	1:00 PM – 1:10 PM
16	Wyoming - Lear	NYC - Savari	1:10 PM – 1:20 PM
17	NYC - Danlaw	Tampa - SiriusXM	1:20 PM – 1:30 PM
18	Wyoming - Lear	Tampa - Savari	1:30 PM – 1:40 PM
19	Tampa - Commsignia	NYC - Danlaw	1:40 PM – 1:50 PM
20	NYC - Savari	Wyoming - Lear	1:50 PM – 2:00 PM
21	Tampa - SiriusXM	NYC - Danlaw	2:00 PM – 2:10 PM
22	Tampa - Commsignia	Wyoming - Lear	2:10 PM – 2:20 PM

2:30 PM – 4:30 PM: Test Case 13.5: IMA Host Vehicle Stopped

Table 28. Schedule for IMA Host Vehicle Stopped **(Source: ITS JPO, 2018)**

ID	Host Vehicle	Remote Vehicle	Time
23	Tampa - Commsignia	NYC - Danlaw	2:30 PM – 2:40 PM
24	NYC - Savari	Tampa - SiriusXM	2:40 PM – 2:50 PM
25	NYC - Danlaw	Tampa - Savari	2:50 PM – 3:00 PM
26	Tampa - SiriusXM	NYC - Savari	3:00 PM – 3:10 PM
27	Tampa - Savari	NYC - Danlaw	3:10 PM – 3:20 PM
28	NYC - Savari	Tampa - Commsignia	3:20 PM – 3:30 PM
29	NYC - Danlaw	Tampa - SiriusXM	3:30 PM – 3:40 PM
30	Tampa - Commsignia	NYC - Savari	3:40 PM – 3:50 PM
31	Tampa - SiriusXM	NYC - Danlaw	3:50 PM – 4:00 PM
32	NYC - Savari	Tampa - Savari	4:00 PM – 4:10 PM
33	NYC - Danlaw	Tampa - Commsignia	4:10 PM – 4:20 PM
34	Tampa - Savari	NYC - Savari	4:20 PM – 4:30 PM

Day 3: Wednesday June 27, 2018

9:00 AM – 10:00 AM: Test Case 13.6: V2I/RLVW

Table 29. Schedule for V2I/RLVW **(Source: ITS JPO, 2018)**

ID	Host Vehicle	Remote Vehicle	Time
35	Tampa - Commsignia	N/A (V2I)	9:00 AM – 9:10 AM
36	NYC - Savari	N/A (V2I)	9:10 AM – 9:20 AM
37	Tampa - Savari	N/A (V2I)	9:20 AM – 9:30 AM
38	NYC - Danlaw	N/A (V2I)	9:30 AM – 9:40 AM
39	Tampa - SiriusXM	N/A (V2I)	9:40 AM – 9:50 AM

10:00 AM – 1:00 PM: Test Case 13.4: FCW Moving Remote Vehicle and EEBL

Table 30. Schedule for FCW Moving Remote Vehicle and EEBL **(Source: ITS JPO, 2018)**

ID	Host Vehicle	Remote Vehicle	Time
40	NYC - Savari	Tampa - SiriusXM	10:00 AM – 10:10 AM
41	Wyoming - Lear*	NYC - Danlaw	10:10 AM – 10:20 AM
42	NYC - Savari	Tampa - Commsignia	10:20 AM – 11:30 AM
43	NYC - Danlaw	Tampa - Savari	10:30 AM – 10:40 AM
44	Tampa - SiriusXM	NYC - Savari	10:40 AM – 10:50 AM
45	Wyoming - Lear*	Tampa - Savari	10:50 AM – 11:00 AM
46	Tampa - SiriusXM	NYC - Danlaw	11:00 AM – 11:10 AM
47	Wyoming - Lear*	Tampa - Commsignia	11:10 AM – 11:20 AM
48	NYC - Savari	Tampa - Savari	11:20 AM – 11:30 AM
49	Tampa - Commsignia	NYC - Danlaw	11:30 AM – 11:40 AM
50	Wyoming - Lear*	Tampa - SiriusXM	11:40 AM – 11:50 AM
51	NYC - Danlaw	Tampa - Commsignia	11:50 AM – 12:00 PM
52	Tampa - Savari	NYC - Savari	12:00 PM – 12:10 PM
53	NYC - Danlaw	Tampa - SiriusXM	12:10 PM – 12:20 PM
54	Tampa - Commsignia	NYC - Savari	12:20 PM – 12:30 PM
55	Tampa - Savari	NYC - Danlaw	12:30 PM – 12:40 PM
56	Wyoming - Lear*	NYC - Savari	12:40 PM – 12:50 PM

* Note: FCW Only Test

1:30 PM – 5:10 PM: Test Case 13.3 FCW Stationary Remote Vehicle Adjacent Lane

Table 31. Shedule for FCW Stationary Remote Vehicle Adjacent Lane (Source: ITS JPO, 2018)

ID	Host Vehicle	Remote Vehicle	Time
57	Wyoming - Lear	NYC - Danlaw	1:30 PM – 1:40 PM
58	NYC - Savari	Tampa - Commsignia	1:40 PM – 1:50 PM
59	NYC - Danlaw	Tampa - SiriusXM	1:50 PM – 2:00 PM
60	Wyoming - Lear	Tampa - Savari	2:00 PM – 2:10 PM
61	Tampa - Commsignia	NYC - Savari	2:10 PM – 2:20 PM
62	Tampa - SiriusXM	Wyoming - Lear	2:20 PM – 2:30 PM
63	Tampa - Savari	NYC - Savari	2:30 PM – 2:40 PM
64	Wyoming - Lear	Tampa - Commsignia	2:40 PM – 2:50 PM
65	NYC - Savari	Tampa - SiriusXM	2:50 PM – 3:00 PM
66	NYC - Danlaw	Wyoming - Lear	3:00 PM – 3:10 PM
67	Tampa - SiriusXM	NYC - Savari	3:10 PM – 3:20 PM
68	Tampa - Commsignia	NYC - Danlaw	3:20 PM – 3:30 PM
69	Tampa - Savari	Wyoming - Lear	3:30 PM – 3:40 PM
70	NYC - Danlaw	Tampa - Commsignia	3:40 PM – 3:50 PM
71	NYC - Savari	Tampa - Savari	3:50 PM – 4:00 PM
72	Wyoming - Lear	Tampa - SiriusXM	4:00 PM – 4:10 PM
73	NYC - Danlaw	Tampa - Savari	4:10 PM – 4:20 PM
74	NYC - Savari	Wyoming - Lear	4:20 PM – 4:30 PM
75	Tampa - Savari	NYC - Danlaw	4:30 PM – 4:40 PM
76	Tampa - Commsignia	Wyoming - Lear	4:40 PM – 4:50 PM
77	Tampa - SiriusXM	NYC - Danlaw	4:50 PM – 5:00 PM
78	Wyoming - Lear	NYC - Savari	5:00 PM – 5:10 PM

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