5.9 GHz Dedicated Short Range Communication Vehicle-based Road and Weather Condition Application

Test Plan

Version 1.1

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Prepared For:

Cooperative Transportation Systems Pooled Fund Study

By:

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REVISION HISTORY

Version	Description
0.1	submitted to CTS PFS for review, October 11, 2013
1.0	submitted updated draft to CTS PFS, November 25, 2013
1.1	submitted final Tet Plan to CTS PFS, December 13, 2013

1 INTRODUCTION

The following subsections of the System Test Plan (STP) provide an overview of the STP.

1.1 Purpose

The purpose of this document is to describe the verification and validation plan for the 5.9 GHz Dedicated Short Range Communication Vehicle Based Road and Weather Condition Application.

The objective of the testing is to uncover defects in the system. This includes nonconformance with the stated requirements and unexpected or undesired side effects of system operation. Even moderately complex systems are nearly impossible to adequately test when fully assembled. Therefore, careful consideration is given to adequately test small units and subsets of the system independently.

1.2 Scope

The scope of this project is to develop, test, deploy and operate 5.9 GHz dedicated short range communication (DSRC) applications for road and weather condition data in maintenance and highway emergency local patrol (HELP) vehicles. The system to be developed will be capable of obtaining data including that from SAE J1939 and J1979 diagnostic buses and various peripheral devices on maintenance vehicles; transmitting this data to compliant 5.9 GHz DSRC roadside equipment (RSE); sending the data from RSEs to a data aggregation server; and finally converting and feeding data to the Weather Data Environment (WxDE) for use in determining and predicting road and weather conditions. It is envisioned that this application will be used by agency maintenance vehicles of the members of the CTS PFS along connected vehicle test beds.

The OBE in this system will read the desired data from controller area network (CAN) buses on the connected vehicles and format those data into a basic safety message (BSM) that includes both Part 1 and Part 2. If the OBE is not within range of an RSE, determined by the absence of a Wireless Access in Vehicular Environments (WAVE) Service Announcement, the BSM is stored for transmission at a later time. When an OBE detects the presence of a WAVE Service Announcement, current weather-related data will be transmitted as part of normal BSM operation and not stored, while previously-stored BSMs will be transmitted at a significantly faster rate than the standard 10 Hz in last-in-first-out order so that the most recent weather related data are sent to the RSE first.

Stored BSMs will be deleted upon transmission and, when storage becomes scarce, the oldest BSM will be deleted first to make room for newer data.

1.3 Definitions, Acronyms, and Abbreviations

This document may contain terms, acronyms, and abbreviations that are unfamiliar to the reader. A dictionary of these terms, acronyms, and abbreviations can be found in Appendix A.

1.4 References

The following documents contain additional information pertaining to this project and the requirements for the system:

5.9 GHz Dedicated Short Range Communication Vehicle Based Road and Weather Condition Application Concept of Operations, May 2013, *Synesis Partners LLC.*

5.9 GHz Dedicated Short Range Communication Vehicle Based Road and Weather Condition Application Messaging Requirements, May 2013, *Synesis Partners LLC.*

The Institute of Electrical and Electronics Engineers, Inc., 1990, *IEEE Standard Glossary of Software Engineering Terminology. IEEE Std 610.12-1990.*

The Institute of Electrical and Electronics Engineers, Inc., 1998, *IEEE Standard for Software Test Documentation. IEEE Std 829-1998*, ISBN 0-7381-1443-X SH94687.

1.5 Overview

The remaining sections of the document contain a review of the system elements to be tested, the approach to testing, tasks and resources required to perform the testing, and any risks or contingencies that must be considered in the creation of the test plan.

Section 2 – Test Items describes what hardware and software configuration items are covered by the test plan. Configuration items may be completely software, completely hardware, or combinations of hardware and software. This section also identifies any features or requirements that will not be tested.

Section 3 – Approach describes the approach or methods to be utilized for each type of testing in this plan.

Section 4 – Activities and Resources describes what must be done to perform the testing. This includes a list of the test deliverables, a description of the required test environment, the test participants, and a description of any special staffing or training required for the tests.

Section 5 – Risks and Contingencies identifies any high risk assumptions made during the development of the test plan. For each risk, a contingency plan is identified that is intended to minimize or eliminate the impact of the risk on the execution of the plan.

2 TEST ITEMS

This section describes what items or components of the system are covered by the test plan. Subsystems may be completely software, hardware, or combinations of hardware and software.

2.1 *Programs and Modules*

System testing is performed on the system as a whole, on major subsystems as appropriate, and on the individual units that make up the system. The proposed deployment diagrams (Figure 1 and Figure 2) illustrate the relationships among the system's components and units for the purpose of identifying the specific hardware configuration items (HCIs) and software configuration items (SCIs) to be tested. Table 1 provides a brief description of each of these configuration items.

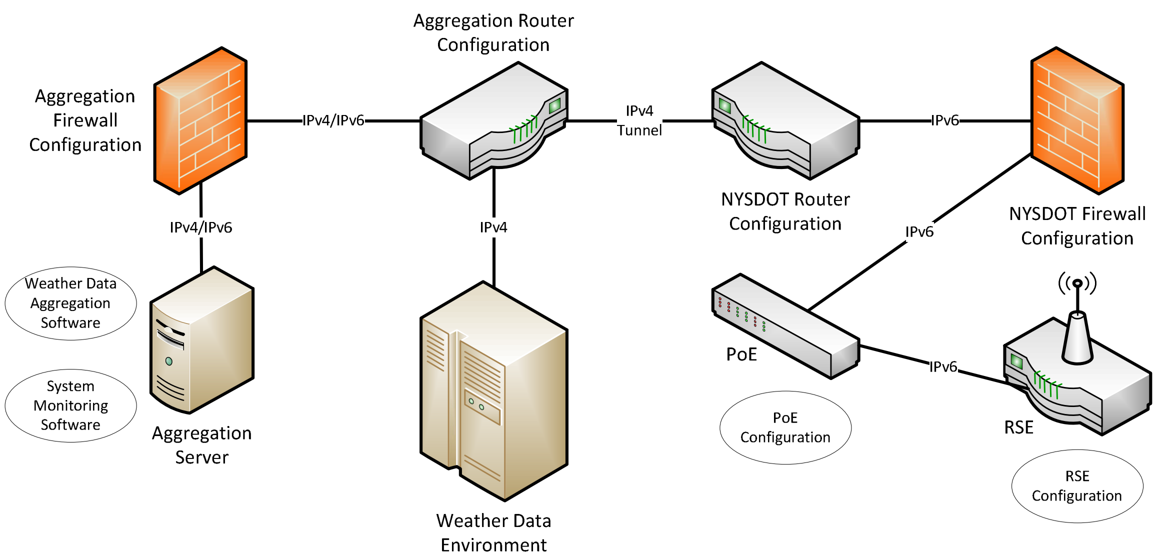

Figure 1 - Proposed Network Element Deployment

Figure 1 reduces the proposed network element deployment to the minimal interfaces required for the system to operate. For example, the NYSDOT network implementation likely contains significantly more components and interconnections than are depicted within the diagram. These additional components are external to the configuration items covered by this test plan and do not provide any useful detail to those that are.

Table 1 - Hardware and Software Configuration Items

HCI	SCI	Name	Description
X		RSE-1	Physical installation of the RSE including mounting arm, antenna placement and orientation, and power and communication wiring.
	X	RSE-2	Configuration settings of a RSE, such as network addresses, security keys, important server addresses, and log file and heartbeat transmission intervals.
X		POE-1	Physical installation of a power-over-Ethernet (PoE) network switch to supply power and communication needs to RSE.
	X	POE-2	Configuration settings for the management of PoE switches such as network addresses, security credentials, and user permission to remotely reset RSE power.
	X	FRW-1	Configuration of the NYSDOT network firewall so that approved hosts can send information to and receive information from the logically isolated internal IPv6 RSE network.
	X	EGR-1	Configuration of the NYSDOT network router responsible for tunneling and routing IPv6 communication between the logically isolated RSE IPv6 network and the external aggregation server over the IPv4 Internet.
	X	EGR-2	Configuration of the weather data aggregation network router responsible for tunneling and routing IPv6 communication between its local IPv6 network and the NYSDOT logically isolated RSE IPv6 network over the IPv4 Internet.
	X	FRW-2	Configuration of the weather data aggregation network firewall so that approved hosts can send information to and receive information from the external NYSDOT logically isolated IPv6 RSE network.
X		WDA-1	The server that hosts the weather data aggregator and system monitoring software within the weather data aggregation network.

HCI	SCI	Name	Description
	X	WDA-2	The weather data aggregation software that receives log files from the NYSDOT RSE and processes those log files into weather observations passed on to the Weather Data Environment.
	X	WDA-3	The system monitor software that receives heartbeat information from NYSDOT RSE and reports any detected problems to administrators for resolution.
	X	WDE-1	The Weather Data Environment that will store and present NYSDOT RSE weather data observations received from and processed by the weather data aggregator.
X		OBE-1	The physical installation of OBE that includes a mounting bracket and the OBE itself.
X		OBE-2	The physical installation of a vehicle power interface that detects when the vehicle ignition is stated and stopped so that the OBE is powered when the vehicle is in operation and unpowered otherwise thus preserving the vehicle battery when parked.
X		OBE-3	The J1939 cable used to connect OBE to a heavy vehicle CAN data bus.
X		OBE-4	The J1979 cable used to connect OBE to a consumer vehicle CAN data bus, otherwise known as OBD-II.
X		OBE-5	An optional serial cable connecting the OBE to common Dickey John road treatment equipment.
X		OBE-6	An optional serial cable connecting the OBE to a mounted IceSight sensor that detects road ice and precise ambient air temperature.
X		OBE-7	The GPS antenna connected to OBE used to determine vehicle location.
X		OBE-8	The DSRC antenna used by the OBE to detect the presence of RSE and transmit weather-related observations when an RSE is within radio range.

HCI	SCI	Name	Description
	X	OBE-9	The OBE software application hosted by OBE hardware that reads the position and sensor inputs to produce Basic Safety Messages containing weather-related observations and send those messages to RSE using a store-and-forward algorithm.

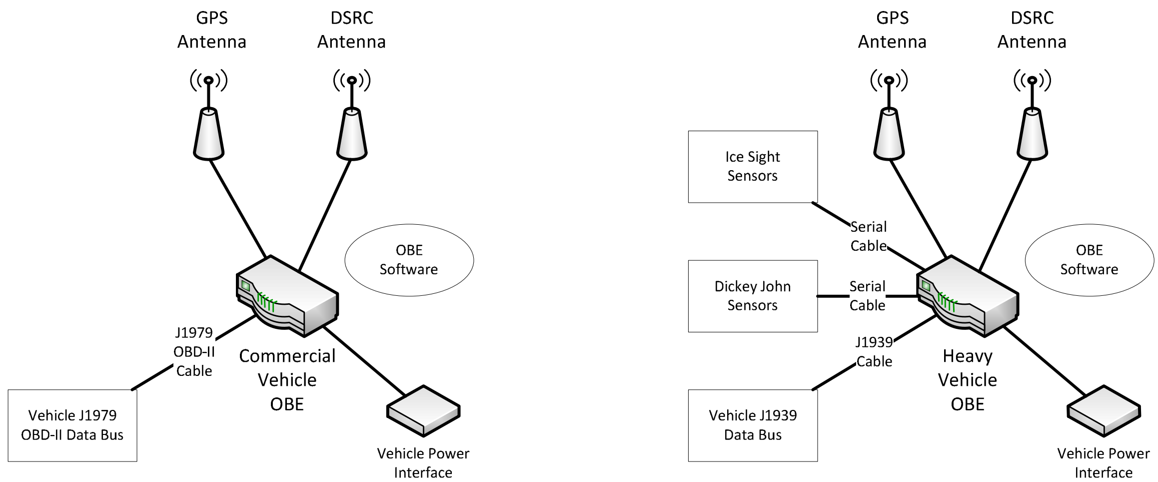

Figure 2 - Proposed Vehicle Element Deployment

There is nothing unexpected shown in Figure 2. OBEs are deployed in vehicles and require power and communication connections to operate. The majority of the sensors are found on the heavy vehicles, but the IceSight sensor alternatively could be installed on other trucks, if desired.

2.2 *Features to Be Tested*

The following classes of functions will be covered by this plan:

Power

- Vehicle power interfaces properly start and shut down OBE
- PoE network switches properly start and shut down RSE

Communication

- OBE acquire IPv6 DSRC addresses, but local RSE is unreachable via IP
- OBE acquire IPv6 DSRC addresses, but RSE network is unreachable via IP
- BSMs are created and stored by OBE
- BSMs are transmitted from OBE and received by RSE J2735 service
- RSE has IPv6 addresses but NYSDOT network is unreachable

- RSE has IPv6 addresses and can only reach WDA network
- RSE regularly transmits heartbeat information
- RSE regularly transmits log files
- PoE switches can only reach WDA network
- WDA server can securely connect to PoE switches
- WDA server can securely connect to RSE
- WDA server cannot reach internal NYSDOT network

Data Collection

- WDA server can read and process RSE log files
- WDA server can read and process RSE heartbeat information
- WDA server can transmit weather observations to WDE
- WDA server can detect RSE failures
- WDA server can notify administrators to resolve RSE failures
- WDE presents weather related vehicle data

2.3 *Features not to Be Tested*

The features not included in this test plan and that will not be verified specifically by test cases are those that are intrinsically verified by other components of the system. For example, it is presumed that NYSDOT has a functioning enterprise network connected to the Internet using IPv4 addressing. Switches and other networking components within that context are expected to operate properly to facilitate data transport between the NYSDOT and weather data aggregator networks. It is also presumed that selected vehicles for this project are functional and that infrastructure for deployment such as power, cabinets, and mounting arms exist and meet physical specifications sufficient to support the deployment of RSEs.

3 APPROACH

This section describes the approach or methods to be utilized for each type of testing in this plan.

3.1 General Approach

The objective for the system acceptance process is to exercise the hardware and software to demonstrate compliance to requirements and that desired features function as expected. The test personnel will use the concept of operations and requirements documentation to prepare test cases and scripts. This process consists of three steps:

1. Review of requirements and features
2. Assignment of verification methodology
3. Assignment of each test type to test cases

It is neither technically feasible, nor economically desirable, to rigorously test every conceivable system element. In assigning a verification method, this plan identifies what items must be tested, and what requirements and features can be validated by the most effective methods. Requirements and features will be verified through three different methods:

- **Inspection** is a means of verifying a requirement or feature visually. This is typically done for physical requirements (e.g., the box shall be painted brown) or for those requirements that are global in nature and cannot be tested explicitly (e.g. a requirement specifying a constraint in the methodology used to design the system). In the case of hardware requirements, inspection may include review of the environmental and electrical tests performed as a part of the hardware acceptance process. Inspection can also include review of vendor provided documentation and accepting statements of compliance as proof that the requirement is met.
- **Analysis** is a means of verifying a requirement or feature by exercising a portion or derivative of the system design and comparing the results to an expected result. Analysis may also be used when a portion of the design has already been tested elsewhere and verification is performed by showing the similarity of the current design to that which was previously tested or analyzed. This method is also used for requirements that cannot be directly tested, but can only be verified through related analytical means.

- **Test** involves the physical and logical comparison between an actual system output when a test case is performed and an expected result.

For each requirement assigned the *Test* method, the requirement is demonstrated by the execution of one or more test cases. Test cases are scenarios that allow logically related requirements to be verified together by performing an action. This reduces the total number of tests required and typically results in testing that is similar to *normal* operation of the system. Requirements verified by test can also be aggregated into separate test cases when a complete test environment may not be available. In cases such as this, assigning separate test cases can reduce the amount of time required for testing when the test environment utilizes a critical resource and there is a desire to minimize the time the critical resource is used.

To demonstrate compliance, Table 2 contains the traceability between requirements, configuration items, verification methods, and test case. References to the system requirements in the concept of operations document are prepended with "RQ" and references to the messaging requirements from their own document are prepended with "MR". References are grouped together where they overlap.

Once the test cases have been developed, the test environment is identified. The test environment provides facilities needed to support the proper execution of the test cases. The components and boundaries that comprise the system test environment are specified in Section 4.3.

Table 2 – System Verification Matrix

Reference	Description	Item	Method	Test
RQ-100	The system shall acquire weather-related data from vehicles.	OBE-1 OBE-2 OBE-9	Analysis	TC-1
RQ-110 MR-002	The system shall be able to acquire weather-related data from a heavy vehicle J1939 data bus.	OBE-3	Analysis	TC-1
RQ-120 MR-003	The system shall be able to acquire weather-related data from a vehicle J1979 data bus.	OBE-4	Analysis	TC-1

Reference	Description	Item	Method	Test
RQ-130 MR-004	The system shall be able to acquire weather-related data from a RS-232 serial data bus.	OBE-5 OBE-6	Analysis	TC-1
RQ-200	The system shall assemble weather-related data acquired from vehicles into messages.	OBE-7 OBE-9	Analysis	TC-2
RQ-210 MR-005	The system shall encode weather-related data elements defined in the SAE J2735 DF_VehicleStatus data frame into a message conforming to the MSG_BasicSafetyMessage specification.	OBE-7 OBE-9	Analysis	TC-2
RQ-220 MR-006	The system shall encode weather-related data elements not defined in the SAE J2735 DF_VehicleStatus data frame into free-form local content within a message conforming to the SAE J2735 MSG_BasicSafetyMessage specification.	OBE-7 OBE-9	Analysis	TC-2
RQ-300	The system shall transmit messages containing weather data from vehicles to roadside units over 5.9 GHz DSRC.	RSE-1 RSE-2 OBE-8	Analysis	TC-2
RQ-350 MR-001	The system shall encode digital signatures according to the ToBeSigned message format defined by IEEE 1609.2.	OBE-9	Analysis	TC-2
RQ-400	The system shall aggregate probe data from RSEs.	POE-1 FRW-1 EGR-1 EGR-2 FRW-2 WDA-1 WDA-2	Test	TC-3
RQ-450	The system shall associate probe data with its vehicular sources.	WDA-2 OBE-9	Test	TC-3

Reference	Description	Item	Method	Test
RQ-500	The system shall make weather and road condition data available to other systems.	EGR-2 FRW-2 WDA-1	Inspection	TC-4
RQ-510	The system shall make weather and road condition data available to other systems in the form of subscriptions.	WDA-2	Inspection	TC-4
RQ-520	The system shall make weather and road condition data available to the WxDE.	WDA-2	Inspection	TC-4
RQ-530	The system shall make weather and road condition data available to the VDT.	WDA-2	Inspection	TC-4
RQ-600	The system shall monitor the state of its operations.	WDA-3	Test	TC-5
RQ-610	The system shall monitor the state of its RSE operations.	POE-2 WDA-3	Test	TC-5
RQ-620	The system shall monitor the state of its aggregator operations.	WDA-3	Test	TC-5

Generally, sets of requirements are grouped together for individual test cases. This facilitates testing when the testing methodology used is the same among the different requirements and when the functions to be tested are closely related. Table 3 further associates test cases with project tasks and general test script actions to illustrate when test scripts are performed and how they transition from lab testing to field installation and testing. Test scripts will contain detailed step-by-step instructions on how particular tests are to be conducted and their results interpreted. Testing results will be included in the test report. The first five test cases, 1 through 5, are directly derived from requirements. The last three test cases, 6 through 8, are related to project tasks and contain the necessary steps to fulfill those project tasks.

Test Case 1 will confirm that OBE can successfully acquire weather-related data from the various available data buses. Many different values from each of the available sensors are expected so analysis must be used. The OBE rolling data log will be compared against the vendor sensor specification to verify that weather-related data values are within the range of a sensor and make sense given the local environmental circumstances, i.e. an air temperature of 140 F would indicate a problem.

Test Case 2 evaluates the transport mechanisms of the vehicle weather-related data over DSRC. BSM are typically sent at 10 Hz, so analysis must be used for the test method. Both OBE stored BSM, and RSE log files are examined for the data format conforming to the BSM specification and that the associated digital signature matches its specification. Analyzing the RSE log file against the OBE stored BSM will confirm that DSRC was used since that is the only means for OBE to deliver BSM to the RSE.

Test Case 3 evaluates vehicle identification with the aggregation of weather-related data. The aggregation server log will be compared to the expected vehicle identifiers. Since there are only a few vehicles for this project, using the direct test method is reasonable.

Test Case 4 uses the inspection testing method to verify that weather-related observations are being collected by the weather data environment. The aggregation server can be inspected to verify subscription files are produced, and the graphical user interface for the WxDE can be used to verify that the weather-related data are present with associated VDT quality checks and road conditions.

Test Case 5 verifies that monitoring software correctly identifies system problems and notifies administrators to fix the problems. Malfunctions can be simulated by moving processed weather observation files and heartbeat logs from their expected locations. System monitoring software can then be verified that is sends email messages to the configured administrator email addresses with the correct description of the problem that needs to be repaired.

Test Case 6 verifies the field installation and operation of OBEs. Its scripts are similar to Test Cases 1 and 2 in that they verify OBE operation, but the testing environment is different. The Test Case 6 testing environment contains HELP vehicle and plow trucks with external antennas (as well as Dick John equipment that were not available for the initial system testing). Additionally, the OBE field installation test case evaluates independent power control hardware that protects the OBEs from noisy vehicle power supplies and prevents OBEs from discharging vehicle batteries when vehicles are not operating.

Test Case 7 verifies the field installation and operation of RSEs. Just as Test Case 6 shares common scripts with previous test cases, Test Case 7 also shares some scripts from Test Case 3. The RSE field testing environment consists of RSE mounted on poles exposed to the elements as well as relying on power supplied from PoE switches installed in cabinets and using a completely different network.

Test Case 8 verifies the end-to-end system deployment. At this stage, it is important to verify that remote power cycling (used to reboot RSEs when necessary) is possible to minimize the need for on-site maintenance. This test case evaluates OBEs continuously collecting sensor data from operating vehicles and successfully detecting RSEs under moving conditions. Test Case 8 also evaluates each component's ability within the system to store and forward information when some components are unavailable and the weather data aggregator server's ability to identify component problems so that they may be addressed quickly.

Table 3 – Test Cases and Test Scripts by Task

Task	Test Case	Test Script Description
4.7 Prepare and Test OBEs	TC-1	Verify OBE reads J1979 data
	TC-1	Verify OBE reads IceSight data
	TC-2	Verify OBE reads GPS data
	TC-2	Verify OBE formats data as BSM
	TC-2	Verify OBE stores BSMs
	TC-2	Verify OBE transmits BSMs
4.8 Prepare and Test RSEs	TC-2	Verify RSE receives BSM from OBE
	TC-3	Verify RSE forwards BSM to weather data services
	TC-5	Verify RSE transmits heartbeat message
4.9 Install and Field Test OBEs	TC-6	Verify OBE reads J1939 data from plow trucks
	TC-6	Verify OBE reads J1979 data from HELP vehicles
	TC-6	Verify OBE reads IceSight data
	TC-6	Verify OBE reads Dickie John data
	TC-6	Verify OBE reads GPS data
	TC-6	Verify OBE transmits BSMs
	TC-6	Verify vehicle power control correctly starts up and shuts down OBE
4.10 Install and Field Test RSEs	TC-7	Verify IPv6 switches power RSEs
	TC-7	Verify RSE receives BSM from OBE
	TC-7	Verify RSE forwards BSM to weather data services
	TC-7	Verify RSE transmits heartbeat message

Task	Test Case	Test Script Description
4.11 Deploy Weather Data Service(s) to Center	TC-3	Verify data are received from RSE
	TC-3	Verify vehicle sources are identified
	TC-4	Verify subscriptions are created for WxDE
	TC-4	Verify subscriptions are created for VDT
4.12 Deploy *Clarus* Collector	TC-4	Verify WxDE collector receives subscription
	TC-4	Verify VDT collector receives subscription
4.13 Perform Integrated System Tests	TC-5	Verify the system receives RSE heartbeat messages
	TC-5	Verify the system reports expected RSE messages are absent
	TC-5	Verify the system reports expected OBE messages are absent
	TC-5	Verify the system reports data aggregation is unavailable
	TC-8	Verify remote PoE control
	TC-8	Verify OBE stores BSM when not in range of RSE
	TC-8	Verify OBE transmits BSM when in range of RSE
	TC-8	Verify RSE stores BSMs when weather data aggregator unavailable
	TC-8	Verify RSE forwards BSMs when weather data aggregator is available

3.2 *Unit Testing*

Unit testing will be performed by the system developers at the completion of each software or hardware module. Unit tests evaluate the following:

- Code paths
- Decision conditions
- Error handling conditions
- Calculations
- Numerical accuracy, including round-off errors

- Database query performance

The methods and results of the unit testing are used to help prepare the final test scripts. Unit testing and results are not typically maintained as quality records or formal documentation.

3.3 Integration Testing

Integration testing is the testing of incrementally larger assemblies of units up to the complete system. Integration testing will be performed as the final system is assembled. Integration testing evaluates the following:

- Module interfaces
- Module interaction

The methods and results of integration testing will be used to help prepare the final test scripts. Integration testing and results are not typically maintained as quality records or formal documentation.

3.4 Acceptance Testing

Acceptance testing is typically conducted under the guidance or direct control of the client. The coverage for acceptance testing is usually the minimum acceptable functionality necessary to demonstrate the completeness of the delivered system. The requirements referenced in Table 2 form the basis of the system acceptance testing as they relate directly to the test cases and results as evidence.

This plan is intended to cover all of the testing required for system acceptance. The system may be accepted as tested, or accepted with exceptions, or accepted with additional changes.

3.5 Evaluation of Test Results

A “Passed” test indicates that the observed output of executing a test script complies with the expected output. Test scripts are composed of one or more individual steps, some of which may have an observed output that contributes to the overall passing of the test. In other words, a “Passed” test is indicated by a test script in which all of its steps meet the expected output. Test script steps may include comments that provide further testing context or record other notable system behaviors.

A “Failed” test indicates that there is a discrepancy between the expected output and the actual output for at least one step of a test script. Comments may be recorded for each step to document any additional information during execution of the test, deviations from the test script, if any, or anomalies discovered during the testing.

Test observations and data will be documented in the "results column" of the test script. Formal comments received during test script execution are recorded as an addendum and included as part of the completed test report.

3.6 Suspension and Resumption

3.6.1 Suspension Criteria

Testing activities will be suspended whenever the system has failed critical steps within test scripts related to system operation and when system applications fail to operate correctly. Application failures occur when the testing results are inconsistent with the "Expected Results" listed in the test scripts. Critical tests are defined to be those whose failure prohibits further execution of the test script.

Testing may continue after a test failure if testing *can* be continued and there is potential to discover other failures in subsequent test script steps. After corrections are made, the extent of regression testing that will be performed will be determined, coordinated with the client if it occurs as part of acceptance testing, and completed.

3.6.2 Resumption Requirements

The test resumption process requires that new versions of system components and configurations be produced following a suspension.

The areas of the design that were modified in the new component versions are tested along with any required regression testing. Regression testing is the process of testing changes to a system to make sure that existing unmodified components still work with the new changes. This is required for those functions that were affected by the defect found at the time of suspension to ensure that it is an isolated defect. Additional regression testing is required if the defect fix is not localized or if the fix caused other components or functions to be modified.

The extent of any regression testing to be performed in acceptance testing will be jointly determined between the client and consultant team.

4 ACTIVITIES AND RESOURCES

4.1 Test Deliverables

Test Plans identify system components to be tested, the testing methods to be used, and group components with related requirements into test cases. Test cases describe each testing goal and the environment needed to execute testing and contain one or more test scripts. Test scripts may further describe adjustments to the testing environment and list step-by-step actions and the results of those actions along with any formal comments. This Test Plan and the Test Report containing the test scripts and the results of their execution make up the complete set of test deliverables.

4.2 Testing Activities and Participants

This section contains a work breakdown of the effort needed to prepare the test scripts, acquisition and setup of testing environments, assembly and execution of the test scripts, and evaluation of the results.

Table 4 summarizes the testing efforts and activities and lists the participants and the location of the activity.

Table 4 - Testing Effort and Participants

Effort	Participants	Location	Test Case
OBE application testing IceSight integration testing	Synesis	KS	TC-1 TC-2
RSE configuration RSE IPv6 connectivity	Synesis, PB	KS, MD	TC-2 TC-3 TC-5
Weather Data Aggregator server WDA IPv6 Tunnel	Synesis	KS	TC-3 TC-4 TC-5
Vehicle Data Translator Server	NCAR	CO	TC-4
OBE, RSE, PoE integration testing	Synesis	NY	TC-6
OBE, RSE, PoE acceptance testing NYSDOT IPv6 tunnel	Synesis, NYSDOT	NY	TC-7 TC-8

4.3 Environmental Needs

The testing environments need dual-stacked IPv4 and IPv6 network routers, switches, and firewalls. The availability of at least one PoE network switch and either native or tunneled IPv6 Internet connectivity are also required.

The availability of the weather data aggregator server is necessary to test RSE heartbeat and log file transmission. Additionally, independent workstations may be needed to remotely connect and login to OBE and RSE for configuration, application deployment, and testing.

Super user credentials for each device need to be securely stored and shared among team members. Public and private device keys need to be shared among connected equipment to enable key-authenticated login. Servers should restrict remote users to their home directories and require elevation to access protected server resources.

4.4 Staffing and Training Needs

Staff must possess at least a minimum of experience and several skills to successfully assemble testing environments and properly execute test scripts:

- Familiarity with Linux operating systems
- Familiarity with secure shell (SSH) and secure copy (SCP) Linux applications
- Familiarity with configuration of Linux public and private keys
- Familiarity with configuration Linux user permissions
- Experience with RSE documentation and configuration
- Experience with OBE documentation and configuration
- Experience with dual-stacked IPv4 and IPv6 networks and network components
- Experience with IPv6 transition technologies and configuration
- Experience with heavy vehicle power and communication systems
- Experience with commercial vehicle power and communication systems
- Experience with SAE J2735 communication
- Experience with IEEE 1609.x protocols
- Experience with DSRC communication technologies

RISKS AND CONTINGENCIES

The topic of hardware interoperability occurs invariably when discussing the current state of connected vehicle research. At this point, there exists a qualified product list from which the equipment in this project was selected. The equipment selected for this project has also been show to interoperate in related projects such as the Safety Pilot test bed in Ann Arbor, Michigan. While there remain few vendors in this space, if the selected equipment does not sufficiently interoperate, it is possible to select a different vendor.

One of the more recent challenges in connected vehicle research is the move to IPv6 network technology. While IPv6 is not necessarily new, the United States is the pioneer in Internet communication and as such the networking communities within it maintain a significant investment in IPv4 infrastructure. To ease the transition to IPv6, specifications and methods were created to transport IPv6 over IPv4 infrastructure.

There are a couple of tunneling protocols used to send IPv6 data packets over IPv4 networks. The simplest tunneling protocol is intended to be used on this project since the communication is essentially point to point: each RSE sends its data to one aggregation server. If the first tunneling approach does not work, the second tunneling solution that uses a third party IPv6 broker can be attempted. It is also possible to configure each RSE with its own logical IPv6/IPv4 tunnel or to deploy an additional network appliance that would handle the tunneling locally.

The risk of not having IPv6 networking connections available is relatively low given the number of options to achieve it, and that only vary with the level of configuration and procurement effort.

Another challenge related to connected vehicle research is the management of security certificates and certificate revocation lists from a security certificate management system (SCMS). This project is using public fleet vehicles and there is no concern of exposing personally identifiable information or wirelessly stalking vehicle operators. Consequently, a few long-term certificates will be used as an alternative to a complete SCMS deployment. The weather data aggregation server has sufficient capacity to host the SCMS if it is determined necessary at a later time.

APPENDIX A - DEFINITIONS

The following table provides the definitions of all terms, acronyms, and abbreviations required to properly interpret this System Test Plan.

Term	Definition
BSM	Basic Safety Message
CAN	Controller Area Network. An electrical specification and signaling protocol developed by Bosch to facilitate simple data communication between connected equipment control units.
Clarus Initiative	A Federal Highway program supporting the open sharing of weather data with the goal of enabling transportation agency decision support systems that improve safety and reduce costs.
Clarus System Instance	Existing *Clarus* System software functionality and data captured at a specified and agreed upon date and time. The instance is expected to evolve into the WxDE and is not intended to replace the current operational *Clarus* System.
DSRC	Dedicated Short Range Communication. A low-latency, line-of-sight wireless data transmission standard designed for interactions between vehicles and infrastructure in a dynamic transportation environment.
Interim Environment	Temporary environment in which the *Clarus* instance is hosted and maintained, until the WxDE becomes available.
FTP	File Transfer Protocol
GHz	Gigahertz
GPS	Global Positioning System
HCI	Hardware Configuration Item
HTTP	Hyper-Text Transfer Protocol
IEEE	Institute of Electrical and Electronics Engineers
IPv4	Internet Protocol version 4
IPv6	Internet Protocol version 6
KS	Kansas
MD	Maryland

Term	Definition
NCAR	National Center for Atmospheric Research
NY	New York
NYSDOT	New York State Department of Transportation
OBE	On-board equipment. DSRC equipment connected directly to a vehicle data bus.
PB	Parsons Brinckerhoff
PID	Parameter identifier. A unique code used in a controller area network to request specific equipment operational and state data.
PGN	Parameter Group Number. A unique identifier used as a network address in the SAE J1939 data standard to group similar data parameters.
PoE	Power over Ethernet
PSID	Provider service identifier
RSE	Roadside equipment. DSRC equipment deployed near a roadway or intersection.
SAE	Society of Automotive Engineers
SCI	Software Configuration Item
SCMS	Security Certificate Management System
SP	Synesis Partners
SPN	Suspect Parameter Number. A lower-level identifier within a PGN that describes what a particular data value represents, its update frequency, and its unit of measure.
STOL	Saxton Transportation Operations Laboratory
STP	System Test Plan
U.S. DOT	United States Department of Transportation
WAVE	Wireless Access in Vehicular Environments
WDA	Weather Data Aggregator
WDE or WxDE	Weather Data Environment