**USDOT GlidePath Project**

**Prototype Requirements Compliance Test Plan**

**Version 2.1, November 17, 2015**

LEIDOS

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**Revisions**

|  |  |  |  |
| --- | --- | --- | --- |
| Revision Number | Date | Status | Description of Change |
| 1.0 | 12/2/2014 | Internal | Preliminary Version |
| 1.1 | 1/23/2015 | Internal | Update to Introductory Material |
| 1.2 | 2/10/2015 | Internal | Update to Test Case Outline |
| 1.3 | 2/12/2015a | Released to FHWA/Noblis for Internal Review | Full Draft of Introductory Material |
| 1.4 | 2/13/2015 | Submitted for Review | Full Draft of Test Cases |
| 2.0 | 4/22/2015 | Delivered | Used for acceptance tests |
| 2.1 | 11/17/2015 | Delivered | Updated per acceptance test comments |

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# Introduction

This document contains the protocols and procedures to evaluate the compliance of the completed Automated GlidePath Prototype that has been developed as part of the Saxton Lab Task Order 17 for the Federal Highway Administration’s Office of Operations, Research and Development (FHWA-HRDO). The purpose of this project is to create a fully-integrated Automated GlidePath Prototype that incorporates a speed control algorithm with automated speed control on a vehicle instrumented with an audio/visual display, wireless communication, as well as in-vehicle processing, and positioning components. In accordance with the requirements specified in “GlidePath Prototype Development – Final Requirements Document,” the prototype will implement automated speed control as the vehicle approaches the Intelligent Intersection at the Turner Fairbank Highway Research Center (TFHRC), based on the current traffic signal status to improve the environmental performance of the vehicle and minimize delays where possible.

This Test Plan illustrates the individual test cases that are required to ensure compliance with the final requirements, as approved by USDOT. The test cases contained herein provide the methodology for conducting each test to verify compliance with the specification and by establishing consistent test procedures that the outcome of the tests is independent of the test conductor, which may be any of various organizations equipped with an adequate Test Environment, as defined in Section 4.0 of this document.

Any associated material, such as documentation or output files, that is relevant to the test results will be documented in the individual test cases and can be accessed upon request from the Saxton Lab Staff.

## Test Scope

System Compliance is defined as the ability of the systems (or components) to adhere to the system requirements defined in “GlidePath Prototype Development Final Requirements Document,” as approved by the USDOT. System Compliance testing and evaluation will be conducted to confirm the system capabilities of the completed Prototype’s technical, functional and operational capabilities in conformance with the requirements, contained in version 6.0 of the requirements document.

System Compliance testing focuses on the ability of the vehicle to fulfill the primary Task Order objective; to operate with an automatically controlled speed on the westbound approach of the Intelligent Intersection at TFHRC, by interpreting the Signal Phase and Timing (SPaT) and Geographic Information Description (GID/MAP) messages that will are broadcast locally over DSRC. Additionally, System Compliance testing will verify that the prototype complies with all other requirements, including functional, state transition, interface, security, driver-vehicle interface, and data logging requirements.

### Software Unit Testing

Throughout the development of the application and driver-vehicle interface (DVI), software testing will be conducted to ensure successful integration with the vehicle and other components of the prototype. Software testing will be conducted by unit in phases, starting with the basic functionality of the DVI and building up the commands necessary to fully operate the prototype. The individual phases are described in the Software Test Cases in Section 5.0 of this report.

### Bench Testing

Bench testing will be conducted iteratively throughout the process of integrating the individual hardware components into the vehicle. These tests will not be conducted with formalized protocols, but as needed to ensure that all devices and constituent equipment meets the physical, functional, and interface requirements before the integrated prototype is deployed for field testing. Specific procedures for operation and management of individual components will be contained in the User Manual, which will be developed upon completion of system integration and testing.

Successful outcomes in preliminary testing on the bench will serve as a “qualifier” for Field Testing, which requires the deployment and configuration of both vehicle-based and roadside infrastructure and should not be conducted unless preliminary functionality is first verified on the bench.

### Field Testing

Field testing must be conducted to ensure that devices and all constituent equipment in the integrated prototype can operate successfully in the field environment. Once the team has fully installed and tested the individual components, formalized test cases will be used to evaluate the performance of the prototype, including predefined test environments and procedures to ensure that the results can be easily replicated. Upon successful completion of all field test cases, the prototype will be submitted for final approval by USDOT for use in future technical demonstrations and on-going research.

Explicit provisions for field test safety are outlined in Section 4.3.3 of this report to ensure that the field tests are conducted in a manner that is not disruptive or harmful to the staff or facility at TFHRC. Additionally, a separate document will be created for technical demonstrations of the prototype to provide explicit instruction for on-going use of the prototype.

### Provide Analysis and Report Findings

Data collected during bench and field tests will be used for post-processing and analysis to quantify the performance of the automated prototype. The evaluation results and overall research findings will be documented in a comprehensive, final project report for submission to USDOT. These results may be disseminated to a broader stakeholder group and used in general tours and technical demonstrations at the Saxton Lab. Additionally, the data sets generated from field tests and demonstrations may be made available to support information exchange and collaboration with USDOT through an online data portal.

## Test Objective

The primary objective of this plan is to evaluate the operational compliance and overall performance of the automated GlidePath prototype, in accordance with the GlidePath Prototype Development Final Requirements.

The tests will evaluate all requirements contained in version 6.0 of the specifications document.

## Stakeholders

Stakeholders in this project include a cross-section of transportation researchers and professionals, from both the public and private sectors, academic and industry backgrounds. The project’s key stakeholders in developing the prototype requirements and project objectives included various staff members from the Federal Highway Administration’s Office of Operations, Research and Development (FHWA-HRDO) and the USDOT Applications for the Environment: Real-time Information Synthesis (AERIS) program, which jointly funded the research.

University researchers, contractors, and other industry professionals also provided stakeholder input during the development of the requirements and designs for the prototype, drawing on a body of completed research to advance the state-of-the-practice in automating Infrastructure-to-Vehicle (I2V) applications.

Ultimately, future research that stems from and builds off of this prototype is expected to impact a much broader community of stakeholders and the general traveling public as the applications mature and are deployed in a production environment.

# Test Schedule, Personnel and Documentation

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

## Test Schedule

Table 1 lists the activities anticipated for the evaluation process, including an estimated duration of each activity. Some activities may not be necessary or may be carried out concurrently. These estimates assume no interruption of testing activities due to weather or other unexpected delays.

Table 1. Test Activities

|  |  |  |  |
| --- | --- | --- | --- |
| ID | Name | Estimated Duration | Estimated Start Date |
| 1 | Preparation of Bench Test Environment | 1 week | 11/3/2014 |
| 2 | Conduct Bench Testing | 2 – 4 weeks | 12/1/2014 |
| 3 | Prepare Field Testing Sites | 1 week | 2/2/2015 |
| 4 | Conduct Field Testing | 1-3 weeks | 2/16/2015 |
| 5 | Document Results | 2 weeks | 2/16/2015 |
| 6 | Demonstrations | On-Going | 4/15/2015 |

## Personnel

The following staff is anticipated to complete the activities in the estimated amount of time listed in Section 2.1 Test Schedule. Table 2 is a list of the general personnel required for compliance evaluation. Some roles may be combined such that a single person can assume up to two roles (i.e. the Test Director may also be the Driver, or the Lead Passenger may also be the Data Recorder).

Table 2. Test Personnel

| Title | Minimum Number |
| --- | --- |
| Test Director | 1 |
| Driver | 1 |
| Lead Passenger | 1 |
| Data Recorder | 1 |
| Traffic Safety Controllers | 3 |
| Support Staff | 1 |
| Test Observers | As needed |

### Test Director

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

### Driver

The driver will be responsible for safe operation of the vehicle throughout the test runs, including during test set-up, experimental runs, and post-test activities. Drivers must have completed the XGV vehicle training and shall be pre-approved by the Test Director. The driver will wear a seat belt at all times and remain alert for direction from Traffic Safety Controllers on the roadside. The driver will be responsible for confirming the selected parameters to the Data Recorder for each test run, validating the entrance criteria, verifying the readiness of test equipment, and announcing the start and end of each test run. The driver will narrate any relevant observations during testing for the Data Recorder to ensure that any test irregularities or results are properly documented.

At all times, the driver will be responsible for navigating incidents, exceptions, cancellations, or re-scheduling tests in the event of a failure that prevents a test from being executed.

### Lead Passenger

The lead passenger will sit in the front passenger seat of the test vehicle during all testing activities to monitor the development interface of the application from a laptop. The lead passenger will wear a seatbelt and remain alert for any discrepancies in the expected application performance and notify the driver if a manual override is necessary.

### Data Recorder

The data recorder is responsible for recording the outputs and overall results of each test. The data recorder will wear a seatbelt throughout testing and ride in the back of the vehicle with a copy of the test procedures. The data recorder will read out test instructions and write down results as dictated by the driver. The data recorder will provide all observations to the test director at the end of the test day.

### Traffic Safety Controllers

The traffic safety controllers will wear reflective traffic safety jackets and be stationed with traffic cones at identified locations around the test site to direct staff vehicles entering or exiting the premises during testing. Traffic safety controllers will have hand radios to communicate with each other, the driver, and the test director to coordinate vehicle movements during test activities. Traffic safety controllers will direct staff vehicles to wait for a test run to complete before proceeding through the test area or to re-route around the back of the facility; depending on the location of the vehicle.

### Support Staff

Support staff will be on-hand to fill in for or take over the responsibilities of other test staff at the discretion of the test director.

### Test Observers

Test observers witness test runs at the USDOTs discretion.

## Documentation

### Test Records

Specific test information, including test environment, test execution, and attendees/ participants/ observers will be captured for each individual test. Each step in the procedure shall be marked with a P or an F after completion, indicating success (Pass) or failure (Fail). All failures, as well as any deviations from the procedure or work-arounds, will be recorded in a Comments section of the form. These entries will be entered electronically during test execution.

# Test Strategy

The overall test strategy is organized into four (4) major test categories (Integration, Regression, Performance, and Acceptance Testing) that will be implemented and executed during the design, integration, and final system acceptance testing. The procedures and test cases outlined in this document pertain to the System Acceptance Testing that will be conducted with the FHWA General Task Manager to verify that the implemented prototype meets all of the Final Requirements.

All System Acceptance Testing will be conducted on-site at the TFHRC Intelligent Intersection using project staff to administer and document final test procedures for FHWA sign-off upon completion.

## Physical Inspection, Bench and Field Testing

### Physical Inspection

Upon receipt of the vehicle and completion of the initial configuration of the prototype hardware, the team completed a physical inspection of all prototype components and interfaces to ensure implementation was consistent with the design. After completing a full, preliminary run of all the test cases included in this document, the project team will conduct a similar physical inspection and overview of the prototype with the FHWA General Task Manager.

### Bench Testing

To complete the initial configuration of the prototype hardware, the project team completed high-level bench testing of the individual prototype components to ensure all hardware was fully functional as expected. For commercial-off-the-shelf components, a review of technical specifications will be conducted in lieu of specific bench tests; however, the performance of all components will be monitored during the development and implementation of the application to identify any potential problems

### Field Testing

The project staff will conduct preliminary field tests during the development and implementation of the application to completely integrate major system components and validate proper system functions. During these preliminary tests, the project staff will monitor for errors early in the development phase and correct any defects that are identified during implementation. Upon successful completion of integration and regression testing, the team will conduct additional runs to practice experimental protocols and to monitor system performance for general reliability and availability. These early tests are intended to ensure the success of System Acceptance Testing which will be conducted more formally, in compliance with the test cases and procedures outlined in Section 5.0 of this document.

## Test Organization

### Test Groups

Test Cases contained in this document are organized around the verification method for the individual requirements for the final System Acceptance Testing, including physical inspection, demonstration and test. Those requirements that can be verified by physical inspection or demonstration will be completed in the TFHRC Smart Garage in a formal walk through of the prototype with the FHWA General Task Manager, followed by the sequential test cases to verify the remainder of the requirements.

## Test Methodology

### Test Sequence

The physical inspection and demonstrations will be completed at the onset of testing for FHWA to verify and sign off on the overall implementation of the prototype. Although the order of the test cases is not interdependent, the test plan is written in such a way that sequential implementation of the test cases follows a logical order to minimize the redundant activities to verify compliance of all requirements. Individual tests will be performed consecutively unless otherwise specified by the Test Director and documented in the test report.

## Configuration Management

The project team implemented several provisions to properly manage configuration of the prototype, including use of the server to maintain code, conducting file exchange over a shared drive with revision control, and redundant in-vehicle processors.

In the development stage, all code is maintained on a server to avoid accidental loss due to any possible damage to the processors or staff computers. Additionally, documentation of the code and other relevant project files are maintained on a shared drive with revision control to allow for free file exchange between team members without risk of violating version control.

The GlidePath Prototype Vehicle has two (2) in-vehicle processors to maintain configuration management; one for development testing and one for the final application. The team will upload and regression test all code on the development processor before making changes to the final prototype. Any conflicts observed during testing will be recorded and tracked to resolution.

During integration, regression, and performance testing, the Test Director will maintain logs of interim test case outcomes along with tracked conflicts and resolution matrices. These logs will be maintained in a spreadsheet in conjunction with each iterative software build package identifier.

Configuration management will be key to track changes during all test phases to ensure that the components under test are meeting all requirements and when there are conflicts they are recorded and tracked to resolution. Periodic testing and verification of configuration management will be performed as part of the preliminary testing and will not be included in the System Acceptance Testing.

Upon successful completion of System Acceptance Testing, the software build package identifier will be finalized as the delivery software version number and any subsequent changes will require additional development and testing. This version number will be used in the documentation of all final software code and documentation and be uploaded to both in-vehicle processors and the server for redundancy during operations.

# Test Environment

This section describes the facilities necessary for environmental, bench and field test activities required to conduct all tests. Prior to conducting tests, the test environment should be inspected to ensure all hardware and software required to execute the compliance evaluation are readily available.

## Physical Inspection

For the physical inspection, the project team will arrange the vehicle to be stationary in the garage so as to make as much of the implemented system as possible visible for inspection. This includes turning down the seats and lifting or removing internal vehicle coverings to the extent requested by the FHWA General Task Manager. Some components of the prototype, especially Ethernet interfaces and embedded controllers, may not be completely visible, but are illustrated in the design document and assumed to be installed sufficiently based on component functionality.

## Bench Tests

Bench tests involve conducting tests in a controlled environment to establish a basic level of compliance with the requirements. The list below contains general equipment and facility requirements that were necessary to facilitate bench testing. Because all bench tests were conducted informally, no documentation of the exact procedures is included in this document; however, all of the equipment and facility requirements listed below can be recreated to demonstrate component functionality at the request of the FHWA General Task Manager.

### General Equipment Requirements

The equipment required to conduct the bench tests include:

* AC and DC power supplies
* Network switch
* GPS repeater (where facilities do not have a clear view of the sky)
* Ethernet cables
* DSRC Protocol Analyzer
* PC Monitor, Keyboard, and Mouse

### General Facilities Requirements

The facilities required to conduct the bench tests include:

* Workbench space
* Surge Protection power strips
* Vehicle preparation space
* 8:00 am to 5:00 pm, Monday through Friday, access to the workbench, conference room, vehicle preparation space
* Afterhours access to the workbench, conference room, garage, and parking lot space as requested by the test team

## Field Tests

Most field testing will take place outdoors and will be scheduled for good weather as time permits. The list below contains general equipment and facility requirements that are necessary to facilitate the field tests, but specific provision for weather-related equipment or facility needs should be considered during inclement weather. No field testing will be conducted during storms or when roads are icy.

**Caution: The vehicle can be moved using manual driving; however, field testing the vehicle requires specific protocols and knowledge of the prototype vehicle that are the result of specific training and should be conducted by authorized users only.**

### General Equipment Requirements

All equipment required for field testing is installed in the vehicle; however, for additional data collection and diagnostics, an additional laptop can be connected locally via WiFi to monitor the status of various system components. Additionally, a DSRC Protocol Analyzer can be used to monitor and log over-the-air communication.

### General Facilities Requirements

Field testing is intended to be conducted at TFHRC in McLean, Virginia and the experiment was designed to be run on the Westbound approach to the Intelligent Intersection on-site. Additional consideration should be given to field test safety provisions, described below in Section 4.3.3.

### The facilities required to conduct the field tests include:

* RSU site locations safely accessible by the test team (i.e. test team can access the RSU from a safe distance from vehicle traffic)
* Workbench space
* 8:00 am to 5:00 pm, Monday through Friday, access to the workbench, garage, and parking lot space.
* Afterhours access to the workbench, garage, and parking lot space as requested by the test team

### Field Test Safety Provisions

#### The driver and all vehicle passengers should always wear a safety belt when the vehicle is in motion.

#### Driver Safety

Only authorized users will drive the prototype vehicle to ensure its safe operation during field testing and demonstration. Authorized users will complete full training of the XGV vehicle and GlidePath application, including proper operating procedures and all safety-specific equipment.

When the vehicle is in manual mode, the driver will operate the vehicle in a safe manner that is consistent with all relevant driving rules and regulations. The driver will observe local traffic patterns and clear on-coming traffic before maneuvering around the test course, specifically for the U-Turns necessary at the beginning and end of each experimental run.

When the vehicle is in automated mode, the driver will remain alert of all surroundings with both hands on the steering wheel to ensure safe navigation of the vehicle across the test course. If the driver identifies a potential conflict with the intended test course and any local traffic, the driver will take over manual control of the vehicle and re-start the experiment.

The driver is ultimately responsible for the vehicle’s operation and will alert the Test Director of any abnormalities in its performance or status, including all standard equipment, electronic components, and overall vehicle body.

#### Vehicle Safety

The vehicle is equipped with several safety-specific components, including audio/visual alerts and emergency override capabilities to promote safe operation of the vehicle. The brake pedal and yellow emergency override button can be used to halt automated acceleration of the vehicle to facilitate a return to manual driving. An audible alert will accompany the flashing light on the top of the vehicle during automated operation to alert the surrounding environment of a test-in-progress.

#### Traffic Safety

Project staff, wearing traffic safety vests, will be positioned around the facility to direct local traffic during testing. These team members will use traffic safety cones to indicate when the test route is closed and will redirect traffic to the back route around the facility to avoid potential conflicts.

When the field experiments are concluded for the day, the project staff will return the traffic signal head to flashing mode for normal traffic operations.

# Test Cases

This section contains information about and provides a brief introduction to the individual test cases that will be used to verify the compliance of the prototype with the stated requirements. Specific test procedures will be developed during early phases of testing and finalized prior to the System Acceptance Tests. Preliminary procedures may be included below. To complete the System Acceptance Test, a printed copy of the test cases, complete with procedures, will document final approval of the implemented prototype with signatures from the Principal Investigator and FHWA General Task Manager.

## Security

The security requirements for the Automated GlidePath Prototype deal with general practices and procedures, enforced by the project team and FHWA General Task Manager. The first test case is included as documentation that all relevant project staff have agreed to observe the specified security protocols and to act conservatively in any situations not covered by the requirements listed below.

| **Test Case #** | TO17\_SEC\_01 |
| --- | --- |
| **Test Case** | Prototype Security |
| **Reference** |  |
| **Objective** | To document the agreement to comply with the requirements listed below, including physical and operational security. |
| **Requirements verified** | * *TO17\_SEC\_01v1* * *TO17\_SEC\_02v1* |
| **Brief Description** | The team will provide signed agreements to abide by and enforce the listed security protocols. |
| **Data Outputs** | Signed agreements will be provided to the FHWA General Task Manager and saved on file. |

| **Test Case #** | TO17\_SEC\_02 |
| --- | --- |
| **Test Case** | PC Password Protection |
| **Reference** |  |
| **Objective** | Verification of the restrictions implemented for system access to the in-vehicle processors. |
| **Requirements verified** | * *TO17\_SEC\_03v1* |
| **Brief Description** | The team will log into the in-vehicle PCs using the provided user name and password, which will be shared with the FHWA General Task Manager and referenced in the Prototype Operation and Maintenance document. There will be at least one alternative set of credentials with administrative access to the computer. |
| **Data Outputs** | none |

## Infrastructure

The infrastructure requirements will be verified by visual inspection and demonstration prior to any field testing. The Intelligent Intersection at TFHRC will be configured to support the application using a fixed time signal cycle that is broadcast over DSRC.

| **Test Case #** | TO17\_INF\_01 |
| --- | --- |
| **Test Case** | Infrastructure Readiness |
| **Reference** |  |
| **Objective** | Verification of the fixed-time signal cycle and the accurate broadcast of SPaT, MAP, and WSAs over DSRC. |
| **Requirements verified** | * *TO17\_FUN\_17v1* * *TO17\_FUN\_18v1* |
| **Brief Description** | Using the appropriate tools and methods, the test conductor will verify that the signal cycle of the intersection is set to fixed-time and will not be actuated by any of the local loop detectors. Additionally, the test conductor will verify that SPaT, MAP, and WSAs are being broadcast over the air using DSRC. |
| **Configuration** | * Vehicle is equipped with a DSRC Protocol Analyzer * Traffic controller is set to normal function (not flash) * SPaT black box is connected to traffic controller over Ethernet and pointed to the test RSU * Loop detectors are not active * Traffic signal operates with constant, fixed time cycle * SPaT, MAP and WSAs are captured in the vehicle |
| **Data Outputs** | Saved capture from DSRC Protocol Analyzer and documentation of observed signal timing for at least three cycles. |

## Vehicle

The vehicle related requirements require multiple test cases be run to verify the component functionalities of the prototype that will ultimately build to the full application. Many of these test cases reference the “XGV Start Up Procedures” in their Entrance Criteria; these procedures are documented as part of the XGV training materials and a quick-start guide will be mounted on the passenger side of the vehicle.

| **Test Case #** | TO17\_VEH\_01 |
| --- | --- |
| **Test Case** | Documentation of Vehicle Functionality |
| **Reference** |  |
| **Objective** | Verify documentation of vehicle settings and configurations that will not be field tested, such as automated lateral control and the maximum acceleration thresholds. |
| **Requirements verified** | * *TO17\_FUN\_09v1* * *TO17\_FUN\_10v1* * *TO17\_INT\_02v1* |
| **Brief Description** | Review of documentation that prototype vehicle has the capability for automated lateral control and the maximum speed and acceleration thresholds for automated longitudinal control of the vehicle. Verification that vehicle utilizes JAUS via Ethernet as the command structure for control commands to the vehicle. |
| **Configuration** |  |
| **Data Outputs** | User manual for XGV |

| **Test Case #** | TO17\_VEH\_02 |
| --- | --- |
| **Test Case** | In-Vehicle Equipment |
| **Reference** |  |
| **Objective** | Visually inspect DSRC Communication, Positioning, and Processing components installed in the vehicle, as well as Ethernet cable connections. Component functionality is documented in component user manuals which will be available for reference. |
| **Requirements verified** | * *TO17\_FUN\_14v1* * *TO17\_FUN\_15v1* * *TO17\_FUN\_19v1* * *TO17\_INT\_01v1* |
| **Brief Description** | The project team will provide an in-person overview of the vehicle components and interfaces as compliant with the requirements listed above. |
| **Configuration** |  |
| **Data Outputs** |  |

| **Test Case #** | TO17\_VEH\_03 |
| --- | --- |
| **Test Case** | Basic Longitudinal Control |
| **Reference** |  |
| **Objective** | Verify capability of the vehicle to receive and implement electronic speed commands in the forward and reverse direction. |
| **Requirements verified** | * *TO17\_FUN\_01v1* * *TO17\_FUN\_02v1* * *TO17\_FUN\_04v1* * *TO17\_FUN\_05v1* |
| **Brief Description** | Using the TORC-furnished XGV Operator Control Unit (OCU) application, the test conductor will demonstrate the basic capabilities of the vehicle to operate under automated longitudinal control in compliance with the requirements. |
| **Configuration** | In accordance with the XGV Start Up Procedures, the vehicle must be in the Automated state for this test |
| **Data Outputs** | Saved capture from DSRC Protocol Analyzer and documentation of observed signal timing for at least three cycles. |

| **Test Case #** | TO17\_VEH\_04 |
| --- | --- |
| **Test Case** | Vehicle Behavior |
| **Reference** |  |
| **Objective** | Verify that the vehicle behavior is compliant with the requirements listed below and activated using the required control mechanisms. |
| **Requirements verified** | * *TO17\_FUN\_05v1* * *TO17\_FUN\_06v1* * *TO17\_FUN\_07v1* * *TO17\_BEH\_01v1* * *TO17\_BEH\_02v1* * *TO17\_BEH\_03v1* * *TO17\_BEH\_04v1* * *TO17\_BEH\_05v1* * *TO17\_BEH\_06v1* * *TO17\_BEH\_07v1* * *TO17\_BEH\_08v1* * *TO17\_BEH\_09v1* * *TO17\_BEH\_10v1* |
| **Brief Description** | The test conductor will demonstrate the transition between each state listed in the requirements to verify that the vehicle behaves as expected, especially as dictated by the required physical control mechanisms (activation key, brake pedal, emergency override button). |
| **Entrance Criteria** | The vehicle must be: 1  - Disconnected from shore power ; and,  - Parked outside at TFHRC.  The Test Driver must be seated in the driver’s seat. The Driver and all Passengers must have their safety belts fastened.  Traffic control staff must be deployed and ready to monitor and manage traffic for  the test runs. |
| **Configuration** | Activation Key must be turned to ‘0’. |
| **Data Outputs** | Saved capture from DSRC Protocol Analyzer and documentation of observed signal timing for at least three cycles. |

## Algorithm

The primary functionality of the algorithm will be verified through both a high-level, and ‘behind-the-scenes’ demonstration, as well as a post-processing analysis of the output data.

| **Test Case #** | TO17\_ALG\_01 |
| --- | --- |
| **Test Case** | Demonstration of Algorithm Functionality |
| **Reference** |  |
| **Objective** | Verify that application functionality is consistent with the behavior described in the relevant requirements. |
| **Requirements verified** | * *TO17\_FUN\_20v1* |
| **Brief Description** | The project team will conduct a preliminary drive in the vehicle from the test start point through the intersection to completion with the FHWA General Task Manager to demonstrate the operational application for the scenario in which the vehicle comes to a full stop at a red light and must be re-engaged by the driver. This drive will be repeated for the remaining scenarios to demonstrate the full-functionality of the algorithm at different phases of the signal cycle. |
| **Entrance**  **Criteria** | The Test Driver must be seated in the driver’s seat. The Driver and all Passengers  must have their safety belts fastened.  Traffic control staff must be deployed and ready to monitor and manage traffic for the test runs. |
| **Configuration** |  |
| **Data Outputs** |  |

| **Test Case #** | TO17\_ALG\_02 |
| --- | --- |
| **Test Case** | Demonstration of Algorithm Process |
| **Reference** |  |
| **Objective** | Verify that the software components that address the algorithm-specific requirements listed below both exist and function properly. |
| **Requirements verified** | * *TO17\_FUN\_16v1* * *TO17\_FUN\_27v1* |
| **Brief Description** | The project team will conduct a drive in the vehicle with the FHWA General Task Manager with a remote connection to the in-vehicle PC to demonstrate the functionality of the individual software components. |
| **Entrance**  **Criteria** | The Test Driver must be seated in the driver’s seat. The Driver and all Passengers  must have their safety belts fastened.  Traffic control staff must be deployed and ready to monitor and manage traffic for the test runs. |
| **Configuration** | * PC is configured to access the in-vehicle processor over 4G |
| **Data Outputs** |  |

| **Test Case #** | TO17\_DATA\_01 |
| --- | --- |
| **Test Case** | Output Data Post-Processing |
| **Reference** |  |
| **Objective** | Evaluate prototype data output logs to ensure all data requirements are met. |
| **Requirements verified** | * *TO17\_FUN12v1* * *TO17\_FUN22v1* * *TO17\_FUN23v1* * *TO17\_FUN24v1* * *TO17\_FUN25v1* * *TO17\_FUN26v1* * *TO17\_DAT\_01v1* * *TO17\_DAT\_02v1* * *TO17\_DAT\_03v1* * *TO17\_DAT\_04v1* |
| **Brief Description** | The project team will provide an annotated sample of the output data along with an actual output file from one of the test runs to both the evaluation team and FHWA General Task Manager to verify that all related data requirements are fulfilled by the application. |
| **Configuration** |  |
| **Data Outputs** | Full log of live demonstrations as well as an annotated sample output log for cross-reference. |

## Driver-Vehicle Interface

The various screens used in the Driver-Vehicle Interface will be printed for off-line review by the FHWA General Task Manager and used during the test drives for comparison.

| **Test Case #** | TO17\_DVI\_01 |
| --- | --- |
| **Test Case** | Driver-Vehicle Interface |
| **Reference** |  |
| **Objective** | Verify that all DVI related requirements are met. |
| **Requirements verified** | * *TO17\_DVI\_01v1* * *TO17\_DVI\_02v1* * *TO17\_DVI\_03v1* * *TO17\_DVI\_04v1* * *TO17\_DVI\_05v1* * *TO17\_DVI\_06v1* * *TO17\_DVI\_07v1* |
| **Brief Description** | The project team will provide a printed copy of the various DVI screens for preview by the FHWA General Task Manager to verify the content of the DVI and a specific test drive will be conducted to verify the compliance of the DVI functionality in accordance with the requirements listed above. |
| **Entrance**  **Criteria** | The Test Driver must be seated in the driver’s seat. The Driver and all Passengers  must have their safety belts fastened.  Traffic control staff must be deployed and ready to monitor and manage traffic for the test runs. |
| **Configuration** | The vehicle should be at the Experimental Start Location, in Automated mode. |
| **Data Outputs** | Printed DVI material with annotations |