APPENDIX I- System Verification Plan

Spokane Regional Transportation Management Center

Advanced Traffic Management System Replacement

System Verification Plan

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Chapter 1
Purpose of Document

1.1. Introduction

This document describes the framework for verification of the SRTMC ATMS replacement at the whole system and subsystem levels. The implementation of this plan ensures that all System Requirements are verified before WSDOT accepts the system. Therefore, this plan defines the basis of system acceptance with conceptual definitions, activities, and methodologies for verification.

The System Requirements document is closely associated with the System Verification Plan. As these requirements were generated and refined, system verification concepts were considered to ensure that each requirement is written in a verifiable manner. As the RFP is developed and the requirements are further refined, the System Verification Plan will be referenced to assure the final set of requirements in the RFP will also be written in a verifiable manner. Verification is the process to ensure that the system being built fulfills its defined requirements. Therefore, the requirements need to be written in specific and unambiguous terms in order to be objectively verifiable.

In other industry contexts, the concept of verification is sometimes muddled with validation. For this project, these terms are distinct. Validation is the process that evaluates how well the system meets stakeholder needs, and verification is the process that objectively evaluates that the system fulfills specifically defined requirements. Although validation and verification (V&V) are complementary, this System Verification Plan document is only concerned with verification.

1.2. Report Organization

As recommended by the WSDOT Design Manual, Chapter 1050 Intelligent Transportation, Section 1050.03, this System Verification Plan follows the Verification Plan template in the USDOT/CalTrans document, *Systems Engineering Guidebook for Intelligent Transportation Systems*, Version 3, November 2009. Table 1 shows the adapted chapter numbering and high-level contents.

Table 1: Concept of Operations Chapter Overview

Number and Name		Contents
1	Purpose of Document	This section describes the background and purpose of verification activities to be performed for the Verification Plan.
2	Scope of Project	This section gives a brief description of the planned project and the purpose of the system to be built. Special emphasis is placed on the project's complexities and challenges that must be addressed and verified by the systems engineering efforts.
3	Referenced Documents	This is a list of all documents used in the preparation of this Verification Plan.
4	Test Conduct	This section provides details on how the testing is accomplished. It defines: who does the testing; when and where it is to be done; the responsibilities of each participant before, during, and after each test; the hardware and software to be used.

5	Test Identification	This section is the heart, and largest, section of the Verification Plan. Here we identify the specific test cases to be performed. A test case is a logical grouping of functions and performance criteria [all from the Requirements Documents] that is to be tested together.

1.3. Objectives

The objective of system verification, per IEEE standard 1012, is to provide the evidence that requirements have been met correctly, completely, consistently and accurately. The verification process is used by the system's owner and by other stakeholders to show that the as-built system, sub-system, and components meet all of their requirements and design.

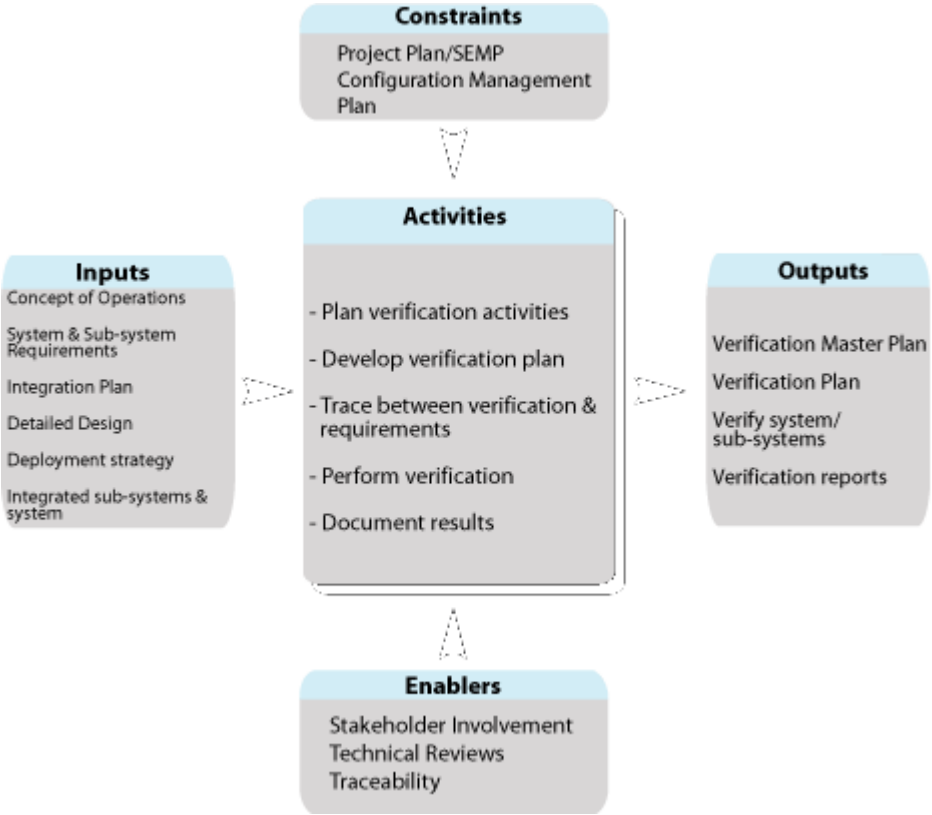

Figure 1: Verification Process

Figure 1 from IEEE 1012, illustrates the verification process with several outputs shown. For this project, the "Verification Master Plan" is this document.

Based on this Plan, the Contractor shall develop test cases and methods for testing against the requirements at each level - component, sub-system and system. In addition to the verification test cases, this Plan gives general guidance for all of the verification activities, including:

- the identification of all verification participants,
- descriptions of their roles and responsibilities,
- a schedule for verification activities

Based on the particular system products and implementation, the Contractor will identify:

- test equipment needed
- software drivers or simulators needed to model the interfaces to the system under test.

1.4. Systems Engineering

Recognizing the value of systems engineering in successful Intelligent Transportation Systems (ITS) programs, both the Federal Highway Administration and the Washington State Department of Transportation (WSDOT) require use of the systems engineering process. This Systems Verification Plan is structured to include elements necessary for systems engineering. It is part of several activities and documents throughout the process to procure the new ATMS that collectively fulfill the systems engineering requirements, requirements that are proven to enhance ITS investment.

The FHWA rules are contained within Chapter 23 of the Code of Federal Regulations in section 940.11. The WSDOT Design Manual's Systems Engineering section is designated 1050.03.

As shown in the generalized systems engineering vee diagram in Figure 2 the System Verification Plan draws from the Systems Requirements to establish the System Verification & Deployment process during integration.

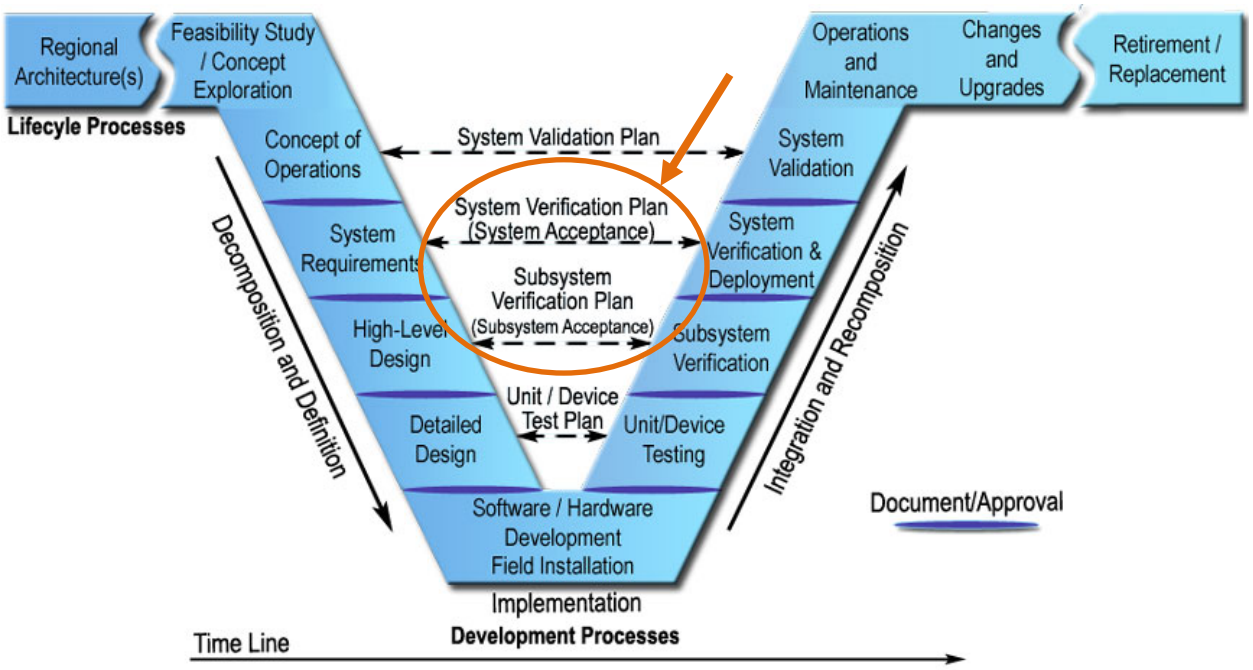

Figure 2: Systems Engineering Vee Diagram Highlighting the System Verification Plan

Following through the steps of system installations and testing, note that System Verification references back to the System Requirements. System verification is the check that the system that has been designed and implemented fulfills the requirements established in the System Requirements.

1.5. Definitions

The following provides definitions used in this document. It is meant to support use of a common language among WSDOT and its consultants when communicating about system verification and testing.

1.5.1. Acronyms

The following table presents commonly used acronyms. Many are used within this document, while others are not in this document, but are provided for information.

Table 2: List of Acronyms

ATMS	Advanced Transportation Management System
AVL	Automated Vehicle Location
C2C	Center to Center
C2F	Center to Field
CDR	Critical Design Review
CM	Configuration Management
CMP	Configuration Management Plan
CMP	Congestion Management Process
ConOps	Concept of Operations
COTS	Commercial Off-The-Shelf
CTM	Contractor Test Manager
DMS	Dynamic Message Signs
FAT	Factory Acceptance Test
FHWA	Federal Highway Administration
GOTS	Government Off-The-Shelf
GUI	Graphical User Interface
HAR	Highway Advisory Radio
ICD	Interface Control Document
IEEE	Institute of Electrical and Electronics Engineers
ITS	Intelligent Transportation System
HDD	Hardware Design Description
HRS	Hardware Requirements Specification
HW	Hardware
IDD	Interface Design Document
IRS	Interface Requirements Specification
IT	Information Technology
ITD	Idaho Transportation Department
IV&V	Independent Verification and Validation
KPI	Key Performance Indicator
KPP	Key Performance Parameter
MTP	Master Test Plan
MVP	Master Verification Plan
NHS	National Highway System
NTCIP	National Transportation Communications for ITS Protocol
OAT	Operational Acceptance Test
OTM	Owner Test Manager
O&M	Operations & Maintenance
PeMS	Performance Measurement System
PMP	Project Management Plan
RTM	Requirements Traceability Matrix

RTMS	Remote Traffic Microwave Systems
RWIS	Road Weather Information System
SAT	Site Acceptance Test
SIT	System Integration Test
SME	Subject Matter Expert
SDD	Software Design Description
SQMP	Software Quality Management Plan
SEMP	Systems Engineering Management Plan
SR	State Route
SRR	System Requirements Review
SRS	Software Requirements Specification
SRTMC	Spokane Regional Transportation Management Center
SW	Software
T&E	Test & Evaluation
TIM	Traffic Incident Management
TMC	Traffic Management Center
TRR	Test Readiness Review
QA	Quality Assurance
V&V	Verification and Validation
WBS	Work Breakdown Structure
WSDOT	Washington State Department of Transportation

1.5.2. Stakeholders

The core stakeholders who are the primary sources for development of the Systems Requirements are the five agencies that comprise the SRTMC Board and one ex officio member:

- City of Spokane
- City of Spokane Valley
- Spokane County
- Spokane Transit Authority (STA)
- Washington State Department of Transportation, Eastern Region
- Spokane Regional Transportation Council (SRTC) (ex officio)

Other supporting stakeholders include:

- Federal Highway Administration (FHWA)
- Federal Transit Administration (FTA)
- Washington State Patrol (WSP)
- Idaho Transportation Department (ITD) District 1
- City of Spokane Police Department
- City of Spokane Fire Department
- Spokane Valley Police Department
- Spokane Valley Fire Department
- Broadcast Media

Chapter 2
Scope of Project

This section gives a brief description of the planned project and the purpose of the system to be built. Special emphasis is placed on the project's complexities and challenges that must be addressed and verified by the systems engineering efforts.

2.1. SRTMC Functionality

In general, an ATMS is essential software and hardware used by a TMC to efficiently enable many transportation management functions. The general concept for ATMS has developed from a collection of software controlling individual ITS device types to a powerful tool consolidating multiple systems in a user-friendly interface including visualizing monitoring and control of a variety of ITS devices and other inputs as well as archiving data, facilitating coordination among agencies, and automating some functions. An ATMS can now also provide a single platform for both devices traditionally found on freeways and arterials.

As reported in the Concept of Operations document, the overarching vision for the SRTMC is provided in the 2013 Spokane Regional ITS Plan:

> *The vision for the SRTMC is to actively coordinate and support the overall regional transportation infrastructure and respond to events across jurisdictional boundaries through a joint partnership that reduces congestion and maximizes the efficiency and safety of the transportation network.*

The Concept of Operations document summarizes the Regional ITS Plan for the SRTMC as including: network surveillance, traveler information dissemination, incident response coordination, and a clearinghouse for regional databases. Goals for the SRTMC ATMS Replacement are categorized in Section 4.5 as follows:

- Integration of Transportation Management (4.5.1)
- Regional Traffic Control (4.5.2)
- Regional Traveler Information (4.5.3)
- Road Weather Operations (4.5.4)
- Maintenance and Construction Operations (4.5.5)
- Incident Management (4.5.6)
- Public Transportation (4.5.7)
- Regional Communications Infrastructure (4.5.8)
- Archived Data Management (4.5.8)

2.1.1. Project Challenges

From the general functionality described above for the SRTMC upgrade, it can be seen that most of the requirements will be software- or database centric with a high level of integration requirements.

Integration is the process of making components or subsystems function together as a whole system. A simplified example is illustrated in Figure 3 below. Within the ATMS, representative subsystems x and y are integrated. Within subsystems x and y, there are hardware (HW) and software (SW) components that are also integrated. The ATMS as a system is also integrated with other external systems.

In principle, integration at the system-system and subsystem-subsystem levels is the same as at the component-component level. In practice, complexity increases from the component level to the subsystem level and again up to the system level. As complexity increases, the interfaces between systems become more subtle and the integration task becomes much more difficult. Generally, it's unrealistic to expect the Systems Requirements document to adequately define the interfacing between subsystems and systems.

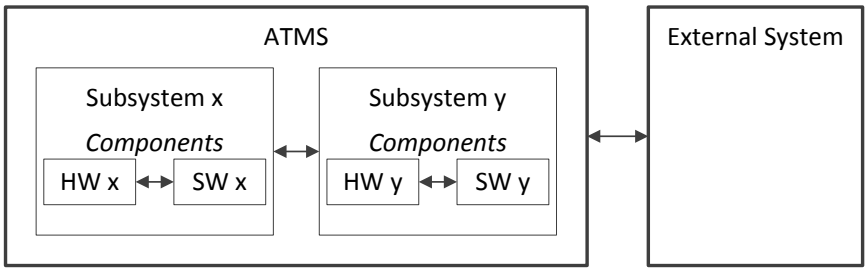

Figure 3: Integration Issues

IEEE 1012 summarizes the potential integration issues among the system, software, and hardware for when these elements are developed relatively individually.

- Software size relative to hardware capability
- Hardware compatibility with software language and structure
- System timing relative to software design and hardware capabilities
- System and software architecture relative to hardware capabilities
- Capability to validate software in environment representative of the hardware architecture
- Hardware restrictions relative to system environment
- Software integrity relative to hardware architecture
- System maintainability relative to hardware acquisition
- System maintainability relative to software architecture
- Hardware availability relative to projected system lifetime

Chapter 3
Referenced Documents

The table below lists the documents that served as references for development of this System Verification Plan.

Table 3: List of Referenced Documents

Code of Federal Regulations Title 23: Highways (Part 940: ITS Architecture & Standards) January 2001
USDOT/CalTrans Systems Engineering Guidebook for Intelligent Transportation Systems Version 3, November 2009
WSDOT Design Manual (Chapter 1050: ITS) July 2014
IEEE Std 1012™-2012, IEEE Standard for System and Software Verification and Validation
IEEE Std 829TM-2008, IEEE Standard for Software and System Test Documentation

Chapter 4
Test Conduct

This section provides details on how the testing is accomplished. It defines: who does the testing; when and where it is to be done; the responsibilities of each participant before, during, and after each test; and the hardware and software to be used.

The Contractor will develop and submit a Master Test Plan that describes how testing activities will be conducted and coordinated with details on test organization, test schedule, test resources and responsibilities. This chapter provides general requirements for the Master Test Plan.

4.1. Scope of Verification

All individual requirements will be tracked in the Requirements Traceability Matrix (RTM). In order to qualify as a valid requirement in the RTM, each requirement must be testable in some fashion. In other words, requirements must be measureable. The RTM will define the kind of testing needed for verification. While other Contract Documents will reference the RTM, other documents such as the Specifications will describe the way requirements are to be met.

Therefore, the scope of Verification is limited to assuring that system requirements as defined in the RTM are met, not that Contract requirements in general are met. However, test procedures will be written by the Contractor to match how the system is actually built.

4.2. Types of Tests

The ATMS requirements will be verified with the following tests:

- *Factory Acceptance Test (FAT)* is performed on the Contractor's premises using the approved test procedures submitted by the Contractor. FAT verifies each requirement in the RTM. External system data inputs/outputs and interfaces are simulated.

- *Site Acceptance Test (SAT)* is performed at the TMC with the same test procedures used for FAT. SAT verifies the same requirements in the same manner but is performed and witnessed on-site on the complete ATMS.

- *System Integration Test (SIT)* is performed at the TMC with the new ATMS interfaced to the actual external system with live data inputs/outputs.

- *Operational Acceptance Test (OAT)* is an endurance test where the new ATMS system is made fully available for actual operation by the TMC operators. Anomalies are noted during OAT, categorized by severity and corrected.

4.3. How Tests Will be Conducted

FAT is performed on the Contractor's premises. These tests will be unwitnessed, and performed according to the approved test procedures submitted by the Contractor. FAT acceptance is contingent on a satisfactory demonstration of each requirement.

These tests will simulate interfacing systems to the ATMS with actual data to the extent that this data can be captured and input to the factory system configuration. The feasibility of simulation certain requirements will vary. Therefore, the determination of what constitutes a satisfactory demonstration will be a judgment call. However, the FAT test procedures will clearly define satisfactory results with specific criteria.

Testing may be performed on hardware other than the final ATMS hardware platform for final installation. Tests may also be performed on partial configurations of the complete ATMS platform if the requirement is self-contained to certain subsystems and can thus be satisfactorily demonstrated.

After FAT acceptance the complete ATMS hardware platform will be delivered to the site. The complete platform will be set up and physically installed according to the accepted Installation and Phasing Plan submitted by the Contractor.

In preparation for SAT, the new ATMS will be set up off-line and isolated from any of the existing on-line and operational systems at the TMC. Isolation will be implemented with an air-gap between the TMC operational network(s) and the temporary network for the new ATMS. Power and space requirements for the new hardware installation will also be addressed in the Installation and Phasing Plan.

After physical installation the Contractor will perform pre-SAT to confirm that the system is ready for SAT. Pre-SAT is an activity performed at the discretion of the Contractor, and is complete upon written notification from the Contractor that the system is ready for SAT.

Test procedures used for FAT are updated as necessary and re-purposed for SAT. External systems data inputs/outputs and interfaces are simulated in the same manner as for FAT. SAT differs from FAT in that it is performed on site, witnessed, and uses the complete production hardware platform.

After SAT testing is completed and accepted, system integration proceeds according to the approved Installation and Phasing Plan. External systems will be cut over to the new ATMS while maintaining the integrity and operability of the existing TMC. SIT can commence for individual subsystems as they are cut over. The sequence of subsystem cutover may be strategically coordinated with sequence of SIT test procedures.

Procedures for SIT will be based on the prior FAT/SAT procedures, but will be modified as necessary for being performed on live systems. SIT procedures will be coordinated with WSDOT to eliminate operational impacts.

OAT is a 30 day endurance test that begins after SIT is completed and accepted. During OAT the TMC operators and remote users will have full access and use of the new ATMS while the existing system remains viable. A log of anomalies reported by the operators will be maintained during OAT. Each alleged anomaly will be evaluated to determine if it is a problem with the new ATMS. If it is a problem with the new ATMS, a severity level for the error will be applied. Minor problems will be corrected by the Contractor without resetting the 30 day clock. Major problems will be corrected, but the 30 day clock is reset. If a problem is classified as Critical, the test process resets to re-perform all of part of SAT after corrections are applied.

The following tables provide a summary of guidance for each test required.

Factory Acceptance Test		
Description	The FAT is an in-lab test, conducted in a controlled environment. During the FAT, the system is tested against simulated scenarios. FAT procedures will exercise all aspects of system functionality as specified in the requirements.	
Purpose	The FAT is a test of the complete ATMS with simulated interfaces. The test demonstrates, in a controlled environment, that the functional and technical components have been correctly implemented and properly integrated to satisfy the project requirements.	
Precursors	Approved FAT Test Plan	
Next Steps	Upon successful completion of the FAT, the Vendor will prepare for the Site Acceptance Test (SAT).	
Roles and Responsibilities	Organization	Roles include but are not limited to:
	Contractor	▪ Provide FAT Plan ▪ Set up Test Environment ▪ Conduct pre-testing to ensure the system is ready for the FAT ▪ Develop simulated interfaces ▪ Provide data sets for the simulation ▪ Conduct test ▪ Document test results ▪ Perform remediation if required ▪ Certify test results
	Owner	▪ Approve FAT Plan ▪ Review test reports and test results
Key Considerations	▪ Use cases ▪ Test data ▪ Interface simulation tools (e.g. exercisers, scripts) ▪ Limitations on test environment (and results). Understand the relevancy of the results to a fully implemented system.	
Entry Criteria	▪ Contractor has approved testing ready to commence. ▪ Configuration baselines for all software and hardware to be used for the FAT have been established and identified. ▪ Simulation tests have successfully validated that the modules are ready for testing. ▪ Contractor has conducted “dry run” tests to confirm system is ready for FAT.	
Exit (Success) Criteria	▪ All tests completed with no faults requiring remediation and/or retest. ▪ Resolution of punch list items. ▪ Delivered test documentation.	

Site Acceptance Test		
Description	The Integration is conducted on the production system at the SRTMC. External systems data inputs/outputs and interfaces are simulated in the same manner as for FAT. This test will be witnessed by the Owner.	
Purpose	To demonstrate, in a controlled environment, that the system satisfies the system requirements. This test ensures that the system is ready for live interfaces and integration testing.	
Precursors	Successful FAT Approved Site Acceptance Test Plan	
Next Steps	Upon successful completion of the Site Acceptance Test, the Contractor will be given authorization to move forward with the next phase of testing, the System Integration Test.	
Roles and Responsibilities	Organization	Roles include but are not limited to:
	Contractor	▪ Provide Site Acceptance Test Plan ▪ Set up Test Environment ▪ Conduct pre-testing to ensure the system is ready for the test ▪ Provide data sets for the simulation ▪ Conduct test ▪ Document test results ▪ Perform remediation if required
	Owner	▪ Approve Site Acceptance Test Plan ▪ Witness all test scenarios ▪ Review daily test reports ▪ Certify test results
Key Considerations	▪ Use cases ▪ Test data • Limitations on test data and related test results. Understand the relevancy of the results to a fully implemented system.	
Entry Criteria	▪ Contractor has approved testing ready to commence. ▪ Configuration baselines for all software and hardware to be used for the Site Acceptance Test have been established and identified. ▪ Contractor has conducted “dry run” tests to confirm system is ready for Site Acceptance Testing. ▪ Owner has approved Site Acceptance Test Plan	
Exit (Success) Criteria	▪ All tests completed with no faults requiring remediation and/or retest. ▪ Resolution of punch list items. ▪ Delivered test documentation.	

System Integration Test		
Description	The System Integration Test is conducted in the production environment, under live data and operational conditions.	
Purpose	This test verifies that the system has been integrated with the full operational environment, performs as required, and is ready for full operation.	
Precursors	Approved System Integration Test Plan Completed Site Acceptance Test	
Next Steps	Upon successful completion of the System Integration Test, the system undergo Operational Acceptance Testing.	
Roles and Responsibilities	Organization	Roles include but are not limited to:
	Contractor	▪ Provide System Integration Test Plan ▪ Integrate system into operational environment ▪ Ensure the system is ready for the System Integration Test ▪ Conduct test ▪ Provide adequate resources to respond to issues during the test period ▪ Document test results ▪ Perform remediation if required
	Owner	▪ Approve System Acceptance Test Plan ▪ Provide system users to be part of the System Acceptance Test ▪ Witness test ▪ Review daily test reports ▪ Certify test results
Key Considerations	▪ Use cases ▪ Required data to test all requirements ▪ Test scripts	
Entry Criteria	▪ System Integration Test Plan has been approved by Owner. ▪ Contractor has approved testing ready to commence. ▪ Configuration baselines for all software and hardware to be used for the System Integration Test have been established and identified.	
Exit (Success) Criteria	▪ All tests completed with no faults requiring remediation and/or retest. ▪ Resolution of punch list items. ▪ Delivered test documentation.	

Operational Acceptance Test		
Description	The Operational Test is conducted in the production environment, under live data and operational conditions.	
Purpose	This test verifies that the system performs as required over an extended time period.	
Precursors	Approved Operational Acceptance Test Plan Completed System Integration Test	
Next Steps	Upon successful completion of the Operational Acceptance Test, the Owner will accept the system and the Warranty phase of the project begins.	
Roles and Responsibilities	Organization	Roles include but are not limited to:
	Contractor	▪ Provide Operational Acceptance Test Plan ▪ Ensure the system is ready for the Operational Test ▪ Provide adequate resources to respond to issues during the test period ▪ Document test results ▪ Perform remediation if required
	Owner	▪ Approve Operational Acceptance Test Plan ▪ Provide system users to be part of the Operational Acceptance Test ▪ Perform test ▪ Review daily test reports ▪ Certify test results
Key Considerations	▪ During live operation, randomly rerun test scripts as time allows to ensure functionality.	
Entry Criteria	▪ Operational Acceptance Test Plan has been approved by owner. ▪ Contractor has approved testing ready to commence. ▪ Configuration baselines for all software and hardware to be used for the Operational Acceptance Test have been established and identified.	
Exit (Success) Criteria	▪ All tests completed with no faults requiring remediation and/or retest. ▪ Resolution of punch list items. ▪ Delivered test documentation.	

4.4. Sequencing and Schedule

Verification tests will be performed for the ATMS as a whole system in a sequence of four verification tests: FAT, SAT, SIT and OAT. The sequence for these milestone verification tests is shown below. Acceptance of each test will be represented in the schedule as a major project milestone. With completion of OAT the system enters the warranty period while minor problems, if any, are corrected.

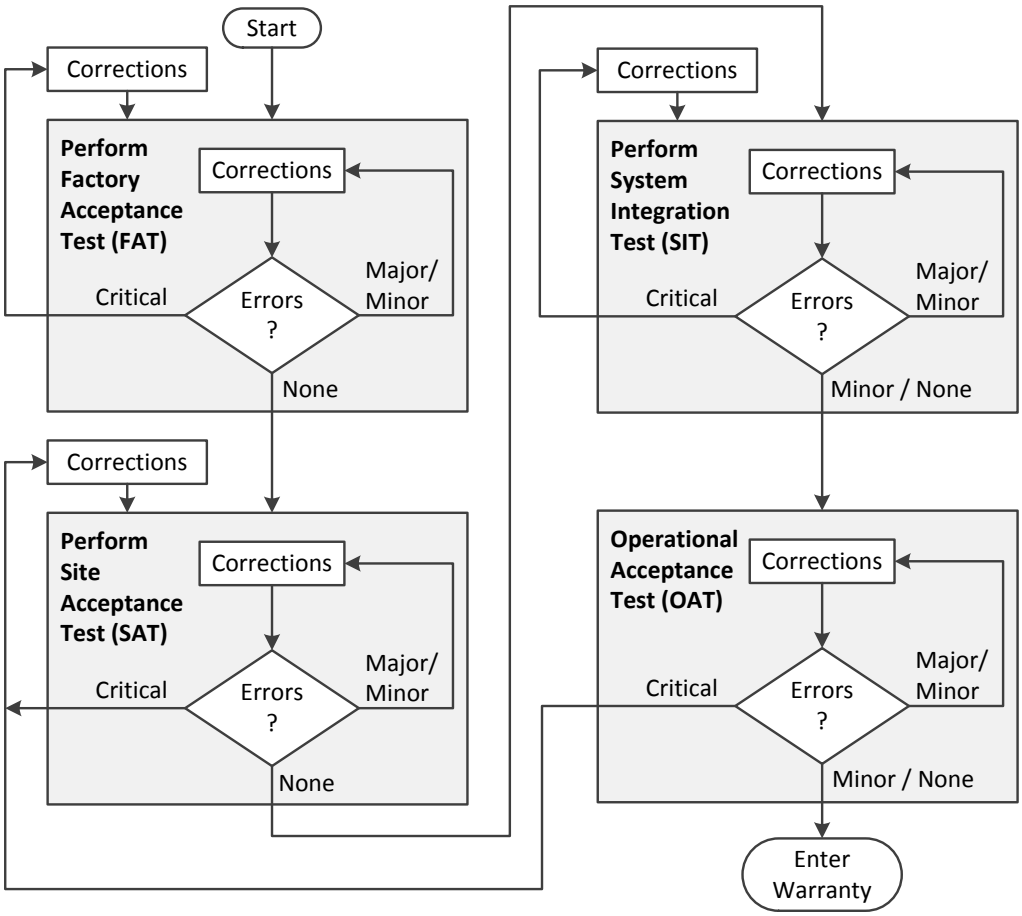

Figure 4 Test Sequence

4.4.1. Success Path

The FAT, SAT and SIT tests will be organized as a set of test procedures. Each procedure will demonstrate one or more requirements in the RTM. A test procedure will be complete when all of its requirements have been demonstrated successfully. If an error occurs during a procedure, the severity of the error is determined by the correction. As shown in Figure 4, error severity determines how far to revert in the procedure for re-testing. Critical errors revert to the beginning of the entire verification milestone. In the case of OAT, a critical error reverts testing back to SAT. Major errors revert testing to the beginning of a test procedure. Minor errors can be corrected, and the procedure can continue without reverting to the beginning.

4.4.2. Error Classification

There are three error classifications: minor, major and critical. The classification is determined from the correction of the error. The approach associates the number of requirements affected and the difficulty troubleshooting the cause of the error.

As shown in Table 4, minor errors affect only one requirement and are diagnosed within an hour. Major errors affect more than one requirement or take more than an hour to diagnose. Critical errors affect multiple test procedures.

Major errors in three or more requirement groups will be considered a critical error.

Table 4 Error Classification

Error Classification	Time To Diagnose	# of Test Procedures Affected	# of Requirements Affected
Minor	< = 1 Hour	1	1
Major	> 1 Hour	1	--
	<= 1 Hour	--	> 1
Critical	--	> 1	> 1

4.4.3. Resolution

In Figure 4, it is possible for minor errors during SIT to be carried forward into OAT. This will be decided by the Owner. The Owner can also allow minor errors to be carried forward from OAT into the warranty period. In either case, all minor errors will be added to the punch list for final correction in a later stage. Resolution of the punch list as a condition for ending the Warranty period will be as defined in the Contract.

4.5. Test Locations

FAT will be performed at the Contractor's facilities. SAT, SIT and OAT will be performed at the Spokane Regional Transportation Management Center.

4.6. Participants and Responsibilities

Testing will be a coordinated effort involving participation by staff from the Contractor, WSDOT and possibly the stakeholder partners. On WSDOT's side, an Owner Test Manager (OTM) will be appointed who reports to the WSDOT Project Manager for the ATMS Replacement Project. The Contractor will designate a qualified Contractor Test Manager (CTM) who will be the principal point of coordination with the Owner Test Manager.

The OTM will work side-by-side with the CTM. There needs to be a clear delineation of responsibilities between WSDOT and the Contractor. Any overlap or unassigned responsibility will be fully defined prior to the start of testing so that efforts are not duplicated or overlooked, which could lead to confusion

and rework. The two test managers should touch base at least once per week during testing activities to ensure everything is on track.

The OTM will be responsible for managing WSDOT and partner stakeholder staff assigned who are made available for testing activities. Other routine responsibilities for the OTM include, but are not limited to:

- Develop a master project schedule that shows how all activities and resources line up;
- Schedule, facilitate, and document all testing meetings;
- Assist in resolving any inconsistencies identified during coordination;
- Manage the issues/punch lists generated from testing efforts; and
- Report the progress of the testing effort to the Project Manager.

The CTM will have full authority to make decisions and implement Contractor resources to ensure testing proceeds in a timely manner. This will include full decision making authority to conduct coordination with other parties, to modify test approaches, to assign staff or other resources to testing, and to implement remediation (if required).

The CTM's responsibilities include, but are not limited to:

- Work closely with the OTM, keeping them informed on a daily basis of the testing status;
- Ensure testing stays on track according to the master project schedule;
- Schedule, facilitate, and document all tests and results review meetings; and
- Lead up the effort to resolve any inconsistencies identified during coordination.

4.7. Testing Meetings and Coordination

During the system development and testing process, several different and distinct meetings and/or coordination activities will take place.

4.7.1. Planning Meetings

Early in the process, test planning meetings will be required. The purpose of the test planning meeting is:

- To review the project scope and schedule, including development and testing. This should include a review of the RTM.
- To schedule development coordination meetings or workshops with their technical teams and the WSDOT development and core testing teams.
- To discuss potential project risks, and develop avoidance and/or mitigation strategies.
- To review the RTM.
- To ensure that assigned staff roles and responsibilities for both the Contractor and WSDOT (and WSDOT contracted staff) are complete and understood by the full team.

WSDOT will hold some test planning meetings on its own, to inform staff and to coordinate as needed with third parties. It is important to include the Contractor (as needed) in the test planning and coordination meetings in order to align the schedules for all organizations, and to ensure that the coordination with third parties provides the needed information. WSDOT and the Contractor should discuss and agree on how and when to incorporate the Contractor into the WSDOT test planning efforts.

4.7.2. Pre-Test Coordination Meetings

Pre-test coordination meetings will begin several months before formal testing. Topics that will be discussed during the initial coordination include: makeup of the testing team, high level schedule, external coordination efforts, and identification of issues and concerns.

WSDOT will clarify their expectations for the testing. The discussions should also address test scripts, scenarios, data sets and other elements key to testing conduct and results, as identified in the test procedures.

4.7.3. Test Data Reviews

Once formal testing begins, the team will hold regular meetings to review exceptions and to troubleshoot issues. This will continue for the duration of the testing effort. The team should identify specific resources to check data at a detailed level and report on the findings during testing. During System Integration Testing, dedicated personnel must be identified to monitor data interfaces to correct issues that may affect operational systems.

4.8. Test Apparatus

Simulation of the external interfaces with data inputs/outputs will be through a test apparatus designed and built by the Contractor. This simulator will emulate the existing interfaces to the current ATMS. Detailed requirements for the simulator will be included in the Contract documents.

4.9. Documentation

Detailed test plans and documentation will be based on IEEE Std 829™, IEEE Standard for Software and System Test Documentation, as applicable for the project. These documents will be developed and submitted by the Contractor. The following test documents based on this standard are recommended:

4.9.1. Master Test Plan

The Master Test Plan (MTP) provides the overall test planning and test management document for all testing. It will describe in general how testing will be conducted and will further refine the structure of the other test documentation. The MTP will define the activities required to meet the contractual, functional, and performance requirements described in the contract. The MTP will include details about the test processes, requirements, and methodologies used to test the system. It will also include the specific tests to be conducted. The MTP shall include:

- An overview and schedule for all of the individual tests to be conducted on the project
- A Requirements Traceability Matrix (RTM) that:
  - Lists all system requirements
  - Maps the system requirements to the test or tests to verify compliance
  - Will be used throughout the system testing to confirm all requirements have been tested and met.
- An overview description of each test including:
  - A description of what is being tested. Reference to the contract requirements and specifications must be included.
  - How the element/system is being tested.

- Entry criteria (how it is that a system is ready for a particular test)
- The roles and responsibilities of those involved. It need not provide specific names for each test at this time, as these can be provided in the individual test plans.
- Resources required of WSDOT and third-party entities to prepare for and accomplish the test. This should include meetings that will be required for each test.
- Exit criteria (how it is that the system is ready to move to the next stage of the project or the next test). This is also known as success or acceptance criteria.
- Test deliverables, which could include samples or templates for the deliverables

4.9.2. Level Test Plans

A Level Test Plan (LTP) defines the scope, approach, resources, and schedule of the testing activities for a group of test procedures. The LTP identifies the items being tested, the features to be tested, the testing tasks to be performed, the personnel responsible for each task, and the possible associated risk(s). In the title of a particular plan, the word "Level" will be replaced by a name appropriate for the group of the tests included. For the ATMS Replacement Project, a suggested reasonable grouping of tests would be by functional category (i.e., traffic management, CCTV and camera control, Dynamic Message Signs, etc.).

The Level Test Plans must include Test Cases to demonstrate how the system and services meet the requirements of the Contract. The Contractor will prepare test cases that outline the steps for each function or group of functions and ability to record the outcome of each step, the entry and exit criteria, the required test equipment, instruments, facilities and labor necessary, and the expected results. Any applicable base and unique scenarios must be included in the test cases. The test cases will be proposed by the Contractor.

The Level Test Plans must include a Test Agenda outlining when each test case is planned for execution during the testing period.

The following elements must be included in the Test Cases, Vendor may add to the list as appropriate:

- Test number
- Description of Requirements being tested
- Resources and equipment needed
- Test data
- Prerequisites for each test
- Initial status and conditions
- Triggering action
- Expected process
- Expected result(s) (end state)
- Test success criteria

The Contractor must submit all Level Test Plans to WSDOT for review and Approval, at least four weeks in advance of the scheduled start date of the test. Any revised Level Test Plans must be submitted to WSDOT at least one week in advance of the start date of the test.

The Contractor must conduct all level tests in the presence of WSDOT or its representative.

Sample Test Plan Outline

1. Test Plan Identifier
    a. Provide a unique name and/or number for the test plan.
2. Introduction
    a. State the purpose of the plan
    b. Provide an executive summary of the plan
    c. Reference other documents such as:
        i. The contract
        ii. Project Quality Assurance Plan
        iii. Project Risk Management Plan
        iv. Configuration management Plan
3. Test Items
    a. What is being tested in the scope of this test plan.
4. Features To Be Tested
    a. Listing of what is to be tested from the Users point of view.
5. Features Not To Be Tested
    a. From the Users point of view, indicate what is not to be tested in this test, and why.
6. Item Pass/Fail Criteria
    a. WSDOT refers to this as "exit criteria", which is simply what is required to determine that this plan is completed, and the project is ready to move to the next phase.
7. Suspension Criteria and Resumption Requirements
8. Test Deliverables
9. Test Tasks
    a. This is where the detail of the test plan is provided including such information as use cases, data sets, ad-hoc testing, etc.
10. Environmental and Resource Needs
11. Staff Roles and Responsibilities
12. Staffing and Training Needs
13. Schedule
14. Risks and Contingencies
15. Approvals

4.9.3. Level Test Procedure

The Level Test Procedure (LTPr) specifies the steps for executing a set of test cases. Each LTPr will demonstrate one of more requirements in the RTM. In the RTM, each requirement will reference its associated LTPr.

4.9.4. Level Test Log

The purpose of the Level Test Log (LTL) is to provide a chronological record of relevant details about the execution of tests. An automated tool may capture all or part of this information. For the ATMS Replacement Project, the LTL may be the input data simulated and output data captured from the simulator.

4.9.5. Level Test Report

The purpose of the Level Test Report (LTR) is to summarize the results of the designated testing activities and to provide evaluations and recommendations based on these results. There is an LTR associated with each LTP. The Level Test Report must be submitted for approval to WSDOT as part of test acceptance. Test reports must document the results for all the tests performed and compare them to the expected results. Test reports must include all applicable test data utilized to verify the outcome of the test in an appendix. A log of modifications to the system, including software and hardware, during each test must be maintained in the test report.

4.9.6. Anomaly Report

An Anomaly Report (AR) documents any event that occurs during the testing process that requires investigation. This may be called a problem, test incident, defect, trouble, issue, anomaly, or error report.

4.9.7. Master Test Report

The purpose of the Master Test Report (MTR) is to summarize the results of all testing activities and to provide a summary evaluation based on the results. The MTR is associated with the MTP and summarizes the results of the implementation of the MTP.

Chapter 5
Test Identification

This chapter describes how individual tests will be identified and associated with requirements. Each requirement will be referenced in the RTM to a level test procedure that verifies its successful implementation. One test procedure may verify one or more requirements depending on how the procedures are constructed.

As described in chapter 4, level test procedures will be grouped together in a level test plan, and the suggested grouping is by functional category. The following categories are defined in the ConOps report and are also used to group requirements in the RTM.

- **Data Collection and Archiving**. The concept is to incorporate data from freeways, arterials, and the transit system into a single data warehouse. An analytics package, accessible through the ATMS with remote access, would provide users with access to the data and the ability to analyze it for a variety of purposes, including planning and performance management.
- **CCTV and Camera Control**. Access to images from and ability to control both analog and digital/IP-based cameras from a single interface. Control will depend on permissions assigned by user. Camera pre-sets will be assigned by time of day and by user.
- **Dynamic message signs (DMS)**. Ability to identify the location of DMS (including portable DMS), remotely display the messages shown on the signs through the ATMS, and remotely control the messages and signs. The CCTV system can visually verify the state of the DMS where cameras are located with a view of the DMS.
- **Traveler Information**. Act as a single point of dissemination for traveler information. This includes interfaces to the website, social media, the State's 511 system, and third party traveler information dissemination systems.
- **Traffic management**. The ATMS will have interfaces to traffic signal systems in the Spokane region. It will be compatible with and be able to log transit signal priority calls and actions. New traffic management capabilities will be added including ramp metering, variable speed displays, and lane use control.
- **Incident/Event Management**. The new ATMS will include the ability to help develop and then store action plans for a variety of incident and event types. This will improve the reaction time to such events and provide a mechanism to easily review and improve action plans. Actions and incidents will be logged in the system as well.
- **Operator and User Features**. Several improvements for the operation of the regional traffic management system will be incorporated in the new ATMS. Maps will be GIS based to allow smoother and continuous scrolling and zooming. Operator windows will be tailored to the operator and will be set by operator log-in. The system will be capable of allowing individual user permissions.

- **Integration with Other Systems**. Center to center features will be built into the new ATMS to allow data exchange with other systems, including signal control systems, WSDOT systems, STA systems, and Idaho Transportation Department systems.
- **Notifications.** Alerts and notifications will be built into the system. Thresholds will be able to be set by time of day. System diagnostics will be built into the system.
- **Logs, Reports and Alarms.** Ad-hoc and predefined report generation.
- **Security and Administration**. ATMS system security and administration features.
- **Performance.** ATMS system performance.