Transportation Systems Management & Operations

System Validation Plan for Marion County ITS Operational Improvements

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List of Acronyms and Abbreviations

ATSPM ..... Automated Traffic Signal Performance Measures
CMGC ..... Construction Manager/General Contractor
ConOps ..... Concept of Operations
CV ..... Connected Vehicle
FDOT ..... Florida Department of Transportation
ITS ..... Intelligent Transportation Systems
MOE ..... Measures of Effectiveness
MOP ..... Measures of Performance
PSEMP ..... Project Systems Engineering Management Plan
RFP ..... Request for Proposal
RTVM ..... Requirements Traceability Verification Matrix
SVP ..... Systems Validation Plan
TMC ..... Transportation Management Center
VCA ..... Validation Certification Authority

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1. Introduction

This is the Systems Validation Plan (SVP) for the Marion County ITS Operational Improvements. Validation is the second step in the verification and validation process and demonstrates the system's ability to meet stakeholder expectations, which was defined previously in the Concept of Operations (ConOps), in its final operating environment.

Validation differs from verification: validation determines if the correct system was created, whereas verification determines if the system was correctly developed. Validation checks that the system functions properly from the perspective of users when operating in its intended environment through review of Measures of Effectiveness (MOE). MOEs assess how effective the system is in achieving its objectives and can be qualitative or quantitative. On the other hand, verification is conducted using Measures of Performance (MOP). MOPs are system performance criteria required for fulfillment of MOEs; sometimes there are several MOPs for each MOE.

System validation follows system verification which follows construction and integration. Validation criteria are developed concurrently with the ConOps—before MOPs are developed. If system functionality does not meet stakeholder expectations during validation, the systems engineering process is reiterated, starting at the decomposition and definition phase, to determine system modifications necessary to address identified deficiencies.

2. Purpose of Document

This section identifies the type of validation activities to be performed for Marion County ITS Operational Improvements. The first section of the SVP document provides two elements: system identification and an overview of the document.

This SVP provides the following:

- Validation cases to be used to demonstrate fulfillment of each system requirement
- Validation type for each case
- Objective of each validation case
- Agencies/Persons involved and resources required for each validation case
- Validation environment where each validation case is to be performed

This document does not prescribe step-by-step procedures. Development of specific validation processes is the responsibility of system users and personnel involved in each validation case and should be developed prior to the start of the validation effort.

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2.1 Identification

Project Name: Marion County ITS Operational Improvements
Financial Project Identification: 436361-1-32-01
Federal Aid Project Number: D521-028-B

2.2 Applicable Documents

The following is a list of applicable documents:

- *Concept of Operations (ConOps) for Marion County ITS Operational Improvements.* DeLand, Florida, 2021.
- *Project Systems Engineering Management Plan (PSEMP) for Marion County ITS Operational Improvements.* DeLand, Florida, 2021.

2.3 Referenced Documentation

Table 1 contains reference information for documentation referred to herein or relevant to the project.

Table 1: Referenced Documentation

Document Name	ID, Revision, Date, etc.	Link, or Contact Info to Obtain
Systems Engineering and ITS Architecture Procedure 750-040-003	2019	FDOT Forms Management/Procedures Procedural Document Library (fdot.gov)
Florida's Statewide Systems Engineering Mangaement Plan: Deliverable 1-10: Technical Memorandum	March 7, 2005, Version 2	https://www.fdot.gov/traffic/its/projects-deploy/semp.shtm
Ocala/Marion TPO 2018 ITS Strategic Plan Update	2018	2018 ATMS Master Plan – Transportation Planning Organization (ocalamariontpo.org)
FDOT District 5 ITS Master Plan	October 2016, Version 1.3	www.cflsmartroads.com/docs/District 5 ITS Master Plan_FINAL.pdf
I-75 Florida Regional Advanced Mobility Elements (FRAME)	FPID 440900-1-52-01 & 440900-2-52-01; February 2019	FDOT Project Manager: Noemi Rodrigues Bonilla, P.E. (Noemi.RodriguezBonilla@dot.state.fl.us)
FDOT Design Manual	2021	FDOT Design Manual

3. Scope of Project

This section is a high-level description of the general nature of the proposed system to which the SVP applies.

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3.1 System Overview

This project will implement enhancements to Marion County's ITS network that is used to interconnect traffic signals, operations facilities, and ITS devices operated and maintained by the County. Enhancements will consist of new fiber optic cabling, new wireless communication components, and new network equipment. The ITS network and the devices and facilities it interconnects are herein referred to as "the system".

The project's objectives include:

1. Enhance Marion County's ITS network's reliability and bandwidth.
2. Expand coverage of Marion County's ITS network.
3. Set the stage, through construction of supporting communication infrastructure, for deployment of future ITS technologies including connected vehicle (CV) equipment and Automated Traffic Signal Performance Measures (ATSPM).

This project will use the Construction Manager/General Contractor (CMGC) procurement method.

Figure 1 is an overview showing the system's major components and their connections.

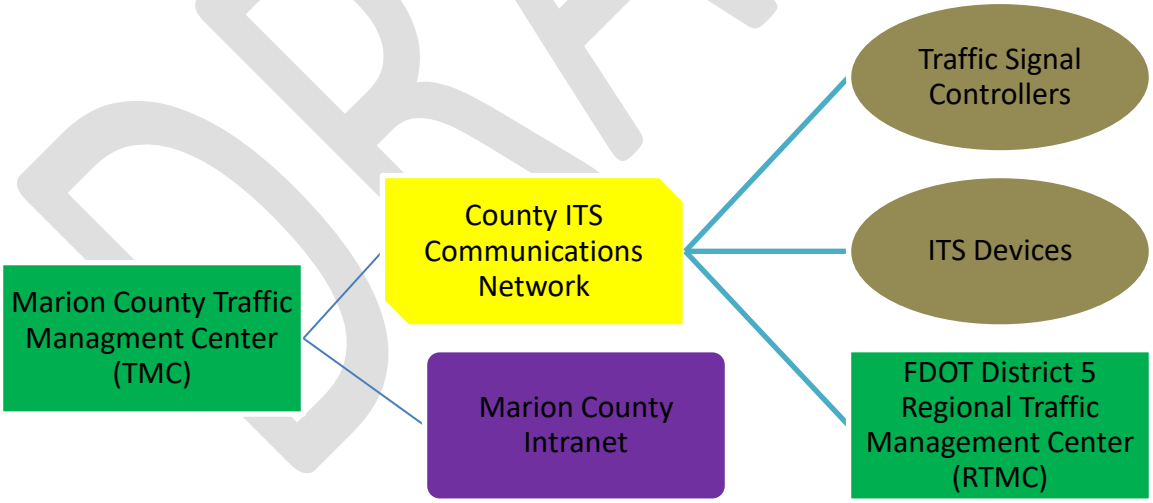

Figure 1: System Overview

3.2 Stakeholders

Table 2 summarizes project stakeholders and their respective roles.

Table 2: Stakeholders

Stakeholder	Project Role
FDOT District 5	- Manage design and construction - Fund design and construction - Provide technical document review - Provide network design support - Acquire a Design Consultant - Acquire a CMGC
Marion County	- Provide technical document review - Maintain and operate the system
FDOT Central Office	- Provide project oversight - Review and approve ITS products and equipment. List approved products on the FDOT APL
Design Consultant	- Prepare plans and specifications (detailed system design and requirements) - Work with the CMGC during the design phase - Assist the CMGC in development of testing and integration plans
Construction Manager / General Contractor (CMGC)	- Provide preconstruction support during the design phase: design document review, schedule assessment, cost estimating, and procurement assessment - Potentially construct, integrate, and test the system. - Develop testing and integration plans

4. Conducting the System Validation

This section provides details on how the validation is to be accomplished. It defines: who does it; when and where it is to be done; the responsibilities of each participant before, during, and after each validation event or activity; the hardware and software to be used and other systems, if any; and the documents to be prepared as a record of the activity.

Another very important part of this section defines how anomalies are to be handled. That is, what to do when something fails, does not match the documented needs, or does not satisfactorily address the original problem.

4.1 Basis of System Validation Plan in ConOps

Section 3.2 of the Concept of Operations contains a table of user needs that this system is intended to fulfil. These user needs serve as the basis for system design and its validation.

4.2 Responsibilities

Responsibility for completing system validation, along with review and approval of this SVP, lies with Marion County. Some validation duties may be delegated to a consultant working on behalf of the aforementioned departments.

The County will be responsible for scheduling and allocating the necessary resources for validation. Communication is important during system validation, since some validation procedures will require multiple personnel.

Final system acceptance will be the responsibility of Marion County, who will review the outcome of all subsystem and system validation processes. System underachievement in some MOEs may be acceptable, whereas other MOE failures might indicate a serious misstep in the system's development, requiring a halt in the validation process and warranting system modifications. It is the role of Marion County to record system requirements that were not successfully validated—MOE failures—and to determine the appropriate course of action.

4.3 Location

System Validation will be conducted primarily at the Marion County TMC by Marion County staff. From the TMC, County staff will access ITS devices, communication equipment, and wireless components to conduct validation using existing personal computers, servers, and other hardware existing at the TMC.

4.4 Schedules

Below is an overview of the project's major events and schedule. Update this section with a more defined System Validation schedule once one is developed.

- CMGC RFP Advertisement ..... August 2021
- CMGC Selection ..... September 2021
- Design & Preconstruction Phase ..... June 2021 to December 2022
- Construction ..... December 2022 to December 2023
- System Verification ..... December 2023 to January 2024
- System Validation ..... January 2024 to February 2024

4.5 Validation Methods

There are four validation methods: inspection, analysis, demonstration, and testing. While the names of these methods are shared with verification methods, they are different in purpose and intent.

4.5.1 Inspection

Visual examination of the realized system typically used to validate physical design features, such as aesthetics, or confirming the application of a certification stamp.

4.5.2 *Analysis*

Analysis is the application of statistical modeling or other analytical techniques for prediction of system performance in meeting stakeholder expectations. Analysis is generally used when a system mock-up or final integrated system is not available, which makes performing demonstration, inspection, or test validation processes infeasible.

4.5.3 *Demonstration*

Utilizes the realized system to show that a set of stakeholder expectations have been achieved. Demonstration is used for confirmation of basic functionality and does not include the comprehensive detailed data gathering typically performed when testing.

4.5.4 *Testing*

Collection of detailed data generated by the system to validate system performance. These data are then used to compare actual system performance against system requirements.

4.6 System Validation Process

For each system requirement, a validation case and MOE is defined in the Requirements Traceability Verification Matrix (RTVM). During system validation, each validation case will be checked for fulfilment of its MOE. The personnel performing validation will then record the resultant MOE in the RTVM.

Marion County will elect a person or group to act as the Validation Certification Authority (VCA). The VCA will review the RTVM recorded MOE for each requirement, then either concur or reject the validation outcome. If concurrence is provided, the validation of that particular requirement is certified as completed in the RTVM by application of the VCA's initials/signature. If rejection is provided, then the VCA will contact the personnel that performed the validation and discuss how to proceed.

If all requirements are validated, and those validations subsequently certified, then the system can proceed to normal operations and maintenance.

4.7 Connection between MOEs & MOPs in System Validation

Completing system verification testing is a prerequisite for system validation. System verification, and the recording of MOPs, demonstrate that each system element is performing correctly and provides data to determine system effectiveness. Some MOEs are not directly measurable; instead, they rely on a set of aggregated MOPs. System verification will be performed by the CMGC during construction.

4.8 System Validation Flow

A flow chart depicting the validation process is included in Figure 2.

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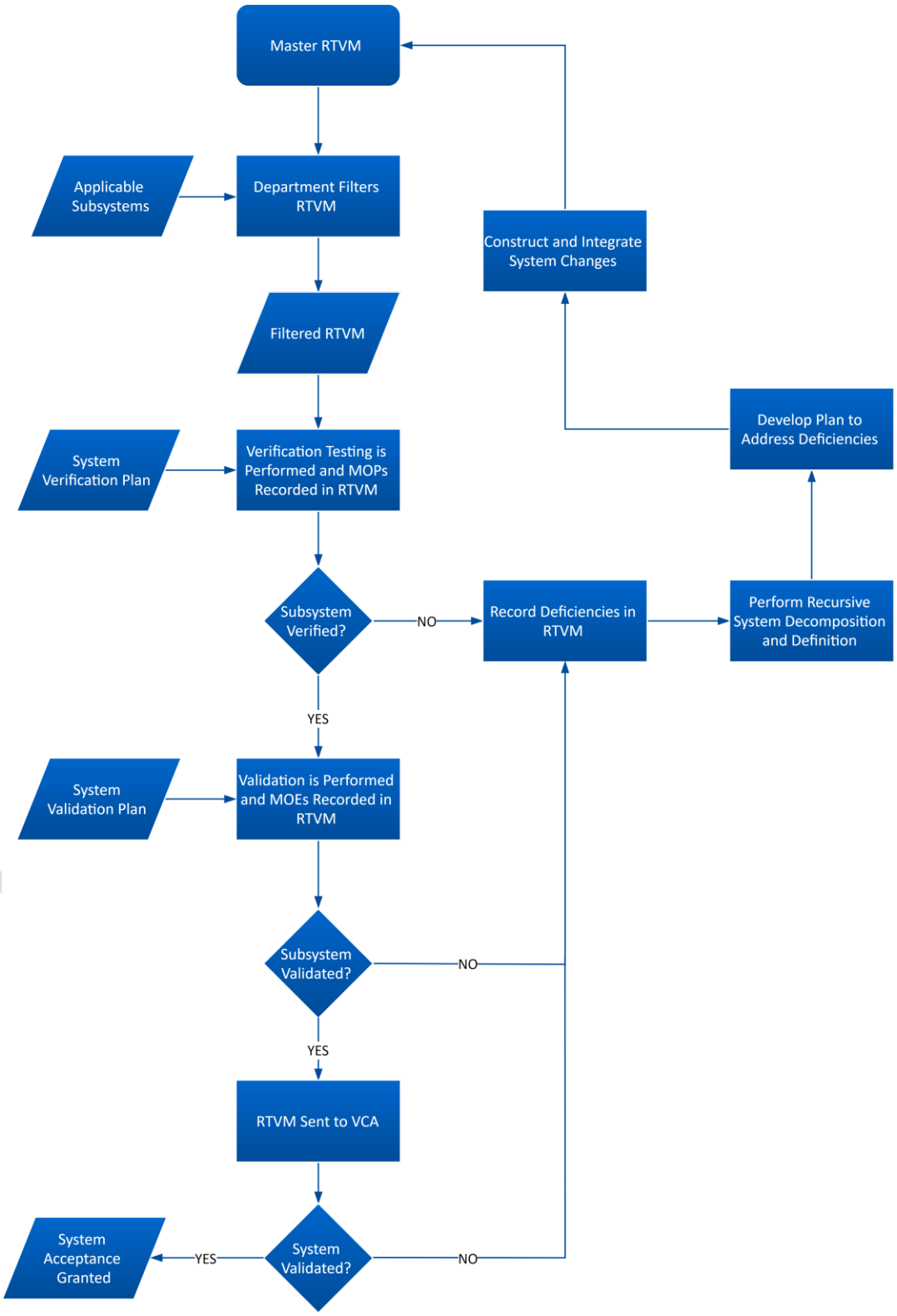

Figure 2: System Validation Process

4.9 Anomaly Handling

Each validation case will be monitored for anomalies, such as system failures and operational problems. All such events will be recorded in the notes/comment section of the RTVM by the system validators and denoted with one of the following severity levels:

- **Minor:** affects a single system element and can be easily resolved; no need to halt validation.
- **Moderate:** affects a single system element but cannot be easily resolved; will require significant effort to address. System validation may need to be halted temporarily while the situation is resolved**.**
- **Critical:** affects multiple system components and requires significant resource expenditure to resolve. Critical issues typically require full-stop of system validation and need to perform recursive system decomposition and definition, in order to develop a plan for system changes necessary to resolve the anomaly.

Moderate and critical anomalies must be reported to the VCA immediately upon occurrence. The VCA will then direct validation personnel how next to proceed.

4.10 System Configuration for Validation

In order to conduct system validation, the system must be fully constructed and integrated. Additionally, the system must have passed all verification tests. Equipment and software configurations required to begin the validation procedures are summarized in this section

4.10.1 *Communcation System Validation*

Equipment requirements:

- Functional personal computers and laptops where the client access interface is installed.
- Fully functional Marion County ITS network with all communication components installed, integrated, and tested.
- All Marion County ITS devices connected to the network are operational.

4.10.2 *Central Management Software Validation*

Software requirements:

- Fully installed and integrated Central Management Software
- Must have a client access interface installed on user's personal computers or laptops configured with appropriate user permissions.

- Communication established between the software and all wireless communication equipment.

Equipment requirements:

- Functional personal computers and laptops where the client access interface is installed.
- Fully functional Marion County ITS network with all wirless communication components installed, integrated, and tested.

4.11 System Validation Test Results Summary

Following System Validation, summarize the results in a final RTVM and attach it as an appendix to this document. Pay special attention to any situation where a failure or deviation from the expected system performance occurred. If the system does not meet a goal or user need, it may not necessarily be rectifiable. If the failure cannot be resolved through equipment and software checks, procedure modifications, re-testing, and so forth, then be sure to document the tests and results. Include comments to add to the ConOps, such as an explanation of the outcome.

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5. Appendices

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5.1 Requirements Traceability Verification Matrix

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User Need	Requirement Summary	Validation Method	Validation / Test Case	Measure of Effectiveness (MOE)	Pass / Fail Criteria	Applicable to the Project Y/N	Validation Outcome (recorded MOE)	Pass / Fail	Notes/Comments	Tester Initials	Validator Initials
UN001	Establish a fiber optic cable connection between the TMC and the Marion County Landfill Tower. Store sufficient slack at major intersections along the fiber path to allow for installation of future fiber drops without the need to replace portions of the backbone fiber optic cable.	Inspection	Validation Case 1	Has a fiber connection between the Marion County TMC and the Marion County Landfill Tower been established?	If MOE is yes, then pass. Otherwise fail.						
UN001	Establish a fiber optic cable connection between the TMC and the Marion County Landfill Tower. Store sufficient slack at major intersections along the fiber path to allow for installation of future fiber drops without the need to replace portions of the backbone fiber optic cable.	Inspection	Validation Case 2	Has 200' of slack been stored at major intersections along the fiber path in splice boxes for installation of future fiber drops?	If MOE is yes, then pass. Otherwise fail.						
UN002	Improve ITS network: expand coverage, improve reliability, and increase bandwidth.	Demonstration	Validation Case 3	Has the County's ITS network been expanded in both terms of geographic coverage and number of connected devices?	If MOE is yes, then pass. Otherwise fail.						
UN002	Improve ITS network: expand coverage, improve reliability, and increase bandwidth.	Demonstration	Validation Case 4	Has the County's ITS network been made more reliable?	If MOE is yes, then pass. Otherwise fail.						
UN002	Improve ITS network: expand coverage, improve reliability, and increase bandwidth.	Demonstration	Validation Case 5	Is the network's throughput sufficient to function without noticeable lag or delay when accessing and controlling ITS devices?	If MOE is yes, then pass. Otherwise fail.						
UN003	Install fiber optic cable in areas where it would provide significant network benefits at a relatively low cost.	Inspection	Validation Case 6	Has fiber optic cable been installed in at least one area where it provides significant network benefits at relatively low cost?	If MOE is yes, then pass. Otherwise fail.						
UN004	Maximize communication system uptime given the project's budget.	Testing	Validation Case 7	Are 90% of all traffic signals and ITS devices available 95% of the time over a 90-day test period?	If MOE is yes, then pass. Otherwise fail.						
UN005	Support 1080p video streaming (H.264 compression) at the TMC for field deployed CCTV cameras for up to four simultaneous video streams without noticeable lag in pan-tilt-zoom control.	Demonstration	Validation Case 8	Can four 1080p video streams be simultaneously viewed from remote signalized intersections at the TMC without noticeable video quality degradation?	If MOE is yes, then pass. Otherwise fail.						
UN005	Support 1080p video streaming (H.264 compression) at the TMC for field deployed CCTV cameras for up to four simultaneous video streams without noticeable lag in pan-tilt-zoom control.	Demonstration	Validation Case 9	While four 1080p video streams are simultaneously viewed at the TMC, can a CCTV camera pan-tilt-zoom control be used without noticeable delay that affect usability?	If MOE is yes, then pass. Otherwise fail.						
UN006	Provide network capacity for future ATSPM data exchange between the TMC and traffic signals (assume 10 megabytes per day with 1-minute polling intervals per signal).	Analysis	Validation Case 10	Have all communication links been provided with sufficient bandwidth to support ATSPM data exchange based on the total number of traffic signals using each link?	If MOE is yes, then pass. Otherwise fail.						
UN007	Provide network capacity for future Connected Vehicle (CV) Roadside Units (RSU) data exchange between the TMC and field deployed RSUs (assume 40 megabytes per day with 30-second polling intervals per signal between SunGuide and the RSU).	Analysis	Validation Case 11	Have all communication links been provided with sufficient bandwidth to support RSU data exchange based on the total number of traffic signals using each link?	If MOE is yes, then pass. Otherwise fail.						
UN008	Minimize communication system maintenance effort.	Inspection	Validation Case 12	Can the County maintain the system with their staff, equipment, and budget?	If MOE is yes, then pass. Otherwise fail.						
UN008	Minimize communication system maintenance effort.	Inspection	Validation Case 13	Is the system as or more reliable that the existing system when compared over a 90-day sample period?	If MOE is yes, then pass. Otherwise fail.						
UN009	Provide N+1 redundancy (ring topology) for communication between signalized corridors and the TMC or point-to-multipoint aggregation sites. N+1 redundancy to each individual traffic signal is desired, but not required.	Testing	Validation Case 14	Does the system maintain communication upon loss of one network link between signalized corridors and the TMC or point-to-multipoint aggregation sites? Test all corridors.	If MOE is yes, then pass. Otherwise fail.						
UN010	Provide N+2 redundancy (ring topology with wireless and fiber backhaul) for backhaul communication between point-to-multipoint communication sites and the TMC.	Testing	Validation Case 15	Does the system maintain communication upon loss of two backhaul communication network links? Test all backhaul connections.	If MOE is yes, then pass. Otherwise fail.						
UN011	Leverage existing fiber optic cabling installed by FDOT to improve the network while minimizing cost.	Inspection	Validation Case 16	Was FDOT owned fiber used for network links where it is present?	If MOE is yes, then pass. Otherwise fail.						
UN012	Leverage existing communication towers owned by the County, FDOT, or other public agencies when deploying network improvements to minimizing cost.	Inspection	Validation Case 17	Were existing tower sites owned by the County, FDOT, or other public agencies used where possible instead of installing new towers?	If MOE is yes, then pass. Otherwise fail.						
UN013	Obtain any FCC licenses required for the system enhancements.	Inspection	Validation Case 18	Were FCC licenses obtained for all wireless equipment operating in licensed frequency bands? Or does all wireless equipment operate in unlicensed frequencies?	If MOE is yes, then pass. Otherwise fail.						
UN014	Use wireless communication equipment from a single-vendor to reduce maintenance, management, and deploy complexity.	Inspection	Validation Case 19	Was wireless communication equipment from a single vendor used?	If MOE is yes, then pass. Otherwise fail.						
UN015	Provide a Central Management Software for centralized management of the wireless communication system and its components.	Inspection	Validation Case 20	Was a Central Management Software installed that allows management of the wireless communication system and its components?	If MOE is yes, then pass. Otherwise fail.						
UN015	Provide a Central Management Software for centralized management of the wireless communication system and its components.	Demonstration	Validation Case 21	Does the Central Management Software provide access for managing all wireless communication devices?	If MOE is yes, then pass. Otherwise fail.						
UN015	Provide a Central Management Software for centralized management of the wireless communication system and its components.	Demonstration	Validation Case 22	Does the Central Management Software provide various categories of users with access restriction based on user category. For instance, administrators should be able to make configuration changes to equipment whereas general users may only be able to observe device status?	If MOE is yes, then pass. Otherwise fail.						
UN015	Provide a Central Management Software for centralized management of the wireless communication system and its components.	Demonstration	Validation Case 23	Does the Central Management Software provide automatic topology generation and overviewing capacities from within the software?	If MOE is yes, then pass. Otherwise fail.						

User Need	Requirement Summary	Validation Method	Validation / Test Case	Measure of Effectiveness (MOE)	Pass / Fail Criteria	Applicable to the Project Y/N	Validation Outcome (recorded MOE)	Pass / Fail	Notes/Comments	Tester Initials	Validator Initials
UN015	Provide a Central Management Software for centralized management of the wireless communication system and its components.	Demonstration	Validation Case 24	Does the Central Management Software provide an overview showing communication link and device status for all wireless equipment?	If MOE is yes, then pass. Otherwise fail.						
UN015	Provide a Central Management Software for centralized management of the wireless communication system and its components.	Demonstration	Validation Case 25	Does the Central Management Software provide device data logging of device and connection status for wireless components?	If MOE is yes, then pass. Otherwise fail.						
UN015	Provide a Central Management Software for centralized management of the wireless communication system and its components.	Demonstration	Validation Case 26	Does the Central Management Software provide bulk firmware updates that can be pushed to devices remotely (physical access to devices are not required for routine firmware updated)?	If MOE is yes, then pass. Otherwise fail.						
UN015	Provide a Central Management Software for centralized management of the wireless communication system and its components.	Demonstration	Validation Case 27	Does the Central Management Software provide user ID and password management features?	If MOE is yes, then pass. Otherwise fail.						