Transportation Systems Management & Operations

Concept of Operations (ConOps) for [Marion County ITS Operational Improvements]

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List of Acronyms and Abbreviations

APL ..... Approved Products List
ATC ..... Advanced Transportation Controller
ATSPM ..... Automated Traffic Signal Performance Measures
CEI ..... Construction Engineering Inspection
CMGC ..... Construction Manager/General Contractor
ConOps ..... Concept of Operations
CV ..... Connected Vehicle
EOC ..... Emergency Operations Center
FAC ..... Florida Administrative Code
FCC ..... Federal Communications Commission
FDOT ..... Florida Department of Transportation
FRAME ..... Florida Regional Advanced Mobility Elements
GIS ..... Geographic Information System
IMSA ..... International Municipal Signal Association
IP ..... Internet Protocol
ITS ..... Intelligent Transportation Systems
MOE ..... Measure of Effectiveness
MSP ..... Modified Special Provision
RITSA ..... Regional ITS Architecture
RSU ..... Roadside Unit
RTVM ..... Requirements Traceability Verification Matrix
SVP ..... System Validation Plan
TCP ..... Transmission Control Protocol
TMC ..... Transportation Management Center
TPO ..... Transportation Planning Organization
TSP ..... Technical Special Provision
UDP ..... User Datagram Protocol
VLAN ..... Virtual Local Area Network

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1. Overview

The first section of the Concept of Operations (ConOps) document provides six elements: system identification, purpose and audience, an overview of the document, a high-level overview of the proposed system, stakeholders, and references. These elements are described in the following sections.

1.1 Identification

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

1.2 Purpose and Intended Audience

The purpose of this ConOps is:

- To communicate user needs and system expectations
- To communicate the system designer's understanding of the user needs and how the system will meet them
- To build a consensus among stakeholders
- To create a basis for requirements, develop and verification
- To create a framework for system validation

The intended audience for this ConOps is:

- Non-technical program management and sponsors
- Technical management of participating agencies
- System developers
- Operations managers and operators
- Others who fulfill special roles or oversee the project

The audience may consist of people from multiple parties with varying levels of technical knowledge. It is therefore important that the document is written to clearly define technical terms and use layman's English.

1.3 Document Overview

This ConOps document describes the existing system or operation, the shortcomings or unmet needs, changes that would address the needs, and the final system after the changes are made to the system or operation.

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1.4 High-Level 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.

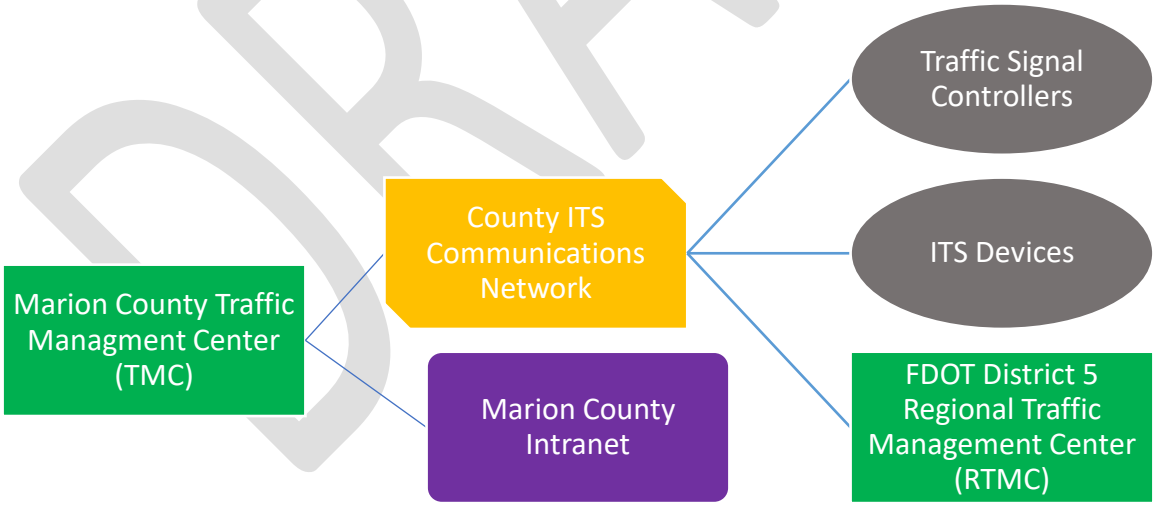

Figure 1: System Overview

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1.5 Stakeholders

Table 1 summarizes project stakeholders and their respective roles.

Table 1: 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.

1.6 Referenced Documentation

Table 2 contains reference information for documentation referred to herein or relevant to the project.

Table 2: 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)

Document Name	ID, Revision, Date, etc.	Link, or Contact Info to Obtain
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: Noemí Rodriguez Bonilla, P.E. (Noemi.RodriguezBonilla@dot.state.fl.us)
FDOT Design Manual	2021	FDOT Design Manual

2. Current System Situation

2.1 Background, Objectives, and Scope

Marion County Traffic Operations operates and maintains ITS consisting of traffic signals, ITS devices, a Traffic Management Center (TMC), an Emergency Operations Center (EOC), and communication system. The communication system interconnects the various elements and enables remote monitoring and management of ITS devices and traffic signals. Additionally, the County's ITS communication system is used for center-to-center data exchange between the FDOT District 5 Regional Traffic Management Center (RTMC) and the Marion County TMC. Of the 116 traffic signals maintained by Marion County, around 1/3 are connected to the County's ITS communication system. Moreover, the County has 58 CCTV cameras and around 52 Bluetooth travel time sensors. The County uses TACTICS as their Advanced Transportation Management System (ATMS) software to manage traffic signals and ITS devices; the County uses Siemens' traffic signal controllers.

Figure 2 is a regional map of Marion County showing major roadways, the County TMC, the EOC, County traffic signals, and communication towers owned by FDOT and local municipalities.

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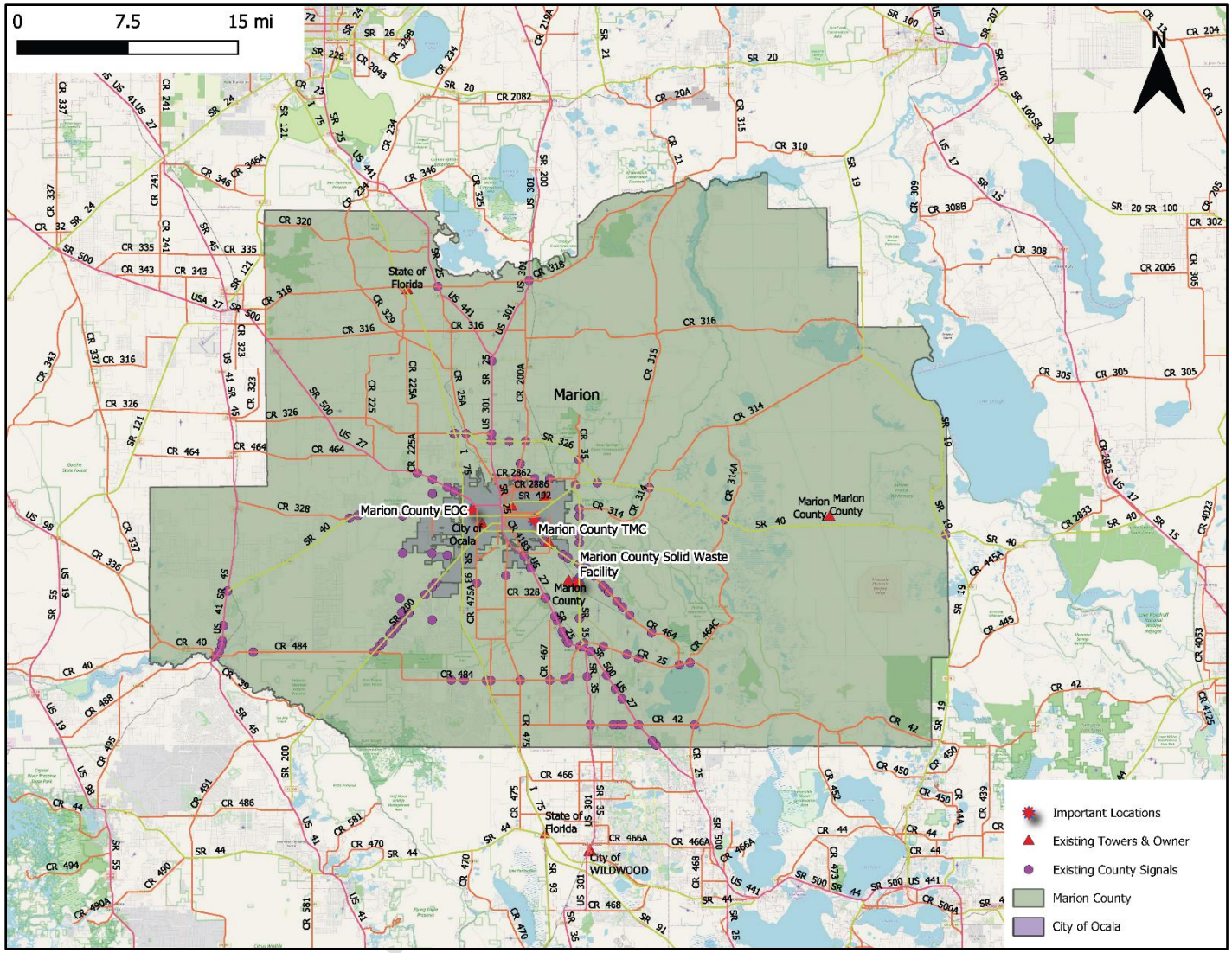

Figure 2: Regional Map

2.2 Operational Constraints

Marion County continues to experience substantial growth. Effectively supporting the traffic generated by this growth requires traditional capacity improvements and application of ITS to achieve the regional goals[1] of:

1. Facilitating efficient multimodal movement of goods and people.
2. Improving the safety and security of all transportation network users.
3. Providing predictable transportation experience.

The County's existing communication system lacks the capacity to support the County's future ITS objectives and has insufficient redundancy to provide the high-availability needed for the County to actively and reliably manage their transportation system.

2.3 Description of the Current System or Situation

The County's existing communication system mainly uses wireless communication, but uses some fiber optic cable installed by the County or FDOT District 5; furthermore, Marion County has an agreement with the City of Ocala to pay the city to use portions of the Ocala Fiber Network[2]. The communication system uses TCP/IP over Ethernet and UDP/IP over Ethernet protocol stacks.

Marion County's existing wireless communication system is set up as a tree topology. The root is the TMC, with branches leading to a wireless tower at the Marion County Solid Waste Facility (often referred to as the Marion County Landfill) and Marion County's internal network. Wireless connections then run from the landfill tower out to wireless antennas on traffic signals and other towers. Point-to-point connections between adjacent traffic signals chain corridors of signals together, then from one end of the chain a connection is made to the tower. A point-to-point backhaul connection between the tower and the TMC serves as the single connection for traffic between the TMC and field devices, which creates a bottleneck and single point of failure—if this link goes down the County loses access to all ITS devices and traffic signals. The County uses Proxim wireless communication equipment operating in unlicensed frequency bands. Figure 3 is a diagram of the County's existing ITS network topology. The Marion County Landfill is owned and maintained by the Marion County Solid Waste Department.

[1] Documented in the *Ocala/Marion TPO 2018 ITS Strategic Plan Update*.
[2] The Ocala Fiber Network is a city-owned internet service provider that serves the Ocala region.

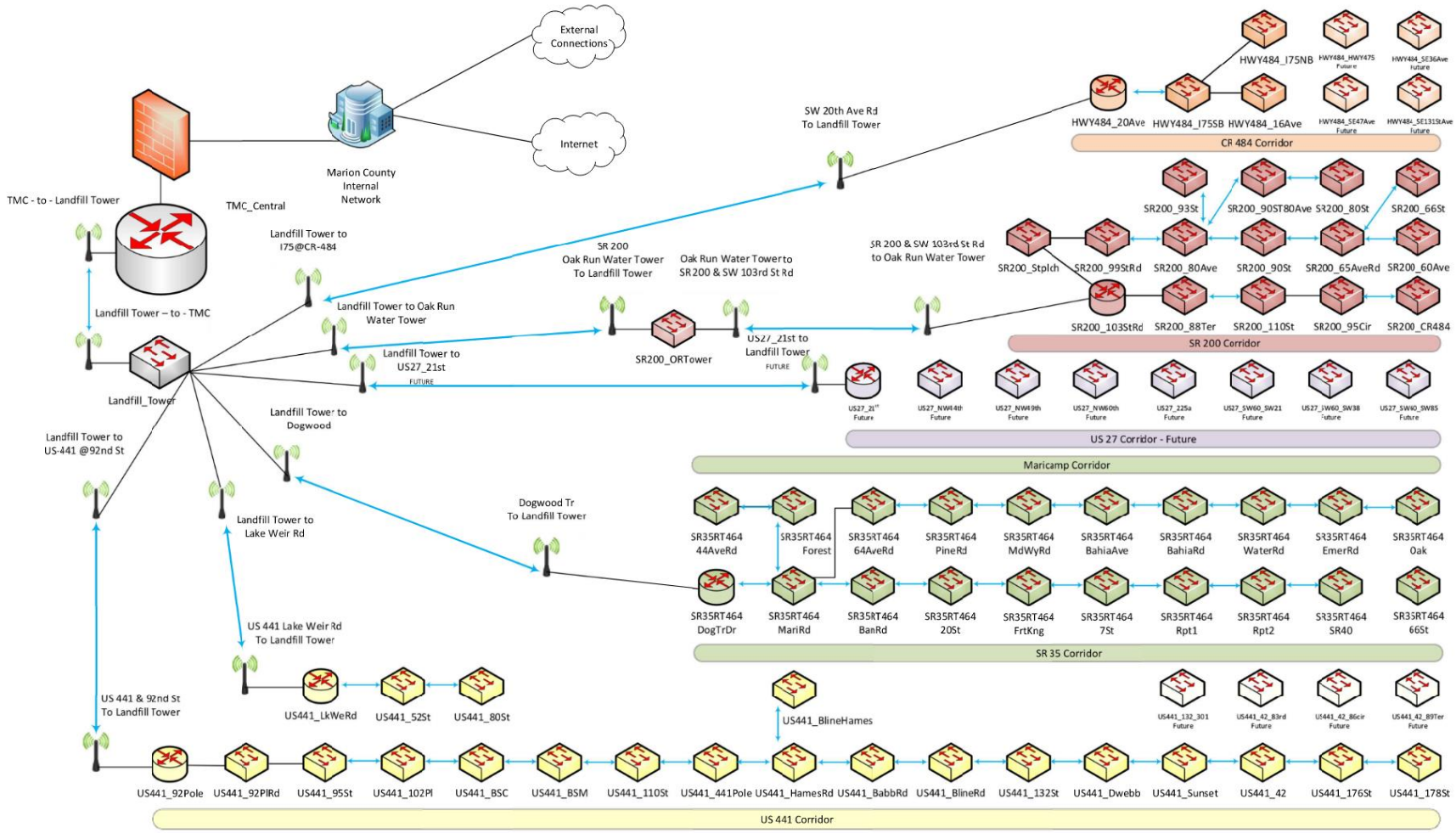

Figure 3: Existing Network Topology

An Ethernet switch is used to connect the traffic signal controller and ITS devices at the signalized intersection within each network connected traffic signal. Generally, Layer 2 Ethernet switches are installed in signal cabinets, but there are Layer 3 Ethernet switches installed in the signal cabinets that have wireless point-to-point connections to the Marion County Landfill Tower. A core router and firewall are installed at the Marion County TMC. The County uses Virtual Local Area Networks (VLANs) to segregate network traffic over shared physical network infrastructure.

Figure 4 is a map depicting existing regional fiber optic cabling and the County's existing wireless communication links.

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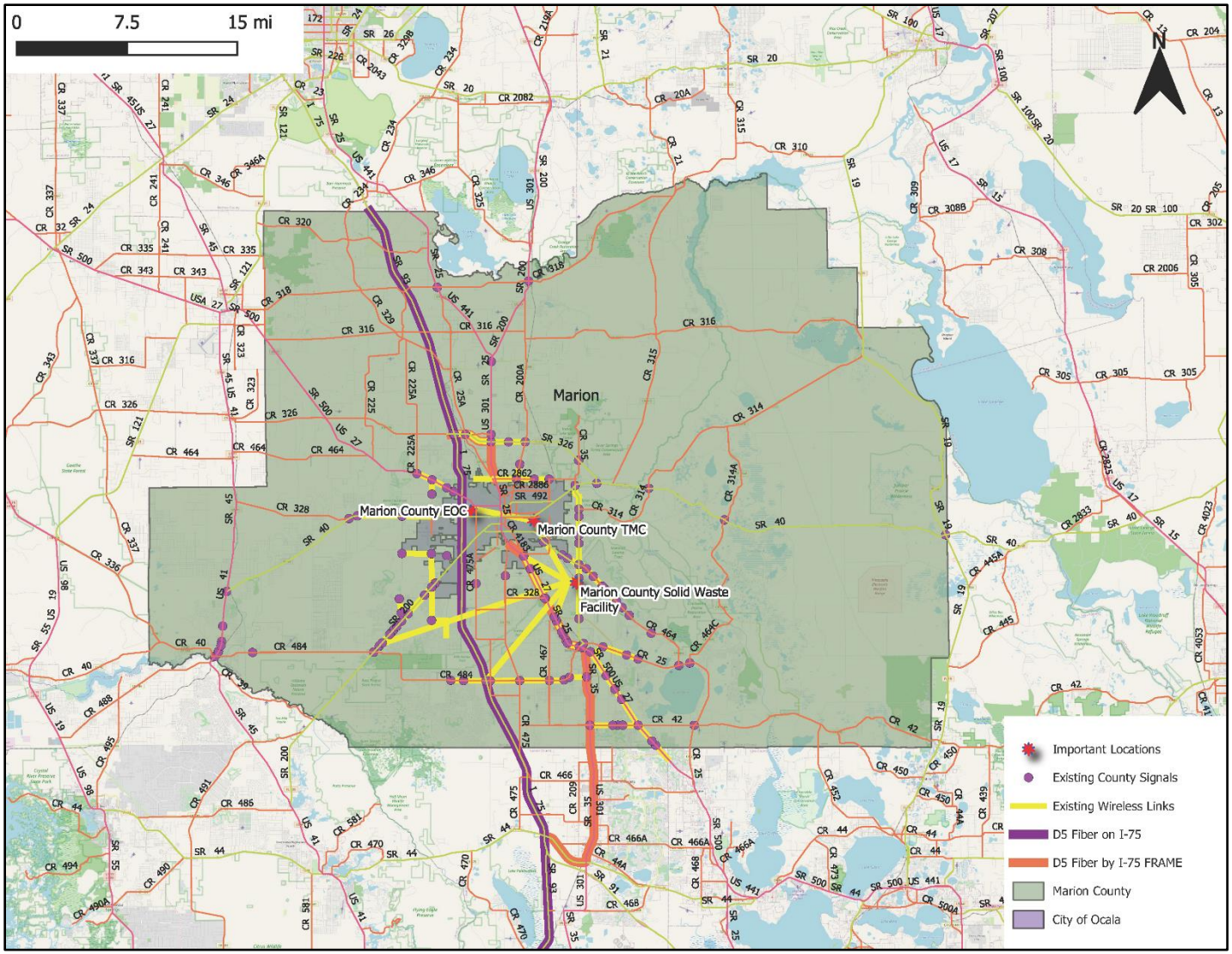

Figure 4: Existing Communication Infrastructure

2.3.1 I-75 Florida Regional Advanced Mobility Elements (FRAME)

I-75 FRAME is an ITS project focused on the I-75 corridor that endeavors to increase safety for I-75 users, improve travel reliability on I-75, reduce trip delay on I-75, accommodate population and economic growth and demand for moving people and freight, and enhance regional emergency evacuation and response. I-75 FRAME, in Sumter and Marion County, is installing CV road side units (RSUs) on I-75 and at signalized intersections along I-75 diversion routes; enhancing traffic signal detection and installing Advanced Transportation Controller (ATC) traffic signal controllers at signalized intersections along I-75 diversion routes; and installing fiber optic cable and supporting networking equipment in traffic signal controller cabinets along SR 44, US 301, US 441, and SR 326. The fiber optic cabling and networking equipment installed by I-75 FRAME connects traffic signals and ITS devices on the aforementioned corridors to the Marion County TMC.

2.3.2 Marion County Re-IP Project

Recently the County's network underwent an IP address update to ensure compatibility with FDOT District 5's network—the design effort was completed in December 2019. This effort included assigning IP addresses for all equipment using an address range that ensures no conflicts with FDOT's network, setting up VLANS for various uses, configuring switches, configuring routers, and documenting the network topology. The documentation created by the Marion County Re-IP Project should be referred to when designing network enhancements.

2.4 User Class Profiles

The following section provides user class profiles for the Marion County ITS communication system. User classes are based on the types of users of the system, according to common responsibilities, skill levels, work activities, or the ways they interact with the system. A list of user classes is provided along with the distinguishing characteristics of each.

2.4.1 County Traffic Signal/ITS Engineer

Performs design review, safety audits, traffic studies, and evaluates the performance of roadways and traffic signals, in real time, from the Marion County TMC. This user interacts with the TACTICS ATMS software running at the TMC. Usually a licensed Florida Professional Engineer. Today there is one full time county staff member in this user profile.

2.4.2 County Traffic Signal Analysts/Technician

Supports the County Traffic Signal/ITS Engineers and performs many of the same duties. Are usually not licensed Florida Professional Engineers. Today there is one full time county staff member in this user profile.

2.4.3 Traffic Signal Maintenance Technician

Performs troubleshooting, emergency repair, and routine maintenance of the County's ITS and traffic signal systems, including the ITS communication system. Responds to problems pointed out by County Traffic Signal/ITS Engineer and County Traffic Signal Analysts/Technicians regarding the health of the County's ITS. Maintenance Technicians are usually International Municipal Signal Association (IMSA) certified to perform work on traffic signals. Today there are four full time county staff members in this user profile.

2.5 Support Environment

The County operates and maintains their ITS communication system using members of the user class profiles described in Section 2.4. Funding for maintenance includes County contributions and reimbursement for maintenance of traffic signals on the State Highway System as described in the ***Traffic Signal Maintenance and Compensation Agreement*** between Marion County and FDOT—the agreement provides a yearly fixed reimbursement per traffic signal maintained with additional compensation provided for certain additional features, like whether or not the traffic signal is network connected. Marion County's operations and maintenance staff, during coordination meetings, stated that they are short-handed and are strained in keeping up with maintenance and operations of the County's transportation system.

The County is not involved in managing Federal Communications Commission (FCC) licenses for its ITS communications network as it employs unlicensed wireless communication. The ITS communication system operates 24 hours a day, seven days a week, and 365 days a year. Network expansions are generally associated with capacity improvement projects, which could include new traffic signals or traffic signal upgrades, where funding is provided by the County, FDOT, or the Ocala/Marion Transportation Planning Organization (TPO) using standard transportation project funding mechanisms.

3. Change Justification

3.1 Justification for Changes

The County's existing ITS communication system is unreliable, has insufficient capacity to support future regional ITS objectives, and does not reach all signalized intersections under the County's control.

3.2 User Needs

Table 3 contains the system's user needs identified during stakeholder coordination. The User Need Identification Number (ID) will be used in the Requirements Traceability Verification Matrix (RTVM) as a reference for the specific need. User needs will help define system requirements and performance criteria used to evaluate the project's success during system validation.

Table 3: User Needs

User Need ID	User	Need
UN001	Marion County	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.
UN002	Marion County	Improve ITS network: expand coverage, improve reliability, and increase bandwidth.
UN003	Marion County	Install fiber optic cable in areas where it would provide significant network benefits at a relatively low cost.
UN004	Marion County	Maximize communication system uptime given the project's budget.
UN005	Marion County	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.
UN006	Marion County	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).
UN007	Marion County	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).
UN008	Marion County	Minimize communication system maintenance effort.
UN009	Marion County	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.
UN010	Marion County	Provide N+2 redundancy (ring topology with wireless and fiber backhaul) for backhaul communication between point-to-multipoint communication sites and the TMC.
UN011	Marion County	Leverage existing fiber optic cabling installed by FDOT to improve the network while minimizing cost.
UN012	Marion County	Leverage existing communication towers owned by the County, FDOT, or other public agencies when deploying network improvements to minimizing cost.
UN013	Marion County	Obtain any FCC licenses required for the system enhancements.
UN014	Marion County	Use wireless communication equipment from a single-vendor to reduce maintenance, management, and deploy complexity.
UN015	Marion County	Provide a Central Management Software for centralized management of the wireless communication system and its components.

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4. Concepts for the Proposed System

4.1 Background, Objectives, and Scope

Marion County's enhanced ITS network will provide improved reliability, performance, and capacity for expansion. The system's objectives are to:

1. Improve network reliability and bandwidth.
2. Expand network coverage.
3. Support deployment of future ITS technologies including connected vehicle (CV) equipment and Automated Traffic Signal Performance Measures (ATSPM).

4.2 Operational Policies and Constraints

4.2.1 Operating Times

The system will operate 24 hours a day, seven days a week, and 365 days a year.

4.2.2 Approved Use

Marion County's ITS network should only be used for transportation-related network traffic.

4.2.3 FCC Compliance

All equipment must comply with FCC rules and regulations. For wireless communication equipment, restrictions include operating within a specific frequency range and under a maximum output signal strength value. For equipment operating in a licensed frequency band, the equipment must operate in compliance with the licenses' provisions.

4.2.4 Regional Security Standards

The ***District 5 ITS Master Plan***, in Section 7.2 of the Master Plan, contains regional network and security standards that should be adopted for this system to achieve a regionally-compatible, secure ITS network.

Further description of system security requirements are discussed in Section 4.3.9.

4.3 Description of the Proposed System

The system will contain existing elements and new components installed to upgrade the existing network. These new components consist of wireless communication equipment, fiber optic cabling, conduits, and other networking equipment like Ethernet switches and routers.

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New wireless communication equipment will either replace existing or add new connections, with the ultimate goal of improving bandwidth and redundancy. Antennas will be mounted on either traffic signal poles or existing wireless towers owned by Marion County or FDOT.

Fiber optic cabling installed by I-75 FRAME, FDOT owned fiber optic cabling, City of Ocala owned fiber optic cabling, and new fiber optic cabling to be installed will service the most important and highest bandwidth connections of the network. As installing fiber optic cable is expensive relative to wireless communication in this context, new fiber will be reserved for high-benefit areas.

Further into the design phase, when the future network topology is determined, this section should be updated to include it along with maps showing physical locations of new components installed.

4.3.1 Fiber Route Between TMC and Landfill Tower

A fiber connection between the Marion County TMC and the Marion County Landfill Tower will be installed to bolster this critical communication path. Figure 5 shows the proposed fiber path that the Design Consultant will refine during detailed design.

A 96 single-mode fiber will be installed. The conduit bank used to house the fiber will consist of 3-1.25” underground conduits with pull boxes positioned per FDOT Standard Specifications.

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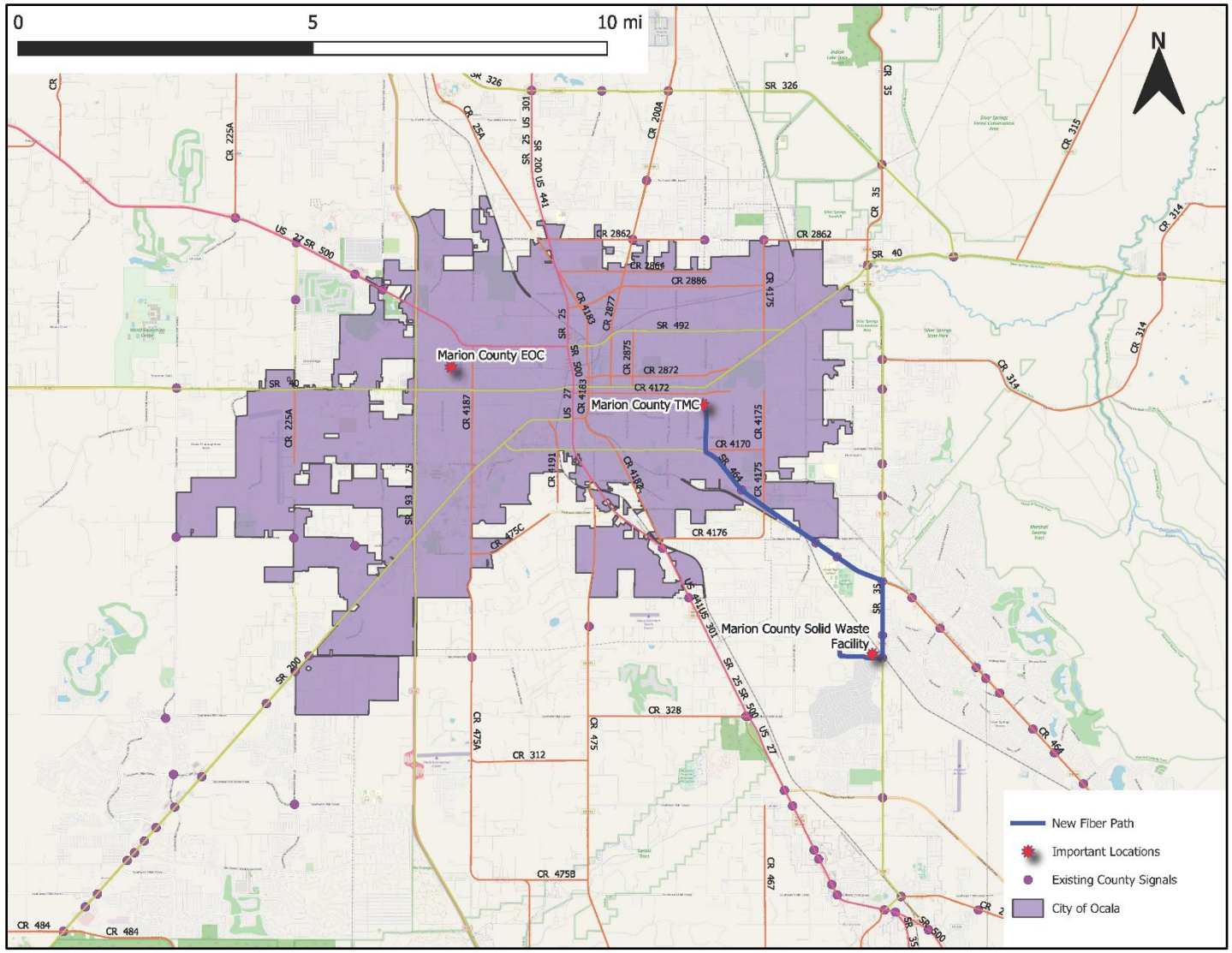

Figure 5: New Fiber Path

4.3.2 Ocala/Marion TPO 2018 ITS Strategic Plan Update

This is a strategic plan to guide ITS enhancements within the City of Ocala and Marion County. The plan recommends 18 projects worthy of ITS improvements on various corridors within Marion County—six of the 18 recommend wireless communication equipment that should be considered when designing ITS network enhancement for this project. Figure 6 shows the recommended projects and associated proposed network expansions (new wireless links).

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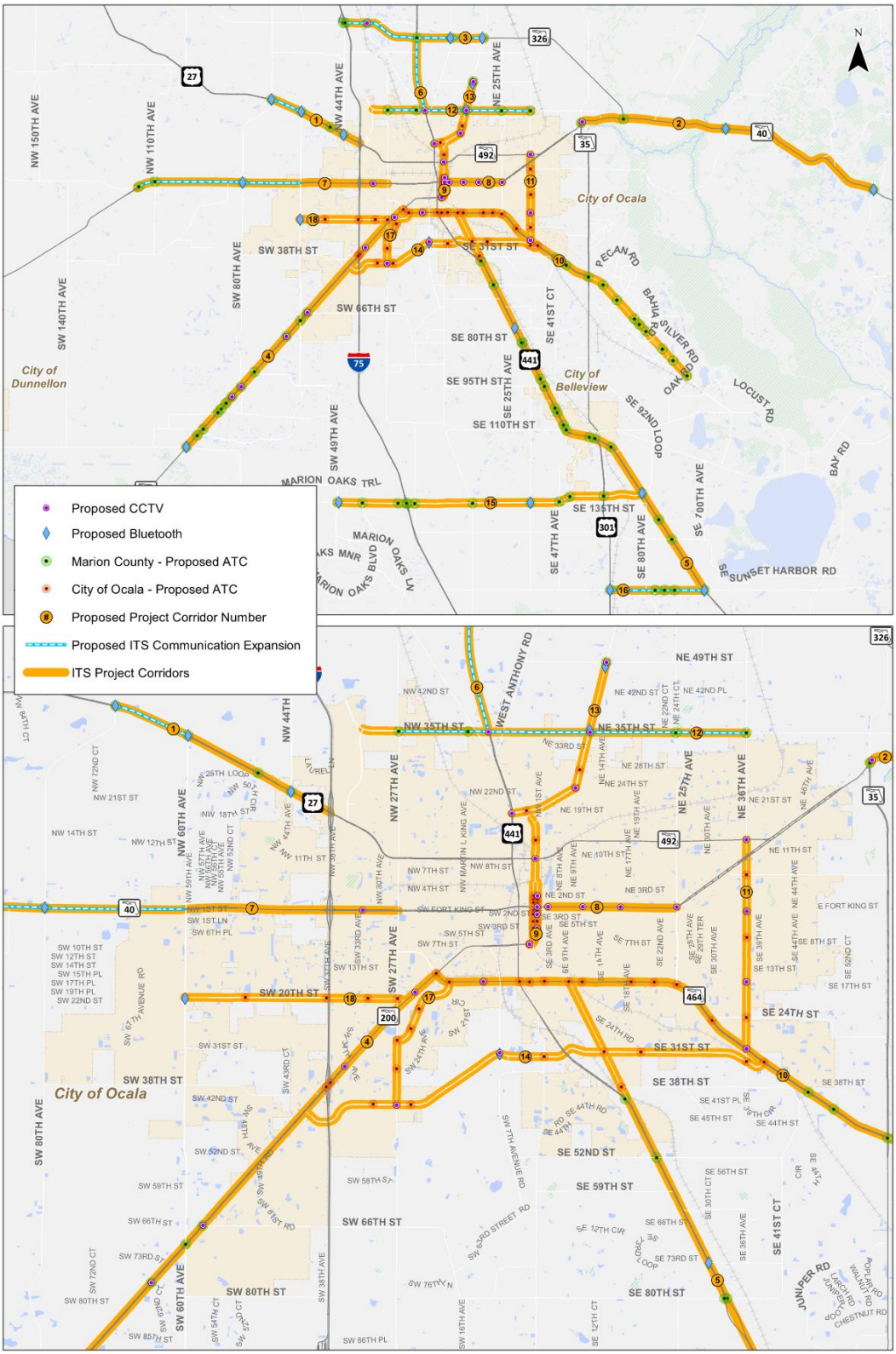

Figure 6: Ocala/Marion TPO 2018 ITS Strategic Plan Recommended Projects

4.3.3 Existing Towers

There are a series of wireless towers of various sizes, owned by FDOT and local municipalities, located within Marion County or nearby as shown in Figure 2. Use of these towers should be considered during detailed design when identifying new wireless connection opportunities.

4.3.4 Compatibility with D5 RITSA

The system will improve communication between the TMC, ITS devices, and traffic signals in Marion County which support numerous D5 RITSA service packages. This project is not included in the D5 RITSA. It will, therefore, have to be added by following the standard RITSA update processing using FDOT's standard architecture update form. Updates to the RITSA are performed by a consultant working for FDOT Central Office.

4.3.5 Compatibility with D5 ITS Master Plan

A Districtwide ITS master plan creates a consensus on what items are to be integrated, what ITS strategies are to be implemented, and what standards need to be met—security, maintenance, staffing, etc.—to facilitate future regional ITS goals. The master plan:

- Documents Marion County's existing ITS, existing operations resources, and existing maintenance resources
- Provides staffing guidance for the future
- Identifies potential ITS strategies for implementation in Marion County
- Sets forth mandatory regional ITS communication, security, data, common clock, and cabinet locking mechanism standards that must be considered when designing this project's network enhancements for Marion County
- Lists recommended ITS security, maintenance, operational, training, system testing and acceptance, and asset management standards that should be considered.

4.3.6 Throughput

During discussion with the County, the following throughput objectives were determined and should be used as a means to calculate throughput required for each communication link.

- 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.
- 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).
- 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).

4.3.7 Redundancy

The system aims to provide N+1 communication path redundancy through a ring topology to all traffic signals. For all backhaul connections, N+2 communication path redundance is the goal: ring topology with fiber optic and wireless communication (rings using two different communication media).

4.3.8 System Cost Limitations

The construction cost estimate as of 2021-04-29 is $1,274,619.52—recorded in FDOT's Long Range Estimates system. The system's cost estimate should be revisited throughout the design phase to ensure it can be constructed within the budget.

4.3.9 Security Requirements

As it interfaces with FDOT's network, the system must comply with Florida Cybersecurity Standards (FAC 60GC-2).

The ***District 5 ITS Master Plan***, in Section 7.2 of the Master Plan, contains regional network and security standards that should be adopted for this system to achieve a regionally-compatible, secure ITS network.

Wireless communication must be secure and employ data encryption such as Wi-Fi Protected Access, second version (WPA2-AES). Additionally, firewalls with strict policies limiting access to only approved network traffic must be installed between Marion County's ITS Network and external networks.

4.3.10 Central Management Software

The wireless communication system components, used to establish the point-to-point and point-to-multipoint connections, will be manageable using a single Central Management Software that provides a single unified interface for wireless equipment management. The Central Management Software must be compatible with the wireless equipment and provide the following minimum features:

1. Provide access for managing all wireless communication devices.
2. 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.
3. Automatic topology generation and overviewing capacities from within the software.
4. Overview showing communication link and device status for all wireless equipment.
5. Device data logging of device and connection status for wireless components.

6. Bulk firmware updates that can be pushed to devices remotely (physical access to devices are not required for routine firmware updated).
7. User ID and password management.

4.3.10.1 System Hardening

Most of the systems components will be installed outdoors or within cabinets located outdoors without air conditioning systems. It is, therefore, imperative that these components be capable of withstanding Florida's environment in order to provide reliable long-term operation. For outdoor equipment, all components should be corrosion resistant and NEMA 3R/IP64 rated at a minimum, with a preference for NEMA 4X or IP65 or higher ratings. All equipment not located within air-conditioned facilities should meet the environmental requirements of NEMA TS2-2003.

4.4 Modes of Operation

4.4.1 Standard

The system will operate normally in standard mode. All links are functional and all devices are accessible.

4.4.2 Maintenance

The system will operate in maintenance mode during system maintenance. During maintenance certain portions of the ITS network may be taken down. Prior to doing any scheduled work that will require portions of the network to be taken offline, advance warning will be given to the TMC staff so that they can plan around the downtime. Scheduled maintenance should occur during off-peak periods.

4.4.3 Link Failure

If a network link fails, due to either equipment failure or damage to the communication media, portions of the network may become inaccessible. Some of the network will be designed to provide N+1 communication path redundancy; with N+1, network access isn't compromised with a single link failure. Other more critical portions will be designed to provide N+2 redundancy; with N+2, network access is maintained for up to two link failures.

4.5 User Involvement and Interaction

Marion County staff working from the TMC use the ITS network to remotely assess the health of the County's roadway network and traffic signals. CCTV cameras are installed on traffic signal poles at critical intersections and TMC operators view live video streamed over the ITS network to assess traffic conditions. Traffic signal controllers are accessed by Marion County staff over

the ITS network to adjust signal timings, gather data collected by the controller, and receive alerts about abnormal operation (flash mode, detector failure, etc.). Travel time sensors connected to the ITS network allow the County to review travel times, average travel speed, and origin-destination data for the roadway network.

4.6 Assumptions and Constraints

4.6.1 System Coverage and Usage

The system will cover Marion County, with a focus on the areas with dense traffic signal spacing around Ocala and arterials connecting to I-75.

Marion County's ITS network should only be used for transportation-related network traffic.

4.6.2 Use of Existing Towers

Using existing towers for new wireless equipment may require an agreement with the tower owner and utilization fees. During detailed design, when communication links are being considered, an assessment of agreements necessary to attach to certain towers should be considered.

4.6.3 Compliance with Specifications

All equipment must be in compliance with the specifications package prepared during the design phase. While most of the new system components are expected to be covered in FDOT's Standard Specification language, Modified Special Provisions (MSPs) and Technical Special Provisions (TSPs) will be necessary for components that are not. All components, that require such listing per FDOT Standard Specifications, must be listed on the the FDOT's Approved Products List (APL).

4.6.4 Construction Budget

Refer to Section 4.3.8 for system cost constraints.

4.6.5 FCC Licensing and Compliance

All wireless communication components must comply with FCC requirements. FCC licenses are required for all wireless equipment operating in licensed frequency bands.

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4.6.6 Regional Compliance

The ***District 5 ITS Master Plan***, in Section 7.2 of the Master Plan, contains regional network and security standards that should be adopted for this system to achieve a regionally-compatible, secure ITS network.

4.7 Risks

This section will be updated after completing the first risk assessment meeting as described in the Project Systems Engineering Management Plan.

4.8 Support Environment

Marion County will maintain the system. Marion County's operations and maintenance staff have challenges keeping up with maintenance and operation of their existing transportation infrastructure. Design of the new system should consider this constraint as should future staffing assessments by the County[3].

The County's maintenance budget should also be considered as the system's expansion is expected to increase maintenance obligations. As a means to help offset maintenance costs, the County should update their ***Traffic Signal Maintenance and Compensation Agreement*** with FDOT to maintain traffic signals on the State Highway System—additional compensation is provided for network connected traffic signals and this will help offset the increased maintenance cost.

5. Operational Scenarios

5.1 Normal Operations

Calvin, a County Traffic Signal/ITS Engineer, is working in the Marion County TMC. He is able to access all CCTV cameras, traffic signal controllers, and other ITS devices through the TACTICS ATMS software—all communication from field devices to the TMC runs over Marion County's enhanced ITS Network. To check the system's health, Calvin opens up the wireless equipment's Central Management Software, from which he is able to observe that all wireless links and devices are functional.

[3] The District 5 ITS Master Plan contains staffing guidance for the future transportation system operations and maintenance.

5.2 Maintenance

5.2.1 Unscheduled Repair

Peter has just been informed, by a County Traffic Signal/ITS Engineer working in the TMC, that a traffic signal is not network accessible and that the links to the traffic signal from adjacent signals are down—as a Traffic Signal Maintenance Technician, he has been tasked with troubleshooting and fixing the outage.

Peter arrives at the traffic signal and finds that the antennas pointing towards adjacent signals have been knocked out of alignment. He re-aims them, using the antenna manufacturer's recommended procedures, and logs into the device to check signal strength—everything appears to be functioning normally. Peter then contacts the TMC and a staff member informs him that the link is now active.

5.2.2 Routine Scheduled Maintenance

Matt is a Traffic Signal Maintenance Technician with Marion County who has been tasked with repairing an Ethernet switch at a traffic signal that has been causing problems over the last few months. Matt has reviewed the network topology Marion County maintains and understands that temporarily taking this switch offline will isolate five traffic signals from the Marion County ITS network. Two days prior to the work occurring, Matt notifies the TMC of the anticipated downtime; in the notification he includes an estimate of the duration, he estimates four hours during an off-peak period, and a summary of the extent of the network that will be offline.

Matt arrives at the signal cabinet housing the Ethernet switch he is replacing, calls the TMC right before unplugging the existing switch, then replaces it and configures the new switch. Afterwards, Matt calls the TMC to confirm that the network is operating normally before leaving the intersection.

While the Ethernet switch was being replaced, operators at the TMC could not access five traffic signals but the system was otherwise operating normally and traffic signal operation was not affected. Since they were provided with advance notification of the outage, they were not surprised when it occurred and planned around the short-term outage.

5.3 Failure

5.3.1 Fiber Cut

It is 3:00 PM and Steven, a County Traffic Signal/ITS Engineer working at the Marion County TMC, notices that some traffic signals on US 441 were not accessible over the Marion County ITS network for a short period. After further investigation he sees that the network is suffering a link failure and that the short outage occurred while the network was recovering from this failure

by falling back to a redundant communication path. Steven notifies Marion County's maintenance staff and a technician is dispatched to investigate the failure—the notification contains the intersections on either side of the link failure to help narrow down the search.

A Traffic Signal Maintenance Technician named Bob is dispatched to investigate. After a short time, Bob notices ongoing construction on US 441 in the area where the outage occurred. Then, upon talking with the construction crew, he is informed that the ITS fiber optic cable was damaged. Bob notifies FDOT's CEI of the damage and FDOT's construction personnel instruct the contractor that caused the damage to repair the damaged fiber using their ITS subcontractor. Bob remains on site while the repairs occur and then calls the TMC to confirm the repairs before leaving the site.

5.3.2 Wireless Backhaul Failure

Wind-blown debris during a hurricane has damaged one of the wireless backhaul antenna causing the backhaul link to fail. As the system provides N+2 redundancy for backhaul connections, the network is still functional but has reduced fault tolerance. Marion County schedules a Traffic Signal Maintenance Technician to repair the antenna.

6. Summary of Impacts

6.1 Developmental

The system will be designed to allow for addition of new traffic signals and ITS devices that are connected to the network with wireless or fiber connections. In the future, Marion County should consider connecting existing signals to the network that were not connected during initial deployment due to budgetary or other constraints. And the County should request that new traffic signals be connected to the network as a standard approach for all new traffic signals located near existing network infrastructure with a focus on signals located along heavily trafficked corridors.

6.2 Operations

Marion County's Traffic Signal/ITS Engineers, Traffic Signal Analysts/Technicians, and Signal Maintenance Technicians will have better access to existing traffic signals and ITS devices, which will improve their ability to assess real-time traffic conditions. They will interface with the new Central Management Software to assist with operations and troubleshooting of the wireless communication equipment. The improved network reliability provided by the system, compared to existing conditions, will result in less connection failures.

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6.2.1 Training

Marion County's staff should receive training in how to operate the Central Management Software, such that they are aware of how to add devices, review network status, and help troubleshoot connection failures.

6.2.2 Staffing

The system is not expected to require additional staff to operate or maintain. The County should, however, consider following the ***District 5 ITS Master Plan'***s recommendations for staffing levels.

6.3 Maintenance

6.3.1 Asset Management

Marion County's existing asset management system, which consist of detailed Geographic Information System (GIS) data, must be updated to include the new system's equipment.

6.3.2 Training

Traffic Signal Analysts/Technicians and Signal Maintenance Technicians working for Marion County must be trained in deployment, operation, and troubleshooting of new wireless and networking components. As fiber and wireless communication exist within the County, the County's staff is generally familiar with these types of systems, so the training should focus on equipment-specific training on what was installed.

6.3.3 Spare Parts

The County should consider retaining an inventory of spare parts for new components that routinely fail or are damaged based on their past experience maintaining the existing system. This could include optical transceivers, wireless antenna, Ethernet switches, and communication cabling.

6.3.4 Cost

To assist with budgetary planning, the following operations and maintenance costs per year are provided. These values were obtained from the USDOT's ITS costs database and have been adjusted for inflation to 2021:

- Fiber Optic Cable (per mile): $ 1,670 - $4,000 per year
- Terrestrial Microwave (per link): $790 - $1,670 per year

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The County should assess their operations and maintenance budget to ensure sufficient funding is allocated to operate and maintain the system.

6.3.5 Maintenance Agreement

A Maintenance Agreement between FDOT and Marion County will be required to solidify maintenance responsibilities for all ITS infrastructure located outside of the State Highway System right-of-way: often referred to as "off-system". Marion County will be solely responsible for operations and maintenance of all infrastructure installed off-system.

6.4 Potential Environmental and Cultural Resource Impacts

Underground conduit installation, using both trench and directional drilling installation methods, must occur for the new fiber path from the Marion County TMC to the Marion County Landfill Tower. This work may affect wetlands and other surface waters and protected species; during the design phase, the Design Consultant must investigate these potential environmental impacts and avoid them where practicable. Similarly, the conduit installation may affect existing cultural resources and the Design Consultant must review and avoid impacts where practicable.

6.5 Structural Impacts

Existing structures, such as traffic signal structures and towers, will have new antennas attached to them that could have structural impacts. The Design Consultant, during the design phase, must consider these potential structural impacts. Installation of new structures is not anticipated.

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7. Analysis of the Proposed System

7.1 Alternatives

Alternative operational approaches were not considered for this system at its function is primarily support for regional traffic operations.

7.2 Cost, Schedule, and Procurement Options

7.2.1 Cost

Refer to Section 4.3.8 for a current cost estimate. The system's cost estimate should be revisited throughout the design phase to ensure it can be constructed within the budget. This section should be periodically updated to reflect updated cost estimates.

7.2.2 Schedule

Refer to the *Project Systems Engineering Management Plan* for a project schedule.

7.2.3 Procurement Options

FDOT Central Office has directed the use of the Construction Manager/General Contractor procurement method for this system. No other procurement options were considered.

7.3 Systems Engineering Plan

This ConOps is part of a larger systems engineering process that is defined in the project's Systems Engineering Management Plan.

The ConOps will be used as the basis for creation of the System Validation Plan (SVP) and Requirements Traceability Verification Matrix (RTVM); these documents will facilitate systematic tracking of user needs from conception in this ConOps to their validation in the realized system.

The Design Consultant will apply the user needs and proposed system concepts described in this ConOps during design of the system and its various components.

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7.4 Performance Measurement for System Validation

MOEs will be used during system validation to check whether or not the system built truly meets its user needs. A more detailed discussion of system validation, which includes a list of user needs and corresponding MOEs, can be found in the SVP.

8. Notes

This section will be annotated, as needed, with changes to the approved ConOps document made over the course of the project. There are no notes at this time.

9. Appendices

This section will be updated, as needed, with changes to the approved ConOps document made over the course of the project. There is no appendix at this time.

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DOCUMENT REVISION HISTORY			
Version Number	**Approved Date**	**Description of Change(s)**	**Created/ Modified By**

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