CENTRAL FLORIDA
EXPRESSWAY AUTHORITY

ITS
Master Plan

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Executive Summary

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Background Information

The Central Florida Expressway Authority (CFX) was established in 2014 with an expanded mandate to build and maintain a regional transportation network that connects Brevard, Lake, Orange, Osceola and Seminole counties. CFX's role in developing a world-class regional mobility network has taken on new meaning with enabling legislation which allows CFX to incorporate multimodal corridors and intermodal facilities within its right-of-way. CFX is responsible for the construction, maintenance and operation of a limited-access expressway system that serves a region with more than 3 million residents in five counties, plus an estimated 75 million visitors each year. The CFX system includes 125 centerline miles (including the new Wekiva Parkway), 815 lane miles (including ramps), 69 interchanges, 335 bridges and 18 mainline toll plazas. The entire system is supported by tolls; no taxes of any kind fund CFX operations.

A master plan is a dynamic long-term planning document that provides a conceptual layout to guide future growth and development. The intent of this document is to provide guidance through the next decade and should be updated every 3-5 years in accordance to regional plans and guidelines from CFX and the state of Florida.

A vision statement is the anchor point of any ITS Master Plan and provides guidance and inspiration as to what CFX is focused on achieving in the future. After reviewing vision statements and documents from the CFX 2040 Master Plan, CFX Five-Year Work Program Plan, CFX Strategic Plan, 2045 Florida Transportation Plan (FTP) and the Florida Department of Transportation (FDOT) District 5 ITS Master Plan the following CFX ITS Vision Statement was established:

> "To provide a safe and innovative world-class mobility network that enhances quality of life while ensuring reliability, security and sustainability for all system users."

As Central Florida expands with population growth due to increased development in downtown Orlando and the urban sprawl from the Greater Orlando area, an improved transportation network using Transportation Systems Management and Operations (TSM&O) tools, including Intelligent Transportation Systems (ITS), will allow CFX to better accommodate the congestion brought on by this growth. Using these tools adequately will allow CFX to move away from accommodating more vehicles exclusively through roadway widening, an already difficult task due to the geographical makeup. TSM&O has proven to be a tried-and-true way of providing unmatched service to freeway management agencies within Florida. With this in mind and to achieve the ITS Vision, the following goals of the CFX ITS Master Plan were established:

The Federal Highway Administration (FHWA) has been promoting the approach of using TSM&O to improve the overall performance of the transportation network (Freeway and Arterial). TSM&O is a performance driven approach for solving traffic related problems and minimizing congestion through the utilization of ITS, signal system control, and other management and operational strategies to locate and minimize the causes of delays in real-time. The objective of the TSM&O program is to improve the efficiency of the existing transportation network through performance monitoring and coordinating freeway and arterial management strategies, such as incident management. The TSM&O Program also considers future technologies and the importance of improving the overall efficiency of the transportation network.

The CFX ITS Master Plan provides the framework for improving the roadway network in the future by using effective TSM&O strategies. The plan will assess the conditions of the existing and future infrastructure of CFX as well as surrounding counties to determine the needs, identify applicable ITS strategies/deployments, and detail the operations and maintenance needs within the system. Sustainability is also a large part of CFX's initiative as they are currently entering into the first phase of a multi-year program to identify and explore beneficial projects that can increase sustainability throughout its roadways, facilities, and properties in Central Florida. CFX conducted a study in 2019 to evaluate the viability of several sustainability initiatives for the CFX infrastructure and system. The sustainability study provided an assessment of the energy potential, system size, costs, risks, and benefits associated with each option, the required equipment, and the recommended locations of each project.

CFX operates an electronic toll collection system known as E-PASS, the first electronic toll-collection device in Florida and one of the first systems of its kind in the United States. Today, over a half-million transponders are in circulation in Central Florida.

CFX continues to evaluate and plan for the implementation of new and emerging technologies to meet the mobility needs of their customers. The master planning process incorporates utilizing Connected and Automated Vehicle technologies, ITS, and data management strategies facilitating stakeholder involvement, pilot deployments and system upgrades. The acceleration of Connected Vehicle (CV) technology has the potential to dramatically affect the Master Plan over the next decade as the onboard unit technology saturation is expected to increase in the next 10 years.

Incorporation of ITS technologies as well as cooperation with other local leaders in transportation enable CFX to continue to provide its customers with a world class mobility network that upholds quality, safety, sustainability, and efficiency.

Stakeholder Coordination

The overall transportation network is made up of several different entities as well as non-traffic specific stakeholders (municipalities, police departments, multimodal facilities, etc.). As part of the Master Plan, stakeholder coordination meetings were held with each stakeholder identified below. These meetings helped identify the existing infrastructure of the stakeholders as well as any future projects to expand or improve their infrastructure. As a result of these meetings, the Master Plan has provided recommendations for increased data collection and sharing systems that will allow for operator/maintainer agencies to share data and operate traffic on a more regional scale.

ITS Master Plan primary stakeholders were identified as any local agency, Metropolitan Planning Organization (MPO) or Transportation Planning Organization (TPO) that operates and/or maintains existing or future ITS or signalization technologies within the CFX region.

These stakeholders are identified as follows:

- Brevard County
- Brightline
- CFX
- City of Orlando
- FDOT District 5
- FDOT Turnpike Enterprise
- Greater Orlando Airport Authority
- I-4 Mobility Partners
- Lake County
- LYNX
- MetroPlan Orlando
- Orange County Traffic Engineering
- Osceola County
- Sanford Airport Authority
- Seminole County
- Space Coast TPO
- SunRail

ITS Strategies

A significant part of this ITS Master Plan entails sorting through the various technological options that are available within the ITS industry that can better serve the transportation system. Emerging technologies tried and true safety applications, along with up-and-coming initiatives, bring together a melting pot of viable and attainable strategies to implement within the region. These strategies touch on all facets of a transportation system, and when implemented in concert, will further the flow of goods, safety of travelers and keep the public informed. ITS technologies can vary in different types of applications, including different types of traffic signal controllers, variable message signs, vehicle speed detections and

road weather information, to more complex applications, which integrate real time data to actively manage the traffic. ITS Strategies presented in this Master Plan cover a wide range of technology solutions; and each solution serves as a "tool" within a toolbox. It must be understood that one strategy is not always an "end-all" solution and that some of these tactics have multiple applications, while a few may only be warranted for unique situations.

A review of the 1999 OOCEA ITS Master Plan was performed to identify how far the agency has come within the past 22 years. Within the document, OOCEA stated that they wanted to position themselves as a leader in the region with the deployment of new "high tech" systems and the following strategies were set forth by the 1999 OOCEA ITS Master Plan which have been met and/or exceeded.

- Make use of the expressway system by Central Florida's residents and visitors even more attractive by ***providing up-to-date information on traffic conditions;***
- Create an ***even safer system of roadways;***
- ***Minimize delays to customers*** by further reduction of toll plaza congestion and by rapid response to delay-causing incidents such as traffic accidents;
- ***Prolong the useful life of its current infrastructure*** investment by increasing its capacity to handle increasing volumes of traffic; and
- ***Coordinate with the region's other transportation agencies*** to form a seamless transportation system, enhanced by shared information, combined fare/toll collection and coordinated operations.

Many of these initiatives were achieved over the past 22 years through the successful deployment of a robust Intelligent Transportation System. Key improvements included:

- Immediate Traveler Information
- Enhanced E-PASS Toll Collection
- Reliable Incident Management and Response
- Rapid Emergency Response
- Tourist Information Dissemination
- Ongoing Agency Cooperation/Coordination

While there has been great progress in achieving the goals and strategies outlined in the 1999 OOCEA ITS Master Plan, CFX can use many of the same fundamental guiding principles to continue its leadership within the region. To this end, the following strategies were identified as applicable ITS strategies since they involve operations on the limited-access expressway system or require a consensus on standards by CFX to be implementable:

- Advanced Traveler Information Systems
- Incident Management and Highway Assistance
- Active Transportation and Demand Management (ATDM) Active
- Passive Demand Management
- Work Zone Management
- Part Time Shoulder Use (PTSU)
- Public Transportation Management
- Public Travel Security
- Electronic Payment Services
- Connected and Automated Vehicles
- Freight Advanced Traveler Information Systems (FRATIS)
- Traffic Data Information Management
- Event Management
- Asset Management

- Alternative and Innovative Intersection Designs
- Traffic Signal Systems
- Active Parking Management

Existing Infrastructure

An important initial step in creating an all-encompassing ITS Master Plan is to understand and document existing conditions and infrastructure to form a foundation from which to build upon. By compiling information pertinent to the ITS vision, objectives, and goals from all involved agencies and municipalities, it allows the plan to take shape and provide the magnitude of the plan for a direction most beneficial to those involved.

Below is a snapshot of the existing system as it stands today:

- 125 centerline miles of limited access expressway (830 lane miles)
- 69 interchanges
- 13 mainline plazas that handle both cash and electronic collection
- 5 AET locations
- 74 ramp facilities (includes three ramp gantries)
- 339 bridges
- 8 named expressways
- Fiber Optic Network (FON)
    - Approximately 500 miles of fiber optic communication lines along the CFX Expressways
    - 2-72 Single Mode FOC (Backbone and Feeder Fiber) installed on both sides of the roadway
- 277 Closed Circuit Television (CCTV) cameras
- 55 Walk-in and 78 front access Dynamic Message Signs (DMS)
- 188 Data Collection Sensors (DCS)
- 63 Wrong Way Driving Detection Devices (WWD)
- 447 Traffic Management Systems (TMS)
- Server Environment
- Firewall Appliances

Determination of Needs

After consulting with stakeholders and identifying both transportation and technology needs, along with dedicated O&M funding and capital improvements, key areas throughout CFX's infrastructure were identified for improving management of the transportation network, decreasing the amount of congestion and addressing safety needs. Specific O&M needs were identified, and the capital improvements were described as deployments, this included engineering and construction projects that address immediate capital needs, establishes timelines for emerging technologies and sustainability.

The needs are identified in **Table 1**, on the following page:

Table 1: Identified O&M Needs

Transportation Needs	
Improved Travel Time Reliability	Maintain Future Acceptable LOS Standards During Peak Periods Reduction of Primary Crashes and Corresponding Delays Reduction of Secondary Crashes and Corresponding Delays
Event Management	SR 408 and in the vicinity of Camping World Stadium
Improved Safety at Interchanges/Intersections	Reduction of Left-Turn Crashes: SR 408 at Chickasaw Trail, SR 429 at CR 437A, SR 528 at Tradeport Road, and SR 528 at Narcoossee Road Reduction of Red-Light-Running Violations and Angle Crashes: SR 408 at John Young Parkway, SR 528 at Goldenrod Road, and SR 528 at Narcoossee Road Reduction of Intersection Sideswipe Crashes: SR 414 at US 441 are occurring within dual left-turn lanes and are an indication the driver may not be aware of the lane assignment or the proper lane they need to access downstream Alternative Intersection Design: Intersections of SR 536 at International Drive, SR 417 at John Young Parkway, SR 417 at Lake Nona Boulevard and SR 417 at Narcoosee Road.
ITS and Technological Needs	
Network and Roadway Infrastructure	Network and device security Planning for additional transportation technology advancements Hardware and Storage
CAV	Evaluation and use of applicable CAV applications Regulatory requirements (FCC, SCMS) Device testing Devices needed to support a CV Pilot Device Procurement considerations
ITS and Technological Needs	
Policy Updates	Future planning and documentation updates Evaluation and use of applicable CAV applications Stakeholder and data sharing partnerships Workforce and skillsets Professional development and continued education
Data	Data collection, storage and sharing Data formats Data reliability and security Machine learning Automated reporting Data management tools Data policy and governance Data maintenance
Regional Partner Needs	
Stakeholder Needs	CAV Readiness and Compatibility Data Storage/Sharing and recommendations Pilot projects collaboration Updates to the Central Florida Regional Integrated Corridor Management

Stakeholder Needs (Continued)	System (R-ICMS) Long-term Data Collection: DIVAS, ICM, ATSPM, Asset Management, etc. Part-Time Shoulder Use (PTSU) Continued coordination and collaboration i.e. Integrated Transportation Application Strategy, Wrong Way Driving Communication redundancy and security/cyber security readiness End of Queue Warning Systems Regional Fiber Sharing Smart Parking and Operations Strategy Transit Signal Priority (TSP), as required Wekiva Expansion - Active Arterial Management (AAM) and Integrated Corridor Management (ICM) Synergy with Road Rangers along SR 528 and I-95 Evacuation Needs and Event Coordination: Information dissemination and advance information prior to decision points
Sustainability Needs	
Per Sustainability Plan (2019)	Implementing technologies such as photovoltaics (PVs), electric vehicle charging stations and electric vehicles.

Solutions and Recommendations

In establishing a vision, goals, and objectives for ITS improvements within CFX's infrastructure, this Master Plan provides the foundation for improvements to the roadway network that will benefit all users. These improvements are recommended to be put in place to allow CFX to have a greater return on large capital roadway investments that have already been made. Specific O&M needs were identified, and the capital improvements were described as deployments, including an Early Deployment that addresses immediate capital needs and establishes a method for real-time management operation of the system (including reporting on system performance). ITS improvements will allow CFX to increase return on large investments already put in place (i.e., roadway network, traffic signals, etc.). They will also allow for increased coordination between user agencies due to the increase in communications and surveillance technologies that will be deployed. A summary of recommended priorities is listed below and are discussed in further detail in Section 5.6 - Project Identification by Type and Need of the ITS Master Plan.

1. **Traffic Operations Projects**
    a. Event Management - Capitalize on the capital improvements per the work plan on SR 408 from John Young Parkway to Orange Avenue. Provide operational support and augment the capital improvements as needed
    b. Event Management - Smart Parking Deployment
    c. Continue Incident Management

2. **Engineering and Construction Projects**
    a. Smart Work Zone Pilot Project

3. **Maintenance Projects**
    a. Various Signalization and Signing/Striping Pavement Improvements

4. **Network/Cybersecurity**
    a. Conduct a network/cybersecurity reassessment study

5. **CV and Data Needs Assessment**
    a. Conduct a CV and Data Needs Assessment Project
6. **Deploy Alternative Power Solutions**
7. **Deploy Smart Power Metering**
8. **Big Data Pilot**
    a. Conduct a Big Data Pilot Project
9. **CV Deployment Pilot**
    a. Conduct a CV Deployment Pilot Project
10. **Artificial Intelligence (AI) and Computer Vision Pilot**
    a. Conduct an AI and Computer Vision Pilot
11. **Sustainability Study Projects**
    a. Deploy Sustainability Study Projects as identified in the CFX Sustainability Study

Future Planning Updates

CFX is actively laying the groundwork while implementing advanced technologies through a robust Intelligent Transportation System (ITS). Working towards the goal of a world-class system, the CFX ITS Master Plan upholds a vigorous and diverse approach that will allow CFX to continue to invest in the existing system for the next ten years, while simultaneously looking for opportunities to address the mobility needs of Central Florida. With technology continually growing at a rapid rate and various levels of vehicle autonomy becoming more common, technology and sustainability are key elements when looking into the 2032 horizon. Taking this into consideration, updates to this Master Plan should be performed every 3-5 years, or as necessary, in order to ensure future planning efforts are incorporated.

Opportunity Costs

Several deployments identified in Section 4 - Intelligent Transportation System (ITS) Needs and also included as part of the deployments detailed in Section 5 - Identification of Applicable ITS Strategies would benefit from added ITS improvements. The absence of these resources can be considered as the potential Opportunity Cost, meaning how much the traveling public could be estimated to pay if improvements are not made. It has been determined that should the improvements recommended by this Master Plan not be put in place, the cost incurred by CFX users, and its surrounding communities could be up to an estimated $568.7M over the course of the next 10 years. This cost was obtained by utilizing FDOT's crash costs based on crash severity type i.e., fatal, severe injury, moderate injury, minor injury and property damage. Each of these factors were assigned a dollar amount based on severity and applied to all crashes attained from Signal Four Analytics on CFX's system in 2018 and 2019.

Costs of Improvements/Solutions

To identify what size of an investment will be required, a high-level cost analysis was performed to estimate the capital investments and the amount of O&M funding required for each deployment. These investments aim to bolster CFX's ITS infrastructure and accommodate inevitable population growth that will come as the region becomes more developed. These costs were developed by using several resources such as the FDOT Six Month and Twelve Month Moving Statewide Average prices, existing CFX project

bids, referenced pilot projects, and annual operations and maintenance costs contracts. The estimated cost to build out the recommended deployments and operate and maintain them adequately for 10 years is $59.3M. See Section 5.8 - Project Costs for a detailed breakdown of this cost.

Benefit/Cost Analysis

A Benefit/Cost ratio is a measure to determine the viability of an effort when utilizing public funding. It quantifies the public benefit received for every public dollar spent. Any value greater than one indicates a positive return to the public. The benefit/cost for CFX is the ratio of the total opportunity cost divided by the cost to implement the ITS Master Plan recommendations, both as described above. Previous industry studies and FHWA's Crash Modification Factors Clearinghouse indicate that approximately 13% to 20% of the overall crashes have traditionally been reduced by implementing strategies such as the Smart Work Zone pilot project, signalization improvements, and Smart Parking improvements. Since CFX's system is mature where some benefits have likely already been realized, a conservative crash reduction factor of 15%, slightly below the range average, was used for this analysis. The corresponding benefit/cost ratio was calculated to be 9.59, which indicates that the project's estimated benefits significantly outweigh its costs. This tells us that for every dollar not spent on implementing and preserving these ITS applications, there is a resulting cost to the local economy of $9.59, or conversely for every dollar spent there is an estimated $9.59 in benefit to the economy.

Overall Benefits

In an era of decreasing budgets and limited resources, CFX has recognized that not only a monetary benefit is important but also the opportunity to improve congestion and safety on arterial roads by leveraging their strengths and their needs for partnership. As some roadways have already reached their capacity, management of congestion also provides additional benefits and safety to the public. Some of the benefits that CFX attains through implementing the recommended projects are:

- Reduce delays for travelers
- Improve travel time reliability
- Reduce costs of delay
- Increase safety for motorists
- Increase safety for first responders
- Increase real-time management of roadway network
- Fewer secondary incidents
- Fuel savings/reduced negative environmental impacts
- Improve real-time management of work zones
- Improve environmental factors (reduction of air pollutants)

The development of a well-defined vision and expected goals for this ITS Master Plan along with continued dialogue across planning and operations, will provide the basis for CFX to further progress. Further activity is required to build on the progress of the workshop and work towards the established vision for the future and a detailed plan for achieving that vision.

Table of Contents

Background Information i
Stakeholder Coordination iii
ITS Strategies iii
Existing Infrastructure v
Determination of Needs v
Solutions and Recommendations vii
Future Planning Updates viii
Opportunity Costs viii
Costs of Improvements/Solutions viii
Benefit/Cost Analysis ix
Overall Benefits ix
Table of Contents x
List of Tables xvii
List of Figures xviii
1. CFX ITS Vision, Goals, Objectives 2
1.1 Background 2
1.2 CFX ITS Master Plan Vision 3
1.3 CFX ITS Master Plan Goals 4
1.4 Objectives Relating to the ITS Master Plan 5
1.4.1. Event Management 5
1.5. Looking Ahead 14
1.6. Graphical Summary of Goals, Objectives, and Performance Measures 14
2. Defining ITS 17
2.1. Overview of ITS Strategies 17
2.1.1. Transportation Management Center 17
2.1.2. Communication System 17
2.1.3. Visual Surveillance 18
2.1.4. Vehicle Detection Systems 18
2.1.5. Advanced Traveler Information Systems (ATIS) 19
2.1.6. Incident Management and Highway Assistance 20
2.1.7. Active Transportation and Demand Management (ATDM) 21
2.1.8. Passive Demand Management 23
2.1.9. Electronic Payment Services 23

2.1.10. Work Zone Management 23
2.1.11. Part Time Shoulder Use (PTSU) 24
2.1.12. Event Management 25
2.1.13. Safety Measures 25
2.1.14. Connected Vehicles 26
2.1.15. Traffic Data Information Management 31
2.1.16. Traffic Signal Systems 31
2.1.17. Public Transportation Management 33
2.1.18. Freight Advanced Traveler Information Systems (FRATIS) 33
2.1.19. Asset Management 33
2.1.20. Public Travel Security 34
2.1.21. Innovative Bicycle and Pedestrian ITS Solutions 34
2.1.22. Active Parking Management 34
3. Existing Conditions 37
3.1. CFX Facilities 37
3.1.1. SR 408 (Spessard L. Holland East-West Expressway and Arnold Palmer Expressway) 37
3.1.2. SR 414 (John Land Apopka Expressway) 38
3.1.3. SR 417 (Central Florida GreeneWay) 39
3.1.4. SR 429 (Daniel Webster Western Beltway and Wekiva Parkway) 40
3.1.5. SR 451 41
3.1.6. SR 453 41
3.1.7. SR 516 (Lake Orange Expressway) 41
3.1.8. CR 522 (Osceola Parkway Extension) 41
3.1.9. SR 528 (Martin Andersen Beachline Expressway) 42
3.1.10. SR 538 (Poinciana Parkway) 42
3.1.11. SR 551 43
3.1.12. Traffic Congestion in Central Florida 43
3.2. Existing CFX ITS Infrastructure 44
3.2.1. Previous ITS Master Plan 45
3.2.2. CFX Existing ITS Infrastructure 47
3.2.3. Existing ITS Devices 48
3.2.4. Information Dissemination 49
3.2.5. Fiber Optic Network 50
3.2.6. Network Communications, Security and Monitoring 52
3.2.7. Server Environment and Storage Capacity 52

3.3. Neighboring Municipalities and/or Modal Agencies 53
3.4. Planned and Committed Improvements 56
3.4.1. Existing System Improvements 56
3.4.2. System Expansion Projects 57
3.4.3. Interchange Projects 59
3.4.4. Facilities and Sustainability Projects 59
3.4.5. Transportation Technology Projects 59
3.4.6. Information Technology Projects 60
3.4.7. Signing and Pavement Markings Projects 60
3.4.8. Renewal and Replacement Projects 60
3.4.9. Non-System Projects 61
3.5. Future/Expected Expansion of Express Lanes 61
3.5.1. Future CFX Expressway Improvements 61
3.5.1.1. SR 408 Eastern Extension 61
3.5.1.2. SR 538 Poinciana Parkway Extension/I-4 Connector 61
3.5.1.3. SR 538 Widening from Ronald Reagan Parkway to CR 580/Cypress Parkway 63
3.5.1.4. Lake/Orange County Connector 64
3.5.1.5. SR 414 (Apopka Expressway) Extension 64
3.5.1.6. CR 522 (Osceola Parkway Extension) 65
3.5.2. FDOT Express Lanes Projects 66
3.5.2.1. I-4 Ultimate and I-4 Beyond the Ultimate 66
3.6. Identification and Response to Traffic Incidents 67
3.7. Park & Ride Facilities 70
3.8. Evacuation Routes 70
3.9. Multimodal & Intermodal 76
3.9.1. LYNX 77
3.9.2. SunRail 77
3.9.3. Brightline 78
3.9.4. CFX's Multimodal Initiatives 79
3.9.5. Regional Transit Study 80
3.9.6. Geographic Information System (GIS) 80
3.10. Existing Coordination Efforts 81
3.10.1. FDOT's Integrated Corridor Management (ICM) Program 82
3.10.2. FDOT's Decision Support System (DSS) 82
3.10.2.1 Current Progress of FDOT's Decision Support System (DSS) 83

3.10.3. Stakeholder Coordination - Existing Conditions 83
3.11. Connected and Automated Vehicle (CAV) Deployment 87
3.11.1. CFX and CAV Technology 88
3.11.2. HERE, Wejo and CAV Technology 88
3.12. LiDAR Technology Optimization 89
3.12.1. CFX Wrong Way Driving LiDAR Vehicle Detection Pilot 89
3.12.2. LiDAR 3D Surveying Equipment Technology Pilot Program 92
3.13. CFX Analytics (iPaas) Pilot Test 92
4. Intelligent Transportation System (ITS) Needs 95
4.1. Overview of ITS Strategies 95
4.2. CFX Transportation Needs 95
4.2.1. System Congestion 96
4.2.2. Safety 97
4.2.3. Event Management 100
4.2.4. Summary of Needs – System Roadways (Goals 1 & 2) 101
4.3. CFX Technology Needs (Goals 3, 4 & 5) 102
4.3.1. Future Traffic Management Center (TMC) 103
4.3.2. Network Infrastructure 104
4.3.3. ITS Devices 105
4.3.4. Connected and Automated Vehicle (Goals 4 & 5) 107
4.3.5. CAV Infrastructure Readiness 108
4.3.6. Connected Vehicle Devices and Application 111
4.3.7. Business Policy and Outreach Considerations 114
4.3.8. Regulatory Requirements – Federal Communications Commission (FCC) 115
4.3.9. Security Credential Management System (SCMS) 117
4.3.10. Device Procurement 119
4.3.11. Geographic Information System 119
4.3.12. Telematics 121
4.3.13. ITS and Technological Strategies 121
4.3.14. Infrastructure and Hardware 122
4.3.15. Storage 122
4.3.16. Cloud-Ready Needs 122
4.3.17. Data Considerations 123
4.3.18. Description of Data Needs Categories 123
4.3.19. Infrastructure Assessment (IA) 123

4.3.20. Existing and Known Data (ED) 125
4.3.21. Potential Future Data Needs (FD) 126
4.3.22. Data Policy and Governance (PG) 127
4.3.23. Maintenance Data (MT) 128
4.3.24. Summary of Data Needs 129
4.4. Sustainability Needs 130
4.5. Regional Partner Needs 130
4.5.1. Project Stakeholders 130
4.5.2. MetroPlan 130
4.5.3. FDOT District 5 131
4.5.4. FDOT Turnpike 132
4.5.5. City of Orlando 132
4.5.6. Orange County 133
4.5.7. Seminole County 133
4.5.8. Osceola County 133
4.5.9. Lake County 134
4.5.10. SpaceCoast TPO 134
4.5.11. I-4 Mobility Partners 134
4.5.12. Brightline 135
5. Identification of Applicable ITS Strategies 137
5.1. Congestion Strategies 137
5.2. Safety Strategies 138
5.2.1. Work Zone Safety Strategies 138
5.2.2. Ramp Intersection Safety Strategies 139
5.3. CFX Technology Strategies 140
5.3.1. Future Traffic Management Center (TMC) Strategy 140
5.3.2. ITS Device Replacement/Upgrade Strategies 140
5.3.3. Connected Vehicle Strategies 145
5.4. Data Related Strategies 154
5.4.1. Infrastructure Assessment (IA) 154
5.4.2. Existing and Known Data Needs (ED) 155
5.4.3. Evaluation of Potential Future Data Needs (FD) 156
5.4.4. Data Policy and Governance (PG) 156
5.4.5. Data Maintenance (MT) 157
5.5. Other Strategies 157

5.5.1. Event Management 157
5.5.2. Integrated Transportation Application Strategy 159
5.5.3. Sustainability 159
5.5.4. Service Patrol 160
5.6. Project Identification by Type and Need 161
5.6.1. Project Identification for Transportation Needs 161
5.6.2. Project Identification for Technology and Data Needs 163
5.6.3. Project Identification for Other Needs 165
5.7. Staffing Analysis 166
5.7.1. Existing Operations and Maintenance Staffing 166
5.7.2. Connected Vehicle and Data Staffing Considerations 167
5.7.3. Updated Staffing Considerations 170
5.8. Project Costs 172
5.8.1. Capital Improvement Costs 172
5.8.2. Operations and Maintenance Costs 174
5.8.3. Life Cycle Costs 175
5.9. Opportunity Cost and Benefit/Cost Ratio 177
5.10. ITS Standards Recommendations 178
5.10.1. ITS Maintenance Standards 178
5.10.2. ITS Operations Standards 180
5.10.3. ITS Device System Monitoring and Reporting 181
5.10.4. Roadway Monitoring and Reporting 181
5.10.5. Event Management 182
5.10.6. Performance Monitoring 183
5.10.7. Data Standards 183
5.10.8. Connected Vehicles Interoperability and Device Standards 185
5.11. Training Considerations 186
5.11.1. Operations Training 186
5.11.2. Maintenance Training 186
5.11.3. Network Training 187
5.11.4. Connected Vehicle Training 188
5.12. Stakeholder Coordination 189
6. Regional ITS Architecture (RITSA) 191
6.1. Background 191
6.2. CFX Related Service Packages in the FDOT District Five RITSA 192

6.3. Projects Listed in the District Five RITSA 194
6.4. Proposed Changes for Consideration 194
7. Concept of Operations 198
7.1. Identification 198
7.2. Purpose and Intended Audience 198
7.3. Document Overview 198
7.3.1. High-Level System Overview 199
7.3.2. Stakeholders 199
7.3.3. Referenced Documentation 199
7.4. Current System Situation 200
7.4.1. Background, Objectives, and Scope 200
7.4.2. Operational Constraints 200
7.4.3. Description of the Current System or Situation 201
7.4.4. User Class Profiles 201
7.4.5. Support Environment 202
7.5. Change Justification 202
7.5.1. Justification for Changes 202
7.5.2. User Needs 203
7.6. Concepts for the Proposed System 204
7.6.1. Background, Objectives, and Scope 204
7.6.2. Description of the Proposed System 204
7.6.3. Modes of Operation 207
7.6.4. User Involvement and Interaction 207
7.6.5. Assumptions and Constraints 207
7.6.6. Risks 207
7.6.7. Support Environment 208
7.7. Operational Scenarios 209
7.8. Summary of Impacts 210
7.9. Analysis of the Proposed System 211
7.9.1. Alternatives 211
7.9.2. Cost, Schedule, and Procurement Options 211
7.9.3. Systems Engineering Plan 211
7.9.4. Performance Measurement for System Validation 211

List of Tables

Table 1: Identified O&M Needs vi
Table 2: Levels of Part Time Shoulder Use (Adapted from FHWA Decision Support 25
Table 3: SR 408 Tolling Facility Locations 38
Table 4: 414 Tolling Facility Locations 39
Table 5: SR 417 Tolling Facility Locations 39
Table 6: SR 429 Tolling Facility Locations 40
Table 7: SR 453 Tolling Facility Locations 41
Table 8: CR 522 Tolling Facility Locations 42
Table 9: SR 528 Tolling Facility Locations 42
Table 10: SR 538 Tolling Facility Locations 43
Table 11: SR 551 Tolling Facility Locations 43
Table 12: Existing ITS Communication Systems 56
Table 13: CFX Device and Equipment Life Cycle 107
Table 14: Operational/Mobility, Safety and Maintenance Needs 113
Table 15: CAV Operations/Mobility Focus Areas 114
Table 16: CAV Safety Focus Area 114
Table 17: Business Needs and Outreach Considerations 115
Table 18: Infrastructure Assessment Data Needs 124
Table 19: Existing and Known Data Needs 125
Table 20: Potential Future Data Needs 127
Table 21: Data Policy and Governance Data Needs 127
Table 22: Maintenance Data Needs 128
Table 23: Summary of Identified Technology and Data Needs 129
Table 24: Ramp Intersection Safety Strategies 139
Table 25: Device and Equipment Replacements based on Life Cycle 142
Table 26: Identification of Transportation Needs 162
Table 27: Recommended Maintenance Projects 163
Table 28: Recommended Staffing Guidelines 171
Table 29: Capital Costs per Project 173
Table 30: Operations and Maintenance Costs Per Year 174
Table 31: Life Cycle Replacement Costs 176
Table 32: Stakeholders 199
Table 33: Referenced Documentation 199
Table 34: User Needs 203
Table 35: Transportation Needs Project List 205
Table 36: Risk Register 208

List of Figures

Figure 1 : ITS Master Plan Goals, Objectives, and Performance Measures 15
Figure 2: SAE Levels of Driving Automation 28
Figure 3: US DOT Published V2I Hub System View 30
Figure 4: Current CFX Existing Roadway Map and Tolling Plazas 45
Figure 5: CFX Fiber Optic Network (FON) Infrastructure 51
Figure 6: System Expansion Map 58
Figure 7: Future Expansion of SR 408 (East-West Expressway) 61
Figure 8: SR 538 Poinciana Parkway Extension/I-4 Connector Expansion 62
Figure 9: SR 538 Widening Ronald Reagan Parkway to CR 580/Cypress Expressway 63
Figure 10: Lake/Orange County Connector Expansion 64
Figure 11: SR 414 (Apopka Expressway) Future Extension 65
Figure 12: CR 522 (Osceola Parkway) Future Extension 66
Figure 13: CFX Traffic Incident Management Plan 68
Figure 14: CFX Scene Management Plan 69
Figure 15: CFX Shared Evacuation Routes 71
Figure 16: Brevard County Evacuation Zones and Routes 72
Figure 17: Lake County Evacuation Zones and Routes 73
Figure 18: Orange County Evacuation and Routes 74
Figure 19: Osceola County Evacuation Zones and Routes 75
Figure 20: Seminole County Evacuation Zones and Routes 76
Figure 21: CFX GIS Road Map Short and Long-Term Goals 81
Figure 22: Project Flow Schedule of R-ICMS Program 83
Figure 23: CFX WWD Lidar Pilot Program Test Site 90
Figure 24: Processing Map for WWD Lidar Pilot Project 91
Figure 25: Examples of Notifications via Text or Email 91
Figure 26: LiDAR 3D Surveying Equipment Technology Pilot Program Study Timeline 92
Figure 27: Depiction of a Connected Vehicle Environment 110
Figure 28: V2I Functional Architecture 111
Figure 29: Connected Vehicle Implementation Plan 112
Figure 30: USDOT Illustration of SCMS Communication between Devices 118
Figure 31: USDOT Illustration of SCMS Communication between Devices 118
Figure 32: Recommended CFX ArcGIS Roadmap Workflow 121
Figure 33: Connected Vehicle Considerations 146
Figure 34: Arc-IT Toll Collection Diagram 148
Figure 35: Illustration of Primary Ramp Metering Application Components 149
Figure 36: CFX Operational/Mobility, Safety and Maintenance Needs 150
Figure 37: Mobility and Safety Technology Short-Term and Mid-to-Long-Term 152
Figure 38: 2020 United States Auto Sales by Brand 153
Figure 39: CFX Existing ITS Organizational Chart 166
Figure 40: Staffing Considerations by Project Phase 170
Figure 41: Impact Costs and Savings to Society 177
Figure 42: CFXs Focus Areas for Stakeholder Coordination 189

List of Acronyms

AADT ..... Average Annual Daily Traffic
AAS ..... Automatic Announcement System
AET ..... All-Electronic Tolling
AFAD ..... Automated Flagger Assistance Devices
AACN ..... Advanced Automatic Crash Notification Relay
AI ..... Artificial Intelligence
APC ..... Automatic Passenger Counter
APL ..... Approved Products List
ARC-IT ..... Architecture Reference for cooperative and Intelligent Transportation
ASCT ..... Adaptive Signal Control Technology
AAM ..... Active Arterial Management
ACC ..... Adaptive Cruise Control
ADMS ..... Arterial Dynamic Message System
APC ..... Automatic Passenger Counter
AST ..... Adaptive Signal Control Technology
ATC ..... Advanced Traffic Controllers
ATDM ..... Active Transportation and Demand Management
ATIS ..... Advanced Traveler Information Systems
ATMS ..... Advanced Traffic Management Software
ATS ..... Adaptive Traffic Signal
AV ..... Automated Vehicle
AVI ..... Automated Vehicle Identification
AVL ..... Automatic Vehicle Location
BSM ..... Basic Safety Message
C-V2X ..... Cellular Vehicle-to-Everything
CAMP ..... Crash Avoidance Metrics Partnership
CAV ..... Connected and Automated Vehicle
CBRAS ..... Citizens Band Radio Advisory System
CCTV ..... Closed Circuit Television
CFR ..... Code of Federal Regulations
CFX ..... Central Florida Expressway Authority
CV ..... Connected Vehicle
CVRIA ..... Connected Vehicle Reference Implementation Architecture
ConOps ..... Concept of Operations
COTS ..... Commercial Off-The-Shelf
CSW ..... Curve Speed Warning
CVP ..... Connected Vehicle Professional
D-PTSU ..... Dynamic Part Time Shoulder Use
DBA ..... Database Administrator
DCS ..... Data Collection Sensors
DDI ..... Diverging Diamond Interchanges
DOT ..... Department of Transportation
DSRC ..... Dedicated Short-Range Communications
DSS ..... Decision Support System

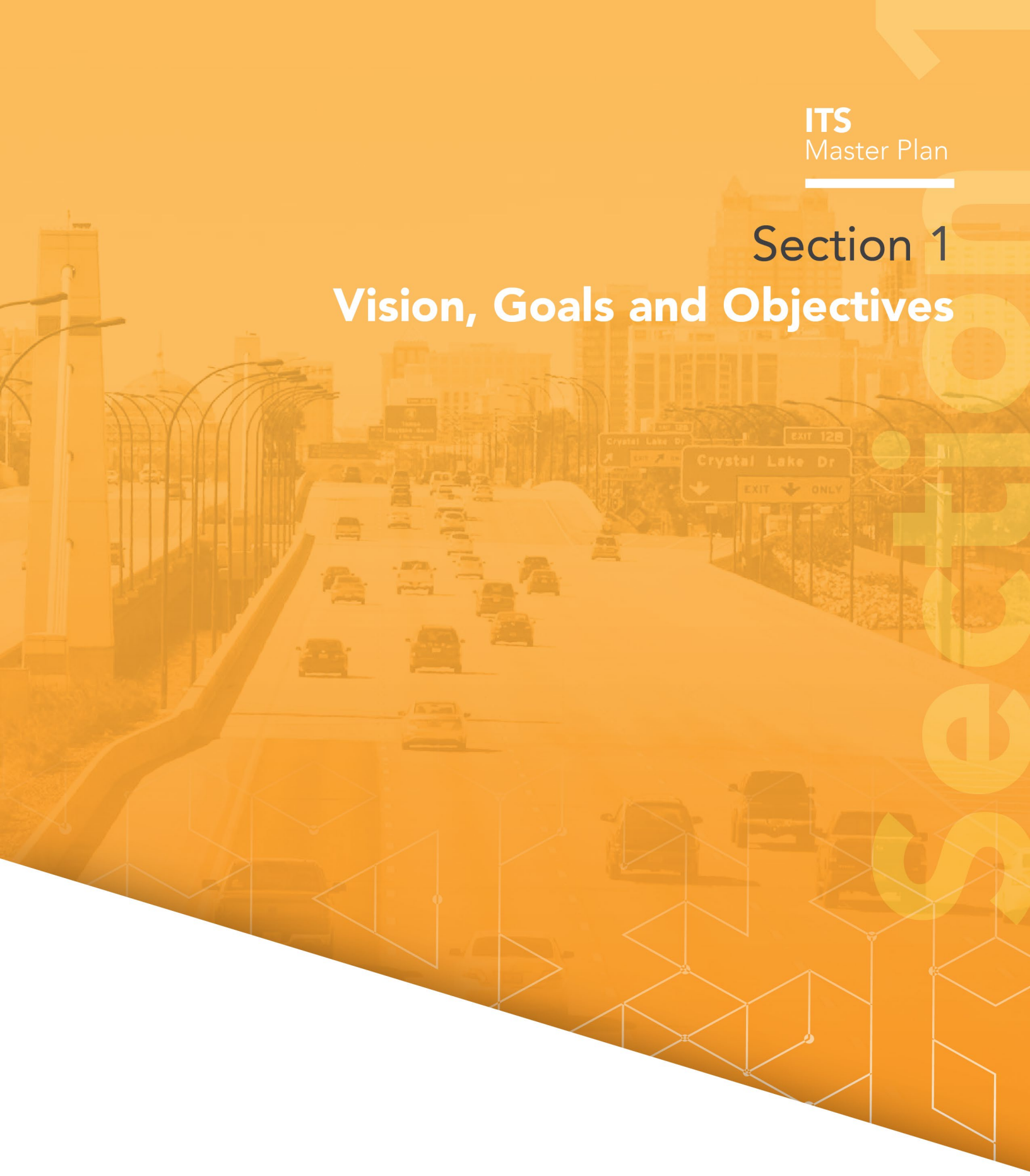
DTTM ..... Design Traffic Technical Memorandum
DMS ..... Dynamic Message Signs
DMZ ..... Demilitarized Zone
ED ..... Existing and Known Data
EOC ..... Emergency Operations Center
EPA ..... Environmental Protection Agency
ERE ..... Expert Rules Engine
EVE ..... Evaluation Engine
EVAC ..... Advanced Automatic Crash Notification Relay
FCC ..... Federal Communication Commission
FD ..... Potential Future Data Needs
FD ..... Future Data Needs
FDOT ..... Florida Department of Transportation
FEC ..... Florida East Coast
FL511 ..... Florida 511
FNPRM ..... Further Notice of Proposed Rule Making
FHP ..... Florida Highway Patrol
FHWA ..... Florida Highway Administration
FOC ..... Fiber Optic Cable
FON ..... Fiber Optic Network
FRATIS ..... Freight Advanced Traveler Information Systems
FTE ..... Florida Turnpike Enterprise
FTP ..... Florida Transportation Plan
FYA ..... Flashing Yellow Arrow
GUI ..... Graphical User Interface
HAR ..... Highway Advisory Radio
HAWK ..... Highway Advisory Radio High Intensity Activated Cross Walk
HMI ..... Human Machine Interfaces
HOV ..... High-Occupancy Vehicle
I2V ..... Infrastructure-to-Vehicle
IA ..... Infrastructure Assessment
ICE ..... Internal Combustion Engine
ICM ..... Integrated Corridor Management
IDP ..... Intrusion Detection and Prevention
IEEE ..... Institute of Electrical and Electronics Engineers
iPaas ..... InNovo Platform as a Service
ISS ..... Integrity Security Services
ITS ..... Intelligent Transportation Systems
ITSFM ..... Intelligent Transportation System Facilities Management
IVP ..... Integrated V2I Prototype
IVS ..... Intelligent Video Integration Solution
JPO ..... Joint Program Office
LAN ..... Local Area Networks
LRTP ..... Long Range Transportation Plan
MAP ..... Map Data Messages
MAW ..... Motorist Alert and Warning
MIMS ..... Maintenance Inventory Management System

MT ..... Maintenance Data
MOT ..... Maintenance of Traffic
MUT ..... Median U-Turns
NHTSA ..... National Highway Traffic Safety Administration
NITSA ..... National ITS Architecture
NTCIP ..... National Transportation Communications for ITS Protocol
O&M ..... Operations and Maintenance
OBU ..... On-Board Units
OTP ..... OpenTrip Planner
PEV ..... Plug-in Electric Vehicle
PG ..... Policy and Governance
PKI ..... Public Key Infrastructure
PRE- ..... Predictive Engine
PSEMP ..... Project Systems Engineering Management Plan
PTSU ..... Part Time Shoulder Use
PTZ ..... Pan Tilt Zoom
PV ..... Photovoltaic
Q-WARN ..... Queue Warning
RADAR ..... Radio Detecting and Ranging
RAD-IT ..... Regional Architecture Development for Intelligent Transportation
R-ICM ..... Regional Integrated Corridor Management
RESP-STG ..... Incident Scene Pre-Arrival Staging Guidance
RFID ..... Radio Frequency Identification
RISC ..... Rapid Incident Scene Clearance
RITSA ..... Regional ITS Architecture
RMA ..... Return Merchandise Authorization
RPMs ..... Retro-Reflective Pavement Markers
RRFB ..... Rapid Rectangular Flashing Beacons
RSU ..... Roadside Units
RSWZW ..... Reduced Speed Work Zone Warning
RTMC ..... Regional Traffic Management Center
RTME ..... Route and Mode Choice Engine
RTVM ..... Requirements Traceability Verification Matrix
SAE ..... Society of Automotive Engineers International
SCMS ..... Security Credential Management System
SEQ ..... Sequential Flashing Warning Lights
SFTP ..... Secure File Transfer Protocol
SH ..... Speed Harmonization
SITSA ..... Statewide ITS Architecture
SPaT ..... Signal Phasing and Timing
SWIW ..... Spot Weather Impact Warning
SWZ ..... Smarter Work Zones
TCD ..... Traffic Control Devices
TDMS ..... Tolls 2-Line DMS
THEA ..... Tampa Hillsborough Expressway Authority
TMS ..... Traffic Monitoring Station
TIM ..... Traffic Incident Management

TMC ..... Traffic Management Center
TMP ..... Transportation Management Plan
TPMS ..... Tire Pressure Monitoring Sensor
TPAS ..... Truck Parking Availability System
TSM&O ..... Transportation Systems Management and Operations
TSP ..... Transit Signal Priority
UCF ..... University of Central Florida
UDN ..... Utility Distribution Network
UI ..... User Interface
USDOT ..... United States Department of Transportation
V2I ..... Vehicle-to-Infrastructure
V2N ..... Vehicle-to-Network
V2P ..... Vehicle-to-Pedestrian
V2V ..... Vehicle-to-Vehicle
V2X ..... Vehicle-to-Everything
VHD ..... Vehicle Hours of Delay
VMT ..... Vehicle Miles of Travel
VSL ..... Variable Speed Limit
WWD ..... Wrong Way Driving
WWVDS ..... Wrong Way Vehicle Detection Systems
WZIA ..... Work Zone Intrusion Alarm

ITS
Master Plan

Section 1
Vision, Goals and Objectives



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1. CFX ITS Vision, Goals, Objectives

The development of an ITS Master Plan requires clear direction at inception. This section will detail a vision, goals, and objectives for the Master Plan that will serve as a guide for the project team. Performance measures will also be defined in order to track progress towards the goals and objectives established within the ITS Master Plan. The goals, objectives, and performance measures detailed in this section provide the necessary guidelines for success. Transportation Systems Management and Operations (TSM&O) is an innovative way of actively managing and maintaining the multimodal transportation network, measuring performance, streamlining and improving the existing system, promoting effective cooperation/collaboration, and delivering positive safety and mobility outcomes to the travelling public. This ITS Master Plan will take on a TSM&O approach. Please note that throughout this document, the term "transportation" refers to the transportation system as a whole, rather than individual forms such as cars or buses.

1.1 Background

The Central Florida Expressway Authority (CFX) is an independent agency of the state that operates and maintains a regional network of expressways for over 3 million residents and an estimated 75 million visitors in Brevard, Lake, Orange, Osceola and Seminole Counties. Created by the Florida Legislature in 2014, CFX's 125-mile user-funded system includes 830 center lane miles, 72 interchanges, 19 mainline tolling facilities, 74 ramp tolling facilities and 342 bridges and eight named expressways. The CFX Governing Board has seven local elected officials, representing the counties of Brevard, Lake, Orange, Osceola and Seminole, the city of Orlando, three governor appointees, and the executive director of Florida Turnpike Enterprise as a non-voting advisory member.

CFX's purposes and powers as well as other legal authorities are defined in Florida Statute 348, Part III. CFX was created and established to acquire, hold, construct, improve, maintain, operate, own, and lease in the capacity of lessor of the Central Florida Expressway System in Orange, Seminole, Lake, Brevard, and Osceola Counties. CFX can further expand the Central Florida Expressway System beyond these County limits with the consent of the County in question. As a part of this role, CFX has numerous rights and powers that are defined in F.S. 348.754(2). For instance, in the construction of the Central Florida Expressway System, the authority may construct any extensions, additions, or improvements to the system or appurtenant facilities, including all necessary approaches, roads, bridges, avenues of access, rapid transit, trams, fixed guideways, thoroughfares, and boulevards with any changes, modifications, or revisions of the project which are deemed desirable and proper. To support these efforts, CFX has the ability to fix, alter, charge, establish, and collect rates, fees, rentals, and other charges for the services and facilities of the Central Florida Expressway System. It is important to note that CFX not only has legislative constraints, but also bonding constraints. Therefore, any improvement and/or charges must also comply with the covenants made with the holders of the bonds issued.

Of particular note, since ITS and TSM&O improvements are regional and multimodal in nature, CFX may within the right-of-way of the expressway system, finance or refinance the planning, design, acquisition, construction, extension, rehabilitation, equipping, preservation, maintenance, or improvement of an intermodal facility or facilities, a multimodal corridor or corridors, or any programs or projects that will

improve the levels of service on the expressway system. Further, per its Master Bond Resolution – Article V, CFX may not participate in the acquisition, construction or operation of any non-tolled road except for a "feeder road" that is less than one mile. However, this does allow for a "feeder road" less than one mile that could function as an intermodal connection for instance. Finally, CFX cannot allow competing facilities within the right-of-way, parallel to the Expressway System, that will result in a reduction of system pledged revenue.

The above indicates that CFX can collaborate regionally at an intermodal, multimodal and/or programmatic level (within legislative and bonding constraints) in order to improve the expressway system has a whole. This allows CFX to use a broad swath of ITS and TSM&O strategies (Discussed in later sections) to improve the expressway system for its customers[1].

1.2 CFX ITS Master Plan Vision

CFX delivers a regional approach to transportation planning in the Central Florida region. Therefore, an ITS Master Plan is key in creating direction. Before establishing goals and objectives for the ITS Master Plan, a clear vision must be established. Vision statements and documents from the CFX 2040 Master Plan, CFX Five-Year Work Program Plan, CFX Strategic Plan, 2045 Florida Transportation Plan (FTP) and the Florida Department of Transportation (FDOT) District 5 ITS Master Plan were used as a guide in assisting the project team with the development of the CFX ITS Vision Statement.

CFX 2040 Master Plan Vision Statement:

"To provide the region with a world-class, integrated mobility network that drives economic prosperity and quality of life."

FDOT Vision Statement:

"As one FDOT team, we serve the people of Florida by providing a transportation network that is well planned, supports economic growth, and has the goal of being congestion and fatality free."

FDOT ITS Master Plan Vision Statement:

"Be the national leader in ITS by promoting multi-jurisdictional coordination for the provision of an efficient, secure, reliable, and safe transportation system."

2045 FTP Vision Element:

"Our vision for Florida in 2045 is for a robust transportation system to meet the needs of a dynamic state by accomplishing the seven goals of the FTP. If we work toward these goals as a set, our transportation system in 2045 and beyond will have zero fatalities, reliable travel times, seamless mobility, and universal accessibility."

[1] An intermodal transportation system is defined as the movement of cargo from origin to destination by several modes of transport where each of these modes have a different transport provider or entity responsible, each with its own independent contract. Multiple carriers contracted to fulfill a single journey. A multimodal transportation system is the movement of cargo from origin to destination by several modes of transport where each of these modes have a different transport provider or entity responsible, but under a single contract. A single carrier contracted to fulfill a single journey.

The project team has proposed the following statement be utilized as the vision statement for the CFX ITS Master Plan based upon the aforementioned vision statements:

"To provide a safe and innovative world-class mobility network that enhances quality of life while ensuring reliability, security and sustainability for all system users."

Efficiency, reliability, safety, and sustainability should be a priority of any project, and the existing CFX transportation system can be built upon and improved to increase these four main themes. Automobile users are considered the primary benefactor of ITS projects but the ITS Master Plan will also include multi-modal and intermodal elements with an emphasis on technology applications.

1.3 CFX ITS Master Plan Goals

To fully realize the ITS Vision and provide a guiding framework for developing the ITS Master Plan, the 2040 Master Plan, 2045 Florida Transportation Plan, CFX Five-Year Work Program Plan, and the CFX Strategic Three-Year Plan were reviewed to determine how ITS strategies could support the primary goals outlined in the Strategic Plan. After reviewing the goals of all interested parties, the following goals of the CFX ITS Master Plan have been established:

1. **Effectively Manage a Safe, Secure and Efficient Transportation System for All Users:** The Management, Expansion and Modification of the ITS infrastructure will build upon the solid foundation of safety and security within the region. The addition/expansion of ITS and other advanced technologies to provide a reliable and secure network can be achieved through technology and other innovative enhancements. These enhancements will benefit all users by reducing congestion, delays, and travel times. It will also augment cybersecurity benefits such as intrusion detection and prevention. Moreover, providing a safer roadway due to reducing response times for emergency vehicles and a safer work environment for construction workers due to work zone safety efforts or informing the motorist of potential delays.

2. **Provide Service Excellence with a Resilient and Quality Infrastructure:** Improvements to the infrastructure's mobility network through effective management and operations of the existing and forthcoming transportation system will be key in providing service excellence. This infrastructure will adapt to customer needs and create seamless connections by streamlining and simplifying customer touchpoints and interaction, expand customer services, and broaden the awareness of toll road benefits.

3. **Invest in Innovative Solutions to Support Commerce, Equity, Quality of Life and Safety:** Implementation of new technologies to primarily focus on leveraging the resources and opportunities associated with CFX's extensive infrastructure will provide the framework needed for the development of the overall purpose of the ITS Master Plan. These strategies may include examining traveler information services, trip planning and management services, management of toll/fare collection and electronic payment systems, integrating electronic payment between E-PASS and other transportation activities, parking services, and development of connected and Automated vehicle ITS infrastructure for existing and future use.

4. **Provide a Connected and Reliable System for People and Freight through Regional Collaboration:** Connectivity of people, services and goods is a common goal among all transportation and planning agencies. The primary objective is to connect regions and economic centers through a multimodal/intermodal transportation system while encouraging long term economically sustainable development.

5. **Proactively take Measures to Sustain our Environment:** ITS infrastructure can be brought into use in ways that are not only economically feasible but are also environmentally friendly which reduce environmental impacts. This ITS Master Plan aims to increase sustainability of our environment and natural resources by reducing emissions, as well as avoiding and mitigating impacts on conservation land for future generations. These efforts can be done in conjunction with the integration of regional coordination and collaboration to maintain service excellence.

   This master plan will focus on supporting different modes through technology applications. This goal also addresses the added value and purpose of Regional Coordination/Collaboration within the surrounding areas to ensure common goals and foresight within the industry and its stakeholders.

1.4 Objectives Relating to the ITS Master Plan

Once ITS strategies supporting the ITS Master Plan goals were identified, the project team created an objectives list that will support the realization of these goals by identifying which specific ITS strategies could be reported and measured.

To quantify the objectives, a performance measure has been identified for each as a starting point for assessing the goal being targeted by the objective. ITS related performance measures have been generated based on the measures outlined for the primary objectives discussed in this section. CFX will rely on the following performance measures and targets to evaluate progress towards achieving the ITS Master Plan goals and ultimately, the goals of the FTP and FDOT D5. To strive for consistency of measurements over time, CFX will set a current baseline data point for each performance measure. Once the baseline is established, CFX can update the performance measures and track progress.

1.4.1. Event Management

The primary ITS objectives and corresponding performance measures applicable to the ITS Master Plan are identified throughout this section. They are numbered in the following fashion: Goal, Objective, and Measure. *For example, the number 1.2.3 would mean Goal 1, Objective 2 and Measure 3.*

Objective 1.1 – Improve Safety for all users

Measure 1.1.1 – Perform Systemwide Safety Enhancements to maintain acceptable levels of traffic operation

ITS Performance Measure: Technology and innovation can be used to upgrade the standards of operations. This measure will enhance the existing and future system by upgrading the ITS Network, installing security cameras at plazas, ramps and service centers, incorporating work

zone safety elements, continuing to tackle Wrong-Way Driving Countermeasures for future development, and the potential deployment of Dynamic Curve Warning systems (DCWS) to name a few. Performance measures for some of these applications can include measuring documented turnarounds at WWD locations, measuring number of WWD crashes and citations on the system, number of WWD system wide deployments, percentage system coverage, number of crashes/incidents in work zones and measured speed in work zones and speed and incidents at locations with DCWS deployments.

Objective 1.2 – Reduce system-wide delay for all users

Measure: 1.2.1 – Vehicle hours of delay (VHD) on the system

ITS Performance Measure: Average VHD per person per day is used as a basic measure of user experience. CFX along with the surrounding counties in the region are experiencing heavier than normal growth rates within their jurisdictions (primarily Orange and Osceola County), bringing an increase in the amount of traffic which, if not taken into consideration, will greatly decrease the efficiency of the roadways. Expansion of ITS devices (CCTV, DCS, etc.) to facilitate focused Traffic Incident Management (TIM) as well as consistent traveler information will assist in keeping the VHD at an acceptable level. Performance measures should be routinely measured to mitigate VHD increase based on population growth. The acceptable level of VHD should be determined for each roadway on the CFX system.

Measure: 1.2.2 – Increased data archiving and performance measurement

ITS Performance Measure: The 2022 – 2026 CFX Five-Year Work Plan notes that basic data collection practices (i.e., crash data, traffic counts, etc.) are in place, but there is a growing need for additional installation of data collection devices. In order to realize the vision of the Master Plan, the practice of collecting data should be continued and expanded. It is recommended that the operating agencies generate reports using the data, so that progress can be tracked and presented to funding agencies and show the value of ITS improvements. Measure the amount of data archived. In addition, consistently review the performance measures being used for relevance and potential expansion.

Objective 1.3 – Increase Operational Efficiency for all users

Measure 1.3.1 – Perform analyses on Tolling Systems

ITS Performance Measure: CFX is currently in the process of upgrading elements of the entire toll collection system. The project includes lane and plaza toll equipment, the centralized transaction server and unpaid toll/image processing. This investment supports the mix of electronic/coin/attended lanes, as well as a possible future transition to All-Electronic Tolling (AET).

Measure 1.3.2 – Perform analyses on Infrastructure

ITS Performance Measure: ITS field equipment and advanced technology systems are engrained into CFX's infrastructure. These devices and systems are primarily operated by partners through an agreement which includes action items to enhance system uptime via monitoring, operations, and proactive maintenance. As a measure, system reliability and efficiency of these systems are

key in determining operational efficiency for all users. The performance assessment associated for systems availability is to ensure uptime of the existing systems with prompt notification through hourly system checks and response from ITS maintenance based off of contracted performance measures which includes device uptime (i.e., CCTV's, TMS, DMS, etc.), network uptime and system uptime. Per industry standards as well as information gathered from FDOT, performance goals have been set as follows:

- **Device Uptime:** ≥ 95% Device (CCTV, DMS, TMS) Availability
- **Network Uptime:** ≥ 99% Network Uptime
- **System Uptime:** ≥ 95% System's Availability

Measure 1.3.3 – Perform Traffic Management with DCS, CCTV and DMS Upgrades

ITS Performance Measure: There are approximately 270+ Closed-Circuit Television (CCTV) cameras covering the existing system. The camera feeds are viewed by team members as well as operators at the FDOT D5 RTMC to identify and assist in the management of traffic incidents. Additionally, CFX has agreements in place with a number of local media stations, as well as media websites, to broadcast video during television newscasts. In order to keep up to date with traffic conditions, a travel-time system that leverages AVI-based Data Collection Sensors (DCS) placed at 188 locations including interchanges, system boundaries and Dynamic Message Sign (DMS) locations is installed. These sensors are accompanied by a data server and software system that provide accurate, reliable and trustworthy traveler information. The data server posts travel times to 74 DMS locations (includes Arterials and Mainline Travel Time DMS) and feeds exclusively to SunGuide, which then feeds FDOT's 511 traveler information service through center-to-center communication. Performance Metrics being used at the RTMC should be monitored to ensure no degradation of performance due to equipment faltering, becoming unreliable or obsolete.

Measure 1.3.4 – Perform Fiber Optic Network (FON) Utility Adjustments

ITS Performance Measure: CFX currently maintains a Fiber Optic Network (FON) of more than 250 miles, per the 2040 Master Plan. The FON serves the immediate and long-term telecommunications needs for data, voice, video transmission, tolls and future Intelligent Transportation System (ITS) applications. The network is installed along both sides of the roadway in a route-redundant configuration along all system facilities and provides linked telecommunication services between the headquarters, mainline toll plazas and ramp toll plazas. A direct fiber optic connection also exists between the headquarters and the FDOT District 5 Regional Traffic Management Center (FDOT D5 RTMC). This connection allows the sharing of video and data for coordinated traffic management purposes. FON utility adjustments must be made as necessary to ensure the integrity of the FON network. The FON reliability should match or exceed the network uptime of ≥ 99%.

Objective 2.1 – Improve reliability and predictability of travel

Measure 2.1.1 – Perform analyses on Travel Time Reliability and Predictability

ITS Performance Measure: Travel time reliability and predictability can also be measured using the following annual data that is more accessible based on current ITS conditions:

- Travel time
- Average incident response time (coordinate with local fire and police services)
- Miles and average duration of lane closures
- Weather
- Special events
- Crashes per lane mile

This measure involves an Integrated Corridor Management (ICM) and provides CFX with the ability to treat transportation as a single system while increasing the operational efficiency of transportation network as a whole and maximizing the impact of transportation investments. It is recommended that CFX works with its surrounding counties and agencies to implement the regular collection of one or more of the data sources above. Travel time reliability should be ≥ 90%.

Measure 2.1.2 – Percent of travelers with access to accurate real time traffic/transit information

ITS Performance Measure: Giving users the choice to switch their methods of travel should be encouraged in areas that have significant congestion or where economics dictate to lessen the number of vehicles on the roadway. Dissemination of real time mobility information and predictive travel time information may encourage some to make the desired switch. A traveler survey could be conducted (personal vehicle and transit users) to determine what percentage of travelers currently have access to traffic and transit information. This traffic and transit information can include parking availability information and real-time congestion information. The form of accurate access to traveler information (i.e., DMS, 511, CFX's mobile app, WAZE, etc.) should be noted as well. An additional survey should take place after any applicable ITS improvements have been put into place in order to measure the effectiveness of any new methods of disseminating data to the public by measuring the number of travelers informed.

Objective 2.2 – Increase Efficiency in Traffic Incident Management and Event Planning

Measure 2.2.1 – Provide a steady travel time to the motorist

ITS Performance Measure: Traffic Incident Management and event planning is a strategy that appeals to all stakeholders because most agencies have events that take place within their limits. Both traffic incidents and events can wreak havoc on a transportation system due to the nature of an influx of vehicle and pedestrian traffic for a specific amount of time within a condensed area. Traffic Incident Management can be classified as planned or unplanned events. Planned events include such things as normal recurring congestion, roadway construction/maintenance and special events. Unplanned events include incidents and activities that the RTMC was not previously aware of, including roadway construction/maintenance, special events, natural disasters, etc.

Local Agencies benefit from relationships with Major Special Event Coordinators, local roadway construction and maintenance agencies, as well as requesting information about planned construction and special events. This allows for exchange of information so that, if indicated, signal timing plan changes can be utilized for these lane blocking or traffic generating events.

When an incident occurs, the RTMC identifies incident details through CCTV, Emergency Responder Agency contacts and other sources. When an incident is confirmed by sources outside of the local agency, the RTMC gathers details from available CCTVs and notifies the appropriate agencies, including but not limited to: local police, fire/rescue and the Traffic Signal Engineer if an alternate timing plan may be warranted based upon the severity of the incident and the percentage of lanes blocked. This coordination reduces lane closure times and improve overall travel times for the CFX's customers.

Objective 3.1 – Integrate Big Data Management, Analytics and Security/Cyber Security of Data

Measure 3.1.1 – Number of roadway miles that have Connected and Automated (CAV) applications

ITS Performance Measure: Connected vehicle technology has advanced significantly within the past several years and will continue to be at the forefront of any agency's directive. The National Highway Traffic Safety Administration (NHTSA) revealed steps to enable vehicle-to-vehicle (V2V) communication technology, which heavily relies on wireless technologies and ITS connections, for vehicles and has issued its notice of proposed rulemaking regarding V2V technology. Connected vehicles use radio communications to converse between each other and the roadway corridor infrastructure to warn drivers and government agencies about potentially dangerous situations (i.e., Curve Speed Warnings (CSW) and Wrong Way Driving (WWD)). In addition to improving the safety of the traffic flow, this technology can also be used for other purposes such as toll collection and expanding into emerging markets that are compatible with CFX's current technology services and infrastructure, such as traveler information services, parking, etc.

Measure 3.1.2 – Number of devices/assets that are deployed for CAV applications

ITS Performance Measure: CAV systems are comprised a complex network of advanced wireless communications, on-board computer processing, advanced vehicle-sensors, GPS navigation, smart infrastructure, fiber optic cable, electrical cable, and an array of field devices. Integration requires actively managing assets in a unified manner so that actions can be taken to benefit the corridor as a whole while keeping track of the constantly changing system, whether it is expansion, maintenance, and/or upgrades. This measure is imperative to the upkeep of the infrastructure. An asset management database tool would help operate and maintain CAV deployments along CFX's infrastructure.

Measure 3.1.3 – Perform analyses on Dynamic Tolling Pricing/Tolling on Demand

ITS Performance Measure: CFX is widely known for its E-PASS system which is the first electronic toll collection system in Florida. This system was launched in 1994 and now supports more than 600,000 E-PASS accounts where users have the option to pay for tolls without the use of cash and without the need to stop at a toll plaza. Customers pay 23% less on average than motorists using cash. Customer can link a credit card to their account. Alternatively, users can visit a customer service location and add cash to the prepaid account. Extensive deployment of electronic toll collection throughout CFX's infrastructure has reduced operating costs and provided a higher level of customer experience.

CFX has the option to examine Dynamic Tolling technologies to enable the use of dynamic pricing on toll roads within the region. Pricing varies based on time of day or with sensors that can be

used to establish existing traffic conditions to drive the variation in tolls. In most cases the objective of this strategy is to maintain the target level of service on the toll road.

Tolling by Demand is a part of a demand management strategy to relieve congestion within a particular area. In most cases, the objective of this strategy is to relieve congestion within the Central Florida area not only for traffic but for parking as well. This strategy could be used to deter drivers from entering metropolitan areas during major events or during peak hours of the day. It would encourage users to park and ride into these restricted areas.

Objective 3.2 – Integrate Connected and Automated Vehicle Communication and Technology

Measure 3.2.1 – Targeted Information Gathering, Analysis and Dissemination Monitoring

ITS Performance Measure: All analytics products that provide data should align with the direct needs of CFX, its partners and stakeholders. To ensure that this goal is met, it is recommended that coordination with all of the identified stakeholders take place to establish the specific needs and ensure that those needs are met at all times. Frequent and active high movement of data usage should be monitored bi-weekly to ensure that the data being collected is valuable, has been stored efficiently and that it is being shared in a reliable manner. It is expected that there should be a 90% up-time on direct support to operational responses of, not only day-to-day operations, but also of special events and federal/state declared disasters.

Data speed is also a key element and is dependent on current bandwidth allocations. Optimized speed and robustness will help monitor the performance based on predefined thresholds which can also be achieved through dashboard development and data movement tracking.

Measure 3.2.2 – Number of transportation related datasets captured within a local data warehouse for business consumption

ITS Performance Measure: The transportation agencies deploy various types of roadway data monitoring, management and collection devices such as radar detectors, signal controllers, closed circuit television cameras and more. These devices produce various types of data that are streamed to a central Regional Traffic Management Center (RTMC). The data may then be stored within a data warehouse to be used immediately or in the future for to analyze for traffic related trends. This data is important and key to assisting transportation planners and engineers with designing roadways to address common and uncommon transportation related issues. Various datasets may be combined with data from other transportation entities and stored within the local data warehouse to enhance the overall data collected.

Measure 3.2.3 – Quality of analytic programs used to determine and predict transportation related trends

ITS Performance Measure: Data has become a prime commodity, bringing a wealth of insight to solving common problems through analyzing raw data to find trends and metrics. Within the transportation industry, programs are being developed to utilize data from common ITS devices to assist with understanding traffic flow, congestion, predicting crash conditions and developing hot spot zones for incidents based on historical data. These types of analytic programs provide an enormous safety benefit to road users and owners. With this strategy deployed, transportation agencies may gain deeper insight to its everyday challenges and provide its users with much better solutions.

Measure 3.2.4 – Number of data security threats detected and prevented

ITS Performance Measure: Data security has become extremely important over the last few years within the transportation industry. As data becomes more widely shared, data sources such as transportation industries become a more attractive target for individuals seeking to sabotage systems or illegal gain access to servers and systems hosting data owned by transportation industries. Transportation organization have already begun deploying security strategies to ensure data and systems are safe and secure from intruders.

Objective 3.3 – Support the expansion of electronic payment and E-Pass services

Measure 3.3.1 – Number of E-Pass services/facilities monitored

ITS Performance Measure: The collection of parking revenue using E-PASS/E-PASS mobile app could be expanded as a service to other parking garages that are not necessarily owned by CFX. This could lead to an integrated transportation system for the region allowing, parking, tolls, and transit fares to be paid from one consolidated account such as parking lot operators, transit agencies. On average, more than 1 million toll transactions are recorded daily with approximately 85% of them collected electronically. The next steps will be to incorporate Bluetooth payments for the Automatic Coin Machine (ACM) and integrate E-Pass/E-PASS mobile app along with security measures by utilizing sensors, telecommunications, and command-and-control features for public and private businesses.

Objective 3.4 – Investigate and Deploy Innovative Technology for TSM&O and ITS applications

Measure 3.4.1 – Improve the region and surrounding agencies with the latest technologies

ITS Performance Measure: ITS technologies have been segregated between arterial and freeway applications, but with the initiation of the TSM&O program and its goal of intertwining operations between the arterials and freeways (i.e., Integrated Corridor Management), ITS technologies are blending together in their fields of application.

Emerging technologies, tried and true safety applications and with up-and-coming initiatives, bring together a melting pot of viable and attainable strategies to implement. These strategies touch on all facets of a transportation system, and when implemented in together, further the flow of goods, safety of travelers and keep the public informed. ITS technologies can vary in types of applications, including different types of traffic signal controllers, dynamic message signs, vehicle speed detectors as well as more complex applications. Each solution serves as a "tool" within a toolbox. It must be understood that one strategy is not always an "end-all" solution and that some of these strategies have multiple applications, while a few may only be warranted for unique situations.

CFX should evaluate various technologies and then measure their effectiveness upon implementation. This will ensure that only technologies that benefit CFX's customers are deployed throughout the system.

Objective 4.1 – Support Multimodal Transportation Services through ITS applications

Measure 4.1.1 – Number of corridors servicing significant passenger and freight facilities being monitored

ITS Performance Measure: Legislation allows CFX to take a leadership role in the planning, design, construction and operation of multimodal corridors and intermodal facilities. These types of projects are critical elements of CFX's future network. Projects can include space monitoring at parking garages or park-and-ride lots, etc.

The demand for freight travel generated by Florida imports is constantly increasing as the Panama Canal widening provided direct access from the Asia-Pacific markets to the East Coast. Freight mobility has an extremely high impact on the efficient operation of freight activities and Florida has significant freight activity originating from the ports forming a significant component in the state economy. This measure will connect drivers, dispatchers and intermodal transportation providers with the ability to take advantage of real time traffic information and optimize operations.

Measure 4.1.2 – Collaborate with the region and state to provide data for transportation selection applications

ITS Performance Measure: This measure makes use of the existing information management systems to create a centralized database for traveler services and reservation options. This includes options for trip destination which will be relayed to the user in an application that provides the user with multiple options/logistics based on travel research and recommends modes of travel specific to your travel preferences. By using technology, the user can dynamically access information such as existing service possibilities for transit routes, modes of travel, flight/hotel information, plus many more details to identify the best options suitable for the user. This strategy provides a comprehensive start to finish solution to guide and support travelers from original origin to final destination which would help to integrate smart cities and improve the visitor experience.

Objective 4.2 – Integrate current CFX infrastructure with surrounding counties

Measure 4.2.1 – Number of roadway miles integrated with surrounding counties.

ITS Performance Measure: The future needs for additional highway capacity in Central Florida will extend beyond the current System. CFX is authorized to expand services into Lake, Osceola and Seminole counties as well as participate in non-tolled feeder roads within one mile of the existing system. This expanded geographical reach provides more flexibility and opportunities to respond to shifting development trends and regional needs. To accommodate regional economic welfare, investment into new toll roads and interchange projects in Lake, Orange, Osceola and Seminole counties are anticipated. It is also beneficial to investigate partnership opportunities with toll roads in adjacent counties. The ITS infrastructure should be appropriately expanded to allow for efficient operation of these facilities.

Measure 5.1.1 – Perform analyses based on Sustainability Options

ITS Performance Measure: CFX is entering the first phase of a multi-year program to identify and explore beneficial projects that can increase sustainability throughout its roadways, facilities, and properties in Central Florida. The priority of this program is to maintain a level of excellence with the aim of providing an infrastructure that remains both environmentally and technically feasible. Photovoltaics (PV's) are electronic devices that convert the solar energy of sunlight into electricity.

Per the CFX Sustainability Study, CFX has identified several options on the following page for sustainability for PV as well as other areas of evaluation which include:

Traditional PV Solar: Traditional ground-mounted PV solar farm approach that will be evaluated for applicability to the CFX land inventory.

Floating PV Solar (wet pond): Maintains a floating array of solar panels and will be evaluated for applicability to the CFX retention ponds.

Elevated Pond PV Solar (dry pond): Includes the traditional ground-mounted PV solar farms and is examined for its applicability to CFX dry retention ponds.

Rooftop PV Solar: This application involves the evaluation of CFX office building, on and off ramps, and plaza structures for the viability of rooftop solar PV systems.

Building Energy Efficiency Study: This study will evaluate a CFX office building for potential energy enhancements by measuring benchmark factors, costs, etc.

EV Charging Stations: Examines electric vehicle charging solutions that can be utilized by CFX employees or the public.

Fleet Vehicle Analysis: This will assess the maintenance costs, gas consumption, GHG, mileage, etc., of the existing CFX fleet vehicles and compare the findings with possible EV fleet improvements.

Landscape Sustainability: Reviews effective sustainable landscaping on CFX's roadways through creative plant selection, arrangement, and maintenance practices.

Roadway Sustainability: CFX follows the FDOT's roadway design guidelines and construction requirements. This measure will examine FDOT guidelines and construction requirements for the use of recycled materials in highway projects.

1.5. Looking Ahead

This technical memorandum's primary purpose is to outline the necessary guidelines for success throughout the course of the next ten years. This particular section establishes CFX's Visions, Goals, and Objectives along with other transportation system performance measures which will be used to apply these solutions with a significant positive impact. Utilization of effective ITS strategies will allow CFX to realize increased performance of the overall infrastructure through the use of systems, services, and projects that preserve capacity, improve safety, improve security, and provide increased travel reliability.

1.6. Graphical Summary of Goals, Objectives, and Performance Measures

Figure 1 on the following page summarizes the goals, objectives, and performance measures established for the ITS Master Plan.

Figure 1 : ITS Master Plan Goals, Objectives, and Performance Measures

ITS
Master Plan

Section 2
ITS Technical Terms and Concepts

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2. Defining ITS

The primary purpose of this section is to define ITS technological terms and concepts. An Intelligent Transportation System (ITS) is a technology, application or platform, that improves the quality of transportation, or achieves other outcomes based on applications that monitor, manage or enhance transportation systems. Intelligent Transportation Systems enable CFX to work with partner agencies to the deliver multi-modal solutions to reduce congestion.

The goal of ITS is to equip the existing roadway system with the innovative tools and techniques that will allow CFX to meet current and future traffic demand.

2.1. Overview of ITS Strategies

This section provides a definition of ITS strategies in use today that are discussed in later sections.

2.1.1. Transportation Management Center

TMCs serve as the nerve center of the transportation management system. Data collected from ITS field devices is sent back to the TMC, where it is processed and joined with operational and control data and distributed as necessary. From the TMC, roadway performance can be monitored, and control systems can be activated accordingly with the goal of improving traveler mobility and safety. TMCs can act as a hub where numerous agencies work together with the common goal of improving transportation system performance. In Central Florida, CFX facilities are currently operated from the FDOT District 5 Regional Traffic Management Center (RTMC). The majority of transportation data is routed through the SunGuide software (Florida's Statewide Software). CFX has its own installation (or Instance) of SunGuide that is monitored at the RTMC.

2.1.2. Communication System

Communication systems unlock potential for numerous ITS technology deployments and information sharing between stakeholders, and CFX has the capability of providing redundancy for stakeholders for highly available continuing communications in the event of infrastructure damage or fiber cuts. The National Transportation Communications for ITS Protocol (NTCIP) Framework provides a layered approach to communications standards for the transportation industry to foster compatible communications and working interconnections between devices and applications. Interconnection of Closed-Circuit Television Cameras (CCTVs) video and pan-tilt-zoom control signal transmission, DMS message transmission, and Vehicle Detection System data transmission are all example uses for transportation agency communication systems.

The most common physical media used for communications is fiber optic cabling, which uses thick flexible fibers with glass cores to transmit light pulses with very little signal degradation over distance: light pulses are converted to electrical signals at the end of fiber optic links. A common alternative to fiber optics is wireless communication links between sites. With this approach, directional antennas are placed on ITS or Traffic Signal poles, that form links between locations over which data can be transmitted. Both technologies provide distinct pros and cons, but ultimately serve the same purpose.

Operator/maintainer agencies in the region use both fiber optic cables and wireless links as a part of their communication systems. All operator/maintainer agencies that overlap with CFX sections stated during

stakeholder meetings that improvement and expansion of their communication systems is a goal moving forward to accomplish objectives like increasing the number of connected traffic signals and interconnecting remote facilities for data sharing.

2.1.3. Visual Surveillance

CCTVs provide a means to visually monitor traffic in real-time. Visual monitoring of traffic, weather conditions, work zones, and incidents allow transportation agencies to collect valuable information not provided by Vehicle Detection Systems. An example is the ability for TMC operators to determine the severity of a crash, how many lanes are affected, and the types of vehicles involved, then relay this information to emergency responders so that the level of response can be determined before they arrive on scene. Another benefit is the ability of maintenance personnel to remotely confirm the functionality of Dynamic Message Signs and other field equipment, resulting in decreased troubleshooting response times. Sharing of roadway surveillance CCTV streams with the media is a common practice in the State of Florida and is currently done by CFX.

By far the most common types of CCTV cameras used for public roadway surveillance are pan-tilt-zoom capable cameras in dome-style housings, which allow for 360-degree viewing from a single camera location. In some instances, static cameras are used to monitor locations of particular interest and to confirm equipment functionality. TMC operators can access CCTV cameras at their workstation and, if an event of note is occurring, project the video stream to the TMC video wall for review. In specific circumstances, such as areas with high probability of fog or areas with little night-time illumination, thermal imaging or infrared capable cameras are deployed. CFX has recently upgraded all CCTVs to high definition (HD) cameras capable of sharing variable resolution and compression rates to provide bandwidth flexibility.

2.1.4. Vehicle Detection Systems

Vehicle Detection Systems are an overarching category of equipment including an assortment of functional types and technologies that collect real-time traffic data and perform vehicle presence detection/classification. This section will focus on the traffic data detection and probe data detection functional types, whereas the vehicle presence technologies will be discussed in the subsequent Traffic Signal System section. Traffic data detection and probe data detection systems work in concert to provide an accurate picture of transportation system performance. CFX owns and operates several types of Vehicle Detections Systems. The first classification is the Data Collection Sensor or DCS (Neology Toll Transponder Readers or Blyncsy Bluetooth/Tire Pressure Monitor Sensor (TPMS) detectors. The second classification is the Traffic Monitoring Stations (TMS) which include Wavetronix and Houston Radar side fire microwave vehicle detection systems.

Traffic data detection systems provide presence, volume, occupancy, and speed data for the lanes they monitor. Common types of traffic data detection technologies include microwave vehicle detectors, inductive loop detectors, video detectors, and wireless magnetometers. These detectors collect instantaneous spot readings of prevailing traffic conditions at the sensor location, and do not perform unique vehicle identification. Traffic data detection systems strive to detect 100% of vehicles within the lanes they monitor. In order to provide the greatest amount of detection, CFX detection requirements include lane by lane and zone by zone separation of detection inputs.

Probe data detection systems provide speed and travel time information for a road segment. Common types of probe data detection technologies include: MAC address-based device identification using Bluetooth and Wi-Fi capable devices; vehicle identification using RFID transponders mounted to vehicles; and license plate recognition. Probe data detection systems detect and record the exact time a unique vehicle passes a sensor location. Once the vehicle passes two such sensor locations, the detection system software determines segment travel time and average speed, by comparing the distance between probe sensors and respective vehicle passing times. Probe data detection systems typically only capture a fraction of the vehicles that pass by the sensor, then create approximations of the prevailing traffic conditions. Due to the tolling nature of CFX, RFID transponders are currently in use on the system.

Information gathered by these sensors may be used to identify incidents within a roadway segment—if a freeway segment commonly operates at an average speed of 55 miles per hour at a given time of day but is operating at 10 miles per hour at that time today, a signal can be sent to TMC operators notifying them of a potential problem, allowing them to react by instituting changes to the freeway management system, such as posting messages on a DMS or deploying service patrol vehicles. Recently, vehicle detection systems have been used to feed information to adaptive transportation control systems, permitting these systems to adapt in real-time; an example is automated activation of freeway ramp meters and adaptive metering rate adjustments.

2.1.5. Advanced Traveler Information Systems (ATIS)

ATIS are a collection of equipment and technologies that update drivers on current roadway conditions, allowing them to make informed travel decisions about travel modes, route selection, and departure times. Better informed drivers tend to more efficiently utilize existing surface transportation system capacity, through avoidance of congested areas and use of underutilized routes or travel modes. This section will describe a handful of ATIS technologies.

Dynamic Message Signs (DMS)

DMS are roadway sign panels, of various shapes and sizes that display changeable messages. The message on display is typically controlled from the TMC and can range from estimate travel times between interchanges to upstream incident warning and alternative route guidance. DMSs are also used as a part of dynamic toll pricing systems to display current toll rates—express lane systems in the State of Florida rely on DMS panels for this and other purposes. The I-4 Ultimate project is an example of dynamic toll pricing. CFX and local operator maintainer agencies operate and maintain a large number of DMS located on highways and freeways, and on arterials, where they are commonly referred to as Arterial DMS (ADMS). In addition, the CFX DMS system includes the use of 2-Line Tolls DMS which precede mainline toll plazas.

Traveler Information Systems

FL511 is a system that provides travel information collected by ITS to travelers via phone, web site, and mobile applications. FDOT operates FL511, which is fed data collected by FDOT's Vehicle Detection System, the TMC and third-party sources. Historically this service has primarily been used for freeway travel information but is being expanded to arterial roadways as SunGuide events are expanded to the arterials.

In-Vehicle Dynamic Route Guidance

A combination of in-vehicle navigation systems and dynamic traffic information, that adapts the recommended travel route based on real-time travel conditions, selecting alternate routes on the fly to decrease travel times. Examples of such systems are Google Maps and Waze mobile applications.

2.1.6. Incident Management and Highway Assistance

A coordinated effort by numerous parties—law enforcement agencies, medical personnel, towing companies, hazardous material clean-up companies, contracted service providers, and roadway maintenance crews—to quickly and effectively respond to incidents and clear disabled vehicles, debris, and cargo from the roadway.

Traffic Incident Management (TIM)

TIM teams bring together all agencies involved in responding to and clearing incidents from the roadway; working together to reduce the impacts of incidents on motorists and increasing incident management safety. TIM teams are active throughout Florida - these teams conduct monthly meetings and educational seminars to improve team synergy. CFX has been a strong supporter and has participated in the FDOT District 5 TIM Team. In the past, TIM teams have focused their efforts on the State Highway System, in support of the *State of Florida Open Road Policy Agreement*[2].

Road Ranger Service Patrols

Road Ranger Patrols provide free highway assistance services during incidents with the goal of reducing delay and improving safety for the motoring public and incident responders. The program was started in 2000 and has since made over 5 million service assists. Road Rangers are vehicles that patrol congested areas and high incident locations, and also respond to specific service calls, providing an array of services including tire change assistance, providing a limited amount of fuel, incident clearance, and performing other minor emergency repairs to vehicles. The historical focus area of Road Rangers has been freeways. CFX currently has its own Road Ranger Service Patrols for their facilities.

Rapid Incident Scene Clearance (RISC)

RISC is an initiative by FDOT/CFX to provide monetary incentives for private partners, through the auspices of contracted services, to clear major incidents quickly in support of the *State of Florida Open Road Policy Agreement*. Activation of RISC is primarily reserved for incidents of complete roadway closures on limited access highways, where typical wreckers are incapable of clearing the incident in a timely manner. Florida's Turnpike Enterprise was the first FDOT District to implement RISC. Due to the program's success, FDOT expanded the practice statewide, allowing each FDOT District to implement their own RISC program at their discretion. CFX has participated with FDOT District 5 in the RISC program.

[2] An agreement between Florida Highway Patrol (FHP) and FDOT that establishes a policy for FHP and FDOT personnel to expedite the removal of vehicles, cargo, and debris from the State Highway System.

Emergency Preparation, Security, Response & Recovery

There exists an assortment of ITS strategies to use prior to, during, and after emergency events to improve evacuation procedures, permit supply deliveries to reach areas in need, expedite clean-up, and repair or protect infrastructure. Examples of such strategies include: pre-designated evacuation routes supported by special signal timings to improve traffic flow away from the evacuated area; during emergency events, using roadway CCTV cameras to gather valuable information about the event to the benefit of response personnel and using handheld radios to maintain communications between agencies should normal communication become non-operational; and after an emergency, using CCTVs to assess damage to the transportation infrastructure quickly and enable determination of necessary repair response scope and prioritization of repair resources.

2.1.7. Active Transportation and Demand Management (ATDM)

The Federal Highway Administration (FHWA) defines ATDM as: "the dynamic management, control, and influence of travel demand, traffic demand, and traffic flow of transportation facilities." To achieve this, the transportation system is continuously monitored, then using archived data and/or predictive models, control actions are performed to improve system performance. The remainder of this section will describe a series of common ATDM systems and strategies.

Active Arterial Management (AAM)

AAM is defined by the FHWA as: *"The active prioritization of objectives and collection of information to efficiently manage traffic signal infrastructure and control devices to maximize safety and throughput while minimizing delays. The working definition of traffic signal maintenance is the preventative and responsive activities to preserve traffic signal infrastructure and control devices necessary for the safe and efficient utilization of arterial, collector and local roadways."*

Essentially, AAM is the use of sensors and advanced traffic signal control on major arterials that are used to collect traffic flow and travel time data, while TMC operations provide the ability to adapt signal timings to prevailing traffic conditions. A lower-cost version of AAM involves the use of a more limited range of sensors and less sophisticated traffic control, supported by the technical resources with a focus on maintaining traffic signal timings on a regular basis.

Integrated Corridor Management (ICM)

ICM allows transportation agencies to maximize utilization of existing infrastructure by redistributing travelers to areas with underutilized capacity in a transportation corridor: travelers are encouraged to change transportation route or mode choice in response to changing traffic conditions. Strategies such as modal choice suggestion, ramp metering rate adjustment, and traffic signal timing adjustment (See AAM above) support ICM by accounting for fluctuations in demand. ICM systems are generally multijurisdictional partnerships between agencies, who come together to create a collaborative and multimodal system.

All CFX Freeways are operated from FDOT's D5 RTMC through an agreement between CFX and FDOT D5. All signalized intersections at CFX ramps are maintained by the CFX signal contractor and operated through agreements between CFX and Local Agencies in the area of the ramp. Essentially, CFX matches the City/County controller standard in the area of the ramp so that the signals can be operated out of the local agency ATMS as a part of coordinated signal systems.

FDOT D5 encompasses the Central Florida area, and it has the largest district population size in the State of Florida having over four million permanent residents, accounting for 20% of the State of Florida's urbanized area population. The permanent resident population of the D5 area is expected to continue to grow at a rate of 1-3% each year and there are increasingly limited opportunities for constructing new roadways in densely developed urbanized areas while further expansion of existing arterials may not be cost feasible in consideration of the cost of right-of-way acquisition and in consideration of the potential for negative impacts to local community interests. FDOT D5 and CFX have established an agreement which will allow the Local Agency in control of R-ICM operations during the daytime hours when the local TMC is open and will then subsequently transfer after-hours operations to FDOT D5.

Managed Lanes

Managed lanes differ from other traditional forms of freeway lane management in that they employ the use of active management strategies. The operating agency proactively manages system demand, and available capacity. From the outset, an agency defines the operational objectives for the managed lanes, along with what actions to take once the pre-defined performance thresholds are met. An example of a managed lane strategy in use in the State of Florida are express lanes—optional tolled lanes, that run alongside traditional non-tolled lanes, which statically limit vehicle eligibility and access while dynamically adjusting toll rates as a means to proactively manage demand. Currently, express lanes are operational on I-95 and I-595 in South Florida, while some express lanes projects, like I-4 Ultimate, are under construction. FDOT is actively funding design and construction of express lanes throughout the State of Florida. Another example of Managed Lanes is Reversible Lanes. Reversible lanes change the directional capacity of a freeway to accommodate peak directional traffic demands. To warrant reversible lanes, peak-period traffic volumes should exhibit or are anticipated to exhibit significant directional imbalance. If warranted, reversible lanes can use right-of-way more efficiently and economically.

Ramp Metering

Ramp metering involves the installation of traffic signals on freeway on-ramps that control the rate at which vehicles enter the freeway traffic flow. Ramp metering results in reduced congestion on the freeway by both breaking up the on-ramp merging platoons and managing the number of vehicles entering the freeway. When ramp metering is activated on an on-ramp, vehicles enter the on-ramp from an arterial, queue at the ramp meter stop bar, and then are released, either individually or in pairs, at a rate typically dependent on freeway traffic conditions and ramp queue length.

Historically, areas that have implemented ramp metering have seen beneficial results for the following metrics: freeway average travel speed, freeway travel time reduction, collision reduction on the freeway and ramp merge area, and reduction in freeway vehicular emissions. Ramp meters have been installed on I-95 in South Florida and are planned for installation on I-4 as part of the I-4 Ultimate project.

Variable Speed Limits

Variable speed limits provide a means to change the roadway speed limit based on upstream traffic conditions. When upstream congestion is detected, the variable speed limit system provides a slower but overall, more consistent speed limit in an attempt to eliminate the cumulative ripple effect—also known as the "accordion effect." The accordion effect results in decreased roadway throughput, and increased frequency of read-end collisions. These signs had previously been placed on I-4 but have since been removed.

Real-time Ridesharing

Real-time ridesharing services provide an automated system that matches drivers and riders on a one-time basis with short notice or en-route. Real-time ridesharing enables and promotes ridesharing without the need to pre-plan commutes or travel arrangements. These services are typically through the use of mobile phone applications—with the most notable services being Uber and Lyft. The goal of ridesharing is to reduce the total number of vehicle trips, by maximizing the occupancy and utilization of vehicles.

2.1.8. Passive Demand Management

An umbrella term for the application of strategies and policies that reduce or redistribute the demands placed on a transportation system in a passive manner, where the management and control of travel demands are not dynamically managed. This section describes a few passive demand management strategies.

Passive Ridesharing

The sharing of vehicles by passengers to reduce the total number of vehicle trips, resulting in less congestion and vehicular emissions. To support passive ridesharing, regional public parking lots, such as park and ride facilities, are often employed to serve as a meeting place for drivers to rideshare.

Encouragement of Alternative Travel Modes

Alternative travel modes reduce the number of cars using the roadway transportation system, by redistributing the demand to other modes, such as public transportation systems, bicycle, and pedestrian facilities. By encouraging travelers through incentives, clear information sharing, advertisement campaigns, and improved facilities, the use of alternative travel modes can be promoted.

2.1.9. Electronic Payment Services

Regional Payment Systems

Allows regional travelers to remit payment for transit tickets, parking fees and tolls through a common mean without the use of cash. Payment methods such as mobile phone applications, RFID toll tags, and smart cards are used to improve efficiency and traveler convenience. CFX currently uses the EPASS system as a regional payment system for tolls and some parking facilities. Items under this system include but are not limited to the following: E-PASS transponder, E-PASS mobile application, E-PASS Visitor Toll Pass, ParkMobile, LYNX PawPass, etc.

2.1.10. Work Zone Management

Effective management of work zone traffic during roadway construction helps to reduce congestion, minimize delays, promote worker and traveler safety, and maintain access for businesses and residents. Development of strategies for reducing work zone impacts begins with assessing the anticipated impacts, then developing solutions in a Transportation Management Plan (TMP)—FHWA's Work Zone Safety and Mobility Rule requires TMPs for all Federal-aid highway projects. Utilization of ITS technologies for work zone management can improve travel conditions and safety in and around work zones. Example ITS solutions include notifying the traveling public about upcoming work zone delays and providing

alternative routes, either through static temporary signs or through the use of DMS/ADMS. Temporary work zone ITS equipment can be installed to supplement the existing ITS infrastructure as needed to support work zone management objectives. CFX currently posts construction information to the public using FL511.

2.1.11. Part Time Shoulder Use (PTSU)

Part-time shoulder use (PTSU), also known as hard shoulder running, is typically used to address recurring congestion by adding temporary capacity during peak periods to the peak direction of travel. Dynamic PTSU, or D-PTSU, has variable hours of operation that are controlled by facility operators in real time and the shoulder can be opened for recurring congestion, nonrecurring congestion, or incident management (i.e., diverting traffic around incidents). The shoulder can also be rapidly closed if it becomes blocked. The open/closed status of the shoulder is communicated to drivers with overhead lane control signals. There are no static signs displaying the hours of operation because they may vary.

CFX is in the process of completing design plans for the widening of SR 429 from Stoneybrook West Parkway to SR 414. This portion of SR 429 currently has two lanes in each direction and a grass median. The widening will be accomplished by building inward. A third lane will be built in each direction, a 19' left shoulder will be paved, and a concrete median barrier will be added.

SR 417 widening design plans from International Drive to SR 528 are also currently underway. This portion of SR 417 currently has two lanes in each direction and a grass median. Similar to SR 429, the widening will be accomplished by building inward. A third lane will be built in each direction, a 19' left shoulder will be paved, and a concrete median barrier will be added.

The SR 429 and SR 417 corridors have seen major growth in recent years. This, coupled with ongoing major expressway projects in the area, creates uncertainty in future traffic volume forecasts and the potential for recurring congestion within the design life of the widening project. To provide operational flexibility at project opening and into the future, CFX will implement part-time shoulder use (PTSU) on the left shoulders of SR 429 and SR 417 in conjunction with the widening project. In the near term, PTSU will be implemented to enable opening of the left shoulder for incident management, such as crashes blocking right-side general-purpose lanes. In the long term PTSU will be implemented to enable opening of the left shoulder as a congestion mitigation strategy. Lane control signals will be placed over all lanes including the left shoulder, creating the opportunity to open and close the shoulder and lanes dynamically in response to incidents on the roadway.

PTSU systems nationally vary greatly in terms of appearance to drivers and real-time responsiveness to traffic conditions. The PTSU system on SR 429 and SR 417 will be a modern, state-of-the-art system incorporating the following Active Traffic Management (ATM) strategies:

- Dynamic PTSU (variable hours of operation for the shoulder), controlled on a real-time basis from a RTMC. This differs from Static PTSU, where the hours of operation are pre-determined and fixed. Dynamic PTSU (D-PTSU) will be deployed on day one for Incident Management relief and will be transitioned to level 3 for the future.
- Closed-circuit television (CCTV) cameras providing full remote monitoring capability of the shoulder and visual confirmation of displays on PTSU-related devices (lane control signs, incident management DMSs, variable speed limit signs)
- Traffic Monitoring Sensors continuously collecting lane-by-lane volume and speed data at bottleneck locations, which on SR 429 and SR 417 are at the entrance and exit ramp gores

- Operations staff monitoring the facility (Discussions with D5 are ongoing for use of the FDOT District 5 RTMC)
- Dynamic Lane Assignment for general purpose lanes - lanes can be closed (through the use of overhead signs) for incident management purposes
- Variable Speed Limits to reduce the speed on all lanes when the shoulder is open due to stopping sight distance restrictions

Table 2: Levels of Part Time Shoulder Use (Adapted from FHWA Decision Support Framework and Parameters for Dynamic Part-Time Shoulder Use)

0	No part-time shoulder use (PTSU)	Shoulder is never opened to traffic.
1	Static PTSU	Shoulder is only opened to traffic at predictable, fixed hours of day and days of week.
2A	Dynamic PTSU for incident management	No planned openings or congestion-related openings, but the shoulder is opened for incidents.
2B	Dynamic PTSU with core hours and scheduled variation	Shoulder is opened to traffic during recurring "core" hours and days of the week and may also be opened outside of those core hours in a scheduled, pre-determined manner for special events or seasonal variations.
3	Dynamic PTSU with core hours and unscheduled variation	Shoulder is opened to traffic during recurring "core" hours and days of the week and may also be opened outside of those core hours in response to real-time or anticipated traffic conditions.
4	Fully Dynamic PTSU	Shoulder is opened and closed purely in response to or in anticipation of factors such as traffic congestion, demand surges, events, incidents, weather, maintenance needs, incident management needs, or enforcement needs. There are no "core" hours and days of the week when the shoulder is always opened regardless of traffic conditions

2.1.12. Event Management

Event Management uses ATDM, traveler information system, and parking management strategies in unison to optimize surface transportation system performance during special events with large attendance numbers, including sporting events and spring breaks. Generally, pre-determined event management plans are developed and implemented during the special event—with oversight and active management occurring from a TMC.

2.1.13. Safety Measures

Wrong Way Driving Detection

Wrong way driving related crashes often result in head-on collisions with a high level of severity. Wrong way driving detection systems provide a means to detect vehicles traveling in the wrong direction, then warn and deter these drivers and notify the TMC of the event, allowing TMC operators to initiate the

appropriate responses before collisions occur. Warning and deterring the wrong way drivers is often achieved through the use of flashing beacons activated upon detection of wrong way vehicles. Detection technologies include radar, laser, thermal imaging and LiDAR. These systems are especially beneficial when installed on freeway on-ramps in an attempt to prevent wrong way access to the freeway mainline. The Central Florida Expressway Authority has deployed wrong way driving detection systems on numerous on-ramps leading to facilities they operate and maintain.

2.1.14. Connected Vehicles

Connected Vehicles include the use of various technologies to communicate with the driver, to the roadside infrastructure (vehicle-to-infrastructure/V2I), vehicle (vehicle-to-vehicle/V2V), or vehicle to anything (V2X). By communicating roadway or safety information to the driver, real-time information and data are shared to motorists providing the opportunities for quick and informed or alternate decision-making. Similarly, bi-directional data may be communicated from the vehicle to the cloud or network infrastructure to be used for planning evaluations and safety applications. With V2V communication technology providing vehicle location, heading and speed to nearby vehicles, crash avoidance applications may significantly prevent incidents related to side swipes and other lane changing related incidents. Many of these V2V safety applications exist to-date and are readily available for deployment.

In addition to the continued advancement of CV, members of the Automated Vehicle Safety Consortium (AVSC) are actively testing on-road pilots of automated vehicles and the safe deployment of the Society of Automotive Engineers (SAE) Level 4 and Level 5 automated driving systems. The following describe the automated technologies.

- **Automated Vehicles** operate without the direct input of the driver. Self-driving vehicles will first progress through six (6) levels of driver assistance technology. According to the National Highway Traffic Safety Administration (NHTSA), the six adopted SAE levels of automated driving include:

- **Level 0:** At this level, there is no automated vehicle control, and the human is in charge. Although there may be some systems in place to assist the human/driver such as issuing warnings, or emergency braking, these do not qualify as automation.

- **Level 1:** This is the lowest level of the automated vehicle classifications. Here, the vehicle provides driver assistance, however, the driver must be ready to take control of the vehicle. Automated systems at this level may include Adaptive Cruise Control (ACC) where the vehicle keeps a safe distance behind the next car yet requiring the driver to monitor steering and braking. Other examples may include parking assistance and Lane Keeping Assist (LKA) which may warn the driver and/or deploy the steering if the vehicle moves out of the lane.

- **Level 2:** At this level, there is partial driving automation with execution of steering, accelerating/decelerating and braking. If the automated system fails to execute and respond, the driver can immediately respond and take over the vehicle controls.

- **Level 3:** With "environmental detection" capabilities, the vehicle can make the informed decisions themselves, but still requires the human interaction and override if the system is unable to execute automated and safe tasks. With level 3, there is conditional driving automation.

- **Level 4:** At this level, and where it is legal to do so, the vehicle operates in self-driving mode, where driver interaction is not required in most circumstances. The automated system may control the vehicle when the driver enables the automated operation, thus allowing manual override.

- **Level 5:** At this level, vehicles will not have a steering wheel, nor will there be human interaction with vehicle controls. The initial deployment of this technology may include cost effective and ride-share fleet options. Level 5 may be described as Automated Vehicles (AV). **Automated Vehicles (AV)** are "driverless". The AV is capable of sensing and operating within its environment. Automated vehicles rely on actuators, sensors, complex algorithms and processors, machine learning and testing.

Relative to automated vehicles, we are already at Level 4 testing. In 2019, the mobility solutions provider, Beep and the French shuttle manufacturer, NAVYA launched their driverless shuttles to operate within a 17-square-mile area in Orlando's rapidly growing community, Lake Nona. Across the United States, not only are we performing testing in controlled environments, but the self-driving trucks are operating on our highways today. TuSimple, a self-driving truck company is actively laying the groundwork for developing a Level 4 automated driving freight network. By the year 2023, TuSimple strives to have their self-driving trucks on routes between Los Angeles and Jacksonville, Florida. Nationwide, their Phase III implementation plan is scheduled by the year 2024.[3]

The beginning stages of these technologies can be seen today, but the full impact will likely have widespread profound affects and is difficult to quantify. FHWA recommends agencies prepare for these technologies, at this time, in the following ways:

- Begin to incorporate the concept of Connected Vehicles in the planning process.
- Upgrade Regional ITS Architecture (RITSA)
- Upgrade existing systems (such as communication systems) and consider making them Connected Vehicle ready. Buy USDOT connected vehicle certified equipment.
- Consider how automated vehicles may enter your system: platoons, low speed urban, etc.
- Participate in the V2I Deployment Coalition, Connected Vehicle pooled fund study, and other similar ways to influence deployment path.

Figure 2 on the following page, provides the NHTSA graphical descriptions of the six levels of driving automation.

[1] https://www.tusimple.com/wp-content/uploads/2020/07/TuSimple-Autonomous-Freight-Network-Announcement.pdf

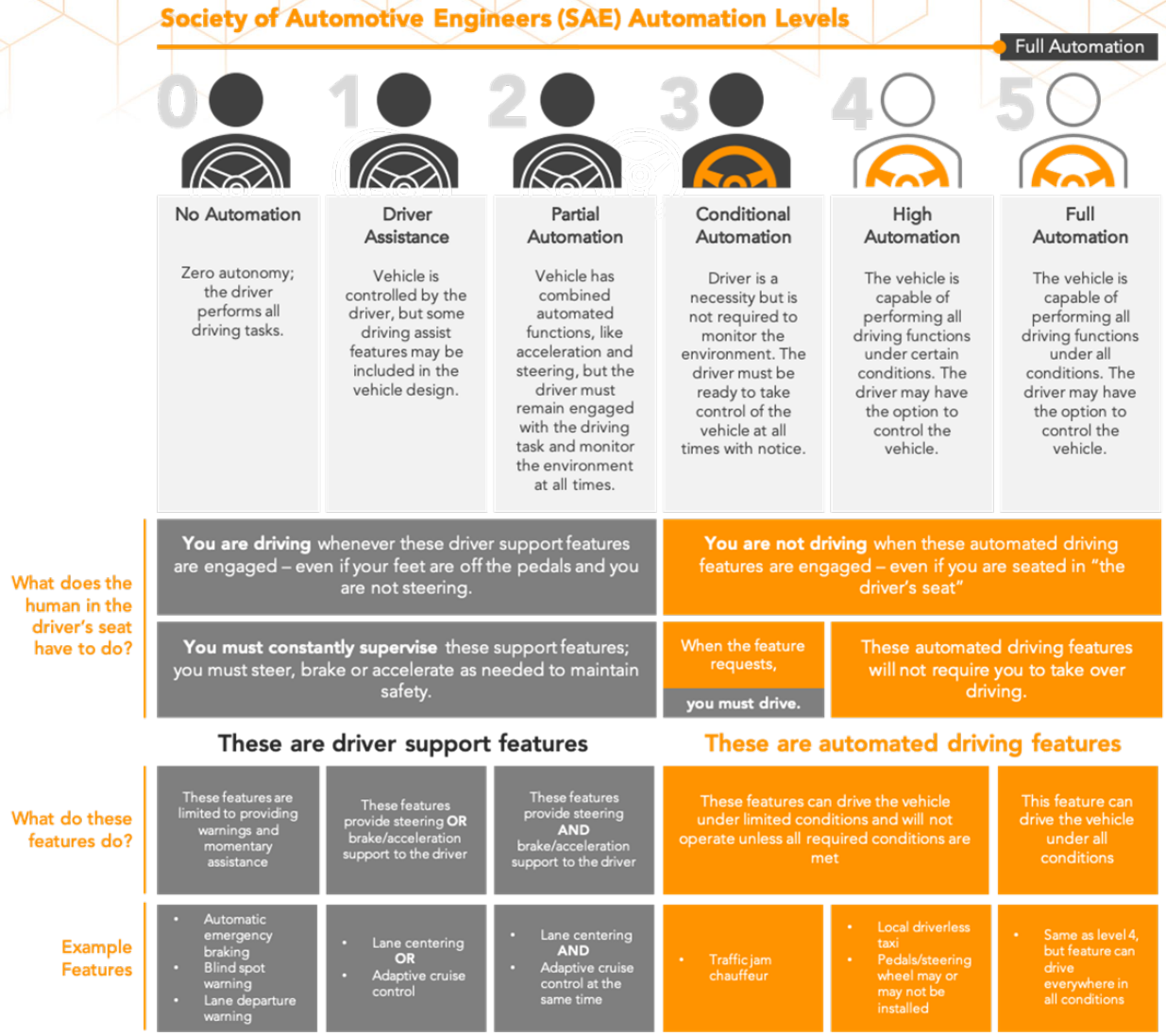

Figure 2: SAE Levels of Driving Automation

Source : https://www.nhtsa.gov/

The following sections discuss the various components and roadside infrastructure needed to support and provide wireless communication for CFX's recommended CV pilot.

Roadside and Onboard Units

The RSUs provide the wireless communication between the roadway infrastructure and the vehicles that are equipped with Onboard Units (OBU). These devices communicate on the 5.9 GHz band to transmit and receive CV messages. To date, there are several vendors who manufacture and provide dual-mode, dual-active RSUs allowing communication in both DSRC and C-V2X simultaneously. This provides the backward compatibility for any previously deployed DSRC devices. Once the recent FCC ruling is filed, there will be a transition period between DSRC and CV2X communication protocols. However, CFX may opt to procure CV2X-only devices at the time of construction based on the viability and saturation of DSRC.

With an evaluation of real data and the determination of areas with high and repetitive incidents, the use of CV technologies may be implemented to mitigate the problems by providing advance warning messages to motorists in real-time. An areawide assessment of reoccurring incidents is needed to define suitability for the deployment of CV technologies.

OBUs, combined with present-day systems such as flashing beacons and other warning systems may be combined to mitigate incidents of rear end collisions at ramps (queue warning), wrong way driving, etc. Human machine interfaces (HMIs) may be installed on the vehicles to help provide the visual displays to the motorists. The notification alerts to be received by the motorists are customizable.

Relative to the readiness and availability of onboard units to display and transmit CV messages, the present-day saturation rates are not currently high. Based on data from the Orlando/Cisco deployment on Colonial Drive, about 90K packets = approx. 200 cars daily were received. It was found that the DSRC OBU saturation is very low currently. There are zero CV2X OBU deployments and it should be noted that OEMs are currently awaiting direction. Ford indicated that by 2022 they will be rolling out CV2X in their production units.

CFX's robust communication and roadway infrastructure allows for planned RSUs to be mounted to the available concrete poles at approximately one (1) RSU for every half-mile, or as needed based on RSU line of sight and signal strength for successful communication. Communication testing may be done with the use of an OBU or packet sniffer. “Sniffing” allows a method to view, in detail, the individual packets to confirm that the data is being transmitted and received. This is used to validate data accuracy and non-fragmented packets.

These devices may be placed on fleet, Road Ranger, emergency, CFX partner agency and private vehicles. For inclusion of private vehicles, offering incentives such as toll discounts may be an alternative consideration as a test incentive. The Tampa Hillsborough Expressway Authority (THEA) CV pilot deployment offered a 50% toll rebate (up to $550) for private individuals participating in the program, traveling along the Lee Roy Selmon Expressway.[4] The vehicles were equipped with HMIs and were built into the rearview mirrors to display the V2V and V2I messages.

Integrated V2I Prototype (IVP) or V2I Hub

The Integrated V2I Prototype serves as a computing platform that interfaces with a variety of ITS field equipment, such as traffic signal controllers, dynamic message signs, road/weather sensors, integration with LiDAR technology, and the RSU. Although the RSU is capable of handling and processing CV applications, there is some benefit to utilizing an intermediary “box” to store and process applications, handling and processing (at the edge) the large amount of data from sensors, thus allowing the RSU to perform “radio” functions only. This hardware allows for expandability and scalability of integrating additional ITS devices, providing the added computational power, depending on the use case and immediate or future need. IVP hubs are dual-mode/dual active IVP and are capable of broadcasting CV messages in both DSRC and C-V2X simultaneously.

If the addition of an IVP Hub is not yet a viable alternative for consideration given the time and availability of resources, this may be implemented as a later solution. The use of the IVP hub will be dependent on the CV applications being deployed. These can also work with some of the other ITS equipment such as the Road Weather Information System (RWIS), and future WWD notification devices. This will be determined based on the CV application deployed use case. For example, if the LiDAR technology is

[4] https://www.tampacvpilot.com/what-were-doing/get-involved/driver/

deployed for WWD, CSW, Q-WARN, the intermediary box is needed to handle the LiDAR magnitude of data coming in for CV message broadcasting, dedup processes, etc. In some cases, the sensor itself may process and streamline some of the data then this gets passed to the IVP Hub for the additional processes.

Figure 3 below depicts the CV architecture and workflow integrating the IVP hub, and interfacing with a variety of field devices such as the RSU, OBU, infrastructure sensor systems, software and data handling. This may be used as reference for CFX's planned CV architecture considerations.

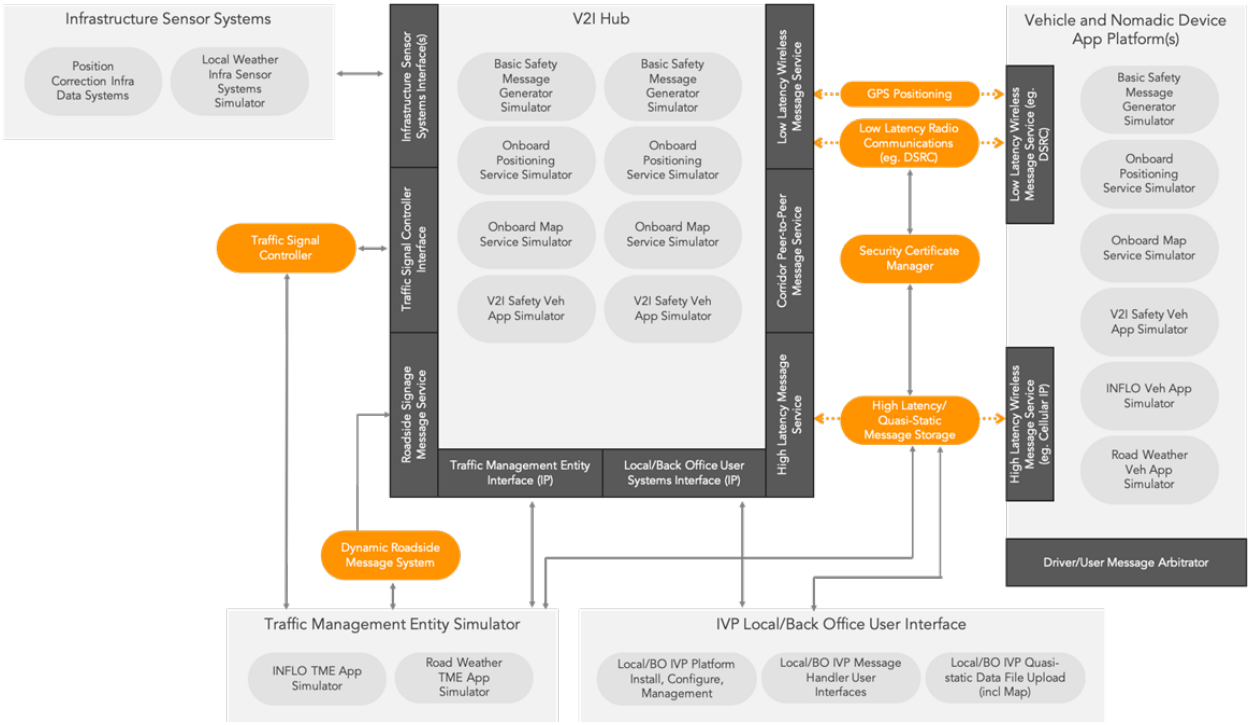

Figure 3: US DOT Published V2I Hub System View

Sensor Technology - LiDAR, Radar, Pan-Tilt-Zoom (PTZ) and Thermal Cameras

The use of existing sensors on the CFX system may be expanded and implemented in areas where there may be the additional need for utilizing a CV interface and applied to applications such as WWD detection, dynamic curve speed detection for warnings useful at ramps, queue detection and warning, ramp metering, passive pedestrian detection, to name a few. The sensors (LiDAR or camera) are used in conjunction with the IVP Hubs to track and analyze (based on configuration parameters) the conditions for appropriate CV message broadcasting. There are various options for sensor devices which provide smart sensing and mapping applications. The sensors detect and track driver behavior with great precision, allowing the CV devices such as the RSU or IVP hub to make real-time intelligent decisions and providing critical alerts and activating systems in real time. With connected vehicle technology and sensor data combined, motorists in the surrounding area of an incident can be notified with advanced warning to make well-informed decisions.

Evaluations and deployments of LiDAR technologies continue to date. CFX's 2019 LiDAR 3D Technology Semi-Annual Report documented the performance measures of LiDAR technology used for data collection by the Florida Highway Patrol and Orlando Police Department, in partnership with CFX, FDOT District Five, and MetroPlan Orlando. The pilot was intended to determine the appropriate data collection solutions to achieve the results of the Florida's Open Roads Policy. The final report includes an overview of the pilot

program, performance measures and conclusions. The performance measures evaluated the differences of the average clearance times between LiDAR and traditional technology means. In short, the following observations are noted:

- Evaluating incident clearance times using LiDAR, a 21.8% reduction was observed on limited access facilities when using LiDAR,
- A 16% mean clearance time difference was observed using LiDAR versus traditional methods over a 6-month period

In short, from the data and analysis conducted, LiDAR methodology events document a shorter mean duration and provide time savings and a reduction in road closure duration when compared to traditional survey methods. A value of time analysis, delay savings, and fuel consumption analysis is documented in the report. Initial findings were in support of the LiDAR survey technology.

Mean Clearance Duration Comparison

Type of Survey Method	Number of Events	Mean Clearance Duration	Percent Difference
Traditional	22 Events	298.8 minutes	16.0 %
LiDAR	7 Events	250.1 minutes	

2.1.15. Traffic Data Information Management

ITS components generate data that can be used for a number of beneficial purposes from future planning to deployed system validation. This strategy uses transportation data analytics, archived data, and data management technologies to the benefit of transportation agencies in determining results proven improvements and to effectively guide future planning. FDOT Central Office is in the process of studying the use of data analytics techniques in the transportation sphere. In addition, data analytics are being used in the development of the ICMS software in the Central Florida area.

2.1.16. Traffic Signal Systems

While electrical Traffic Signal Systems have been in operation in the United States for nearly 100 years, these systems have seen a continual increase in complexity and operational efficiency. The remainder of this section will discuss a handful of modern ITS techniques and technologies used to improve the operation of Traffic Signal Systems. CFX is currently responsible for the traffic signals at their interchanges. The maintenance for the traffic signals has been contracted out and the operations of the traffic signals has been coordinated with the area maintaining agencies.

Traffic Signal Vehicle Detection

These sensors detect the passing or presence of vehicles for use by actuated traffic signals. Common technologies used for this type of detection include inductive loops, magnetic sensors, microwave vehicle detectors, radar detection, video image processors, wireless magnetometers, ultrasound vehicle detectors, and infrared vehicle detectors. The most common detector technologies in use by the operator/maintainer agencies in the region today are inductive loops and video image processors. Detector inputs are used by the traffic signal controller to truncate or extend green intervals, and determine which movements need to be served. Vehicle detectors in advance of signalized intersections can also be used to provide dilemma zone protection. Recent advances in detector

technology have seen the advent of vehicle detectors that track estimated time of arrival for oncoming individual vehicles and provide enhanced dilemma zone protection beyond what older systems were capable of.

Traffic Signal Retiming and Coordination

Traffic signal coordination is a tool that provides a means to synchronize multiple intersections to enhance the operations of one or more directional movements along a corridor. Adjustment to traffic signal timings enable optimization of performance for traffic patterns that change over time—a process conducted on a periodic basis for heavily traveled signalized corridors. Connecting area traffic signals to a Communications System allows the controlling jurisdiction the ability to monitor performance, adjust timings and implement different timing plans remotely, monitor equipment failures, and assess performance measures.

Adaptive Traffic Signal (ATS) Control Systems

Conventional Traffic Signal Systems utilize pre-programmed timing plans, selected based on time-of-day and day of the week. ATS systems allow Traffic Signal Systems to modify signal timings in real-time to accommodate changing traffic patterns, resulting in reduced congestion and decreases in travel time. These systems are best suited for arterials with unpredictable traffic demand or that experience large variations in traffic demand, where conventional timing plans fall short.

Traffic Signal Preemption

A method that allows normal operation of traffic signals to preempt normal traffic signal operations; the most ubiquitous use is to alter traffic signal timings for the approach of trains, marine vessels, and emergency vehicles to clear cars from their path. In the case of emergency vehicles, these systems result in reduced response times and increased safety for first responders when traveling to an incident scene.

Typically, marine and train preemption use wired connections to drawbridge control houses and rail crossing controllers respectively. Upon the approach of a marine vessel or train, an electrical signal is sent to the traffic signal controller, activating a specific preemption phase that clears vehicles from the draw bridge or railroad tracks. The most common types of preemption devices for emergency vehicles are infrared and radio/GPS based, with the latter being the modern incarnation capable of additional features. Emergency vehicle preemption systems are currently in operation on select signal systems within the region.

Transit Signal Priority (TSP)

A set of operational strategies that reduce transit vehicle travel time by holding or shortening green signal indications longer upon the approach of transit vehicles. It is important to note the differences in operation between TSP and Traffic Signal Preemption systems. TSP systems can be implemented at isolated intersections, or across an entire region's traffic signals. TSP systems require four major components: emitter mounted on transit vehicles; on-vehicle or centrally located priority request generator; priority request strategy; and a TSP management system. Two System Architectures exist for TSP systems: Centralized where a central system organizes and manages priority requests from many vehicles; and distributed where all priority decisions are made at the intersection level.

2.1.17. Public Transportation Management

Public transportation can benefit from ITS technologies to be more accessible, secure, and convenient. This section includes a series of ITS technologies applicable to improving public transportation.

Automatic Vehicle Locations (AVL) and Automatic Passenger Counter (APC)
AVL and APC systems allow transit agencies to precisely track the location and ridership of their vehicles. Using this information, transit agencies can provide optimized routing and scheduling. Security of the transit system is also improved when the location of all vehicles is known at all times. Activation of TSP is contingent upon information provided by AVL and APC systems.

Transit Traveler Information
A means to disseminate transit related travel information to the public, such as current vehicle locations, occupancy levels, routes, stops, schedules, and travel options. AVL and APC systems allow up-to-date information to be collected for use by transit traveler information systems. Examples of such systems include arrival/departure boards, mobile applications, and websites.

Personalized Public Transit
Personalized Public Transit offers on-demand, flexibility routed, transit vehicles. Passengers place reservations with the transit agency, who dispatches a vehicle. Through the use of ITS, the transit agency attempts to optimize the number of passengers per transit vehicle per trip. Reservations are placed using web services or mobile phone applications. Personalized public transit is particularly useful for passengers that have difficulties using traditional transit systems, due to physical disabilities. Uber and Lyft are examples of this type of service.

2.1.18. Freight Advanced Traveler Information Systems (FRATIS)

FRATIS uses ITS strategies to facilitate more efficient movement of goods. This section provides two major FRATIS applications.

Freight-Specific Dynamic Travel Planning and Performance
Provides freight specific enhancements to traveler information systems; provides enhanced communication between drayage companies, drivers, and intermodal facilities; and provides real-time travel information and dynamic rerouting for drivers.

Drayage and Truck Routing Optimization
Optimizes truck and load movements between freight facilities, by assigning optimal time windows for pick-up and drop-off. Also, uses port terminal and travel information to optimize operations and provide best route guidance to freight facilities for drivers.

2.1.19. Asset Management

With increasing transportation system scope and complexity comes a need to optimize and automate management of inventory and maintenance requests. ITS requires perpetual maintenance following deployment, up until system retirement, to ensure proper system functionality; therefore, it is critical to protect the investment in ITS by ensuring that good maintenance practices are implemented. FDOT has its own such systems: Maintenance and Inventory Management System (MIMS) and Intelligent Transportation System Facilities Management (ITSFM).

2.1.20. Public Travel Security

Overarching category of technologies and strategies that provide increased levels of security for the traveling public. Components commonly used include motion detectors, CCTV cameras, explosion sensors, and AVL devices that generate alarms when certain events occur. An example system is the I-4 St. Johns River Bridge Security System, where thermal imaging cameras are deployed to establish a secure perimeter around sensitive bridge elements, that when crossed will notify the FDOT District 5 Regional Traffic Management Center (RTMC) of a breach event.

2.1.21. Innovative Bicycle and Pedestrian ITS Solutions

Technologies that target improving bicycle and pedestrian safety. This section includes brief descriptions of two such technologies. The Complete Streets policy requires streets to be planned in a manner that allows safe travel for those walking and bicycling; ITS solutions can be deployed to assist in meeting this objective. This would be primarily relevant at CFX's traffic signal locations.

Pedestrian Crosswalk Systems

Typically deployed at mid-block crossings to provide high intensity flashing lights or beacons that alert drivers to the presence of crossing pedestrians. Examples of such systems include High Intensity Activated Cross Walk (HAWK), in-pavement flashing LED lights, and Rapid Rectangular Flashing Beacons (RRFB). Activation of such systems can be manual, through the use of pushbuttons, or automatic, by using microwave, infrared, or pressure sensing pedestrian detectors.

Accessible Pedestrian Signals

Accessible Pedestrian Signals provide audible tones to aid hearing impaired pedestrians in crossing signalized intersections. The audible tone can either be “beeps” or spoken word. Deployment of these systems has occurred throughout the State of Florida.

Bicycle Warning System

Bicycle warning systems use bicycle detectors to detect bicycle traffic in advance of a roadway crossing, and then notify motorists that a bicyclist is approaching the crossing. Motorist notification is typically automated and achieved through electronic signs activated by the bicycle detectors.

2.1.22. Active Parking Management

Active parking management systems are particularly helpful in urban areas with limited parking, during special events, for public parking (such as park and ride), for public transportation parking facilities (bus stations, train stations, etc.), and for freight facilities. These systems provide better utilization of parking capacity, improved driver guidance, automatic ticket dispensing and payment systems, and many other benefits.

Dynamic Parking Guidance and Reservation

Helps to maximize parking facility utilization and improve travel demand through reductions in parking space search times by providing dynamic management of parking facilities. Dynamic parking guidance, also known as dynamic wayfinding, provides automated guidance of drivers to parking facilities with open spaces. Dynamic parking reservation allows drivers to reserve a parking space in advance to guarantee availability. For both of these systems, parking availability is constantly monitored by a central management system, which then facilitates dynamic guidance and reservation functions.

Another beneficial application of dynamic parking guidance and reservation is for truck parking management systems. Truckers can determine if spaces are available, or reserve a space in advance, prior to exiting the freeway. Since semi-tractor trailers create a large amount of wear and tear on the roadway surface, and contribute substantially to carbon emissions, large benefits can be reaped from efficiency improvements in parking space locating. FDOT's Truck Parking Availability System (TPAS) is being deployed by FDOT throughout the State serving rest areas, welcome centers, and weigh stations.

Dynamic Overflow Transit Parking

Dynamic Overflow Transit Parking opens overflow parking facilities in the vicinity of transit stations when the standard parking areas are at or near capacity. Overflow parking areas are typically underutilized parking lots, such as large shopping mall parking lots, for which transit agencies enter into an agreement with the proprietor for occasional use of designated areas. Transit station parking capacity is constantly monitored by a central control system, which dynamically opens overflow parking spaces when required.

Dynamically Priced Parking

Dynamically calculated parking fees based on demand and availability in order to influence arrival time choice and parking facility selection to maximize parking utilization, reduce peak period trips, and reduce impacts of parking spot searching by drivers. Space occupancy is constantly monitored, and prices are adjusted as a means to dynamically manage demand and influence parking facility choice.

ITS
Master Plan

Section 3
Existing Conditions and Infrastructure

CENTRAL FLORIDA EXPRESSWAY AUTHORITY

3. Existing Conditions

Central Florida Expressway (CFX) is responsible for the construction, maintenance and operation of a limited-access expressway system that serves a region with more than 3 million residents in five counties, plus an estimated 75 million visitors each year. The entire system is supported by tolls; no taxes of any kind fund CFX operations. On average, more than 1 million toll transactions are recorded every day, and more than 80% occur electronically. Introduced in 1994, the E-PASS transponder was the first electronic toll-collection device in Florida. Today, over a half-million transponders are in circulation in Central Florida.

The expansion of ITS strategies throughout the region will allow operating agencies to bolster their capabilities and increase the potential for regional cooperation regarding the operation of the transportation system.

In keeping with the first section of this Master Plan, which details overall goals and objectives, performance measures will play a key role in measuring the success of any ITS improvements put in place. For these performance measures to be properly analyzed, baseline conditions must be identified. To aid in the creation of these baseline conditions, inventories of existing ITS infrastructure for CFX and its stakeholders were obtained through stakeholder coordination, as well as GIS information provided by each agency where available. It should be noted that inventories of ITS infrastructure continue to change, and this report reflects information available at the time of stakeholder response.

3.1. CFX Facilities

3.1.1. SR 408 (Spessard L. Holland East-West Expressway and Arnold Palmer Expressway)

SR 408 (Spessard L. Holland East-West Expressway and Arnold Palmer Expressway) serve as an east-west commuter to traffic across the Orlando urban area and provides access to the Orlando Central Business District. It currently extends from an interchange with Florida's Turnpike in the west to an interchange with SR 50 east of Alafaya Trail. CFX is responsible for the 22 miles of SR 408 between SR 50 west (at Clarke Road) and SR 50 east. SR 408 has 30 existing tolling facilities as detailed in **Table 3**, on the following page, with 2 future site locations expected to be placed in Pine Hills on the on and off ramps for Tampa Ave.

Table 3: SR 408 Tolling Facility Locations

TOLLING FACILITY LOCATIONS	MAINLINE/RAMP	DIRECTION	RAMP	EXIT/MP
Hiawassee	Good Homes Rd	WEST	ON	2
	Good Homes Rd	EAST	OFF	2
	Hiawassee Mainline Channelized Lanes	EAST	N/A	3
	Hiawassee Mainline Channelized Lanes	WEST	N/A	3
	Hiawassee Rd	EAST	ON	4
	Hiawassee Rd	WEST	OFF	4
Pine Hills	Pine Hills Mainline Channelized Lanes	EAST	N/A	6
	Pine Hills Mainline Channelized Lanes	WEST	N/A	6
	Ortman Dr/Old Winter Garden	EAST	ON	7
	Old Winter Garden Rd/Ortman Dr	WEST	OFF	7
	John Young Pkwy	EAST	ON	8A
	John Young Pkwy	WEST	OFF	8A
	Tampa Ave	EAST	ON	8B
	Tampa Ave	WEST	OFF	8B
	Orange Blossom Trail	EAST	ON	9
	Orange Blossom Trail	WEST	OFF	9
	Mills Ave	EAST	OFF	11B
Conway	Bumby Ave	WEST	ON	12A
	Bumby Ave	EAST	OFF	12A
	Conway Rd	WEST	ON	13
	Conway Rd	EAST	OFF	13
	Conway Mainline Channelized Lanes	WEST	N/A	14
	Conway Mainline Channelized Lanes	EAST	N/A	14
	Yucatan Dr (Semoran Blvd)	EAST	ON	14
	Andes Ave (Semoran Blvd)	EAST	OFF	14
	SR 436 (Semoran Blvd)	WEST	OFF	14
Dean	Dean Rd	WEST	ON	19
	Dean Rd	EAST	OFF	19
	Dean Mainline Channelized Lanes	WEST	N/A	19
	Dean Mainline Channelized Lanes	EAST	N/A	19
	Rouse Rd	EAST	ON	20
	Rouse Rd	WEST	OFF	20

3.1.2. SR 414 (John Land Apopka Expressway)

SR 414 (John Land Apopka Expressway) provides a bypass around the City of Apopka. SR 414 extends Maitland Boulevard to the west from US 441/Orange Blossom Trail to US 441 near Plymouth Sorrento Road for a total of 9 miles. Out of the total 9 miles, 3 miles are a part of the dual route with SR 429 (SR 429/414). Future extension of SR 414 includes the SR 414 Expressway Extension project which is currently a PD&E study from US 441 to SR 434. SR 414 has 6 existing tolling facilities as detailed in **Table 4**.

Table 4: 414 Tolling Facility Locations

TOLLING FACILITY LOCATIONS	MAINLINE/RAMP	DIRECTION	RAMP	EXIT/MP
Coral Hills	Coral Hills Mainline Channelized Lanes	WEST	N/A	5
	Coral Hills Mainline Channelized Lanes	EAST	N/A	5
	Keene Rd	EAST	ON	6
	Keene Rd	WEST	OFF	6
	Hiawassee Rd	EAST	ON	8
	Hiawassee Rd	WEST	OFF	8

3.1.3. SR 417 (Central Florida GreeneWay)

SR 417 (Central Florida GreeneWay) begins at the International Drive interchange near SR 535 and runs east, south of the Orlando International Airport, and then turns north to the Seminole/Orange County line for a total of 32 miles. The portions of SR 417 north of the Seminole/Orange County line and south of International Drive are owned and operated by the FDOT. SR 417 has 34 existing tolling facilities as detailed in **Table 5** below.

Table 5: SR 417 Tolling Facility Locations

TOLLING FACILITY LOCATIONS	MAINLINE/RAMP	DIRECTION	RAMP	EXIT/MP
John Young	John Young Mainline Channelized Lanes	NORTH	N/A	7
	John Young Mainline Channelized Lanes	SOUTH	N/A	7
	John Young Pkwy	NORTH	ON	10
	John Young Pkwy	SOUTH	OFF	10
	Orange Blossom Trail	NORTH	ON	11
	Orange Blossom Trail	SOUTH	OFF	11
	Landstar Blvd	SOUTH	ON	14
	Landstar Blvd	NORTH	OFF	14
Boggy Creek	Boggy Creek Mainline Channelized Lanes	NORTH	N/A	16
	Boggy Creek Mainline Channelized Lanes	SOUTH	N/A	16
	Boggy Creek Rd	NORTH	ON	17B
	OIA South Access (Boggy Creek)	NORTH	ON	17A
	Boggy Creek Rd	SOUTH	OFF	17B
	OIA South Access (Boggy Creek)	SOUTH	OFF	17A
	Lake Nona Blvd	NORTH	ON	19
	Lake Nona Blvd	SOUTH	OFF	19
	Narcoossee Rd	NORTH	ON	22
	Narcoossee Rd	SOUTH	OFF	22
	Moss Park Rd	NORTH	ON	23
	Moss Park Rd	SOUTH	OFF	23
	Innovation Way/Dowden Rd	NORTH	ON	24
	Innovation Way/Dowden Rd	SOUTH	OFF	24

TOLLING FACILITY LOCATIONS	MAINLINE/RAMP	DIRECTION	RAMP	EXIT/MP
Curry Ford	Lee Vista Blvd	SOUTH	ON	27
	Lee Vista Blvd	NORTH	OFF	27
	Curry Ford Mainline Channelized Lanes	SOUTH	N/A	28
	Curry Ford Mainline Channelized Lanes	NORTH	N/A	28
	Curry Ford Rd	NORTH	ON	30
	Curry Ford Rd	SOUTH	OFF	30
University	SR 50 (Colonial Dr)	SOUTH	ON	34
	SR 50 (Colonial Dr)	NORTH	OFF	34
	University Mainline Channelized Lanes	NORTH	N/A	36
	University Mainline Channelized Lanes	SOUTH	N/A	36
	University Blvd	NORTH	ON	37
	University Blvd	SOUTH	OFF	37

3.1.4. SR 429 (Daniel Webster Western Beltway and Wekiva Parkway)

SR 429 (Daniel Webster Western Beltway and Wekiva Parkway) provides a shorter and more economical travel route between west Orange County and the Orlando Central Business District. SR 429 extends north from I-4 in Osceola County to SR 46 in Lake County. CFX's portion includes 31 miles from Seidel Road to just south of the Orange/Lake County line. Of the total 31 miles, 3 miles are a part of the dual route with SR 414 (SR 429/414). The portions of SR 429 from south of Seidel Road to I-4 and north of the Orange/Lake County line are owned and operated by the Turnpike. SR 429 has 22 existing tolling facilities as detailed in **Table 6** below.

Table 6: SR 429 Tolling Facility Locations

TOLLING FACILITY LOCATIONS	MAINLINE/RAMP	DIRECTION	RAMP	EXIT/MP
Independence	Schofield Rd	SOUTH	ON	13
	Schofield Rd	NORTH	OFF	13
	New Independence Pkwy	SOUTH	ON	15
	New Independence Pkwy	NORTH	OFF	15
	Independence Mainline Channelized Lanes	SOUTH	N/A	17
	Independence Mainline Channelized Lanes	NORTH	N/A	17
	Stoneybrook West Pkwy	SOUTH	OFF	18
	Stoneybrook West Pkwy	NORTH	ON	18
	CR 535 (Winter Garden-Vineland Rd)	NORTH	ON	19
	CR 535 (Winter Garden-Vineland Rd)	SOUTH	OFF	19
Forest Lake	Plant St/Franklin St/SR 438	SOUTH	ON	24
	Plant St/Franklin St/SR 438	NORTH	OFF	24
	West Rd (Clarcona-Ocoee Rd)	SOUTH	ON	26
	West Rd (Clarcona-Ocoee Rd)	NORTH	OFF	26
	Forest Lake Mainline Channelized Lanes	SOUTH	N/A	27
	Forest Lake Mainline Channelized Lanes	NORTH	N/A	27

TOLLING FACILITY LOCATIONS	MAINLINE/RAMP	DIRECTION	RAMP	EXIT/MP
Forest Lake (Continued)	CR 437A (Ocoee-Apopka Rd)	SOUTH	ON	29
	CR 437A (Ocoee-Apopka Rd)	NORTH	OFF	29
Coral Hills	Ponkan Mainline ORT Lanes	SOUTH	N/A	35
	Ponkan Mainline ORT Lanes	NORTH	N/A	35
	Mount Plymouth ORT Lanes	NORTH	N/A	40
	Mount Plymouth ORT Lanes	SOUTH	N/A	40

3.1.5. SR 451

Originally part of State Road 429 (Daniel Webster Western Beltway), State Road 451 connects State Road 414 (John Land Apopka Expressway) and State Road 429 north to U.S. Highway 441 (State Road 500/Orange Blossom Trail). This road is well traveled by commuters in northwest Seminole County and northeast Orange County. At only 1.9 miles, State Road 451 is the shortest and the only non-tolled expressway in the CFX System.

3.1.6. SR 453

SR 453 (Mount Dora Connector) opened in March 2018 and is a 2-mile facility that serves as a connection from SR 429 in Orange County to SR 46 in Lake County. SR 453 is a connector between the Wekiva Parkway and SR 46 near Mount Dora in Lake County. SR 453 connects with the parkway's interchange at Haas Road-Ondich Road and Plymouth Sorrento Road (CR 437). SR 453 has 2 tolling facilities that report back to Forest Lake as shown in **Table 7** below.

Table 7: SR 453 Tolling Facility Locations

TOLLING FACILITY LOCATIONS	MAINLINE/RAMP	DIRECTION	RAMP	EXIT/MP
Forest Lake	Coronado Mainline ORT Lanes	SOUTH	N/A	3
	Coronado Mainline ORT Lanes	NORTH	N/A	3

3.1.7. SR 516 (Lake Orange Expressway)

SR 516 is currently in design and is expected to be constructed from US 27 to SR 429. SR 516 will include an interchange with US 27 and realignment of US 27 to accommodate the interchange while avoiding impacts to Lake Louisa State Park. The design includes a potential future extension of CR 455, which is being coordinated with Lake County. The systems interchange with SR 429 will construct 8 toll gantries at the interchange ramps, and a segment of Valencia Parkway between the interchange ramps and Schofield Road.

3.1.8. CR 522 (Osceola Parkway Extension)

CR 522 (Osceola Parkway Extension) begins at the South Victory Way Interchange and extends eastbound along the Orange/Osceola County line for approximately 6 miles before turning south into Osceola County to meet the Florida Turnpike (TPK). This facility also includes a future planned north/south segment linking to SR 417 within vicinity of the Boggy Creek Road interchange. The goals of this proposed new limited-access facility include providing for additional east-west capacity within the project area, enhancing mobility of the area's growing population and economy, relieving congestion on local roads, providing for the incorporation of transit options, and promoting regional connectivity. CR 522 has 4 tolling facilities as

shown in **Table 8,** below. These tolling facilities are currently maintained by Osceola County. CFX supports the processing of the electronic transactions for Osceola County.

Table 8: CR 522 Tolling Facility Locations

TOLLING FACILITY LOCATIONS	MAINLINE/RAMP	DIRECTION	RAMP	EXIT/MP
Shingle Creek	Shingle Creek Mainline Channelized Lanes	WEST	N/A	10
	Shingle Creek Mainline Channelized Lanes	EAST	N/A	10
	Poinciana Blvd	WEST	ON	7
	Poinciana Blvd	EAST	OFF	7

3.1.9. SR 528 (Martin Andersen Beachline Expressway)

SR 528 (Martin Andersen Beachline Expressway) provides a direct connection between South Orlando and Cape Canaveral and serves Orlando International Airport. SR 528 extends from I-4 west to Cape Canaveral east but relies on CFX to manage 23 miles of roadway from Boggy Creek Road/McCoy Road in the west to SR 520 in the east. The portions of SR 528 east and west of CFX's jurisdiction are owned and operated by the FDOT. SR 528 has 14 tolling facilities located in Beachline and Dallas as shown in **Table 9** below.

Table 9: SR 528 Tolling Facility Locations

TOLLING FACILITY LOCATIONS	MAINLINE/RAMP	DIRECTION	RAMP	EXIT/MP
Beachline	McCoy Rd (Rebate)(Shoulder)	WEST	ON	8
	Jetport Dr (Rebate)	EAST	OFF	8
	Jetport Dr/Boggy Creek Rd	EAST	ON	8
	McCoy Rd/Boggy Creek Rd	WEST	OFF	8
	Tradeport Dr	EAST	ON	9
	Conway Rd	WEST	OFF	9
	Beachline Mainline Channelized Lanes	EAST	N/A	17
	Beachline Mainline Channelized Lanes	WEST	N/A	17
	Innovation Way	EAST	ON	19
	Innovation Way	WEST	OFF	19
Dallas	Dallas Blvd	WEST	ON	24
	Dallas Blvd	EAST	OFF	24
	Dallas Mainline Channelized Lanes	WEST	N/A	26
	Dallas Mainline Channelized Lanes	EAST	N/A	26

3.1.10. SR 538 (Poinciana Parkway)

SR 538 (Poinciana Parkway) is 7.2 miles long and extends from US 17-92 and Kinny Harmon Road through Osceola County connecting to Cypress Parkway in Polk County. SR 538 is a key corridor serving the residents of Poinciana in Osceola County, which is one of Florida's fastest-growing areas. SR 538 provides a critical north-south connection to US 17-92 facilitating access to regional transportation networks, theme parks, and the metro Orlando area. In February 2021, CFX began widening SR 538 (Poinciana Parkway) to create a divided four lane expressway from Ronald Reagan Parkway to CR 580 (Cypress Parkway). This 7-mile widening is expected to improve traffic flow and operations in the area and is

expected to be completed in 2023. Future extensions are planned for Poinciana Parkway that include two project segments, Ronald Reagan Parkway to South of US 17/92 and South of US 17/92 to County Road 532. The projects are currently in the design phase. SR 538 has four tolling facilities located in Marigold and KOA as shown in **Table 10**.

Table 10: SR 538 Tolling Facility Locations

TOLLING FACILITY LOCATIONS	MAINLINE/RAMP	DIRECTION	RAMP	EXIT/MP
Marigold	Marigold Mainline ORT Lanes	EAST	N/A	N/A
	Marigold Mainline ORT Lanes	WEST	N/A	N/A
KOA	KOA Mainline ORT Lanes	EAST	N/A	N/A
	KOA Mainline ORT Lanes	WEST	N/A	N/A

3.1.11. SR 551

SR 551 (Goldenrod Road Extension) extends 2.7 miles from Goldenrod Road at Narcoossee Road south to Cargo Road. The extension connects Goldenrod Road to SR 528 (Beachline Expressway), east of the Orlando International Airport. SR 551 has two tolling facilities located in Beachline as shown in **Table 11** below. This an off-system roadway and is managed differently than the roadways identified above. CFX does not maintain ITS Infrastructure on this portion of the roadway. The FON is extended to the toll plaza building on this roadway to facilitate the tolls network.

Table 11: SR 551 Tolling Facility Locations

TOLLING FACILITY LOCATIONS	MAINLINE/RAMP	DIRECTION	RAMP	EXIT/MP
Beachline	Goldenrod Channelized Lanes	NORTH	N/A	12
	Goldenrod Channelized Lanes	SOUTH	N/A	12

3.1.12. Traffic Congestion in Central Florida

Central Florida is constantly growing in population which in turn creates several traffic hot spots throughout the region. According to an Orlando Business Journal Article5, the region is expected to add 1,500 residents per week going into 2030. The average metro resident traveling via car spends an average of 57 hours a year stuck in traffic, and with the expected increase in residents, traffic will only get worse if not acted upon.

The I-4 corridor contains the highest amount of traffic in the area since it provides access to many of the most popular them parks in the world such as Walt Disney World, Universal Orlando Resorts, Sea World, etc. Currently, I-4 is undergoing a $2.3 billion project called 'I-4 Ultimate' (Discussed previously) that spans 21 miles from Southwest Orange County to Seminole County.

Many of the CFX corridors contain high traffic areas as well. Below identifies some of CFX's busiest corridors.

SR-408 provides relief for commuters traveling along SR-50, which is one of the busiest highways in Orlando. SR-408 also provides access to motorist traveling to venues in the Downtown Orlando areas such

[5] https://www.bizjournals.com/orlando/news/2019/11/29/driving-us-crazy-here-are-orlandos-50most.html

as Amway Center, Camping World Stadium, and several downtown entertainment venues. At its peak, more than 164,000 vehicles a day travel SR-408 as it crosses downtown Orlando.

SR-429 provides motorist relief from congestion by extending nearly 23 miles from US 441 in Apopka south to I-4 in Osceola County, providing West Orange and Osceola counties with an alternate north-south route to heavily traveled I-4. An extension of SR 429 (Daniel Webster Western Beltway), the Wekiva Parkway is a 25-mile expressway that represents the final link in the Central Florida Beltway encircling Metro Orlando. The expressway provides travel alternatives to congested area roads and relieves US 441 and SR 46. The SR 429 also greatly enhances access to the Florida's Turnpike and area attractions. At its peak, more than 77,500 a day travel SR-429.

SR-417 provides relief for commuters traveling along Goldenrod Road, Semoran Boulevard, SR-434, and I-4. SR-417 also provides access to motorist traveling to OIA, Valencia College, University of Central Florida, and International Drive. SR-417 is the second busiest road, just behind SR-408, and carries more than 95,000 vehicles a day (mostly in the areas of east Orlando).

SR-528 provides motorists direct access to Orlando's International Drive shopping and entertainment district, Sea World Parks, OIA, Cape Canaveral, and beaches along the east coast. Particularly just east of I-4 and SR 528, the Average Annual Daily Traffic (AADT) count is at 91,900 according to FDOT. This is due to the high amount of tourist traveling from OIA to the attractions, as well as residential areas along John Young Parkway and Orange Blossom Trail.

3.2. Existing CFX ITS Infrastructure

CFX is a primary transportation system operator within the region and includes the following expressways as shown in **Figure 4**:

- State Road 408 (East-West Expressway)
- State Road 414 (Apopka Expressway)
- State Road 417 (Central Florida GreeneWay)
- State Road 429 (Western Beltway) & (Wekiva Parkway)
- State Road 451
- State Road 528 (Beachline Expressway)
- State Road 453
- State Road 538 (Poinciana Parkway)

CFX's revenues are collected by tolls within the system, these tolls pay for the entire system and are reinvested into local transportation projects in the Central Florida region. CFX's roadways expand over 125 centerline miles of limited access expressway (830 lane miles), 69 interchanges, 13 mainline plazas that handle both cash and electronic collection, 5 AET Mainline Plazas, 74 ramp facilities (includes three ramp gantries) and 339 bridges and eight named expressways. This system continues to grow to meet the needs of the region, additional details of this planned expansion can be found in the 2045 Master Plan.

Central Florida Toll Roads

Figure 4: Current CFX Existing Roadway Map and Tolling Plazas

3.2.1. Previous ITS Master Plan

In the 1999 CFX ITS Master Plan, CFX stated that they wanted to position themselves as a leader in the region with the deployment of new "high tech" systems such as the implementation of the E-Pass electronic toll collection system and other strategies that are designed to optimize the operation of its

expressway network. In reviewing the 1999 CFX ITS Master Plan, the following strategies were set forth by the 1999 CFX ITS Master Plan which have been met and/or exceeded.

- Make use of the expressway system by Central Florida's residents and visitors even more attractive by ***providing up-to-date information on traffic conditions;***
- Create an ***even safer system of roadways;***
- ***Minimize delays to customers*** by further reduction of toll plaza congestion and by rapid response to delay-causing incidents such as traffic accidents;
- ***Prolong the useful life of its current infrastructure*** investment by increasing its capacity to handle increasing volumes of traffic; and
- ***Coordinate with the region's other transportation agencies*** to form a seamless transportation system, enhanced by shared information, combined fare/toll collection and coordinated operations.

The following was CFX vision looking forward 20 years from the 1999 CFX Master Plan which has placed them as a leader in the transportation industry today.

An ITS Vision for the Commuter Before *leaving home, the commuter electronically checks a personalized traffic report, finds traffic flowing smoothly, and heads for work on the East-West Expressway. Tolls are automatically calculated and debited from a prepaid, integrated regional transportation account.*

An ITS Vision for the System Operator. *A system operator at the Orlando Area Regional Traffic Management Center is alerted to a traffic slowdown on a busy section of the Greene Way. Video surveillance cameras reveal a minor traffic accident has occurred and a traffic advisory message is selected, thus reducing delays at the accident site.*

Immediate Traveler Information. *Advances in traveler information systems will allow customers to know current traffic conditions on the Expressway system and throughout the region both prior to or during travel. Customers will know when and where incidents are occurring, how long the delays are expected to be and the best alternate routes available to get to their destinations. Among the media by which customers will obtain information will be:*

- *Variable message signs along expressway routes*
- *In-Vehicle Navigation receiving real-time reports from traffic management centers*
- *Internet Web Sites*
- *Cable/broadcast TV Traffic Stations*
- *Radio*
- *Public Kiosks*
- *Hand-held Personal Digital Assistants*

Enhanced E-PASS Toll Collection. *Tolls will be collected without the need for present day toll-plazas. Sensors on entrance/exit ramps will record each vehicle's usage of the system. Local residents will be registered directly with the Authority and their prepaid accounts will be debited monthly.*

Reliable Incident Management and Response. *Incident management systems will immediately detect and verify incidents using equipment such as closed-circuit television, will dispatch the appropriate response services, and will remove and mitigate the effects of incidents throughout the expressway system.*

An ITS Vision for the Business Traveler. *Late for another meeting, the business traveler enters the Expressway's automated lane, and switches the car to auto-pilot.*

Rapid Emergency Response. *Emergency management will be closely coordinated with incident management. Appropriate authorities will be notified of the need to dispatch emergency vehicles to the site of a collision or incident.*

Commercial Vehicle Roadside Automated Safety Checks/Mainline Weigh-In-Motion. *With completion of the Greene Way to I-4 in Seminole County, that roadway will become more important for commercial vehicles. Together with FOOT, the Authority will have implemented pre-clearance systems, mainline weigh-in-motion and automated roadside safety checks.*

Advanced Vehicle Control. *As traffic levels on the Authority's busiest roadways such as the East-West Expressway increase, the Authority will provide peak-hour, high-speed automated lanes for vehicles equipped with advanced vehicle control systems (A VCS) to allow them to operate in automated mode. Customers with equipped vehicles will reach their destinations quicker while customers without equipped vehicles will experience less congestion in non-automated lanes as a result of the automated lanes.*

An ITS Vision for the Tourist *A first-time Orlando area visitor stops by the computerized regional travel information center at the Orlando International Airport after picking up a rental car. The cost of the rental vehicle includes toll, parking, and other regional transportation charges.*

An ITS Vision for the Telecommuter. *A weekly telecommuter takes a LYNX bus to a neighborhood telecommuting center near the UCF campus, where a cubicle is rented twice a week. Communications between the electronic systems at the community center and the telecommuter's office are delivered through a partnership with the Authority, which provides access to their regional fiber optic system.*

Ongoing Agency Cooperation/Coordination. *The future success of the region's advanced technology deployment will, to a large degree, depend on mutual cooperation among the transportation agencies. All agencies, including the Authority, FOOT, municipal traffic agencies, public transportation and aviation authorities and local fire, police, and medical service providers, will work together to promote and encourage the most productive and safest operation of the transportation system. Agencies will work together to plan, design, implement and operate ITS systems.*

Many of these forward-thinking initiatives were achieved over the past 20 years, while some such as the Advanced Vehicle Control and the ITS Vision for the Business Traveler have yet to come to realization. It should be noted that the projects/approach identified in this current Master Plan will help to bring us closer to the realization of the vision laid out in 1999, while also identifying the industry development required for a more ubiquitous approach to Automated Vehicles. Key improvements in the Connected and Automated Vehicle technologies in coming years will support the realization of this vision in years to come. Improvements have also been made in emergency management, rapid emergency response, communications between agencies, system operator advancements, and headway in traveler information systems. Additionally, current studies are being completed on the Smart Parking and Integrated Transportation Applications which will help achieve the vision of seamless travel to the commuter by allowing the concept of on-demand mobility where customers can discover/plan travel options, request, and pay for a door-to-door service using a smartphone or a web application.

3.2.2. CFX Existing ITS Infrastructure

An important initial step in creating an overarching ITS Master Plan is to understand and document the existing conditions and infrastructure to form a foundation from which to build upon.

Overall, CFX maintains over 125 centerline miles (including the new Wekiva Parkway), 830 lane miles (including ramps), 69 interchanges, 339 bridges and 13 mainline toll plazas with approximately 2000+ ITS

devices installed throughout the CFX roadway network. These devices are used to monitor the CFX transportation network to ensure the safety of motorists. CFX operates two independent local area networks (LAN), one for the internal CFX users and tolls collection and the other for the ITS network, which focuses on incident management and information dissemination for traffic incidents. Each network is maintained and operated by different internal departments. For the purpose of this document, the focus will be on the ITS network to provide an understanding of the current capacities and/or need to support a future ready data and technology infrastructure upgrade.

CFX has deployed ITS infrastructure spanning a majority of Central Florida to operate the Expressway ITS System and to connect to arterial operator/maintainer agencies. CFX currently maintains and operates the following ITS deployments:

- Fiber Optic Network (FON)
  - Approximately 500 miles of fiber optic communication lines along the CFX Expressways
  - 72 Single Mode FOC in orange conduit for backbone trunk cable and 72 Single Mode FOC in blue conduit for feeder trunk cable
- Closed Circuit Television (CCTV) cameras
- Dynamic Message Signs (DMS)
- Data Collection Sensors (DCS)
- Wrong Way Driving Detection Devices (WWD) at ramp locations (SR 408, SR 528, SR 417, SR 414, SR 429, and SR 451)
- Dynamic Curve Warning System (DCW)
- Traffic Management Stations (TMS)

3.2.3. Existing ITS Devices

Closed Circuit Television (CCTV) cameras - CFX system includes 277 CCTVs along SR 408, SR 417, SR 429, SR 451, SR 453, SR 528, SR 414, and SR 538. Components of the CCTV system include CCTV cameras, CCTV poles and grounding, CCTV lowering devices, SunGuide Interface, and video wall which all are maintained by CFX. The CFX design approach for CCTV coverage seeks to provide full roadway coverage of the CFX system as well as visual verification to all Dynamic Message Signs owned and operated by CFX. As the roadway system expands additional CCTV cameras will be installed using this deployment approach.

Dynamic Message Signs (DMS) - CFX currently operates 55 Walk-in DMS and 78 front access DMS. There are four front access DMS Signs installed per toll plaza, two in each direction. The DMSs are controlled remotely using the SunGuide software installed on the toll plaza supervisor's computer.

For the Skyline signs, the Ethernet switches are installed inside the DMS housing. That said, all Skyline signs have been issued an end-of-life notice and will be replaced within the 599-545A and 599-545B projects listed in the 21-25 Work Plan.

Data Collection Sensors (DCS) - CFX system includes 188 DCS sensors along SR 408, SR 414, SR 451, SR 453, SR 417, SR 528, SR 520, SR 429, and Turnpike. The majority of DCS deployed by CFX utilizes automatic vehicle identification (AVI) detectors which reads the toll tags transponders within the motorist vehicles. The AVI readers and its components are strategically placed at each exit ramp and at most Walk-In 3-Line DMS' along the toll roadways. The information collected from the E-Pass toll transponders is simply the transponder ID, using Title 21, which is sent to a data collection server and is then encrypted by the server software. The data collection server matches the transponder ID received at various DCS along the roadway to create travel times from one DCS to the other. The calculated travels times are then sent to

SunGuide® to be posted to the DMSs for user awareness. Components of the AVI based DCS system include antennas and mounting brackets, Antenna cables, RF/Reader modules, Communication cables, Poles. The DCS units are the field devices used to pull tag reads for data used in CFX's Travel Time Data Server system. The current system employs all tag transponder data for the calculation of travel times. Use of other technologies such as Bluetooth, WiFi and Tire Pressure Monitoring Sensors has been evaluated and will be deployed systematically throughout the CFX roadway network to provide an alternate means of travel time generation. Additionally, CFX is deploying Blyncsy units on Poinciana Parkway and SR 516. DCS sensors are typically installed at DMS locations and at interchange locations. As the CFX roadway system expands future deployment of DCS locations will follow this deployment approach.

Wrong Way Driving Detection Devices (WWD) - CFX has deployed Wrong Way Driving Ramp Detection System at 53 locations on the expressway system.

In addition to the Ramp Detection system, CFX has deployed 10 Mainline Wrong Way Detection Systems throughout the expressway system. This system consists of one incoming thermal detection camera which is mounted on a sign structure over the detection lanes.

Traffic Management Stations (TMS) - CFX system includes approximately 447 TMS sensors along SR 408, SR 417, SR 429, SR 451, SR 453, SR 528, and SR 414. CFX has specified use of two different types of TMS for deployment, Wavetronix and Houston Radar devices. TMS Sensors provide real time and archived reporting data on Speeds and Volumes on the CFX mainlines and ramps.

3.2.4. Information Dissemination

This section will describe the ways in which traveler information is disseminated by Information Service Providers (ISPs) to motorists traveling along CFX roadways.

Florida 511 - This service provides motorists with information regarding incidents/congestion on the CFX roadways. The online portal shows incident locations and congestion information in real-time and allows website visitors as well as mobile app users to view screenshots and video of CCTVs currently on the system. CFX currently maintains a software application that provides snapshots to all CFX operated CCTV to the 511 portal.

Specific features that FL 511 includes are the following:

- Commuter travel times and reposts on crashes, congestion, and construction.
- Public transit, airport, and seaport information.
- AMBER, Silver and Law Enforcement Officer (LEO) Alerts.
- Travel information, traffic camera views and free personalized services, including customized, travel routes and email, text, and phone call alerts, available on FL511.com.
- Voice-activated and touch-tone navigation available when calling 511.
- The 511 phone calls

DMS – The information posted on these electronic signs display meaningful and accurate traveler information, such as travel time, evacuations routes, amber alerts, construction related closure information, and traffic incident related updates. The information posted on the DMS come from TMC operator as well as travel-time systems that are strategically placed along CFX roadways. The SunGuide traffic management center software is used to control the DMS system.

Road Ranger Work Zone Safety Measures - Through the iCone technology Road Rangers can send a notification through the WAZE application when their hazard lights are activated. The activation of the hazard lights sends an automated notification of their GPS coordinates warning the travel motorist of a Road Ranger ahead through the WAZE application.

Travel Time System and Data Server Software - The Data Server Software uses inputs from DCS devices to generate and ultimately disseminate Travel Times through SunGuide. Additionally, the data server software is used to create custom messages such as travel time alerts, destinated for motorists, which are also sent to SunGuide® to be posted to the DMSs. Since 2005, CFX has been deploying DCSs along each of its roadways to provide full coverage and generate travel times for each roadway segment. The data server software also archives data, monitors AVI status, generate travel time and custom reports and checks for abnormal travel times based on historical information.

3.2.5. Fiber Optic Network

Over the years, through its roadway projects, CFX has deployed an interconnected fiber optic backbone along both sides of the roadways. As it stands today, CFX has enough fiber through its own infrastructure as well as through fiber sharing agreements with its local agency partners to support any of its future projects for the next few years. In addition, as part of the current widening projects on 417 and 429, an additional 72 strand single-mode (SM) fiber optic cable is being installed to support the PTSU devices and network.

Figure 5 on the following page is a pictorial overview representation of the ITS Fiber Optic Network (FON) infrastructure currently deployed by CFX.

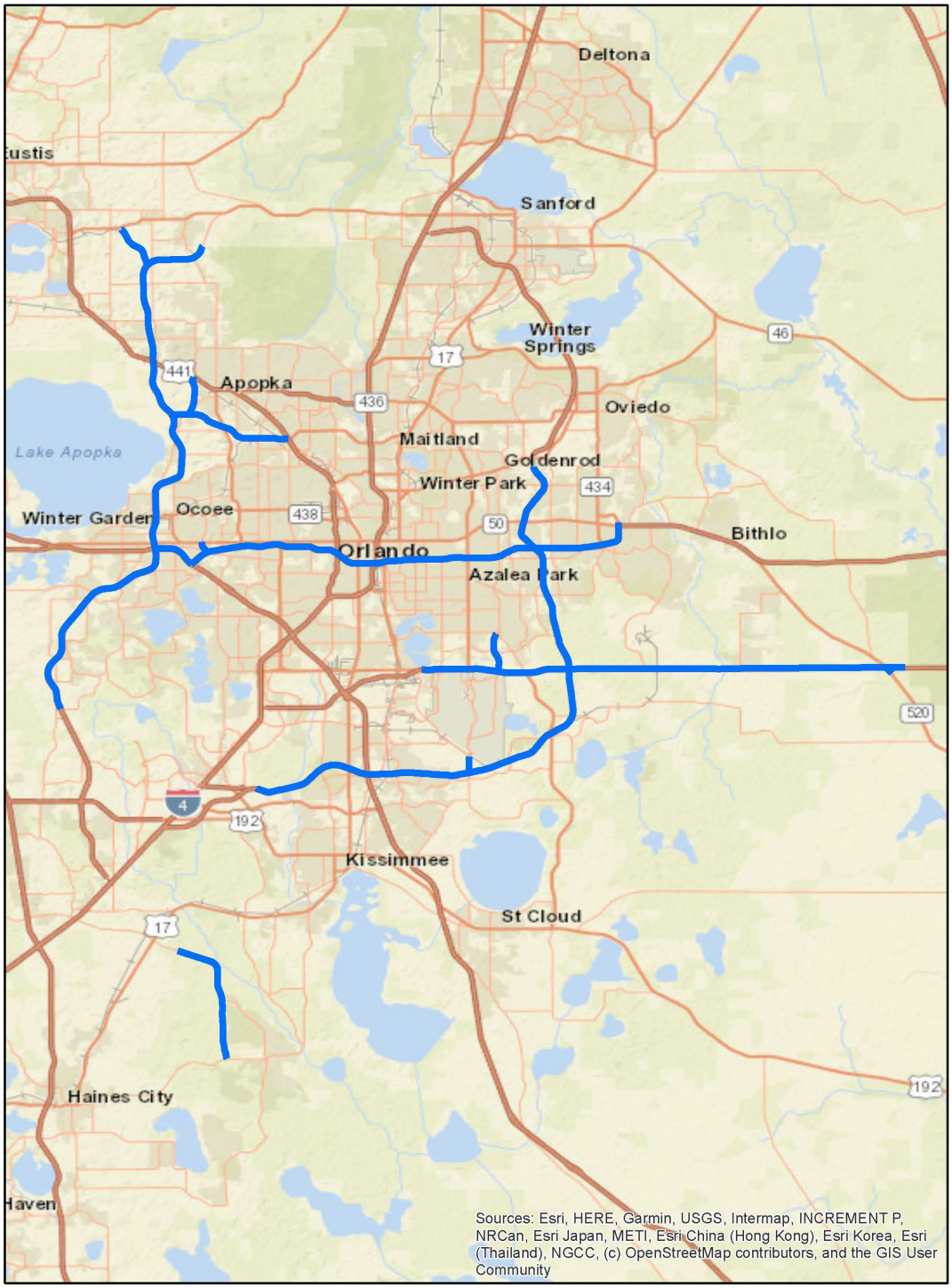

Figure 5: CFX Fiber Optic Network (FON) Infrastructure

3.2.6. Network Communications, Security and Monitoring

CFX has developed a local area network (LAN) that is comprised of layer 2 and 3 network communications equipment, security appliances, virtual and physical servers, ITS field devices, and network monitoring software. The network architecture is structured to provide redundant access from the CFX HQ to its field devices as well as its field devices to the Regional Traffic Management Center in Sanford, FL, which is owned by FDOT District Five. The RTMC has the responsibility to monitor the CFX traffic roadways via CFX's CCTV cameras. The ITS Fiber project, which was recently completed, included the redesign of the CFX ITS LAN. The redesign has provided additional redundancy to the edge devices to ensure resilience and scalability.

Communication Equipment

CFX ITS has been making improvements to its network over the last few years to withstand several field issues such as fiber cuts, power outages, devices failures and misconfigurations to ensure network continuity and data flow. CFX has data centers comprised of carrier grade network router and aggregate switches to provide redundant connections for each server that hosts its critical software and services. Each data center is connected to each other via a set of 40 Gbps fiber connections. Within each data center, servers are connected to a pair of aggregate switches which then connect redundantly to each router. Additionally, all ITS field devices are connected to a layer 2 switch within a local hub. Local hubs have a 1Gb fiber optic connection to one another in a daisy-chained fashion skipping every 6th local hub to create a ring. At the end of each ring is a separate layer 3 switches located within a plaza site. The layer 3 switches act as the redundant gateways and provides a path back to both data center locations over a 10 Gb fiber optic connection.

Network Security

CFX ITS has installed firewall appliances to prevent unwanted and unauthorized access to the network or any CFX resources.

In the field, CFX has installed secure access controls at the cabinet level to prevent unauthorized access to the local hub cabinets. Each hub requires a physical key that communicates to a secure access control server on the CFX network which provides access to cabinets based on the level of permissions assigned to each individual key.

When accessing network equipment from the network, all switches and routers require a secure connection to provide a secure communication session to configure network equipment. All switches require user accounts and permission for switch and router access. Once a user attempts to log into a router or switch, it first checks the accounts validity and assigns permissions for access or denies access based on the roles associated.

Network Monitoring

CFX ITS utilizes network monitoring software for Layer 2 and Layer 3 to monitor the health status of each of its network switches and ITS field devices. This software provides network statistics and analytics to help not only detect, diagnose, resolve but also analyze network performance issues or outages. It also provides uptime performance reports to determine any historical issues with specific devices.

3.2.7. Server Environment and Storage Capacity

CFX ITS has a server environment consisting of 23 servers that support all ITS applications.

Storage Capacity
CFX maintains a scalable storage platform. This platform allows CFX to continue to add storage capacity to existing solutions as needed.

In addition to the current ITS infrastructure in place, CFX is planning to expand and upgrade the overall CFX system. The ITS infrastructure will be expanded in the future to accommodate these projects:

- System expansion into various Counties in Central Florida (see 2045 Master Plan for details).
    - SR 414 Expressway Extension
    - Lake County Connector (SR 516)
    - Poinciana Parkway Extension (SR 538)
    - Osceola Parkway Extension
- In general, all system expansion projects at a minimum will include 72ct feeder and 72ct backbone cables on both sides of the new roadway, DMS at key decision points, Tolls DMS at each mainline plaza, 100% CCTV coverage, TMS spaced at approximate 1/2 mile and at ramps, DCS at each DMS and ramp location and WWD systems at each off ramp.
- Capacity improvement projects, which include the widening of SR 417, SR 429, SR 528, and SR 538 (54 centerline miles – 15 Projects).,
- Completing upgrades at the systems interchanges at the SR 408/I-4 Interchange as well as SR 408/Turnpike and SR 429/Turnpike Interchanges.
- Interchange improvements to SR 528 at Dallas Boulevard and SR 429 at Stoneybrook West Parkway - SR 528 at SR 436
- Installing solar systems (Photovoltaic Systems) at various locations throughout the CFX system to provide Net Metered power to existing Toll Plaza Buildings.
- Replacement of older out of warranty 3-Line DMS throughout the system
- Installing 24 additional WWD detection sites for various ramps and 10 WWD detection mainline sites.
- Improving interchange operations for the following ramp movements:
    - SR 408 westbound exit ramp to Old Winter Garden Road
    - SR 408 eastbound exit ramp to Mills Avenue
    - SR 429 New Independence Parkway

3.3. Neighboring Municipalities and/or Modal Agencies

The following describe various ITS/ATMS communications systems, technologies, devices, and networks used by neighboring municipalities and/or modal agencies that border the CFX roadway system.

FDOT District 5

- ITS/ATMS deployments include: FOC, DMSs, CCTVs, Bluetooth, Video Detection, Wrong-Way Detection, TSP.
- ITS technologies: Visual Surveillance/Vehicle Detection Systems, Advanced Traveler Information Systems, Incident Management and Highway Assistance, Electronic Payment Services, Automatic Vehicle Locations and Automatic Passenger Counter, Active Transportation and Demand Management, Integrated Corridor Management, and Connected and Automated Vehicle Applications.

Florida's Turnpike

- ITS deployments include: 96-Strand FOC, DMSs, CCTVs, MVDSs, Bluetooth
- ITS technologies: Visual Surveillance/Vehicle Detection Systems, Advanced Traveler Information Systems, Incident Management and Highway Assistance, Electronic Payment Services, Automatic Vehicle Locations and Automatic Passenger Counter, Active Transportation and Demand Management, and Connected and Automated Vehicle Applications.

City of Orlando

- ITS/ATMS deployments include: FOC, ADMSs, CCTVs, Bluetooth, Video Detection, TSP
- Connected Vehicle Deployment:
    - PedSafe - an innovative pedestrian and bicycle collision avoidance system designed by FDOT District Five, that is part of their ATTAIN Central Florida program alerting drivers when a pedestrian or cyclist is in the area and traffic signals will be designed to become aware of pedestrians crossing the road.
- ITS technologies: Visual Surveillance/Vehicle Detection Systems, Advanced Traveler Information Systems, Incident Management and Highway Assistance, Electronic Payment Services, Active Transportation and Demand Management, Integrated Corridor Management, Traffic Signal Systems, Connected and Automated Vehicle Applications.

Orange County

- ITS/ATMS deployments include: FOC, ADMSs, CCTVs, MVDSs, Bluetooth, Video Detection, TSP
- Connected Vehicle Deployment:
- AV Shuttles at Lake Nona
    - Automated Vehicle (AV) shuttles that transport residents, workers, and visitors along Tavistock Lake Boulevard. Route is 1.2 miles; shuttle arrives every 10 to 15 minutes.
- Connected Vehicle Deployment:
    - Pedsafe - an innovative pedestrian and bicycle collision avoidance system designed by FDOT that is part of FDOT's ATTAIN Central Florida program alerting drivers when a pedestrian or cyclist is in the area and traffic signals will be designed to become aware of pedestrians crossing the road.
- ITS technologies: Visual Surveillance/Vehicle Detection Systems, Advanced Traveler Information Systems, Incident Management and Highway Assistance, Electronic Payment Services, Active Transportation and Demand Management, Integrated Corridor Management, Traffic Signal Systems, CAV applications.

Osceola County

- ITS/ATMS deployments include: FOC, ADMSs, CCTVs, MVDSs, Bluetooth, Video Detection, TSP
- Connected Vehicle Deployment:
    - Osceola County Connected Vehicle Systems
        - Deploying RSUs at two signalized intersections, Osceola Parkway at Orange Blossom Trail and Orange Blossom Trail at Poinciana Boulevard, to gain experience and compile lessons learned in the deployment of CV infrastructure and applications.
- ITS technologies: Visual Surveillance/Vehicle Detection Systems, Advanced Traveler Information Systems, Incident Management and Highway Assistance, Integrated Corridor Management, Traffic Signal Systems, Connected and Automated Vehicle Applications.

Seminole County

- ITS/ATMS deployments include: FOC, ADMSs, CCTVs, MVDSs, Bluetooth, Video Detection, TSP
- Connected Vehicle Deployment:
    - SR 434 Connected Vehicle Deployment
    - Deploy Roadside Units (RSU) and utilize signal phasing and timing, TSP, and preemption applications along SR 434. The project is anticipated to complete deployment by 2020.
- ITS technologies: Visual Surveillance/Vehicle Detection Systems, Advanced Traveler Information Systems, Incident Management and Highway Assistance, Electronic Payment Services, Active Transportation and Demand Management, Integrated Corridor Management, Traffic Signal Systems, Connected and Automated Vehicle Applications.

Lake County

- ITS/ATMS deployments include: FOC, DMSs, CCTVs, MVDSs, Bluetooth, Video Detection
- ITS technologies: Visual Surveillance/Vehicle Detection Systems, Advanced Traveler Information Systems, Incident Management and Highway Assistance, Electronic Payment Services, and Traffic Signal Systems, Connected and Automated Vehicle Applications.

Brevard County

- ITS/ATMS deployments include: FOC, DMSs, CCTVs, MVDSs, Bluetooth, Video Detection
- ITS technologies: Visual Surveillance/Vehicle Detection Systems, Advanced Traveler Information Systems, Incident Management and Highway Assistance, Electronic Payment Services, Integrated Corridor Management, Traffic Signal Systems, Connected and Automated Vehicle Applications.

LYNX

- ITS technologies: Visual Surveillance/Vehicle Detection Systems, Advanced Traveler Information Systems, and Electronic Payment Services, Automatic Vehicle Locations and Automatic Passenger Counter.

SunRail

- FOC along track is 96-strand
- ATMS tools installed on all cars: AVL, Automatic Announcement System (AAS), Bike racks, Promoting mode choice
- ITS technologies: Advanced Traveler Information Systems, Electronic Payment Services, and Automatic Vehicle Locations and Automatic Passenger Counter.

Table 12, on the following page, illustrates which ITS technologies are currently being used by the respective modal agency and/or municipality.

Table 12: Existing ITS Communication Systems

Municipality/ Modal Agency	Visual Surveillance/ Vehicle Detection Systems	Advanced Traveler Information Systems (ATIS)	Incident Management & Highway Assistance	Electronic Payment Services	Automatic Vehicle Locations (AVL) & Automatic Passenger Counter (APC)	Active Transportation and Demand Mgmt. (ATDM)	Integrated Corridor Mgmt. (ICM)	Traffic Signal Systems	Connected and Automated Vehicle Applications
FDOT	●	●	●	●	●	●	●		●
Florida's Turnpike	●	●	●	●	●	●			●
City of Orlando	●	●	●	●		●	●	●	●
Orange County	●	●	●	●		●	●	●	●
Osceola County	●	●	●	●			●	●	●
Seminole County	●	●	●	●		●	●	●	●
Lake County	●	●	●	●				●	
Brevard County	●	●	●	●				●	
LYNX	●	●		●	●				
SunRail		●		●	●				

3.4. Planned and Committed Improvements

One of the primary goals of CFX is to provide and maintain a satisfactory level of service to its clients, while accommodating a rapidly increasing, high level of usage. This level of usage and the rapidly increasing traffic growth have led CFX to plan for roadway and system improvements to maintain the level of service provided to its customers. The 2040 Master Plan identified a number of system improvements and expansion projects which are described below.

3.4.1. Existing System Improvements

Improvements to the existing CFX infrastructure include capacity improvement projects and operational/safety improvements. Projects within the first two years of the 2022-2026 Five-Year Work Plan include:

- SR 408 Widening from Pine Hills Plaza to East of Church Street
- SR 408 Widening Westbound from Mills Avenue to Bumby Avenue
- SR 408 Widening from West of SR 436 to Goldenrod Road
- SR 417 Widening from International Drive to SR 528 (5 projects)
- SR 417 Widening from Curry Ford Road to SR 408
- SR 429 Widening from Tilden Road to SR 414 (3 projects)
- SR 528 Widening from SR 436 to Goldenrod Road
- SR 528 Widening from Goldenrod Road to Innovation Way (3 projects)

- SR 528 Farm Access Road 1 Bridge Removal
- SR 528 West Mainline Toll Gantries
- SR 538 Widening from Ronald Reagan Parkway to Cypress Parkway

3.4.2. System Expansion Projects

As noted in Section 1, CFX is expected to expand on the existing infrastructure. System expansion projects detailed in the FY 22-26 CFX Work Plan include new alignments for four studies and four complete (design, right-of-way, and construction) projects:

Studies:

- Northeast Connector Expressway Phase I Project Development and Environment (PD&E) Study
- SR 414 Expressway Extension PD&E Study
- Osceola/Brevard County Connectors Concept, Feasibility & Mobility (C, F, &M) Study
- Southport Connector Expressway PD&E Study

Complete Projects:

- SR 414 Expressway Extension
- SR 516 Lake Orange Expressway (3 projects)
- SR 538 Poinciana Parkway Extension and CR 532 Widening (3 projects)
- Osceola Parkway Extension (3 projects) (design and right-of-way only)

Figure 6, on the next page, shows an overall view of the studies and design projects currently identified in the work plan. Additional studies for future expansion projects in Brevard, Lake, Orange, Osceola, and Seminole Counties were also included.

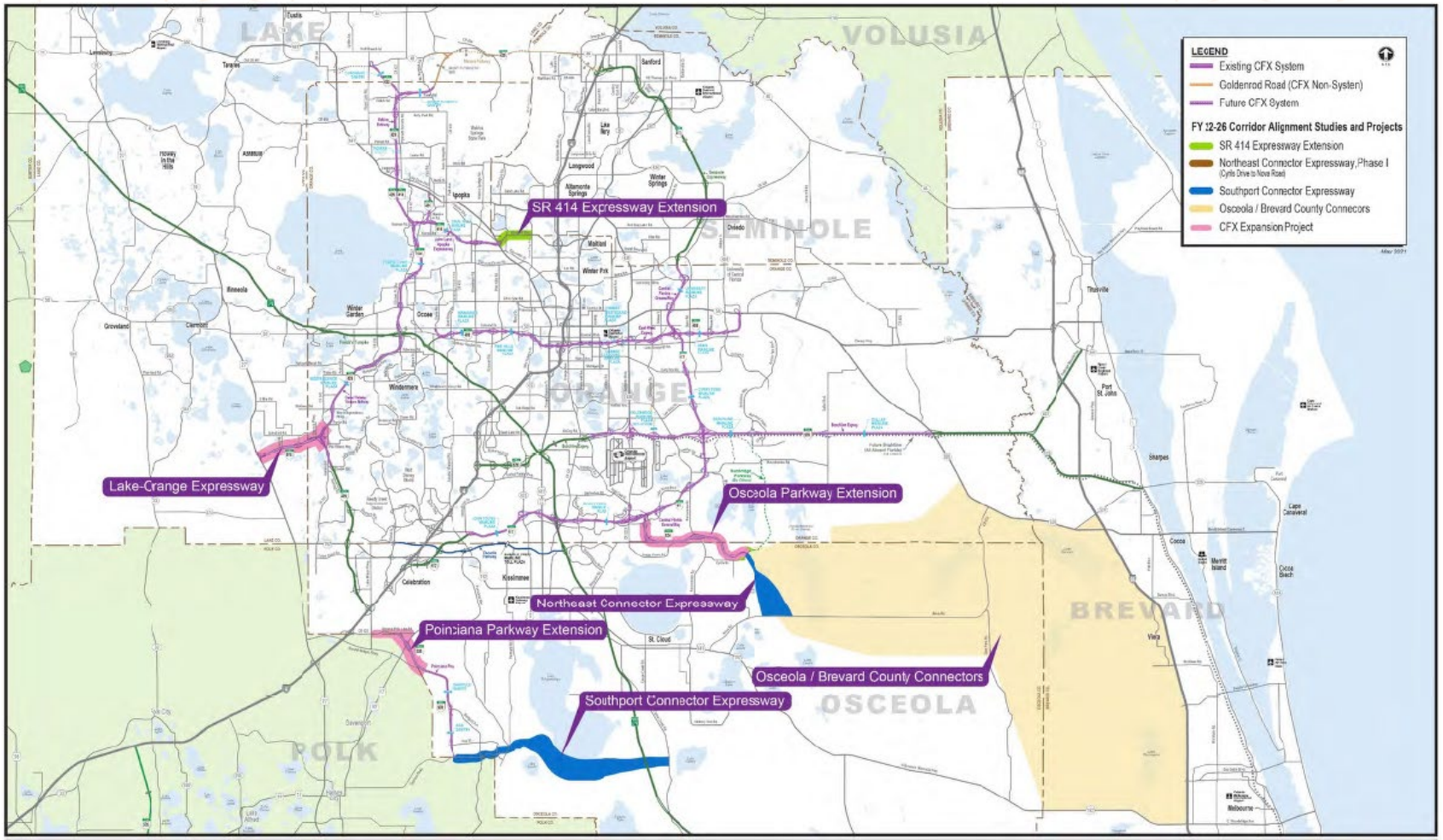

Figure 6: System Expansion Map

3.4.3. Interchange Projects

CFX is currently developing plans for major improvements to several interchanges and has also identified new interchanges as potential projects. The FY 2022-2026 Work Plan details the following improvements:

- SR 408/I-4 Interchange
- SR 408/Tampa Avenue Interchange
- SR 528/Dallas Boulevard Interchange

The SR 408/I-4 Interchange is part of the I-4 Ultimate Project currently under construction by FDOT and consists of five new flyover ramps at the SR 408/I-4 Interchange which opened to traffic in May 2020. The SR 408/Tampa Avenue Interchange is currently under design and the widening project on SR 528 from SR 436 to Goldenrod also includes major interchange improvements to the SR 528/SR 436 Interchange.

3.4.4. Facilities and Sustainability Projects

CFX is also invested in improving and connecting its existing facilities based on the FY 2022-2026 Work Plan. These projects include systemwide toll plaza projects, miscellaneous headquarter improvement projects, renovation to the E-PASS Magnolia Avenue Service Center, East and West District Facility projects and sustainability program projects. Also included in this category are generator, air conditioner and roof replacement projects.

CFX's sustainability projects include performing additional research and implementing technologies such as photovoltaics (PVs), electric vehicle charging stations, electric vehicles and retro-commissioning efforts. The retro-commissioning efforts include improvements to building efficiencies by replacing the Facilities Control System as well as the fluorescent lighting with LED fixtures. One project currently underway is a design-build project which will implement elevated PVs at the Hiawassee Mainline Plaza. Additionally, CFX is implementing a functioning DMS floating solar concept on SR 429 at Mile Marker 11.7 Northbound.

3.4.5. Transportation Technology Projects

Transportation Technology projects include projects related to field devices, the ITS server environment, traffic monitoring systems, traffic safety enhancements and security improvements. Per the FY 2022-2026 Work Plan these projects include:

- Regional ITS Partnership Projects - are systemwide Transportation technology projects funded for ITS studies by regional partners to further improve the benefits of ITS technologies for CFX customers.
- Advanced Expressway Operations Performance Measures - includes the development and implementation of systems and methods to fully leverage CFX's ITS system to provide advanced expressway operations performance measures and provide data for enhanced decision making.
- Wrong-Way Driving Countermeasures - will deploy wrong-way countermeasures equipment at ramp locations along SR 408, SR 417, and SR 528.
- Three-Line DMS Upgrade Program - includes systemwide new full-color DMS roadway signs.
- Connected Vehicle Pilot Project and Technology Deployment - is a selection of connected vehicle pilot projects to be made from a list of potential projects identified in the Connected Vehicle Study. Includes designing and constructing a mini-pilot project to prepare for connected vehicle technologies. Installation also includes software development.
- Transportation Technology Hardware Replacements

- Lane Control Operations Software - operations software for lane control associated with Part Time Shoulder Use.
- Hiawassee to HQ Direct Connect - Fiber optic cable installation from Hiawassee to CFX Headquarters.

3.4.6. Information Technology Projects

Information Technology and security is also a primary goal of CFX. The projects detailed in the FY 2022-2026 Work Plan include projects related to system automation software and electronic toll operating systems. The Toll Collection System Upgrade project is currently underway with funding allocated within the first two years of the Work Plan. Other projects include:

- IT Infrastructure Upgrade
- CFX Operations Software Update
- Software Development
- Financial/Accounting Software Replacement
- Toll System Hardware and Software Enhancement/Refresh
- Toll Plaza Security Cameras

3.4.7. Signing and Pavement Markings Projects

The 2022-2026 Work Plan also includes funding for the design and construction of systemwide miscellaneous signing and marking projects and guide sign replacements. Four guide sign replacement projects are included in the Work Plan, two of which are nearing completion of the design phase. Additional projects include systemwide annual toll rate signing updates, systemwide trailblazer upgrades and systemwide signing replacement projects.

3.4.8. Renewal and Replacement Projects

Upgrades to the existing system are always expected. The majority of funds dedicated to renewing and replacing the existing infrastructure are committed to milling and resurfacing projects. The scheduled projects follow the CFX's recommendations included in the pavement management plan per the FY 2022-2026 Work Plan:

- SR 408 from Lake Underhill Road to SR 417 (2 Projects)
- SR 408 from Woodbury Road to East SR 50
- SR 408 from Good Homes Road to Hiawassee Road
- SR 417 from SR 528 to the Canal E-4 Bridge (2 Projects)
- SR 429 / 414 from SR 414 to US 441
- SR 429 from US 441 to North of CR 435 (2 Projects)
- SR 451 from SR 414 to US 441
- SR 453 from SR 429 to SR 46
- SR 528 from McCoy / Boggy Creek Road to SR 436
- SR 528 Miscellaneous Resurfacing

This section also includes a pavement improvements project on SR 429 from CR 535 to CR 437A, drainage improvements, bridge, coatings and fence projects, as well as retro-reflective pavement markers (RPM) and thermoplastic striping replacement. It should also be noted that funding has been allocated for traffic signal and UPS replacements and upgrades.

3.4.9. Non-System Projects

CFX is invested in its community and stakeholders and as a result has taken on projects which may impact the overall infrastructure. This includes resurfacing projects such as the Goldenrod Road extension which is a non-system road operated and maintained by CFX.

3.5. Future/Expected Expansion of Express Lanes

3.5.1. Future CFX Expressway Improvements

The following includes future CFX Expressway Improvements.

3.5.1.1. SR 408 Eastern Extension

SR 408 (East-West Expressway) Eastern Extension is proposed to expand connectivity from the SR 50 interchange to the SR 50/SR 520 Intersection in East Orange County and is approximately 7 miles in length. The eastern extension of SR 408 would provide an east-west high-speed corridor with future connectivity to I-95 as shown in **Figure 7** below. SR 408 is expected to add 2 tolling facilities at Tampa Avenue.

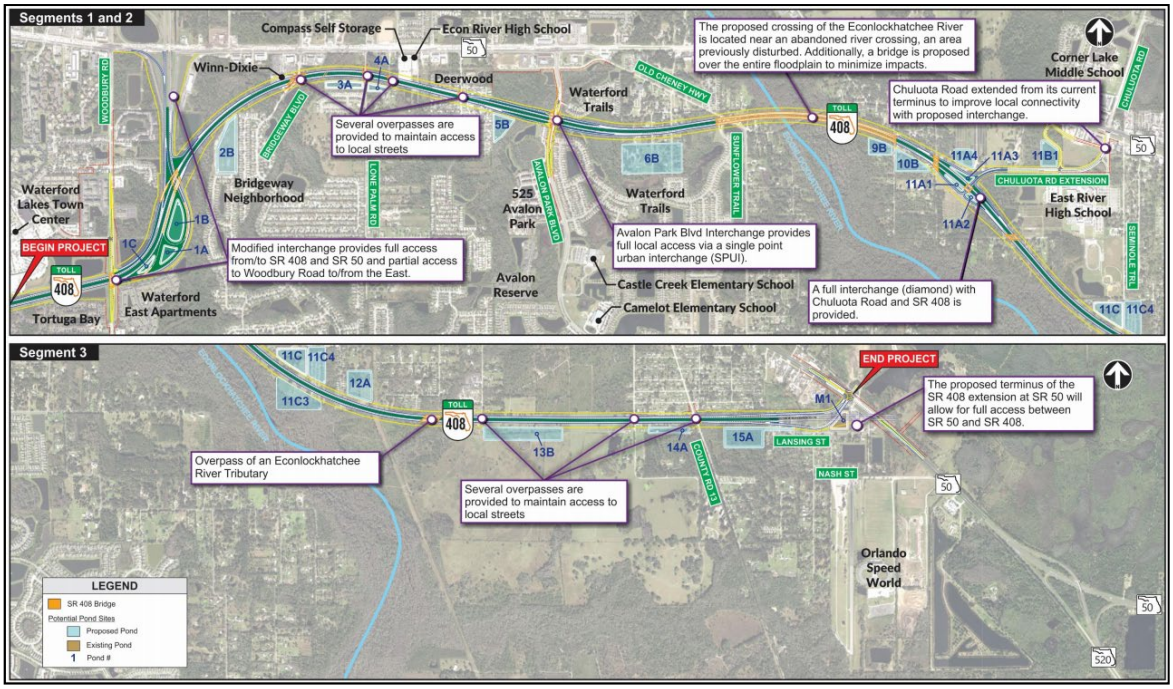

Figure 7: Future Expansion of SR 408 (East-West Expressway)

3.5.1.2. SR 538 Poinciana Parkway Extension/I-4 Connector

The SR 538 (Poinciana Parkway Extension/I-4 Connector) projects are expected to start at the northern end of the existing bridge over the Reedy Creek Mitigation Bank to CR 532 in Osceola and Polk Counties as seen in **Figure 8,** on the following page. These projects are currently under design. The plans for this project include a tolled 4-lane expressway within approximately 330 feet of CFX's right-of-way (ROW) and also provides infrastructure for any intended future expansion which includes additional lanes and/or other multimodal travel options if needed in the future. This project also includes the construction of a

bridge/flyover which is approximately 0.9 mile in length over the wetlands in the Reedy Creek Mitigation Bank and the Upper Lakes Basin Watershed.

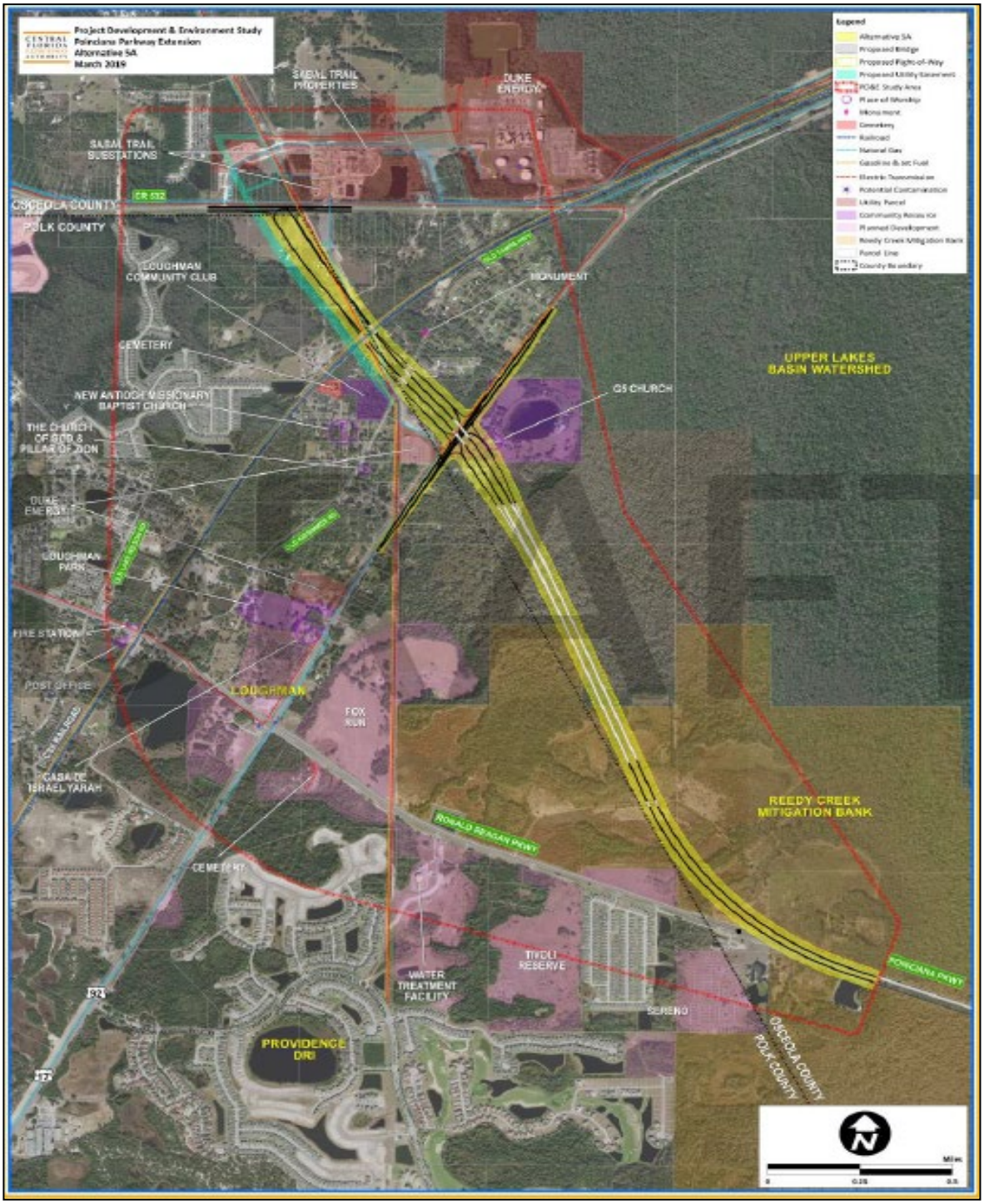

Figure 8: SR 538 Poinciana Parkway Extension/I-4 Connector Expansion

3.5.1.3. SR 538 (Poinciana Parkway) Widening from Ronald Reagan Parkway to CR 580/Cypress Parkway

This design/build project will widen the existing Poinciana Parkway by adding two lanes to create a divided four lane expressway on SR 538/Poinciana Parkway from Ronald Reagan Parkway to CR 580/Cypress Parkway. This 7-mile widening is currently under construction and is expected to improve traffic flow and operations in the area. The project also includes three proposed sound walls; re-aligning the intersection of CR 580/Cypress Parkway at Solivita Boulevard; building a second bridge over the Reedy Creek Mitigation Bank; and two new ramps at the existing interchange with Marigold Avenue as showing in **Figure 9** below.

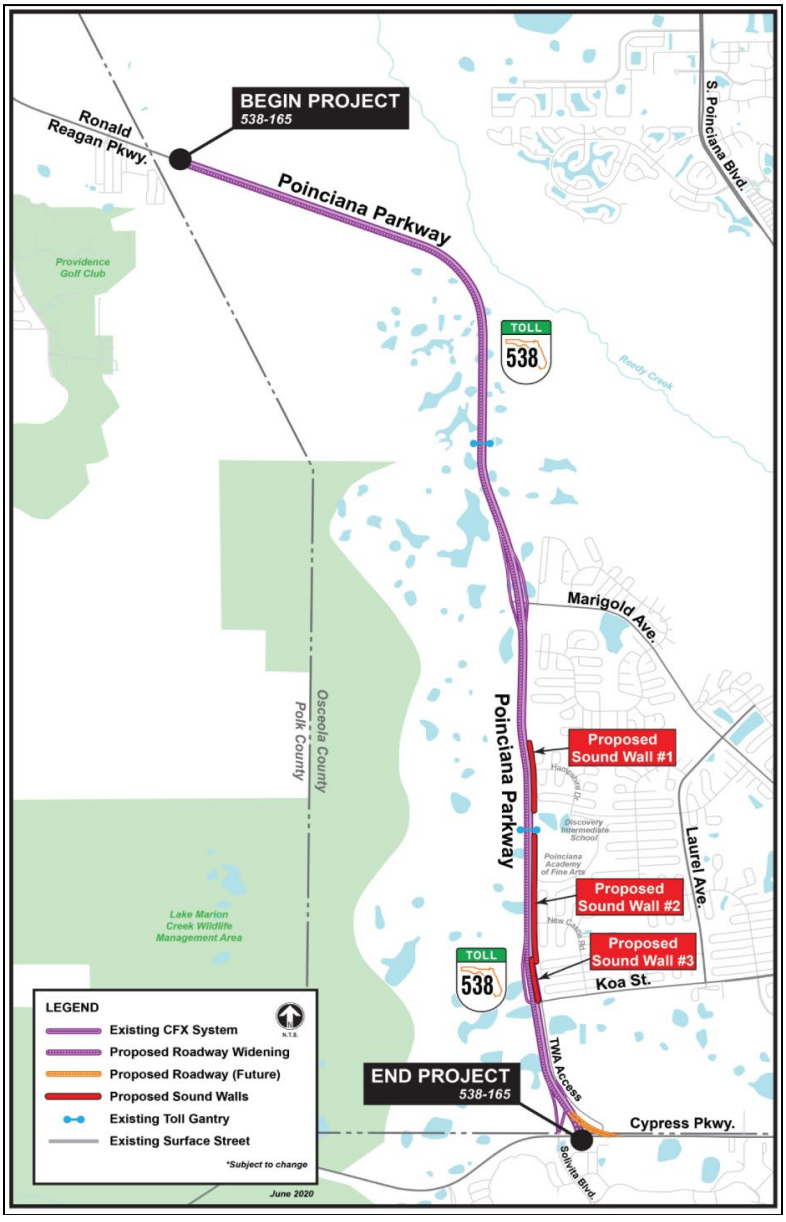

Figure 9: SR 538 Widening Ronald Reagan Parkway to CR 580/Cypress Expressway

3.5.1.4. Lake/Orange County Connector

The Lake/Orange County Connector is expected to provide a nonstop access route linking traffic on US 27 in south Lake County to SR 429 in west Orange County. This future 5-mile tolled expressway is currently under design with construction potentially beginning by the end of 2022. The connector will begin with an interchange approximately 1,800 feet north of the Frank Jarrell Road intersection on US 27 and proceeds in a northeasterly direction when it then merges with the previous two alignments just east of the Lake/Orange County line as seen in **Figure 10** below.

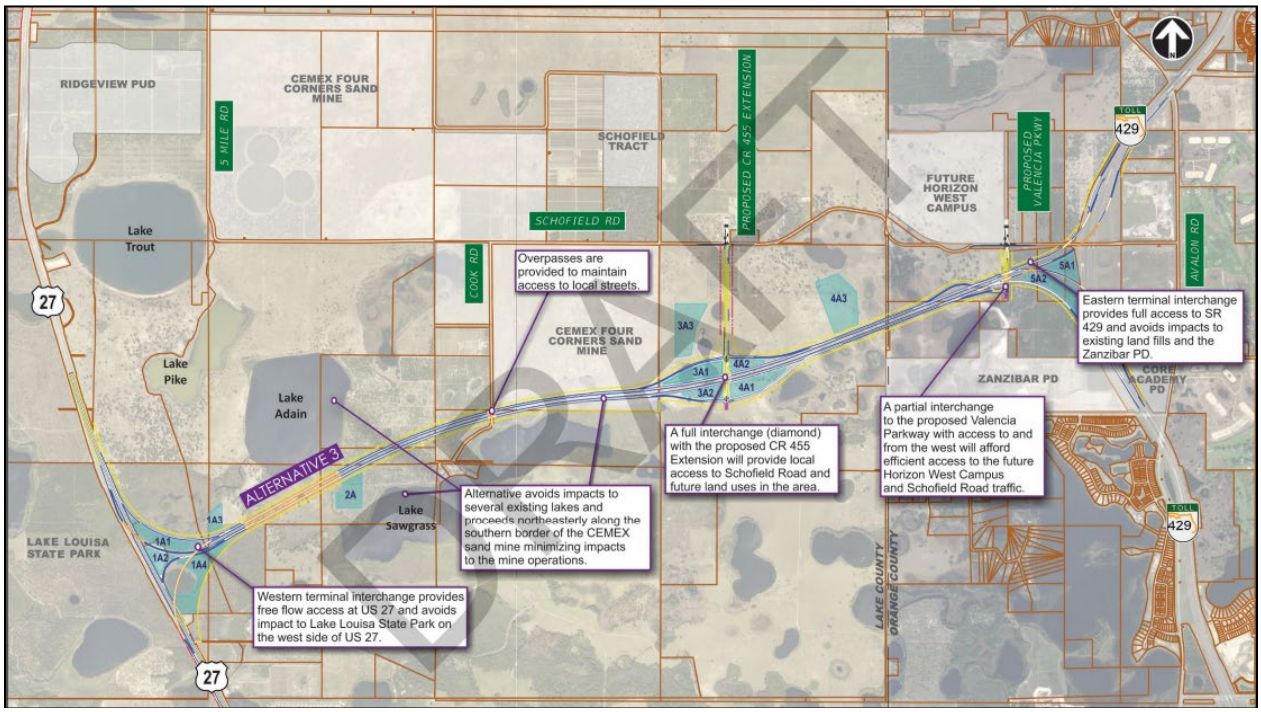

Figure 10: Lake/Orange County Connector Expansion

3.5.1.5. SR 414 (Apopka Expressway) Extension

This proposed 2.3-mile project will provide a direct connection between the eastern end of the SR 414 (Apopka Expressway) and SR 434. This project will include limited-access toll lanes on SR 414 (Maitland Boulevard) to provide needed capacity between US 441 and SR 434 while maintaining the existing local access lanes. A Project Development and Environment (PD&E) study for this project is currently underway. The proposed improvements also included the reconfiguration of the existing infrastructure for SR 414 (Maitland Boulevard) to accommodate the SR 414 toll facility while maintaining two local access lanes in each direction of SR 414, see **Figure 11**, on the following page, for project limits.

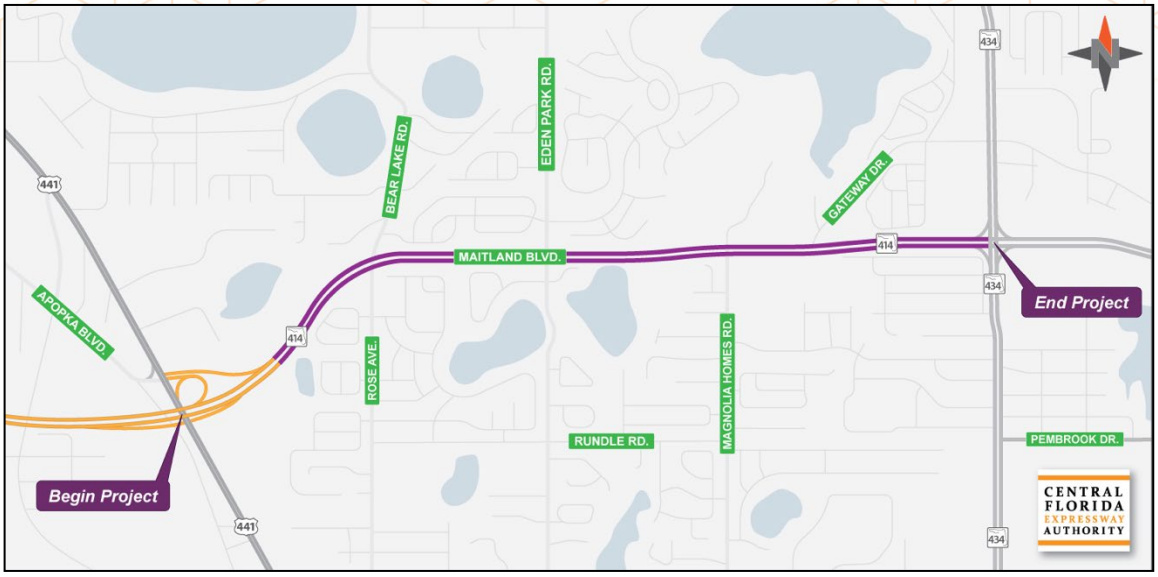

Figure 11: SR 414 (Apopka Expressway) Future Extension

3.5.1.6. CR 522 (Osceola Parkway Extension)

This proposed 9 mile limited-access toll road is expected to connect SR 417 near Boggy Creek in Orange County to Cyrils Drive in Osceola County. The project will begin at the interchange with SR 417 and extends approximately 1.5 miles south as seen in **Figure 12**, on the following page. The facility will then turn eastward just north of the Orange County/Osceola County line and extend east/southeast for approximately 8 miles before connecting to Cyrils Drive. It also provides an opportunity to connect to the proposed Sunbridge Parkway to the east and a future Northeast Connector to the south.

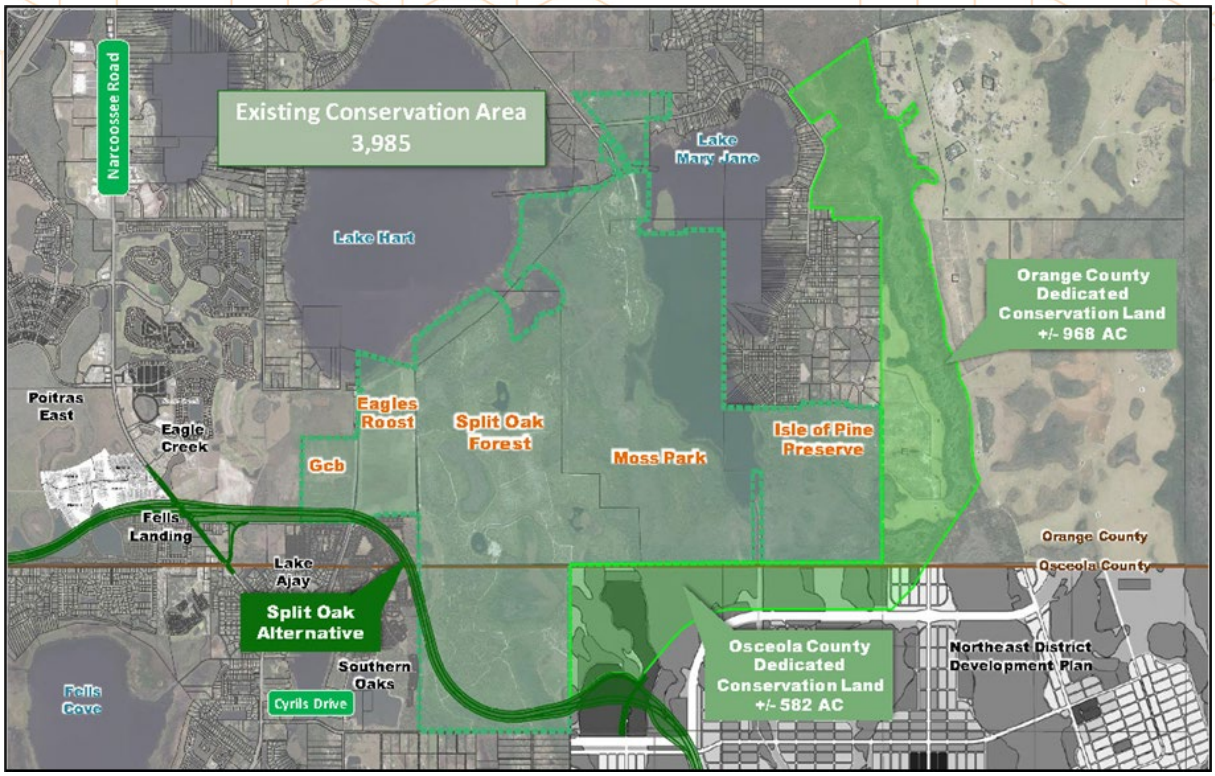

Figure 12: CR 522 (Osceola Parkway) Future Extension

3.5.2. FDOT Express Lanes Projects

The following includes FDOT Express Lane Projects.

3.5.2.1. I-4 Ultimate and I-4 Beyond the Ultimate

The I-4 Ultimate project is more than 21 miles from west of Kirkman Road (Orange County) to east of State Road 434 (Seminole County). The total estimated cost of design and construction for this project is $2.3 billion. The I-4 Ultimate project is expected to lessen congestion and improve overall quality of travel throughout the Orlando vicinity. This project consists of 140 bridge improvements/additions, reconstruction of 15 major interchanges and implement express lanes with dynamic toll pricing to the center of I-4, two in each direction, and rebuild the general use lanes and auxiliary lanes.

The project is a public-private partnership (P3) which is a contractual agreement between a public agency, in this case FDOT, and a private sector proposer or bidder known as the concessionaire, in this case I-4 Mobility Partners. P3s transfer some of the responsibilities, risks and/or rewards of project ownership from the public sector to a private entity for a fixed period of time.

The I-4 Ultimate project is expected to expand the existing ramp toll plaza located at the SR 408 westbound exit to Orange Blossom Trail by adding an additional cash/E-Pass Lane and toll booth per CFX's design standards. All ramps connecting SR 408 and I-4 are included in the operation and maintenance limits. The tolling facilities along SR 408 are owned and operated by CFX. The mainline fiber and fiber drops on State Road 408 within CFX's right of way were replaced and is expected to provide equal or better coverage and level of service.

I-4 Beyond the Ultimate covers 21.2 miles of I-4 from US 27 in Polk County east to Kirkman Road in Orange County and 19 miles from State Road 434 in Seminole County east to State Road 472 in Volusia County which will impact travel patterns within Seminole, Volusia and Polk counties.

Construction on the I-4 Beyond the Ultimate has begun. Reconstruction of the E.E. Williamson Road overpass and the addition of the eastbound I-4 auxiliary lane from the end of the I-4 Ultimate project to Lake Mary Boulevard began in summer 2019. Milling and resurfacing work on the westbound Interstate 4 (I-4) travel lanes in Seminole County started in June 2020. Milling and resurfacing work on the eastbound Interstate 4 (I-4) travel lanes in Seminole County was completed in summer 2020.

3.6. Identification and Response to Traffic Incidents

The RTMC is the central point of contact/dispatch for all agencies and responders. Incident management uses operators stationed in a RTMC or local TMC that identify non-reoccurring active traffic incidents such as vehicle crashes, disabled vehicles and severe weather through the use of roadside detectors and camera surveillance. Upon detection of an incident, the operators are instructed to follow a pre-developed set of standard operating guidelines (SOG) to notify the appropriate first response agencies (i. e. Fire, Police, etc.). In addition, not only are the emergency first responders notified, but the traveling public is also notified via the ITS traveler information system (i.e., HAR, DMS, FL 511, etc.). The technologies and strategies utilized by these programs have drastically improved incident response practices and incident clearance times. Statewide, the average roadway clearance times on freeways have been cut almost in half since the inception of incident management.

Overall, incident management has shown significant savings in terms of reducing unnecessary delay, idling, fuel consumption, automotive gas emissions and secondary crashes. Currently, incident management operations along Florida's freeways are recognized at the highest level throughout the nation. As stated earlier, up until just recently, these practices were limited to the state's freeways. However, with the advent of ICM, which recommends that all types of roadways work to balance traffic within a region, the desire to bring incident management to the arterial corridors is growing. The below **Figures 13** and **14** demonstrate CFX Traffic Incident Plan and their specific notification process along with their Scene Management Plan.

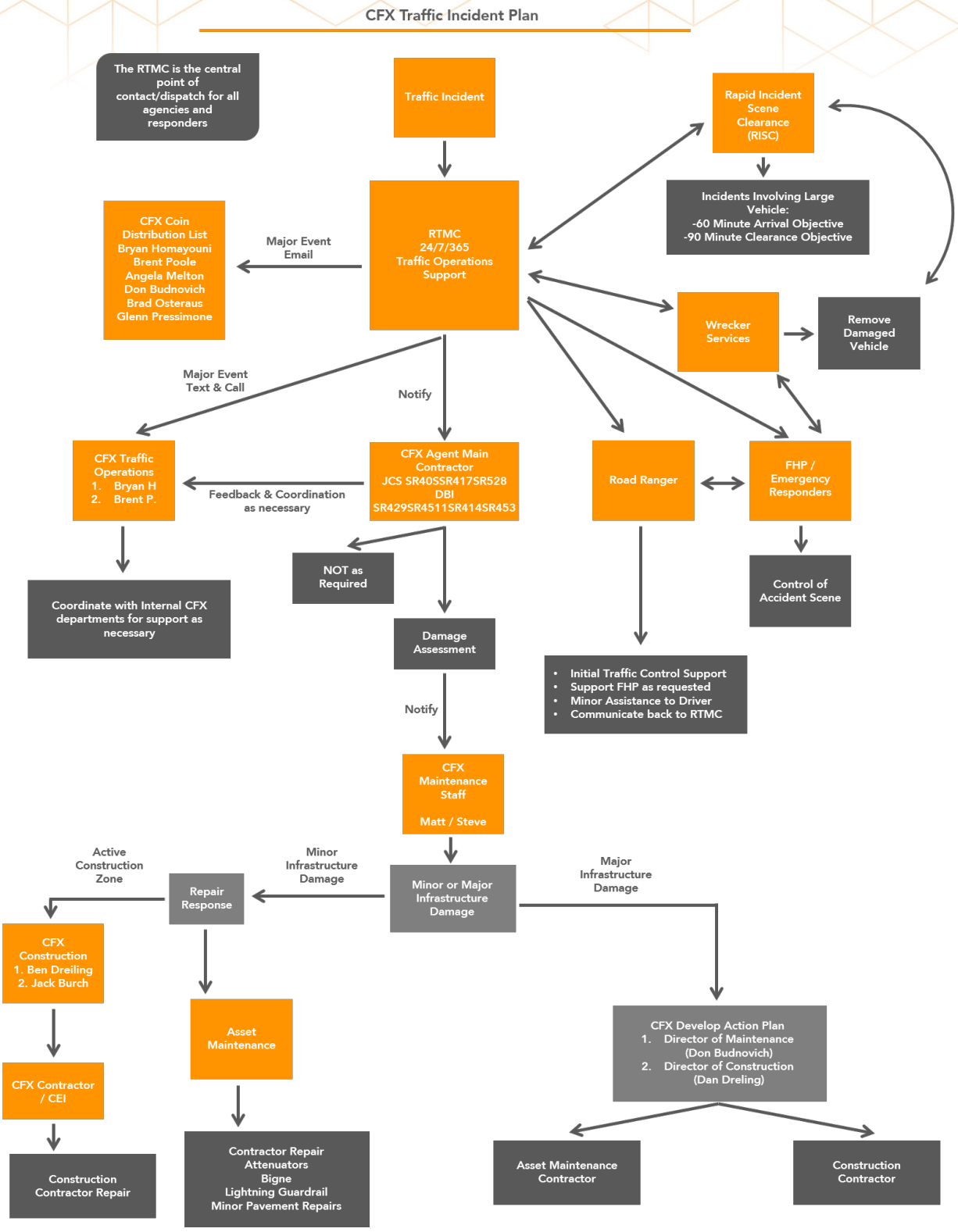

Figure 13: CFX Traffic Incident Management Plan

Scene Management

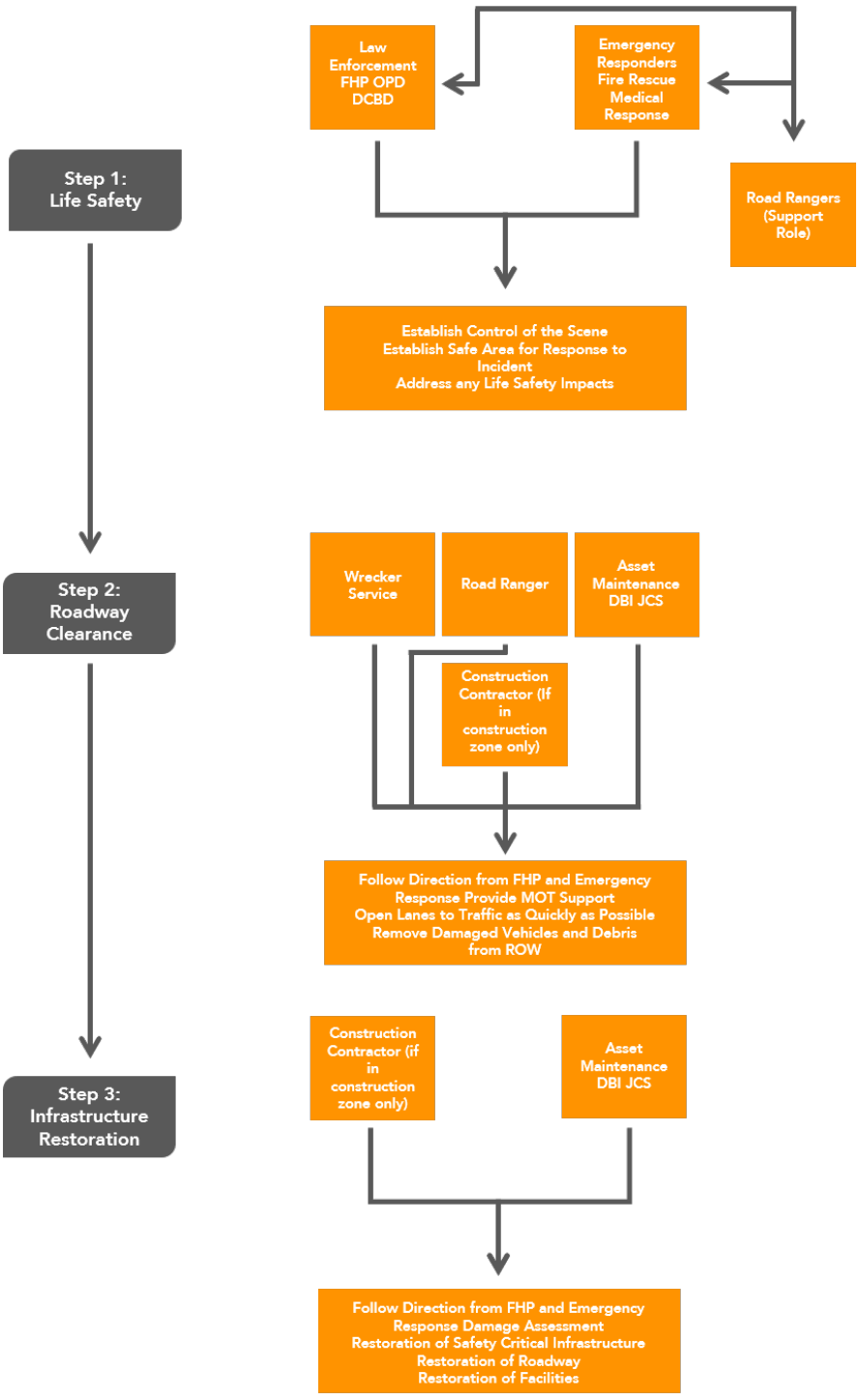

Figure 14: CFX Scene Management Plan

3.7. Park & Ride Facilities

Park and Ride facilities serve as locations for motorists to collect and transfer to higher occupancy modes of travel such as transit, carpools/vanpools, and ridesharing. Within the CFX system, there are several LYNX stops that serve as transit support facilities for motorists.

Below identify various routes in the vicinity of SR-408, SR-417 and Osceola Parkway:

- **KnightLYNX Blue 210**
  - Provides service between the University of Central Florida and Waterford Lakes Town Center.
- **Avalon Park School Connector 320**
  - Provides services from Colonial Drive, Avalon Park and Old Cheney Highway.
- **Chuluota Park and Ride Lot**
  - A parking facility located just west of Chuluota Road and has available 87 parking spaces with 5 for handicapped and 2 bike lockers.
- **NeighborLink 621**
  - Provides several stops along Colonial Drive, Avalon Park Boulevard and Sunflower Trail.
- **FastLink 407**
  - Serves the Kissimmee Intermodal Station/SunRail, OIA, the United States Tennis Association National Campus, and Medical City at Lake Nona.
- **FastLink 418**
  - Serves the Meadow Woods SunRail Station, the Meadow Woods Recreation Center, Medical City at Lake Nona, and the Florida Mall SuperStop.

3.8. Evacuation Routes

Evacuation routes are critical in the event of an emergency, and especially in times of extreme weather. Every summer there are dozens of named tropical storms and hurricanes that form along the Gulf of Mexico and Atlantic Ocean. This makes it even more critical that the need for efficient evacuation operations is properly set forth when a major weather event takes place in the Central Florida region. Currently, SR-528 and SR-408 serve as CFX's primary evacuation routes.

CFX also shares the following evacuation routes in the surrounding County's which are highlighted in red in **Figure 15,** on the following page.

- **Brevard County -** SR 91, SR 528
- **Lake County -** SR 417, SR 429, SR 528, SR 408
- **Orange County -** SR 408, SR 429, SR 414, SR 417, SR 528
- **Osceola County** - SR 417, SR 429

Also see below **Figures 16-20** which displays various evacuation routes in and around the jurisdictions of CFX for each County.

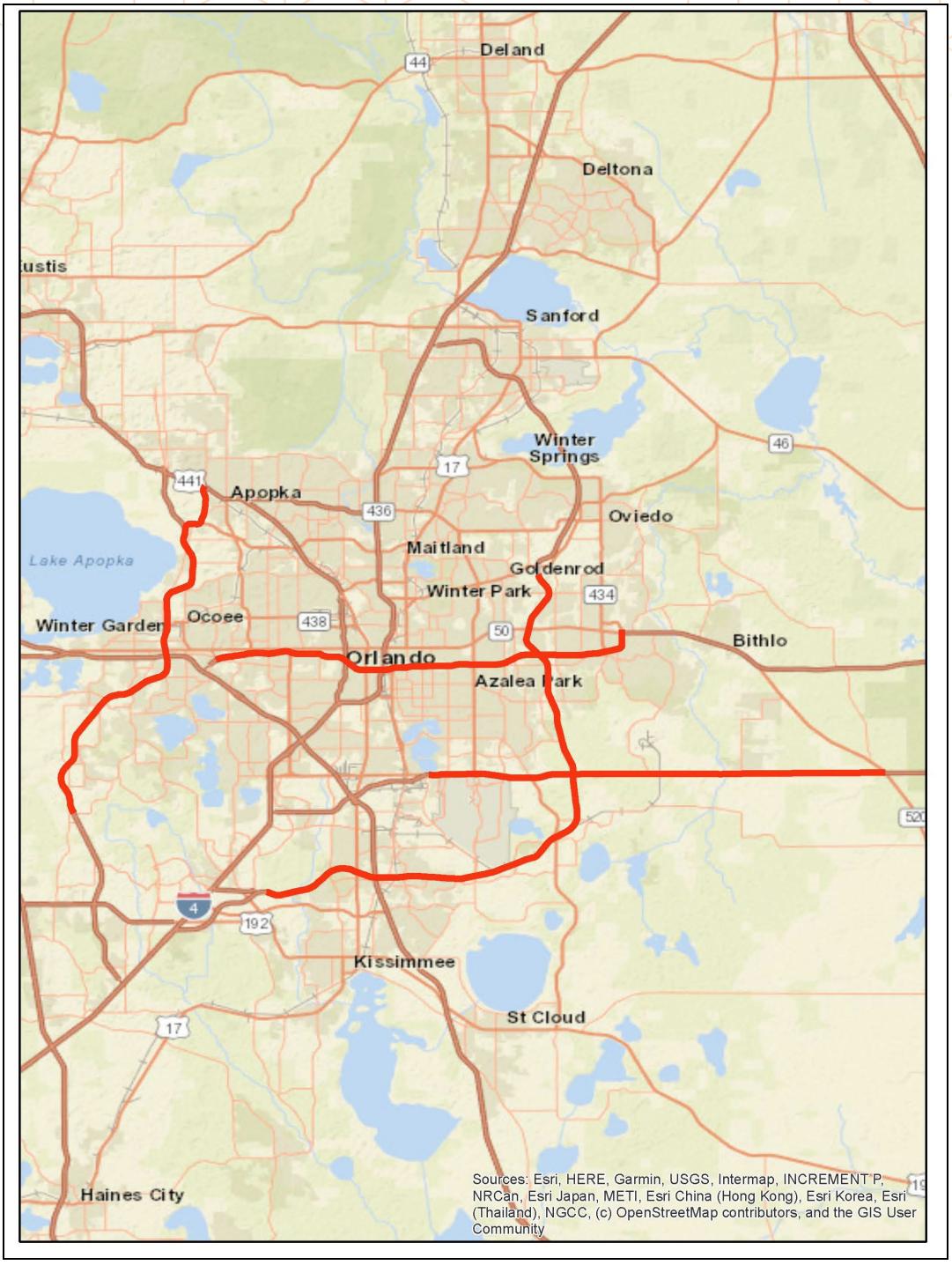

Figure 15: CFX Shared Evacuation Routes

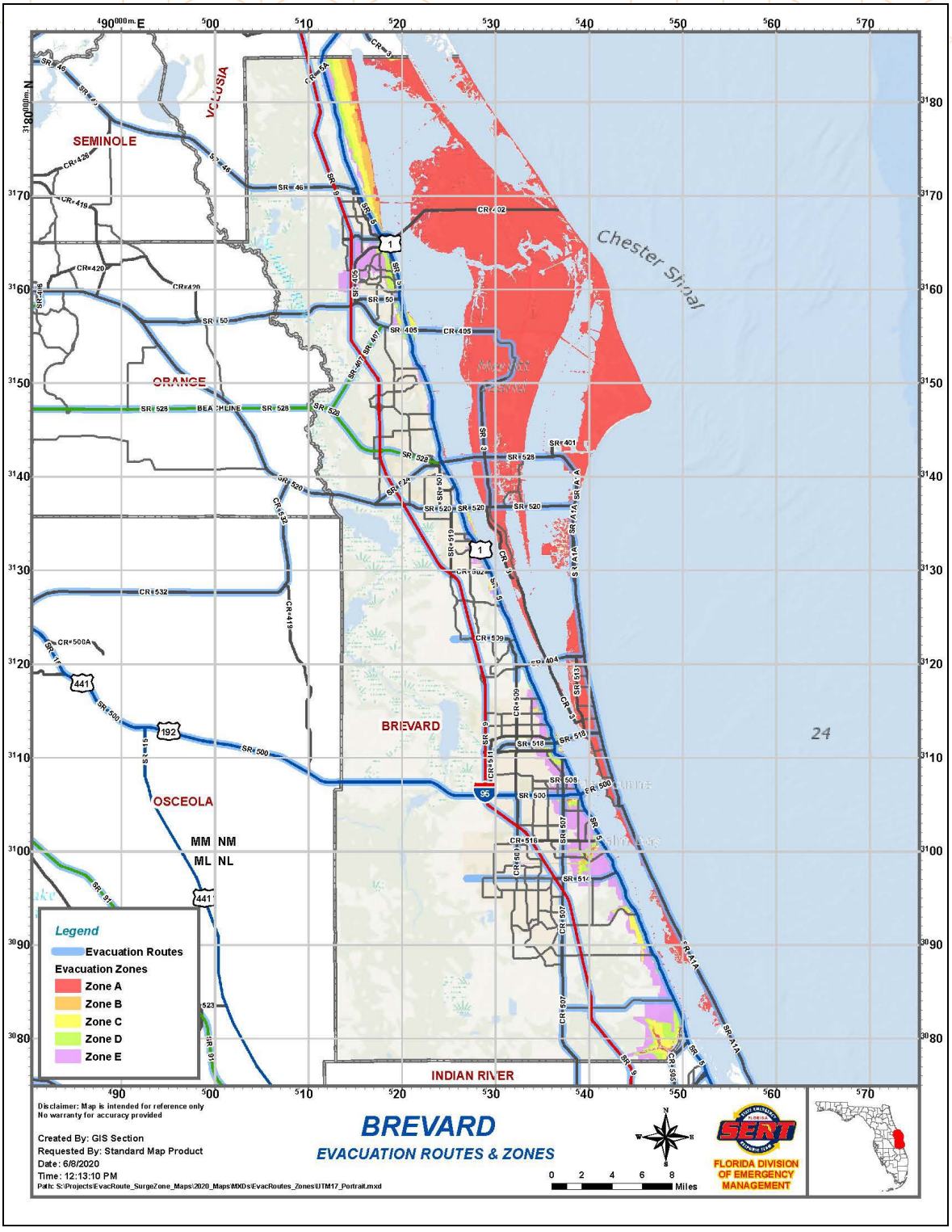

Figure 16: Brevard County Evacuation Zones and Routes

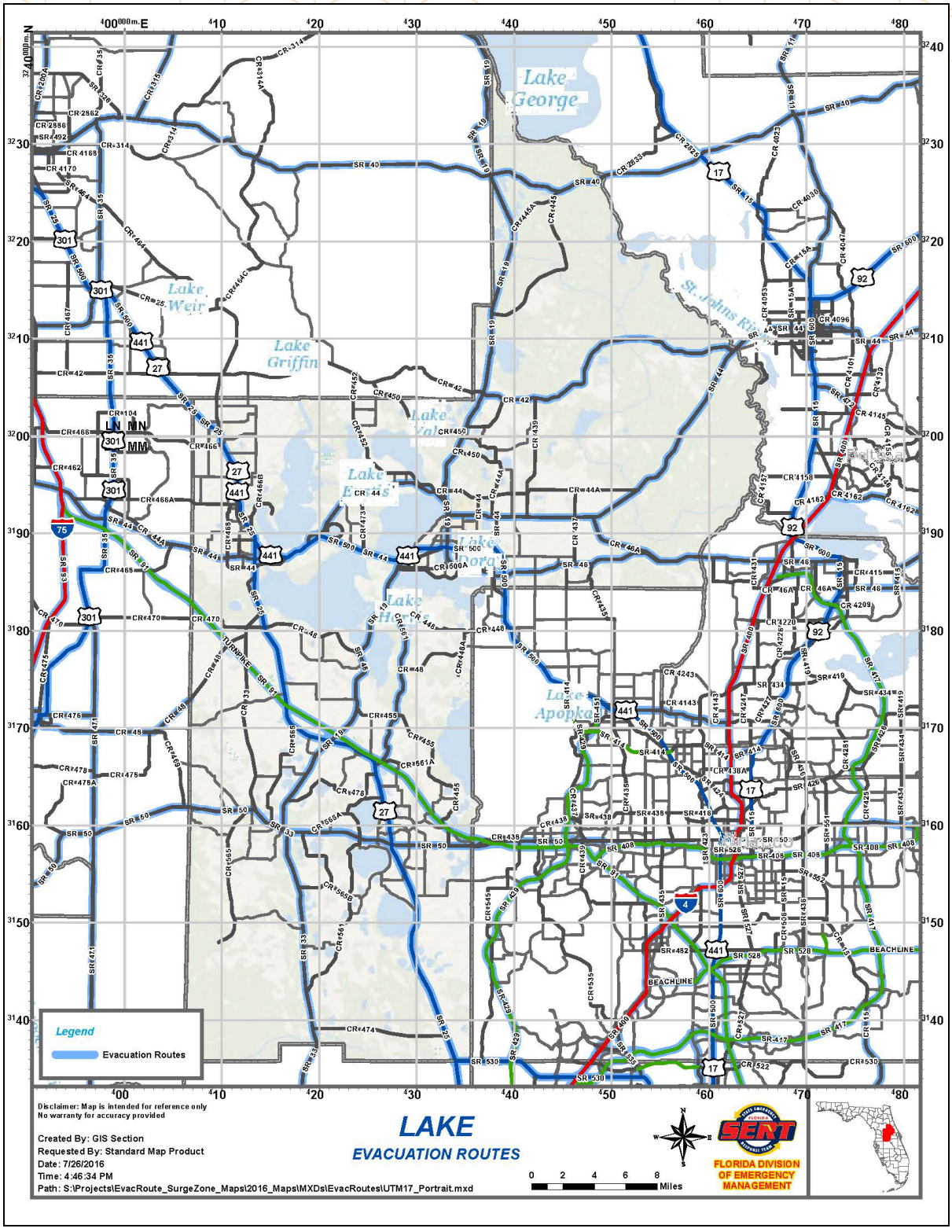

Figure 17: Lake County Evacuation Zones and Routes

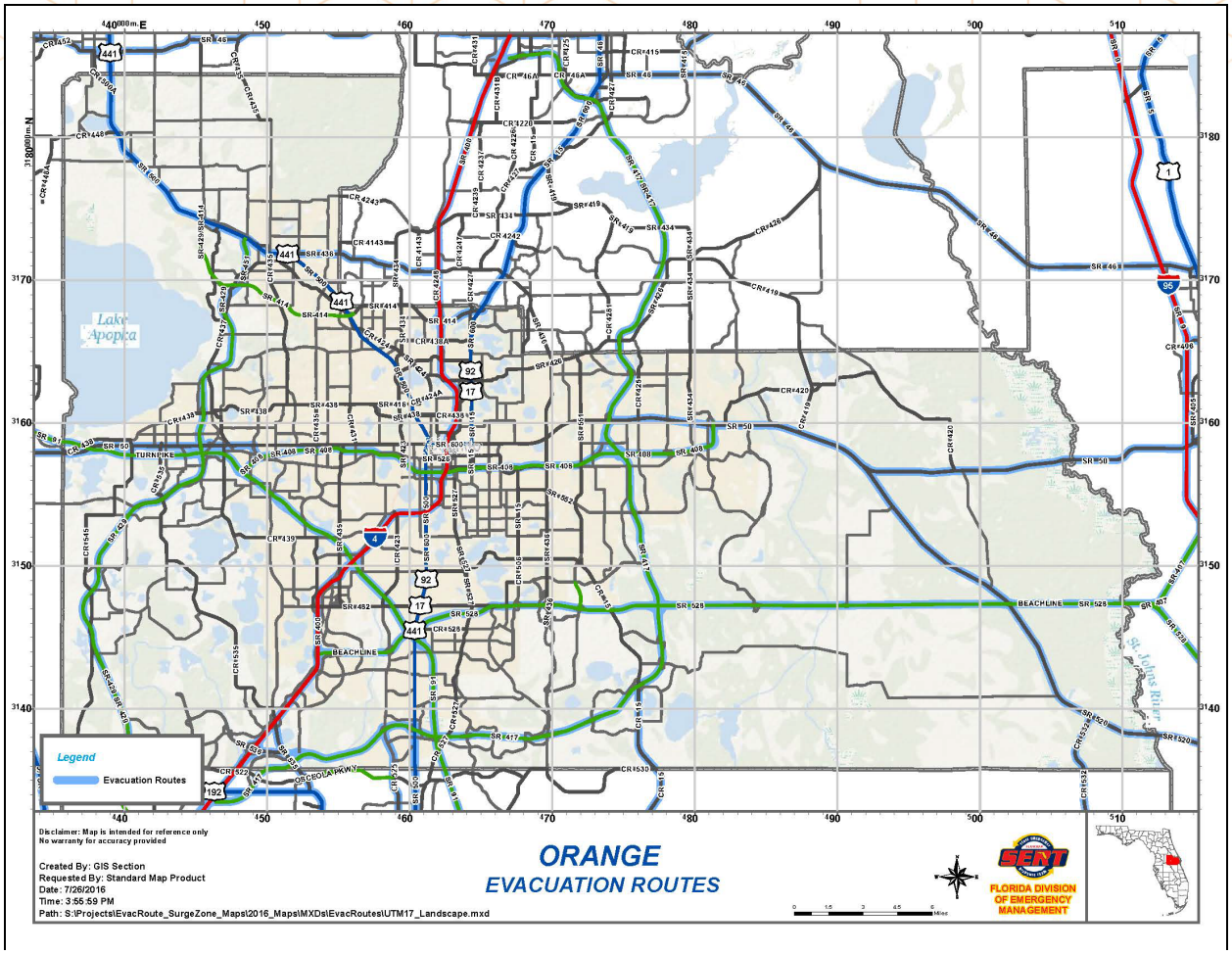

Figure 18: Orange County Evacuation and Routes

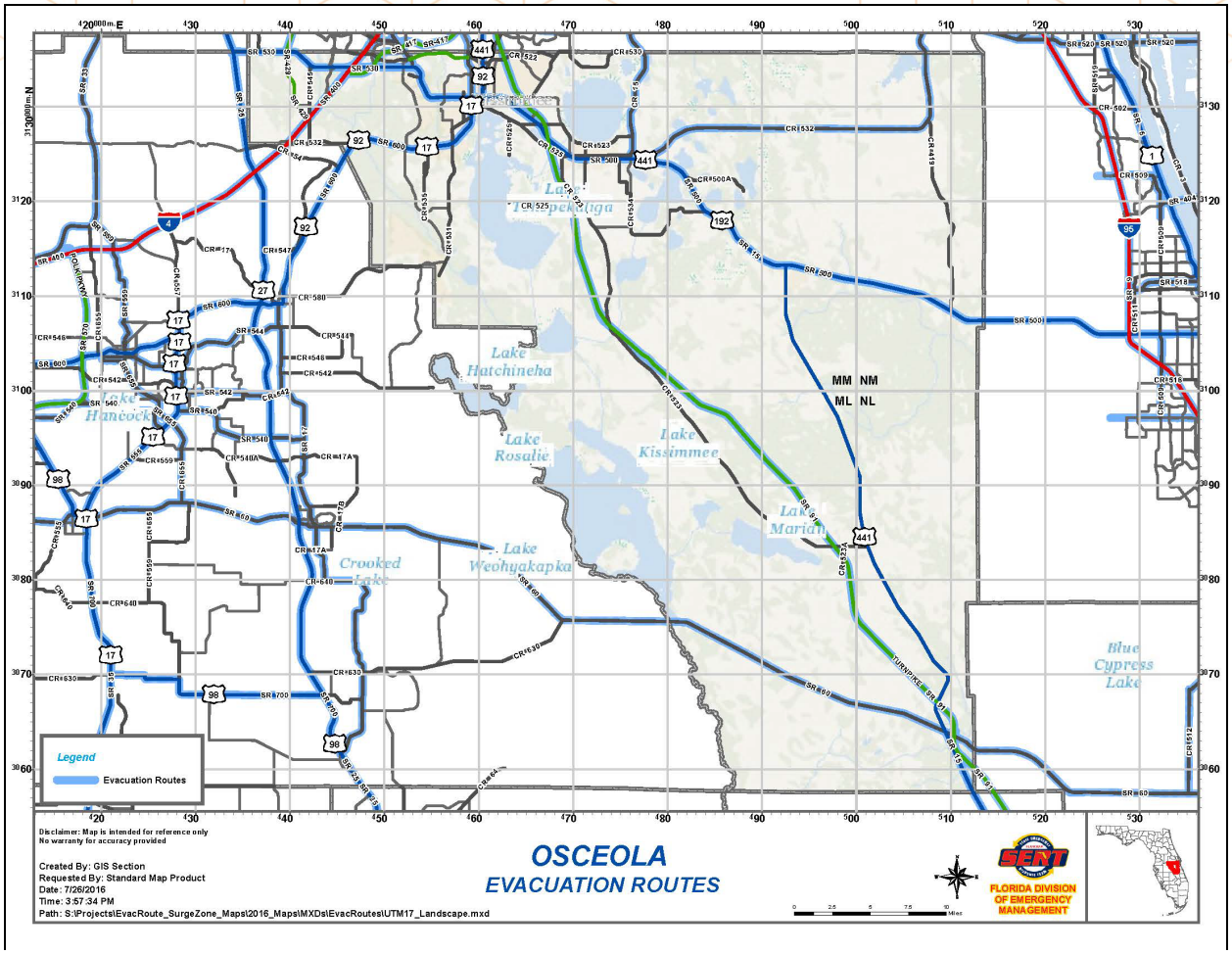

Figure 19: Osceola County Evacuation Zones and Routes

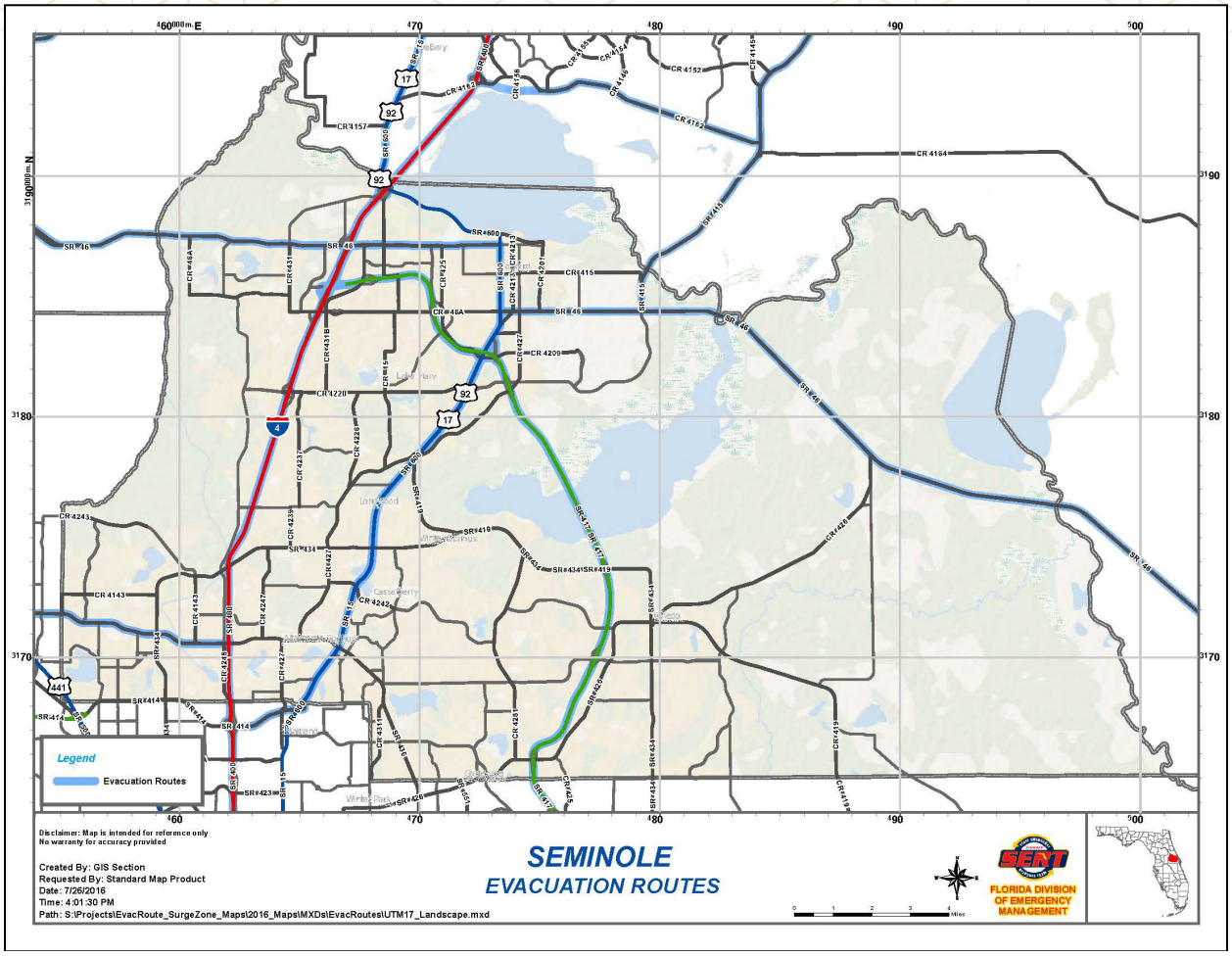

Figure 20: Seminole County Evacuation Zones and Routes

3.9. Multimodal & Intermodal

CFX is committed to expand multimodal routes within the Central Florida region. In fact, the enabling legislation is allowing the agency to take a lead role in the planning, financing, and maintenance of multimodal and intermodal projects. With roughly 37 agencies providing public transportation services throughout Florida and an annual ridership estimated to be approximately 270 million passengers, multimodal planning is critical for CFX. Multimodal routes allow CFX customers to choose various corridor options to connect them from one facility to another. The facility, in this case, is considered the intermodal point, such as a bus-stop, train station, airport, etc.

Currently, there are several intermodal facilities to move people and goods in the most efficient manner bordering the CFX system.

3.9.1. LYNX

LYNX is Central Florida's public bus service aimed at providing the citizens of Lake, Orange, Osceola, Seminole, and parts of Polk County with transportation services. The buses provide more than 81,000 passenger trips each weekday, spanning an area of approx. 2,500 sq. miles with a population of more than 2.4 million, as of 2019.

LYNX operates a total of 84 bus routes with 310 buses, and various services such as LYMMO (a free downtown Orlando circulator), a commuter assistance Vanpool program, ACCESS LYNX paratransit service, 13 NeighborLink community circulators, three FastLink commuter bus lines, Grapefruit Line (which operates between Amway Center and Lake Eola), and KnightLYNX (which provides bus service on Friday and Saturday evenings between the University of Central Florida campus and downtown Orlando). Lynx Central Station provides transportation both outbound/inbound from Downtown Orange Avenue to Orlando International Airport.

LYNX is funded from local partners such as Orange, Osceola, and Seminole counties, as well as the City of Orlando. LYNX system generated funds (fares, advertising, contract services, interest, and other income) account for 24.5% with federal (13.1%) and state (8.8%) funding completing the operating budget. However, the majority of the funding is provided by the local Counties, approximately 54%.

CFX is currently partnering with LYNX to develop the following services:

- A long-range transit strategy which includes working with CFX and the Florida's Turnpike Enterprise that addresses the use of the region's toll roads. This will help meet their objective to continue to forge relationships with key regional partners and stakeholders.
    - LYNX has updated its future transit plans for each of the three counties it serves within the Central Florida region. Some of those services are referenced in their 2020 Transit Development Plan. Continued coordination for the development of this strategy is expected at this present time.
- Park-n-Ride Program that identifies strategic locations for new facilities.
    - Plan completion by 2021

3.9.2. SunRail

SunRail is Central Florida's commuter rail train that totals 61.5 miles and stretches from Poinciana, Florida to DeBary, Florida. The SunRail train has 16 stops and runs through Osceola, Orange, Seminole, and Volusia County along the existing CSX Transportation corridor, which FDOT purchased. The SunRail train rides north and south, includes 29 miles of double track and three miles of single track, and generally parallels I-4 and US 17-92. SunRail operates Monday to Friday, every half hour during mornings, and evening peak service with mid-day and late evening services that vary.

With the current expansion of Orlando International Airport (OIA), the state is planning for a 5.5-mile extension of the rail system north of Meadows Woods Station into an intermodal station being built south of OIA. Once the intermodal facility is built, passengers will have various transfer options which include:

1. An automated people mover to take them north to the airport terminal.
2. A planned Brightline (now known as Virgin Train) that would go to West Palm Beach, Fort Lauderdale, and Miami.
3. A planned people mover from OIA to Orange County Convention Center / International Drive area.

SunRail had an increase in ridership numbers by 83% from April 2018 to April 2019, especially after launching its southern expansion into parts of Osceola County. SunRail's expected operating budget for FY 2020 is $57,837,7746. Additionally, SunRail's ridership numbers have decreased during the COVID 19 pandemic as their total numbers of ridership from July 2019 - June 2020 was 1,197,565 compared to July 2020 - June 2021 at 324,339. Funding for operations has been coming from FDOT but will end in 2021.

3.9.3. Brightline

Brightline will soon bring express inner-city passenger rail service along Florida's east coast from Orlando to Miami. At speeds near 79 miles per hour, the passenger train is also proposed to have two intermediate stops at Fort Lauderdale and West Palm Beach. Additionally, speeds upwards of 100 miles per hours will be used from West Palm Beach to Cocoa and Cocoa to OIA. The commuter train will use approximately 195 miles of existing Florida East Coast (FEC) railway track going north to south from Orlando to Miami. Going east to west, 40 miles of new rail is proposed alongside SR 528 from Cocoa to OIA. Bid process and negotiations with CFX, including design characteristics of the alignment, have already been held to use right-of-way along SR-417 and SR-528. It should be noted that construction efforts have started alongside SR 528 as well as from Miami to West Palm Beach. Below highlights the current status, per SunRail meetings held in mid-20207.

Zone 1: Vehicle Maintenance Facility

- Sitework of 62 acres completed – Spring 2020
- Building construction began – June 2020

Zone 2: Orlando International Airport Corridor

- Clearing complete
- Embankment 80% complete
- EB Cargo Road underpass and soil retention nearly complete
- Cargo Rd interchange reconstruction begins in early 2021
- Trenches at Mid Crossfield, TR 4, and TR 2 over 50% complete
- DF Trackwork complete, ballasted TW to continue in early 2021

Zone 3: Orlando International Airport to Cocoa

- 99% of corridor alignment cleared/grubbed
- 58% of rail embankment complete
- 20 of the 21 bridges are underway
- 3.5M CY of rail earthwork excavated
- SR 528 shoofly first traffic shift - June 2020
- Goldenrod Rd. box jack completed – September 2020
- SR 528 / US-1 box jack prep underway – February 2021

[6] https://corporate.sunrail.com/wp-content/uploads/2019/05/CFCRC-Meeting-Materials-May-30-2019.pdf
[7] https://www.cfxway.com/wp-content/uploads/2020/11/F.1.-FinalBLPresentation_CFX_11122020_revised.pdf

Box-Jack Project Under Goldenrod Road

- Third project in US using Petrucco box-jacking technology
- Install rail underpass in 10 days instead of a year – using hydraulic jacks
- September 8 – September 17
- Two pre-cast concrete boxes
    - Box 1: 3,730 US tons (42'x29'x146')
    - Box 2: 3,144 US tons (42'x29'x126')
- One of two on the project
    - SR 528/US 1 (Spring 2021)

3.9.4. CFX's Multimodal Initiatives

As stated in the CFX Multimodal Investment Assessment Report from 2017, $3.2 billion has been committed into the five-year work program for projects covering system improvements, enhancements, and rehabilitation. It is also estimated that $2 billion will be reinvested into the existing system over the next 20 years, and another $6 to $9 billion into new expressway projects. All of CFX's roadways serve as Multimodal corridors, the agency is striving to take a lead in the region by providing corridor relief, reliable toll system, and mobility options for customers and the community.

As CFX explores ITS and TSM&O strategies, it is important to be aware of the work that CFX has already done regarding its role within the region regarding multimodal facilities. CFX commissioned the University of South Florida (USF) Center for Urban Transportation Research (CUTR) to perform a Multimodal Investment Assessment that was presented to the Board in February 2017. The objective of this initiative was to provide a set of policy recommendations for investing in regional multimodal initiatives and to evaluate opportunities in Central Florida for multimodal investment by CFX. This Study looked at 18 agencies and their approach to multimodal investment. These multimodal agencies tended to exist in large, dense and mature regions that had "significantly worse highway congestion than Central Florida." In addition, the ability of these agencies to increase highway capacity was constrained. Basically, the tendency of these agencies to become involved with multimodal needs within the region increased as the appetite for expanding the highway system decreased or was simply not possible. Therefore, since the CFX Work Program indicates substantial activity in expanding the highway system at this time, the study recommended continuing to expand as a multimodal financier and regional partner, but not as an owner/operator of multimodal facilities, such as transit.

The following are some project opportunities that were identified by the study:

- State Road 408 – Bus Rapid Transit/Express Bus Treatment/Higher Education Connectivity (Supported by LRTP)
- I-Drive Tourist Corridor to Orlando International Airport – High-Capacity Transit Evaluation (Supported by LRTP, 2040 Master Plan Improvement)
- State Road 417 – Express Bus Accommodation (Included in LRTP, 2040 Master Plan Improvement)
- Area Wide – Parking Structure Funding Feasibility
- Area Wide – Integrated Regional Fare/Toll Services
- Area Wide – Variable Pricing Study
- Area Wide – Transit Joint Development Opportunities

In addition, it was recommended that CFX consider establishing a multimodal project Development & Evaluation (D&E) program. Any recommended multimodal initiative should also meet one or both of two

potential policy positions: (1) The initiative has clear benefit to the CFX customers, and/or, (2) The initiative meets financial and revenue tests.

3.9.5. Regional Transit Study

The Regional Transit Study (RTS) is the implementation of the fifth of nine recommendations provided by the East Central Florida Corridor Task Force to develop a consensus-driven Regional Transit Vision for a ten-county region in Central Florida, including Brevard, Flagler, Lake, Marion, Orange, Osceola, Polk, Seminole, Sumter and Volusia Counties, that will better inform the East Central Florida Corridor Evaluation Study.

The scope of the study included: establishing a base transit condition, identifying gaps in regional transit connections, identifying existing and future funding gaps and potential funding sources, identifying and analyzing existing transit supportive plans and policies, estimating regional travel desire lines and transit market demand for years 2040 and 2060, identifying strong candidate corridors for higher capacity transit investments, identifying a conceptual regional transit framework including interim and long-term priority transit investments, and the development of strategies for advancing the conceptual regional transit vision framework.

3.9.6. Geographic Information System (GIS)

With the planning and management of big data associated with smart growth, ITS, or Connected Vehicles (CV) technologies, it is important to recognize and consider the various data components - availability, applicability and use cases. Understanding current and planned deployment efforts allows additional opportunities for CFX to expand on the successful development of a data management plan which may include data analysis (the identification of hot spots) and application development utilizing the power of GIS.

CFX's GIS Road Map (October 2019) identifies several key components which include – data collection and database workflow, big data environment and content management, GIS/mapping and application needs, staffing and overall short- and long-term goals of each department. This document identifies several goals to be accomplished over a 3-year period. **Figure 21** on the following page, identifies CFX's 3-year timeline.

Short- and Long-Term Goals Executive Overview

CFX Roadmap - Goals Executive Summary						Recommended Timeline			
Goal Number	GOAL/Need	Description	Department	Effort Level	Goal Dependent	First 6 Months	6-12 Months	Year 2	Year 3
	Access to Plans	Ability to access AFC, record drawings and as-built plans.	All Departments	Moderate					
1	Access to plans - Pilot Area	Pilot area for all plan collection and metadata validation	All Departments	Low					
2	Expand OnBase	Expansion to OnBase to include additional documents including reports, lease agreements, etc	Traffic Operations	Moderate	1				
3	Expand OnBase	Expansion to OnBase to include additional documents including geotech, drainage, etc.	Engineering	Moderate	1				
4	Interactive map with Comprehensieve document library	Interactive map to provide user friendly option for users to select GIS asset and view complete document history of item in conjunction with OnBase	Engineering	Low-Moderate	10				
5	Project Management Dashboard	Interactive dashboard to serve as a project management dashboard. Potentially served by or through OnBase	Construction	Moderate - High	1				
6	Access to GIS and Spatial Data	Ability to access GIS and Spatial data through interactive maps, web maps, and field devices	Expressed by All Departments	Moderate					
7	Collect and Maintain Additional Assets	Spatial data collection of assets including bridges, guardrail, signs, and other features	Maintenance	Moderate					
8	View and Map Additional Assets	Ability to view in ArcGIS maps and web apps assets including bridges, guardrail, signs and other features	Engineering	Low	3				
9	View TMS and DMS Data	Ability to view TMS and DMS data through an interactive map with reference to associated reports and documents	Engineering	Low-Moderate					
10	Asset Management - Pilot Project	Pilot project to build out asset management solution with full ArcGIS and database support	Maintenance	Moderate					
11	Robust Asset Management Solution	Deploy a complete asset management	Maintenance	High	7				
12	Purchase of new Trimble Unit	New Trimble GPS unit to improve data collection	Traffic Operations	Low					
13	OSPInsights SOPs	Develop Standard Operating Procedures (SOP) for OSPInsight Data and Data Review Workflow	Traffic Operations	Low					
14	OSPInsight Red Line Tool	Design and Deploy ArcGIS Red Line Tool	Traffic Operations	Low	4				
15	Develop API for further data integration	Expand and Implement APIs and Data Connections to allow other CFX data products (OSPInsight, MIMS, WhatsUpGold, etc.) to better communicate and integrate	Traffic Operations	Moderate	4				
16	Develop SOPs for submital	Develop SOPs for CEI's to submit reports	Construction	Low					

Figure 21: CFX GIS Road Map Short and Long-Term Goals

When considering the future of self-driving cars and the role of GIS in the transportation space, sourcing intensive geospatial data is critical for infrastructure planning and the success of navigation systems. Building 3-D representations of the current transportation conditions and space (streets/maps, roadway conditions, asset management data, etc.) provides for current and accurate data to supplement LiDAR and other sensor systems providing the needed real-time routing information. From Figure 21, above, CFX has a plan for the continued asset management solution utilizing ArcGIS and appropriate database structure to support future development.

3.10. Existing Coordination Efforts

Florida Turnpike Enterprise (FTE) and FDOT ITS systems cross several CFX corridors throughout the region.

Although both FTE and CFX operate independent instances of event management software along SR 408 and SR 417, the agencies monitor wrong way driving events leading to coordination of events across jurisdictions. CFX's detection system includes 63 WWD devices on the Expressway Authority-operated highways. SR 408 and SR 417 warns drivers with high-intensity flashing lights that he or she has entered the highway going the wrong way. If the driver continues onto the highway, cameras from the RTMC capture an image of the vehicle and instantly alert law enforcement to dispatch patrols to the area.

CFX also closely coordinates with FTE, as well as FDOT, on toll data. CFX exchanges toll data with FTE and FDOT. Finally, CFX is also able to view some of FTE's CCTV cameras through the C2C connection with D5 RTMC. CFX has and will continue to conduct coordination efforts to utilize, leverage and provide support to bordering agencies with regard to existing or planned ITS infrastructure.

3.10.1. FDOT's Integrated Corridor Management (ICM) Program

ICM is a highly effective program set forth by FDOT which manages the multimodal system as a whole rather than individual transportation networks. This is done using ITS technologies installed along the roadway network. The end goal of the ICM program is to efficiently and proactively manage the movement of people and goods in major transportation corridors along Central Florida's Roadways. However, in order to create a successful ICM program, collaboration and multijurisdictional partnership between agencies is critical to produce the envisioned multimodal system.

CFX has the following fiber sharing agreements which help with collaboration between partnership agencies:

- FTE permitted the installation of additional CFX fiber on SR 91 for redundant connectivity to SR 429, SR 414, SR 453 and SR 451,
- CFX shares fiber strands on our corridors to support both FTE ITS and Tolls,
- FTE shares fibers for connection to the Poinciana Parkway.

Over the last several years throughout the Central Florida region, ATMS advancements have played a critical role in the growth of the ICM program. CFX has recently executed the R-ICM agreement drafted by D5 to share use of the software application and allow for continued data sharing between agencies. Many advancements in computer and Decision Support System (DSS) technology are becoming increasingly intelligent and capable of providing advanced reasoning and sophisticated decisioning. The following section will describe FDOT's D5 (DSS) which is part of the ICM program.

3.10.2. FDOT's Decision Support System (DSS)

DSS is a component of the ICM software that provides current and predicted conditions of the Central Florida transportation network to help operators make smart decisions in managing both recurring and non-recurring congestion conditions. DSS has evolved from simple table-based libraries of response plans to sophisticated predictive solutions that use the latest machine learning and simulation technologies to support regional multi-agency and multi-modal mobility solutions. The components within DSS include Expert Rules Engine (ERE), a Predictive Engine (PRE), and an Evaluation Engine (EVE) that build and select response plans, model the predicted outcomes of the selected response plans, evaluate and score the plans, coordinate with operators and local agency maintainers through the Information Exchange Network (IEN), and invoke the approved response plan actions through the SunGuide® software system. This also includes recommended DMS messaging. As an example, if FDOT has an incident along one of their roadways, the operator at the TMC will input data in the SunGuide® software system, the information from this subsystem will send basic information on the incident (such as location, number of lanes, severity) to the DSS. In turn, the DSS will query its database based on its criteria and pre-approved response plan. Once the system has deployed a response plan to the SunGuide® software system, the DSS will continue to monitor event status for changes and until the congestion has been alleviated so response plans can be modified or deactivated. The core responsibilities of the DSS are as follows:

- Monitor, evaluate, and respond to recurring congestion along the arterial network.
- Evaluate and respond to non-recurring congestion within the identified network. This can include posting DMS messages, etc.
- Evaluate and respond to non-recurring congestion on arterial roadways within the identified network.

3.10.2.1 Current Progress of FDOT's Decision Support System (DSS)

As stated previously, DSS is a component of the much larger ICM software; therefore, it's safe to say that DSS falls under the same schedule as Central Florida's Regional Integrated Corridor Management System (R-ICMS). **Figure 22**, below, illustrates an overall project flow of the Central Florida's R-ICMS.

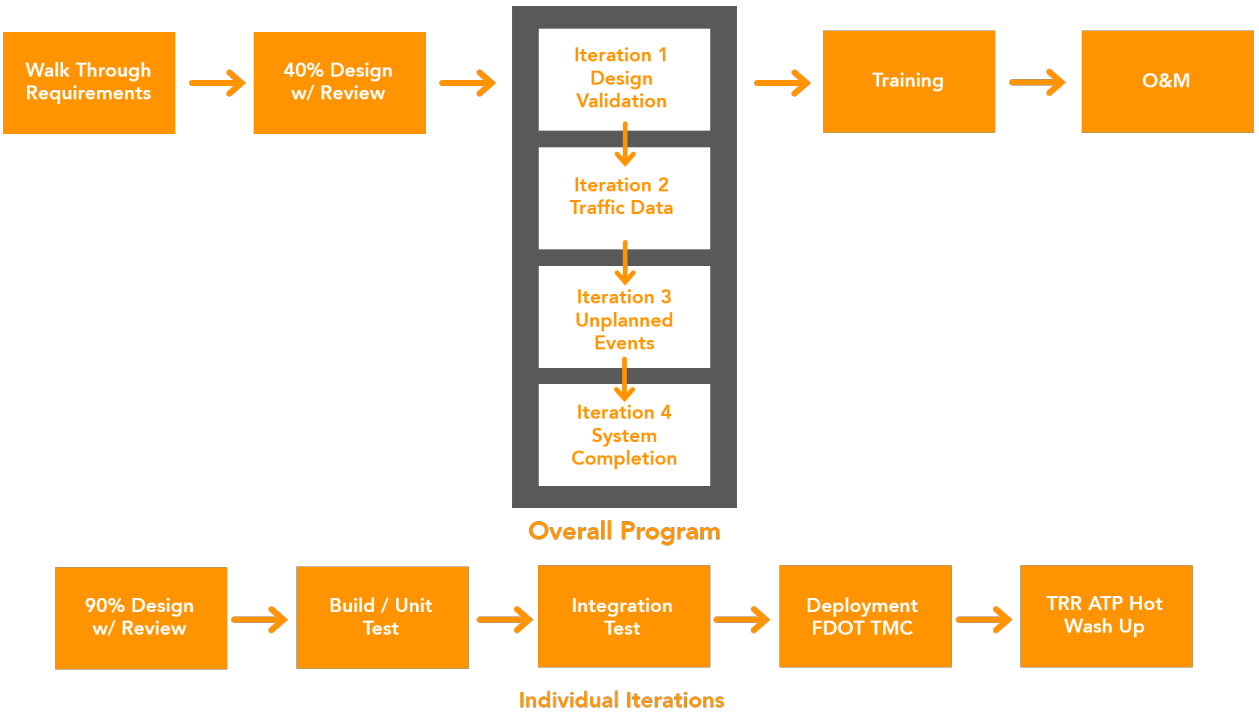

Figure 22: Project Flow Schedule of R-ICMS Program

(Source: FDOT)

Currently, FDOT is on iteration 4 which is set to be completed in 2021.

3.10.3. Stakeholder Coordination - Existing Conditions

Once stakeholders were established, an individual one on one meeting with each was held to discuss the overall scope of the CFX ITS Master Plan and to request documentation on their current systems and deployments. Each individual one on one meeting discussed the rapid advancement in technology with the advent of CAV as well as any other existing conditions and strategies that relate to the overall goal of the CFX ITS Master Plan. The discussions of existing conditions on the current systems and deployments of each stakeholder can be found below:

Orange County

- ITS/ATMS deployments are maintained by CFX but operationally ran by Orange County. This includes retiming and troubleshooting calls which are then transferred to CFX to address.
- Orange County utilizes MAXIMO as an asset management/inventory tool.
- Utilizes Emergency Vehicle Preemption (EVP).
- Testing of Intelight Adaptive Systems for adaptive expansion.

- Orange County Priority Project List:
  - Conversion of controllers to Intelight. This project is expected to be completed by mid-2021 and includes CFX intersections. Currently 250 of 600 controllers have been converted.
  - Upgrade cabinets to Type VI. This project is expected to upgrade 160 cabinets to smart signal standards and includes CFX cabinets. Orange County is expecting funding to be allocated to this project by the end of the year.
  - Upgrade Bluetooth readers for CV's. This project will be upgrading existing Bluetooth readers to BlueToad devices and is expected to be completed by the end of this year/early next year.
  - I-4 FRAME upgrades which will include one CFX intersection at SR 417.

FDOT D5

- R-ICMS: Firewall to Firewall, Predictive Model with ICMS, SEA Maintenance side Asset Management, Permissions with CFX (MOU's).
- Long term Data Collection: Asset Management (MIMS and ITSFM) for Signals.
- Single Payer Efforts: ITS for US Grant - Single Payer by MetroPlan, SunRail payer system coordinated with Lynx, Trip Engine (OTP) - end of calendar year bikeshare, carshare, zipcar, SunRail lynx, Omni Modal - parallel to Future City and Transit Wallet.
- Events - UCF, Citrus Bowl, Space, Launches, Venues.

City of Orlando

- ITS/ATMS deployments are maintained by CFX but operationally run by Orange County. This includes retiming, FOC network and troubleshooting calls which are then transferred to CFX to address.
- FHWA Grant - allows the City of Orlando to be more adaptive in traffic signal timings specifically for events.
- Utilizes Emergency Vehicle Preemption (EVP).
- Automated Shuttle with Tavistock at Lake Nona and 417. Currently in the planning phase with efforts to install RSU's.
- Future Ready Cities Concepts:
  - Integrated Transportation Application Strategy - In 2018, FDOT- D5, began to develop an engine that will have the ability to power multi-modal trip planning. This engine is called the Route and Mode Choice Engine (RMCE) and it's based on the open-source software OpenTrip Planner (OTP). The concept of the RMCE aligns well with the need for a City-developed user interface. The RMCE allows for the processing of single or multimodal trips and can support front-end mobility and wayfinding applications with real time mobility information. Users will be able to input their destination requests from an application and provide decision-making parameters and constraints: such as time, cost, walking distance, etc. Following the user's request and provided information, the engine will process all available data sources to determine the available trips and provide the user with information on findings. The engine will provide users trip options that include both single and multimodal options, for example transit and bicycle. In addition, it will also provide users timely updates based on delays, schedule or route changes, providing the users the ability to modify a previously planned trip based on real-time information. It is expected that the RMCE will be active and ready to use by December 2021. The RMCE

is being developed as a web-based service and the objective is for users to access the information through the use of embedded mobile applications and transit kiosks. The development of the Route and Mode Choice Engine includes four (4) primary components:

  - Application Programming Interfaces (APIS) and Data Sources (i.e., TNCs, Bike-Sharing, Public Transit, Third-Party Data, and SunGuide Data)
  - Routing Engine
  - Trip Scoring
  - Real-Time Trip Planning and Monitoring

- Smart Parking and Operations Strategy - The City operates 1,000 smart metered on-street parking spaces and has integrated smart parking technology into two (2) garages. The smart parking technology implemented in the two (2) garages are smart gates that provide information on how many cars are accessing and egressing the garages. The on-street smart parking meters track parking trends and supply information on different payment options. This information is accessed through a smart phone and web-based free application called ParkMobile. In addition to the previous smart parking solutions, the City also provides residents and users with information about the parking services offered. Users can find on the web information on the following: parking garages and lots, parking rates, event parking purchases and reservations, meter rental applications, month parking availability and rates, among other services.

- The following concepts are also a part of the Future Ready City Concepts/Strategies which are currently being explored by City of Orlando:
  - Camera Analytics - Allows for the automation of the review of countless hours of camera surveillance in real time, freeing up human personnel to actively fix any issues that have been detected
  - CAV Infrastructure Readiness - Prepare the City of Orlando and its infrastructure for CAV deployment
  - CAV Pilot Downtown - Develop a CAV pilot project in Downtown Orlando to showcase CAV capabilities at both a user and operator level.
  - Energy Microgrid - Develop a back-up resilient power source at all critical infrastructure (i.e., solar + storage generators, city buildings) to ensure that smart city applications and general services remain up and running while also supporting the needs of the larger Utility Distribution Network (UDN) in the event of a disaster causing power outage/shortage
  - Expanded Fiber Infrastructure - Expand the essential communications backbone to enhance existing and future ready capabilities
  - Fast Charging EV Infrastructure - Incorporate a well-planned grid of EV charging stations

- Capacity improvements at two locations listed below:
  - 408 at Tampa
  - 408 at Orange Blossom Trail

FDOT Turnpike

- Currently reevaluating existing Express Lanes on SR 528.
- Deployed Queue Warning Systems primarily targeting interchanges.
- Automated Vehicle Tandem Trucks — a testing program for vehicle platooning pilot projects — meaning driverless vehicles trailing manned vehicles on highways.
- Focus is on interoperability with transponders (SunPass).
- Evacuation:
  - C2C communications providing existing travel times.
  - CFX gets traffic feed and travel times from FTE and the same occurs in reverse where FTE gets the same data from CFX.
- Regional Fiber Sharing.

Lake County

- EVP at numerous intersections primarily focusing on new/upgraded signals.
- Master Hub in Lake County (west of SR 46).
- Lake County is currently taking over SR 46 near Wekiva at the Expansion Connection.

MetroPlan

- MetroPlan Orlando developed their ITS Master Plan four years ago in which several projects were identified and have made the prioritized list. MetroPlan Orlando currently reviewing list for relevant projects in today's technology.
- ITS for US Grant – This grant is focused on single payer efforts for underserved communities.
- CAV study completed by MetroPlan Orlando and is currently under review.
- Retiming efforts – CFX maintains their exit/entrance ramps.
- MetroPlan reflects what CFX is doing in their planning efforts.
- Regional partnership with CFX and FDOT D5 for the LiDAR 3D Pilot Program.

Osceola County

- Currently sharing ITS devices with Osceola through FDOT D5.
- Osceola County Connected Vehicle Systems (deploying RSU's) program still ongoing.
- Poinciana Interchange/CR 532 Widening Project ongoing.
- Osceola developed an ITS Strategic Plan which is currently under review as related to Poinciana Parkway.
- Osceola Parkway –
  - CFX does processing for tolling and is currently obtaining connection installing ITS fiber for redundancy from Dyer Boulevard to I-4
- Applied for two grants focused on obtaining analytics as related to CV's –
  - Transportation Alternatives Program (TAP-LA)
  - Community Development Block Grant Mitigation Program (CDBG-MIT)

Seminole County

- Existing Strategies:
  - ICM, Active Arterial Management (AAM), Transit Signal Priority (TSP), EVP, and Automated Traffic Signal Performance Measures (ATSPM).
- Does not sustain a Maintenance/Operations Database.
- Majority of signals along SR 46 are currently being removed.

SpaceCoast TPO

- Current touch points in regards to CFX and the Space Coast TPO is the Beachline Facilities (Mile post 8.5 to State Road 520).
- Maintains Inventory System for signals – (iWork) which is a web-based asset management tool.
- Currently implementing ATSPM – They recently replaced puck deployment with GridSmart.
- Performing updates to the Space Cost TPO ITS Master Plan.

Brightline

- Will serve as a multimodal drop-off point at the Orlando International Airport which will give passengers the option to take continue on with travel i.e., take a flight, rent a car, Uber, or Lyft, etc. Construction is estimated to be completed in 2022.
- The Rail Capacity is 400-500 passengers with a starting passenger capacity of 220.
- New Brightline Extension (Tentative) will possibly include a Disney station and extension on to Tampa.
- Possible new stops for Brightline include Cocoa Beach, Treasure Coast, and Disney.

I-4 Mobility Partners

- Maintenance/Operations responsibilities in respect to the CFX roadway will be handed over upon completion of construction in 2021. However, I-4 Mobility Partners will continue to have maintenance and operations responsibilities on the I-4 Corridor as a part of the I-4 Ultimate P3 project. Outreach efforts for the transition process is planned for the fourth quarter, near December 2020. Final acceptance is estimated in December 2021.
- Road Ranger Service Patrol and Evacuations are handled by FDOT D5 in which the I-4 Mobility Partners provide support.
- Data and Video sharing handled by the FDOT D5 RTMC.
- Fiber sharing - has an availability requirement in contract with FDOT to keep fiber online.
- Maintenance and Inventory being incorporated into ITSFM.

3.11. Connected and Automated Vehicle (CAV) Deployment

As the transportation industry prepares for a future with Connected and Automated vehicles (CAVs) it must adapt to provide customers with a truly connected, secure and safe experience. That experience demands a platform supported by increased connectivity and cloud infrastructure. Some connected and automated vehicle technologies are in use today such as self-parking vehicles and auto-collision avoidance software; however, these technologies are expected to see widespread deployment and significant improvements in capabilities within the next few years.

The beginning stages of these technologies can be seen today, but the full impact will likely have widespread profound affects and is difficult to quantify. FHWA recommends agencies prepare for these technologies, at this time, in the following ways:

- Begin to incorporate the concept of Connected Vehicles in the planning process.
- Upgrade Regional ITS Architecture (RITSA).
- Upgrade existing systems (such as communication systems) and consider making them Connected Vehicle ready. Buy USDOT connected vehicle certified equipment.
- Consider how automated vehicles may enter your system: platoons, low speed urban, etc.

- Participate in the V2I Deployment Coalition, Connected Vehicle pooled fund study, and other similar ways to influence deployment path.

3.11.1. CFX and CAV Technology

CAV technology is a strategic advancement towards CFX's goal of delivering a world class mobility network to the Central Florida community and its customers. By utilizing current and emerging ITS along with the integration of best practice solutions, CAV technologies will effectively support commerce, increase highway efficiency and improve quality of life as well as motorist safety.

CAV technology will offer a "smart" environment on CFX's network that will connect vehicles, infrastructure, mobile devices and other equipment. This goal will be achieved through transmitting real-time data that will provide drivers and CFX systems with relevant information for improved safety and decision support. The collected data will also be used to provide insights on past, present, and future traffic trends in order to deliver an efficient, informed and improved driving experience on CFX roadways.

CFX has already begun utilizing CAV technologies and created a plan for future use. A list of potential projects was developed after thorough consideration of CFX's needs, technologies discussed by potential industry partners and results of the technology gap assessment. The potential projects consist of quantifiable elements being implemented in a phased approach that will result in a systemwide CAV program by 2030.

Each potential project includes a description of the project and the anticipated timeframe to complete. A key element in taking on these projects starts with building relationships between partnering agencies. This includes strengthening existing relations and fostering new partnerships to ensure seamless system integration. As these projects are developed and information is gathered, on-going applications will be developed to make use of the data generated and collected. These applications will help remedy CFX's operational, safety and maintenance needs.

3.11.2. HERE, Wejo and CAV Technology

HERE and Wejo are primary mapping companies that provide in-vehicle navigation systems for the majority of vehicles that are equipped with this technology. They have also strategically placed themselves as a key variable in the traffic data market, collecting probe data from millions of vehicles to generate and distribute travel times and speeds along the corridors. The collected data is then provided to multiple DOT's, including FDOT and can be used by CFX to compare and fuse with the data collected by the Data Server system for display on travel times to display travel times on DMSs throughout CFX's infrastructure. HERE also collects data from other sources which include DOT's and toll agencies that are integrated into the HERE database to improve their traffic congestion measuring.

HERE and Wejo both have a number of available products that could support existing operations at CFX by providing additional data and associated analytics to CFX to improve operations. Some of those elements include connected vehicle services, in which real-time and historical data can be analyzed to predict where incidents may occur due to traffic patterns and environmental factors, and API for hazard alerting which could be utilized in CFX's mobile application for alerting drivers of potential hazards.

HERE and Wejo also continuously collect LIDAR data from roadways throughout the nation in support of the Automated Vehicle goals and deployments. This data could be beneficial to CFX, FHP and their stakeholders for design, development of as-builts, maintenance activities and crash reconstruction.

3.12. LiDAR Technology Optimization

As an industry leader, CFX has been heavily involved in exploring advanced technologies that will benefit their overall system and Light Detection and Ranging Technology is no exception. CFX has deployed successful WWD countermeasure systems along some of Florida's busiest limited-access tolling corridors. The WWD Prevention and Detection Pilot Program began in 2012 in partnership with the University of Central Florida (UCF). The program's main objective was to evaluate the use of "Wrong Way" signs equipped with flashing beacons to prevent wrong-way drivers from entering CFX's expressway system. CFX is in the process of evaluating LiDAR technology as a potential detection technology for the WWD system.

Furthermore, CFX in conjunction with FDOT D5 and MetroPlan Orlando launched their Lidar 3D Technology for Surveying Equipment Technology Pilot Program. This program investigated new Lidar technological methods that would assist FHP with conducting their traffic homicide investigations and making them more efficient. This enhanced surveying technology for roadway homicide investigations is an internationally practiced solution intended to expedite law enforcement's investigative process and is a proven solution to aid in the reduction of closure times related to homicide incidents in many agencies. Laser scanners assist with getting roads open more expediently which greatly reduces the potential for secondary crashes and the amount of time first responders are exposed to roadside hazards. The final report for this pilot study will be released in 2021.

3.12.1. CFX Wrong Way Driving LiDAR Vehicle Detection Pilot

CFX recently launched a new cloud based WWD Detection and multi-channel alerting system to help combat dangerous road use by inattentive motorists. The new pilot deployment was installed at the SR 528 Westbound offramp on each side of the ramp at Tradeport Drive and utilizes dual LiDAR, see **Figure 23**, on the following page.

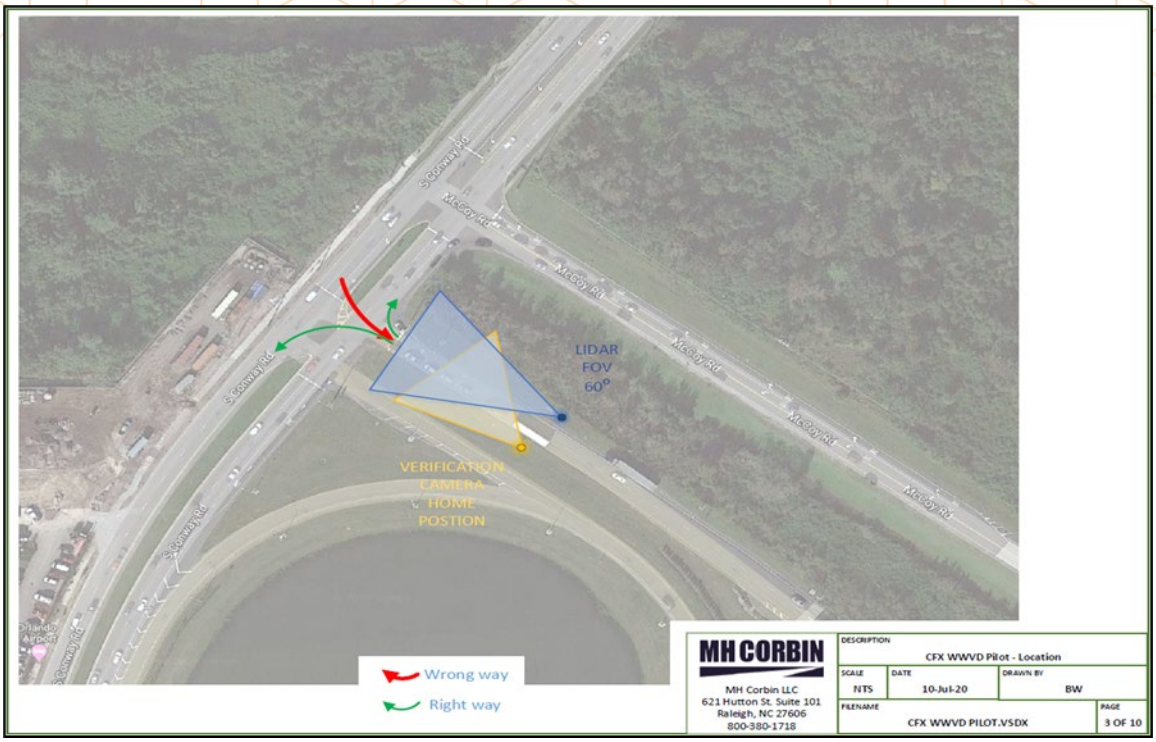

Figure 23: CFX WWD Lidar Pilot Program Test Site

This pilot program is currently being tested for accuracy and reliability in real life conditions. The technology contains a notification system that alerts the driver with flashing messages and beacons, telling them to stop and turn around. It also notifies designated authorities immediately via text or email message, both methods contain links to video when available, and alerts other drivers of the wrong-way vehicle via DMS, 511 traveler information systems, TMCs and social media applications as shown in **Figures 24** and **25,** on the following page.

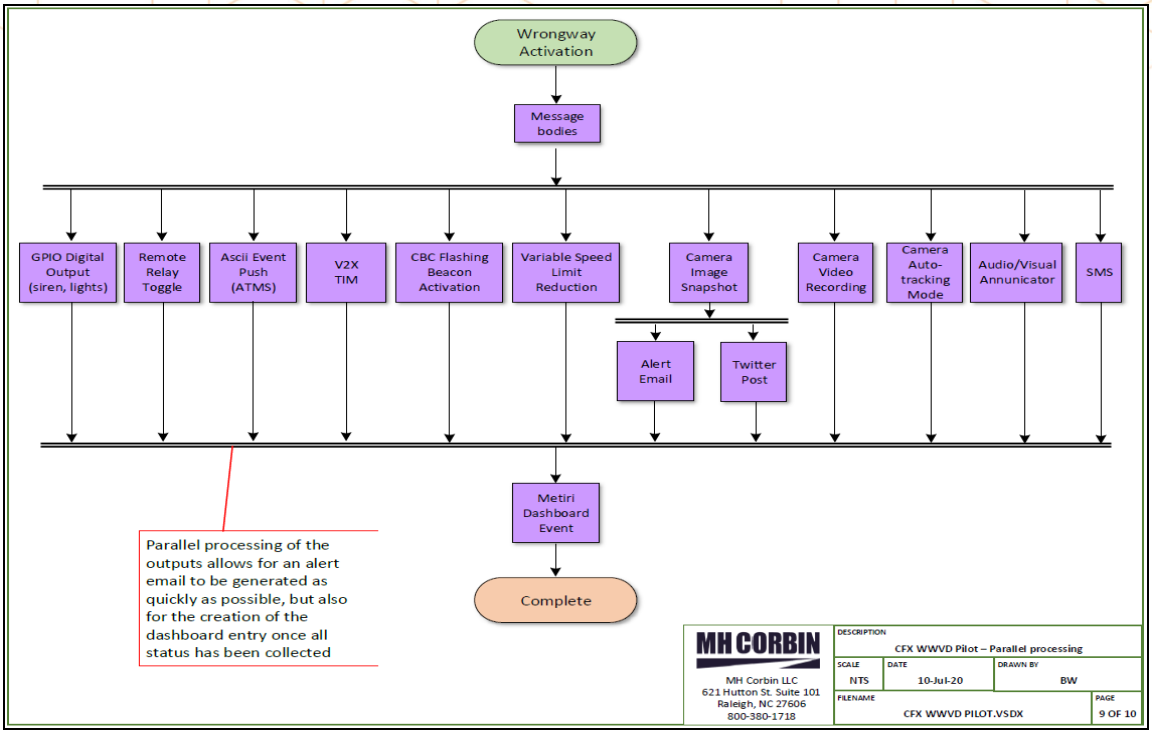

Figure 24: Processing Map for WWD Lidar Pilot Project

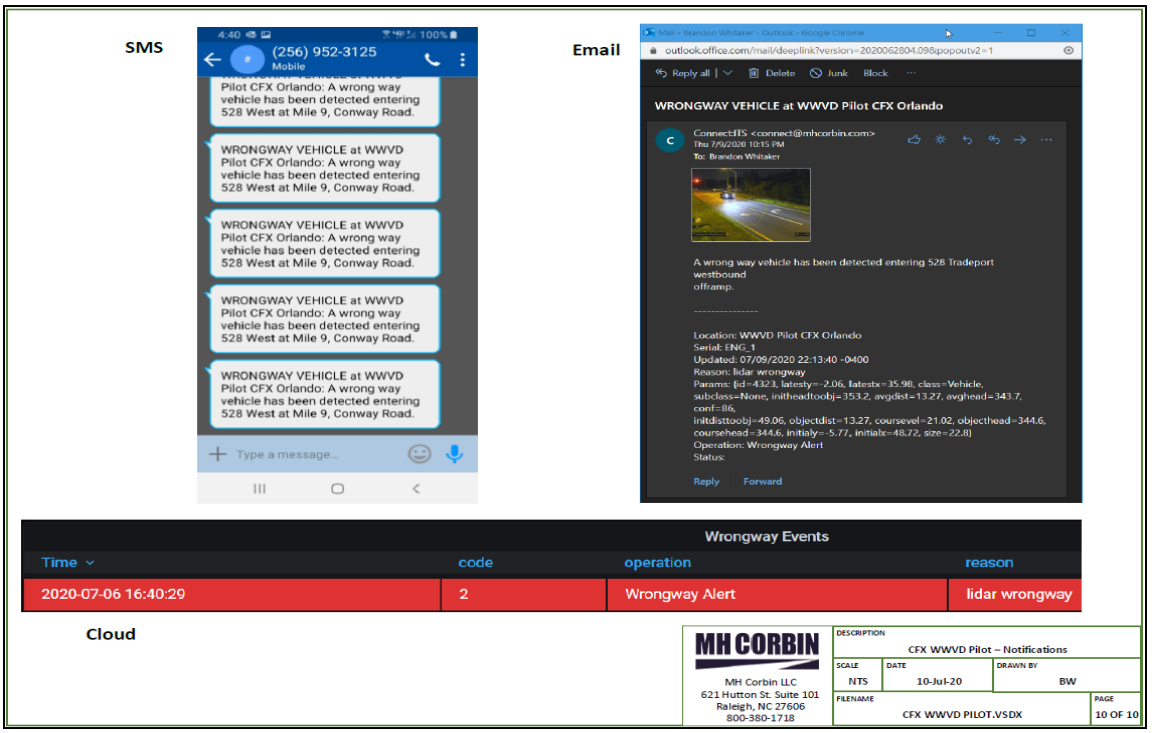

Figure 25: Examples of Notifications via Text or Email

3.12.2. LiDAR 3D Surveying Equipment Technology Pilot Program

CFX, MetroPlan Orlando and FDOT D5 acquired funding through a collaborative Joint Participation Agreement (JPA) where each entity contributed a portion to the purchase of two LiDAR 3D Laser scanning units to assist the local FHP, Troop D and OPD with conducting their traffic homicide investigations in a more effective and efficient manner. This enhanced surveying technology is intended to expedite law enforcement's investigative process and was established as a three-year pilot program with a completion date of April 10, 2020.

Two units were distributed for use in the three-year trial period and the equipment procurement included all licensing, maintenance, warranties, training, expert witness services, and auxiliary components necessary to successfully operate, support, and maintain the equipment. CFX contributed to the capital and managed purchase of the units and provided the manpower necessary to manage the Pilot Program and provided the reporting and accountability tracking to ensure the project is successful and provides useable information to all stakeholders.

The LiDAR technology has been deployed at 311 (258 FHP and 53 OPD) traffic homicide investigation case locations from November 2016 until May 2020. **Figure 26**, below, illustrates a detailed timeline of start and end times of the before and after study phases.

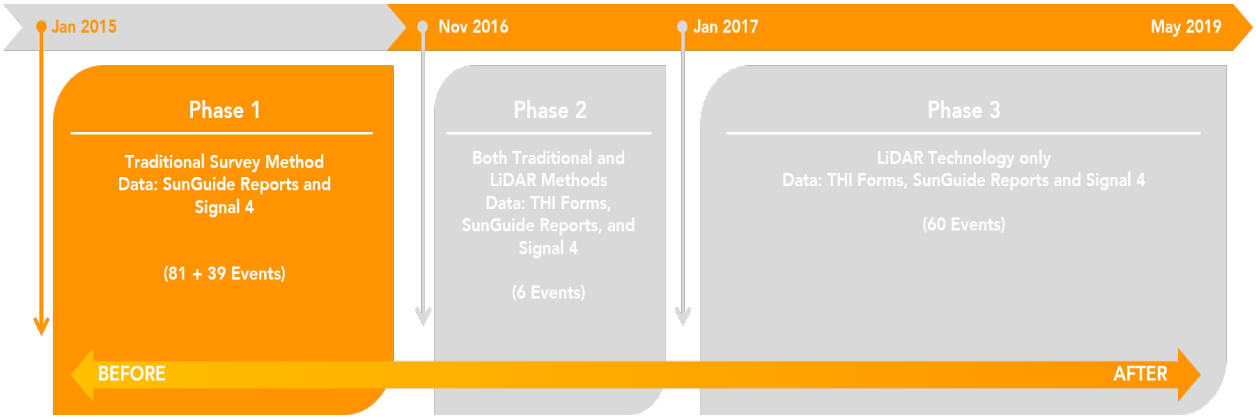

Figure 26: LiDAR 3D Surveying Equipment Technology Pilot Program Study Timeline

This pilot program has been completed and is currently undergoing finalization of the testing results, but several secondary benefits have been determined. These benefits include showing that the LiDAR technology is valuable in reducing the closure times compared to traditional incident surveys for both arterial and limited access facilities. This results in a reduced number of secondary incidents, increased efficiency for emergency responders, reduced delays on alternative routes by limiting the amount of rerouting of traffic by shorter closure times, and cost savings as a result of avoiding the secondary crashes and subsequent delays.

3.13. CFX Analytics (iPaas) Pilot Test

iPaaS or similar systems, are advanced Intelligent Video Integration Solutions (IVS) that generate analytics such as traffic volume, speed, lane occupancy and trajectory by dynamically measuring information from deployed equipment, such as CCTV cameras or drone videos. The software uses computer vision, machine learning, and artificial intelligence to dynamically analyze different objects such as pedestrians, bicycles,

cars, trucks, and motorcycles. These traffic analytics provide real time reporting information is then stored in a database which is dynamically downloaded and processed by the iPaas reporting tool.

CFX conducted a pilot test using the iPaas software in January 2020 on SR 528 heading towards Cocoa Beach. The intent of this project was to understand real time traffic analytics to support activities such as transportation planning, corridor management, ramp metering, and incident management. iPaaS can be deployed on the cloud via remote servers/IOT or on-premises servers/IOT. A good bandwidth is highly recommended to analyze the objects in the live streaming videos. The iPaaS user interface is web service based accessible via desktop, laptop, tablets, or mobile phone through any web browser (Chrome, Firefox, or Internet Explorer).
The initial step after deployment was for the software to define an object to analyze. To do this iPaas must perform the following steps:

- **Object Recognition**: iPaaS recognizes, identifies, and classifies each object.
- **Tracking Object Trajectory**: iPaaS identifies the locational coordinates of each object to track its trajectory across different frames in via the video feed which in turn generates the object path.
- **Generating Analytics**: iPaaS generates and shows the traffic volume and speed analytics of the recognized objects in the iPaaS Reporting Tool.

The software then breaks the information down into two categories to create diagnostics for Traffic Volumes and Speeds. Operational Analytics are available if needed. The Traffic Volume analytic is calculated for either direction (if more than one travel direction is captured in the image), specific roadway lanes, or turning movement counts at intersections during specified date and timeframes. iPaaS users define a counting line on the lane(s) where the traffic volume is required. Users also specify the following parameters. The Speed Analytic for each Counting Zone specified in the video is determined by calculating the time of each object to travel the distance of the counting zone. This information is provided per vehicle detected and as an average speed of the specified time frame defined by the user to generate analytics. For this pilot project with CFX, the average speed was measured at approximately 75 mph.

ITS
Master Plan

Section 4

Identification of Transportation and Technology Needs

CENTRAL
FLORIDA
EXPRESSWAY
AUTHORITY

4. Intelligent Transportation System (ITS) Needs

This section of the ITS Master Plan's primary purpose is to define Intelligent Transportation Systems (ITS) strategies and identify needs that may provide the optimum return on investment, by targeting the specific strategies and deployment locations which best fulfill the insufficiencies in CFX's transportation system (See **Section 5** for Identification of Applicable Technology Strategies). Preceding sections have established ITS Visions, Goals, and Objectives, and provided an existing conditions summary. These needs, along with other transportation system performance measures, will be used to prioritize where the application of ITS and TSM&O solutions will have the most significant positive impact. Utilization of effective ITS and TSM&O strategies will allow CFX to realize increased performance of the multimodal infrastructure using systems, services, and projects that preserve capacity, improve safety, improve security, and provide increased travel reliability.

4.1. Overview of ITS Strategies

CFX is faced with the challenge of increasing the movement of people and goods in the area, while under financial and geographical constraints. Consequently, it is becoming more difficult to increase transportation system capacity through traditional methods, such as roadway widening. Application of ITS strategies provide an alternative means to meet the transportation system challenges CFX faces, through the use of cost-effective advanced technologies that maximize the capacity and efficiency of roadways without increasing the roadway footprint. Examples of ITS strategies would include the items below:

- Transportation Management Center
- Communication Systems
- Visual Surveillance
- Vehicle Detection Systems
- Advanced Traveler Information Systems
- Incident Management and Highway Assistance
- Active Transportation and Demand Management (ATDM)
- Passive Demand Management
- Work Zone Management
- Part Time Shoulder Use (PTSU)
- Public Transportation Management
- Public Travel Security
- Electronic Payment Services
- Connected and Automated Vehicles
- Freight Advanced Traveler Information Systems (FRATIS)
- Traffic Data Information Management
- Event Management
- Asset Management
- Innovative Bicycle & Pedestrian TSM&O Solutions
- Alternative and Innovative Intersection Designs
- Traffic Signal Systems
- Active Parking Management

Please reference Section 2 glossary for a full description of the ITS strategies listed above.

4.2. CFX Transportation Needs

To help identify CFX transportation needs for the 2040 Master Plan, FY 2022-2026 5-Year Work Plan (dated 5/13/2021), individual project reports, the May 2021 Traffic Monitoring Report, the October-December 2020 Traffic Congestion Quarterly Update, and crash monitoring reports were reviewed. The following sections include specific items that were highlighted related to system congestion, safety, and event management.

4.2.1. System Congestion

Pre-COVID and post-COVID traffic congestion conditions were evaluated from the May 2021 Traffic Monitoring Report and the October-December 2020 Traffic Congestion Quarterly Update, respectively, and planned Improvements were referenced from the FY 2022-2026 5-Year Work Plan (dated 5/13/2021).

SR 408

- Pre-COVID, all segments west of SR 408 operated at or above vehicle to capacity (V/C) ratios of 0.85 during the peak hour, and some segments operated at capacity. East of I-4, pockets of congestion existed between Bumby Avenue and Rouse Road.
- Post-COVID, congestion has largely cleared with the exception of recurring delay near I-4 in the westbound direction during the AM peak and the eastbound direction during the PM peak. The Eastbound congestion is being addressed as part of the Tampa Ave Interchange project, which includes the widening to 4 lanes from Tampa Avenue to Orange Avenue. This project is currently under design.
- Current work plan projects are expected to address the congestion needs referenced above.

SR 417

- Pre-COVID, pockets of SR 417 operated near or over capacity in different segments throughout the corridor.
- Post-COVID, some minor PM peak period congestion is beginning to show on the latest reports which is currently concentrated in the Southbound direction south of SR 528.
- SR 417 widening is planned from International Drive to SR 528. As part of the widening from 4 to 6 lanes, CFX is also incorporating Part-Time Shoulder Use (PTSU) functionality into the design, allowing for the inside shoulder to open to traffic during congested peak periods or incident management events.

SR 429

- Pre-COVID, portions of SR 429 operated near peak hour capacity, particularly between CR 535 and West Road.
- Post-COVID, reports showed that a dip in speed (40-45 mph) was identified southbound between Warrior Road and CR 535 in the PM peak. Design for widening in this section is underway.
- SR 429 is planned for widening from Tilden Road to SR 414. As a part of the widening from 4 to 6 lanes, CFX is also incorporating PTSU functionality between Stoneybrook West Parkway and SR 414, allowing for the inside shoulder to open to traffic during congested peak periods or incident management events.

SR 528

- Pre-COVID, portions of SR 528 operated near peak hour capacity, particularly between Tradeport Drive and Innovation Way.
- Post-COVID, no peak hour congestion was reported.
- SR 528 is programmed for widening from Goldenrod Road to Innovation Way.

4.2.2. Safety

Vehicular crashes on the system are a safety concern and one of the primary causes of non-recurring congestion. Identifying and addressing crash hotspots through safety improvements can provide significant relief to sources of non-recurring congestion.

SR 408

West of I-4, the segment from Old Winter Garden Road to I-4 saw a 75% increase in crashes for the 2019 fiscal year when compared to the Average Annual Crashes (2014-2018). As documented in the FY 2018-2019 Annual Accident Monitoring Report, 235 crashes occurred within this segment during the 2019 fiscal year. The previous five-year annual average was 134.4. It was also documented that the majority of these crashes occurred on ramp sections and approaches to I-4 during periods of construction of the I-4 Ultimate Project. This construction likely influencing crashes within this segment.

East of I-4, the segment from Mills Avenue to Bumby Avenue saw an 81% increase in crashes for the 2019 fiscal year over the previous Average Annual Crashes (2014-2018). 33 crashes were documented within this segment during the 2019 fiscal year. The previous five-year annual average was 18.2. No discernible trends in crashes or crash types were discovered. There was a resurfacing project that occurred during this time that could have affected the crashes within this segment.

The 2019 crashes were reviewed at the ramp intersections to note if a recurrent crash pattern is developing. The following locations were flagged with potential improvement considerations:

- Chickasaw Trail: Angle crashes were noted at the Chickasaw Trail ramp intersections. A review of the crash reports noted northbound and southbound drivers disregarding the traffic signals and striking eastbound/westbound vehicles. It appears retroreflective backplates are installed on all signal heads. Consideration should be given to checking the yellow and red clearance intervals to confirm they meet the minimum values for the intersection (based on approach speed, width of the intersection).
- John Young Parkway: Northbound/southbound left-turn crashes were noted at the SR 408 at John Young Parkway ramp intersections. 4-section Flashing Yellow Arrow (FYA) signal heads are provided at both intersections. Consideration should be given to evaluating the time-of-day operations for the FYA to determine if protected-only left-turn phasing is warranted for specific hours of the day.

With construction still ongoing for the I-4 Ultimate Project, it is recommended the crashes within these segments be monitored after construction is completed.

SR 414

The segment from SR 429 to Keene Road saw a 94% increase in crashes for the 2019 fiscal year when compared to the Average Annual Crashes (2014-2018). As documented in the FY 2018-2019 Annual Accident Monitoring Report, 21 crashes occurred within this segment during the 2019 fiscal year. The previous five-year annual average was 10.8. Additionally, 57% of the crashes were off-road crashes and most were influenced by wet weather conditions at the time of the crash. The Central Florida Expressway Authority Five-Year Work Plan indicates a planned resurfacing project on SR 414 from west of Keene Road to U.S. 441. It is recommended to reevaluate crashes within this segment after the roadway is resurfaced to determine its effect on the off-road and wet weather crash trend.

The 2019 crashes were reviewed at the ramp intersections to note if a recurrent crash pattern is developing. The following locations were flagged with potential improvement considerations:

- US 441: Sideswipe crashes were noted to occur within the southbound dual left-turn lanes. Based on a review of the intersection, the skip guide striping and the lane delineation pavement markings are faded/missing. Consideration should be given to restriping the pavement markings to better define the turning paths and lanes for the eastbound on-ramp to SR 414.

SR 417

The segment from International Drive to John Young Parkway saw a 76% increase in crashes for the 2019 fiscal year when compared to the Average Annual Crashes (2014-2018). The segments from John Young Parkway to the Turnpike and the Turnpike to Boggy Creek Road saw 65% and 85% increases in crashes, respectively. It is noted that the Turnpike interchange was under construction during this period. Current work plan projects, including roadway widening, are expected to alleviate congestion in these segments and potentially alleviate crashes. It is recommended to reevaluate crash trends after widening and construction in all segments are completed.

The segment from University Boulevard to the Orange/Seminole County Line saw the highest increase in crashes for the fiscal year 2019 at 113%. A total of 49 crashes occurred within this segment during the 2019 fiscal year as compared to the previous five-year annual average of 23. It should be noted this segment was under construction (widening) in 2019. It is recommended this segment be reevaluated after the current construction is completed.

The 2019 crashes were reviewed at the ramp intersections in order to note if a recurrent crash pattern is developing. The following locations were flagged with potential improvement considerations:

- Narcoossee Road: Left turn and angle crashes were noted at the Narcoossee Road ramp intersections. A review of the crash reports noted northbound and southbound drivers disregarding the traffic signals. It appears retroreflective backplates are installed on all signal heads on the southbound SR 417 ramp intersection and 5-section protected/permissive signal heads are provided for the northbound/southbound left-turn approaches. This interchange is being reconstructed as part of a widening project and additional turn lanes will be added to Narcoosee Road and the ramps. Consideration should be given to ensuring retroreflective backplates are provided on all signal heads as part of the reconstruction. Additionally, the yellow and red clearance intervals should be assessed to confirm they meet the minimum values for the intersection (based on approach speed, width of the intersection) and a time-of-day operation should be evaluated to determine if protected-only left-turn phasing is warranted for specific hours of the day. Consideration should also be given to checking

SR 429

Three segments, including from the Turnpike to SR 438, SR 438 to West Road, and Seidel Road to CR 535, all experienced increases in crashes over 100% for the fiscal year 2019 when compared to the previous five-year average. The largest increase of crashes at 148% occurred in the segment from the Turnpike/SR 50 to SR 438/Plant Street in which 60 crashes occurred in FY 2019 when the five-year annual average was 24.2. According to the FY 2018-2019 Accident Monitoring Report, the majority of these crashes were rear-end and side-swipe crashes that occurred during peak hours with high congestion.

The 2019 crashes were reviewed at the ramp intersections to note if a recurrent crash pattern is developing. The following locations were flagged for potential improvement considerations:

- CR 437A: Southbound left-turn crashes were noted at the CR 437A at southbound SR 429 ramp intersection. A 4-section Flashing Yellow Arrow (FYA) signal head is provided. Consideration should be given to evaluating the time-of-day operations for the FYA to determine if protected-only left-turn phasing is warranted for specific hours of the day. The SR 429 widening project is also reconstructing the bridges at this interchange to provide better sight distance.

Current work plan projects, including the widening of SR 429, will improve capacity within these segments. Additionally, FDOT has planned improvements for the Turnpike/SR 429 interchange where congestion is high and where the increase in rear-ends and side-swipe crashes occurred. It is recommended to reassess crashes within these segments after construction with capacity issues addressed.

SR 451

No existing crash issues are noted on SR 451. A total of five (5) crashes were recorded on the roadway in fiscal year 2019, a slight increase to the 3.4 annual average over the previous five years.

SR 528

The segment from Goldenrod Road to Narcoossee Road saw an 89 % increase in crashes for the 2019 fiscal year when compared to the Average Annual Crashes (2014-2018). A total of 39 crashes occurred within this segment during the 2019 fiscal year, compared to an annual average of 20.6 crashes. The FY 2018-2019 Accident Monitoring Report analysis determined that clusters of these crashes occurred during the P.M. peak hour and were rear-end crashes located at the beginning of the eastbound off-ramp to Narcoossee Road, where three lanes merge to two lanes.

The 2019 crashes were reviewed at the ramp intersections in order to note if a recurrent crash pattern is developing. The following locations were flagged with potential improvement considerations:

- Tradeport Drive: Left-turn crashes were noted at the Tradeport Drive and eastbound SR 528 intersection. Southbound left-turning drivers failed to yield to northbound through vehicles, resulting in left-turn crashes. A 5-section protected/permissive signal head is provided for the southbound approach. Consideration should be given to replacing the 5-section signal head with a 4-section FYA and 3-section signal heads. The time-of-day operations should be evaluated to determine if protected-only left-turn phasing is warranted for specific hours of the day. Consideration should also be given to checking the yellow and red clearance intervals to confirm they meet the minimum values for the intersection (based on approach speed, width of the intersection).
- Goldenrod Road: Angle crashes were noted at the Goldenrod Road and SR 528 ramp intersections, occurring as a result of northbound/southbound drivers disregarding the traffic signals. Backplates are not currently provided on the northbound/southbound signal heads at either intersection. Consideration should be given to installing retroreflective backplates on the northbound/southbound approach signal heads. Consideration should also be given to checking the yellow and red clearance intervals to confirm they meet the minimum values for the Intersection (based on approach speed, width of the intersection).
- Narcoossee Road: Left-turn crashes were noted at the Narcoossee Road and eastbound SR 528 intersection. Southbound left-turning drivers failed to yield to northbound through vehicles, resulting in left-turn crashes. A 5-section protected/permissive signal head is provided for the

southbound approach. However, it is aligned over the southbound inside through lane. Consideration should be given to evaluating the traffic volumes and time-of-day operations should be evaluated to determine if FYA signal head warrant with protected-only left-turn phasing for specific hours of the day. Consideration should also be given to checking the yellow and red clearance intervals to confirm they meet the minimum values for the intersection (based on approach speed, width of the intersection). This interchange will be reconstructed as a part of a widening project and these operational recommendations should be communicated to the engineering team for consideration.

The segment from Innovation Way Road to SR 520 saw a 52% increase in crashes for the 2019 fiscal year (154 crashes) when compared to the Average Annual Crashes (2014-2018) (101.2 crashes). A toll booth is located within this segment.

The current work plan includes widening SR 528 from Goldenrod Road to Innovation Way which includes the Narcoossee Road interchange. Crash trends within this segment should be reevaluated after construction is completed.

4.2.3. Event Management

Event management is another major cause of non-recurring congestion. For events at Camping World Stadium, SR 408 serves as a primary regional route for ingress and egress. The area between John Young Parkway and downtown experiences congestion during pre-event traffic management, particularly at the Tampa Avenue and Orange Blossom Trail Interchanges. Interchange improvements at SR 408 and Tampa Avenue are currently under design to provide new access from SR 408 westbound and access to SR 408 eastbound. The eastbound SR 408 off-ramp to Orange Blossom Trail will also be rebuilt as a part of this project. As part of the CFX project, streetscape improvements are planned along Tampa Avenue between Gore Street and SR 408.

The City of Orlando is engaged in a downtown Venues Traffic Management Strategies project. With the SR 408/Tampa Avenue interchange improvement under design, the City is anticipating new routing to utilize the direct access from Tampa Avenue to SR 408 eastbound. Currently, all southbound Tampa Avenue traffic is forced to SR 408 westbound, and much of that traffic immediately exits at John Young Parkway to re-route north or south or to U-turn and head east on SR 408. This contributes to substantial congestion on John Young Parkway.

However, with the Tampa Avenue interchange improvements in place, traffic management strategies will be updated to utilize both the SR 408 westbound and SR 408 eastbound movements from Tampa Avenue. Utilizing SR 408 eastbound as the new forced movement will allow vehicles direct access to any direction along SR 408 or I-4 without impacting surface street operations. To support this, the City has an ongoing Venues Traffic Management Study that also suggests limiting/closing the SR 408 off-ramps to Tampa Avenue and to Orange Blossom Trail during the post-event egress periods. Exit ramps to John Young Parkway and downtown would remain open.

The City's downtown Venues Traffic Management Strategies Project is also considering turn lane Improvements on Orange Blossom Trail within the SR 408 vicinity to optimize event management strategies.

4.2.4. Summary of Needs – System Roadways (Goals 1 & 2)

Based on a review of the 2040 Master Plan, FY 2022-2026 5-Year Work Plan (dated 5/13/2021), individual project reports, Traffic Monitoring Report (May 2021), the October-December 2020 Traffic Congestion Quarterly Update, and the FY 2018-2019 Accident Monitoring Report the following needs have been identified:

- **Improved Travel Time Reliability (Goals 1 & 2)**
  - Additional Mainline Capacity During Peak Periods - Widening projects are planned for most of the system corridors that will address much of the current capacity needs. In addition to adding through lanes, other opportunities should be considered, such as temporary capacity during peak hours or traffic incidents (by use of PTSU) or the ability to identify and clear incidents more rapidly.
  - Reduction of Primary Crashes and Corresponding Delays - A reduction in primary crashes will result in a reduction in travel time. As stated by the Florida Highway Administration, for every minute that a freeway travel lane is blocked during a peak period, four minutes of travel delay results after the incident is clear.
  - Reduction of Secondary Crashes and Corresponding Delays - A decrease in primary crashes and delays will result in a reduction of secondary incidents, which are incidents that result from an initial incident. Motorists moving through and upstream from a traffic incident site are vulnerable to secondary incidents caused by sudden slowing of traffic, lane changes, and the situation or movement of emergency vehicles. Freeway incidents not only cause severe traffic congestion and travel delays, but can also result in secondary accidents, the risk of which has been estimated to be six times greater than that of a primary accident.
- **Event Management (Goal 2)** - Identification for event management has been specifically identified along SR 408 and in the vicinity of Camping World Stadium. This could include limiting or closing adjacent ramps during post even periods or turn lane Improvements at surrounding Intersections.
- **Reduction of Left-Turn (failing to yield) (Goal 1)** - This type of crash along SR 408 at Chickasaw Trail, SR 429 at CR 437A, SR 528 at Tradeport Drive, and SR 528 at Narcoossee Road has been identified. These crashes are typically occurring under a permissive left-turn phase at the intersections, with drivers either disregarding the signal or misunderstanding the signal head indications (green ball versus green arrow). Adjustments to phasing (protected versus protected-permitted), clearance intervals and types of signal heads (5-section versus 4-section flashing yellow arrow) would be potential items to review when addressing these crashes.
- **Reduction of Red-Light-Running Violations and Angle Crashes (Goal 1)** - This type of violation and crash along SR 408 at John Young Parkway, SR 528 at Goldenrod Road, and SR 528 at Narcoossee Road has been identified. Improving the visibility of the signal heads and providing adequate clearance time between phases could reduce the occurrence of red light running.
- **Reduction of Intersection Sideswipe Crashes (Goal 1)** - These crashes on SR 414 at US 441 are occurring within dual left-turn lanes and are an indication the driver may not be aware of the lane assignment or the proper lane they need to access downstream.
- **Alternative Intersection Design (Goal 1)** - This type of design was recommended in the 2019 SR 417 Design Traffic Technical Memorandum (DTTM), specifically at the intersections of SR 536 at International Drive, SR 417 at John Young Parkway, SR 417 at Lake Nona Boulevard and SR 417 at

Narcoosee Road. Alternative intersection design would include a variety of options, including roundabouts, Median U-turns (MUT), and displaced left-turn to optimize intersection efficiency.

The above needs identified will support the CFX ITS Master Plan Goal #1 Effectively Managing a Safe, Secure and Efficient Transportation System for all Residents, Visitors, and Businesses by improving safety for all users, Reducing system-wide delay for all users, and Increase operational efficiency for all users. The needs above will also support Goal #2 which is to provide service excellence with a resilient and quality system by improve reliability and predictability of travel and Increasing efficiency in Traffic Incident Management and Event Planning.

4.3. CFX Technology Needs (Goals 3, 4 & 5)

This section details some key needs and transportation technology considerations to satisfy the mobility goals for the Central Florida Expressway (CFX) Authority's upcoming Work Plan projects. With an evaluation of CFX's existing infrastructure (conducted under Section 3), the direction of Connected and Automated vehicles and current efforts of testing and deployments occurring locally and nationally, CFX has their own role in the planning and implementation phases to support the operational and safety needs of their customers.

Policymakers, State, Local and private organizations are planning for and considering the impact of supporting this rapidly evolving technology. CFX may prepare for these technologies with consideration of the following:

- Monitor state of the industry and the ability to safely deploy connectivity solutions
- Evaluate existing stakeholder partnerships with a focus on data sharing and collaboration opportunities and to reduce operational redundancies
- Evaluate the existing workforce to determine gaps in skillsets necessary to adopt a successful CAV program
- Update existing policies and architecture where applicable to support lifecycles and retention strategies
- Evaluate the Regional ITS Architecture (RITSA), develop a Concept of Operations and CAV roadmap
- Strategize a maintenance and operations plan
- Evaluation of the existing infrastructure (roadway and data network) to support a CAV environment
- Determine applicable use cases for the application of CV technologies
- Monitor state of the Industry and the ability to safely deploy connectivity solutions
- Prepare for Integration of different types of CV data for best support of safety applications

ITS advancements have, to date, greatly improved a number of transportation challenges. However, as the technologies continue to improve and rapidly evolve, there will be a significant and profound impact on the transportation ecosystem, and agencies must be prepared to support these technologies.

From conducting an industry assessment and providing the opportunity of hearing the voices of industry partners, to an evaluation of Connected Vehicle (CV) needs conducted to date, CFX continues their goal to be ready to support the needs of their customers. This section involves a comprehensive review of

CFX's existing needs in key operational areas related to transportation infrastructure, CV applications, network, data, and the policy and staffing considerations to support technology improvements to mitigate immediate problems related to congestion and safety.

4.3.1. Future Traffic Management Center (TMC)

CFX facilities are currently managed from the FDOT District 5 Regional Traffic Management Center (RTMC). The FDOT District 5 RTMC is located in Seminole County in close proximity to the I-4/SR 417 Interchange and includes shared facilities with the Florida Highway Patrol Troop D Regional Communications Center and the Florida Fish and Wildlife Conservation Commission Law Enforcement Unit. This state-of-the-art, hurricane-ready facility is 44,994 square feet and serves as the communications hub for traffic management across the nine counties of Florida Department of Transportation's District Five. The RTMC houses more than 50 traffic management operators, signal timing engineers, and incident management specialists. Operating 24 hours a day and seven days a week, the RTMC monitors traffic and coordinates responses to incidents and crashes on 795+ miles of highways and state roads across the region. Through an agreement with the Central Florida Expressway Authority, the RTMC also provides traffic management operations for all Expressway owned roadways. The regional fiber-optic networks connect hundreds of closed-circuit television cameras, dynamic message signs, V2X devices, and vehicle detector sensors on I-4, I-95, I-75, SR 408, SR 417, SR 429, SR 528, and other arterial state roads. With the Florida Highway Patrol Troop D Regional Communications Center being co-located in the RTMC it aids in immediate, coordinated incident response.

The FDOT District 5 RTMC uses an interagency agreement between its agency and CFX. This agreement states that CFX will supply the utilization of twenty-four strand (24) single mode fiber optic strands to FDOT D5 throughout CFX's facilities and in return will receive the following services:

- CFX operator to monitor CFX facilities 24/7/365. The operator provides the following services:
  - Posts messages on DMSs
  - Manages events
  - Support for Wrong Way Driving System
  - Dispatch Road Rangers
  - Coordinate with Asset Maintenance Contractors during long-term lane closures
- Supervision of CFX facilities (Supervisor and TMC Manager) - Note that the supervision staff also supervises FDOT operations in Central Florida
- Traffic Incident Management (TIM) - this includes representation at the TIM Team meetings
- IT Services within the RTMC

At this time, colocation in the District 5 RTMC meets the needs of CFX. However, if for some reason it was no longer practical to co-locate at the D5 RTMC, a future independent Traffic Management Center (TMC) would be a future need. The existing CFX ITS Control room could be modified to accommodate a limited number of TMC personnel (maximum 2 people). Additional furniture would need to be purchased to accommodate both operators. If a new facility is built, the following are the recommendations based on the minimum available staffing:

- 2-4 Full Time Equivalent operator positions for 24/7/365 coverage
- One supervisor - Should also be able to function as a back-up operator

- TMC Manager
- IT Support Specialist
- TIM Support Specialist
- PTSU Services staff

The above would require 4-5 workstations and a video wall at a minimum. The TMC would need to continue to maintain and operate its existing connection to the FDOT District 5 RTMC and the Florida Turnpike Enterprise TMC via Center-to-Center communications. In addition, 30+ servers would be either moved or procured and would be a mix of production and non-production. The following are the servers that would continue to be operated and maintained and/or procured:

- Physical Servers
  - EXi Server - Host virtual server
  - 4-10 for Video Wall
- 25 Virtual Servers
  - C2C SRV (2)
  - Maintenance Jumpbox
  - Network Monitoring Software
  - DMS Server
  - Secure Access Control for Cabinets
  - MIMS
  - RR Manager
  - CCTV Snapper
  - OSP Insight
  - SG - Prod (4) and Develop (4)
  - SG - Application Test
  - SG -DB Srvs Test and Prod
  - DB Servers (2)
  - Developer SRV (2)

A layer 3 router would be required in addition to 4-48 port layer 2 switches for the servers and distribution throughout the TMC. This requirement does not account for the use of Virtual Servers. In a virtual environment, less switches will be needed. Finally, funding would need to be allocated for the capital and the operations costs for the facility.

It should also be noted that PTSU Services could potentially be added to the existing District 5 RTMC Operations in the future. Per the PTSU Concept of Operations, it is recommended that the operator be a separate staffing requirement apart from the normal operator of that segment of roadway. This service is not included in the MOU and Shared Communications Agreement between CFX and D5. This additional service should be addressed in a future separate agreement. As it currently stands, discussions between CFX and FDOT D5 is still on-going and nothing concrete has been determined.

For more detailed information on the approach and requirements for this strategy, please see **Section 5**.

4.3.2. Network Infrastructure

An existing inventory of the CFX ITS baseline conditions were outlined in Section 3. CFX has deployed a robust ITS infrastructure and is currently using the following ITS technologies:

- Fiber Optic Network (FON)
- Network Communications, Security and Monitoring
- ITS Devices
  - Closed Circuit Television (CCTV) Cameras
  - Data Collection Sensors (DCS)
  - Wrong Way Driving Detection Devices
  - Dynamic Message Signs (DMS)
  - Traffic Monitoring Stations (TMS) (Microwave Vehicle Detection System (MVDS) technology)
  - Connected Vehicle Devices

4.3.3. ITS Devices

CFX has deployed several ITS technologies to assist with traffic monitoring and dissemination information to the traveling public. Currently CFX has deployed CCTV cameras for traffic monitoring and incident confirmation, DMS for information dissemination and TMS and Data Collection Sites for volume, speed and travel time data.

CFX's ITS system will undoubtedly change over time. As the system evolves, there will be changes to the concepts of operations, advancement in technologies, and ITS device life cycle requirements. In order for the ITS system to continue to be successful, it will be necessary to both maintain the ITS devices and replace the devices appropriately, depending on their life cycle. The benefits of a properly maintained and updated ITS device system include reduced driver delays, faster incident response, reduced secondary accidents, reduced fuel consumption, and increased driver safety.

CFX has recently replaced most of the devices on their system within the past 1-5 years. The previous and current work plans accounted for the replacements of the following devices:

- **3-Line Dynamic Message Signs (DMS) Replacements** – Note this replacement is an on-going process
- **Field Ethernet Switch Replacement** – Note this replacement is an on-going process
- **Terminal Server Replacement** – Replacement completed in 2020
- **Remote Power Manager Replacement** – Replacement completed in 2020
- **CCTV Replacement** – Replacement completed in 2020
- **Lowering Arm Upgrade** – Replacement completed in 2021
- **2-Line DMS** – This was recently replaced as part of the 599-525 project in 2016
- **Traffic Monitoring Station** - The majority of these units were installed in 2013.

The following provides additional details on CFX ITS device life cycle:

Data Collection Sensors (DCS) – CFX system includes 188 DCS sensors along SR 408, SR 414, SR 451, SR 453, SR 417, SR 528, SR 520, SR 429, and Turnpike which were replaced as part of the DCS replacement project 599-520 in 2015. The warranties have expired on DCS units. However, the manufacturer is providing repair services and have not issued end of life notice. In addition, CFX has tested Bluetooth/WIFI/TPMS readers manufactured by Blyncsy to eventually replace the Neology readers. The current work plan includes funding to deploy Blyncsy units to begin the conversion process. As Blyncsy units are deployed throughout the system CFX will be able to leverage the new data inputs through use of the ITSIQA (Intelligent Traffic Systems Quality Analysis) platform which has the ability to receive

multiple data sources and provide a single consolidated output. The Poinciana Parkway and SR 516 will also feature the Blyncsy units for the travel time system.

Traffic Monitoring Station (TMS) – The CFX system includes approximately 447 TMS sensors along SR 408, SR 417, SR 429, SR 451, SR 453, SR 528, and SR 414. CFX deployed the Wavetronix units which were a part of the 599-511 project in 2013. At this time, the warranties on the TMS units installed as part of the 599-511 project have expired and the manufacturer has issued an end-of-life notice for the 400 units originally deployed as part of project 599-511. Annual replacement budget has been added to the upcoming 5-year Work Plan. CFX has tested the Houston Radar Speed Lane Pro unit which are Ethernet based and features POE for the power supply. The application of a POE solution has the potential of eliminating the surge issues encountered in the field and reducing points of failure. The accuracy of the devices is comparable to the current units and the radar will be used on Poinciana Parkway at SR 516.

Wrong Way Driving Detection Devices (WWD) - CFX has deployed Wrong Way Driving Ramp Detection System at 53 locations on the expressway system. In addition to the Ramp Detection system, CFX has also deployed ten (10) Mainline Wrong Way Detection Systems throughout the expressway system. This system consists of one incoming thermal detection camera which is mounted on a sign structure over the detection lanes. The system was installed starting in 2015 with pilot projects and has continued through 2021. The manufacturer is currently providing repair services and have not issued end of life notice.

Uninterruptible Power Supply (UPS) – CFX currently deployed the Alpha 650 XM units which were part of the 599-520 project in 2015 and replaced the older Minuteman units. The warranties have expired on these units; however, the manufacturer is still providing repair services. Alpha recently announced a new unit (FXM-HP 650) that will replace the current ones. Typically, this will lead to end-of-life declaration by the manufacturer and replacement will be required. Rather than repair damaged Alpha 650 XM units, CFX has negotiated a cost to exchange damaged units for new FXM-HP 650 units.

Uninterruptible Power Supply (UPS) Batteries – The UPS batteries throughout CFX system have reached their end-of-life cycle and have frequently failed. The 2022-2026 Work Plan has allocated funds for the replacement of all the existing UPS batteries. The process of replacing batteries and recycling old batteries is underway.

Switch Replacement – Most of CFX ITS Networks equipment has been issued an end-of-life cycle by the manufacturer. The 2022-2026 Work Plan includes the replacement of the ITS Networks equipment. Funds were allocated for the equipment during the 2023 fiscal year. CFX currently has spare units to temporally use as a backup until the units are replaced and have not experienced any type of failure rates on the current units.

Detailed on the following page, **Table 13** provides a snapshot of CFX current conditions of device and equipment life cycle:

Table 13: CFX Device and Equipment Life Cycle

DEVICE/ EQUIPMENT TYPE	DEVICE INSTALLED	EXPECTED REPLACEMENT	CONDITION
Closed Circuit Television Cameras	2018	6-10 Years	Devices replaced in 2018.
3-Line Dynamic Message Signs	Ongoing	15 Years	Device replacement ongoing process.
2-Line Dynamic Message Signs	2016	15 Years	Devices replaced in 2016.
Data Collection Sensors	2015	5-7 Years	The warranties have expired on DCS units.
Traffic Management System	2013	10 Years	The warranties have expired on TMS sensors.
Wrong Way Driving Detection Devices	2015-2016 (Pilot) 2020	6-10 Years	Devices currently installed in 2020 and manufacturer is providing repair services and have not issued end of life notice.
Remote Power Management Unit	2020	5 Years	Devices replaced in 2020.
UPS System	2015	5 Years	The warranties have expired on the units.
UPS Batteries	2021	5 Years	The UPS batteries have reached their end-of-life cycle and have frequently failed. Replacement is expected by the end of 2021.
Switch Replacement	2014	10-12 Years	Equipment has been issued an end-of-life cycle by the manufacture. To be replaced in 2023

4.3.4. Connected and Automated Vehicle (Goals 4 & 5)

This section identifies the key considerations and relevance to support a connected, and quickly emerging automated vehicle environment. Connected and Automated vehicles fit into the landscape in the development and future of smart city growth. With the Internet of Things (IoT), maximized use of existing technologies and integration of smart transportation with CAV planning, benefits to be seen include intelligent mobility solutions, reduced congestion, improved motorist safety, and promoted transportation and accessibility services.

Local to Florida, bordering cities with potential partnerships to CFX, agencies are evaluating and adopting CAV technologies to solve real-world problems, to be on-board and to be part of the CAV readiness environment and quickly evolving culture. CFX, by exploring the deployment of a CV pilot and the current transportation technology and data needs assessments, are doing their part by being ready to support the changing needs of their transportation services.

Connected Vehicles include the use of various technologies to communicate with the driver, to the roadside infrastructure (vehicle-to-infrastructure/V2I), vehicle (vehicle-to-vehicle/V2V), or vehicle to anything (V2X). By communicating roadway or safety information to the driver, real-time information and data are shared to motorists providing the opportunities for quick and informed or alternate decision-making. Similarly, bi-directional data may be communicated from the vehicle to the cloud or network infrastructure to be used for planning evaluations and safety applications. With in-vehicle communication technology providing vehicle location, heading and speed to nearby vehicles, crash avoidance applications may significantly prevent incidents related to side swipes and other lane changing related incidents.

Many of the objectives and benefits of the implementation of CV technology are related to safety, mobility, and data collection for planning efforts and increased operational performance, as well as benefits related to the environment. Some of these benefits include:

- Reduction in the likelihood of collisions - forward, rear end and lateral (merging or lane changes)
- Reduction in road departure crashes
- Reduction of impacts of incidents relative to the flow of traffic
- Improved efficiency of roadway capacity
- Improved accuracy and timeliness of traveler information to motorists
- Improved roadway reliability for freight movement
- Improved asset management/condition monitoring
- Improved speed and accuracy of electronic payments
- Reduction on the dependence of traffic monitoring infrastructure
- Provides the availability of information and data for performance measurement
- Reduction in excess emissions and improvement in fuel efficiency by efficient traffic operations and improved mobility
- The need for sensors, signage, smart cities, incident management, temporary lane closures

The following identify some of the needs for consideration as CFX prepares its infrastructure. These items are discussed in detail in upcoming sections:

- Evaluate CAV infrastructure readiness
    - Network and roadside infrastructure
    - Hardware and software
    - Data handling
- Evaluate and deploy connected vehicle applications
    - Vendor device testing
    - Pilot CV deployment based on criticality and safety needs
        - Data requirements, visualizations, retention strategies
    - Regulatory requirements
- Business policies updates
    - Information Technology
    - Roles and responsibilities
    - Stakeholder, partnership involvement and data sharing
        - State, Local, MetroPlan Orlando, Academia relationships
- Staffing requirements
    - Evaluation and upkeep of skilled workforce to manage, implement and operate CV technologies
    - Training and professional development

4.3.5. CAV Infrastructure Readiness

The Vehicle-to-Infrastructure (V2I) communication framework enables vehicles to share vehicle-generated data and wirelessly provide information from the existing infrastructure to the motorists. Information provided may inform motorists of mobility, safety and environmental conditions. The installation of V2I infrastructure alongside existing ITS equipment facilitates the Dedicated Short-Range

Communication (DSRC) or LTE/Cellular Vehicle to Anything (C-V2X or LTE2X) Roadside Units and services. Data may be captured from a variety of devices and sensors which include Light Detection and Ranging (LiDAR), cameras, RADAR (Radio Detecting and Ranging), Radio Frequency Identification (RFID) readers, and others. Automated vehicles navigate with in-vehicle sensors and dynamic maps within an environment that is shared with cyclists, pedestrians, debris, inanimate objects, and working with the environmental conditions such as the weather. This data will ultimately be available to IOOs to help understand dynamic roadway conditions. CFX will continue to monitor changes in AV technological advancements.

While infrastructure testing and regulations are underway, investments on infrastructure upkeep, the consideration for and maintenance of streetlights, lane markers and striping, signage, infrastructure-to-vehicle (I2V) connections, and/or future planning considerations - for example, constructing infrastructure to collect fees on shared AV lanes, are some of the thoughts and considerations as the path is paved for safe AV deployments. Roadway maintenance will be a major concern as deteriorating roadways (fading road markers or deteriorating physical structure) are impediments for AVs. As this technology advances, agencies may consider forming partnerships with mapping agencies, utility departments, and FDOT to ensure coordinated efforts, or establishing processes to ensure that, for example, needed high-definition maps, or utility infrastructure repairs are coordinated or reflected when roadway improvements are made.

Within a CV environment, real-time information is transmitted to the motorist via Traveler Information Messages (TIM) which may include but are not limited to providing incident advisories or information related to roadway congestion or queue warnings, roadway conditions, construction or work zone advisories, or wrong way driving (WWD) advisories.

Coupled with the monumental advancement of the IoT, ITS as well as the private and public transportation services nationally, roadway crashes may be significantly avoided by deploying CV technology. With V2V, vehicles may broadcast and receive omni-directional messages from surrounding vehicles to determine potential threats, thus providing advanced warning for the driver to take the necessary actions. The USDOT indicates that approximately 80% of vehicle crashes may be avoided with advanced vehicle connectivity.[8]

Figure 27, on the following page, depicts a connected environment with intermodal communication.

[8] https://blog.rgbsi.com/what-is-v2i-technology

Figure 27: Depiction of a Connected Vehicle Environment

Source : https://ops.fhwa.dot.gov/

Figure 28, on the following page, provides a schematic of the V2X system functional architecture integrating both the infrastructure computing and application platform as well as the vehicle computing platform. Each provides their necessary software and hardware interfaces for data exchange. The infrastructure application platform provides the interface and data exchange component with the traffic signals, road signage systems, etc. The vehicle application platform provides the interface and the driver warning system by DVI display. Together, these components achieve the safety objectives of a CV deployment of integrating and processing data to deliver messages wirelessly to the motorist.

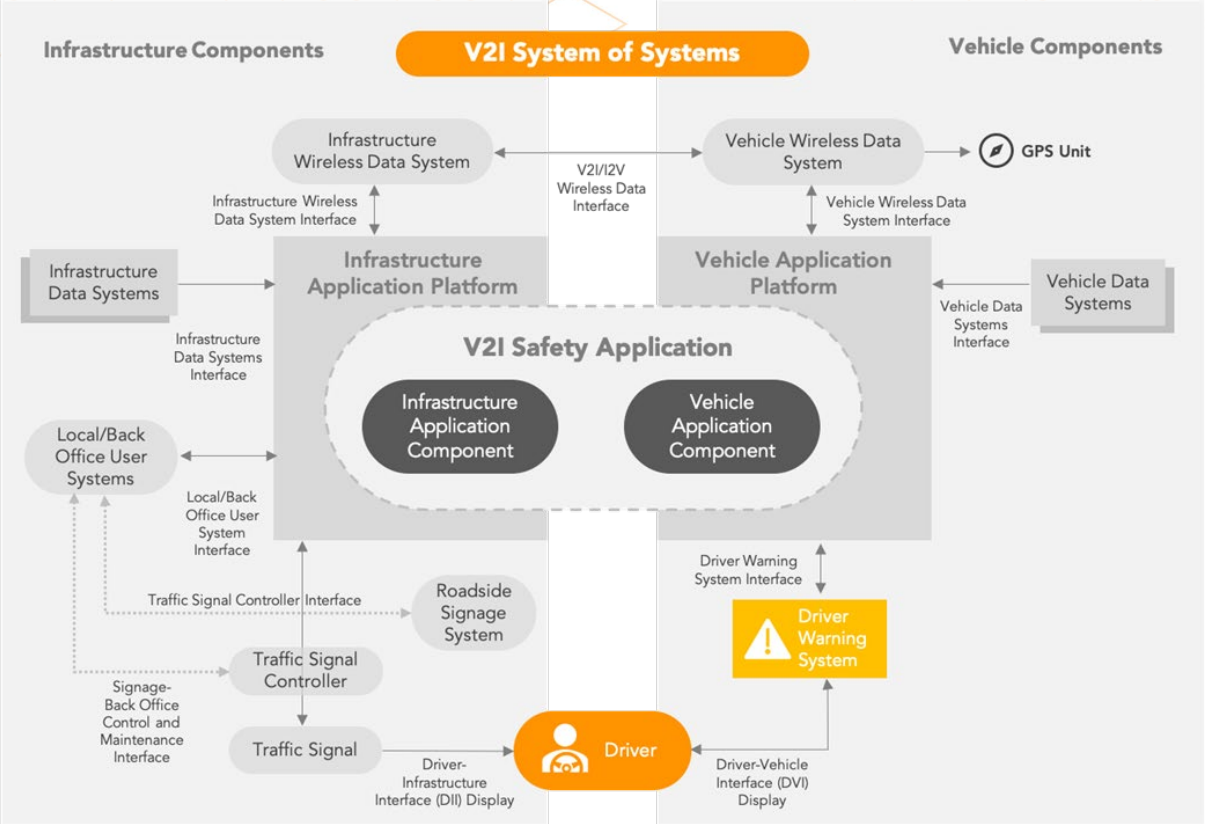

Figure 28: V2I Functional Architecture

There are several key supporting components that fulfil the V2I safety application system infrastructure. These include, but are not limited to GPS position correction, data input, output and validation, application processing speed, operational platforms, error handling, infrastructure-based systems and implementation of the National Transportation Communications for Intelligent Transportation System Protocol (NTCIP) and object definitions, roadside signage, back-office communication and interfaces, to name a few. The USDOT defines the V2I functional architecture as well as the common performance requirements in more detail. Section 4.3.16 identifies some of the network and roadside infrastructure needs to support V2I applications.

4.3.6. Connected Vehicle Devices and Application

In 2017 CFX published a Connected Vehicles Study, which was comprised of a Needs Analysis, Technology Scan, Readiness Analysis and Project List Report. Since the publication of the report there have been several notable milestones in the evolution of the CV industry; while the report provides a good baseline for CFX's intended approach to CAV, the quick progression and constant evolution of the industry merits the revisiting of the report and identification of appropriate adjustments. The document outlines a concept for a CV pilot program on CFX facilities, the operational impacts, and the elements necessary (safety, operational and maintenance needs) for the development and implementation of a CV program. Candidate technologies, technology and potential partnerships were outlined. These include:

- Reduce congestion and increase efficiency.
- Collecting operational performance measure data

- Notifications and alerts for incidents and other issues
- Development of guidance and policy actions
- Efficiency between agencies and services (FHP, police departments, etc.)
- Operational, safety, and maintenance needs
- Deployment of a CV pilot with suggested CV applications encompassing up to 10 Roadside Units (RSU) and up to four (4) OBUs within a 4-6-mile geographic area
- Potential updates to the communications infrastructure

The previously published CFX CV implementation plan suggests potential projects and timelines through the year 2030, depicted on **Figure 29**, below.

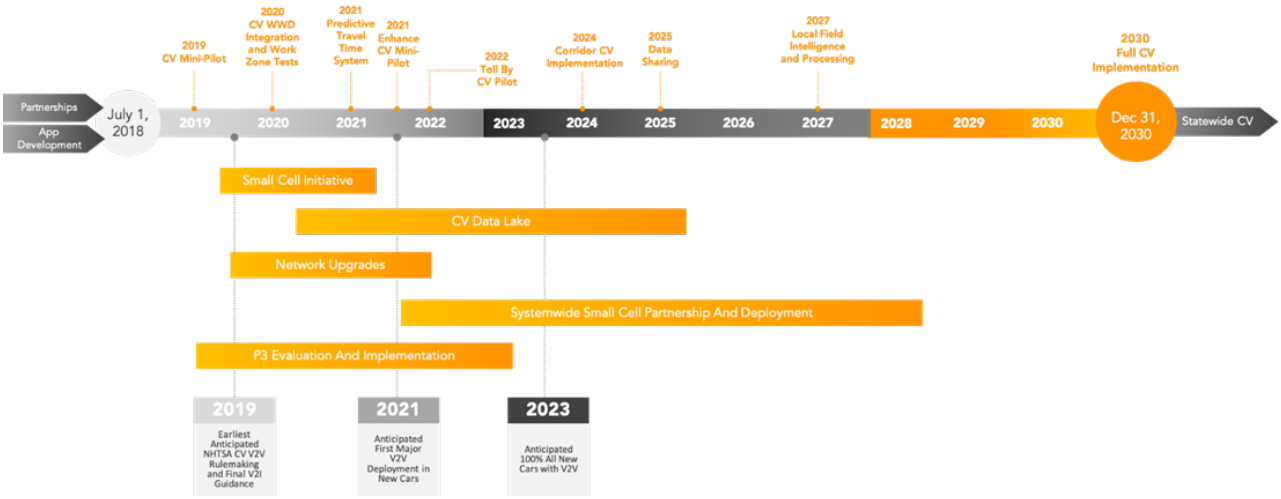

Figure 29: Connected Vehicle Implementation Plan

The CFX CV study recommends deploying an initial CV pilot utilizing 10 RSUs and 4 OBUs using DSRC. With this in mind, it is recommended that CFX conducts a data study to determine areas of repeated incidents for a CV pilot deployment. In addition, CV2X appears to be a more appropriate communications protocol. There are significant benefits to understanding the management and deployment aspects of CV technology - functionality and limitations. By getting involved, hands on, and with industry involvement, the advancement and progress of CV applications in tolling operations may be beneficial.

Connected Vehicle Device Testing

Device testing is a critical phase prior to procurement and deployment. Testing should include independent device testing as well as the inclusion of interoperability testing against other CV devices (RSUs, OBUs, IVP hubs, sensors, traffic signal controllers, etc.), as each variation may exist on the roadways. Additionally, each vendor's out-of-the-box capabilities may vary requiring more advanced customizations or support.

CFX may leverage existing resources and testing efforts undertaken to date. FDOT District Five, for their I-75 Florida's Regional Advanced Mobility Elements (FRAME) project, conducted extensive interoperability testing in a lab and field environment and has published their documentation, available HERE. In October 2020, FDOT District One conducted multiple device testing for a 12-week period in preparation for their US 41 FRAME project. The purpose of testing the devices is to evaluate device functionality (full system

capabilities and reporting functionality) for the use case intended. Often, vendors rely on agencies such as CFX to provide input on what technologies are of interest to them. This drives vendor direction, innovation and contributes to competitive technological edge. Similarly, vendors refer to testing documentation as a mechanism for improving their capabilities.

CFX may use the Seminole County CV lab resources made available by FDOT District Five in partnership with Seminole County Government. In addition to physical testing efforts, vendors welcome opportunities to provide online demonstrations of recent device upgrades. CFX is strongly encouraged to take advantage of these resources to have first-hand knowledge of available technologies and to stay abreast of upcoming advancements.

CFX has identified the following as operational/mobility, safety and maintenance needs, many of which may be solved by using available connected vehicle technology and/or data collection and retention strategies as shown in **Table 14**, below.

Table 14: Operational/Mobility, Safety and Maintenance Needs

Operational/Mobility	Safety	Maintenance
Alleviate congestion along the mainline and at the ramps to reduce incidents and improve travel times, improving access for emergency vehicles	Eliminate incidents related to: • Wrong way driving • Work zone safety • Curves • Secondary Crashes • Sideswipes • Wet pavements • Distracted driving	Dissemination of timely road quality information to maintenance personnel
Improve communications around active construction zones	Reduce Speeding	Improve equipment and tolling facilities security
Improve tolling efficiencies and promote use of electronic payment at parking facilities	Increase awareness of hazardous conditions	Increase visibility of maintenance of traffic equipment
Predict travel times		Asset management for underground infrastructure
Develop strategies to better leverage FEMA alerts		Facilitate collection of maintenance data for reporting
Enhance reporting needs, optimize data reporting and improving performance measures reporting		Improve data storage organization and space
Enhance customer service needs		
Enhance data/technology distribution needs, increase data sharing, create data storage, improve data reliability, enhance data and systems cybersecurity		
Coordinate technology deployment with surrounding agencies		
Optimize incident response times		
Reduce crash clearance times		
Tolling with CV		

As a visionary and a leader in the transportation industry, CFX strives to explore and plan for the delivery of cutting edge and emerging technologies to serve the needs of its customers. A roadmap with the identification and prioritization of foundational needs are discussed in this section. Many of these desired operational needs or reduction/mitigation of incidents are achievable by using CAV devices and applications to optimize operations and mobility or to detect and provide advanced warnings to motorists as traveler information messages. **Tables 15** and **16** on the following page define these focus areas.

Table 15: CAV Operations/Mobility Focus Areas

Operational/ Mobility Focus Areas	CAV Applications
Traffic Management/Traffic Network	• Advanced Traveler Information Systems • Vehicle Data for Traffic Operations, Planning and Performance Monitoring • Speed Harmonization (SPD-HARM)
Traveler Information	• Vehicle Data for Traffic Operations • In-Vehicle Signage • Traveler Information Messages (TIM)
Tolling Methods	• Electronic Toll Collection • Congestion Pricing/Variable Tolls
Incident Response Times/Incident Management	• Incident Scene Pre-Arrival Staging Guidance for Emergency Responders (RESP-STG) • Advanced Automatic Crash Notification Relay (EVAC) • Road Weather Information for Maintenance and Fleet Management • Road Weather Information and Routing Support for Emergency Responders

Table 16: CAV Safety Focus Area

Safety Focus Area	CAV Applications
Roadway Safety	• Queue Warning (Q-WARN) • End of Ramp Deceleration • Curve Speed Warning (CSW) • Wrong Way Driving (WWD) • Wrong Way Entry (WWE)
Work Zones	• V2V Safety Applications • Upcoming Work Zone Advisories; Hazards in a Work Zone • Reduced Speed Zone Warning/Lane Closure
Road Weather	• Spot Weather Impact Warning (SWIW) • Road Weather Motorist Alert and Warning (MAW) • Variable Speed Limits for Weather-Response Traffic Management (WxTINFO)

4.3.7. Business Policy and Outreach Considerations

As part of the development of a roadmap for CAV implementation, several foundational needs and existing policy updates are suggested for CFX's CAV deployment readiness. **Table 17**, on the following page, identifies some of these needs.

Table 17: Business Needs and Outreach Considerations

Focus Area	Description of Needs
Policies	▪ Update existing manuals, policies and procedures for the development and future support of CFX's CAV program (beyond budget planning). ▪ Consider the various stages of project development from project planning, testing, deployment, operations and maintenance ▪ Consider Short-Term, Mid-Term, and Long-Term deployments ▪ Evaluate the Regional ITS Architecture (RITSA) and develop a Concept of Operations document ▪ Develop funding strategies to support on-going technology advancements and the growth of CAV applications and solutions
Infrastructure	▪ Plan to deploy CAV infrastructure knowing that the industry is headed toward the implementation of these technologies ▪ Plan to stay abreast of advancement and deployment of new and improved technologies ▪ Prepare and implement a robust network, data environment and communication infrastructure to support the growing demands of CAV applications
Security	▪ Expand and implement cyber- security solutions and data management/data sharing strategies
Workforce/Staffing	▪ Identify staffing and skillset capabilities and/or gaps needed to deploy a successful CAV program ▪ Provide staff training and leadership opportunities
Outreach and Stakeholder Partnerships	▪ Identify stakeholders to provide input to CFX's existing CAV goals, to collaborate on existing and surrounding deployments and system upgrades, to share lessons learned and to collaborate on data sharing ▪ Consider the Metropolitan Planning Organization (MPO) in area ▪ Consider academia and their roles to support CFX ▪ Plan to share data with other agencies ▪ Involve the automobile industry and other private organizations ▪ Consider multi-modalism and the application of evolving technologies to fit into an efficient and equitable transportation system
Professional Participation	▪ Deploy a plan to stay abreast of quickly evolving technological advancements by participating in webinars, reviewing documentation provided by FHWA and the USDOT

4.3.8. Regulatory Requirements – Federal Communications Commission (FCC)

For almost 20 years, the USDOT, automakers, equipment vendors, transportation safety advocates, and Infrastructure Owners and Operators (IOOs) have been evaluating, planning for, and deploying V2X equipment to enable a broad connected vehicle environment that improves safety and mobility in transportation. The FCC set aside 75 MHz of wireless spectrum in the 5.9 GHz band specifically for this purpose and Dedicated Short Range Communication (DSRC) systems (hardware and standards) were developed to operate in this band.

In 2015, the USDOT contracted for the deployment of three pilot projects requiring matching funds from the local agencies to take connected vehicle technology from the development stage to practical, sustainable deployment using the DSRC technology. These pilots demonstrated interoperability and integrated the security management system, both of which are essential to the deployment of this technology.

With the initiation of the Signal Phase and Timing (SPaT) Challenge in 2016, deployments grew rapidly. IOOs and other transportation stakeholders recognized the long-term potential of V2X communication for safety and improved mobility and desired to move the technology forward. An automaker deployed the technology on one of their vehicle models, and others made public statements that they were considering deployment. Additionally, in 2016 NHTSA issued a NPRM proposing to mandate V2V communication with DSRC or "alternate interoperable technologies". While the NPRM was not advanced to a rule, these events provided additional incentive for IOOs to prepare for a connected vehicle ecosystem.

In 2017, a second 5.9 GHz communication technology was standardized at the radio level, Cellular Vehicle-to-Everything (C-V2X). C-V2X has two components: C-V2X Direct (also known as C-V2X (PC5)) which is a short-range equivalent of DSRC, and C-V2X Network (also known as C-V2X(Uu)) which employs the cellular network. In this document, C-V2X Direct is the referenced component unless otherwise stated. Although both DSRC and C-V2X use the same spectrum and message applications and have identical goals, the two technologies are not interoperable. A national debate ensued over whether one or both of these technologies should be adopted. The USDOT took a neutral stance on this issue. Simultaneously, the cable industry and some in the wireless industry lobbied the FCC to open up additional spectrum for Wi-Fi use, and the FCC and other stakeholders continued to consider proposals for sharing some of the 5.9GHz spectrum with unlicensed Wi-Fi. Testing of various sharing schemes ensued. Transportation safety advocates strongly opposed efforts that would cause harmful interference to V2X applications.

In November 2020, these issues came to a head; the FCC Commissioners voted approval for a Report and Order (R&O) to allow unlicensed operations use the lower 45 MHz of the 5.9 GHz band, require all DSRC operations to temporarily move into the upper 30 MHz by July 2, 2022, and to formalize the use of C-V2X in the upper 30 MHz. Formal promulgation of this initial FCC Report and Order[9] (hereafter called the first R&O) on use of the 5.850-5.925 GHz Band was triggered on May 3, 2021, when it was published in the Federal Register. The rules become binding on July 2, 2021, 60 days after publication. Additionally on May 3, 2021, the FCC offered a Further Notice of Proposed Rulemaking (FNPRM)[10] (which will result in a second R&O, and hereafter referred to as the second R&O) which, among other things, calls for the eventual sunsetting of DSRC in favor of C-V2X.

For the IOOs who have deployed DSRC systems, these recent FCC decisions have raised a number of questions about how these actions impact existing and proposed deployments. Two NCHRP 23-10 documents[11] (one released in March 2020 and another in March 2021) provide significant background on the FCC actions.

As a part of the RSU deployment and licensing process, FCC coordinates with the National Telecommunication and Information Administration (NTIA), which is responsible for managing the federal

[9] https://www.federalregister.gov/documents/2021/05/03/2021-08802/use-of-the-5850-5925-ghz-band
[10] https://www.federalregister.gov/documents/2021/05/03/2021-08801/use-of-the-5850-5925-ghz-band
[11] https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4902

use of spectrum. Obtaining a license to turn on and evaluate the RSE of a CV pilot is required if operating in the licensed 30 MHz of the spectrum allocation. Signal transmission interference would contribute to safety concerns for both the CV deployment operations and nearby airports. CFX will continue to coordinate with the FCC for licensing as required for CV deployments.

4.3.9. Security Credential Management System (SCMS)

Although CFX has its cybersecurity plans and systems in place from a network hardening perspective, device security and data management is another consideration. Security for CV devices uses the Institute of Electrical and Electronics Engineers (IEEE) standards and security called SCMS to validate and secure the communication and transmittal of data between RSUs and OBUs. The SCMS system uses a Public Key Infrastructure (PKI) approach which uses a combination of encryption and digital certificate management methods to assist in secured communication within the CV environment. Systems and data hacking are real-world problems of familiarity and users must feel secure in knowing that security is in place to ensure the data transmittal remains confidential and authenticated.

SCMS is being offered as a service to agencies looking to deploy CV technology. There are three (3) primary vendors that have developed a PKI infrastructure to offer this service; INTEGRITY Security Services (ISS), Escript and 7 Layers. FDOT has selected the services of ISS for their statewide SCMS solutions and platform. At the time of deployment, CFX will work with the selected agency for enrolling their devices. To ensure interoperability and statewide consistency, CFX may consider following the FDOT SCMS vendor solution. From the FDOT perspective, they have formulated an SCMS onboarding workflow and stepped process that provides the guidance and points of contact. This may be used as guidance by CFX as they plan and structure their road mapping guidance documentation.

Figures 30 and 31 on the following page, provide illustrations of SCMS communication between devices and an adopted SMCS onboarding workflow 7-step process which CFX may use as guidance toward the development of their process.

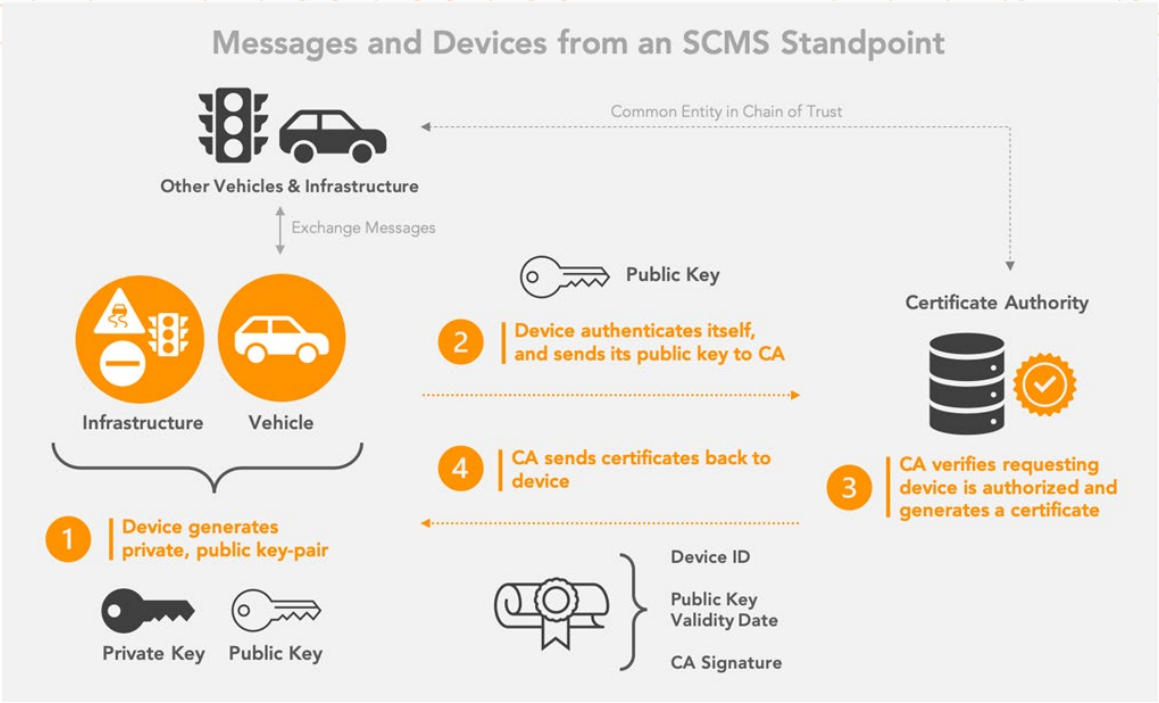

Figure 30: USDOT Illustration of SCMS Communication between Devices

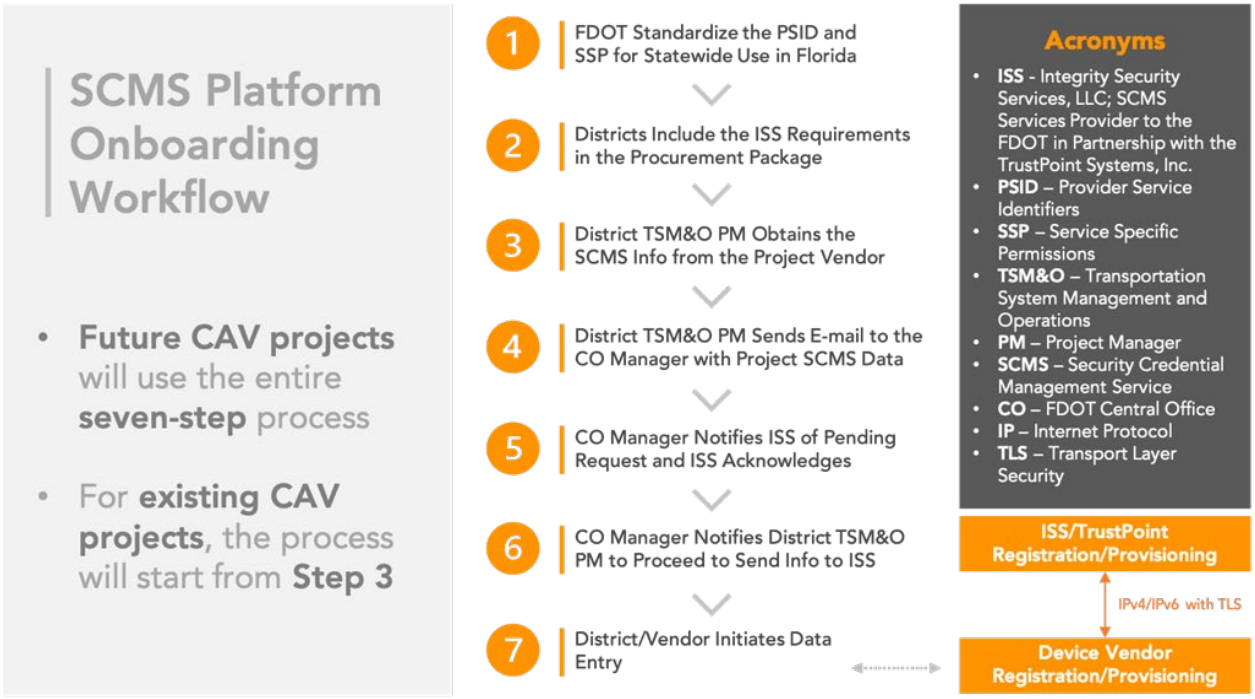

Figure 31: USDOT Illustration of SCMS Communication between Devices

4.3.10. Device Procurement

Industry concerns regarding the device procurement process have surfaced as a challenging topic. This may be due to limitations with experience with procuring connected vehicle devices. Additional consideration for the procurement of vendor support is critical to be defined in contractual services agreements. The following provide some key considerations as CFX plans to procure devices to support the CAV program:

- Documentation of compliance with Standards for device interoperability
    - Mechanical, electrical, and environmental specifications
    - Inclusion of wireless and Ethernet interfaces as specified in the USDOT RSU 4.1 Specifications
    - FCC requirements for RSUs and antennas
    - OmniAir Certification
- Device kit inclusions (connection cables, power supplies, antennas/GPS connectors, mounting hardware, etc.)
- Device pre-configuration requirements needed to support use case
- Platform compatibility to work within CFX's infrastructure
- Software and graphical user interface (GUI) requirements for device central management, configuration, system logging and management of alerts
- Support and warranty services
    - Firmware/software device updates, and frequencies
    - Subscription based software requirements
    - Training material and guidance documents
    - On-the-job hands-on device training

4.3.11. Geographic Information System

CFX and the regional partners continue to prepare to accommodate an ever-increasing influx of geospatial data, underlying the need for a comprehensive approach to GIS data.

GIS data can be generalized into two categories: Reference data and location data. Reference GIS data are datasets that form the basis for analysis. This includes datasets such as base maps, work program, and land use to name a few. GIS location data refers to any data that contains a location component. Examples include infrastructure and sensors real time data, CAV data, and asset management data.

This data can serve as one of the foundational elements for various types of initiatives, from dashboarding and planning to big data and machine learning efforts. Thus, the accuracy and portability of this GIS data becomes highly critical. The accuracy and portability, or ability to integrate with other datasets and systems, will provide internal and external partners the ability to integrate GIS data into their systems and processes.

GIS data portability is the key to unlocking future uses, not only of geospatial data, but other ancillary data sources. The use of other data sources such as INRIX®, HERE®, WAZE® or integration into systems such as R-ICMS, requires that the relationship between these and GIS data sources be defined. This could require

refinement to existing GIS data source indexes and segmentation and will require continued effort as new data sources are created, identified, and integrated to the CFX data ecosystem.

A recommendation to enable GIS data portability is defining the GIS data to be system-agnostic. This allows external stakeholders the ability to use the CFX data in different technology platforms as well as allows CFX to implement tools and processes using alternate GIS platforms. Portable and system-agnostic GIS data also creates the ability for an easier transition to other GIS platforms should CFX ever desire that. As such, care should be taken to avoid, or minimize where possible, implementation of proprietary datasets.

Generally speaking, GIS can be a node of a larger CFX data architecture and should be thoroughly assessed to ensure full support for existing and future needs. Thus, the data considerations, as defined in the Transportation and Technology Needs - Section 4.3.16 Data Considerations of the CFX ITS Master Plan, are largely directly applicable to GIS data. Data needs associated with availability, security, networking, business intelligence, and retention are integral to the continued success of GIS solutions and defined in the CFX ITS Master Plan. There are unique characters to GIS data, and these would be identified and defined in a comprehensive data needs assessment as recommended on Existing and Known Data Needs strategy ED-28 – Perform a detailed data need study.

The data needs study will provide a framework for identifying the essential metadata, data format for storage, strategies for hot and cold data storage for each GIS dataset within the CFX Data Architecture. It will also provide the venue through which duplicated data sources are identified, data structure is standardized, necessary processes and tools for disseminating data are identified, and data stewardship is determined minimizing data duplication. The CFX data needs assessment is recommended and will also provide an opportunity to assess the progress and integrate the CFX GIS Roadmap into the CFX ITS Master Plan. The recommended architecture based on the assessment will be designed with long term implementation in mind and will include an infrastructure for a big data environment. It is important to consider future enhancements into the architecture to ensure that as these systems are needed or become available the overall consideration and workflow has already been included. **Figure 32,** on the following page, represents the recommended CFX ArcGIS Roadmap workflow, which was published by CFX in 2019.

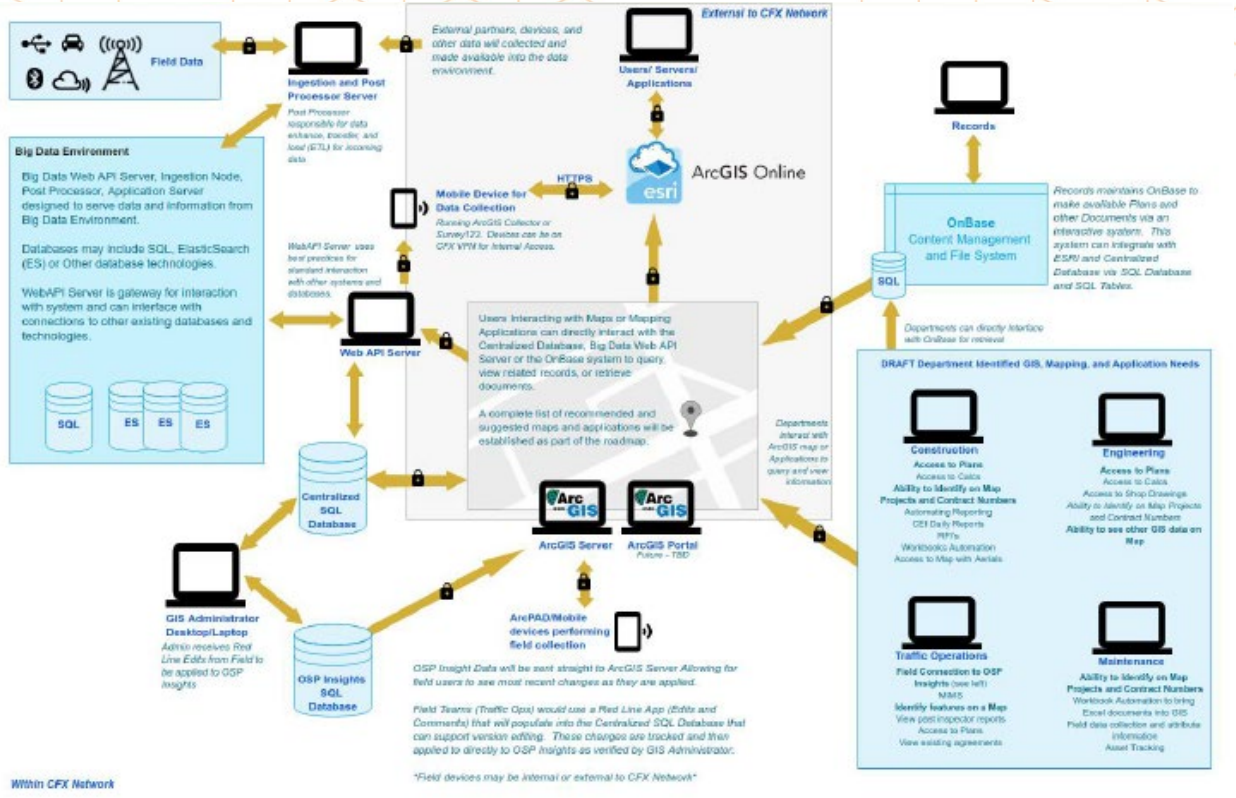

Figure 32: Recommended CFX ArcGIS Roadmap Workflow

4.3.12. Telematics

Telecommunications and availability of data positively impact business operations in the transportation industry. Mobility and fleet leaders are embracing telematics technology to obtain insight from OEM sources (connected vehicles) to help transform their existing operations. From basic safety message (BSM) data received for example, from OBU to RSU, information related to rapid acceleration or hard braking, vehicle location, are just some fleet information that may be obtained that either provides more visibility into roadway operations/roadway conditions or to help identify at-risk drivers - all data (existing real-time or historical) may be used to increase safety, minimize fuel waste and operating expenses.

4.3.13. ITS and Technological Strategies

For CFX to achieve their vision of being a world class leader in mobility, there are a few technological enhancements that would need to be considered. Infrastructure enhancements, storage capacity and needs, cloud readiness and data management must be planned. Fortunately, due to CFX's forward thinking and preparedness, there are only a few technological items needed to be addressed within the existing infrastructure. The considerations and recommendations below will ensure CFX achieves its goals and is prepared for CAV and other future technologies.

The identification of applicable ITS and technological strategies are derived from an evaluation of existing conditions, agency needs and available technologies. This section identifies the needs of the elements outlined in Section 3.

4.3.14. Infrastructure and Hardware

As it stands today, CFX Infrastructure has been prepared to support and handle most future technologies. It's carrier grade switches and network upgrades made within the last year have enhanced the network's resilience, redundancy and performance. In the near future, CFX will need to replace its core routers due to the age and vendor support. CFX will need to deploy a suitable replacement that is equivalent to the existing solution to handle the data, multicast streams, and compute power needed to support this infrastructure. In considering CAV, there may be a need to utilize additional virtual servers to support CAV applications once CFX decides which applications to deploy.

Additionally, consideration needs to be given for the CV equipment once CFX has decided on a vendor. Roadside equipment/units (RSU) will be mounted on the CCTV poles at each local hub in the field and connected to the local layer 2 switch. Depending on the CV solution, an IVP hub and industrial computer (IC) may also be installed at the local hub locations. CFX Is currently utilizing 1Gb connections at the local hubs and 10G from plaza locations back to the data center and therefore does not need to upgrade their network hardware at this time.

4.3.15. Storage

While CFX has a scalable storage platform, much consideration for storage capacity will be needed as they approach a CV solution. CFX must consider whether it will collaborate with its partner agencies to collect and store data or if the agency will identify a storage solution independent of its partners. There are many factors that come into play when attempting to determine the storage needs for CV solutions. Storage capacity needs can range from a few hundred terabytes to a few petabytes based on the solution, data collection and data retention requirements. To err on the side of caution, CFX should estimate the need for future storage based on its most stringent data requirements while taking into consideration the existing system and provide recommendations.

4.3.16. Cloud-Ready Needs

In the start of 2021, CFX IT began preparing for a cloud-based environment. CFX ITS has the ability to take full advantage of the existing environment, however, there are a number of things to first consider. CFX ITS would need to consider which services would be right to operate in the cloud. Since most of CFX ITS's business functions require communication to field devices and roadway users, there Is no need to migrate any of those functions to the cloud nor would it be cost feasible. However, as CFX ITS continues to plan for CAV operations, big data and CV applications become increasingly necessary to operate. In planning, CFX would need to consider the following:

- The type of data to be stored
- Data Retention periods
- Frequency of accessing the data
- How much data will be stored
- The Type of applications or services to cloud-host
- Determine the location of the applications and the database
- Determine the bandwidth requirements between on-premises servers and cloud-services

Due to existing preparation, CFX ITS is currently cloud ready. Once CFX ITS determines the desired servers, web apps and services to deploy, a coordinated effort between ITS and IT staff would need to take place to work through the logistics.

4.3.17. Data Considerations

Over the last 22 years CFX has adopted an ITS Master Plan that has guided the implementation of multiple technologies to serve its customers and the community. By adopting and implementing TSM&O strategies and the deployment of ITS, CFX has accomplished technology and data advancements including the use of dedicated software such as SunGuide®, the use of ATMS, development and adoption of multiple TSM&O strategies, and the use of proprietary data such as INRIX®, HERE®, WAZE®.

More recently, CFX and the region are preparing to accommodate increased CAV penetration and to adopt dynamic technologies such as V2I, V2V, V2X, and RSUs for data and information exchange with OBUs and connected vehicles that use real time data to support the proactive management of the road network. These technology transformations will continue to increase data generation and volume, handling, maintenance needs, technology infrastructure needs, and data policies to address evolving data sets and needs.

Existing conditions of the CFX data and technology implementation were discussed in Section 3. This section will discuss anticipated data needs that can guide CFX for the upcoming phase of the transportation industry's technological evolution focusing on maintaining, and leveraging prior investments made in the technology and data and identifying areas for improvement and growth.

4.3.18. Description of Data Needs Categories

The CFX data needs will be presented in 5 categories:

- Infrastructure Assessment (IA)
- Existing and Known Data Needs (ED)
- Potential Future Data Needs (FD)
- Data Policy and Governance (PG)
- Data Maintenance (MT)

4.3.19. Infrastructure Assessment (IA)

As data volume grows and the management of the road network becomes more dynamic and adaptive to existing traffic conditions based on real time data, using adequate infrastructure and software development technologies is recommended to minimize impacts due to data latency delays. Identifying the infrastructure needs assessment to receive, connect, disseminate, or discard these data sets will support the dynamic data integration. **Table 18**, on the following page, references the Extraction Transformation and Load (ETL) process as a method of moving data from various sources into a destination data store. The ETL process facilitates data extraction, transformation and data loading processes and is identified as a recommended data need for consideration.

The following are the identified infrastructure needs anticipated for the increasing volume of data.

Table 18: Infrastructure Assessment Data Needs

Category	Data Need	Recommendations
IA-1	Improve data storage organization and space	▪ Perform existing data storage assessment and project growth for short (1 to 3 years) and mid (3 to 5 years) terms
IA-2	Expand the ITS IT infrastructure by creating a big data store augmenting the existing IT environment and data governance	▪ Create a big data store with hybrid infrastructure (hardware and virtualized components). Evaluate if data storage with universities is an alternative
IA-3	Network speed adequate to handle large volumes of data influx and dissemination	▪ Revisit existing network infrastructure with the goal of achieving the demand of a big data platform. Coordinate activity with the CFX IT group.
IA-4	Determine big data store needed nodes based on data and operational characteristics	▪ Evaluate existing infrastructure and use and identify what can be re-used or expanded as well as what needed nodes will need to be created
IA-5	Review of skillsets and identify training needs	▪ Assess IT and software development skillsets of CFX and Consulting staff to interact with a big data store environment
IA-6	Evaluate how to offload Extraction Transformation and Load (ETL) and other resource-intensive data preparation tasks	▪ Automate and standardize data ingestion, collection, and ETL processes to achieve better speed and consistency
IA-7	Identify the format data will be stored - Raw versus processed	▪ Identify the format data will be stored (JSON, XML, CSV, etc.). Raw data versus processed data based on cost and future data use/needs
IA-8	Minimize downtime of data availability and protect data integrity	▪ Have data storage redundancy

4.3.20. Existing and Known Data (ED)

CFX has existing and known data needs as a part of their current business model, through planned infrastructure deployments, and regional CAV collaborative efforts. Additionally, as TSM&O strategies are considered for improvement alternatives, the data needed to make these evaluations and assessments must also be considered. The following are the identified existing and known data needs per stakeholder interviews and review of other CFX studies and documents. Stakeholder interviews were conducted during the mid-year 2020. It is important to note that since this timeframe, some of the identified conditions, below, may have been accomplished.

Table 19: Existing and Known Data Needs

Category	Data Need	Recommendations
ED-1	Review data insights/lessons learned and existing data inventory	Review data insights or lessons learned to date. Review existing data inventory and determine environment placement, ETL, data maintenance, data growth ratio for each dataset
ED-2	Automate data visualization, reporting and Business Intelligence (BI) processes	Automate data visualization, reporting and BI processes. Will be beneficial for performance measures
ED-3	Minimize data duplication, identify new data needs, identify data standards for data exchange	Evaluate data needs, data changes, data standards, and other data related activities and actions needed to be taken internally at CFX and with select external key stakeholders
ED-4	Automate auditing and calibration of tolling equipment per lane	Automate validation of comparison between historical and current data.
ED-5	Use tolling data to evaluate vendor equipment performance and minimize revenue loss	Develop a program that can evaluates system performance based on tolling collection.
ED-6	Use data of existing deployments to support multiple internal processes such as asset management, planning, machine learning and prioritization of new deployments, alignment of deployments with surrounding facilities owned by CFX or by other partnering agencies	Enhance existing GIS (ESRI/Open-Source Platform) that represents deployment of ITS devices and fiber enabling the data visualization of status of the ITS system, creation of "what if scenarios" Use machine learning and deep learning to support predictive analysis. CFX's Traffic Operations maintains their GIS database to include their existing devices and fiber optic network and are expanding the process to include additional group and asset management.
ED-7	**Utilize real time data for:** 1. Wrong way detection and alerts 2. Improving safety in work zones (smart work zones) 3. Congestion Management 4. Emergency Evacuation	Consider emerging technologies to detect and alert about events of wrong way driving on the main line in addition to existing ramp detection systems. Real time data may be used to support smart work zones. Use existing Visual Surveillance equipment to extract real time traffic conditions and support congestion management and early incident detection programmatically Use real-time data for loading into existing systems and processes to support emergency evacuation procedures

Category	Data Need	Recommendations
ED-8	**Collect data programmatically for:** 1. Toll collection in construction zones 2. Identification of hazardous areas (real-time and historic) 3. Operational and safety data for ramps and arterials 4. Identification of incidents sooner	Investigate technologies that can actively collect and provide data for ramp metering. During the mid-year 2020, CFX's main source of their programmatic data was from roadside ITS devices including sensors, CCTV and their WWD system. Additionally, several data processes were accomplished from travel time, work zone data and analysis of traffic volumes/speed data.
ED-9	**Enhance data quality for:** 1. Improved Florida Transportation Commission (FTC) metrics 2. Data reliability for long-erm planning 3. Collaborative data sharing between public and private partnerships	
ED-10	Share data to support research and development of facility sustainability projects, evaluation of major land use changes, and implementation of emerging technologies	Create data dissemination mechanisms for existing CFX data OR use existing data stores (i.e., SunStore or V2X) to support researching by universities and other entities. Use data to support forecasting volumes. Relatably, CFX was completing their Sustainability Report in 2019.
ED-11	Perform a detailed data need study	Perform a comprehensive overview of existing and potential future datasets, sizes, use cases and associated data decisions such as policy, environment and maintenance needs

4.3.21. Potential Future Data Needs (FD)

Potential future data needs have been identified based on high level needs assessment. Many of these data needs may originate for data sets that will be available from future CAV fleets, and methods of identifying and determining the use of those would be considered part of the Data Policy and Governance needs. **Table 20,** on the following page identifies data needs for this category.

Table 20: Potential Future Data Needs

Category	Data Need	Recommendations
FD-1	Create a self-service capability for the data lake users	Create data dissemination mechanisms that attend technical and non-technical users of both internal CFS users and external stakeholders' users.
FD-2	Vehicle or user specific representation of real time system utilization and evaluate overall sentiment of facilities users	Evaluate applicability of potential data from individual CAVs and nontraditional data sources (such as social media) as part of the overall data solution for CFX.
FD-3	Adopt programmatic methods to identify assets and asset conditions	Use nontraditional data such as LiDAR and video data to programmatically collect assets and extract features for identification of asset condition
FD-4	Access to accurate real time conditions, analytics of the system despite level of congestion	Maximize the use of data from deployed technology to generate real time data
FD-5	Use data from systems that add redundancy to maximize effectiveness of tolling equipment by lane	Use emerging technologies such as computer vision to create redundancy of data collection for equipment calibration per lane
FD-6	Access to real time data for -Brightline operating within or adjacent to CFX right of way	
FD-7	Automatic Tolled Lane data from Bus Rapid Transit initiatives that will use CFX facilities	

4.3.22. Data Policy and Governance (PG)

A data driven organization needs data policies and governance in place to support decision making. The data governance procedures identified by data policies are recommended to include the entire data cycle: from collection, to maintenance, and to storage or disposal. Data governance is a key component in any enterprise data management strategy and will guide how organizational data is managed and protected as an asset. The establishment of policies, roles and processes are part of a data governance structure which creates a comprehensive roadmap for an organization's use of data. **Table 21** below, shows the recommended high-level data policy and governance needs.

Table 21: Data Policy and Governance Data Needs

Category	Data Need	Recommendations
PG-1	Refine the data ingested: Create standards, metadata, and data dictionaries, define ETL for data integration.	Refine the data as soon as possible establishing data preparation steps for enrichment, transformation, and improvement of data quality and consistency.

Category	Data Need	Recommendations
PG-2	Determine big data lake architecture - centralized or not	Determine the purpose of the data lake early to guide how the architecture of data access will be (centralized or not)
PG-3	Define data management tools	Define data management tools to support environment management and create a data recovery strategy
PG-4	Establish a data governance for the data store	Develop and establish data governance
PG-5	Parallelize data solutions using the data from the data lake	Data solutions built using the data from the data lake must parallelize processing and take advantage of distributed computing from the data store
PG-6	Access to other agencies data sources (video feeds from arterials as example)	Develop a data workflow model to determine how to consume and disseminate data - Unified payment system, Transit data, FDOT V2X platform, etc.
PG-7	Develop data governance for video management system	Data governance to video management system to include revisiting operators' procedures to handle video cameras. Document rotation times and duration, establish procedure to return to "home" position after using camera videos for surveillance or incident response.
PG-8	Establish a process to handle raw data	Develop ETL procedures focused on CFX needs to ensure data quality
PG-9	Create minimum standards for automated data exchange between multi agency systems	
PG-10	Identify data standards to enable V2X and I2V	
PG-11	Identify a plan to periodically evaluate changing technologies	Develop a plan on how to keep-up with technologies to understand best practices, etc.

4.3.23. Maintenance Data (MT)

As a data driven organization, maintenance best practices and procedures are recommended for CFX to establish for existing and anticipated data sets. Having clean and reliable data will support CFX develop insights, enable data integration strategies, and allow for automation of processes. **Table 22,** below, identifies the recommended high-level data maintenance considerations and needs.

Table 22: Maintenance Data Needs

Category	Data Need	Recommendations
MT-1	Identify CFX data goals for the ITS / TSM&O group	Knowing the data goals will provide clarity of how data should be collected and maintained to reduce data duplication.

Category	Data Need	Recommendations
MT-2	Determine cybersecurity parameters for data store	Perform a penetration study to the data store to evaluate gaps, breach and develop recommendations and prioritize data protection and security
MT-3	Create data, environment, and security maintenance workflows	Create data governance workflow focusing on data quality
MT-4	Establish benchmarks and automate reporting of big data store performance	Establish benchmarks for data store and run periodic reports to evaluate availability, efficiency, and growth ration
MT-5	Define data lake indexes	Define data lake indexes

4.3.24. Summary of Data Needs

Table 23, below, is intended to be used as a reference of the overall high-level and big picture needs for each of the identified core areas. The details to describe each of the needs and their use cases are available for review in the previous sections.

Table 23: Summary of Identified Technology and Data Needs

Core Areas	Summary of Data Needs by Core Area
Network and Roadway Infrastructure	▪ Network and device security ▪ Planning for additional transportation technology advancements ▪ Hardware and Storage
CAV	▪ Evaluation and use of applicable CAV applications ▪ Regulatory requirements (FCC, SCMS) ▪ Device testing ▪ Devices needed to support a CV Pilot ▪ Device Procurement considerations
Policy Updates	▪ Future planning and documentation updates ▪ Evaluation and use of applicable CAV applications ▪ Stakeholder and data sharing partnerships ▪ Workforce and skillsets ▪ Professional development and continued education
Data	▪ Data collection, storage and sharing ▪ Data formats ▪ Data reliability and security ▪ Machine learning ▪ Automated reporting ▪ Data management tools ▪ Data policy and governance ▪ Data maintenance

4.4. Sustainability Needs

Sustainable transport systems make a positive contribution to the environmental, social and economic sustainability of society and the communities they serve. One of CFX's primary Goals and Objectives identified in this Master Plan is Goal 5 - Proactively take Measures to Sustain Our Environment, Objective 5.1 - Improve sustainability throughout CFX's infrastructure. By providing a sustainable transportation network, CFX is contributing to sustainability on both a global and local level by providing long term stability of the earth's environment and availability of resources to support human activities as well as positively impacting environmental pollution.

CFX is entering the first phase of a multi-year program to identify and explore beneficial projects that can increase sustainability throughout its roadways, facilities, and properties. These projects include performing additional research and implementing technologies such as photovoltaics (PVs), electric vehicle charging stations and electric vehicles. CFX conducted a study to evaluate the viability of several sustainability solutions for the CFX infrastructure and system. The sustainability study provided an assessment of the systems, costs, risks, and benefits associated with each option, the required equipment, and the recommended locations.

Based on this study, six sustainability projects implementing photovoltaics (PVs) and renewable energy sources to the system were identified in the 2022-2026 Work Plan with one project currently underway. This project was identified as a design-build project which will implement elevated PVs at the Hiawassee Mainline Plaza. This study can be referenced in the Appendix.

4.5. Regional Partner Needs

CFX is responsible for the construction, maintenance and operation of a limited-access expressway system that serves a region with more than 3 million residents in five counties, plus an estimated 75 million visitors each year. On average, more than 1 million toll transactions are recorded every day, and more than 80% occur electronically. Due to the size and scope of the CFX system, numerous regional partners exist and are important to the success of the CFX system as well as the Central Florida transportation system as a whole. The following discusses project stakeholder needs that were identified throughout stakeholder coordination.

4.5.1. Project Stakeholders

In the past, ITS technologies have been segregated between arterial and freeway application, but with the initiation of the TSM&O program and its goal of intertwining operations between the arterials and freeways, ITS technologies are blending together their fields of application. For this reason, individual one on one meetings with each stakeholder took place to discuss both current and future needs. The importance of ITS and upcoming CAV technology demands were among the topics discussed. The stakeholders identified needs as they relate to CFX.

4.5.2. MetroPlan

The following are the needs identified by MetroPlan Orlando. CFX should note where cooperation and coordination with these needs are appropriate:

I. MetroPlan Orlando's ITS Master Plan - MetroPlan Orlando is currently reviewing the priority project list to confirm the projects are still relevant as they weigh in on new technologies and other updates since the plan was created.
II. Submitted for a grant (ITS for Us) for a single payer system for underserved communities
III. Connected Automated Vehicles - MetroPlan Orlando completed a CAV readiness study.
IV. Data Storage/Sharing and recommendations
    1. Coordinating with FDOT
    2. Data Sharing
        a. Possible coordination with FDOT to house data
        b. MetroPlan Orlando looking into policies to implement monetization of the data
V. Pilot projects collaboration – MetroPlan Orlando is continuing to identify new technologies to test with the key goal in mind to ensure interoperability

4.5.3. FDOT District 5

The following are the needs identified by FDOT District 5. CFX should note where cooperation and coordination with these needs are appropriate:

I. The following Central Florida Regional Integrated Corridor Management System (R-ICMS) needs were identified:
    1. Base mapping updates
    2. Advanced Traffic Controllers (ATC)
    3. ComputerVision/Gridsmart
    4. Data format and sharing
    5. Maintenance Asset Management coordination with CFX and development of Memorandum of Understanding (MOU)
    6. Identifying permissions with CFX
II. Connected vehicles:
    1. Security Credential Management System (SCMS) compatibility over time
III. Long-term Data Collection:
    1. Data Integration and Video Aggregation System (DIVAS)
    2. Integrated Corridor Management (ICM)
    3. Automated Traffic Signal Performance Measures (ATSPM)
    4. Connected Vehicles
    5. Asset Management - Maintenance Inventory Management System and Intelligent Transportation System Facilities Management (ITSFM) for Signals
    6. Express Lanes – Traffic Incident Management (TIM) response plans.
IV. Part-Time Shoulder Use (PTSU) - CFX is currently implementing and coordinating along SR 417 and 429. SR 528 is a potential ESU corridor for evacuation events but requires pinch point resolution through bridge widening.
V. Coordination and operations with Brightline
VI. Multi-modal trip planning engine in development
VII. Communication redundancy for expansion of CFX overall system and security/cyber security readiness.

4.5.4. FDOT Turnpike

The following are the needs identified by the Florida Turnpike Enterprise (FTE). CFX should note where cooperation and coordination with these needs are appropriate:

I. Connected Vehicles - This includes data storage needs, security of infrastructure, cybersecurity of future data, and processing of data.
II. Road Rangers – As it exists today there are two separate contracts for the Road Rangers on CFX and FDOT TPK.
III. Wrong Way Driving - FTE and CFX each manage and operate their own instance of BlinkLink. Each agency manages deployments along shared corridors on SR 417. Consideration for consolidation is applicable.
IV. Events Coordination - SR 429 SB at MP 8, approaching I-4, backs up onto SR 429 due to Disney events.
V. End of Queue Warning Systems - Coordination with Queue Warning Systems. Several Turnpike interchanges have backups daily that involve rear-end crashes with long queues.
VI. Regional Fiber Sharing - Continued support and collaboration for expansion with expected growth in the future.

4.5.5. City of Orlando

The following are the needs identified by the City of Orlando. CFX should note where cooperation and coordination with these needs are appropriate:

I. Automated Traffic Signal Performance Measures (ATSPM) Detection and implementation
    1. Need to change out controllers to ATC.
    2. Cabinets to be upgraded to Type VI.
II. Asset maintenance software - The City of Orlando expressed interest in the Maintenance Inventory Management System (MIMS). This could then be tied into CFX as CFX currently utilizes the MIMS System.
III. Parking solutions for venue and event planning which involve extending E-Pass parking for venue applications and streamlining payment process with E-Pass.
IV. Integrated Transportation Application Strategy – Continued coordination and collaboration for the development of multi-modal trip planning engine. The concept aligns well with the need for a City-developed user interface and allows for the processing of single or multimodal trips. This trip engine can support front-end mobility and wayfinding applications with real time mobility information.
V. Smart Parking and Operations Strategy - Integrate smart parking technology into more infrastructure (i.e., parking garages and lots, parking rates, event parking purchases and reservations, meter rental applications, month parking availability and rates, among other services). This information is accessed through a smart phone and web-based free application called ParkMobile.
VI. The following concepts are also a part of the Future Ready City Concepts/Strategies which are currently being explored by City of Orlando:
    1. Camera Analytics
    2. CAV Infrastructure Readiness
    3. CAV Pilot Downtown

4. Energy Microgrid
5. Expanded Fiber Infrastructure
6. Fast Charging EV Infrastructure

4.5.6. Orange County

The following are the needs identified by Orange County. CFX should note where cooperation and coordination with these needs are appropriate:

I. Training regarding new technologies related to adaptive systems with their new controller types. This includes troubleshooting cameras, processors, parts replacement, following up with vendors, warranties, and financial needs to maintain the system.
II. Automated Traffic Signal Performance Measures (ATSPM) Detection and implementation of smart signal standards
III. Transit Signal Priority (TSP), as required – GPS Opticom
IV. Inventory for each cabinet - Orange County currently uses MAXIMO for their Inventory. FDOT D5 will be creating a link between Maximo and Maintenance Inventory Management System (MIMS).
V. Install communications for isolated signals. See list of signals below:
    1. SR 417 and Boggy Creek Road NB off ramp
    2. SR 417 and Boggy Creek Road SB off ramp
    3. Valencia College Lane and William C Coleman Drive
    4. SR 528 EB at Innovation Way
    5. SR 528 WB at Innovation Way

4.5.7. Seminole County

The following are the needs identified by Seminole County. CFX should note where cooperation and coordination with these needs are appropriate:

I. Wekiva Expansion - Active Arterial Management (AAM) and Integrated Corridor Management.
II. Fiber sharing along SR 429 and on any other relevant routes.
III. CFX Signals
    1. Handling of the maintenance of the signal intersections in Seminole County to be determined
    2. Connection on SR 417 to Lake Mary Blvd. to connect to Sanford Airport.
IV. Data and video sharing similar to FDOT D5

4.5.8. Osceola County

The following are the needs identified by Osceola County. CFX should note where cooperation and coordination with these needs are appropriate:

a. Poinciana Interchange/532 Widening - Maintenance agreements between CFX and Osceola County need to be established for the signalized intersections in the region
b. Incorporation of ICM with Poinciana Parkway
c. Review Osceola Strategic Plan as it relates to Poinciana Parkway
d. Applying for grants for new projects to obtain analytics as related to connected vehicles

1. TAP-LA Grant – Transportation Alternative Program Grant
2. CDBG-MIT Grant - Community Development Block Grant Mitigation Program

e. Poinciana Parkway - Direct connection to CFX for redundancy
f. Osceola Parkway - Direct connection to CFX for redundancy

4.5.9. Lake County

The following are the needs identified by Lake County. CFX should note where cooperation and coordination with these needs are appropriate:

I. Master Hub (Lake County) west of SR 46 - Establish connection back to FDOT D5 from Lake County microwave network.
II. Establish fiber sharing agreement between CFX and Lake County - Signal connection is top priority within Lake County
III. Ability to view both CFX CCTVs and FTE CCTV's.
IV. Possible roundabout connection at (Schofield)/455 as a part of the expressway to US 27

4.5.10. SpaceCoast TPO

The following are the needs identified by Space Coast TPO. CFX should note where cooperation and coordination with these needs are appropriate:

I. Active Arterial Management (AAM) and Integrated Corridor Management System (ICMS) within SpaceCoast jurisdiction
II. Synergy with Road Rangers along SR 528 and I-95
III. Fiber sharing along SR 528
IV. Data and Video sharing - Primarily with Brevard Traffic Management Center (TMC) to increase coordination
V. Evacuation Needs
    1. Information dissemination
    2. Advance information prior to decision points.
VI. Event Coordination
    1. Coordinate with CFX for big events within the area
    2. Information dissemination and coordination CFX about rocket launches, primarily pertaining to larger launches which might cause disruptions
VII. Central Florida Automated Vehicle Partnership Collaboration

4.5.11. I-4 Mobility Partners

The following are the needs identified by I-4 Mobility Partners. CFX should note where cooperation and coordination with these needs are appropriate:

I. Coordination between agencies for Road Ranger Service Patrol
II. Event Management – Traffic coordination during special events
III. Wrong Way Driving Coordination - CFX is currently deploying Wrong Way Driving detection systems on sections of the mainline and ramp areas. However, CFX has avoided

including any I-4 Ultimate Project limits but will address the ramps within the project limits once their construction process is complete.

IV. Provide on the ground support for evacuation efforts - This is currently coordinated by the Regional Traffic Management Center and provides support such as putting in place lane and ramp closures and staging.

V. Safety Issues along infrastructure - I-4 Mobility Partners will develop risk analyses to determine design issues in an area that has repeat accidents, lane closures, and property damage. This will be addressed with a cost-benefit analysis.

VI. Technology Upgrades within infrastructure to keep up with CAV technology as directed

4.5.12. Brightline

The following are the needs identified by Brightline. CFX should note where cooperation and coordination with these needs are appropriate:

a. Event Management – Coordination with CFX during special events
b. Trip Generation Engine through single payer option
c. Data storage/security: Procure specific secured systems for their Wi-Fi data sharing such as within the train and CFX
d. Regional Integrated Corridor Management System – Coordination between CFX and Brightline for R-ICMS as appropriate.
e. ITS Data Interface between CFX and Greater Orlando Aviation Authority as appropriate

ITS
Master Plan

Section 5
Identification of Applicable Technology Strategies

section 5

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5. Identification of Applicable ITS Strategies

This section's primary purpose is to identify ITS solutions that provide best solutions and practices, by targeting the specific strategies and deployment locations which best fulfill any immediate needs for the Central Florida Expressway Authority (CFX). Preceding sections have established ITS Visions, Goals, and Objectives, provided an existing conditions summary and identified needs within the CFX system.

These findings, along with other transportation system performance measures, will be used to determine where the application of ITS solutions will have the most significant positive impact. Use of effective ITS strategies will allow CFX to realize increased performance of CFX's multimodal infrastructure through the use of systems, services, and projects that preserve capacity, improve safety and sustainability, and provide increased travel reliability.

Moving forward, this symbol will point to any text describing a recommendation or action.

5.1. Congestion Strategies

As a part of Section 4, system congestion needs were identified for pre-COVID and post-COVID traffic congestion conditions from the May 2021 Traffic Monitoring Report and the October-December 2020 Traffic Congestion Quarterly Update, respectively, and planned improvements were referenced from the FY 2022-2026 5-Year Work Plan (dated 5/13/2021). In general, during recurring congestion, the system operated at or above vehicle to capacity (V/C) ratios of 0.85 during the peak hour and some segments operated at capacity. In the instances where this was not the case, construction projects had been identified to resolve any capacity issues. Further, some of these construction projects included Part-Time Shoulder Usage (PTSU) accommodations to address capacity issues. **Therefore, since the work plan has addressed the capacity issues, it is recommended that PTSU continue to be considered on future CFX projects and that ITS's focus be on non-recurring congestion.**

Please note that the strategies for non-recurring congestion include, but are not limited to:

- **Integrated Corridor Management**
- **Traveler Information**
- Dynamic Routing
- **Traffic Incident Management (TIM)**
- Dynamic Roadway Warning
- Queue Warning
- Reduced Speed Zone Warning
- **Work Zone Management/Road Closure Management**
- Dynamic Roadway Warning
- Queue Warning
- Reduced Speed Zone Warning
- **Wrong Way Driving (WWD) Detection and Notification**
- **Planned Special Events Traffic Management**
- **Road Weather Management**

5.2. Safety Strategies

A review of safety needs in Section 4 identified two primary needs that can be addressed as a part of this Master Plan: implementing ITS/TSM&O work zone safety strategies to reduce crashes and resolution of interchange intersection crashes.

5.2.1. Work Zone Safety Strategies

During the review of the CFX roadways, it was noted that crashes increased within construction work zones. Furthermore, the CFX work plan includes a robust list of upcoming construction projects that could potentially result in increased crashes. Therefore, the implementation of ITS/TSM&O work zone strategies as a part of these projects should be considered, as appropriate.

Smarter Work Zones (SWZ) – SWZ are among a few select initiatives being promoted by the FHWA's Every Day Counts initiative. SWZ are work zones that use innovative strategies to minimize work zone safety and mobility impacts. The focus is on coordination of construction projects and use of technology applications to dynamically manage work zone impacts. These strategies include coordination of roadway construction projects to reduce work zone impacts and increase work zone safety by using technology applications to dynamically manage traffic within the work zone environment.

- Colorado DOT used Smart Work Zone processes and TSM&O strategies to maximize incident management efficiency and improve safety during two high profile construction projects, I-25 project, and I-70 project.
    - I-25 Project: Since the I-25 project was an 18-mile-long project, a standalone specific Project Operation Center (POC) was set up to respond to identified incidents, monitor cameras, change postings on the Smart Work Zone devices using a central software, and inform incident responders using radios.
    - The I-70 project was supported by two of CDOT's existing operation centers (Golden and Eisenhower tunnel).
    - The Smart Work Zone innovative elements initiated from the I-25 and I-70 Project team included the following:
        - A SWZ comprehensive live mobile plan
        - Daily SWZ field inspection plan
        - A management plan to enforce the specifications of the equipment
        - A managed satellite traffic center (16 hours weekdays and 10 hours on weekends) to monitor traffic.
        - Courtesy patrol support/dispatching
        - Data collection and analysis (volumes, speeds, incidents, response times, etc.), used in daily decision making to enhance safety
        - SWZ meetings to review data and address safety hotspots
        - Safety follow-up meetings
        - Colorado State Patrol Data Review, including types of tickets written within the project limits
        - Communication protocols

- Texas DOT used Smart Work Zone processes for the I-35 project and were able to demonstrate how current wireless technology can transmit information such as video images, speed data, and traffic volumes provided by temporarily installed closed-circuit televisions (CCTVs) and Bluetooth speed sensors. Data collected are processed on a computer server that instantaneously relays it to portable variable message signs placed at chosen strategic sites along the affected segment of the highway.
    - I-35 Project: On TxDOT's I-35 construction (90 miles), they were able to successfully accomplish the following:
        - Real-time queue warning
        - Lane and road closure information
        - Current travel time
        - Expected construction delay
        - Daily volumes
        - Spot speeds
        - Traffic video streaming
        - All of the above were gathered, collected, and made available to the traveling public to give them the ability for timely reactions and allow them to plan their trips based on the traffic conditions provided by the Smart Work Zone system.

Portable Variable Speed Limit System - A variable speed limit (VSL) system is a type of SWZ system that uses traffic detection, weather information, and road surface condition technology to determine appropriate speeds at which drivers should be traveling, given current roadway and traffic conditions.

Work Zone Intrusion Alarm - A work zone intrusion alarm (WZIA) is equipment that provides highway workers with additional warning of unauthorized vehicles and errant motorists that enter a work zone. WZIA uses vehicle-detection technology and audible, visual, or tactile alarms to alert workers to intrusions while giving them enough reaction time to move away from the hazardous location.

5.2.2. Ramp Intersection Safety Strategies

The following areas, as shown in **Table 24** below, have been highlighted as potential improvement considerations to reduce intersection crashes. Please also refer to Section 4.2.2 Safety for additional details.

Table 24: Ramp Intersection Safety Strategies

Facility	Location	Need	Strategy
SR 408	• SR 408 at Chickasaw Trail	Left turn crash reduction	Traffic signal system improvements (signal retiming and coordination) and Flashing Yellow Arrow (FYA) time-of-day operations)
	• SR 408 at John Young Parkway	Angle crash reduction	Traffic signal system improvements (signal retiming and coordination) and adjusting the yellow and red clearance intervals
SR 414	• SR 414 at US 441	Sideswipe crash reduction	Lane delineation pavement markings

Facility	Location	Need	Strategy
SR 417	• SR 417 at Narcoossee Road	Angle crash reduction	Traffic signal system improvements (signal retiming and coordination, FYA analysis and FYA time-of-day operations)
	• SR 417 at John Young Pkwy • SR 417 at Lake Nona • SR 417 at Narcoossee Road	Maintain Future Acceptable Ramp Intersection LOS (Per SR 417 Design Traffic Technical Memorandum (DTTM))	Alternative intersection design (Roundabouts, Median U-Turns (MUT), and displaced left-turn
SR 429	• SR 429 at CR 437A	Left turn crash reduction	Traffic signal system improvements (signal retiming and coordination and FYA time-of-day operations)
SR 528	• SR 528 at Tradeport Drive • SR 528 at Narcoossee Road	Left turn crash reduction	Retroreflective backplates, traffic signal system improvements (signal retiming and coordination), FYA analysis and FYA time-of-day operations and adjusting the yellow and red clearance intervals.
	• SR 528 at Goldenrod Road	Angle crash reduction	Retroreflective backplates, traffic signal system improvements (signal retiming and coordination and adjusting the yellow and red clearance intervals.)

5.3. CFX Technology Strategies

The following subsections address the technology needs identified in Section 4.

5.3.1. Future Traffic Management Center (TMC) Strategy

CFX's ITS facilities are currently managed through the Florida Department of Transportation (FDOT) D5 Regional Traffic Management Center (RTMC), which operates 24 hours a day/seven days a week. The RTMC fiber-optic network connects hundreds of closed-circuit television cameras, dynamic message signs, Cellular Vehicle- to-Everything (C-V2X) devices, and vehicle detector sensors on I-4, I-95, I-75, SR 408, SR 417, SR 429, SR 528, SR 538, and other arterial state roads via the extensive fiber optic network.

In the future, a CFX Traffic Management Center is a possibility. However, given the current positive cooperative environment between CFX and FDOT, the relatively low cost to CFX as a part of this partnership and the substantial increase in overall capital and operations costs to CFX, a new TMC is not recommended at this time.

5.3.2. ITS Device Replacement/Upgrade Strategies

ITS field elements such as CCTV's, DMS's, Wrong Way Driving (WWD) devices and data collection sensors are an important part of CFX's infrastructure. The ITS field equipment life cycle requires the repair or replacement of in-service equipment when it has reached the end of its useful life. CFX systematically integrates maintenance into their program planning, resource allocation, policies, system planning and

design, and other related activities. The following includes a brief description of this field equipment and provides an upgrade/replacement plan.

CCTV (Closed-Circuit Television) Cameras

CFX has replaced most of the CCTV cameras on their system within the past 1-5 years. The previous work plans accounted for the replacements of the analog CCTV's which was completed in 2020.

Wrong Way Driving Detection Devices (WWD)

CFX has deployed Wrong Way Driving Ramp Detection Systems at 53 locations along SR 408, SR 528, SR 417, SR 414, SR 429, and SR 451 on the expressway system and has deployed 10 additional Mainline Wrong Way Detection Systems throughout the expressway system. The Mainline Wrong Way Detection System consists of incoming and outgoing thermal detection cameras which are mounted on a sign structure over the detection lanes.

Traffic Monitoring Station (TMS)

CFX's infrastructure includes approximately 447 TMS sensors along SR 408, SR 417, SR 429, SR 451, SR 453, SR 528, and SR 414. In 2013, CFX deployed Wavetronix units which were a part of the 599-511 project listed in their Work Plan. Since installation, the warranties have expired on the TMS units however, the manufacturer is still providing repair services. That said, the manufacturer has issued an end-of-life notice on all units that were installed as a part of the 599-511 project. CFX deployed the Houston Radar (which is ethernet based and features POE for the power supply) as a part of a dynamic curve warning system project. A comparison was performed between the existing Wavetronix devices and the Houston Radar at Hiawassee Road and SR 408. The accuracy of the Houston Radar was found to be comparable to the Wavetronix units as it was noted that there was a difference of 1-2 vehicles which accounted for a speed difference of 0.6 MPH. The Houston Radar has an HD camera built into it and can be programmed remotely. It should be noted that this device is currently not on the Approved Products List. The Houston Radar was successfully integrated into Sunguide and tested. The model will be used for a permanent application.

Data Collection Sensors (DCS)

CFX's system includes 189 DCS sensors along SR 408, SR 414, SR 451, SR 453, SR 417, SR 528, SR 520, SR 429, and Florida's Turnpike which were replaced as part of the DCS replacement project 599-520 in 2015. The warranties have expired on the majority of Neology (FKA Sirit) DCS units; however, the manufacturer is providing repair services and have not issued an end-of-life notice. In addition, CFX has tested Bluetooth/WIFI/TPMS readers manufactured by Blyncsy to eventually replace the existing Neology readers. The current work plan includes funding to deploy Blyncsy units to begin the conversion process throughout the system. The Poinciana Parkway and Lake County Connector will also feature the Blyncsy units for the travel time system. In addition, CFX is in the process of evaluating the Kapsch Janus reader as an alternative toll transponder reader.

Dynamic Message Signs (DMS)

CFX currently operates 55 Walk-in DMS and 78 front access DMS. The walk-in DMS are installed along CFX corridors to provide traffic information to motorists, while the front access DMS are installed at the toll

plazas to provide toll information and along arterial roadways to provide traffic information to motorist. CFX is in the process of adding 5 new walk-in DMS along SR 417 and SR 528 as a part of the DMS Replacement Phase II project and widening projects.

Video Wall Controller

CFX currently utilizes a hardware-based Jupiter Video Wall Controller to receive and route all video data from the roadway ITS network, for customizable display on the video wall in the traffic management room. This controller takes one or several inputs (sources), and splits the content for delivery onto multiple displays, and generally enables administrators to manage the configuration or contents of their video wall. Jupiter has issued an end-of-life notice for the video wall controller and the device is expected to be replaced within the next year.

Based on projects identified in the 2040 Master Plan and the 2022-2026 Work Plan, the devices found in **Table 25** were identified to be in need of an upgrade/replacement within the next 15 years.

Table 25: Device and Equipment Replacements based on Life Cycle

Device/Equipment	Installation Date	Life Span	Condition	Replacement Date
Closed Circuit Television Cameras	2020	6-10 Years	Devices currently replaced in 2020.	Expected replacement and/or upgrade 2027-2028.
3-Line Dynamic Message Signs	Ongoing	15 Years	Device replacement ongoing process.	Expected replacement and/or upgrade starting 2035 (If appropriate).
2-Line Dynamic Message Signs	2016	15 Years	Devices replaced in 2016.	Expected replacement and/or upgrade 2031.
Data Collection Sensors	2015	5-7 Years	The warranties have expired on DCS units.	Expected start of replacement and/or upgrade 2021.
Traffic Monitoring Station	2013	10 Years	The warranties have expired on TMS sensors.	Expected start of replacement and/or upgrade 2021.
Wrong Way Driving Detection Devices	2015-2016 (Pilot) 2020	6-10 Years	Devices currently installed in 2020 and manufacturer is providing repair services and have not issued an end-of-life notice.	Expected replacement and/or upgrade beginning in 2025.
Remote Power Management Unit	2020	3 Years	Varies	Expected replacement and/or upgrade starting 2024.
UPS System	2015	5-8 Years	The warranties have expired on the units.	Expected replacement and/or upgrade 2023.
UPS Batteries	2015	5 Years	The UPS batteries have reached their end-of-life cycle and have frequently failed. Current replacement underway in 2021.	Expected replacement and/or upgrade 2021.

Device/Equipment	Installation Date	Life Span	Condition	Replacement Date
Switch Replacement	2014	10-12 Years	Equipment has been issued an end-of-life cycle by the manufacturer.	Expected replacement and/or upgrade 2023.
Video Wall Controller	2012	8-11 Years	Equipment has been issued an end-of-life cycle by the manufacturer.	Expected replacement and/or upgrade 2021-2022

Communication Equipment

CFX has data centers comprised of a carrier grade network router and aggregate switches to provide redundant connections for each server that hosts its critical software and services. Each data center is connected to each other via a set of 40 Gbps fiber connections. Within each data center, servers are connected to a pair of aggregate switches which then connect redundantly to each router. Additionally, all ITS field devices are connected to a layer 2 switch within a local hub. Local hubs have a 1Gb fiber optic connection to one another in a daisy-chained fashion, skipping every 5th local hub to create a ring, with the exception of the 3-Line DMS ring where they are on their own network. At the end of each ring is a separate layer 3 switch located within a plaza site. The layer 3 switches act as the redundant gateways and provides a path back to both data center locations over a 10 Gb fiber optic connection. The network has been redesigned to withstand several field issues, such as fiber cuts, power outages, devices failures and misconfigurations, to ensure network continuity and data flow.

CFX should continue to provide a resilient and redundant system utilizing the appropriate communications equipment for their needs.

Network Security

CFX ITS has firewall appliances to prevent unwanted and unauthorized access to the network or any CFX resources.

As data and connections increase due to Big Data and Connected Vehicle applications, the firewalls should be upgraded as appropriate.

In the field, CFX has installed secure access controls to prevent unauthorized access to the local hub cabinets. Each hub requires a physical key that communicates to a secure access control server on the CFX network which provides access to cabinets based on the level of permissions assigned to each individual key.

CFX should continue to utilize secure access controls to ensure security on the edges of the system.

When accessing network equipment from the network, all switches and routers require a secure connection to provide a secure communication session to configure network equipment. All switches require user accounts and permission for switch and router access. Once a user attempts to log into a

router or switch, it first checks the accounts validity and assigns permissions for access or denies access based on the roles associated.

Threats are constantly changing. As CFXs data and access increase, so do the potential for threats. CFX should continue to be proactive with all aspects of Cybersecurity. Please see later in this section.

Network Monitoring

CFX ITS utilizes network monitoring software to monitor the health status of each of its network switches and ITS field devices. This software not only helps to detect, diagnose, and resolve but also analyzes network performance issues or outages. It primarily monitors the status of a device's connection to the network, alerts the appropriate staff of connection loss to specific devices and provides uptime performance reports to determine any historical issues with specific devices.

Network Monitoring should be maintained and upgraded as appropriate.

Network Security Upgrades

For a number of years, the CFX ITS network has remained a closed network and only visible to the CFX staff. However, Cybersecurity strategies will need to be considered by CFX as more publicly accessible websites and services are deployed and planned. A recommendation would be that CFX consider a Cybersecurity solution to cover the following at minimum:

- Continued Network Vulnerability Scanning - To discover, locate and prioritize potential areas in the network in which threats can take advantage of.
- Threat Hunting - Software that continuously scans the network to proactively detect and isolate advanced threats that evade most common security solutions
- Intrusion detection and prevention (IDP) capabilities with the existing firewall to all deep packet inspection to ward off cyber threats.

This will become increasingly necessary as connected vehicle deployments occur due to the attractiveness of the CV devices to potential attackers.

Network and Storage Upgrades

Over the past few years, CFX has wisely invested into building and strengthening their ITS communications network to support future needs. Investments have been made towards expanding the bandwidth from 10Gb to 40Gb between the Data Centers. Also, significant investments have been made to modify the physical and logical network architecture to ensure it is scalable, reliable, and resilient to field issues. The entire network relies on its two Core routers which handle the transmission and routing of all data on the network back to the headquarters location.

As the two Core routers are now approaching their established End of Life term, CFX will need to consider a suitable replacement for both Core routers.

As the Connected Vehicle program at CFX grows, CFX will need to consider adding more storage to support the data retention needs of the programs. CFX has two options as it relates to data collection and retention for its future projects. One option would be to partner with other agencies and use a shared data warehouse to store the data collected from the CFX sensors or other sources. This option would greatly minimize their storage capacity needs. Option 2, CFX would build its own data warehouse and store the data internally. The second option would need to consider the initial CV Pilot and Big Data Projects in order to determine the storage capacity needs for the future. Previously, CFX conducted a CV needs assessment, however, due to the advancement of emerging technologies an updated CV and data needs assessment is recommended to properly ascertain the true data storage needs, cost, growth and performance requirements for a successful data warehouse implementation and/or storage solution. That said other studies have been conducted throughout the State and should be leveraged as a part of this project.

Hardware Considerations

As CFX ITS expands its CV program, additional CV application servers may be needed to support the application to be developed.

A needs assessment will need to be complete to determine the amount of hardware resources needed based on the direction of the CV program. Additionally, CFX will need to consider the purchase of CV equipment such as Roadside Units (RSU's), On-Board Units (OBU's), Integrated V2I Prototype (IVP) hubs and Industrial Computers (field processors) to scale out its CV deployments. Finally, CFX is also expanding its cloud-based platform. CFX ITS should consider cloud-based services for its CV program for data management and application-based programs and/or collaboration with regional and state partners.

5.3.3. Connected Vehicle Strategies

Connected vehicle technologies continue to advance and be tested throughout the world including Florida. Vendors and manufacturers of the CV devices have expressed the desire to receive feedback from agencies such as CFX on what their needs are and how these technologies, applications, and interfaces may be best used efficiently. The identified needs of agencies become the pathway for further development and advancement of technology.

A connected vehicle deployment strategy should consider many variables including regulations and rulings, establishing key personnel and stakeholder relationships, as well as some pre-deployment and post deployment operations.

Figure 33 on the following page identifies some of the key areas for consideration.

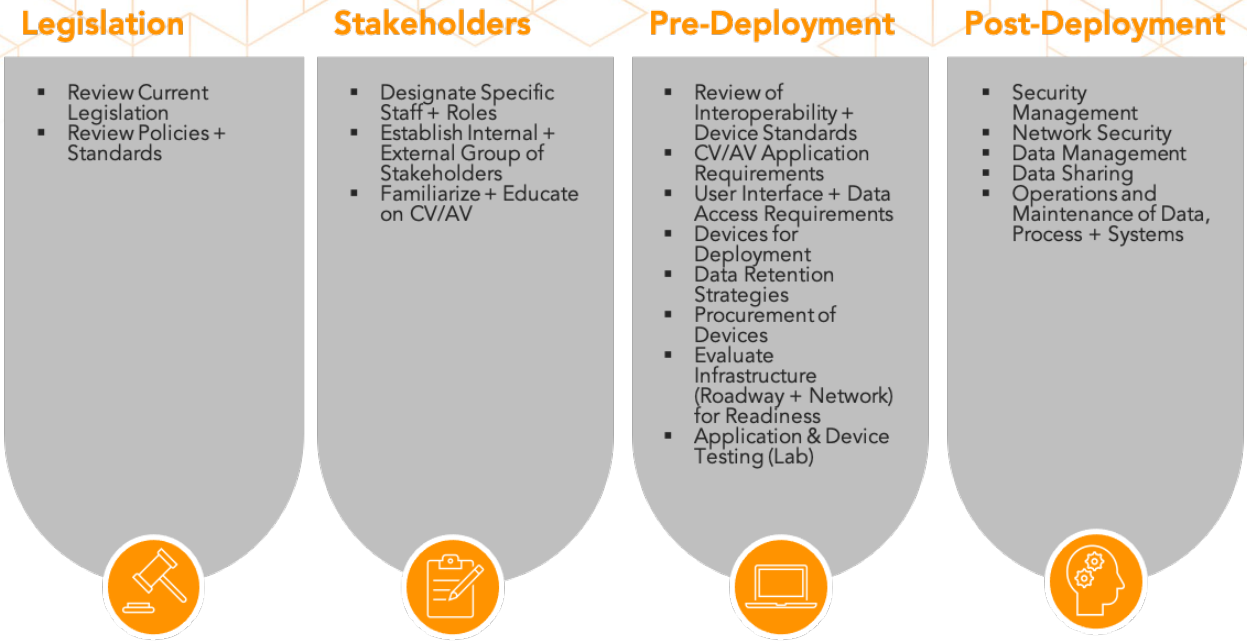


Figure 33: Connected Vehicle Considerations

Per CFX's CV Potential Projects Report (2018), CFX is expected to establish its CV implementation and data sharing schedule by the year 2024. Toward this goal, CFX will begin efforts related to small cell initiatives, CV data lake explorations, network upgrades and partnerships to support their readiness efforts by the year 2030; CFX expects a full CV implementation. These goals align with a systemwide connected and pathway to automated environments.

Connected and Automated Vehicle (CAV) For Operational/Mobility and Safety Improvements

An alternative to managing roadway capacity and adding lanes is the exploration of the use of existing technologies to solve problems related to congestion. The potential effects of CAV on the alleviation of congestion along the mainline and at the ramps are mobility-focused and are inspired by the **adaptive cruise control** and **speed harmonization (SH)** applications. SH is a strategy used for delaying the onset of congestion by collecting trajectory data from connected vehicles, predicting future traffic, and broadcasting new and updated speed limits to the connected vehicles. Additionally, utilizing the platform of C-V2X communications for tolling applications such as **electronic tolling collection** can provide a fast, highly reliable tolling and efficient payment method (operator does not need to manage transponder transactions). The SAE standard for tolling transactions is expected to reach its final ballot by the end of 2021, thereby enabling vehicles to pay tolls directly through V2X equipment. Several automakers are currently in the pilot phase for developing these systems. **Congestion pricing** (sometimes referred to as value pricing) is an alternative way of harnessing the power of the individual drivers, discouraging overuse during rush hours and motivating motorists to use alternative travel modes such as carpool or transit as methods to reduce congestion.

The Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT) version 8.3 provides the physical components (shown in **Figure 34**, on the following page) of the ITS roadway payment equipment interfacing with the CV devices (roadside and OBU) for payment and services.

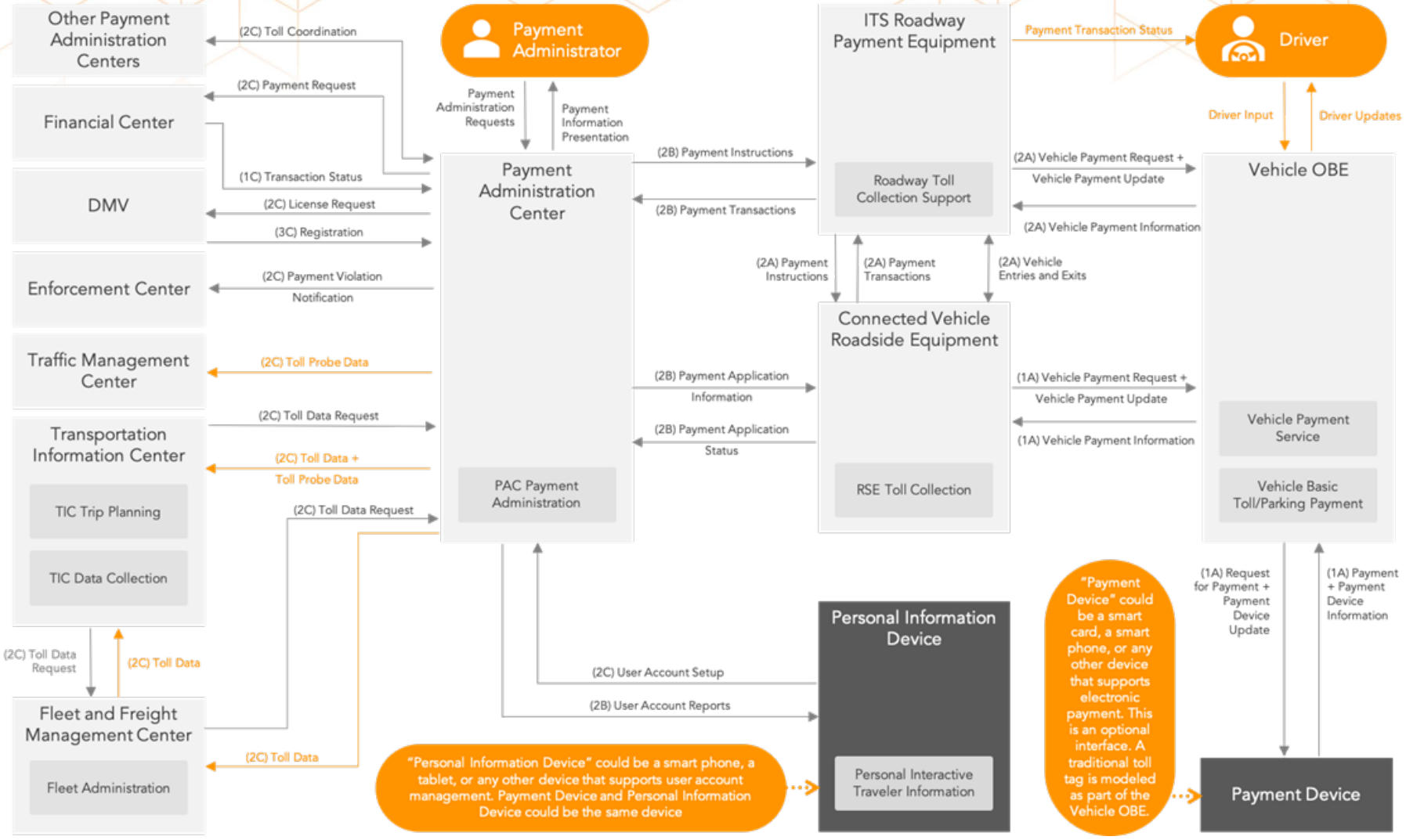


Figure 34: Arc-IT Toll Collection Diagram

The optimization of incident response times or traffic incident management is supported by the **incident scene pre-arrival staging guidance (RESP-STG)** application for emergency responders. This application provides situational awareness, allows the establishment of incident scene work zones while in route, and provides coordination among the emergency responders. Additionally, the **advanced automatic crash notification relay (AACN)** allows a vehicle in distress or involved in a crash to automatically transmit an emergency vehicle message to emergency services as well as to other connected vehicles nearby. The notification feature transmits data that is recorded by the sensors on the vehicle.

Figure 35, shown below, shows an example of communication technologies supporting **ramp metering** adopted by the Minnesota Department of Transportation. The ramp meter signal controller interfaces with the CV, or the Advanced Traffic Management Systems (ATMS), so that it may broadcast data directly to the CV infrastructure systems. [12]

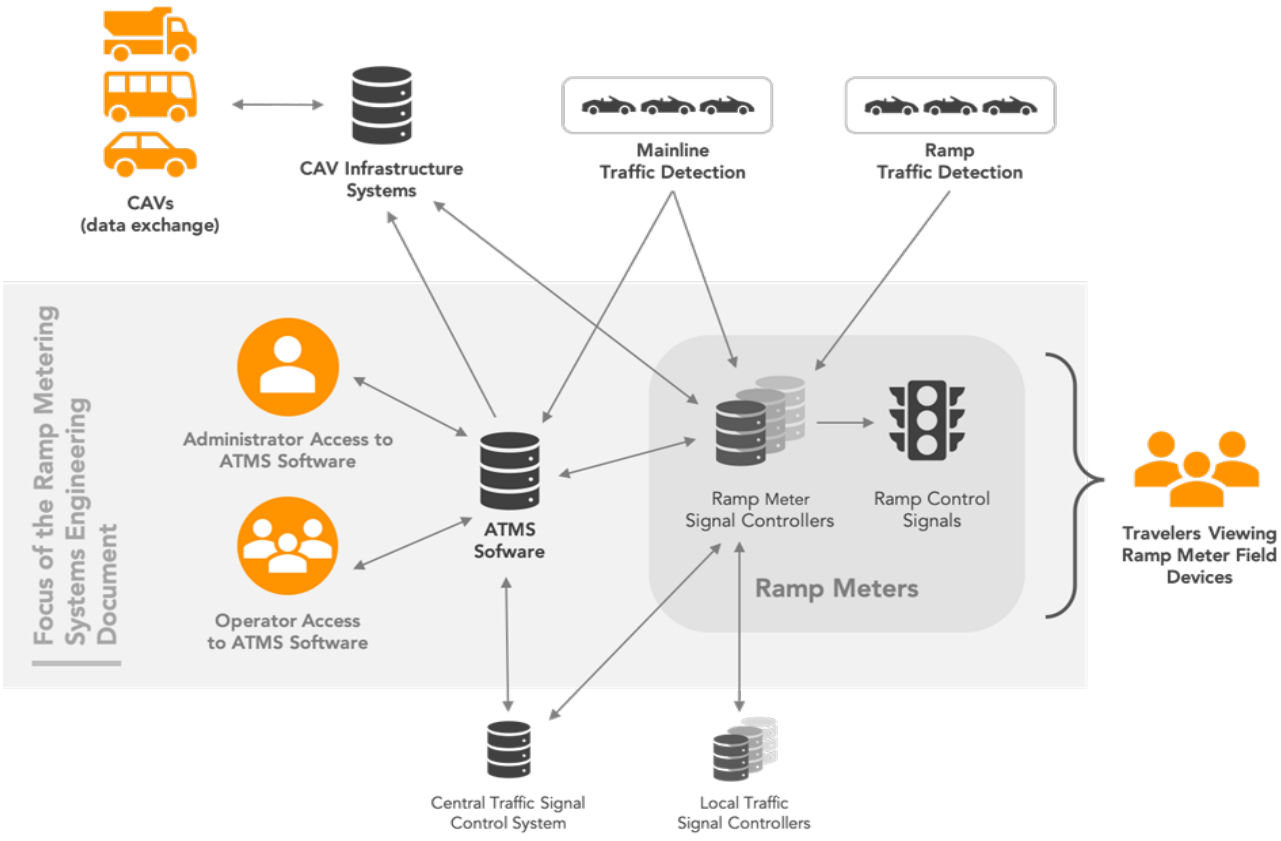


Figure 35: Illustration of Primary Ramp Metering Application Components

From the identified operational/mobility, safety and maintenance needs summarized, see **Figure 36** on the following page. Several CV applications have been identified to support to support these needs.

[12] https://www.dot.state.mn.us/its/projects/2016-2020/systemsengineeringforitsandcav/rampmeteringse.pdf

Figure 36: CFX Operational/Mobility, Safety and Maintenance Needs

The prioritization of applications may be established using existing and historical incident data to determine frequencies and weighting criteria. For instance, ramp related incidents may be attributed to speeds at the curves and run-offs. With the deployment of **curve speed warning (CSW)** advisories, these incidents may be reduced and have insignificant impact on truck or larger vehicles. Statistics related to wrong way driving may also be available for evaluation and deployment of existing technologies - roadside infrastructure and in-vehicle to mitigate some of the occurrences.

Many of the short-term CV applications identified in **Figure 37** are available to-date and provide in-vehicle warnings by delivering real-time notifications to the motorists so that caution may be taken. For example, in keeping with the identified needs, the **Reduced Speed Zone Warning (RSZW)** CV application is useful to notify road users downstream of an approaching construction zone. Advanced notifications of reduced speed ahead, lane closures, lane shifts, and notifications to workers of oncoming motorists. The connected vehicle will use the revised speed limit and roadside configuration to determine whether to provide alerts. This application uses the RSU to broadcast TIM to the OBU relative to speed and other warnings. Because the desired level of OBU saturation is currently low, however, these advisories may also be supplemented using dynamic message signs (DMS) or flashing beacons. The same is true for **Queue warning (Q-WARN), Curve Speed Warning, Wrong Way Driving (WWD)**. These are ready-to-deploy applications are available, to-date, by CV vendors.

Although WWD incident occurrences may occur at a less frequent rate, these do have the potential to cause significant injuries and fatalities. Advanced warning detection devices in this case will provide significant benefit to motorists, allowing situational awareness and adequate time to make well-informed decisions. Agencies are aware of these types of incidents that do occur and are already implementing solutions to provide warning of a WWD if, for example, entering a ramp in the wrong direction. In this case, existing deployments may include the use of flashing beacons with communication back to the traffic management centers (TMC) and emergency services dispatch alerting of a wrong way driver. With the use of CV technology, however, sensors interact with the RSUs to provide instantaneous indication of a WWD, communicates to nearby vehicles while still performing dispatch functionality. With the use of CV technology, the detection system interacts with the RSU or Integrated V2I Prototype (IVP) hub which acts immediately to interpret the message of a WWD. At that time, while beacons activate, wireless traveler information messages are broadcasted out to nearby vehicles via the OBU, instantly notifying motorists, and the TMC to take appropriate action. Along with the video processing and recording, event logs and photos of the incident are stored on the devices for later reference and/or data sharing. The vendor solutions integrate with the roadside infrastructure to provide a comprehensive system of detecting and warning motorists. Emerging technologies such as Artificial Intelligence (AI) or computer vision software should be explored applicable to CV applications such as wrong way driving.

Road weather safety advisories and warnings related to wet pavement conditions are facilitated by weather advisory applications such as **spot weather impact warning (SWIW)** and **road weather motorist alert and warning (MAW)**. These applications serve to warn motorists of local hazardous weather and roadway conditions, with advisories managed by the TMC from source weather data. Weather advisory warnings are received by the nearby vehicles broadcasted from the roadside equipment.

Figure 37, on the following page, outlines the supporting CV applications and deployment timeframes. Deployments of these mobility and safety technologies may be strategized for deployment in two (2) stages based on technology readiness and funding opportunities. The short-term phase (0-5 years) begins once the OBU saturation rate reaches the desired market penetration of 10% (for a specified region). This timeframe considers the criticality and readiness of safety applications while the mid-to-long-term (5-10+ years) may be advanced as the technology or needs advance. Please also see the following CV Industry Readiness Section.

Short-Term (0-5 years)	Mid-to-Long-Term (5-10+ years)
• Advanced Traveler Information Systems • Queue Warning (Q-WARN) • Curve Speed Warning (CSW) • Wrong Way Driving (WWD) • Wrong Way Entry (WWE) • Reduced Speed Zone Warning/Lane Closure • Spot Weather Impact Warning (SWIW) • End of Ramp Deceleration • Electronic Toll Collection	• Vehicle Data for Planning and Traffic Operations • In-Vehicle Signage (TIM) • V2V Safety Applications • Road Weather Information for Maintenance and Fleet Management • Traffic Incident Management – Incident Scene Pre-Arrival Staging Guidance for Emergency Responders (RESP-STG) • Congestion Pricing • Speed Harmonization (SPD-HARM) • Traffic and Performance Monitoring • Advanced Automatic Crash Notification Relay (EVAC) • Road Weather Information and Routing Support for Emergency Responders • Road Weather Motorist Alert and Warning (MAW) • Variable Speed Limits for Weather-Response Traffic Management (WxTINFO)

Figure 37: Mobility and Safety Technology Short-Term and Mid-to-Long-Term

CV Industry Readiness

The current OBU saturation rate for connected vehicle application operations is <1%. Although agencies are actively involved in purchasing and installing test OBUs as part of their roadside infrastructure deployment and test initiatives, the overall penetration is anticipated to remain low until 2022 to 2023. It is at this time when OEMs anticipates deploying C-V2X technology in their vehicles and when 5G technology becomes ubiquitous. The current turnover of the vehicle fleet is approximately 20 years. Therefore, a reasonable percentage turnover would be 5% per year. Therefore, it would appear that by 2026, 10% saturation should be reached.

Figure 38, on the following page, provides a snapshot of the 2020 United States auto sales by brand analysis. This table highlights the percentage of auto sales by the OEM brand and may be used as a tool to evaluate potential market penetration (based on trends) of CV-ready vehicles in the near-future. From industry research and publications, both Ford and Toyota are actively involved in CAV testing efforts to date. Ford plans to deploy C-V2X technology in their vehicles beginning year 2022. As can be seen in Figure 38, these two manufacturers are part of the top two brands for the highest market penetration in the US for 2020.

OEM Brand	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	% of Sales by OEM (2020)
Ford	158,843	205,646	124,562	73,985	164,416	172,634	182,874	162,555	176,101	171,770	140,429	195,380	1,929,195	13%
Toyota	146,244	173,013	120,145	62,563	139,028	145,980	146,044	164,750	172,370	178,658	177,725	211,378	1,837,898	13%
Chevrolet	140,809	178,302	110,418	59,471	132,149	138,761	157,488	139,990	151,656	175,755	144,370	200,864	1,730,033	12%
Honda	92,395	107,742	70,116	52,705	110,636	102,703	102,374	122,278	114,117	113,197	90,723	120,819	1,199,805	8%
Nissan	75,370	97,576	59,102	29,024	64,574	67,719	71,456	63,516	86,782	75,112	61,690	85,841	837,762	6%
Jeep	59,331	76,811	46,525	31,808	70,685	74,220	77,918	69,260	75,033	72,096	59,222	82,397	795,306	5%
Ram	45,630	59,074	35,782	22,983	51,073	53,626	61,425	54,599	59,150	61,160	50,238	69,897	624,637	4%
Hyundai	42,744	53,013	35,118	33,968	57,619	47,791	57,677	58,361	54,790	57,395	55,171	66,278	619,925	4%
Subaru	46,285	51,695	32,611	30,620	51,988	53,911	51,458	57,885	60,103	61,411	50,413	63,558	611,938	4%
Kia	40,355	52,177	45,413	31,705	45,727	47,870	52,479	57,015	55,519	56,084	47,897	53,764	586,005	4%
GMC	38,559	49,921	30,238	18,317	40,704	42,738	46,547	41,375	44,824	54,680	44,917	62,493	515,313	4%
Volkswagen	24,382	31,565	51,168	12,588	27,972	29,373	29,634	26,342	28,538	31,751	26,082	36,289	355,684	2%
Mercedes-Benz	24,445	31,650	19,170	12,112	27,901	29,492	29,675	26,377	28,576	32,153	26,411	36,746	324,708	2%
Tesla	22,350	20,450	10,000	6,624	14,720	15,456	48,846	43,418	47,036	21,591	17,736	24,675	292,902	2%
BMW	22,009	25,002	15,141	9,171	20,382	21,403	24,351	21,565	22,523	33,313	27,363	38,074	280,297	2%
Mazda	23,621	28,385	15,664	10,940	24,933	25,326	24,085	26,089	24,237	22,736	21,752	31,308	279,076	2%
Lexus	19,621	21,139	15,585	9,082	20,182	21,194	23,440	27,091	24,754	26,691	28,040	38,223	275,042	2%
Dodge	28,795	37,279	22,582	7,875	17,503	18,378	25,224	22,421	24,290	21,246	17,452	24,281	267,326	2%
Audi	13,438	17,396	10,537	6,270	13,935	14,634	16,795	14,928	16,173	21,090	17,327	24,102	186,625	1%
Buick	11,001	14,242	8,627	6,395	14,207	14,919	17,238	15,333	16,599	14,907	12,244	17,037	162,749	1%
Acura	9,230	12,264	7,037	5,046	10,341	12,071	13,076	13,647	12,941	13,790	11,891	15,648	136,982	1%
Cadillac	9,849	12,752	7,722	4,194	9,317	9,786	11,560	10,275	11,131	14,475	11,890	16,544	129,495	1%
Chrysler	9,785	12,667	7,493	2,494	5,543	5,820	11,175	9,933	10,761	11,677	9,592	13,345	110,285	1%
Volvo	6,157	7,841	5,487	3,866	9,519	10,385	9,697	10,378	10,274	10,691	11,591	14,244	110,130	1%
Lincoln	8,303	10,749	6,510	3,830	8,512	8,938	9,662	8,589	9,304	10,050	8,387	12,571	105,405	1%
Mitsubishi	10,626	15,543	9,394	4,333	3,852	4,012	8,716	7,748	8,393	4,982	4,093	5,694	87,386	1%
Land Rover	7,793	6,927	7,216	2,610	5,800	6,090	5,575	4,955	5,369	9,343	7,675	10,680	80,033	1%
Infiniti	8,300	10,746	6,510	2,899	6,438	6,760	6,090	5,414	5,864	6,910	5,675	7,897	79,503	1%
Porsche	3,896	5,033	3,055	2,195	4,877	5,121	5,452	4,846	5,250	5,924	4,866	6,771	57,286	0%
Mini	1,701	2,202	1,333	952	2,115	2,221	3,173	2,810	2,991	2,884	2,369	3,296	28,047	0%
Jaguar	2,581	2,295	2,390	778	1,728	1,814	1,647	1,466	1,587	1,856	1,523	2,121	21,786	0%
Alfa Romeo	1,202	1,557	943	672	1,494	1,569	1,773	1,576	1,707	2,055	1,688	2,349	18,585	0%
Genesis	1,399	1,587	969	806	1,350	1,429	1,257	1,360	1,128	1,054	935	3,110	16,384	0%
Fiat	366	475	287	241	536	562	386	344	372	248	203	284	4,304	0%
TOTAL													14,697,837	

Figure 38: 2020 United States Auto Sales by Brand

CFX should consider what application and data requirements entail. Vendor discussions should facilitate and streamline CFX's knowledge of what is to be achieved to accomplish the device and application configurations. Correct planning also has bearing on the devices to be deployed, displays to be observed, and output data for analysis and reporting purposes. Of equal importance, the availability of a user-friendly, user interface (UI) should be established as an understanding of vendor assistance pre- and post-deployment may be needed as part of the procurement package. An understanding of what comes standard or "out of the box" versus any application customizations should be pre-defined. Subscription fees for user interfaces, reporting and cloud services should be discussed and considered as part of any deployment.

CV Test Plan Development

The development of a CV Device and Applications Test Plan is strongly recommended. This document describes the evaluation methods that will be used to verify and validate that the equipment being considered for use in future connected vehicle deployments meet the currently defined user needs. Installation, configuration, and functionality of all devices to include the IVP Hubs, RSUs, OBUs, and sensor technology to be deployed should be included in the test plan. Test plans that have been developed throughout the State should be leveraged for this effort. The test plan documentation will serve as a template to record observations and findings related to evaluations performed on specific products. This should be done for both pre- and post-deployment purposes and include the following:

1. Contractor to Integrator Handover Test
2. Integrator to Contractor Handover Test

Primary test objectives (per each device), data broadcasting interoperability, lab environment testing of SCMS (automatic certificate renewals), return merchandise authorization (RMA) procedures, and network communication testing are just some of the considerations to be fully documented on the test plan.

Legislation and Rulings - Federal Communication Commission (FCC)

On November 18, 2020, the FCC adopted new rules which impacts the CV decisions to be made moving forward. The rulemaking designates the lower 45-megahertz (5.850-5.895 GHz) for unlicensed uses, and the upper megahertz (5.895-5.925 GHz) for enhanced automobile safety using Cellular Vehicle-to-Everything (C-V2X) technology. C-V2X uses cellular-based protocols and provides the direct communication services between vehicles, pedestrians, bicyclists, etc. It is anticipated that within a two-year period, there will be a full Dedicated Short-Range Communication (DSRC) transition based on the FCC's Further Notice of Proposed Rule Making (FNPRM), per Section 4.3.8 above.

It is recommended that CFX monitors the development of the rule making as device procurement decisions are made for a CV deployment with the understanding that DSRC operations must cease based on the FNPRM. Please note that some automakers are considering DSRC in the unlicensed spectrum.

5.4. Data Related Strategies

Based on the data needs identified for Section 4 – Section 4.3.5. – Data Considerations, multiple high-level recommendations were identified to guide CFX, to:

- Define how data can assist CFX in meeting business and safety goals
- Have a clear definition of data related activities that will help CFX achieve business and safety goals
- Describe changes that CFX may consider maximizing the value of data activities and have a roadmap on how these changes will be implemented
- Establish a scope and timeline to complete activities associated with shifts in data processes, workflows, data governance, and policies paving the way for the future of the organization data management process
- Discuss financial justifications for the proposed data related activities and how CFX will benefit from it, using insights, and monetization on data.

It is recommended that detailed data related strategies are outlined as part of the recommended focused data needs assessment activity to be performed by CFX in the future.

5.4.1. Infrastructure Assessment (IA)

Data volume and growth require personnel skillsets and considerations to support the increased information generated by technology deployed for the dynamic and adaptive management of the road network. It is paramount to use adequate technology infrastructure to handle the data influx from regular operations and emerging technologies for timely responses to events.

Physical Infrastructure - Physical technology infrastructure underpins any organization's data strategies and should be assessed from several angles to ensure that it can adequately support the organizations current and future data goals. The continuous monitoring of data size, data growth and data latency is needed to ensure sufficient storage is available, either on-premises or via cloud solutions. Redundancy of technology infrastructure can minimize downtime of data availability, protecting data integrity and minimizing impacts caused by data not being available to support operations and decision making.

Data Store Architecture - The existing CFX technology infrastructure can be leveraged to create a robust data store. The first step in such a process is identifying the requirements that will orchestrate the design of the data store architecture. Partnering opportunities should also be explored to offload data storage where possible. Previous initiatives have sought out universities as a potential partner to shoulder some of the costs associated with big data storage. In addition, FDOT has a number of initiatives underway.

A hybrid data store should be explored that makes use of physical hardware in conjunction with virtual components. This will allow CFX to maximize the return on investment in technology infrastructure by leveraging existing resources where possible. The existing CFX IT network will also need to be evaluated and bolstered to handle the bandwidth associated with big data stores. Please note that FDOT District 5 has developed a data store, called SunStore that could be used if a partnership is deemed advantageous.

Workforce Needs - The strategies and recommendations listed here require specialized IT and software development skillsets. Thus, a proper understanding of existing staff skillsets should be pursued in order to identify skillset gaps to fill via additional staff, staff training or through specialized consultant support. This is especially important in identifying and creating automated ETL processes, establishing data governance protocols and processes that will help to reduce time spent by staff on such activities. It should be noted that training and position descriptions are noted in Section 11.

5.4.2. Existing and Known Data Needs (ED)

Data supports many of CFX's current initiatives and processes, generating insights, lessons learned, and business cases for the CFX transportation system and the existing CFX technology and data infrastructure. These recommendations will assist CFX in solving known data needs and will provide crucial information to create a more robust data store to support organizational goals.

Data Assessment and Documentation - As part of a more detailed data needs assessment study, identification and documentation of existing data inventory insights, and data standards should be completed to support data exchange activities. This documentation should include data sources, ETL processes, data maintenance procedures, data standards, and tie in known growth rates for each data set. Existing data sets can be leveraged to automate various visualizations, reporting and performance metrics on the state of its system.

Define Value of Data - It is recommended that CFX investigates the value of its data and develops data sharing and/or data monetization models. A part of this effort will require identifying external partners to assess the value of CFX's data to that external entity.

Maximize access and use of real time data: For example, work zone safety performance measures should be implemented using real time data, as an example. These measures should be supported by agency policies and procedures to quickly address and rectify issues.

Predictive Analysis - Artificial intelligence and machine learning can be implemented to support various CFX needs. This ranges from developing models to predict changes in demand to extracting real-time data from existing deployed hardware. The data extracted from existing hardware, such as CCTV cameras, can be used to identify wrong way driving initiatives, performance measures dashboarding, near-miss applications and AAM efforts to name a few. Please note that FDOT District 5 is developing R-ICMS, which could possibly be incorporated through a partnership, if appropriate.

5.4.3. Evaluation of Potential Future Data Needs (FD)

As future data needs evolve with advancements in the transportation industry, new and emerging technologies should be evaluated to document potential needs as they are adopted. Data needs identified will encompass CFX's agency plans and priorities and will include interviews conducted with agency staff in multiple departments as well as strategic industry partners.

Defining Data Users - In order to facilitate data dissemination, the agency should create mechanisms for two different types of users: technical and non-technical users. When creating such mechanisms, CFX should also ensure that both internal CFX users and external stakeholder's users are supported.

Future Data Sources - There are several data sources that should be further researched to determine their applicability. With the correct use case, data sources from CAVs and social media could be integrated into CFX's overall data solution. Other data sources such as LiDAR and video have already shown promise and resources should be devoted to further incorporating use cases into existing processes.

A potential application for LiDAR and video for asset collection and management. They could also be used, in conjunction with other technologies such as computer vision, to support data validation efforts from other deployed sensors. Aside from validation use cases, the data extracted from these technologies can support performance measures that historically have been difficult to collect.

Data Partners - Potential partners, in addition to existing partners such as the Florida Department of Transportation, should continue to be fostered or developed as appropriate. The transportation system is a complex one and partnerships with other agencies and organizations could provide additional data sets into the organization via data sharing agreements. This work effort will require integrating external partner APIs into internal CFX processes as well as developing CFX's own APIs to fully leverage their data or to provide to external partners.

5.4.4. Data Policy and Governance (PG)

Establishing robust data policy and governance will help in ensuring that CFX can thoroughly leverage existing data as well as set itself up in a favorable position to take advantage of new data sets, and new data sharing opportunities as they become available. Data is an organizational asset and data governance is a key component that will guide how the data is managed and protected.

Existing ingestion processes should be refined to improve quality, consistency, and availability. The policy and governance should also define goals and objectives to guide the data store architectural efforts. This will entail identifying the creation of a centralized or distributed data architecture, identifying opportunities for distributed computing, and developing data workflows so users can easily consume data. As part of this effort, policies and procedures should be developed to align operational workflows with data-centric objectives. One such example of a procedure is refining standard operating procedural language for PTZ camera handling and positioning to better leverage existing technology deployment for collecting data using emerging technologies such as computer vision.

It is recommended that a review plan be developed for CFX to continuously evaluate the applicability and need as new and emerging technologies are released. This will ensure that the agency is able to quickly identify new trends and if applicable, play a leading role in new data initiatives. This plan should include cycles for review, schedules and procedures for evaluating new hardware - software and identifying new and emerging technologies with the potential to further CFX's mission.

5.4.5. Data Maintenance (MT)

As a data driven organization, data maintenance best practices and procedures are recommended for CFX to establish for existing and anticipated data sets. Having clean and reliable data will support CFX in the development of insights, enable data integration strategies, and allow for automation of processes. These will ensure that data duplication is minimized and security policies such as penetration tests are enacted to identify and address any deficiencies. Maintenance policies should include user experience, benchmarks for data availability, data store user experience, and plans for other performance measure reports periodically to evaluate data availability, efficiency and data growth ration. These measures will provide detailed information about the overall health and user experience as it relates to the data environment.

5.5. Other Strategies

5.5.1. Event Management

Event Management is a strategy that appeals to all stakeholders because most agencies have events that take place within their limits. Events can wreak havoc on a transportation system due to the nature of an influx of vehicle and pedestrian traffic for a specific amount of time within a condensed area. Event Management, similar to how incident and active arterial management techniques perform, uses a combination of traffic control and traveler information techniques, along with parking management, to manage the flow of transportation during major events. Typically, this involves a traffic management center and an extensive communication network linked to sensors on the transportation network and staff directing traffic.

Working together as a region to address dissemination of traffic information to the traveling public creates informed drivers who may opt for other mode choices (transit, SunRail, etc.) and/or have a clearer pathway to destinations. Because of this, there is a continuous need for excellence in event management

and event parking. Transit ridership could also benefit from well-coordinated event management plans by encouraging alternate means of transportation other than personal vehicles.

SR 408 serves as a primary regional route for ingress and egress at Orlando's downtown venues (Camping World Stadium, Exploria Stadium, Amway Center, and Dr. Phillips Performing Arts Center) resulting in congestion within the section from John Young Parkway and downtown Orlando.

Locations for event management have been specifically identified along SR 408 and in the vicinity of Camping World Stadium. Event management Strategies include:

- **Limiting/Closing Adjacent Ramps** - This can be considered during post event periods or turn lane improvements at surrounding intersections.
- **Advanced Traveler Information Systems (ATIS)** - ATIS technologies can include components such as Dynamic Message Signs (DMS), Citizens Band Radio Advisory System (CBRAS), Florida 511 (FL511) Traveler Information System, and In-Vehicle Dynamic Route Guidance.
- **Smart Parking and Operations Strategy** - Integration of smart parking technology into more infrastructure (i.e., parking garages and lots, parking rates, event parking purchases and reservations, meter rental applications, month parking availability and rates, among other services). This information is accessed through a smart phone and web-based free application called Park Mobile. Both City of Orlando and Brightline are currently studying this technology and interested in coordinating this strategy with CFX.
- **The City of Orlando downtown Venues Traffic Management Strategies Project** - SR 408/Tampa Avenue Interchange improvement project is under design. The City is anticipating new routing to utilize the direct access from Tampa Avenue to SR 408 eastbound. Currently, all southbound Tampa Avenue traffic is forced to SR 408 westbound, and much of that traffic immediately exits at John Young Parkway to re-route north or south or to U-turn and head east on SR 408. This contributes to substantial congestion on John Young Parkway.

Once the Tampa Avenue Interchange improvement project is in place, traffic management strategies will be updated to utilize both the SR 408 westbound and SR 408 eastbound movements from Tampa Avenue. Utilizing SR 408 eastbound as the new forced movement will allow vehicles direct access to any direction along SR 408 or I-4 without impacting surface street operations. To support this, the City has an ongoing Venues Traffic Management Study that also suggests limiting/closing the SR 408 off-ramps to Tampa Avenue and to Orange Blossom Trail during the post-event egress periods. Exit ramps to John Young Parkway and downtown would remain open.

The City's downtown Venues Traffic Management Strategies Project is also considering turn lane improvements on Orange Blossom Trail within the SR 408 vicinity to optimize event management strategies.

Regional Partners Event Coordination - Coordination of existing and future ITS technology implementation has been and continues to be critical to the effectiveness of the transportation network, as well as the commerce and prosperity of the area in general. During the stakeholder meetings the following event coordination and strategies were articulated:

City of Orlando: Integrating parking solutions for venue and event planning which involve extending E-Pass parking for venue applications and streamlining payment process with E-Pass. Brightline: Coordination with CFX during special events.

For additional details from the stakeholder meetings, please reference Section 4.5 Regional Partner Needs.

5.5.2. Integrated Transportation Application Strategy

Continued coordination and collaboration between agencies for the development of multi-modal trip planning engine is recommended. The concept aligns well with the need for a City-developed user interface and allows for the processing of single or multimodal trips.

- Mobility on Demand (MOD) - As defined by the U.S. Department of Transportation, MOD is an innovative, user-focused approach which leverages emerging mobility services, integrated transit networks and operations, real-time data, connected travelers, and cooperative ITS to allow for a more traveler-centric, transportation system-of-systems approach, providing improved mobility options to all travelers and users of the system in an efficient and safe manner.

  In the past five years, agencies have started to explore options beyond conventional services to meet the needs of residents by implementing MOD or mobility as a service (MaaS) concepts. Both MOD and MaaS refer to the same basic concept of on-demand mobility where customers can discover/plan travel options, request, and pay for a door-to-door service using a smartphone or a web application. The strategy consists of providing users and visitors the ability to plan multi-modal trips; a combination of transit, ridesharing, walking, and biking, all in one centralized location through the use of a mobile application designed to run on smartphones/smart devices and transit kiosks.

Additionally, stakeholder interest in this technology and its potential benefits were identified during the Stakeholder meetings. Coordination between agencies should be considered to ensure a seamless system. Please reference Section 4, Regional Partner Needs, for additional details.

5.5.3. Sustainability

A sustainable transportation system allows the basic access needs of individuals and societies to be met safely and in a manner consistent with human and ecosystem health, and with equity within and between generations. It is affordable, operates efficiently, offers choice of transport mode, and supports a vibrant economy; limits emissions and waste within the planet's ability to absorb them. This system minimizes consumption of non-renewable resources to the sustainable yield level, reuses and recycles its components, and minimizes the use of land and the production of noise. Some suggestions for increasing transportation sustainability on CFX roadways include:

- **Enhance Electric Vehicle Infrastructure:** Expanding infrastructure for charging electric vehicles will be vital as the penetration rate of EVs increases. The current rate of production for electric vehicles is outpacing the construction of charging stations, agencies, limiting consumers in how much they use this new technology. If IOOs take a more strategic approach to increasing the locations of charging stations, they can support and encourage investment in electric

automobiles. CFX's Environmental Stewardship Committee was established to strengthen CFX's commitment to building a world class mobility network by evaluating projects and programs so they are designed to support the responsible use and protection of the natural environment through conservation and sustainable practices.

CFX should consider providing additional EV infrastructure at appropriate buildings/parking lots and it is also recommended that they continually monitor the industry to identify good timing/opportunities for Fast DC Charging stations.

- **Increase Energy Efficiency and Conservation:** Solar energy is an alternative solution for renewable energy. Solar powered devices are now used extensively to reduce energy consumption and thereby reducing the overall total cost of ownership in many applications like traffic system control, transportation, municipal system. Recently, solar powered devices are being used to maximize efficiency and minimize energy consumption throughout transportation infrastructure.

  CFX is entering the first phase of a multi-year program to identify and explore beneficial projects that can increase sustainability throughout its roadways, facilities, and properties in Central Florida. The priority of this program is to maintain a level of excellence with the aim of providing an infrastructure that remains both environmentally and technically feasible. CFX's sustainability projects include performing additional research and implementing technologies such as photovoltaic (PV) or solar arrays, electric vehicle charging stations and electric vehicles. One project currently underway is a design-build project which will implement elevated PV modules at the Hiawassee Mainline Plaza. Additionally, CFX is implementing a functioning floating solar concept for DMS power on SR 429 at Mile Marker 11.7 Northbound.

  CFX should continue to investigate and invest in efforts that provide energy efficiency and conservation via Alternative Power Solutions for ITS devices (i.e., solar, wind, etc.).

5.5.4. Service Patrol

The Road Ranger Service Patrol provides traffic incident management response services and limited no-cost highway assistance to motorists to improve highway safety for emergency responders and the motoring public. Road Rangers provide drivers with free assistance along central Florida's toll roads, including State Road 408, State Road 417, State Road 414, State Road 429, State Road 528 and State Road 451. Currently, the Road Rangers patrol CFX's roadways seven days a week, 365 days a year from 6:00 AM to 10:00 PM and assist more than 4,000 motorists every month who need minor breakdown assistance, like a flat tire changed or gas. They also assist with traffic control at crash scenes and keep the roadways clear of debris and safe for travel.

During the Stakeholder meetings, which can be reviewed in Section 4, it was recommended for CFX to review the Road Ranger routes along SR 528 based on the needs of the SpaceCoast TPO.

5.6. Project Identification by Type and Need

To help define and prioritize projects that address the needs of CFX, both transportation and technology needs were defined separately to keep consistent with the overall structure of the ITS Master Plan. Individual project reports, the 2040 Master Plan, FY 2022-2026 5-Year Work Plan (dated 5/13/2021), the May 2021 Traffic Monitoring Report, the October-December 2020 Traffic Congestion Quarterly Update, and crash monitoring reports were reviewed. The following sections include specific projects that were highlighted related to system congestion, safety, event management, emerging and existing technologies and big data advancements.

5.6.1. Project Identification for Transportation Needs

The following needs have been identified as a part of the TSM&O evaluation process. In order to address these needs, the following categories are used to identify where the projects should be housed:

- Traffic Operations (ITS)
- Engineering and Construction
- Maintenance (Signals)

The transportation needs that were defined for this section consist of the following:

- Continued implementation of PTSU as a part of the overall 2040 Master Plan and Work Plan to continue to address recurring capacity concerns
- Continued deployment of infrastructure to support non-recurring congestion needs such as Integrated Corridor Management (ICM), Incident management and traveler information
- Development of a Work Zone Management pilot project to be incorporated as a part an upcoming construction project. Pre-Deployment crash data should be analyzed, and real time crash data maintained throughout the project duration to determine if the pilot is resulting in improvement. Real-time adjustments should be made to resolve any negative trends. Finally, an after study should be completed with lessons learned identified for future deployments.

In addition, other transportation needs were identified that were maintenance related items such as the addition of backplates to signal heads, signal retiming, protected left turn phasing and pavement markings. The projects list is shown in **Table 26** on the following page.

Table 26: Identification of Transportation Needs

TRAFFIC OPERATIONS PROJECTS

Facility	Location	Need	Strategy
SR 417	International Drive to SR 408 (MM 6-33) SR 50 to Orange/Seminole County line (MM 34-38)	Continue incident Management	ATIS technologies (DMS, HAR, CBRAS, FL511 Traveler Information System, and In-Vehicle Dynamic Route Guidance), ATMS, Incident management, ICM, and PTSU
	SR 417 at John Young Parkway SR 417 at Lake Nona Boulevard SR 417 at Narcoossee Road	Maintain Future Acceptable Ramp Intersection LOS (per SR 417 Design Traffic Technical Memorandum (DTTM))	Alternative intersection design (MUT, and displaced left-turn)
SR 408	West of I-4 (MP 0-10) Mills Avenue to Goldenrod Road/Chickasaw Trail (MP 11-17) SR 417 to Alafaya Trail (MM 18-21)	Continue incident Management	ATIS technologies (DMS, CBRAS, FL511 Traveler Information System, and In-Vehicle Dynamic Route Guidance), and PTSU
	John Young Parkway to Orange Avenue (MM 8-10)	Event management	ATIS technologies, Active Traffic Demand and Management (ATDM) and active parking management (dynamic parking guidance and reservation, dynamic overflow transit parking and dynamically prices parking)
SR 528	Tradeport Drive to Innovation Way (MM 9-19)	Continue incident Management	ATIS technologies (DMS, HAR, CBRAS, FL511 Traveler Information System, and In-Vehicle Dynamic Route Guidance), and PTSU
SR 429	Seidel Road to CR 437A (MM 11-29)	Continue incident Management	ATIS technologies (DMS, HAR, CBRAS, FL511 Traveler Information System, and In-Vehicle Dynamic Route Guidance), ATMS, Incident management, ICM, and PTSU

MAINTENANCE PROJECTS

Facility	Location	Need	Strategy
SR 417	SR 417 at Narcoossee Road	Angle crash reduction	Traffic signal system improvements (signal retiming and coordination, Flashing Yellow Arrow analysis and FYA time-of-day operations)
SR 408	SR 408 at John Young Parkway	Angle crash reduction	Traffic signal system improvements (signal retiming and coordination and adjusting the yellow and red clearance intervals)

SR 528	SR 408 at Chickasaw Trail	Left turn crash reduction	Traffic signal system improvements (signal retiming and coordination and FYA time-of-day operations
	SR 528 at Goldenrod Road	Angle crash reduction	Retroreflective backplates, traffic signal system improvements (signal retiming and coordination and adjusting the yellow and red clearance intervals.)
	SR 528 at Tradeport Drive SR 528 at Narcoossee Road	Left turn crash reduction	Retroreflective backplates, traffic signal system improvements (signal retiming and coordination, FYA analysis and FYA time-of-day operations and adjusting the yellow and red clearance intervals.)
SR 429	SR 429 at CR 437A	Left turn crash reduction	Traffic signal system improvements (signal retiming and coordination and FYA time-of-day operations
SR 414	SR 414 at US 441	Sideswipe crash reduction	Lane delineation pavement markings

ENGINEERING AND CONSTRUCTION PROJECTS

Facility	Location	Need	Strategy
All Facilities	Systemwide	Reduce crashes related to construction zones	Smart Work Zones

5.6.2. Project Identification for Technology and Data Needs

ITS Device/Replacement Projects

The following maintenance projects noted in **Table 27** below are recommended based on the life span discussed previously.

Table 27: Recommended Maintenance Projects

Device/Equipment	Project	Recommended Project Year
Closed Circuit Television Cameras	Replacement/Upgrade	2027
3-Line Dynamic Message Signs	Replacement/Upgrade	2035 (If appropriate)
2-Line Dynamic Message Signs	Replacement/Upgrade	2031
Traffic Monitoring Station	Replacement/Upgrade	2021
Wrong Way Driving Detection Devices	Replacement/Upgrade	2025
Remote Power Management Units	Replacement/Upgrade	2024
UPS System	Replacement/Upgrade	2023
UPS Batteries	Replacement/Upgrade	2026
Switch Replacement	Replacement/Upgrade	2023

Note: Server maintenance and replacement is currently handled as a part of the IT Department. Should this arrangement change, additional costs for server maintenance would be required.

Connected Vehicles and Data Related Projects

CFX has done an exceptional job at keeping its network and computer hardware and software platforms up to date through its 5-year work plan equipment replacement initiatives. To that end, as CFX continues to grow its CV and Data program through various future projects, there will be a need for CFX to re-evaluate its computer network hardware needs. The need for data, bandwidth, cloud access and security will all play a role in the future deployments or upgrades needed in order to support the growth of the ITS system.

It is recommended that CFX conduct a network/cybersecurity reassessment project every 2-3 years (beginning prior to the integration of the initial CV deployment) to gauge existing communications network needs, forecast future needs and assess threats from that period to stay ahead of ever-changing technology. This will ensure CFX's communications network has the capabilities to support any future CV and/or data projects desired without technological delays and remains secure. Currently, the core routers are approaching end of life and a suitable replacement should be identified.

The Connected Vehicle and Data related technology needs are categorized into three main project classifications.:

- CV Needs Assessment/Data Needs Assessment (These efforts can be combined)
- Big Data Pilot (CFX Data/Potentially Leveraging Regional and Statewide Efforts)
- CV Deployment Pilot

As discussed earlier, CV saturation can reasonably be expected to be at 10% by 2026. Therefore, completing the following schedule is recommended:

- CV Needs Assessment/Data Needs Assessment completed by 2024
- Big Data Pilot (CFX Data/Potentially Leveraging Regional and Statewide Efforts) completed by 2026
- CV Deployment Pilot completed by 2026

With the existing and known data needs identified within CFX's previous CV assessment, the focus as it relates to next steps may be shifted to data policy and governance, data and application maintenance, as well as evaluating strategies for continued planning and incorporating testing technological advancements. This will be the foundation for helping to identify future connected vehicle pilot project(s) and big data project(s). Initial steps include the following recommendations:

1. Conduct an evaluation of existing data standard and approaches for filling the data gaps based on the identified needs and applicability.
2. Schedule CV pilot project deployment with CV-ready applications identified as mission and safety-critical to CFX.
3. Create and implement effective and efficient data management strategies which allow for reporting, planning and data sharing efforts.

A more detailed table which describes each of the above-mentioned three (3) recommendations is provided in the Appendix for review.

Additional Emerging Technology Projects

Additional long-term projects that should be considered in the future are pilot projects using AI and Computer vision emerging technologies. These emerging technologies should be tested based on CFX's

goals and needs as well as evaluated for applicability and impacts of less hardware centric solutions. Examples of potential pilot projects are:

- Auditing of deployed equipment
- Near miss hotspots
- Data management and strategy for handling AI and computer vision data
- Identification of new performance measures using AI and computer vision data

5.6.3. Project Identification for Other Needs

Sustainability Projects

Sustainable transportation consists of the efficient use of existing resources to increase mobility while positively impacting economic development, quality of life, and the preservation of the natural environment. CFX's Sustainability Study identifies the existing sustainable transportation initiatives in the region and develops strategies to improve the sustainability of the regional transportation system within the Orlando area and vicinity.

The pilot projects identified as well as the top site recommendations (based on shorter payback periods) within this sustainability study are as follows:

- Ground-Mounted PV Solar:
  - Nine electric meters with high consumption were identified as suitable net-metering opportunities for CFX.
  - Top site recommended choices are Coral Hills, University and John Young Mainline Plazas.
- Floating PV Solar (wet pond):
  - Twenty-four electric meters with high consumption were identified as suitable net-metering opportunities for CFX.
  - Top site recommended choices are Boggy Creek and Pine Hills Mainline Plazas and the meter located at J Lawson BLVD.
- Elevated Pond PV Solar (dry pond):
  - Twelve electric meters with high consumption were identified as suitable net-metering opportunities for CFX.
  - Top site recommended is the Conway West Mainline Plaza.
  -
- EV Charging Station:
  - CFX has 13 total parking lots between 12 toll plazas and 1 Headquarters. To maximize utilization, it was recommended that CFX expands the current infrastructure to accommodate additional PEV charging stations.
- Fleet Vehicle Analysis:
  - Based on the overall total cost of ownership and environmental benefits, it was recommended for CFX to replace all internal combustion engine (ICE) fleet vehicles with plug-in electric vehicle (PEV) over a determined life cycle. The life cycle should be determined based on mileage, age, maintenance, and the availability of a comparable PEV.

Based on this study, six Sustainability projects implementing photovoltaics (PVs) and renewable energy sources to the system were identified in the 2022-2026 Work Plan with one project currently underway. This project was identified as a design-build project which will implement elevated PVs at the Hiawassee

Mainline Plaza. It is recommended for CFX to review the top site recommendations for each proposed pilot project to address any existing sustainability needs. This study can be referenced in the Appendix.

Efforts to reform our dependency on fossil fuels and develop methods of harnessing renewable power sources have given rise to Alternative Power Solutions. These solutions are currently being explored by CFX to ensure a sustainable transportation system by powering ITS devices via alternative methods such as solar or wind. It is recommended that CFX continues to explore these projects as technology expands.

It is also recommended that CFX continues development of sustainability solutions such as Smart Power Metering. This concept entails installing a monitoring device at every load center to monitor impending voltage. This device will contain separate monitors for each breaker and can be added to the existing network to monitor the voltage on each breaker. If there is a voltage drop or spike, a trigger warning would be initiated when outside of determined thresholds. For safety purposes, this device can be remotely accessed to verify that the breakers are off during maintenance.

5.7. Staffing Analysis

One of the major goals of an ITS Master Plan is to proactively manage the operations of all regionally significant transportation facilities within the CFX planning area for all users. The best way to ensure the realization of this goal is to have proper staffing and procedures in place when deploying ITS improvements.

5.7.1. Existing Operations and Maintenance Staffing

A goal of all operating agencies is to ensure that the roadway system be properly operated and maintained. The best way to ensure the realization of this goal is to have proper Operations and Maintenance (O&M) staffing and procedures in place when deploying ITS improvements. However, before determining additional staffing needs, it is important to ensure that the current staffing levels are adequate for existing duties, see organizational chart in **Figure 39** below. It should be noted that CFX has in-house staff but is also supported by contractor and consultant services contracts.

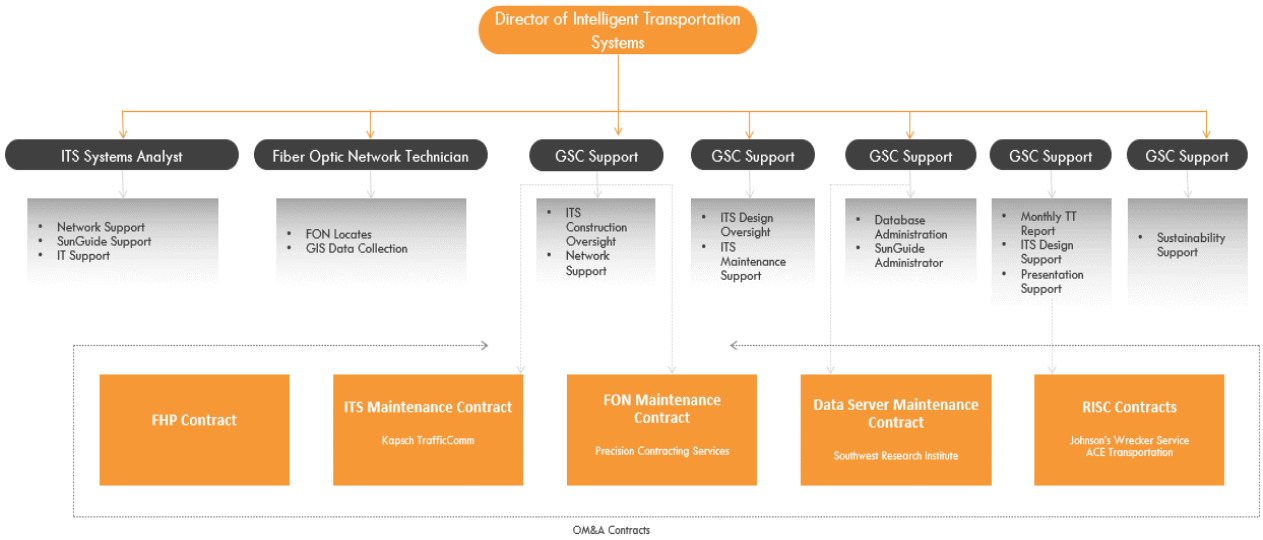


Figure 39: CFX Existing ITS Organizational Chart

Due to the flexibility of CFX's consultant and contractor services contracts to adjust as required by workload, it is recommended that a Data Analyst Position be considered as an existing need at this present time. Based on the following subsections, additional positions may also be required in the future.

5.7.2. Connected Vehicle and Data Staffing Considerations

Knowing that CV technology is constantly changing, it is important to realize that appropriate skillsets are needed to understand and to facilitate the technology's moving components. Some high-level considerations are identified below:

1. **Big Picture Vision** - Understanding the CV deployment scope, direction, and the ability to plan with consideration for existing systems that may affect, impact, or work with the planned CV devices. Understanding the communication between various systems and developing a system workflow/architecture. For example, determining how to integrate CV with existing or planned external programs and/or applications for example roadway weather sensors.
2. **Technological Skills** - Advanced Information Technology (IT), networking and system management experience to be able to connect all system devices for a functional CV environment and having the ability and resources to test the equipment from project inception. System connectivity will involve computer hardware and software, connecting the roadside units (RSU), onboard units (OBU), data management and metrics tools, networking, and security components to name a few.
3. **Communication and Relationships** - Establishing and maintaining relationships with vendors to continue with their support and system upgrades/updates to firmware on their CV devices. Additionally, the ability to identify stakeholders and establish agency roles within a coordinated network of roadways and other infrastructure.

To identify the necessary staff to support CV and Data deployment and maintenance tasks, a bottom-up approach is used to identify a project by its various phases. From inception to completion, the following project phases are identified:

1. Project Planning
2. Plan Design
3. CV Device Specifications Development
4. Equipment Testing
5. Software Development
6. Database Design
7. CV Integration
8. Deployment Testing
9. Operations and Maintenance (O&M)

The following staffing positions have been identified to support the various project phases noted above:

- CV Project Manager
- Operations Manager
- Software Engineer
- Network Engineer

- GIS/Data Analyst
- Senior ITS Technician
- TMC Operators
- External Resources and Support (Consultants, Vendors, Universities)

Please note that although multiple positions are listed, not all of these positions are necessarily additional positions. In some cases, existing positions could simply take on CV duties. For instance, the CV Project Manager role can be served by the existing ITS Project Manager and the Software Engineer role can be served by the existing Software Programmer/Database Administrator (DBA) role. Potential and additional supporting roles may be considered as CFX's CV program expands. In addition, cross-utilization of existing resources and experience may consolidate the described staffing positions:

CV Project Manager

The CV Project Manager is a dedicated position and should have a high-level/general understanding of the CV technology and be able to recognize the positions that are needed for a successful CV deployment. At a minimum, some of these needed positions are outlined and described in this document. The experience needed of a CV Project Manager essentially comes from understanding the workflow and steps by reviewing existing deployments, lessons learned documentation as well as the provided United States Department of Transportation (USDOT) deployment documentation, reviewing and/or participating in webinars, or by participating in hands-on equipment testing and vendor trainings. This is primarily due to the new and emerging world of CV technology and CV requirements. To date, most CV Project Managers are working with the vendors for full testing and deployment support and are learning “along the way”.

This position requires strong communication skills with the ability to coordinate with stakeholders and other agency partnerships to promote a regional and coordinated CV program. Knowledge of existing and emerging CV technologies are beneficial. It is important for the CV Project Manager to understand the existing agency resources, available funding, and to have the support of their management. This position will manage a team of professionals throughout all project phases, will be involved in the development of Scopes of Services, will be the point of contact as the agency resource, and will manage schedules and budgets.

Operations Manager

In this case, the Traffic Management Center (TMC) Manager will be described as an Operations Manager, supported by the Florida Department of Transportation. Position duties will include the management of the day-to-day operations within the TMC as well as the management of the TMC operators. TMC responsibilities may also be expanded to include RSU health status monitoring and reporting system failure to appropriate management or technicians for resolution.

Software Engineer

With the development of CV applications and plans to deploy CV equipment, this position may require coordination with CV vendors to understand how the vendor-provided software [Commercial Off-The-Shelf (COTS)] and open-sourced applications are built and coded on the back end. In most cases, RSU firmware is built upon the Linux platform. The Software Programmer may contribute to updating or building upon existing applications and programs once the product is turned over from the vendor.

This position will have Database Administrator (DBA) experience which includes database design, installation, configuration and performance, health monitoring and will coordinate with IT on data backups and/or data recovery as needed.

Network Engineer

This position will work closely with the Software Engineer/DBA. The Network Engineer must ensure that the communications infrastructure is performing at a high level and will communicate with users as needed. Experience with performing network diagnostics and monitoring is needed.

GIS/Data Analyst

The duties of the GIS/Data Analyst will include analyzing, formatting, and performing metrics on the information and data being stored. This information may be used for data comparison, verification or for future planning efforts to promote safety, mobility, and environmental benefits. Additionally, duties may include collecting and parsing data, patterns, and trend determinations, monitoring gains and identifying new uses for the data. The Data Analyst will ensure the quality and accuracy of the data and will work with the Software Programmer to develop methods of data reporting and data presentation. During the initial data collection and analysis project phase, CFX may work with the Universities to aid in the data analysis tasks.

Senior ITS Technician

This position applies knowledge of ITS and Tolling Operations technologies to support integration activities on transportation technology deployments. This position includes the installation, maintenance, testing, troubleshooting, and repairing of all transportation technology equipment to include ITS devices, Tolling Operations and/or the Traffic Signal Network. This position is expected to carry out extensive job functions within project-oriented, multidisciplinary teams of technology professionals and supports direct interaction with clients.

TMC Operators

The TMC Operator will work with cutting edge technology including those related to CV, freeway management, express lanes and more. Operators will monitor and manage the roads, operate, and control traffic management devices such as CCTV, DMS and other equipment for traffic monitoring.

External Resources and Support

It is anticipated that vendor, academia, and consultant support will be needed, especially during the initial stages of testing and deployment. The development and uploading of the Map Data Messages (MAP) for the RSUs, facilitating software updates, running security protocols, initial configurations, interfacing with the back-end programming platform (Linux) or Graphical User Interface (GUI) if one is available - are just some of the support services provided by the vendors. With the equipment physically available locally and set-up to be tested, the vendors can provide remote access into the equipment to configure and demonstrate functionality. This is useful especially for those vendors that are not local. It is recommended that if these services are handled remotely, the procedures/steps are recorded for future reference and continued testing.

Staffing assignments by their respective project phases are depicted in **Figure 40,** shown below.

Figure 40: Staffing Considerations by Project Phase

5.7.3. Updated Staffing Considerations

Using salary information for comparable positions in the State of Florida and the recommended staffing for CFX, the following staffing considerations were identified in **Table 28** on the following page. It should be noted that in discussions with the current TMC Managers a second operator in the AM and PM Peak hours may be needed for PTSU.

Table 28: Recommended Staffing Guidelines

Position	Existing Staff	Current Recommended Staff	Future Additional Recommended Staff	Average Pay	Average Pay (with 2.2 multiplier)	Total Proposed Cost	Total Proposed Cost (with 2.2 multiplier)
Traffic Engineering Operations Manager	1	1	0	$125,000.00	$275,000.00	$0.00	$0.00
ITS Systems Analyst	1	1	0	$80,000.00	$176,000.00	$0.00	$0.00
Network Engineer (Consultant)	1	1	0	$97,450.00	$214,390.00	$0.00	$0.00
Network Technician	1	1	0	$54,500.00	$119,900.00	$0.00	$0.00
ITS Contract Manager (Consultant)	1	1	0	$83,200.00	$183,040.00	$0.00	$0.00
Software Programmer / DBA (Consultant)	1	1	0	$101,400.00	$223,080.00	$0.00	$0.00
**ITS Maintenance (Contractor)	1	1	0	$67,206.10	$147,853.42	$0.00	$0.00
PTSU Operator	0	2	2	$29,120.00	$64,064.00	$58,240.00	$128,128.00
Data Analyst	0	1	1	$54,080.00	$118,976.00	$54,080.00	$118,976.00
ITS Project Manager (Consultant)	0	1	1	$120,536.00	$265,179.20	$120,536.00	$265,179.20
					Total	**$232,856.00**	**$512,283.20**

Notes:

*All RTMC Operations are managed by FDOT D5. One operator is dedicated to CFX during peak hours. A second operator will likely be added for PTSU during the AM and PM peak hours.

**ITS Maintenance is currently handled by a Contractor. The average pay reflects average pay per employee.

***At this time, as needed CFX has use of a GEC as well as multiple consultant contracts and brings in resources as necessary.

5.8. Project Costs

The following project costs have been developed for the projects discussed in the previous sections.

5.8.1. Capital Improvement Costs

ITS Equipment and Infrastructure

Due to the breadth of the recommended ITS improvements throughout CFX's infrastructure, the Master Plan has recommended a number of deployments of varying sizes and costs. There are a number of items included regarding capital improvements to make sure all deployments function as efficiently as possible.

The capital cost unit prices used for these calculations were obtained using the FDOT Six Month Moving Statewide Average prices (09/01/2020 – 02/28/2021), 12-month averages (03/01/2020 – 02/28/2021) and CFX project bids. For reference, pilot projects were also taken into account to determine an average cost for each determined pilot project. A connected vehicle pilot should consider: conducting a CV and data needs assessment, evaluating incident data for viable project limits, readiness for big data management and identification of some preliminary and high-level cost associated with these efforts. In addition, as a part of the capital cost, a 10% mobilization cost, a 10% cost for MOT for all subsequent deployments, a 10% cost of design, and a 20% contingency cost have been included for all deployments.

Table 29 on the following page details each project and its estimated costs:

Table 29: Capital Costs per Project

TRAFFIC OPERATIONS PROJECTS (ITS)			
Project	**Location**	**Estimated Costs**	**Notes**
Event Management			
Smart Parking	John Young Parkway to Orange Avenue (MM 8-10)	$150,000	Avg. per parking garage
Work Zone Management			
Smart Work Zone Pilot Project	Systemwide	$1,650,000	Avg. based on pilot projects
Connected Vehicle and Big Data Projects			
Network/CyberSecurity Reassessment	Systemwide	$50,000	Every 2-3 years
CV and Data Needs Assessment	Systemwide	$200,000	
CV Deployment Pilot Projects	10 Pilot Locations TBD	$500,000	
Big Data Pilot Projects	Systemwide	$500,000	
AI and Computer Vision Pilot	Systemwide	$1,000,000	
Smart Power Metering	Systemwide	$675,000	
Alternative Power Solutions	Systemwide	$500,000	
CV Technology Deployment Projects (later year investment)	Systemwide	$2,600,000	
Transportation Technology Projects			
WWD Expansion/Deployment Projects	Systemwide	$5,300,000	
	Total Project Cost:	**$13,125,000.00**	

Notes:

- PTSU: Handled as part of larger projects per the 2040 Master Plan and 2022-2026 Work Plan and not associated with cost per the CFX ITS Master Plan.
- Continued Incident Management: Ongoing efforts as part of the RTMC Operations, D5 ICM contract, R-ICMS, etc. Therefore, no additional costs will be noted at this time.
- CV pilot project considers cost incorporating 10 RSUs with CV modules
- Smart Work Zones are typically built into the Construction Budget. However, a pilot project is recommended and may be separate.
- Sustainability projects are identified separately in the CFX Sustainability Study.

5.8.2. Operations and Maintenance Costs

The existing costs were determined by utilizing annual operations and maintenance costs contracts to determine the average dollar amount spent yearly. Through an agreement with CFX, the RTMC also provides traffic management operations for all Expressway owned roadways. Therefore, no RTMC operations costs were factored in. Moving forward CFX will need to consider implementing a standalone Maintenance Contract for the PV deployments currently underway.

The following are the Operations and Maintenance costs for the ITS System. See **Table 30** below.

Table 30: Operations and Maintenance Costs Per Year

	OPERATIONS & MAINTENANCE				
	DESCRIPTION	UNIT	QUANTITY	UNIT COST	COST
EXISTING	ITS Device Maintenance	LS	1	$1,800,000.00	$1,800,000.00
	FON Maintenance	LS	1	$110,000.00	$110,000.00
	Data Server Maintenance	LS	1	$450,000.00	$450,000.00
	RISC Contracts	LS	VARIES	VARIES	$50,000.00
	Network Licensing & Support	LS	1	$120,000.00	$120,000.00
				TOTAL O&M COST PER YEAR	**$ 2,530,000.00**

	OPERATIONS AND MAINTENANCE PROJECT	UNIT	QUANTITY	UNIT COST	COST
FUTURE	*PV Maintenance	LS	1	$50,000.00	$50,000.00
	**ITS Device Maintenance	LS	1	$400,000.00	$400,000.00
	**PTSU Licensing & Support	LS	1	$30,000.00	$30,000.00
				TOTAL ADDED FUTURE COST PER YEAR	**$480,000.00**

Notes:

- *To be determined as a part of the Sustainability Program
- **Estimated increase for future PTSU devices

5.8.3. Life Cycle Costs

Optimal efficiency of all ITS equipment is essential to the success of a transportation network. As such, it is necessary for the region to plan for technology upgrades as they become available. **Table 31** on the following page shows a summary of all costs associated with the various life-cycle replacements.

Table 31: Life Cycle Replacement Costs

ITS/Operations Project Descriptions	Unit	Quantity	Unit Cost	Cost
Vehicle Detection System - AVI, Bluetooth, F&I, Cabinet Equipment	EA	188	$7,500.00	$1,410,000.00
Vehicle Detection System – AVI, Bluetooth, F&I, Above Ground Equipment	EA	188	$9,500.00	$1,786,000.00
Traffic Monitoring Site Speed/Classification Unit, Furnish & Install, Volume Speed and Classification	EA	447	$6,100.00	$2,726,700.00
Vehicle Detection System - Wrong Way	EA	53	$75,000.00	$3,975,000.00
Remote Power Management Unit - RPMU, Furnish and Install	EA	1,083	$581.88	$630,176.04
Managed Ethernet Switch, Furnish & Install	EA	80	$3,214.52	$257,161.60
Video Wall Controller	EA	1	$150,000.00	$150,000.00
Media Server - Translates Video Compatible to iOS And Android Mobile Format	EA	1	$5,000.00	$5,000.00
Network Equipment	EA	1	$300,000.00	$300,000.00
			TOTAL COST	**$11,240,037.64**
		Mobilization	**10%**	$1,011,503.76
		Maintenance of Traffic	**10%**	$1,011,503.76
		Completion of Design	**10%**	$1,011,503.76
		Design Costs	**10%**	$1,011,503.76
		Contingency	**20%**	$2,023,007.53
			GRAND TOTAL	**$17,984,060.22**

***Note:** DMS' are not included due to lifespan of equipment (10-15 years). Costs are expected to fluctuate within that timeframe and there are potential questions related to the viability of equipment after the implementation of CV technology.

5.9. Opportunity Cost and Benefit/Cost Ratio

Opportunity Cost

To demonstrate the powerful effects of ITS improvements, an opportunity cost has been calculated. Opportunity cost is defined as the cost of NOT implementing the recommendations. In this case, this will represent the cost to the traveling public should ITS improvements not be put into place or, alternatively, the savings that will be created by avoiding the effects of crashes through implementing the improvements. Research was performed by looking at previous studies as well as a review of the Crash Modification Factors Clearinghouse website[13] to determine crash reduction factors for several of the improvements recommended such as the Smart Work Zone pilot project, signalization improvements, installation of signal head backplates, signing/striping pavement improvements and Smart Parking improvements. It was determined that approximately 13% to 20% of the overall crashes have traditionally been reduced by implementing these types of strategies. Given that CFX's system is mature and some ITS benefits have been realized, a crash reduction factor of 15% was used for this analysis. The following opportunity costs, in **Figure 41** below, were considered in this Master Plan:

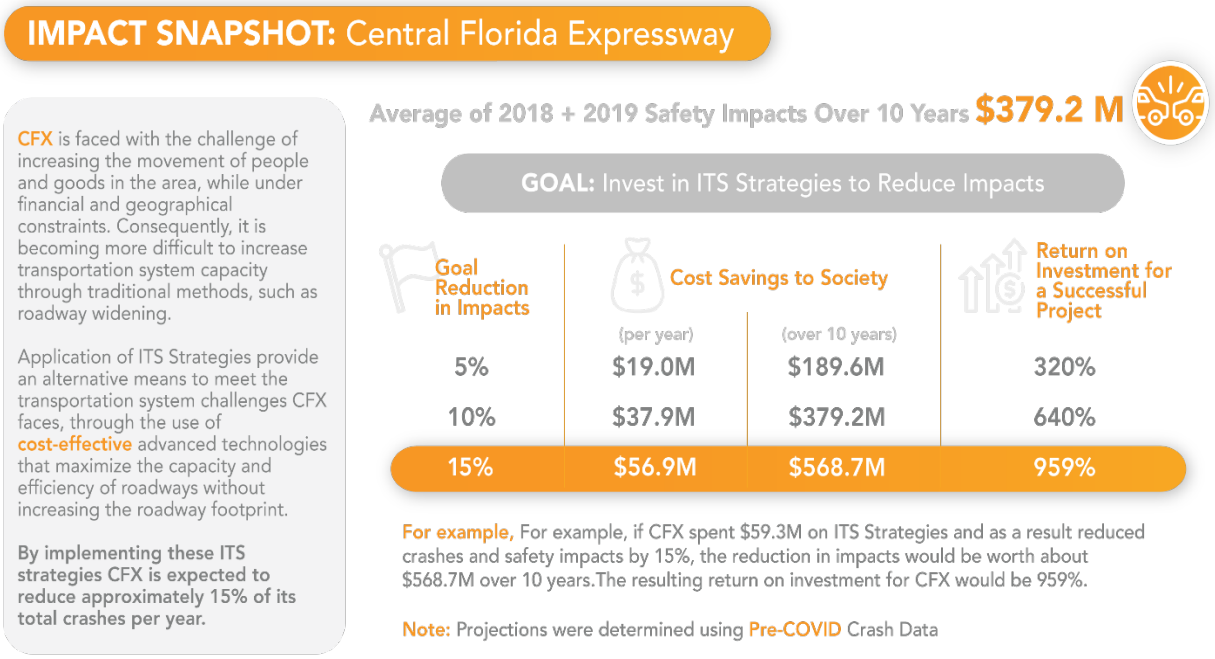


Figure 41: Impact Costs and Savings to Society

The total opportunity cost for all users of the transportation system based on an average of the 2018 and 2019 crash reduction (pre-COVID) and a 15% crash reduction factor is $568,747,320.00 over 10 years. This cost was obtained by utilizing FDOT's crash costs based on severity type. See Appendix for a full breakdown of the opportunity costs.

[13] http://www.cmfclearinghouse.org/

Benefit/Cost Ratio

A benefit to cost ratio demonstrates the public benefit of all deployments. This measure quantifies the benefit to the traveling public in dollars and then the dollar benefit the public receives for every public dollar spent, in this case the dollar amount saved by the taxpayers for every tax dollar spent. This ratio is essential in demonstrating how vast the positive effects of the ITS improvements are when lining up funding for capital improvements, and, most importantly, O&M funding. It is calculated by dividing the 10-year opportunity cost savings by the total Master Plan improvements cost. The benefit/cost ratio is shown in the equation below:

$$\frac{\$568,747,320.00}{\$59,289,060.22} = \mathbf{9.59}$$

Ultimately, this ratio demonstrates that ITS improvements are an extremely effective investment of funding for transportation purposes.

5.10. ITS Standards Recommendations

The purpose of this section is to document standards that either need to be implemented or should at least be considered in order to facilitate a resilient and maintainable system as well as to continue providing connectivity of CFX with other regional stakeholders. The fundamental goal is to allow for connectivity and resource sharing while also allowing CFX to maintain control over their specific systems.

It is important to recognize that technology is ever changing and advancing, therefore the ITS Standards Recommendations section of the CFX ITS Master Plan should be considered a "living document" and should be updated whenever new devices, software or technologies are added to the System.

5.10.1. ITS Maintenance Standards

Although deployments vary greatly in size and features throughout the region, continuing to provide standardized maintenance procedures and processes will allow the ITS system to continue to function at a high level.

The following items represent the minimum items needed to provide consistency of maintenance throughout the CFX system. CFX currently provides the majority of these requirements and should continue to do so as needed.

Documentation

- Preventive Maintenance Plan with activities to include maintenance of the following at a minimum:
  - ITS Cabinet interior
  - Edge/Cut grass and remove weeds/dirt around ITS cabinets, structures, power services, etc.
  - Vehicle Detectors – Cameras, radar, Bluetooth, etc. - per manufacturer's recommendations
  - DMS - per manufacturer's recommendations

- CCTV cameras - per manufacturer's recommendations
- UPS units - per manufacturer's recommendations
- Vehicular Signal Displays - per manufacturer's recommendations

- Standard Operating Guidelines which cover the following areas at a minimum:
  - Preventive Maintenance Activities and Guidelines
  - Routine Maintenance Activities and Guidelines
  - Emergency Maintenance Activities and Guidelines to include on-call duties.
  - Spare Quantities of Replacement Items
  - Tracking Software Maintenance Agreements/Product Licenses and Renewals and Device Warranties
  - Inventory Management Processes and Procedures
  - Staff Positions and Organizational Chart

Software

- The following specialized software packages should continue to be provided by CFX for use by their contractors and consultant personnel to promote consistency throughout the system:
  - Maintenance/Inventory Control Software which can provide the following capabilities:
    - Create and track maintenance work orders
    - Create/read inventory tags (barcodes)
    - Input unique information within the database to describe the item being inventoried.
    - Ease of access and user-friendly interface to input items and update their location.
    - Report generation for inventory, location of inventory, performance measures, etc.
  - Fiber Management Software – GIS based tool to track existing fiber optic cable assets.
  - Data Server
    - Travel Time Software System
    - Data Collection Server Status Page
    - Dynamic Message Signs Status Page
  - Daily TMS Reports
    - Real-time and archived speed and volume reporting data
  - Device specific maintenance and troubleshooting software
    - DMS manufacturer software
    - Vehicle Detection equipment manufacturer’s software
    - CCTV manufacturer’s software
    - Wrong Way Driving manufacturer's software
    - Network performance monitoring

Equipment

- Maintaining field devices and communications infrastructure requires the use of specialized tools/equipment. CFX should consider requiring their ITS Maintenance Contractor to have the following items available for the use of their personnel if this requirement is not already in place:
  - Ruggedized laptops which can stand up to harsh work environments.

- Smartphone with cellular hotspot for updating inventory and other asset information real-time.
- Fiber optic cable testing equipment to include an Optical Time Domain Reflectometer (OTDR), and visual fault locator at a minimum.
- Fiber optic splicing equipment to include environmentally controlled splicing van/enclosure, fusion splicer with heat oven, and fiber cleaver.
- Continuity and Cat 5/6 cable tester.
- Telecommunications tools for stripping and terminating various types of cables/wires.

5.10.2. ITS Operations Standards

This section describes the various types of operations activities related to limited-access expressway systems and the responsibilities for CFX and local agency personnel assigned to operate these systems.

Typical Operations Activities include the following at a minimum:

- ITS Device System Monitoring and Reporting
- Roadway Monitoring and Reporting
- Event Management
- Performance Monitoring
- Staffing Requirements

Day to day operations of the system and ITS devices throughout CFX are the responsibility of the owner agency, unless otherwise documented by MOU or other agreement. It should be noted that there is an agreement between CFX and FDOT D5 which allows all TMC operations to be currently managed by FDOT D5. Daily activities must be centered on utilization of the tools available to operations personnel. Through the analysis of real-time and historical data, adjustments can be made to the various arterial systems to best utilize the available devices and to achieve the highest performance measures possible, which, in turn, increases the Return on Investment (ROI). The quality of performance data is one of the most important factors to the success of the program.

The field components of the Traffic Management system can include the following hardware: CCTV cameras, Dynamic Message Signs (DMS), vehicle detectors/Automated Vehicle Identification (AVI), (TMS, Bluetooth, LPRs, etc.), and associated network equipment. Software and/or web-based programs for the TMC will vary by agency but can include vendor specific control software, SunGuide, 511, and third-party data feeds such as Nokia, Inrix, Waze, Google, etc.

Standard Operating Procedures (SOPs), documenting policies and procedures, must be established to deal with every aspect of the duties of the staff in an effort to maximize the benefit of the hardware and software available. The SOPs must dictate how the system is utilized during normal traffic situations, increased congestion due to non-recurring events, and incidents. All personnel within the TMC must be aware of and familiar with the SOPs regarding their position. It is understood that FDOT has SOPs that can be leveraged for use by CFX. Additionally, it should be noted that a separate SOP will be created for PTSU.

The objectives of the SOPs include but are not limited to the following:

- Maintaining the health of the Roadway System

- Reducing the impact and occurrence of recurring congestion on the arterial roadway system
- Real-time adjustments to accommodate special events and construction
- Maximizing the operational safety and efficiency of the traveling public while using the limited-access expressway system
- Providing motorists with the information necessary, (through tools such as 511, Arterial Dynamic Message Signs, Highway Advisory Radio, social media, etc.) to aid them in making the appropriate route choices.
- Intra-agency communication with law enforcement, the District 5 Freeway Management RTMC, as well as adjacent local agencies for coordination, as necessary, of events that can impact their roadways.

5.10.3. ITS Device System Monitoring and Reporting

The ITS Maintenance Contractor performs daily device checks on ITS Field devices (CCTV, DMS, TMS, AVI, etc.). In addition, the RTMC provides consistent device checks during each shift. This should include verifying the status of the device on the TMS software and sending/receiving commands to the device as applicable. For DMS, the closest CCTV camera should be used to verify that the correct message is being displayed during each device check and upon posting a new message. If a device is being shown in an error state on the TMS software, the operator can check to see if the switch at the device site is communicating with the network. If the device is not responding properly to the operator's commands or not receiving any communications, Maintenance and/or Network personnel should be notified for further troubleshooting.

Please note that FDOT SOPs are currently being followed by CFX and cover these expectations. It is recommended that CFX continue to perform these checks as a part of their existing procedures.

5.10.4. Roadway Monitoring and Reporting

Vehicle Detection zones and/or travel time segments should be monitored constantly on the traffic management system or third-party data feeds and all CCTVs within the system should be checked, at a minimum, every 30 minutes. When reduced speeds are detected by means other than CCTV viewing, the nearest CCTV camera should be used to attempt to find the cause. Once the operator discovers the cause of the traffic slow-down they should enter the pertinent information into the Event Log. Once logging the initial information, the operator should begin disseminating information to motorists, first responders, and others as appropriate. This is further detailed in the following sections.

Available DMS should be used to provide information regarding incidents and congestion to motorists prior to them encountering the issue. This information is provided by posting a succinct message on the DMS to provide the motorist with relevant information. DMS messages are stored in a library on the CFX software system for ease of use by the operator. The structure and content of the developed DMS library matrix should be based on using the DMS for dual phase messaging. The message content must contain enough information to enable the motorist to make an informed decision, while still fitting on the sign, and whenever possible, there should be a uniformity to types of messages. Any abbreviations should be clearly understood, otherwise, it defeats the purpose of the message.

Operators should also provide incident and congestion information to motorists using the Florida 511 system, Twitter, or other social media forums, as per agency protocol. Similar to DMS messages, these messages should be succinct without adding extraneous information or details. Operators must be aware that this information may be passed along to others via word of mouth or social media and only include relevant facts.

All activities performed relating to the incident must be documented on the event log. This includes, persons/agencies contacted, messages posted to DMS/511/Social Media, event responder arrival and departure times, lane blockage, injuries, vehicles involved, Hazmat, etc. The use of event logs proves beneficial for performance measures reporting, after action reports and other documentation as needed.

Please note that FDOT SOPs are currently being followed by CFX and cover these expectations. It is recommended that CFX continue to monitor and report these findings as a part of their existing procedures.

5.10.5. Event Management

Event Management can be classified as planned and unplanned events. Planned events include such things as normal recurring congestion, roadway construction/maintenance and special events. Unplanned events include incidents and activities that the RTMC were not previously aware of including roadway construction/maintenance, special events, natural disasters, etc.

Planned Events

Local Agencies benefit from relationships with Major Special Event Coordinators, local roadway construction and maintenance agencies, as well as requesting (if not already receiving) information from CFX about planned construction and special events.

For planned roadway construction/maintenance or special events, when made aware, the operator or supervisor should make note of the event and provide the information to the personnel who will be on duty the day of the event. The CFX PIO may distribute a weekly construction debrief, and this can be used as advanced notice as well. If the construction is blocking a shoulder, use discretion on whether or not the incident needs to be reported. Information should be disseminated through all sources available, including, but not limited to DMS, 511, social media or other information dissemination methods. The local agency should attempt to get regular updates so that dissemination to the motoring public can be updated in a timely fashion.

For instances of recurring congestion, congestion should be monitored frequently to determine severity and check for rear end crashes. It is also a good practice to compare the congestion on a weekly and monthly basis to determine if the congestion is getting worse.

Please note that FDOT SOPs are currently being followed by CFX and cover these expectations. It is recommended that CFX continue to coordinate special events as a part of their existing procedures.

Incidents

Identify incident details through CCTV, Emergency Responder Agency contacts and other sources. When an incident is confirmed by sources outside of the local agency, gather details from available CCTVs and notify the appropriate agencies, including but not limited to, local police, fire/rescue, etc. If the incident results in a full directional closure, coordinate with adjacent Local Agencies that could be impacted by the closure. It may be beneficial, when CCTV images are available, to take screenshots of the incident and associated lane blockage and congestion for future analysis. Disseminate the traffic related information to the public via any available means, including, but not limited to, DMS, 511, social media or other information dissemination devices. Closely monitor the situation and update other Stakeholders as conditions change. Equally important to posting incident information promptly is to remove it promptly when the incident is cleared, and traffic conditions have returned to normal (for time of day).

Please note that FDOT SOPs are currently being followed by CFX and cover these expectations. It is recommended that CFX continue to perform these checks as a part of their existing procedures along with considering the use of Automated Incident Detection software to determine incidents.

5.10.6. Performance Monitoring

Performance monitoring must be in place to determine the effectiveness of the limited-access expressway system components, infrastructure, and operations program as a whole. By monitoring various aspects of the system and operations program, management staff can determine where available budget can be best utilized and where additional funding may be required.

In addition, Incident Response and Traffic Incident Management Information can be tracked to show adherence to Florida's Statewide Open Roads Policy. The time of initial identification of the incident, as well as the time that all travel lanes were opened allows tracking of the Roadway Clearance Duration. Additionally, operators should track notification times, arrival times, and departure times of incident responders to determine their response times and on-scene times. This type of information can be used to demonstrate the need for more emergency personnel or additional fire houses, etc.

Please note that FDOT SOPs are currently being followed by CFX and cover these expectations. It is recommended that CFX continue to monitor roadway performance as a part of their existing procedures and also consider utilizing Automated Incident Detection software to assist in detecting incidents.

5.10.7. Data Standards

Data standards are a set of rules that govern how data is described, formatted, and recorded. This facilitates how data is shared, exchanged and what it represents. Data Standards establish guiding principles from the acquisition of data, how the data is to be managed, data quality, maintenance cycle, data metadata, and how data should be retrieved and made available for use. Standards provide data integrity, enables its use with accuracy, and documents business rules that can lead to minimized redundancy. Seamless data exchange allows for increased interoperability of systems, stakeholders inside and outside of an organization leading to more efficient processes.

When collecting, exchanging, or sharing data, standards are highly encouraged to be used where applicable. There are multiple data standards currently available. Examples include:

- ***For GIS data:***
  USGS National Geospatial Program Standards and Specifications, FGDC National Data standards Publications, ISO, and US Integrated Taxonomic Information Services (ITIS)

- ***For ITS:***
  TMDD, ARC-IT, ASTM E2259 – 03a(2011) Standard Guide for Archiving and Retrieving ITS-generated Data

- ***For Connected Vehicles:***
  SAE J2735 Dedicated short Range Communications (DSRC) Message Set, SAE J2945/1 Onboard Minimum Performance Requirements for Vehicle-to-Vehicle (V2V) Safety Communications, and IEEE 1609.2-2016 Standard for Wireless Access in Vehicular Environments (WAVE) – Security Services for Applications and Management Messages. SAE J3217 Tolling Applicant Message.

As the transportation industry evolves and emerging technologies increase the volume and variety of data influx, is paramount establishing data governance processes and data standards for organizations and agencies to exchange data. Data standards ideally should be set at the enterprise, local, regional, and national levels.

In previous sections, multiple data needs and recommendations were outlined to guide CFX for the upcoming transportation industry transformation and the anticipated increase of data. To either develop a data store for CFX or for CFX be a stakeholder that collects and shares data with other partnering agencies, it is recommended that data governance and data management procedures are established. These will help CFX avoid common data challenges such as handling incompatible, duplicate, or missing data from undocumented or inconsistently documented sources; siloed projects that use the same data, yet duplicate the efforts and costs associated with that data; and data activities that consume time and resources but do not contribute to overall CFX business objectives.

A well-defined data management strategy to collect, prepare, store, analyze and distribute data is the foundation for consistent project approaches, successful integration, and business growth supporting customer driven goals. Having established data standards is key to achieve these goals. Below are high level recommendations for the development of standards as per the five data needs categories depicted within Section 4:

Infrastructure Assessment (IA)

- Standardize and automate ETL processes to achieve better speed and consistency of the data that will be used or stored at CFX databases.
- Establish rules to govern if data will be stored in its raw or processed format. As an example, raw XML versus transformed JSON data format.

Existing and Known Data (ED)

- Identify data standards currently associated with existing CFX data, including ITS. Evaluate data needs, data changes, data standards, and other data related activities and actions needed to be taken internally at CFX and with select external key stakeholders.

- Review and establish data standards for geospatial data. This will enable data generated from the field devices to have adequate metadata and support internal or external processes ensuring data quality, establishing data stewardship, and thus maximizing accuracy of use by third parties.
- Establish data dictionaries and metadata standards to govern data exchange with CFX internal and external stakeholders.

Potential and Future Data Needs (FD)

- Actively participate in local and regional initiatives that seek input for establishing data governance and data standards for data exchange. Understand impacts to CFX data standards and prioritize implementation accordingly.
- Data standardization will allow for self-service capability for data lake users in both internal CFX users or external stakeholders.

Data Policy and Governance (PG)

- To enrich, transform and improve data quality and consistency, refine the data ingested, creating standards, metadata, and data dictionaries, defining ETL for data integration.
- Standardized data storage, maintenance and procedures will facilitate data recovery strategies when needed, minimizing data loss and production downtime.
- Revisit existing standard operating procedures. As an example, revisit SOPs for operators handling video management systems. Document rotation times and duration and establish procedures to return to "home" position after using camera videos for surveillance or incident response. This will allow for artificial intelligence and computer vision solutions to be incorporated as an available resource to the CFX TSM&O program toolkit.

Maintenance Data (MT)

- Define data security standards for data access and integration solutions.
- Create data, environment, and security maintenance workflows focusing on data quality.

5.10.8. Connected Vehicles Interoperability and Device Standards

The United States Department of Transportation's (USDOT) ITS Joint Program Office (JPO), National Highway Traffic Safety Administration (NHTSA) the Society of Automotive Engineers International (SAE), the Institute of Electrical and Electronics Engineers (IEEE), and the Crash Avoidance Metrics Partnership (CAMP) work collaboratively to publish (and update) connected vehicle standards. These standards are in place to establish interoperability between systems.

Before deployment of CV devices, it is important to establish documentation that the devices follow the CV standards. For example, the SAE J2735 assures that DSRC applications are interoperable. Some applications such as emergency vehicle warnings, signage, and collision avoidance require that this standard is followed. This becomes of greater importance in cases where multiple vendor devices are deployed. Standards must be followed by the various vendors to ensure that communication flow between all devices are translated correctly and broadcasted as to not impede safety application goals.

Existing device testing efforts may be referenced to understand success stories and/or device limitations. A strong recommendation for any deployment efforts, now and in the future, would be to leverage existing resources - contact neighboring CV testing or deployment project managers.

5.11. Training Considerations

The below section provides various recommendations for standardizing aspects of Operations, Maintenance, Networking, and Connected Vehicle management.

Special training and professional development opportunities are available, much of which may be obtained during on-the-job experiences and vendor-provided training. As CFX has consistently required training in their project deployment stages, seeking the additional resources to fill knowledge gaps will be beneficial. CFX should continue this requirement when dealing with new technology. This is especially true given the new and emerging technologies in the connected vehicle space.

5.11.1. Operations Training

As discussed earlier, operations for CFX is handled through an agreement with FDOT District 5 at the RTMC. Operations training is handled through this agreement.

5.11.2. Maintenance Training

The ITS Maintenance Manager Staffing position details suggested educational and training requirements. It is recommended that CFX continue to train their personnel as a part of their existing procedures. This position is responsible for the overall management and oversight of the Maintenance Program.

Required Training for Maintenance Personnel

CFX currently follows guidelines to ensure their personnel attend a vendor provided training course, which is a minimum of 8 hours in duration including both classroom and field training, within 3 months of employment. Professional Development training should also be followed per the manufacturer's recommendation. This training is to be scheduled by the Maintenance Manager through the vendor or as part of a training already being held within the region. The following ITS Devices are required for this training.

- **Closed Circuit Television Cameras**
- **Dynamic Message Signs**
- **Traffic Monitoring Station**
- **Wrong Way Driving Detection Devices**
- **Data Collection Sensors**
- **Grounding and Surge Suppression**
- **Utility Locator**

Fiber Optic and Locate Training

Personnel shall attend a training course provided by a nationally recognized fiber optic training provider within the first year of employment and every 2 years after their initial training date. The course should be a *minimum of 2 days in duration and shall include training on basic fiber optic theory, connectorization, splicing, testing and locating*. This training is to be scheduled by the Maintenance Manager through the nationally recognized provider or as part of a training already being held within the region.

Video Wall Controller Training

Personnel shall attend a vendor provided Video Wall Controller training course, which is a minimum of 8 hours classroom training, within 3 months of employment and every 2 years after their hiring date. This training is to be scheduled by the Maintenance Manager through the vendor or as part of a training already being held within the region.

Advanced Maintenance of Traffic (MOT) Training
Personnel shall obtain their Advanced MOT Training Certification from an FDOT Approved Provider within 6 months of their hire date. Once certification is obtained, personnel may not let the certification lapse.

SHRP2 National Traffic Incident Management Responder Training
Personnel shall attend the 4-hour training course provided by FDOT District Five and receive the certificate of training within one year of their hire date.

5.11.3. Network Training

The following is a list of suggested educational and training requirements by network staff position.

Network Engineer

- This position is responsible for the overall operations and maintenance of the communications network for the CFX limited-access expressway system.
- Responsibilities include design and implementation of Network Architecture, configuration and maintenance of all Layer 3 Network devices, network coordination and planning with other agencies, network security, and licensing/warranty tracking for all network devices. This position requires a combination of training, education and experience for a total minimum of five years and certifications for Cisco Certified Network Professional Routing and Switching and Security or approved equivalent certifications and/or experience. The Network Manager shall have the training as described below.

Network Technician

- This position is responsible for configuration and maintenance of all Layer 2 Network devices, initial troubleshooting for field devices, and repair/replacement of failed ATMS devices. This position requires a minimum of two years experience working with Layer 2 networking devices and Network Plus certification or equivalent certification/experience. The Network Technician shall have the training as described below.

Required Training for Network Personnel

Vendor Specific Layer 2 Switch Training - Personnel shall attend a vendor provided Layer 2 switch training course, which is a minimum of 4 hours in duration within 3 months of employment and every 2 years after their hiring date. This training is to be scheduled by the Network Manager through the vendor or as part of a training already being held within the region.

Vendor Specific Layer 3 Switch/Router Training - Personnel shall attend a vendor provided Layer 3 switch/router training course, which is a minimum of 4 hours in duration within 3 months of employment and every 2 years after their hiring date. This training is to be scheduled by the Network Manager through the vendor or as part of a training already being held within the region.

Vendor Specific CCTV Training - Personnel shall attend a vendor provided CCTV training course, which is a minimum of 8 hours in duration including both classroom and field training, within 3 months of employment and every 2 years after their hiring date. This training is to be scheduled by the Maintenance Manager through the vendor or as part of a training already being held within the region.

Vendor Specific DMS Training - Personnel shall attend a vendor provided DMS training course, which is a minimum of 8 hours in duration including both classroom and field training, within 3 months of employment and every 2 years after their hiring date. This training is to be scheduled by the Maintenance Manager through the vendor or as part of a training already being held within the region.

Fiber Optic Training - Personnel shall attend a training course provided by a nationally recognized fiber optic training provider within the first year of employment and every 2 years after their initial training date. The course shall be a minimum of 2 days in duration and shall include training on basic fiber optic theory, connectorization, splicing and testing. This training is to be scheduled by the Maintenance Manager through the nationally recognized provider or as part of a training already being held within the region.

SHRP2 National Traffic Incident Management Responder Training - Personnel shall attend the 4-hour training course provided by FDOT District Five and receive the certificate of training within one year of their hire date.

5.11.4. Connected Vehicle Training

Special training and professional development opportunities are available, much of which may be obtained during on-the-job experiences and vendor-provided training. As CFX advances into their project deployment stages, seeking the additional resources to fill knowledge gaps will be beneficial. This is especially true given the new and emerging technologies in the connected vehicle space.

The following Connected Vehicle Staffing position details suggested educational and training requirements.

ITS Project Manager

- This position is responsible for the management and oversight of the Connected Vehicle (CV) initiative. The CV Project Manager may opt to partake in an instructor-led certification program led by The NEXT Education. Based in Michigan, their Connected Vehicle Professional (CVP) Credentialing Program is designed to teach students vehicle-to-vehicle (V2V), vehicle-to-pedestrian (V2P), vehicle-to-infrastructure (V2I), vehicle-to-network (V2N), vehicle-to-anything (V2X) connectivity, standards, and other best practices involving CV technology. This position will also handle PTSU Operations.

For more information on the NEXT Education course which is an estimated 20-hour certification program, visit: https://thenexted.com/certifications/#CertificationPrograms

There are several high-priority areas related to data access, data exchange, cybersecurity, emerging and enabling technologies. Many lessons learned and success stories documents are published by the USDOT, available here: https://www.its.dot.gov/pilots/success_lessonslearned.htm

5.12. Stakeholder Coordination

Effective engagement of regional partners provides the advantage for strategy development and consensus building, a coordinated approach to reducing redundancies, shared experiences, and to ensure that CFX's future investments have a regional and meaningful benefit/outcome. Continued stakeholder coordination is encouraged especially as pilot projects are engaged.

CFX's stakeholder partnerships include:

- MetroPlan Orlando
- FDOT District 5
- Florida's Turnpike Enterprise
- City of Orlando
- Orange County Government
- Seminole County Government
- Osceola County Government
- Lake County Government
- Space Coast Transportation Planning Organization
- I-4 Mobility Partners
- Brightline
- Lynx
- SunRail

Section 4 of CFX's Transportation and Technology Needs assessment identifies the needs of each of CFX's stakeholders noted above. The cumulative needs that have been identified focus on a few common areas related to transportation technology advancement, data sharing strategies, data interfaces, asset management, fiber sharing, continued coordination and others. **Figure 42,** shown here, summarizes some of the documented needs and areas for stakeholder coordination.

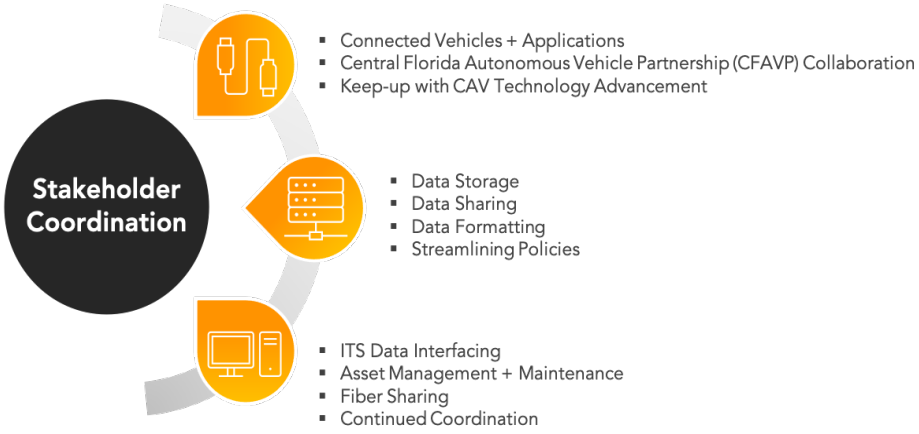


Figure 42: CFXs Focus Areas for Stakeholder Coordination

ITS
Master Plan

Section 6

Regional ITS Architecture (RITSA)

section 6

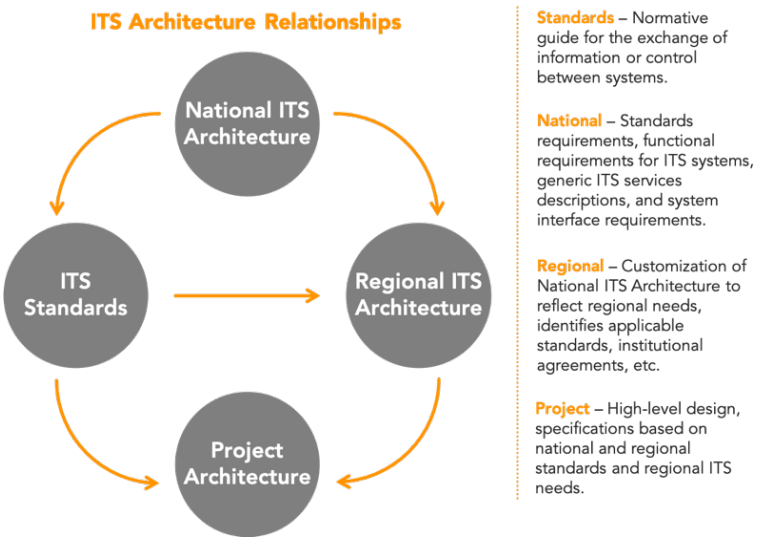
CENTRAL FLORIDA EXPRESSWAY AUTHORITY

6. Regional ITS Architecture (RITSA)

6.1. Background

Section 6 of the CFX Intelligent Transportation Systems (ITS) Master Plan is to provide a section documenting the review and evaluation of the Florida Department of Transportation (FDOT) District Five RITSA. To better understand the findings of this review and evaluation, a more comprehensive background of a RITSA is provided below.

The National ITS Architecture (NITSA), also known as the Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT), is a nationwide tool that is used as framework for planning, defining, and integrating Intelligent Transportation Systems (ITS). It defines the following functions: subsystem functions, where the functions reside (in vehicle, Traffic Management Center (TMC), or field), how the subsystems interface, and communications requirements of the subsystems. It is a mature product that has been developed through extensive cooperation and participation of many different types of agencies that contribute to the ITS network. The NITSA reflects the contributions of a broad cross-section of the ITS community, including systems engineers, system developers, transportation professionals, and technology specialists.[14] A key benefit of utilizing the NITSA is the definition of key interfaces for standardization. ITS standards are crucial as they detail how ITS systems, products, and components can interconnect, exchange information and interact to deliver services within a transportation network. The use of standards encourages industry growth by minimizing development costs, increasing compatibility and interoperability, and increasing buyer and seller confidence in products. This is accomplished by allowing both like and different ITS devices and equipment to exchange and interpret data directly through a common communications interface. This exchange and recognition of data can take place between devices located within a single system or between devices operating in different systems. By using a standards-based approach, agencies can join forces to extend the reach and capabilities of their ITS infrastructure investments.[15]



The Code of Federal Regulations Part 940 (CFR 940) requires a RITSA conforming to the NITSA for all ITS projects receiving federal funding. In adherence to CFR 940, the Florida Department of Transportation

[14] https://www.standards.its.dot.gov/LearnAboutStandards/NationalITSArchitecture
[15] https://www.standards.its.dot.gov/LearnAboutStandards/ITSStandardsBackground

(FDOT) has a Statewide ITS Architecture (SITSA) and seven Regional ITS Architectures (RITSAs), which represent a portion of the NITSA, that has been designed to show how transportation systems are integrated within the State of Florida. The FDOT architecture was developed in 2005 and most recently updated in 2020. As CFX is self-funded, CFX is not required to adhere to CFR 940 and also does not have its own RITSA. However, CFX is an important regional partner for transportation within Central Florida and is therefore a Stakeholder in the FDOT District Five RITSA.

The first software program developed to assist states with adherence to the NITSA framework was called Turbo Architecture and was released in 2000 and was updated to revision 7.0 in early 2012. During that time, DOT agencies used the tool to create and update their Statewide and Regional ITS Architectures as their ITS Systems grew in size and scope. However, from the national perspective the need to consider new service packages and standards to support rapidly developing connected and automated vehicle technologies brought the rise of a second architecture, the Connected Vehicle Reference Implementation Architecture (CVRIA). The CVRIA project was completed in 2014 and developed a website that hosts the architecture viewpoints for 88 connected vehicle safety, mobility, environmental, and support applications.[16] After CVRIA was in place, there were now two different frameworks for ITS Projects, with Turbo Architecture addressing the "ordinary" ITS components, and CVRIA addressing connected and automated vehicle aspects. This quickly became cumbersome, and a need arose to combine the two. In 2017 Architecture Reference for Cooperative and Intelligent Transportation ARC-IT was released, which combines the services of the NITSA with connected vehicle content of CVRIA. ARC-IT, or more specifically, Regional Architecture Development for Intelligent Transportation RAD-IT (a component of ARC-IT) was used in the latest update of the FDOT District Five RITSA, which can be found at the following website: https://teo.fdot.gov/architecture/architectures/d5/index.html

6.2. CFX Related Service Packages in the FDOT District Five RITSA

Service packages represent slices of the Physical View representing integrated physical objects that interact and exchange information that address specific services like traffic signal control. A service package collects together several different physical objects (systems and devices) and their functional objects and information flows that provide the desired service.[17] CFX currently has several service packages listed within the FDOT District Five RITSA. These service packages and the abbreviated descriptions provided below can be found at the following website: https://teo.fdot.gov/architecture/architectures/d5/html/servicepackages/services.html

The service packages identified in the FDOT D5 RITSA which are associated with CFX are:

- **PS02** – Emergency Response (CFX (EM to MCM)) – This service package includes emergency vehicle equipment to provide response status and/or video or images from the vehicle of emergency response personnel in the field.
- **TI01** – Broadcast Traveler Information (CFX Public Website) – This service package provides a digital broadcast service that disseminates traveler information to all equipped travelers within range.

[16] https://www.standards.its.dot.gov/DevelopmentActivities/CVReference
[17] https://local.iteris.com/arc-it/html/servicepackages/servicepackages-areaspsort.html

- **TM01** – Infrastructure Based Traffic Surveillance (CFX) – This service package includes traffic detectors, other surveillance equipment, the supporting field equipment and Center to Field communications to transmit the collected data back to the Traffic Management Center.
- **TM06** – Traffic Information Dissemination (CFX) – This service package provides driver information using roadway equipment such as dynamic message signs or highway advisory radios.
- **TM08** – Traffic Incident Management System (CFX (EM to MCM)) – This service package manages both unexpected incidents and planned events to that the impact to the transportation network and traveler safety is minimized.
- **TM10** – Electronic Toll Collection (CFX) – This service package provides toll operators with the ability to collect tolls electronically and detect and process violations.

The service packages referenced above were included in the previous version of the District Five RITSA and provide a solid base of service packages for most ITS projects. However, with the increasing number of connected and automated vehicle projects, noted previously, additional service packages will be required. After reviewing the Projects Tab for CFX, within the District Five RITSA, it was noted that there were four CFX specific Projects listed (see section 6.3 below for details). Each of these projects show the anticipated service packages for the project and several of the service packages noted are not within the District Five RITSA. The two projects, which have service packages that are not included within the District Five RITSA, are the CFX CAV Project and CFX Wrong Way Driver Deployment Project. These projects are listed below with their associated service packages, which are not currently listed in the District Five RITSA. Because these service packages are not Included in the District Five RITSA, it is recommended that they be added. These service packages and the abbreviated descriptions can be found at the following website:

https://local.iteris.com/arc-it/html/servicepackages/servicepackages-areaspsort.html

CFX CAV Project

- **SU01** – Connected Vehicle System Monitoring and Management – This service package provides monitoring, management, and control services necessary to other applications and/or devices operating within the Connected Vehicle Environment.
- **SU04** – Map Management – This service package defines interfaces that can be used to download or update all types of map data used to support intelligent transportation systems.
- **SU08** – Security and Credentials Management – This service package is used to ensure trusted communications between mobile devices and other mobile devices or roadside devices and protect data they handle from unauthorized access.
- **SU09** – Device Certification and Enrollment – This service package is used to illustrate the certification of devices, typically but not exclusively those intended for the connected vehicle environment.
- **VS02** – This service package exchanges basic safety messages with surrounding Connected Vehicles to support and augment the safety warning and control automation features identified in VS01.

***Note** – VS02 is shown as a service package in the District Five RITSA, but as shown it only relates to Counties and Cities.*

- **VS03** – Situational Awareness – This service package shares information about potentially hazardous road conditions or road hazards with other vehicles to support enhanced driver warnings and control automation.

6.3. Projects Listed in the District Five RITSA

As indicated previously, there are four CFX Specific Projects listed under the Project tab of the District Five RITSA website. These projects and their descriptions can be found at the following website https://teo.fdot.gov/architecture/architectures/d5/html/projects/projects.html

The four projects listed are:

- **CFX CAV** – Central Florida Expressway (CFX) Connected and Automated Vehicles (CAV) project template.
- **CFX CCTV/DMS/VDS/Tolling** – Central Florida Expressway (CFX) generic ITS project encompassing Closed Circuit Television (CCTV), Dynamic Message Signs (DMS), Vehicle Detection Systems (VDS) and tolling.
- **CFX Data Analytics** – Central Florida Expressway (CFX) project involving data analytics for traffic flow and toll rates.
- **CFX Wrong Way Driver Deployment** – Expansion of Wrong Way Driving (WWD) Countermeasures on CFX Roadways.

6.4. Proposed Changes for Consideration

This report recommends multiple changes to the District Five RITSA regarding CFX projects and service packages. A key consideration for these proposed changes is that CFX does not receive federal funding for projects, so changes are only required for items that may interface with FDOT District Five. These changes are provided below as near-term and longer-term considerations. The near-term items should be considered within the next year and the longer-term items should be considered in the next 1-5 years, dependent upon the technologies and projects that CFX will be deploying. FDOT Central Office has a change management process in place, which CFX would need to follow in order to make any changes. CFX would need to complete Form 750-040-04, which can be found on the FDOT Forms website, and follow the directions on the form. The completed form would then be sent to the FDOT District Five TSM&O Program Engineer and the FDOT TSM&O Program State ITS Software Engineer.

Near-term

As detailed in Section 6.2, there are currently service packages assigned to CFX Projects listed on the District Five RITSA website, which are not part of the District Five RITSA because they were not previously defined. Since these are already on the website, but not defined, these service packages should be defined and included within the District Five RITSA. These service packages are:

- **VS02** – This service package exchanges basic safety messages with surrounding Connected Vehicles to support and augment the safety warning and control automation features identified in VS01.
- **VS03** – Situational Awareness – This service package shares information about potentially hazardous road conditions or road hazards with other vehicles to support enhanced driver warnings and control automation.
- **TM12** – Dynamic Roadway Warning (FDOT Wrong-Way Driving) is included within the District Five RITSA and the diagram for this service package shows an existing connection between the CFX Field Equipment and the FDOT District 5 Regional Transportation Management Center (RTMC). However, this service package is generic and includes more hazards than Wrong-Way Driving. The service package below should be considered for inclusion due to the specificity to Wrong-Way Driving and is detailed as per how the current system works for CFX.
- **TM25** – Wrong Way Vehicle Detection and Warning – This service package detects wrong way vehicles on the main roadway and at the exit of divided freeways, tunnels, and bridges. Wrong way vehicle drivers are immediately warned. If the driver continues onto the roadway, warnings are issued to oncoming drivers of the wrong way entry and traffic management and public safety centers are notified.

Finally, there are three service packages that relate to the CFX Network and ongoing projects that are not Included in the District Five RITSA. These service packages should be Included within the RITSA to properly document the current state of the CFX ITS Program. These service packages are:

- **SU07** – ITS Communications – This service package provides secure, reliable communications between ITS devices.
- **TM22** – Dynamic Lane Management and Shoulder Use – This service package provides for active management of travel lanes along a roadway. The package includes the field equipment, physical overhead lane signs and associated control electronics that are used to manage and control specific lanes and/or the shoulders.
- **VS05** – Curve Speed Warning - This service package allows connected vehicles to receive information that it is approaching a curve along with the recommended curve speed.

Longer-term

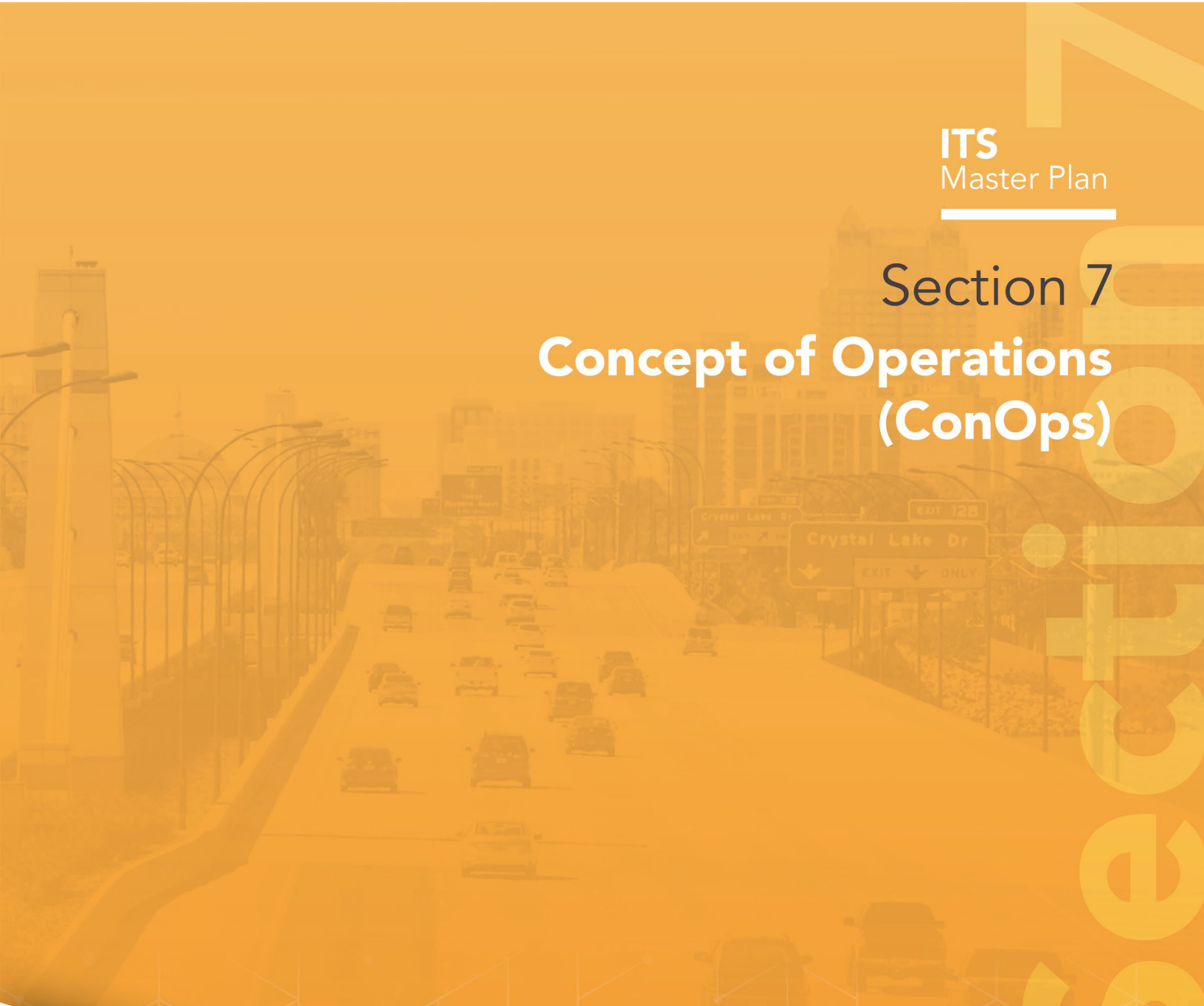
The following service packages have been identified as being related to the Technology Strategies as detailed in this CFX ITS Master Plan. Additionally, the service packages described below could involve FDOT District Five due to their RTMC operating CFX's system or through the use of FDOT's fiber optic cable for communications and redundancy. Because of this, the following service packages should be considered for inclusion in the District Five RITSA, as projects related to the service package description are planned.

- **SU02** – Data Distribution – This service package manages the distribution of data from data providers to data consumers and protects those data from unauthorized access.
- **SU05** – Location and Time - This service package identifies the external systems and interfaces that provide accurate location and time to intelligent transportation system devices and systems.

- **SU06** – Object Registration and Discovery - This service package provides registration and lookup services necessary to allow objects to locate other objects operating within the Connected Vehicle Environment.
- **VS07** – Road Weather Motorist Alert and Warning – This service package collects road weather data from connected vehicles and uses that data to develop short term warnings or advisories that can be provided to individual motorists.
- **VS08** – Queue Warning – This service package utilizes connected vehicle technologies, including vehicle-to-infrastructure (V2I) and vehicle-to-vehicle (V2V) communications, to enable vehicles within the queue event to automatically broadcast their queued status information (e.g., rapid deceleration, disabled status, lane location) to nearby upstream vehicles and to centers (such as the TMC).
- **VS09** – Reduced Speed Zone Warning/Lane Closure – This service package provides connected vehicles that are approaching a reduced speed zone with information on the zone's posted speed limit and/or if the configuration of the roadway is altered (e.g., lane closures, lane shifts).
- **WX01** – Weather Data Collection – This service package collects current road and weather conditions using data collected from environmental sensors deployed on and about the roadway. It also collects data from vehicles in the road network that can be used to directly measure or infer current environmental conditions.
- **WX03** – Spot Weather Impact Warning – This service package will alert drivers to unsafe conditions or road closure at specific points on the downstream roadway as a result of weather-related impacts, which include, but are not limited to high winds, flood conditions, ice, or fog.

ITS
Master Plan

Section 7
Concept of Operations (ConOps)



CENTRAL FLORIDA EXPRESSWAY AUTHORITY

7. Concept of Operations

This document will serve as the Concept of Operations (ConOps) document for the Central Florida Expressway (CFX) Intelligent Transportation Systems (ITS) Master Plan Project. This document is divided into ten (10) Sections and each Section is divided into multiple sub-sections. The document discusses the current system situation, justification for changes to the existing system, concepts for the proposed system, operational scenarios, a summary of impacts and an analysis of the proposed system.

7.1. Identification

Project Name: CFX ITS Master Plan
Financial Project Identification: N/A
Federal Aid Project Number: N/A

7.2. Purpose and Intended Audience

The purpose of this ConOps document is:

- To communicate user needs and the proposed system expectations.
- To communicate the system developer's understanding of the user needs and how the system will meet those needs.
- To build consensus among user groups or developers.
- To create the basis for requirements development and verification.
- To create the framework for system validation.
- To provide an overview for, or to be part of, a press release or information brochure.

The intended audience for this ConOps document is:

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

7.3. 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.

7.3.1. High-Level System Overview

CFX has an extensive ITS program with infrastructure and devices on all of its roadways. CFX existing ITS components include but are not limited to: Fiber Optic Cable (FOC) infrastructure, electrical power infrastructure, Closed-Circuit Television (CCTV) cameras, Dynamic Message Signs (DMS), Microwave Vehicle Detection Sensors (MVDS), Data Collection Sensors (DCS), Wrong Way Vehicle Detection Systems (WWVDS), Network Devices, and required software components to monitor and operate the devices. The monitoring and operations of the CFX ITS devices are performed from the Florida Department of Transportation (FDOT) District Five Regional Transportation Management Center (RTMC), via a fiber optic connection between CFX and FDOT District Five. Additionally, CFX has monitoring capabilities at the ITS Control Room housed on the third floor of the CFX Headquarters building.

7.3.2. Stakeholders

Below, **Table 32** shows a list of CFX's Stakeholders.

Stakeholder	Project Role
CFX	Project sponsor, operator/maintainer
FDOT District 5	Operator
Florida Highway Patrol (FHP)	First responder, system user
County Sheriff's Agencies	First responder, system user
County Fire/Rescue Agencies	First responder, system user
County Emergency Operations Centers (EOCs)	Emergency Coordination
Local Agencies	Emergency Coordination, Operator
Motorists	System User

Table 32: Stakeholders

7.3.3. Referenced Documentation

Document Name	ID, Revision, Date, etc.	Link, or Contact Info to Obtain
Form FM-SE-01 Concept of Operations (ConOps) TEMPLATE	Revision Dated September 4, 2019	https://www.fdot.gov/traffic/ITS/Projects-Deploy/SEMP.shtm
Systems Engineering Project Checklist 750-040-06	2019	FDOT Procedural Document Library https://pdl.fdot.gov
23 Code of Federal Regulations (CFR) Part 940, Intelligent Transportation System Architecture and Standards – Final Rule (latest edition).	Federal Regulation	https://www.transit.dot.gov/research-innovation/its-architecture-final-rule-federal-register-23-cfr-parts-655-and-940-january-8

Table 33: Referenced Documentation

7.4.1. Background, Objectives, and Scope

CFX began installing ITS infrastructure and devices in the late 1990's and has been installing, maintaining, and replacing both infrastructure and devices to current day. All of CFX's roadways are fully instrumented with ITS infrastructure and devices. CFX has retained an ITS Maintenance Contractor and Fiber Optic Network Maintenance Contractor to provide preventive, routine, and emergency maintenance services for their entire system.

As detailed previously, the ITS devices are monitored and controlled by the Florida Department of Transportation (FDOT) District Five Regional Transportation Management Center (RTMC), via a fiber optic connection between CFX and FDOT District Five. Operators at the RTMC utilize Florida's SunGuide® Software to monitor the roadways and provide traffic information to motorists and other systems users. Additionally, the Operators coordinate with Road Rangers, FHP and others for assistance to disabled vehicles and emergency response to accidents along the roadways.

Any additional infrastructure, devices, and/or technologies, which may be installed as a result of this ITS Master Plan, will utilize existing communications, power and ITS device infrastructure, to the extent possible and will be maintained under the current ITS maintenance contract, or similar future contracts. A consideration of this ITS Master Plan was to determine if constructing a CFX TMC had merit. However, due to the strong cooperative partnership between FDOT and CX, as well as the increased costs that CFX would Incur, the construction of a new CFX TMC Is not recommended at this time.

7.4.2. Operational Constraints

CFX uses their own funding for ITS Construction, Operations and Maintenance Contracts. The available funding is determined by the amount of toll revenue generated on their system. This allows them to determine how they want to spend their revenue and means that they are not constrained by many of the FDOT and Federal rules. However, this also means that in times such as recessions and the current global pandemic, revenues may decrease due to less people driving on toll roads.

As detailed previously, CFX currently has FDOT District Five's RTMC monitoring and operating their ITS devices. This allows CFX to provide the District with funding for the services provided without the need to procure their own RTMC software, devices, workstations, etc. along with not having to build a new RTMC or renovate an existing facility to accommodate the video walls, consoles, etc. that are required in an RTMC. In this situation, CFX operates the system within the constraints of FDOT District Five's RTMC.

7.4.3. Description of the Current System or Situation

As it relates to the CFX ITS Master Plan, the current system will be supplemented by many of the recommendations of the final Master Plan document. The current system, as described previously, is robust and encompasses all of CFX's roadways. However, there are new ITS technologies and Transportation Systems Management and Operations (TSM&O) strategies that have recently been developed or are currently being developed that would allow CFX to better manage and operate their roadways. The Master Plan will detail how the existing system and its various components can be leveraged to use these new technologies and strategies in a more cost-effective manner and with less time needed for implementation.

7.4.4. User Class Profiles

The CFX ITS network, which includes the FDOT District Five fiber optic connection and RTMC Operators for CFX roadways, features the following six user profiles:

- **ITS Operators/Supervisors**
  - Has access to and controls ITS devices on Freeway/arterials
    - Utilize Pan Tilt Zoom (PTZ) capabilities of CCTVs to monitor coverage areas
    - Monitor traffic signal control system
    - Gather and report data generated by the travel time system
  - Inform emergency personnel of incidents and coordinate with emergency response personnel throughout the process of clearing any incidents that may occur
  - Monitor performance of the system and inform traffic operations personnel of any faulty equipment so that they may dispatch maintenance personnel to any devices not functioning properly

- **ITS/Traffic Operations Device Maintenance Personnel**
  - Maintain all ITS equipment in the field
  - Ensure minimal equipment downtime
  - Perform routine maintenance
  - Are available as part of the ITS Maintenance contract

- **ITS/Traffic Operations Network Support Personnel**
  - Monitor health and performance of network
  - Perform routine maintenance
  - Implement any required updates
  - Monitor FOC for any physical damage
  - Manage data collected from ITS and CV field devices

- **Traffic Operations Engineers and Personnel**
  - Analyze data generated by ITS devices
  - Make recommendations for future equipment upgrades

- **Emergency Response Personnel**
    - Work with ITS Operators and respond to incidents detected by ITS equipment
    - View video feeds of traffic conditions
    - Use travel time information to determine best route to incidents

- **Motorists**
    - Receive travel time and incident information reported by ITS Operators
    - Receive automated CV alerts for issues such as Wrong Way Driving, Curve Speed Warning, and others
    - Make informed decisions on travel routes to ensure best travel times

7.4.5. Support Environment

All infrastructure and equipment are currently operated and maintained in the fashion described in **Section 2.1.** Any new infrastructure proposed by the ITS Master Plan will be operated and maintained in the same fashion.

7.5. Change Justification

7.5.1. Justification for Changes

CFX's system has been evolving for more than 20 years and CFX personnel have done an excellent job of keeping up with the latest technologies and components to keep the benefits of the system maximized. Evolving technologies, such as Connected Vehicles and Automated Vehicles devices and new TSM&O strategies are being explored as possible ways to make the system even more beneficial to both CFX and its end users. The ITS Master Plan document will propose ways of utilizing existing infrastructure, devices, structures, and even roadway lanes and shoulders to incorporate these new technologies and strategies into their daily traffic monitoring and information dissemination activities. These efforts will result in reduced congestion, improved safety, decreased emissions, and improved travel time reliability to CFX stakeholders.

7.5.2. User Needs

Stakeholder needs to be addressed by this project are identified in **Table 34** below.

User Need ID	User	Need
UN001	Motorists, First Responders, Transit, and Multimodal facilities	Improved safety resulting in a decrease in the number of vehicular crashes
UN002	Motorists, First Responders, Transit, and Multimodal facilities	Reduced congestion resulting in improved travel times and travel time reliability
UN003	Motorists, First Responders, Transit and Multimodal facilities	Reduced Secondary Accidents resulting in reduced congestion, improved travel times and travel time reliability and improved safety for all motorists and First Responders.
UN004	Motorists, First Responders, Transit and Multimodal facilities	Effective communications of traffic safety information resulting in more effective messaging of incident related information to maximize the ability for rerouting and reducing congestion and accidents.
UN005	Motorists, pedestrians, and bicyclists	Improved safety for pedestrians and bicyclists resulting in a decrease in the number of crashes involving vehicles
UN006	First Responders	Reduced response time to arrive at incident scenes
UN007	First Responders	Increased safety while on-scene resulting in fewer struck-by accidents
UN008	First Responders	Video images and additional information related to the scene resulting in faster arrival times, correct equipment being dispatched, reduced open roads duration, and reduced clearance durations.
UN005	Transit	Improved reliability of service and safety of the public resulting in riders having more predictable wait times and fewer missed connections

Table 34: User Needs

7.6.1. Background, Objectives, and Scope

Regarding infrastructure, CFX has a complete and robust communications system in place on all of its roadways, as well as a sufficient power system and backup power where needed. Therefore, the system infrastructure is not being considered for upgrade or replacement outside of standard lifecycle replacements. Instead, recommendations of the ITS Master Plan center around improvements and strategies to improve capacity and reduce crashes. Additional proposals include assessment of current Information Technology (IT) capabilities and the possible need to expand their IT resources in preparation for Connected Vehicles and other Big Data needs. These proposed system enhancements will reduce congestion, improve safety, and prepare CFX for future technology enhancements.

7.6.2. Description of the Proposed System

The system will be enhanced as described above to keep up with the increasing number of vehicles on CFX roadways as the population of Central Florida continues to increase. The specific projects being proposed are listed in the Appendix. Additionally, expansion of the current initiative to implement Part-Time Shoulder Use is being proposed to decrease congestion and improve travel time reliability.

In addition to the projects defined in Section 5.6, the ITS Master Plan proposes the following initiatives:

- Continued implementation of PTSU as a part of the overall 2040 Master Plan and Work Plan to continue to address recurring capacity concerns.
- Continued deployment of infrastructure to support non-recurring congestion needs such as Integrated Corridor Management (ICM), Incident management and traveler information.
- Development of a Work Zone Management pilot project to be incorporated as a part an upcoming construction project. Pre-Deployment crash data should be analyzed, and real time crash data maintained throughout the project duration to determine if the pilot is resulting in improvement. Real-time adjustments should be made to resolve any negative trends. Finally, an after study should be completed with lessons learned identified for future deployments.
- ITS Device Replacement/Upgrade Projects as the devices near end-of-life.
- Various Sustainability Projects/Analyses as detailed within CFX's Sustainability Study, to Include the following:
  - Ground-Mounted PV Solar
  - Floating PV Solar (wet pond)
  - Elevated Pond PV Solar (dry pond)
  - Building Energy Efficiency Study
  - EV Charging Stations
  - Fleet Vehicle Analysis

Table 35 on the following page, provides a summary of the proposed traffic related projects to address CFX's Transportation Needs.

Table 35: Transportation Needs Project List

TRAFFIC OPERATIONS PROJECTS

Facility	Location	Need	Strategy
SR 417	International Drive to SR 408 (MM 6-33) SR 50 to Orange/Seminole County line (MM 34-38)	Continue incident Management	ATIS technologies (DMS, HAR, CBRAS, FL511 Traveler Information System, and In-Vehicle Dynamic Route Guidance), ATMS, Incident management, ICM, and PTSU
	SR 417 at John Young Parkway SR 417 at Lake Nona Boulevard SR 417 at Narcoossee Road	Maintain Future Acceptable Ramp Intersection LOS (per SR 417 Design Traffic Technical Memorandum (DTTM))	Alternative intersection design (MUT, and displaced left-turn)
SR 408	West of I-4 (MP 0-10) Mills Avenue to Goldenrod Road/Chickasaw Trail (MP 11-17) SR 417 to Alafaya Trail (MM 18-21)	Continue incident Management	ATIS technologies (DMS, CBRAS, FL511 Traveler Information System, and In-Vehicle Dynamic Route Guidance), and PTSU
	John Young Parkway to Orange Avenue (MM 8-10)	Event management	ATIS technologies, Active Traffic Demand and Management (ATDM) and active parking management (dynamic parking guidance and reservation, dynamic overflow transit parking and dynamically prices parking)
SR 528	Tradeport Drive to Innovation Way (MM 9-19)	Continue incident Management	ATIS technologies (DMS, HAR, CBRAS, FL511 Traveler Information System, and In-Vehicle Dynamic Route Guidance), and PTSU
SR 429	Seidel Road to CR 437A (MM 11-29)	Continue incident Management	ATIS technologies (DMS, HAR, CBRAS, FL511 Traveler Information System, and In-Vehicle Dynamic Route Guidance), ATMS, Incident management, ICM, and PTSU

MAINTENANCE PROJECTS

Facility	Location	Need	Strategy
SR 417	SR 417 at Narcoossee Road	Angle crash reduction	Traffic signal system improvements (signal retiming and coordination, Flashing Yellow Arrow analysis and FYA time-of-day operations)
SR 408	SR 408 at John Young Parkway	Angle crash reduction	Traffic signal system improvements (signal retiming and coordination and adjusting the yellow and red clearance intervals)
	SR 408 at Chickasaw Trail	Left turn crash reduction	Traffic signal system improvements (signal retiming and coordination and FYA time-of-day operations
SR 528	SR 528 at Goldenrod Road	Angle crash reduction	Retroreflective backplates, traffic signal system improvements (signal retiming and coordination and adjusting the yellow and red clearance intervals.)
	SR 528 at Tradeport Drive SR 528 at Narcoossee Road	Left turn crash reduction	Retroreflective backplates, traffic signal system improvements (signal retiming and coordination, FYA analysis and FYA time-of-day operations and adjusting the yellow and red clearance intervals.)
SR 429	SR 429 at CR 437A	Left turn crash reduction	Traffic signal system improvements (signal retiming and coordination and FYA time-of-day operations
SR 414	SR 414 at US 441	Sideswipe crash reduction	Lane delineation pavement markings

ENGINEERING AND CONSTRUCTION PROJECTS

Facility	Location	Need	Strategy
All Facilities	Systemwide	Reduce crashes related to construction zones	Smart Work Zones

7.6.3. Modes of Operation

Part-time Shoulder Use is discussed within the ITS Master Plan and is an innovative approach included in CFX's current 5-year capital work plan. Although the implementation of Part-time Shoulder Use would not affect the Modes of Operation for CFX or FDOT District Five, there is a concern regarding FDOT operations of Part-Time Shoulder Use. FDOT Central Office approves the use of PTSU on FDOT Roadways on a case-by-case basis and has granted approval for District Five to perform PTSU operations for CFX facilities from the FDOT D5 RTMC. Furthermore, the new ICM Contract advertised by FDOT D5 in early 2021 includes optional services for PTSU operations and support. However, it may be necessary for CFX to provide funding for positions that will work within the FDOT District Five RTMC, who will be responsible for managing any Part-time Shoulder Use that is conducted on CFX Roadways. This potential funding need is dependent on the operational verification method chosen by CFX for the opening and closing of the shoulder during active operations.

7.6.4. User Involvement and Interaction

The only changes to user involvement and interaction that would result from recommendations from the ITS Master Plan are related to CFX taking over TMC Operations as discussed in the section above and elsewhere within this document.

7.6.5. Assumptions and Constraints

The following assumptions and constraints will be considered:

- All devices installed will be compatible with infrastructure that is currently deployed and will be able to be controlled through the Statewide SunGuide® Software, third-party software for PTSU operations, CFX Data Server Software, Blyncsy Pulse Platform (future deployments) and/or Blink Link software.
- CFX uses the FDOT Statewide Approved Products List (APL), as a guide to assist in the review and testing of equipment deployed.

7.6.6. Risks

The Risks in **Table 36,** on the following page, are ranked in a manner of 1 being the lowest risk and 5 being the highest risk.

Table 36: Risk Register

	Risk Owner	Description of Risk and Impact	Likelihood (1-4)	Impact (1-4)	Rating (L + I) (2-8)	Mitigation Strategy	Status
1	CFX	Insufficient Funding for continued operations and maintenance	1	4	5	Project buy-in from stakeholders and prioritization of O&M funding at planning levels	N/A
2	CFX	Cybersecurity	2	3	5	Training of personnel adherence to established security protocols, and regular monitoring and security patches.	N/A
3	CFX	Technology becomes outdated quickly and does not provide significant benefit	2	3	5	Perform Technology Assessments and review industry literature to verify product viability and longevity. This would include the automotive industry in addition to the traditional Technology Sector.	N/A
4	CFX	CV related policy changes at the National and/or State Level	3	3	6	Assign a CFX or Consultant employee the task of keeping abreast of CV related policies and rulemaking from entities such as, but not limited to FHWA, USDOT, NHTSA, FCC, FDOT, etc.	N/A

7.6.7. Support Environment

All TSM&O devices and infrastructure installed through projects resulting from the recommendations of the ITS Master Plan will be maintained in a similar manner as to the existing devices and infrastructure. No changes will be needed to the existing Maintenance contract or how this contract is managed. The

only item that will need to be assessed is training needs of CFX and maintenance staff for any new technologies that personnel are not familiar with, in regard to how to configure, troubleshoot and maintain the equipment. The Sustainability projects planned will likely create a need for a Sustainability Maintenance and Operations plan and separate contract.

7.7. Operational Scenarios

The list below details certain operational scenarios that may be encountered during daily operations of the regional transportation system and how they should be dealt with using the proposed improvements:

- **Normal Operations:** The roadway network is operating efficiently, and congestion is either minimal or non-existent. Operators constantly observe the roadway network using CCTVs and verify that the roadway network is performing up to minimum standards through information provided by the travel time system. Connected Vehicle roadside unit devices (RSUs) are providing traffic related information to on-board units (OBUs) and Apps, while also receiving information from the OBUs and Apps related to vehicle status, speed position, and any relevant pedestrian/bicyclist location and speed information as well. Should any incidents be detected during this timeframe, emergency response personnel will be dispatched to clear the incident in as efficient manner as possible. These incidents include anything that would obstruct the normal flow of traffic. Operations personnel will populate SunGuide® reports to track and document the Incidents and will provide Incident Information to motorists via FL 511, DMS, HAR and CBRAS. Motorists who have vehicles outfitted with CV OBUs will also receive Information from RSUs strategically placed throughout the corridors. Operations personnel will also provide Information directly to first responders and other stakeholders, as needed.

- **Peak Traffic Times:** Morning and evening rush hours bring increased traffic volumes and congestion is increased as a result. Operators will be alerted to increasing travel times from the travel time system and operators will verify the increased congestion using the CCTVs. The improvements recommended as a result of the ITS Master Plan have significantly reduced congestion as compared to before the recommendations were implemented. Additionally, CV RSUs are providing real-time information to motorists with OBUs, which allow them to make smarter route choices based off of this information. Should any incidents be detected during this timeframe, emergency response personnel will be dispatched to clear the incident in as efficient manner as possible. Operations personnel will perform functions in a similar manner to Normal Operations by tracking and documenting the Incident and providing Information to motorists, first responders and stakeholders.

- **Incident Operations:** Major delays can be created by increased congestion that results from incidents that impede normal traffic flow. This increased congestion can occur for a multitude of reasons including decreased roadway capacity and other motorists slowing down to observe the incident scene (“rubbernecking”). As in peak traffic times, operators will be alerted to increasing travel times from the travel time system and operators will verify the increased congestion using the CCTVs. Any incidents, which would result in severe congestion, will result in the Operations staff coordinating with FDOT District Five and local counties to implement Integrated Corridor Management Strategies to relieve the congestion on the CFX roadway and distribute the traffic

along the arterials. Should the local operating agencies deem it appropriate, alternative signal timings will be implemented on roadway sections seeing the most congestion. These changes in signal timing can increase throughput of the arterial roadway, thereby decreasing congestion, travel time delay, and the likelihood of secondary incidents. Additionally, PTSU will be considered to reduce congestion, within the area downstream of the incident. The additional capacity will provide congestion relief and assist. Once congestion has returned to normal, the local agency will change their signals back to their normal signal timing plans. Throughout the incident, operators will use the CCTVs to assess the severity of the incident and dispatch appropriate emergency response personnel (flatbed trucks, HAZMAT, coroner) that will clear the incident scene as quickly as possible to ensure that the roadway can return to normal operations. Operators will also provide traffic information to motorists through DMS, HAR, CBRAS and the Florida 511 system, to inform them of impacts to traffic and expected delays. Additionally, motorists with CV OBUs will receive real-time information being provided by the RTMC, which can provide them additional information and allow them to make route choices based on this information. Once the incident has been cleared, the operators will remove these messages from the DMS and Florida 511 system and revert to normal operations.

- **Evacuation Operations:** Although CFX is located in Central Florida, the region is susceptible to hurricanes and, as such, is likely to be put under mandatory evacuation orders. Should an evacuation order be issued, operations personnel will be ready to shelter in place, if required, and monitor the roadways to monitor the progress of the evacuation in real time. Operators will monitor the roadways using the CCTVs and route evacuating vehicles to less congested roadways to clear the roadways as soon as possible. Should any incidents that could impede the flow of traffic be detected, emergency responding personnel will be dispatched to clear the incident as quickly as possible and incident operations protocols will be put in place as needed. Operations personnel will perform functions in a similar manner to Normal Operations by tracking and documenting the Incident and providing Information to motorists, first responders and stakeholders.

- **Maintenance Operations:** As it relates to ITS Maintenance, the implementation of the improvements recommended by the ITS Master Plan will not change the current procedures and/or processes of the CFX ITS Maintenance Contractor. The ITS Maintenance Contractor will continue to monitor the device functionality daily and provide routine maintenance, as needed, to keep all devices operational. Preventive Maintenance will be performed on a predetermined schedule, to comply with manufacturer recommendations for the various devices. Finally, the ITS Maintenance Contractor will provide emergency maintenance services for any failures which significantly disrupt the ITS system or reduce the operational effectiveness of TMC operations.

7.8. Summary of Impacts

During construction of the improvements proposed by the ITS Master Plan, minimal impacts on traffic flow in areas where various types of construction will be required is anticipated. However, when an impact does occur, proper Maintenance of Traffic (MOT) standards and practices should be implemented and followed. These include but are not limited to advance driver warnings and law enforcement presence.

Additional impacts to operations and maintenance would be an increase to staffing levels and required training on the new technologies and/or devices. The additional staffing and training would cost CFX both time and money for the training of their own personnel and the coordination of the training for CFX consultants. Once all personnel have been properly acclimated to and trained in the use of the new technologies and equipment, decreases in efficiency will cease to be an issue and additional costs will not be incurred. The time and money spent on training should be considered to be minimal as compared to the long-term benefits provided as a result of these improvements.

7.9. Analysis of the Proposed System

7.9.1. Alternatives

The ITS Master Plan proposes various projects and initiatives. These projects and initiatives will be reviewed by CFX personnel and their consultants for consideration of inclusion in upcoming five-year work plans. All options were "on the table" during the creation of the ITS Master Plan, meaning that all projects, Improvements, technologies, and strategies were explored. Therefore, there were no alternatives that were not considered.

7.9.2. Cost, Schedule, and Procurement Options

As noted in the previous subsection, the proposed projects and initiatives will be reviewed for consideration of inclusion in upcoming five-year work plans. Any items that are to be included within the five-year work plans will be further researched to obtain a high-level project estimate, anticipated project duration and determination of the best and/or most cost-effective way of procuring the project.

7.9.3. Systems Engineering Plan

CFX is not required to utilize a systems engineering process for technology projects by any Federal or State regulations. However, as a best practice, the systems engineering process should be followed and all project level systems engineering documents should be created during the design phase of any High-Risk ITS/Technology related improvements. This includes a project level ConOps (this document can serve as a guide), Project Systems Engineering Management Plan (PSEMP), Requirements Traceability Verification Matrix (RTVM), etc.

7.9.4. Performance Measurement for System Validation

System Validation ensures that user needs have been met by using Performance Measurement to show that desired outcomes were achieved due to project implementation. For any projects resulting from inclusion in the ITS Master Plan, system validation should be performed to demonstrate the effectiveness of the project. The following performance measures should be used as a baseline to validate the benefits of the project.

- ***Average Travel Times*** – A reduction in travel times along the corridor will demonstrate a reduction in congestion.

- ***Travel Time Reliability*** – Increased travel time reliability along the corridor will demonstrate that the corridor is more effectively and efficiently handling the volume of traffic.
- ***Number of vehicle crashes*** – A reduction in vehicle crashes will demonstrate that the corridor is safer for motorists.
- ***Incident Response Time*** – A reduction in Incident Response Time will demonstrate that First Responders are able to reach incident scenes faster, resulting in better care for patients and faster removal of incident vehicles resulting in a shorter Open Roads Duration.

ITS Master Plan

Notes

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