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CFX ITS Inspection Reference & Training Manual

Chapter 1

Introduction to Intelligent Transportation Systems (ITS)

1.0 INTRODUCTION TO INTELLIGENT TRANSPORTATION SYSTEMS (ITS)

Intelligent transportation systems (ITS) involves the integration of advanced communication and technologies into transportation infrastructure with the intent of capturing real-time traffic information that allows the movement of People, Data, and Freight to be safer, greener, smarter and more coordinated. ITS technologies can provide the ability for vehicles to move along the roadway more efficiently and therefore increase roadway capacity and reduce the need for roadway widening to accommodate more vehicles.

ITS Technologies include a variety of subsystems that work together to form a complete system that enables Regional Transportation Management Center (RTMC) Operations personnel to view the roadway, detect congestion, verify incidents, and disseminate information to motorists and first responders. Some of the major ITS subsystems are listed below:

- Closed-Circuit Television (CCTV) subsystem – provides pan-tilt-zoom (PTZ) capabilities in addition to live HD quality video to enable RTMC Operators to view traffic conditions in real-time.
- Traffic Monitoring Station (TMS) subsystem – uses side-fire radar to "scan" the roadway to detect vehicles as they pass in front of the sensor. These sensors report vehicle speeds and counts back to the RTMC software, which enables RTMC Operators to determine when traffic slows down, thus alerting them to possible issues on the roadway.
- Data Collection Sensor (DCS) subsystem – uses Radio Frequency Identification (RFID) to read toll tags for use in obtaining travel time information. The system consists of Yagi style antennas that are placed over the roadway, which collect the toll tag information. The antennas are connected to a 3M reader, which collects and distributes the toll tag information to allow the system to calculate travel times for the specific segment. This system is in the process of being replaced by Blyncsy Bluetooth/WiFi units.
- Dynamic Message Sign (DMS) subsystem – displays messages to motorists to alert them of incidents on the highway or other information pertinent to their travels. These messages are created by the RTMC Operators and sent to the DMS using the communications subsystem.
- Communications Subsystem – consists of network servers, switches, routers, fiber optic cables, copper conductors, etc. The communications subsystem provides the means of passing data from the RTMC to the devices and vice-versa. The communications subsystem is a high-speed, high-bandwidth communications means which allows the RTMC to view hundreds of video images at the same time while still sending and receiving information throughout the ITS system.
- Wrong-Way Vehicle Detection Subsystem (WWVDS) – consists of wrong way signs, cameras, and detectors which are installed on entrance ramps to CFX roadways. Additionally, there are wrong-way cameras and detectors on the CFX mainline roadways, which do not have associated signage. The detectors identify a vehicle which is driving in the wrong direction, which could potentially cause a head-on collision. Upon identification of a wrong-way vehicle, the subsystem illuminates LED lights on the wrong way signs (ramps only) to visually notify the driver that they are driving in the wrong direction. Simultaneously, the WWVDS sends an alert to the RTMC and others to inform them of the wrong-way vehicle. The notification includes video from an incoming and outgoing camera, which provide verification of the event. Upon notification, RTMC Operators post messages to DMS to alert drivers on the mainline roadway of a wrong-way driver. Operators also contact law enforcement and apprise them of the situation so that they can dispatch an officer to attempt to pull the vehicle off of the road prior to a head-on collision.
- Power subsystem – consists of power service drops from the local power companies, which provide power to an ITS site or multiple ITS sites, depending on the availability of power in the area. The power subsystem also includes Uninterruptible Power Supplies (UPS) at the individual sites to "back up" the ITS site, should the power company's service be interrupted.

Now that we have discussed some of the basics of ITS, lets discuss the intent of this training. Although ITS has been around for more than 20 years, it is still a very specialized area of expertise in regard to construction and CEI. Like

Roadway CEI, there are ITS specific Specifications and Design Standards to guide Contractors on how to construct the project and provide CEIs with backup to enforce proper installation of ITS devices, infrastructure, and components. This ITS CEI Training will provide an overview of the various areas of ITS that you will be inspecting and will give you a better understanding of what to concentrate your efforts on and where you can locate the CFX Specifications to ensure that the project is being built to standard. Pictures and graphics have been included throughout the Chapters to provide a greater understanding of what is and is not acceptable.

Figure 1.1 shows the CFX Roadway System to include future projects. Please use the map's Legend to determine what roadways belong to CFX and which ones are existing or planned.

Figure 1.1: CFX ITS System

1.1 Overview of CFX's ITS System

CFX has an extensive ITS network which spans their entire 125-mile expressway system. CFX's ITS includes fiber optic cable on both sides of all roadways, DMS in advance of all major interchanges to provide relevant real-time traffic information, CCTV cameras with the ability to see the complete roadway system, MVDS along CFX roadways to provide speed and traffic counts as well as identify congestion, and Wrong Way Vehicle Detection Systems to alert

the RTMC of wrong way drivers entering the roadway. The fiber optic cable connects all of the field devices to the RTMC, which allows RTMC Operators to monitor the roadway and disseminate traffic information as detailed in Section 1.0. Additional details regarding the individual devices and components used on the CFX System are included in Section 1.3.

1.2 COMPONENTS OF CFX'S ITS INFRASTRUCTURE

1.2.1 Conduit – Conduit is a Metal or PVC pipe which provides a protected pathway, or raceway, for electrical and communication cables. The CFX ITS System uses conduits to house the fiber optic cables and multi-conductor cables, which provide communications between the ITS devices and the RTMC. Conduits on the CFX ITS System also house power conductors, which provide power from the local utility company's power service drop to the ITS sites. CFX has standard conduit colors to differentiate what the conduit is being used for, such as tolls fiber, ITS backbone fiber, ITS drop fiber, and power. Conduit will be discussed in further detail in Chapter 2.

Figure 1.2: PVC Conduits

1.2.2 Pull and Junction Boxes – Pull and junction boxes are storage areas installed along a conduit path that provide an intermediate means for cable storage and housing of cable splices as well as facilitating cable pulling for long runs. Pull boxes are installed flush with grade and include concrete pads, surrounding the box, to help protect the box and also decrease the likelihood of it being overgrown with soil and grass. Pull boxes are used to house fiber optic cable, multi-conductor cable, power cable and grounding components. Pull boxes will be discussed in further in detail in Chapter 3.

Figure 1.3: Fiber pull box

1.2.3 Conductors – Conductors are wires that contain conductive materials, typically metals such as copper, which allow the flow of electrical current from one point to another. Conductors are utilized in CFX's ITS infrastructure as a means of providing power to ITS equipment and devices installed throughout CFX's system. Additionally, multi-conductor cables provide both power and communications between devices and grounding conductors connect ITS cabinets or other components to a grounding system. Conductors wills be discussed in further detail in Chapter 4.

Figure 1.4: Power and Data conductors

1.2.4 Fiber Optic Cables (FOC) – Fiber optic cables are cable assemblies containing one or more optical fibers for the purpose of carrying high speed information to and from ITS equipment using light pulses. FOC provides much more bandwidth, or capacity, and much higher speeds than copper conductors. FOC is very important to an ITS System,

because of the large number of CCTV cameras and the related video images that are being transported over the network in addition to data. FOC will be discussed in further detail in Chapter 5.

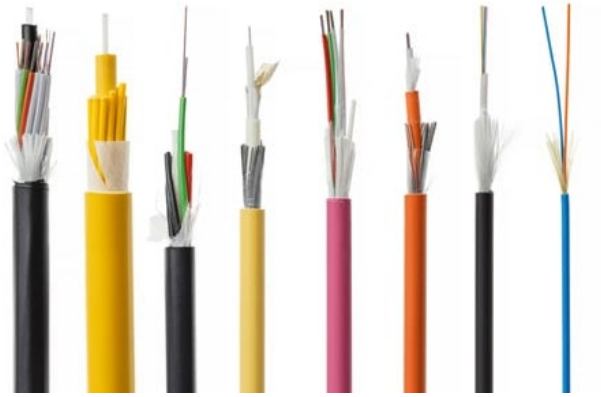

Figure 1.5: Fiber Optic Cables

1.2.5 Fiber Optic Network (FON) – The CFX FON is comprised of single-mode fiber optic cables installed in conduits along both sides of each CFX roadway, which connect ITS cabinets called local hubs (LHUB) to Toll Plaza's along with CFX and FDOT Headquarters. The single-mode fiber optic cables can transmit large amounts of data, as discussed above. The FON is very important, not only to ITS, but also to transmit tolls data throughout the CFX System. By having the FON on both sides of the roadway, CFX has a redundant communications system in place should a portion of the FON be damaged. To safeguard against construction related damage to the FON, CFX has a Line Management System (LMS) (discussed in the next subsection) installed along with the FON to allow contractors, maintenance personnel, and others to accurately locate the FON. The FON and LMS will be detailed further in Chapter 6.

1.2.6 Fiber Optic Accessories – FOC has several accessories, which need to be installed to enable the light pulses to travel from the light source to the receiver. The following items are the main fiber optic accessories used in the CFX ITS Network. These items will be discussed in further detail in Chapter 5.

- Fiber Optic Patch Panel – Fiber optic patch panels are used to terminate fiber optic cables at their point of use. CFX has fiber optic patch panels located in the ITS local hubs, data centers, toll buildings, and other buildings where access to the network is required.
- Fiber Optic Cable Enclosure – Wherever a butt-splice (full end-to-end splice of fiber optic cables) is required or where a fiber optic drop cable is spliced into the feeder cable (mid-span splice), a fiber optic splice enclosure is used to house the fusion splices. These enclosures are stored within manholes, or fiber optic pull boxes throughout the system and are watertight.
- Splice Trays - Splice trays are designed to hold individual or mass fusion spliced fibers. These trays are typically installed within fiber optic enclosures and patch panels. Individual fibers are neatly placed within the splice tray with sufficient bend radius as to not excessively bend or break the fibers.
- Fiber Optic Jumper Cables - Within all of the fiber optic patch panels, there will be fiber optic patch cables, often referred to as jumpers. Fiber optic patch cords are used to connect multiple patch panel ports for passing through, or "jumpering", the fiber optic signal directly through the patch panel or as connections to and from network switches or optical devices.

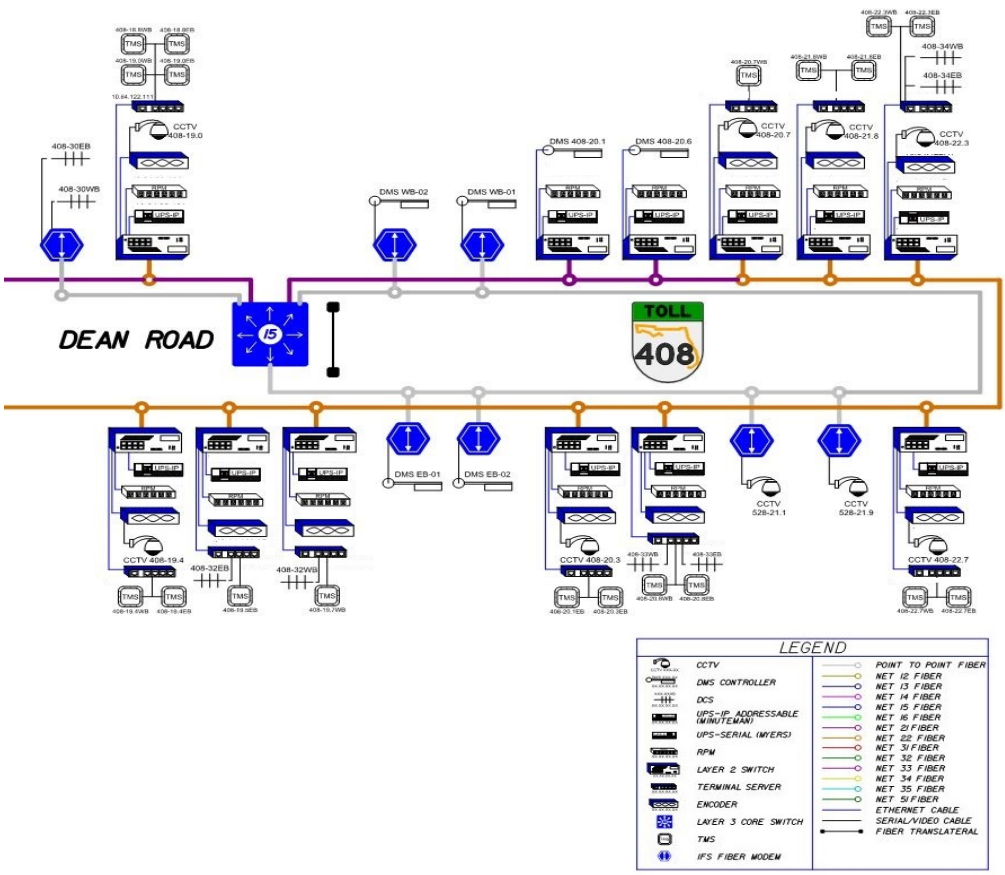

Figure 1.6: CFX FON segment

1.2.7 Line Management System (LMS) – As noted subsection 1.2.5, the Line Management System (LMS) provides a means for construction and maintenance personnel to locate the existing FON conduit system in the field to prevent damage to the FON during any type of excavation in the vicinity of the FON. The LMS is comprised of a #12 AWG insulated copper conductor called a "tone wire" installed along the entire FON conduit system that connects to a transmitter at various Mainline Toll Plazas. The transmitter can be activated or deactivated remotely using a cell phone. When activated the transmitter emits a signal along the tone wire that can be detected remotely in the field with a Radio detection™ locator. The tone wire can also be located using a portable transmitter connected to the tone wire in the field for isolated conduit runs that are not connected to the LMS. The LMS is discussed in further detail in Section 5.

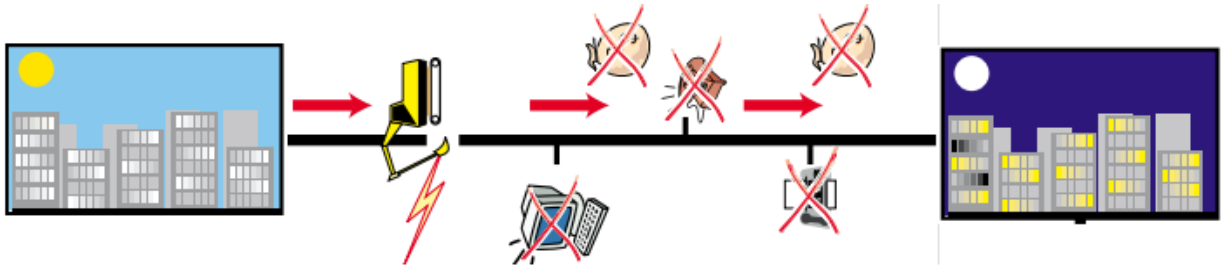

Figure 1.7: CFX LMS Locates

1.2.8 Cabinets – Cabinets and enclosures are used to house ancillary ITS equipment providing a means of access and protection from weather and vandalism. There are a variety of different enclosures secured with electronic locks which will be discussed at length in Chapter 7.

1.2.9 Electric Power Services – Electric power services provide a point of connection to the local electric company's distribution grid, which allows power to be fed to ITS equipment and devices throughout CFX's system. Electric power services will be discussed in further detail in Chapter 8.

1.2.10 Grounding – Grounding provides a means of protection for technicians and the ITS equipment from electrocution or damage by providing a designated path of least resistance for unwanted electrical current, such as lightning or elevated ground potential. A grounding system is comprised of several parts including the grounding electrode, ground wire, grounding bushings, and bussbars/terminal lugs. These parts all work together to create and provide a grounding system or grounding network that offers a robust and long-term solution. Grounding will be discussed in further detail in Chapter 9.

1.2.11 Surge Protection – A surge protection device (SPD) is designed to protect electrical equipment from experiencing voltage spikes or overcurrent by either blocking or shorting to ground any unwanted voltage that may damage the equipment's circuitry. There are various types of SPDs and the type of SPD to be used depends on the application. SPDs range in types from main A/C surges to low voltage, Power Over Ethernet (POE), Ethernet, and more.

1.2.12 Structures – There are several types of structures used on the CFX ITS Network. The type of the structure is dependent on its use. Several structures commonly used on the CFX ITS Network are listed below:

- Device poles are either concrete or steel poles used to install the ITS devices and NEMA cabinets. The poles are buried in the ground and backfilled with concrete to provide a solid foundation for the pole to withstand hurricane force winds as well as other forces.
- DMS structures are used to install DMS above the roadway or shoulder. The DMS includes a drilled shaft foundation, a vertical upright and a tri-chord or box horizontal members. In the case of walk-in DMS, the structure also includes a catwalk, which enables a technician to safely exit the bucket of a bucket truck and enter the DMS.
- Electrical power service poles are made of concrete and are used to install electrical equipment. If the power service feed from the electrical company will be overhead, a 36' tall power service pole will be used to receive the electrical feed from the power company and set the meter. If the power service feed from the electrical company will be underground, a 12' tall power service pole will be used to receive the power and set the meter. Multiple 12' poles are also used to make H-frames to allow for installation of meters, transformers, electrical service panels, and disconnects. Electrical power services are further discussed in Chapter 8.

1.3 CFX ITS DEVICES AND COMPONENTS

The major ITS device subsystems were highlighted above in Section 1.0. Each of these subsystems are comprised of ITS devices and components. The majority of these devices and components are discussed below, in addition to other items related to the Tolling System.

- CCTV – Digital CCTV cameras with pan-tilt-zoom capabilities are used on the CFX ITS Network to allow RTMC personnel to view live video images of CFX roadways. CCTV cameras are installed at locations where they can view the complete roadway section upstream and downstream to the adjacent camera locations.
- DMS – DMS are used to provide traffic information to motorists. They are located downstream of major interchanges so that motorists have time to read the message and exit off of the roadway to detour around any incidents, fuel up the vehicle, get something to eat, etc.

- MVDS – MVDS are installed at half-mile intervals along CFX roadways. They are used to get vehicle speeds to alert RTMC Operators of reduced speeds which could indicate the presence of an accident or congestion. MVDS are also used to count the vehicles as they pass by the device. Vehicle counts are currently used for planning purposes to justify roadway widenings, new roadways and other improvements.
- DCS – The DCS system consists of Yagi style antennas mounted over the roadway and 3M readers, as previously described. The DCS is installed on DMS and sign structures in areas where CFX wants to be able to calculate travel times. As mentioned previously, this system is being replaced by Blyncsy Bluetooth/WiFi units.
- Managed Field Ethernet Switch – MFES are environmentally hardened layer 2 switches that are installed in the ITS cabinets and communicate to the local ITS devices as well as other ITS equipment sites upstream and downstream. The MFES has both copper and fiber ports so that it can send and receive both Ethernet and Fiber Optic communications.
- Layer 3 Network Switch – Layer 3 Network switches combine the functionality of a switch and a router. It connects to the network to send and receive data and also has IP routing intelligence built-in to be able to direct the data packets to their intended destinations. The CFX ITS Network has Layer 3 switches located in all of the toll plazas as well as the CFX Headquarters building, the Hiawassee backup site, and the District Five RTMC.
- Media Converter – A media converter changes the communications medium of the input and outputs the data in different medium. Many times, fiber to ethernet converters are used in ITS when the existing MFES does not have any fiber ports available but does have copper ports available. In these cases, the fiber optic signal is converted from light pulses into Ethernet communications which can be plugged into the available copper port.
- Device Server – Device servers are used at all MVDS locations to convert the serial communications from the MVDS to Ethernet communications that can be received by the MFES.