Managed Field Ethernet Switch CBT

Module 2: MFES Installation

Welcome

Welcome to the Intelligent Transportation Systems, or ITS, Construction Engineering and Inspection, or CEI, Training for the Managed Field Ethernet Switch, or MFES. This is Module 2: Inspection.

MFES Inspection

Now that we have covered the basics of Managed Field Ethernet Switches, we will look at more detail about the role of Construction Engineering and Inspection personnel in MFES installation, integration, configuration, testing, and acceptance.

MFES Field Installation Site

FDOT Standard Specifications for Road and Bridge Construction, Section 684, requires that MFES devices have a minimum of four copper ports and two fiber port pairs (as described earlier in the training), keeping in mind that approved MFES devices can have up to 32 ports.

MFES units can be rack mounted, DIN rail mounted, or even just placed on a shelf. The role of CEI personnel is to ensure that the contractor will provide the right type of MFES and mounting hardware based on the intended mounting type and Cabinet.

MFES Inspection Methods

Methods used for the inspection and acceptance of many ITS devices usually fall into one of four general categories: Document review, physical inspection, functional inspection, and testing.

Physical Inspection

Document review, as so aptly named, is a review of the project submittal documents, the product warranty, and model information. Physical inspection includes a visual examination of the MFES for CEI personnel to verify, including:

1) Does each MFES unit match the submittal documents?

On larger projects, MFES delivery may occur at different times. The CEI Personnel are responsible to ensure that all MFES are the same model approved for the project. The CEI Personnel must immediately notify the CEI Project Administrator, Project Engineer, the Engineer of Record and/or the Department of any apparent discrepancies noted between the approved and delivered MFES.

2) Is the MFES unit installed properly, connected to the rack properly, and installed so that a maintainer can access the ports efficiently without moving the MFES device or other cables?

3) Are the correct ports used?

4) Have the correct transceivers been provided and installed in the correct ports?

5) Are all power and cabling connections proper?

6) Are surge protection devices properly installed for the power supply and for any copper cables connected to the MFES?

Functional Inspection

Functional Inspection includes verification that the MFES unit is connected to each ITS field device at the ITS Field Cabinet and inspection of the MFES configuration. CEI Personnel will verify that the Contractor has configured each access port with the proper VLAN.

Trunk ports should be configured manually, instead of automatically negotiated. Allowed VLANs should also be configured for trunk ports. The CEI Personnel's responsibilities also include ensuring that the Contractor has coordinated with the Department's Network Administrator regarding IP addressing and other MFES configuration requirements.

Testing

The Contractor, Integrator, or System Manager is required to conduct a field acceptance test of each MFES device using a Department-approved testing plan. The purpose of the field acceptance test is to verify the MFES is integrated, configured, and performing properly at the device or local level. The CEI Personnel role is to monitor the testing and verify that the test was conducted in accordance with the test plan and the results meet project requirements.

Often the Contractor will connect a computer to the MFES unit. The computer will have software to view and/or manage each of the ITS field elements attached to the MFES unit. The test verifies that the MFES unit can provide secure and reliable communication between the user and the ITS device.

MFES Document Review

The next few slides will cover review of documents the Contractor is required to submit at various stages throughout construction. Pre-Construction documents, also known as cut-sheet submittals, are required before the Contractor is allowed to begin procurement of equipment for installation.

During Construction refers to documents the Contractor submits while construction is progressing. Post-Construction refers to approved documents submitted by the Contractor during the integration and testing phases and prior to project final acceptance.

Document Review – Pre-Construction

According to FDOT Standard Specifications for Road and Bridge Construction, Section 603, General Requirements for Traffic Control Signals and Devices, prior to the installation of signal equipment and

within 30 days after the preconstruction conference, the Contractor shall submit a completed listing of all traffic devices or hardware with certification numbers to the Engineer for approval on a form provided by the Department.

One such form is 750-010-02. The Contractor shall submit each device information on form 750-010-02 or any other form provided by the Department. The CEI personnel will review the submittal data form provided by the Contractor that includes the device information. The CEI personnel will review the information to ensure that the submittal document information matches the device and verify that the device is listed on the FDOT APL. The Contractor must submit both an electronic copy and hard copy of the form.

Document Review - Construction

For the Plans and Specifications review, the CEI personnel will need to look at the planned quantities, locations, and any specific requirements. These quantities and criteria will need to be verified during the physical inspection.

The CEI personnel are responsible for making sure devices delivered for installation are of the same make, model, firmware, etc., that was approved by the Engineer of Record, or EOR, and the Department. Notify the EOR and the Department of any deviations from the make and model of the approved switches.

If the Contractor delivers a different model stating that the approved model is no longer available or this one is “better,” etc., the designated CEI staff member must bring this to the attention of the EOR and the Department. New versions may not have APL numbers. The EOR and the Department must be given the opportunity to review the replacement model or equipment BEFORE installation. Typically, a project plan set will have a cabinet detail sheet. These details show the various devices installed in a cabinet.

The cabinet detail sheet shown here describes the equipment layout. In this example, you will see the switch installed on the DIN Rail, as well as the associated cabling. All of the components, including the switch, should be inspected to verify their proper installation. The CEI personnel will need to verify that all copper cables connected to the MFES route through Surge Protective Devices.

Document Review – Post Construction

Currently, there are forms which different Districts may require to be used. One of the goals of this training is to ensure that all Districts are using the same forms. All the inspection aspects we’ll be covering here are in the newly developed FDOT Field Acceptance Test Procedures, developed by the Traffic Engineering and Operations Office.

For document review, CEI personnel will need the project Plans and Specifications, form number 750-010-02, final acceptance documentation as required by FDOT Specification 603-6, the device user manual, and the device warranty.

CEI personnel should look through the submittals, make sure that two copies of the Operation Manual, Troubleshooting and Service Manual, and the Installation Instructions are provided. Some manufacturers combine parts of these documents into sections of a larger user manual. Documentation for the cabling, power supply, networking, and surge protective devices, or SPDs, will also be part of the submittal process.

The CEI personnel should ensure that the warranty meets the specifications, modified special provisions, and technical special provisions. Note that some manufacturers' standard warranties do not meet FDOT specifications. However, either the Contractor or the manufacturer must warrant the product for the specified duration. FDOT warranty requirements for the MFES in the Standard Specifications require that the device has a manufacturer's warranty covering defects for five years from the date of final acceptance.

In addition to the Standard Specifications, the CEI personnel must check the project specifications for additional warranty requirements. Once the CEI personnel has verified that the warranty provided meets the specifications, the CEI personnel must make sure that the information on the warranty return service is provided; the owner is named as the warrantee; the warranty includes associated components such as cables, power supply, fiber jumper cables, etc.; and the Start and End Dates for the warranty are identified.

Knowledge Check

1. True or False. MFES Documents are only reviewed during the post-construction phase of the project.
False, MFES documents are reviewed in all phases of the project.

2. MFES documents are reviewed at which three project phases?
1) Pre-construction (or before device procurement) 2) During Construction and 3) Post Construction (Integration & Testing phase).

3. True or False. The Contractor can procure the devices if they are on the APL without Department approval.
False. The Contractor can procure the device after the device has written approval from the Department.

4. True or False. The MFES warranty period begins the day it is installed in the field.
False. MFES warranty begins on the day of final acceptance of the project.

5. For MFES, how many years of warranty is specified in the FDOT Standard Specifications for Road and Bridge Construction Section 684?
5 years

MFES Physical Inspection

During the physical inspection, inspectors will need to verify that the MFES device is properly and neatly installed in the cabinet, the correct make and model of the product has been installed, and the

physical connections for device power and communications are securely fastened. The CEI personnel should also verify that the Contractor has checked for proper voltage levels to the MFES.

Physical Inspection - Preparation

The CEI personnel should have a general knowledge of the network topology. The CEI personnel will need to know the IP addresses, subnet masks, and the default gateway of the devices. The Contractor will need to have a computer that can access the same network and subnets that the device is expected to use.

The switch port will be assigned a specific VLAN ID. Check that the correct ID has been assigned to the switch port. The CEI personnel will need to know the administrative user name and password for each device under test. MFES devices generally require an administrative user name and password to access and view certain configuration settings. Inspection forms are required for inspection during construction, as well as during the device testing phase.

When the MFES device is powered on, the laser on the optic ports could possibly be turned on. If the fiber ports are not covered or the patch cords are not installed, it can potentially cause damage to your eyes if you are in the path of the laser. The light from these lasers is invisible to the naked eye. As a safety precaution, keep the ports and ends of the patch cord covered and never look into the optic ports or into the end of any patch cord or fiber end.

Physical Inspection - Installation

While the CEI personnel are onsite to inspect the physical installation, they should first verify that the MFES appears to be installed properly. Whatever its installation method, rack mount, DIN rail, or shelf mount, give a quick look to ensure that it appears secure and won’t fall from its intended location. The CEI personnel should ensure that all switch vents are not obstructed by adjacent devices. If an MFES vent is obstructed by an adjacent device, CEI personnel are to request the contractor make the required changes to ensure the proper installation of the switch.

Examples of the three types of mounting methods are shown; they are rack mount, on the DIN rail, and shelf mount. The first example is the rack mount installation. This MFES unit spans the entire width of the rack; therefore, the switch brackets align with the rack rails. The brackets can be directly screwed into the rack. CEI personnel should ensure that self-tapping screws are not used for installing MFES.

The second example is the DIN rail installation. The MFES unit in this example does not span the width of the rack. As a result, it must be mounted on a DIN rail that provides a structural element for devices that cannot be attached to the rack directly.

The third example is a shelf that has been mounted to the rack. The shelf provides an island for devices that are unable to be directly mounted to the rack. In each example, notice that the fiber patch cords from the fiber ports are yellow, indicating the use of single mode fiber cable.

The DIN rail mount requires more attention during installation versus the rack or the shelf. There are several steps involved in this installation. First, the DIN rail itself needs to be securely mounted to the rack. Second, a clip needs to be installed on the switch. Finally, the clip on the MFES unit needs to be securely connected to the DIN rail. The CEI personnel should ensure that the clips are firmly attached to the DIN rail.

Sometimes only the top notches are hanging on the rail and the bottom ones are not, and the switch will fall off the rail. The CEI personnel should ensure that self-tapping screws are not used for installing DIN rail. The DIN rail and the attached MFES are part of the surge suppression within the cabinet. Proper attachment is necessary to ensure proper grounding and protection from stray voltages.

The CEI personnel should inspect the wiring and make sure it is neatly installed, and make sure that the wires are correctly labeled and legible. The CEI personnel should also check the terminations of power wires to make sure that they are completely seated and secured, and that there are no bare wires exposed where power enters the MFES device. The CEI personnel should check the communication terminations as well.

If the Ethernet cables in the cabinet are not prefabricated with factory molded connectors, then the CEI personnel should check that the field-installed connectors are terminated so that the outer jacket of the cable is captured in the connector. The CEI personnel are to check and make sure cables are bundled and tied to the rack. Ties must not jeopardize the integrity of the cable jacket. Check the District's Specifications for types of ties that are allowed.

When tying cables, a best practice is to use adjustable ties, such as Velcro. Be aware of the fiber bend radius on the fiber jumpers. Also, when coiling the fiber cable, ensure that the minimum bending radius is not compromised. Make sure that the device is installed and pushed back far enough in the cabinet so the door does not bend or pinch any cables. The power and communication cables should be labeled at the Remote Power Manager, or RPM, and MFES, and those devices need to have the ports labeled internally as well.

The CEI personnel should verify there is a grounding connector to the ground bus bar. All copper cables connected to the MFES unit must be protected from transients and surges by an approved surge protective device, or SPD. If cabinet wiring diagrams do not show the SPDs as required, then notify the Engineer of Record and the Department.

There are several types of SPDs on the FDOT APL. They are used for power, data, or video applications. The CEI personnel should verify that the correct type of SPD is being installed. All SPDs must be properly grounded. The CEI personnel should verify that the SPDs are either installed properly on a DIN rail, or that a ground wire is connected between the SPD and the ground bus bar.

The Contractor should verify that the input voltages to the power supply are the values specified by the manufacturer. Also, the output voltages of the power supply should be verified. The CEI personnel will need to witness that the Contractor verifies all required voltages.

Physical Inspection – Manufacturer/Model

The CEI personnel should note the make and model of the unit by inspecting the device label. Some switch manufacturers have similar models, and while the FDOT APL may include multiple devices in one series, there may be some noted exclusions.

The CEI personnel should verify that the device meets or exceeds the number of copper and fiber ports indicated in the plans. The type of fiber connectors being used, the number of ports occupied, and the number of spare ports should be noted.

Physical Inspection – Status Lights

The CEI personnel should review the manuals provided and inspect the device to verify that the proper power and link lights are on. Some may be flashing and some may be steady. Copper Ethernet ports commonly have two LEDs. One light usually remains solid to indicate connectivity and the other flashes to indicate that the port is actively passing data. The CEI personnel should inspect the LEDs to make sure that the device is functioning normally. Any inconsistencies should be noted.

Functional Inspection - Configuration

The device has already been tested to ensure that it meets FDOT Specifications, so this will be a rudimentary verification that the device has been configured properly. Based on the network configuration, the Contractor may need to connect via a console cable. However, provided the networking information is known, and the laptop being used is on the same subnet, a Web interface connection is likely to be the easiest. If utilizing the Web interface, connect the device and open a command prompt to ping the switch's default gateway, and all known addresses of the devices connected to the switch.

Next, the Contractor will log on to the Web interface and show the MFES system information to the CEI personnel. The CEI personnel will verify that the firmware date matches or is newer than the firmware listed on the FDOT APL. Additional configuration parameters, such as multicast, IGMP, and spanning tree status can also be verified in the Web interface or the Command Line Interface, or CLI.

Prior to deployment into the field, the Contractor will configure the switch at their facility. The switch will be configured for a Virtual Local Area Network, or VLAN. A VLAN is any broadcast domain that is partitioned and isolated in a network at the data link layer. VLANs allow various devices to be grouped together, simplifying network design and deployment. With most MFES, the configured VLANs can be viewed by typing in the command: "show VLAN." CEI personnel should ensure that the designed devices are grouped in their respective VLANs. In other words, CEI personnel should check to see if the switch ports are in the correct VLANs and the devices are connected to the proper ports.

Simple Network Management Protocol, or SNMP, is an internet-standard protocol for collecting and organizing information about managed devices on IP networks and for modifying that information to change device behavior. An SNMP trap destination needs to be configured on the switch. A network

management system, located at a workstation at the Traffic Management Center, will detect any operational or status changes that occur on the switch.

In some Districts, the IEEE 802.1X standard will be configured on the switches. The IEEE 802.1X standard defines a protocol for client-server-based access control and authentication. The protocol restricts unauthorized clients from connecting to a LAN through ports that are not disabled, which otherwise would be readily accessible. An authentication server is used to present a credential challenge to clients requesting access to the network.

In some Districts, the CCTV video is shared through multicast data transmission and routing. Once the video is on the multicast network, it can be accessed at any TMC or facility that supports multicast video. Therefore, the MFES unit shall support all Layer 2 management features and certain Layer 3 features related to multicast data transmission and routing.

The CCTV video can be accessed through the unicast address as well as the multicast address. An example of a multicast address is shown in a red circle. The Districts have an assigned range of multicast addresses that would be configured into the CCTV camera.

The multicast routing functionality can be shown using a monitoring tool such as Wireshark, which is installed on the Contractor’s laptop. The laptop is connected to the switch under test. A CCTV camera’s IP address is inputted, shown as the source address. Each of the cameras should have a corresponding multicast address, which is circled in red.

Some Districts utilize a feature on the switch called Internet Group Management Protocol, or IGMP, snooping. IGMP snooping is the process of listening to IGMP network traffic. This feature allows a network switch to listen in on the IGMP conversation between hosts and routers. By listening to these conversations, the switch maintains a map of links that carry IP multicast streams. Multicast may be filtered from the links which do not need them and thus, IGMP snooping controls which ports receive specific multicast traffic.

Multicast traffic is a broadcast-based network traffic; meaning on a layer 2 switch, multicast traffic is typically flooded to all access and trunk ports in a VLAN. IGMP is used in a network to control listeners' requests to join or leave a multicast group, and is required for multicast to function correctly. IGMP operates at the Network layer, layer 3.

IGMP snooping is used to prevent the flooding of multicast traffic to access ports on the switch where no active multicast listener is connected, reducing the amount of traffic flooded to the broadcast domain. Only the ports/links that have requested a multicast stream from a source on the switch will receive the multicast traffic, when IGMP snooping is enabled. IGMP is a Layer 3 protocol and is required for Protocol Independent Multicast, or PIM, which is a Layer 3 multicast protocol. IGMP snooping is a layer 2 extension of IGMP, which is local to a layer 2 switch.

The CEI personnel should verify that the Rapid Spanning Tree Protocol has been configured by the Contractor. A functional test is accomplished when two trunk ports are utilized and one is disconnected from one of the fiber ports, and then verify the connectivity to the switch is still maintained. The CEI personnel should verify that the connectivity to the switch is still maintained.

Knowledge Check

6. On what form should the Contractor submit MFES documentation to the Department and/or department representative?
750-010-02 Submittal Data – Traffic Control Equipment

7. True or False. The Department will provide the IP address schema for project devices.
True. IP address assignments would come from the District, as part of the technical plans associated with the project, OR, the District would allocate an IP subnet for the project, and the Contractor would utilize the assigned subnet according to the project's parameters.

8. What are three mounting options for the MFES?
Placed on a shelf, mounted on the DIN rail, or in a rack.

9. True or False. MFES status lights are provided at each port to indicate connectivity (excluding serial communications).
True

10. True or False. During physical installation, the inspector ensures that the switch is securely mounted, cables are neatly installed and not bent too tightly, cables will not get pinched when the cabinet door is closed, grounding of the switch, GBIC is installed, and Contractor verification of voltages.
True

MFES Testing

The MFES must undergo Field Acceptance Tests. The Contractor must develop and submit a test plan to the Engineer of Record, or EOR, and the Department for consideration and approval. The EOR and the Department has the right to witness all Field Acceptance Tests. The test must be completed within five calendar days. All new network connections should seamlessly integrate with the existing FDOT network. Testing must not affect the existing network.

Field Acceptance Tests are used on FDOT projects to verify that the Managed Field Ethernet Switches meet the requirements defined in Section 684-1.4 of the FDOT Standard Specifications for Road and Bridge Construction. Conduct local Field Acceptance Tests at the MFES field site according to the approved field test plan.

CEI personnel are to witness the following:

Verify that physical construction has been completed as detailed in the Plans.

Inspect the quality and tightness of ground and surge protector connections.

Verify proper voltages for all power supplies and related power circuits.

Connect devices to the power sources.

Verify all connections, including the correct installation of communication and power cables.

Verify the configuration of the MFES IP addresses and subnetwork mask.

Verify the network connection to the MFES through ping and telnet sessions from a remote personal computer.

Perform testing on multicast routing functionality.

It is necessary to coordinate testing activities with the FDOT Network Administrator. The Contractor is required to configure the MFES prior to performing end-to-end testing of devices such as CCTV, MVDS, DMS, etc. The MFES/Fiber Optic Subsystems of the project are most critical, as without them, end-to-end testing of the other devices is not possible.

According to the FDOT Standard Specifications for Road and Bridge Construction, Section 684-5.2 MFES: Ensure that the MFES has a manufacturer's warranty covering defects for five years from the date of final acceptance by the Engineer in accordance with 5-11 and Section 608. The final acceptance date is the date the warranty begins. Make sure the warranty documentation is updated accordingly.

MFES Project Documentation

After all of the testing and corrective action has taken place, the Contractor must gather all documentation and submit them to FDOT for final acceptance. Documents will include manuals, IP scheme, serial numbers, and as-built documentation. As-built documentation consists of the cabinet layout plan sheet, ITSFM Miscellaneous Communication Equipment Attribute Form, and a port connection diagram showing which devices are connected to the switch port. FDOT may require the CEI and the Contractor to submit all documentation and spare parts to their Operations and Maintenance Contractor upon final acceptance.

MFES Helpful Documents

Here are some important documents to use as reference materials when inspecting MFES. For a full list of important reference documents please visit the resources page.

Knowledge Check

11. What are the four main MFES inspection methods?
Document review, Physical Inspection, Functional Inspection, and Testing

12. During the submittal review, what three things need verification?
Verify switch is listed on the FDOT APL, verify that the devices installed are the devices that were approved, and notify the Engineer of Record and the Department of any deviations from the approved product.

13. When reviewing the Plans for switches, what two things should you look for?
Verify MFES is present at each location specified, verify the switch meets the design need such as

the number of ports called for, etc.
Extra credit: Verify the location of the switch on the cabinet detail sheet.

14. What are the 3 types of manuals that the manufacturer provides to the Department?
Operations Manual, Troubleshooting and Service Manual, Assembly and Installation Manual

15. What other documents may need to be submitted?
Warranty information, factory test certification, and as-built documentation.

16. Name any three things to look for when reviewing device warranties.
Check the duration against the Standard Specifications, check Project Specifications for additional requirements, warranty return service, owner is named, warranty for appurtenances, and warranty start date.

17. True or False. The MFES is functioning if the status light is OFF.
False, status light shall be ON when MFES device is communicating.

18. Where should the “slack” in the cable go?
Store fiber optic cable at each pull box and splice to allow for future splices, additions or repairs to the fiber network. (633-3.1.4 Slack Cable Storage)

Conclusion

This concludes ITS CEI Training for the Managed Field Ethernet Switch Module 2: MFES Inspection computer based training. Thank you for your time and attention.