MICHIGAN
DEPARTMENT OF TRANSPORTATION

SPECIAL PROVISION
FOR
UNLICENSED WIRELESS COMMUNICATIONS LINK

a. Description. This work consists of site evaluation and furnishing, installing, integrating, and testing an unlicensed wireless link at locations designated on the plans. Unlicensed wireless communications links must consist of all cabling, radios, antennas, and the system appurtenances required to complete a functional link. Perform this work in accordance with the standard specifications, except as modified herein.

1. General.

A. Ensure installed field equipment can operate in all weather conditions, as applicable within Michigan.

B. Use interoperable and interchangeable equipment at each field location.

2. Requirements of Regulatory Agencies. Comply with the following codes or standards:

A. FCC Unlicensed Wireless Standards;

B. IEEE 802.1D Media Access Control (MAC) Bridges;

C. IEEE 802.1p Bridging Mode;

D. IEEE 802.1Q Virtual Local Area Network (VLAN);

E. IEEE 802.3 Ethernet; and

F. IEEE 802.3af or IEEE802.3at Power over Ethernet (POE).

b. Materials.

1. Wireless link equipment includes:

A. Transmitter;

B. Receiver;

C. Antenna;

D. Cabling;

E. Patch cords and jumpers;

F. Surge suppressors and lightning protection (paid for by 20SP-826A - Grounding, Bonding, Lightning Protection and Surge Protection for Electrical System Equipment); and

G. Attenuators, splitters, and amplifiers.

2. Functional Requirements.

A. Furnish radios capable of operating in Near-Line of Sight (nLOS) and Non-Line of Sight (NLOS) environments where wireless path obstructions are present. n/NLOS radios and antennas are to support orthogonal frequency division multiplexing (OFDM), multiple-input multiple-output (MIMO) and/or other applications, features and technologies that are suitable for n/NLOS radios and antennas.

B. Furnish unlicensed links 5.8 gigahertz (GHz) capable of transmitting and receiving at distances as called out on the plans. With a minimum rated aggregate throughput of 50 megabits per second (Mbps).

C. Furnish radios capable of being asymmetrically adjusted to enhance bandwidth. Furnish wireless link software that enables configuration up and downstream link splits to accommodate bandwidth needs. Wireless links are to maintain a minimum tested data rate of 12 Mbps for closed-circuit television (CCTV) camera locations and 500 Kilobits per second (kbps) for all other equipment locations. Ensure these data rates are validated and documented during acceptance testing and any exceptions approved by the Engineer.

D. Ensure a minimum link availability of 99.9 percent over the specified distance.

E. Furnish a password protected multi configuration utility or configure the radios via a web browser interface allowing for the remote configuration of the wireless link and the ability for remote software/firmware updates.

F. Furnish radios capable of using the required number of non-overlapping channels to communicate with all radios communicating with it.

G. Furnish radios with dynamic and manual selection of available channels. The capability of locking radio channels manually in either direction and restricting each segment to specified channels is required.

H. Furnish radios with Dynamic Host Configuration Protocol (DHCP) and Network Address Translation (NAT) as network gateway features.

I. Furnish radios with support for security authentication through Advanced Encryption Standard (AES) and authentication via Remote Authentication Dial-In User Service (RADIUS).

J. Ensure the wireless link is fully interoperable with the existing network. All data transmitted from the field devices over the wireless link are transmitted to the designated Transportation Service Center (TSC), Transportation Operations Center (TOC), or communications node/tower and then on to the MDOT ITS communications network by way of the existing network.

3. Minimum technical requirements for unlicensed wireless link radios:

A. Technology Solutions. Line of Sight (LOS) wireless technologies, n/NLOS wireless technologies where wireless paths are obstructed – OFDM, MIMO or other compatible n/NLOS wireless technologies;

B. Fine tune the frequency range (within the specified unlicensed wireless ranges) for optimal communications;

C. Network Connection Types. 10/100Base-TX; 1000Base-T where Gigabit Ethernet is required as designated on the plans;

D. Intelligent packet filtering by network address, protocol, or packet content;

E. Management Information Base (MIB)-I, MIB-II, and MIB-III compliance;

F. Remote Configuration. Wired or wireless Local Area Network (LAN) Station Telnet, File Transfer Protocol (FTP), or Hyper Text Markup Language (HTML) via web browser;

G. Packet Routing. Store and forward capability required where error checking and error correction features and functions are not an option of the submitted equipment;

H. Error Checking. Cyclic Redundancy Check (CRC) 32 Bit and package protocol acknowledgment;

I. Error Correction. Forward Error Correction (FEC), Automatic Repeat Request (ARQ);

J. Network Topology. Point-to-Point (PTP) and Point-to-Multi-Point (PTMP) configurations are required as designated on the plans;

K. Security Configurations. Authentication, IP Address/MAC Address Filtering; and

L. Secure Remote Management. Simple Network Management Protocol (SNMP) version 3, Secure Sockets Layer (SSL), and Secure Shell (SSH).

c. Construction.

1. Wireless Site Evaluation.

A. Conduct a site evaluation during full foliage conditions, nominally May through September. Deliver a Wireless Site Evaluation Report for approval by the Engineer before wireless radios are procured. Do not procure radios until approval of the Wireless Site Evaluation Report is received from the Engineer.

B. Furnish wireless radios for throughput testing during the wireless site surveys. Ensure the test radios are the same make and model as the radios that are used on the project.

C. Include the following information, at a minimum, in the Wireless Site Evaluation Report.

(1) Planned wireless topology identifying PTP and PTMP radio groups.

(2) Frequency analysis, through a spectrum analysis at each site, and proposed frequency allocation.

(3) Live radio test results for each communication link, including Received Signal Strength (RSS), noise floor, throughput using Iperf or similar program, and User Datagram Protocol (UDP) performance.

(4) Link budget calculations utilizing the proposed wireless equipment (radios and antennas) that identify the following criteria:

(a) Link reliability/availability analysis;

(b) RSS levels;

(c) Fade margin values determined from the receiver sensitivity threshold level in decibels (dB);

(d) Data throughput values (Mbps), using Iperf or similar program over a duration of at least 5 minutes; and

(e) UDP test results for packet loss and delay jitter, measured over 5 minutes at the bandwidth requirements of subsection b.2.C of this special provision.

(5) Proposed antenna gain and polarization.

(6) Terrain analysis in accordance with FCC rules and regulations and this special provision.

(7) Line-of-sight/Non-Line-of-sight photographs taken at proposed antenna height level. Conducted photographs using bucket trucks, unmanned aircraft system (UAS), or existing communication towers at the proposed radio locations.

(8) Identification of any wireless interference, line-of-sight concerns, or any other issues that would hinder the Contractor's ability to deliver a clear wireless link free from obstructions that functions as required in this special provision. Recommend alternative paths and/or alternative equipment if throughput or any other requirements cannot be met by the originally proposed path or equipment.

(9) Tower/pole load bearing analysis and equipment placement as applicable for locations where mounting equipment on existing infrastructure or where co-locating multiple radios or antennas.

D. Provide all labor, tools, materials, equipment, and transportation necessary to conduct and complete this evaluation. The cost of the wireless link site evaluation and delivery of the Wireless Site Evaluation Report is included in the unit price of the wireless link pay item(s).

2. Documentation Required.

A. Submit the Wireless Site Evaluation Report to the Engineer prior to procuring the wireless radios. Do not procure radios until approval of the Wireless Site Evaluation Report is received from the Engineer.

B. Furnish complete and detailed cut-sheets on all equipment under this special provision per the Special Provision for Basic Methods and Materials for Intelligent Transportation System Work.

(1) Include equipment/parts list, schematic diagrams, antenna selection, radio equipment, communication equipment and cabling, equipment rack layouts, and device connection/protocol information.

(2) Present a list of tools and test equipment (common and specialized, and including any built-in testing facilities that are functionally equivalent to external test equipment) necessary to install, operate, test, and maintain all equipment proposed in this project.

C. Furnish any exportable electronic configuration files for each wireless link, access point and subscriber unit. The file must contain the location of the wireless link, its serial number, final accepted configuration, and must be named to indicate the device location from which it was obtained.

D. Verify in writing the final hardware and software installation configuration plans, including wiring circuit schematics, with the Engineer prior to any field installation. Ten work days are required to review detailed plans prior to authorization to commence final installation.

3. Wiring Requirements. Cut all wires to proper length before assembly with no wire doubled-back to take up slack. Furnish cabling laced with nylon and plastic straps and secured with clamps. Furnish service loops at all connection points.

4. Configuration. Ensure all equipment required for the configuration of the devices and subsystems contained in this project is supplied as an appurtenance to the equipment included in the project and at no additional cost to the contract.

5. Testing. Develop and submit to the Engineer an acceptance test per 20SP-826H – System Integration and Testing. Ensure wireless links that do not meet the performance requirements during acceptance testing are upgraded or replaced at no additional cost to the contract. Testing based on the Contractor supplied Test Plan must begin 30 days prior to the date of acceptance.

A. At a minimum, the wireless link test process must demonstrate:

(1) Remote operation by the designated TSC or TOC;

(2) Configuration, testing, and maintenance demonstration remotely from designated TSC or TOC;

(3) Actual measured data throughput for each site; and

(4) Adequate RSS indicator at each site.

6. Warranty. Furnish warranty and other applicable documents from the manufacturer, and a copy of the invoice showing the date of shipment, to the Engineer prior to final written acceptance. Furnish the wireless link with a standard manufacturer's warranty, transferable to MDOT. The wireless link must carry a warranty (parts, software, and labor) of 2 years from the date of shipment with at least 1 year of warranty remaining at the start of burn-in.

7. Maintain all equipment through final acceptance, including, but not limited to, providing and installing all available software/firmware upgrades.

d. Measurement and Payment. The completed work, as described, will be measured and paid for at the contract unit price using the following pay item:

Pay Item	**Pay Unit**
Wireless Link, 5.8 gigahertz, Access Point	Each
Wireless Link, 5.8 gigahertz, Subscriber Unit	Each

1. **Wireless Link, 5.8 Gigahertz, Access Point** includes all labor, equipment, and materials to evaluate, procure, construct, and test an Access Point radio.

2. **Wireless Link, 5.8 Gigahertz, Subscriber Unit** includes all labor, equipment, and materials to evaluate, procure, construct, and test a Subscriber Unit radio.