

Twin County 9-1-1 Regional Commission



Request for Proposals RFP 2021-Radio System

Public Safety Voice Radio Communications System Functional Specification

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1. Functional Specifications

These functional specifications describe the general, functional, and operational requirements of the desired system. While not a design, these specifications provide requirements for system architecture, performance, and support, as well as system implementation, testing, and acceptance of the new system.

The term “Offeror” refers to any proposing entity responding to the Request for Proposals (RFP), and to describe responsibilities, requirements, and/or guidelines for submission of proposals prior to the award of the contract.

The term “Selected Vendor” refers to the prime contractor awarded this project and all subcontractors hired by the prime contractor. All RFP requirements throughout the rest of this section referred to as the “Selected Vendor” apply equally to the prime contractor and all subcontractors. The “Selected Vendor” shall have a current Contractor’s License for all jurisdictions where work is performed.

1.1 System Overview

- A. The Twin County 9-1-1 Regional Commission (Commission) intends to purchase and implement an integrated public safety wireless communication system that will provide first responders real time operable and interoperable voice services that support day-to-day, mutual aid, and task force operations. The integrated public safety wireless communication system shall consist of:
 - 1. One distinct system of subsystems including radio sites, radio frequencies, dispatch consoles, and subscriber units for each of the following jurisdictions: Carroll County, Grayson County, and the City of Galax (collectively referred to as “the Jurisdictions”)
 - 2. Shared system control equipment between the three distinct subsystems
 - 3. Three Project 25 (P25) Conventional VHF channels (at a minimum) at all radio sites in each of the three subsystems, leveraging simulcast configurations within each subsystem to the greatest possible extent
 - 4. Microwave backhaul network providing connectivity between the radio sites, system control equipment, and the dispatch centers
 - 5. Dispatch consoles, backup control station radios, and logging recorder systems at each of three dispatch centers
 - 6. Network Management System (NMS) capable of monitoring and controlling above system and subsystems

7. Field/subscriber radios (portable, mobile, and control station radios)
8. Site upgrades, including, but not limited to, equipment shelters, radio towers, and AC/DC power systems

B. Alternate Proposals:

1. It is mandatory that the Offeror submit a compliant proposal, in order for alternate proposal(s) to be submitted and evaluated.
2. In the event an Offeror has a technological solution that meets the functional requirements but not all other requirements in this RFP, the Offeror may offer more than one alternate proposal if each proposal fully addresses the intent of the requirements set forth in this specification document and RFP.
3. Alternate proposals shall be submitted separately under a different cover from the base proposal and clearly marked "ALTERNATE PROPOSAL".
4. The Offeror shall comply with the same submittal instructions outlined in the RFP.

1.2 Project Scope

- A. The Selected Vendor shall furnish all equipment, materials, labor, transportation, and storage facilities, which are necessary to complete the specified work, and required for a fully functional system meeting all requirements of this RFP.
- B. The Selected Vendor shall design, install, and test all required equipment and parts.
- C. The Selected Vendor shall be responsible for providing the following project components:
 1. Project management
 2. Frequency search, coordination, and FCC licensing
 3. Site and microwave path surveys
 4. Environmental impact studies
 5. Engineering and system design
 6. Structural analyses of towers and/or buildings (for all sites requiring the installation of new antennas and/or the relocation of existing antennas)
 7. Detailed drawings and design submittals

8. System installation and construction management
 9. Acceptance testing (factory, site, radio coverage, microwave path, route, system and burn-in)
 10. Software installation and equipment programming
 11. Training
 12. Hardware and software warranty and maintenance, including spares and parts support
- D. The Selected Vendor shall plan, coordinate and conduct all work with minimal interruption of service to the existing mission critical systems. All required outages shall be scheduled in advance with the Jurisdictions and the Commission.

1.3 Standards and Guidelines

- A. The Selected Vendor shall comply with the applicable portions of the following standards, rules, regulations, and industry guidelines (presented here in alphabetical order; not reflective of priority):
1. American National Standards Institute (ANSI)
 2. American Society of Testing Materials (ASTM)
 3. Federal Aviation Administration (FAA)
 4. Federal Communications Commission (FCC)
 5. Institute of Electrical and Electronics Engineers (IEEE)
 6. International Building Code (IBC)
 7. National Electrical Code (NEC) (NFPA-70)
 8. National Electrical Manufacturer's Association (NEMA)
 9. National Fire Protection Association (NFPA) 1221
 10. Telecommunications Distribution Methods Manual (TDMM)
 11. Telecommunications Industry Associations (TIA)
 12. Underwriters Laboratories, Inc. (UL)
- B. The Selected Vendor shall comply with the applicable portions of the following industry best practices for cable installation and management in equipment racks and/or cabinets and within equipment rooms and/or shelters, as outlined in the following standards:

1. ANSI/TIA-942 - Telecommunications Infrastructure Standard for Data enters
 2. ANSI/BICSI N1-2019 - Installation Practices for Telecommunications and ICT Cabling and Related Cabling Infrastructure
 3. ANSI/NFPA 70 - the National Electrical Code® (NEC®), Article 392 Cable Trays
 4. IEEE 802.3ba-2010 - IEEE Standard for Information technology-- Local and metropolitan area networks-- Specific requirements-- Part 3: CSMA/CD Access Method and Physical Layer Specifications Amendment 4: Media Access Control Parameters, Physical Layers, and Management Parameters for 40 Gb/s and 100 Gb/s Operation
 5. ISO/IEC 14763-2:2019 - Information technology — Implementation and operation of customer premises cabling — Part 2: Planning and installation
 6. UL 60950-1 - Information Technology Equipment - Safety - Part 1: General Requirements
 7. UL 62275 - Cable Management Systems - Cable Ties for Electrical Installations
 8. UL 2024 - Cable Routing Assemblies and Communications Raceways
- C. The Selected Vendor shall comply with industry best practices, as applicable, for system installation, grounding, bonding, and transient voltage surge suppression (TVSS), as outlined in any one of the following standards:
1. Motorola R56 - Standards and Guidelines for Communication Sites (latest revision)
 2. Harris Site Grounding and Lightning Protection Guidelines (AE/LZT - 123 4618/1 - latest revision)
 3. MIL-STD-188-124B - Grounding, Bonding, and Shielding for Common Long Haul/Tactical Communications Systems Including Ground Based Communications-Electronics Facilities and Equipment
 4. Other contractor / industry standard - the Selected Vendor shall provide to the Commission for review and approval

1.4 Network Security Requirements

- A. The Selected Vendor shall comply with the following security standards and industry guidelines, as applicable, provided here in no weighted order or priority:

1. FIPS PUB 140-2; "Security Requirements for Cryptographic Modules"
 2. ISO/IEC 27000:2009; "Information Technology - Security Techniques - Information Security Management Systems - Overview and Vocabulary"
 3. ISO/IEC 27001:2005; "Information Security Management Systems - Requirements"
 4. ISO/IEC 27002:2005; "Code of Practice for Information Security Management"
 5. ISO/IEC 27005:2008; "Information Security Risk Management"
 6. ISO/IEC 27010:2012; "Information Technology - Security Techniques - Information Security Management for Inter-Sector and Inter-Organizational Communications"
 7. ISO/IEC 27031:2011; "Guidelines for ICT Readiness for Business Continuity"
 8. ISO/IEC 27032:2012; "Information Technology - Security Techniques - Guidelines for Cybersecurity"
 9. ISO/IEC 27033; "Information Technology - Security Techniques - Network Security"
 10. ISO/IEC 27035:2011; "Information Security Incident Management"
 11. ISO/IEC 18043; "Selection, Deployment, and Operations of Intrusion Detection Systems"
 12. ISO FCAPS; "Fault management, Configuration management, Accounting management, Performance management, Security management"
 13. ITIL Version 3; "Service Design, Section 4.6 Information Security Management"
- B. Routing and switching equipment shall employ Open Systems Interconnection (OSI) model Layer 2 and Layer 3 security best practices to minimize different types of attacks on the data link layer and to filter network traffic on the network layer.
- C. The system shall utilize secure protocols (SNMPv3, SSHv2 and HTTPS) for network management, configuration, alarms, and events.
- D. The Selected Vendor shall supply, install, and configure virtual private network (VPN) hardware and software to allow multiple levels of remote secure access of system RF and control infrastructure equipment.
- E. The Selected Vendor shall supply, install, and configure firewall protection system(s) and intrusion detection system(s).

- F. The Selected Vendor shall supply, install, and configure anti-virus and anti-malware software on all supplied servers and workstations. Anti-virus and anti-malware software shall include all definition updates during the warranty period, as well as during the post-warranty period (should the Commission procure post-warranty services from the Selected Vendor).
- G. The Selected Vendor shall provide operating system (OS) patches for all supplied commercial off the shelf products during the warranty period. Should the Commission procure post-warranty services from the Selected Vendor, the Selected Vendor shall provide similar OS patches during the post-warranty period. The system patches provided shall be no more than one version and/or 8 weeks older than the Software OEM releases.

1.5 Governing Codes and Conflicts

- A. If the requirements of this specification document and/or RFP differ with those of the governing codes and regulations, then the more stringent of the two shall apply.
- B. If the requirements of this specification document and/or RFP conflict with those of the governing codes and regulations, the Offeror is responsible for identifying the conflict and resolving to the satisfaction of the Commission.
- C. If the Offeror cannot meet any of the standards or guidelines listed in Section 1.3 and/or Section 1.4, the Offeror shall list all deviations in their proposal, for approval by the Commission.

1.6 Financing Options

- A. As part of all proposals, Offerors should submit options that the Commission can consider for financing the purchase price of the system through the Selected Vendor. Any provided options should outline financing period durations and projected interest rates and may include lease or term financing.

2. Project 25 Conventional Radio System

2.1 General Requirements

- A. The radio system shall comply with applicable TIA-102 (P25) standards as published at the time of proposal. If revised or new TIA-102 standards are published after the proposal date that affects the designated system components, the Selected Vendor shall work with the Commission to determine an agreeable solution to be compliant with the revised or new standards.
- B. The system shall be built as a P25 Conventional system.
- C. The system shall provide a P25 technology solution capable of operating with all P25 Compliance Assessment Program (CAP) compliant radios.
- D. The land mobile radio (LMR) and microwave backhaul systems shall be fault tolerant and contain no single point of failure that would disrupt communications.
- E. The system shall provide portable and mobile radio coverage throughout the service area as described in Section 2.3.
- F. The existing systems, which shall be replaced by the new radio system, shall support operations during the implementation and testing of the proposed system.
- G. All outages or system resource reduction from existing system operations require a detailed plan of action with contingencies identified and approved by the Commission prior to execution.
- H. The Selected Vendor shall not perform any work until the Commission has approved the Selected Vendor's migration and cutover plans.
- I. Critical hardware shall use devices such as redundant hot standby cards, and power supplies to prevent any single points of failure.
- J. The existing LMR and microwave/fiber backhaul systems shall support operations during the implementation and testing of the new systems.
- K. All equipment, antennas, parts, and accessories shall be new.

2.2 P25 System Equipment

2.2.1 System Control Equipment

- A. The system control equipment shall serve as the central control for all subsystems of the P25 network.
- B. The system control equipment shall consist of redundant equipment installed in geographically diverse locations.
- C. The system control's redundant equipment shall provide all operations and functions independent of the other.
- D. Geographically diverse system control equipment shall not require human intervention to operate in the event of a failure.
- E. Activation of geographically diverse system control equipment shall not result in any reduction of services or functions of the system control equipment.

2.2.2 Simulcast Equipment

- A. The system shall include all necessary simulcast components and signal processing elements required to optimize voice quality in coverage overlap areas.
- B. Non-captured overlap areas with delay spreads in excess of those required to meet the Delivered Audio Quality (DAQ) objective shall be minimized inside the service area.
- C. Simulcast systems shall operate without the need for manual optimization and system/subsystem alignment.
- D. The system shall include redundant simulcast control equipment located at geographically separated sites or distributed across the network.

2.2.3 Receiver Voting Equipment

- A. Receiver voting equipment shall monitor all receivers in the appropriate simulcast cell(s) and select the best signal for processing and rebroadcast through the network.
- B. Receiver voting equipment shall continue to operate in the event of failure of, or lost connectivity with, other control elements.

- C. Receiver voting shall include redundant control equipment located at geographically separated sites or distributed across the network.

2.2.4 RF Site Equipment

2.2.4.1 Repeaters/Base Stations

Repeaters/base stations shall:

- A. Comply with appropriate Part 90 of the FCC Rules and Regulations
- B. Be FCC type-accepted for the appropriate frequency band and type of service
- C. Comply with appropriate TIA-102 and similar standards
- D. Be solid state in design and function and must operate in the temperature range of -20°F - 140°F without degradation
- E. Consist of modular components or field replaceable units allowing for in the field repairs whenever possible
- F. Use linear power amplifiers

2.2.4.2 Antenna Systems

- A. Antenna systems shall:
 - 1. Provide the required guaranteed coverage
 - 2. Match the antenna design used for all coverage modeling
 - 3. Meet applicable FCC rules and regulations
- B. Antennas shall be selected to perform in and endure the anticipated environmental conditions.
- C. Low passive intermodulation (PIM) antennas shall be used to the greatest extent possible.
- D. Transmission line type and length shall be appropriate, given the radio band, to provide the required coverage. Lightning protection and grounding devices shall be used as per the appropriate industry standard(s) and manufacturer requirements.

- E. Combining equipment shall be used to minimize the number of transmit and receive antennas to the greatest extent possible.

2.2.5 Dispatch Console System

2.2.5.1 General Requirements

The dispatch console system shall support dispatch operations for the current dispatch centers and local PSAPs.

- A. The current dispatch centers are:
 - 1. City of Galax – 353 N. Main Street, Galax, VA 24333
 - 2. Carroll County – 605 Pine Street, Hillsville, VA 24343
 - 3. Grayson County – 304 Davis Street, Independence, VA 24348
- B. The dispatch console systems shall provide the following number of console positions at each dispatch center:
 - 1. City of Galax – 4 Consoles
 - 2. Carroll County – 3 Consoles
 - 3. Grayson County – 2 Consoles
- C. The dispatch console system shall support dispatch consoles directly connected to the radio network via the backhaul/interconnection network.
- D. Direct-connect dispatch consoles shall use IP connectivity for all voice, data, control, and parallel console status information.
- E. The dispatch console system must not contain any single point of failure which would disable more than a single operator position or channel resource.

2.2.5.2 Dispatch Console System Operator Equipment Requirements

- A. The dispatch console system operator equipment shall meet or exceed the following requirements:
 - 1. All dispatch console equipment supplied shall operate 24 hours a day, 7 days a week, 365 days a year.

2. The operator positions shall be proposed with a display monitor 20" or larger LCD/LED with resolution of 1920 x 1080 or better.
3. Console shall be capable of displaying all dispatching functions on a single display unit.
4. Console shall allow authorized personnel to determine which functions are available at each operator position.
5. Console shall provide an individual unit ID and text alias readout for calling units and a stacking display to reflect at least the last ten unit calls for the visible channels.
6. Console dispatch position keyboard interface shall be compatible with standard PC USB 2.0 keyboards.
7. Console dispatch position shall be proposed with a standard 101 key PC keyboard and a standard mouse/pointer device.
8. Operators shall be able to perform console functions by positioning a screen pointer (cursor) over the appropriate icon and pressing the mouse button or by touching the monitor screen.
9. Custom mice, trackballs, and accessories may be proposed.
10. Each operator position shall have a high-quality desk microphone.
11. Each operator position shall have a heavy-duty footswitch to allow operators to key the selected channel hands free.
12. All computers supplied shall be based on current production processors running a currently supported operating system. The Commission reserves the right to specify or supply the computer platform(s) in accordance with the Commission's standards. All computers shall be certified for the latest version of operating system available at the time of acceptance.
13. The failure of one or more console positions should have no effect on the remaining console positions.
14. Equipment shall enable operators to acoustically cross-mute channels to eliminate acoustic feedback between operators.
15. Console positions shall respond appropriately to the activation of an emergency alarm by field units.
 - a. Dispatch console system operator positions shall provide an audible alert, provide a visual alert of an emergency activation, and display unit ID of calling unit.

- b. Dispatch console system operator positions shall have the ability to acknowledge the emergency alarm.
 - c. The unit ID and alias for an unacknowledged emergency alarm shall not scroll from the unit ID display.
- 16. Console positions shall decrypt and encrypt secure voice communications and display a distinctive icon signifying a channel's encryption status.
- 17. Each operator position shall have the ability to utilize both a headset (wired and/or wireless) and a desk microphone for transmitting audio.
- 18. The dispatch console system shall provide an instant recall recording capability for each operator position.
 - a. Instant recall recording shall provide an interface to provide connection to the console operators' microphone audio, the selected radio channel receiver audio, and telephone audio.
 - b. Playback shall be available on the operator position.
- B. Conventional resources (e.g., repeaters, base stations, and control stations) capable of operating on multiple frequencies and/or modes shall be reconfigurable to select the desired transmit frequency / mode (select channel).
- C. An audio level meter shall be provided showing the level of transmitted and receive audio.
- D. Operator positions shall have the ability to independently set each channel's volume level. Minimum audio levels should be capable of being set to avoid missed calls.
- E. Operator positions shall have the ability to mute or un-mute audio from unselected channels. The operator's monitor shall indicate muted audio status.
- F. Selected audio and unselected audio shall be presented from separate speakers.
- G. Operator positions shall have the ability to select multiple channels for broadcast to several channels at once.
- H. Operator positions shall have the ability to patch two or more conventional resource channels so that users may communicate directly.
- I. Operator positions shall have the ability to encode two-tone sequential paging tones.

- J. Operator positions shall be equipped such that a minimum of eight simultaneous patches shall be available.

2.2.5.3 Dispatch Console System Configuration Requirements

- A. The dispatch console system shall support new features and screen configurations through software programming and not reconfiguration of hardware.
- B. The dispatch console system shall support the capability to program, store, retrieve, and edit multiple, custom operator screens and configurations for each operator position.
- C. Operator positions' display configurations and alias database shall be stored locally, at each position, or on a centrally located server.

2.2.5.4 Dispatch Console System Headset Requirements

- A. Two headset jacks, configurable for 4-wire or 6-wire, shall be provided for each dispatch operator position and it shall allow the operator to hear select audio via a headset and allow the operator to respond via a microphone attached to the headset.
 - 1. The headset jack box will also have a volume knob to control the received audio volume.
 - 2. A headset plug inserted into the jack shall automatically disconnect the console's microphone and mute the consoles select speakers.
- B. One wired headset shall be provided for each dispatch operator position and it shall allow the operator to hear select audio via a headset and allow the operator to respond via a microphone attached to the headset.
- C. A single headset shall provide the operator with both telephone and radio use.

2.2.5.5 Backup Solution

- A. The Dispatch Console System shall be provided with a backup solution, which at a minimum, provides the following:
 - 1. Maintain dispatch operations in the event of a dispatch system, individual position or multiple position failure
 - 2. Not be dependent on the primary dispatch console system for operations

3. Allow users to change channels at dispatch positions without affecting other dispatch positions
4. Have the capability of encoding two-tone sequential paging tones
5. Be capable of operating with a headset and with a conventional speaker and microphone

2.2.6 Logging Recorder System

2.2.6.1 General Requirements

- A. The proposal shall include an IP-based networked P25 compatible, digital logging recorder for EACH dispatch center.
- B. The logging recorder shall meet or exceed all applicable FCC, IEEE, TIA and APCO standards.
- C. This logging recorder shall provide the ability to log/record the following:
 1. All radio system traffic (new systems concurrently with legacy systems)
 2. All console positions proposed
 3. Screen recording
 4. All 911 calls (number of lines = approximately 20 current analog lines, transitioning to IP-based lines in 2023)
 5. Call taker administrative calls (number of lines = approximately 12)
 6. 911/Administrative SIP IP Trunks (number of trunks = 40)
- D. The logging recorder shall interface directly with the radio system for audio.
- E. The logging recorder shall record and playback encrypted radio system audio.
- F. The logging recorder shall be designed to continuously operate 24-hours per day, 365 days per year, providing recording, storage, assembly, retrieval/playback, and reporting of voice traffic.
- G. The logging recorder shall accommodate 20% future growth of the radio communications system.
- H. The logging recorder shall store a minimum of 80,000 channel-hours per hard drive and shall store two calendar years of data.

- I. The logging recorder shall be capable of being mounted in a TIA standard 19" wide rack.
- J. The logging recorder shall share the common timing reference with the radio system and console system.
- K. The logging recorder shall be based on a client/server architecture that allows for the secure transfer of digital audio, playback, and secure access.
- L. The logging recorder administrative and maintenance capabilities shall be accessible by any Windows-based personal computer (PC) connected and authenticated on the IP network interfaced with the proposed system.
- M. The logging recorder shall be capable of individual user logon. Each assigned logon shall have a specific level of access to channels and authorized permissions.
- N. The logging recorder shall be fault-tolerant to eliminate the possibility of a single point of failure interrupting recording functions, which shall include, but not be limited to the following:
 - 1. Dual power supplies
 - 2. Dual network interface cards
 - 3. Redundant Array of Independent Discs (RAID)
- O. The logging recorder shall report the following failures or issues as a minimum:
 - 1. Hardware failure or malfunction
 - 2. Software failure or malfunction
 - 3. Failure to record audio from any of the connected resources
- P. The logging recorder shall support multiple methods of alarm reporting as a minimum, including, but not limited to:
 - 1. LED (Local)
 - 2. Audible alarm (Local)
 - 3. Monitoring application

2.2.6.2 Transferable Storage Requirements

- A. The logging recorder shall have, as a minimum, the ability to transfer files by the following methods:
 - 1. USB connected flash/thumb drive
 - 2. Network attached storage
 - 3. Network attached playback stations
- B. The logging recorder shall support the ability to retrieve recordings and write them to portable storage media in standard digital media formats (e.g., .wav, .wmv, .mov, .avi, .mp4) for playback.

2.2.6.3 Search Requirements

- A. The logging recorder shall provide the following search and playback parameters for all dispatch console system and CAD positions for any combination of available data elements including the following:
 - 1. Time and date
 - 2. Duration
 - 3. Channel ID(s)
 - 4. Console position(s)
 - 5. Extension number(s)
 - 6. Individual call(s)
 - 7. Subscriber unit ID(s)
 - 8. Dialed number(s)
 - 9. Calling number(s)
 - 10. ANI/ALI data
 - 11. Incoming or outgoing calls
 - 12. Agency or agencies
- B. The logging recorder shall provide the ability to combine any number of search criteria into a single search.
- C. The logging recorder shall be able of searching and playing all channels simultaneously.

2.2.6.4 Playback Requirements

- A. The logging recorder shall allow users to set markers within a recording and the search and replay function shall be able of displaying the markers when playing back.
- B. Automatic gain control (AGC) shall be available for all replayed audio. The system administrator shall have the ability to enable or disable AGC.
- C. The logging recorder shall provide the ability to display and save all recordings associated with an incident to a single directory or location.
- D. The logging recorder shall provide the ability to playback recordings in mixed mode, where the recordings are replayed as they occurred or in sequential mode.
- E. The logging recorder shall provide the ability to vary the playback speed of each recording without pitch distortion.
- F. The following concurrent licenses shall be provided for playback operation:
 - 1. Systemwide – 15 total
 - 2. City of Galax – 5 concurrent
 - 3. Carroll County – 5 concurrent
 - 4. Grayson County - 5 concurrent
- G. The logging recorder shall allow telecommunicators and supervisors to assemble single or multimedia recordings into an event and generate reports for analysis.
- H. The logging recorder shall allow users to locate, assemble, play, and export any recorded data in a single audio (.wav) or standard multimedia file (e.g., .wmv, .mov, .avi, .mp4) for playback.
- I. The logging recorder shall playback assembled single and multimedia events using an integral or external player.
- J. The logging recorder shall allow users to easily switch between recorded source data, and the assembled event file(s).
- K. The logging recorder shall log the source recordings, the sequence in which users assemble them, and all metadata associated with the records for audit purposes.
- L. The logging recorder shall allow users to generate custom reports.

- M. The proposal shall detail the types of reports generated by the logging recorder.

2.2.6.5 Instant Recall Requirements

- A. The logging recorder shall support Instant Recall. Instant recall shall provide users the ability to instantly replay a message from any PC connected and authenticated on the IP network interfaced with the system.
- B. Instant Recall shall allow users to skip forward, skip backward, pause, stop, and play recordings.
- C. Similar to normal playback mode, Instant Recall shall allow users to control the speed of the replay without pitch distortion.
- D. Instant Recall shall allow users to access all calls recorded within the previous 24 hours.
- E. Instant Recall shall be configurable to allow access to a group of channels from each dispatch console position.

2.3 Radio Coverage

2.3.1 Coverage Requirements

- A. Each Jurisdiction's individual subsystem of radio sites shall cover the geographical boundaries of that Jurisdiction. When evaluating coverage from any one Jurisdiction, coverage of either of the other two Jurisdictions' radio sites shall not be considered.
- B. Each of the three Jurisdictions' subsystems shall meet the coverage requirements outlined in this section when evaluated independently of the other subsystems.
- C. As part of the RFP, the Commission provided electronic shapefiles for importing the service area boundaries of the Jurisdictions into a coverage modeling program.
- D. Delivered Audio Quality (DAQ), as defined in this document, applies to both inbound and outbound communications. Table 1 lists DAQ values and definitions.

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Table 1 – DAQ Values and Definitions

DAQ	SUBJECTIVE PERFORMANCE DESCRIPTION
1	Unusable, Speech Present, but unreadable
2	Understandable with considerable effort. Frequent repetition due to noise/distortion
3	Speech understandable with slight effort. Occasional repetition required due to noise/distortion
3.4	Speech understandable with repetition only rarely required. Some noise/distortion
4	Speech easily understood. Occasional noise/distortion
4.5	Speech easily understood. Infrequent noise/distortion
5	Speech easily understood

- E. At a minimum, the system shall provide the following with regards to coverage:
1. Coverage shall not decrease below what is provided by the current VHF radio systems operated by the Jurisdictions. For reference, Appendix C contains coverage maps detailing the current site configurations and coverage provided within the Twin County region.
 2. Talk-in and talk-out radio coverage shall meet or exceed 95% geographic coverage over the entire service area of EACH Jurisdiction for mobile radios, with 95% reliability and a DAQ of 3.4 or better.
 3. Talk-in and talk-out radio coverage that meets or exceeds 95% geographic coverage of EACH Critical Building listed in Appendix B for portable radios (worn in a belt case on hip), with 95% reliability and a DAQ of 3.4 or better.
- F. Offeror shall provide the guaranteed talk-in and talk-out radio geographic coverage percentages over the entire service area of EACH Jurisdiction for portable radios on-street (worn in a belt case on hip), with 95% reliability and a DAQ of 3.4 or better.
- G. Offerors may propose alternate solutions solely to address the Critical Buildings coverage requirement shown in Section 2.3.1.E.3 above. All other coverage requirements must be met by the proposed P25 radio system.
- H. Body loss associated with portable radios worn in a belt case on the hip shall be consistent with values listed in Telecommunication Industry Association (TIA)

Association (TIA) TSB-88 , Table D-5, Median Portable Antenna Loss Outside & Inside Vehicle.

- I. Coverage design, implementation, and testing for the system shall adhere to Telecommunications Systems Bulletin (TSB) TSB 88.3 - Wireless Communications Systems Performance in Noise and Interference-Limited Situations Part 3: Recommended Methods for Technology Independent Performance Verification, current version.
- J. Base station radio output power and Effective Radiated Power (ERP) levels and antenna height and gain shall be the maximum as permitted by FCC rules and regulations, unless system engineering determines that a lower height or ERP is sufficient (such as for tower top amplifiers (TTAs) or to minimize simulcast interference).
- K. Coverage guarantees shall apply to P25 Phase 1 mode.
- L. The Selected Vendor shall complete radio coverage testing with witnesses from the Jurisdictions or Commission, utilizing Bit Error Rate (BER) testing. The Selected Vendor shall submit appropriate documentation confirming lab testing of the Bit Error level for the portable radio, which will yield the equivalent of a DAQ 3.4 audio quality. Likewise, the Selected Vendor shall test the system to that level.
- M. BER testing will be performed in both talk-out and talk-in directions, and the coverage must meet the coverage requirements in BOTH directions, throughout EACH of the three Jurisdictions, to pass the coverage acceptance test.
- N. Subjective DAQ testing will be performed in both talk-out and talk-in directions, and the coverage must meet the coverage requirements in BOTH directions, throughout EACH of the three Jurisdictions, to pass the coverage acceptance test.
- O. The Selected Vendor shall perform RSSI testing in the talk-out direction and provide the results of that testing to the Commission for informational purposes.
- P. The Jurisdictions and/or the Commission will observe and monitor the entire coverage testing process. For test purposes, the Selected Vendor shall divide the service areas into grids and test the system according to Section 6.11.

2.3.2 Coverage Maps

- A. The Selected Vendor shall:

1. Employ a suitable coverage prediction model using appropriate terrain and land cover data for the environment
 2. Provide a detailed description of the propagation models used and the assumptions made in preparation of the coverage maps
 3. Include coverage statistics that account for geographic coverage percentages over the entire service areas of the appropriate Jurisdictions
 4. Submit both talk-out and talk-in subsystem composite coverage maps for all proposed design configurations
- B. All talk-out and talk-in coverage maps shall be clearly labeled and show system gain calculations for each of the following:
1. Mobile radios – standard dash or trunk mount with a unity gain antenna mounted in the center of the roof
 2. Standard portable radio outdoors – a portable radio worn at hip level in a belt case
 3. Standard portable inside a 13 dB loss building – a portable radio worn at hip level in a belt case
- C. All maps shall clearly delineate the difference between areas predicted to be equal to or greater than DAQ 3.4 equivalent coverage and areas that do not meet coverage requirements using a light transparent color or cross-hatching for those areas that meet or exceed the minimum coverage reliability threshold.
- D. The Selected Vendor shall include the effects of simulcast interference in all coverage maps.
- E. Coverage maps shall be provided in two formats:
1. 11"x17" (minimum) full color hardcopy format
 2. In PDF file format with an image resolution greater than 600 dpi when printed at 11"x17" on a flash drive
- F. The Selected Vendor shall provide Esri shapefiles of all proposed coverage footprints. Each shapefile should be descriptively named (e.g., Portable On-Street Talk-Out Coverage) and should contain metadata detailing specifics about the coverage that is contained within the shapefile (e.g., displayed coverage \geq DAQ 3.4).

- G. All maps shall include a background layer suitable for the Commission's reference (e.g., topographic map, roads, and rivers).
- H. Link budgets shall be provided, clearly defining the following minimum information, relating to each map and each site:
 - 1. Propagation model
 - 2. Simulcast timing parameters (if applicable)
 - 3. Reliability %
 - 4. Faded performance criteria
 - 5. Inferred noise floor
 - 6. Base station / repeater transmit power output
 - 7. Antenna gain (transmit and receive)
 - 8. Antenna down tilt (if applicable)
 - 9. Antenna azimuth
 - 10. Antenna height
 - 11. Transmit site effective radiated power (ERP)
 - 12. Receiver sensitivity
 - 13. Tower top amplifier and/or receiver multicoupler gain (if applicable)
 - 14. Total antenna system gains, or losses
 - 15. Calculations utilized to determine antenna system gains, or losses
 - 16. Mobile and portable antenna height for talk-out and talk-in
 - 17. Mobile and portable transmit output power
 - 18. Loss factors used for portable radios (e.g., body loss)
- I. The Selected Vendor shall use terrain elevation data of a resolution no lower than 30-meters.
- J. When performing propagation studies, the Selected Vendor shall use National Land Cover Database (NLCD) clutter data from the NLCD 2016 database, or more current clutter data.

2.4 Site Selection

- A. The system shall utilize the sites necessary to provide the desired coverage.

- B. The Selected Vendor shall use existing sites to the greatest extent possible. The Commission prefers the following priority for site selection:
 - 1. Commission-owned sites
 - 2. Existing sites the Commission currently leases
 - 3. Existing sites owned by other government agencies
 - 4. Existing privately held communications sites
 - 5. Greenfield sites
- C. Appendix A provides a list of existing Commission radio sites as well as potential sites for use. The Selected Vendor shall consider these sites but is not obligated to use them in their design, provided the coverage of the new system meets or exceeds the level of coverage provided by the existing radio systems. The Selected Vendor shall verify all information provided.
- D. If the Selected Vendor selects non-Commission-owned site(s), the Selected Vendor shall conduct due diligence and provide letters from the site owner(s) to the Commission that state:
 - 1. The owner is willing to lease space at the site to the Commission.
 - 2. Site owner is willing to provide last known structural review of the site as well as any proposed improvements by other entities at the time of the request.
 - 3. Space is available on the tower at the Selected Vendor's defined heights and space is also available for equipment in an existing room, or space is available for a shelter to be placed within the secured site area.
- E. If the Selected Vendor identifies a greenfield option in the proposed system design, the Selected Vendor must provide "documentary evidence" that they have communicated with the landowner and that the landowner is amenable to a potential lease agreement.

2.5 Field/Subscriber Radio Equipment

2.5.1 General Requirements

- A. Subscriber units shall have been successfully tested to operate on the radio system infrastructure of at least three different manufacturers through the P25 compliance assessment process (CAP).

- B. All subscriber devices shall be capable of, but not limited to the following set of requirements:
 - 1. The subscriber devices shall be P25 certified to support P25 Phase 1 & 2 conventional operations on VHF land mobile radio channels.
 - 2. The subscriber devices shall be capable of placing and receiving analog VHF conventional mode calls.
 - 3. The subscriber devices shall be capable of placing and receiving digital VHF conventional P25 mode calls.
 - 4. The subscriber devices software shall be flash programmable for adding future software enhancements.
- C. As an OPTION, subscriber devices shall be capable of, but not limited to the following set of requirements:
 - 1. The subscriber devices shall be programmable through a standard workstation computer and Over-The-Air Programming (OTAP).
 - 2. The subscriber devices shall be able to send its location over the P25 network. (GPS).
 - 3. The subscriber devices shall be programmable via a Wi-Fi connection (Wi-Fi Programming)
 - 4. The subscriber devices shall be able to communicate via a Wi-Fi connection when out of range of the P25 RF coverage. (Wi-Fi Operation)
- D. All subscriber radios shall support either the IMBE (Baseline) Project 25 vocoder or the Project 25 Enhanced Full Rate Vocoder (AMBE + 2); however, the latter is preferred.
- E. All subscriber radios shall support scanning of conventional channels (within one group) including: scan groups of 16, priority scan.
- F. Scan selection shall be retained during power-off/on (power-on default shall be the last operator selection).
- G. All subscriber radios shall also support the ability for users to configure or alter scan operations including the definition of a scan list.
- H. The Offeror shall describe how their subscriber devices and programming software will protect against unauthorized subscriber devices being programmed to operate on the proposed P25 system.

- I. All subscriber radios shall support a programming file management feature that allows the subscriber radio programming files to be created and stored in a centralized database, including a description of the programming file and designators of the subscriber radios for which it is to be applied (programmed).
- J. This feature shall allow a remote user to access programming files created by the programming software and stored on the database (and that are specifically designated for their radios by the radio alias) and to program them into those specifically identified radios.
- K. Selected Vendor shall include all software and hardware necessary to support the creation of programming files to be stored on the centralized database as well as for the centralized database itself.
- L. Programming hardware (cables, etc.) and software shall be provided for each purchased model.
- M. Subscriber devices, portables, mobiles, and control stations shall be provided with all the necessary software, hardware, antennas, batteries etc. without the need to purchase any additional hardware, or software for the devices to operate as proposed.
- N. Subscriber devices shall be provided with a 3-year warranty period starting with and aligned with system acceptance.

2.5.2 Portable Subscribers - General Requirements

- A. All portable subscriber radios shall include a flexible, covered antenna (readily removable utilizing a screw-in connector). BNC connectors are not acceptable.
- B. Batteries shall connect securely to portable subscriber radios and shall not require the use of tools to attach or remove.
- C. Internal speaker/ microphone shall include:
 - 1. Connection of an external speaker/microphone that mutes the internal speaker/ microphone
 - 2. Connection of an external earpiece that mutes the internal speaker
- D. Universal or individual connectors with the following features:

1. Microphone and earpiece connections must be capable of supporting the following types of microphone/earpiece devices (including types used in surveillance):
 - a. External speaker/ microphone
 - b. Earpiece
 - c. Programming interface
- E. The attachment point on the portable radio shall be on the portable radio's main chassis and not on the radio's battery. The attachment point shall be at a point on the radio that can be worn at hip level in a belt case.

2.5.2.1 Portable Subscriber Radio - Basic Requirements

- A. A total of 549 portable subscriber radios shall be proposed providing the following capabilities for user controls and displays:
 1. Push-to-talk switch
 2. On-Off/Volume knob, mounted on top
 3. Two soft keys
 4. Minimum of 3 navigation keys
 5. Emergency button, mounted on top with easy access
 6. Top-mounted rotary switches allow use of "banks" of channels, each bank consisting of 16 channels
 7. Front Display with two lines of text (minimum 12 characters per line) and status icons for battery status and in-range indicator
 8. Display shall be readable in all conditions from direct sunlight to total darkness
 9. Indicators shall be capable of being disabled in surveillance mode:
 - a. Transmit
 - b. Receive
 - c. Battery Status
 - d. Encryption Status
- B. Portable subscriber units shall be provided with:

1. Standard Battery (meeting the above-listed requirements)
 2. Radio antenna (with options of quarter-wave flexible dipole or helical)
 3. Single unit rapid charger
 4. P25 Phase 1 (FDMA) conventional operation
 5. Analog conventional operation
 6. Programming of the appropriate codeplug/personality, based on templates developed during the fleetmapping process
- C. Pricing shall be provided for portable subscriber radios in a "Fire Service" configuration that includes:
1. Extended environmental specifications (beyond those listed below)
 2. Larger and easier to access knobs and controls
 3. Highly visible color(s)
 4. Intrinsic Safety certification, optional
 5. Bluetooth capable of interfacing with MSA G1 SCBA systems

2.5.2.2 Portable Subscriber Radio - Environmental Requirements

- A. All Portable subscriber radios shall meet or exceed the following environmental specifications per MIL-STD-810 (latest revision):
1. Operating Temperature: -30 C to +60 C
 2. Low Pressure Operation: 500.3 Procedure II
 3. High Temperature, Storage / Operation: 501.3 Procedure I / II
 4. Low Temperature, Storage / Operation: 502.3 Procedure I / II
 5. Temperature Shock: 503.3 Procedure I
 6. Solar Radiation: 505.3 Procedure I
 7. Humidity: 507.3 Procedure II
 8. Dust, Blowing: 510.3 Procedure I
 9. Vibration: 514.4 Procedure I
 10. Shock, Functional: 516.4 Procedure I
 11. Rain, Blowing / Dripping Water (for metal case): 506.3 Procedure I / II

12. Salt Fog (for metal case): 509.3 Procedure I

2.5.2.3 Portable Subscriber Radio Batteries

- A. All portable subscriber radios shall be equipped with standard-capacity batteries that, when starting with a full charge, allow operations for 10 hours at a duty cycle of 5% transmit, 5% receive, and 90% idle.
- B. Portable subscriber radios shall be OPTIONALLY equipped with high-capacity batteries that, when starting with a full charge, allow operations for 16 hours at a duty cycle of 5% transmit, 5% receive, and 90% idle.
- C. All portable subscriber radios shall be equipped with batteries that have a typical time to charge or recondition from fully drained to fully charged of 8 hours or less.
- D. Both single and multiple-unit (six portable radios, minimum) chargers shall be available for the portable subscriber units, and both shall operate from 110 VAC sources.
 - 1. Both shall support a rapid charge of batteries (complete charge in 1 to 2 hours).
 - 2. Both shall support the standard-capacity and/or high-capacity batteries (connected to their radios or not).

2.5.2.4 Portable Subscribers – Models to be Proposed

- A. Offerors shall propose, describe and price at least three models ("tiers") of portable radios to include:
 - 1. Law Enforcement Portable
 - 2. Fire/Rescue Portable (Officer and Basic versions)
 - 3. Public Service Portable
- B. Offerors shall provide information detailing the differences between the proposed portable subscriber models and how each model's features and functions are beneficial to the three user groups (Law Enforcement, Fire/Rescue, and Public Service)
- C. In addition to these tiers, Offerors are encouraged to propose additional models that meet the minimum requirements of this functional specification.

- D. As an option, pricing for intrinsically safe, waterproof, and ruggedized portables shall be provided.

2.5.2.5 Portable Subscriber Radio – Law Enforcement Model

- A. In addition to the requirements listed for portable subscriber devices, a percentage of the Law Enforcement portable models shall include the following capabilities (the pricing sheets provided with the RFP contain the exact percentage of subscriber units requiring encryption):
 - 1. AES Encryption
 - 2. Multikey option
 - 3. Over the Air Rekey (OTAR)
 - 4. Surveillance mode allowing for covert operation (lights dimmed, tones muted, etc.)
- B. Offerors shall detail which of the following features may be supported by their proposed subscriber devices:
 - 1. Over the Air Programming (OTAP)
 - 2. Programming over Wi-Fi
 - 3. P25 link layer authentication
 - 4. GPS location services
 - 5. Use of broadband (LTE and/or Wi-Fi) when P25 is unavailable.
- C. The Law Enforcement subscriber devices shall include a remote speaker-microphone (heavy-duty, palm-type with push-to-talk switch, emergency button and self-retracting coil cord)

2.5.2.6 Portable Subscriber Radio – Fire/Rescue Models

- A. In addition to the requirements listed for portable subscriber devices, the Fire/Rescue model shall include the following capabilities:
 - 1. Extended environmental specifications
 - 2. Larger and easier to access knobs and controls.
 - 3. Highly visible color(s)
 - 4. OPTIONAL Intrinsic Safety certification

5. Noise reduction technology for fire service environments
- B. Offerors shall detail which of the following features may be supported by their proposed subscriber devices:
1. Over the Air Programming (OTAP)
 2. Programming over Wi-Fi
 3. P25 link layer authentication
 4. GPS location services
 5. Use of broadband (LTE and/or Wi-Fi) when P25 is unavailable.
- C. The Fire/Rescue subscriber devices shall include a remote speaker-microphone designed for Fire/Rescue operation including the following:
1. Extended environmental specifications
 2. Larger and easier to access knobs and controls.
 3. Highly visible color(s)
 4. Emergency button
- D. 10% of the Fire/Rescue subscriber devices shall be “Officer” versions, and the remaining 90% shall be “Basic” versions. All “Basic” versions must meet the requirements for Fire/Rescue portables previously outlined in this section. “Officer” versions, in addition to the same requirements, shall include:
1. A full keypad
 2. Capability of encoding two-tone sequential paging tones

2.5.2.7 Portable Subscriber Radio – Public Service Model

- A. Offerors shall detail which of the following features may be supported by their proposed subscriber devices:
1. Over the Air Programming (OTAP)
 2. Programming over Wi-Fi
 3. P25 link layer authentication
 4. GPS location services

- B. The Public Service subscriber devices shall include a remote speaker-microphone (standard-duty, palm-type with push-to-talk switch, emergency button and self-retracting coil cord).

2.5.3 Mobile Subscribers - General Requirements

- A. The Mobile subscriber radios shall be constructed with the following distinct components:
 - 1. A chassis configured for mounting in the trunk of a vehicle or other similar compartment
 - 2. A control head configured for remote mounting in the console or dash in the front of a vehicle with a cable length of 17 feet minimum and a round-type cable with single protective outer sheath enclosing all other conductors
 - 3. A microphone with a self-retracting coil cord that shall be 4 feet long (minimum) when extended
 - 4. An external speaker
 - 5. Installation brackets and interface cables for all above components

2.5.3.1 Mobile Subscriber Radio – Basic Requirements

- A. A total of 257 mobile subscriber radios shall provide the following capabilities for user controls and displays:
 - 1. Push-to-talk switch on microphone
 - 2. On-Off button
 - 3. Volume knob
 - 4. Rotary knob for mode or zone selection, each bank consisting of 16 channels
 - 5. Five soft keys
 - 6. Emergency button
- B. Display shall contain two lines of text (minimum 12 characters per line) plus one line of icons and one line of menus .
- C. Display shall be readable in all conditions from direct sunlight to total darkness.
- D. Mobiles shall be programmed with the appropriate codeplug/personality per individual agency requirements, as developed during the fleetmapping process.

- E. Installation of each mobile unit shall include proper power and coaxial cables, antennas, external speakers, and microphones.

2.5.3.2 Mobile Subscriber Radio - Environmental Requirements

- A. All mobile subscriber radios shall meet or exceed the following environmental specifications per MIL-STD-810E (or equivalent items in 810 F):
 - 1. Operating Temperature: -30 c to +60 C
 - 2. Low Pressure Operation: 500.3 Procedure II
 - 3. High Temperature, Storage / Operation: 501.3 Procedure I / II
 - 4. Low Temperature, Storage / Operation: 502.3 Procedure I / II
 - 5. Temperature Shock: 503.3 Procedure I
 - 6. Solar Radiation: 505.3 Procedure I
 - 7. Humidity: 507.3 Procedure II
 - 8. Dust, Blowing: 510.3 Procedure I
 - 9. Vibration: 514.4 Procedure I
 - 10. Shock, Functional: 516.4 Procedure I
 - 11. Rain, Blowing / Dripping Water (for metal case): 506.3 Procedure I / II
 - 12. Salt Fog (for metal case): 509.3 Procedure I

2.5.3.3 Mobile Subscribers – Models to be Proposed

- A. Offerors shall propose, describe and price at least three models ("tiers") of mobile radios to include:
 - 1. Law Enforcement Mobile
 - 2. Fire/Rescue Mobile
 - 3. Public Service Mobile
- B. Offerors shall provide information detailing the differences between the proposed mobile subscriber models and how each model's features and functions are beneficial to the three user groups (Law Enforcement, Fire/Rescue, and Public Service)

- C. In addition to these tiers, Offerors are encouraged to propose additional models that meet the minimum requirements of this functional specification.
- A. As an option, pricing shall also be provided for the following types of mobiles:
 - 1. Dual control head
 - 2. Handheld control head
 - 3. Dash mount

2.5.3.4 Mobile Subscriber Radio – Law Enforcement Model

- A. In addition to the requirements listed for mobile subscriber devices, a percentage of the Law Enforcement mobile models shall include the following capabilities (the pricing sheets provided with the RFP contain the exact percentage of subscriber units requiring encryption):
 - 1. AES Encryption
 - 2. Multikey option
 - 3. Over the Air Rekey (OTAR)
- B. The Law Enforcement model shall include a "Motorcycle" Optional configuration that is the same as above, but shall contain:
 - 1. A water-resistant palm microphone (instead of a standard palm microphone)
 - 2. A water-resistant speaker (instead of a standard speaker)
 - 3. Motorcycle power and radio interface cables
- C. Offerors shall detail which of the following features may be supported by their proposed subscriber devices:
 - 1. Over the Air Programming (OTAP)
 - 2. Programming over Wi-Fi
 - 3. P25 link layer authentication
 - 4. GPS location services
 - 5. Use of broadband (LTE and/or Wi-Fi) when P25 is unavailable.

2.5.3.5 Mobile Subscriber Radio – Fire/Rescue Models

- A. In addition to the requirements listed for mobile subscriber devices, the Fire/Rescue model shall include the following capabilities:
 - 1. Extended environmental specifications
- B. Offerors shall detail which of the following features may be supported by their proposed subscriber devices:
 - 1. Over the Air Programming (OTAP)
 - 2. Programming over Wi-Fi
 - 3. P25 link layer authentication
 - 4. GPS location services
 - 5. Use of broadband (LTE and/or Wi-Fi) when P25 is unavailable.

2.5.3.6 Mobile Subscriber Radio – Public Service Model

- A. Offerors shall detail which of the following features may be supported by their proposed subscriber devices:
 - 1. Over the Air Programming (OTAP)
 - 2. Programming over Wi-Fi
 - 3. P25 link layer authentication
 - 4. GPS location services

2.5.4 Control Station Subscribers

- A. A total of five control station subscriber devices shall be provided.
- B. The control station subscriber device shall have the same basic performance characteristics the Mobile Radio with the addition of:
 - 1. The control station configuration shall be configured/equipped as a two-piece unit with an external power supply and a mounting-tray (for use on a desk or other surface) as well as with desktop, "paddle" style microphone.
 - 2. The control station shall be provided with an outdoor permanently mounted antenna, associated coaxial cables and grounding.

2.5.5 Subscriber Radios - Multiband OPTIONS

- A. Offerors shall also provide pricing for multi-band portables, mobiles, and control stations capable of operating in the VHF band as well as a minimum of one other band, either UHF or 700/800 MHz.

2.5.6 Pager Devices

- A. The Commission currently operates VHF analog paging systems alerting tone and voice pagers utilizing two tone sequential paging tones and dispatcher voice.
- B. The Commission anticipates the use of the P25 system for alerting pager devices.
- C. Offerors shall propose 380 pager devices capable of operation in the VHF spectrum.
- D. These pagers shall be capable of decoding existing two-tone sequential paging tones as well as digital decoding P25 messages.
- E. The Offeror shall describe how the dispatch consoles and P25 system will alert single and groups of pagers.

3. Microwave Backhaul System

This section describes the general, functional, and operational requirements of the desired microwave radio backhaul system. While not a design, this RFP specifies requirements for system architecture and performance including redundancy, capacity, and path availability.

The new radio system may be able to leverage existing or planned commercial fiber assets for use as an alternative to microwave backhaul for some links. Appendix E lists information about commercial organizations which expressed interest in working with the Commission for infrastructure sharing initiatives. As an OPTION, Offerors should propose a backhaul system leveraging those potential commercial assets.

3.1 General Requirements

- A. The microwave backhaul system shall be configured using multiple interconnected rings to provide route diversity and minimize single-points-of-failure. Rings shall have a minimum of two connection points to adjacent rings, to provide route redundancy for inter-ring traffic.
- B. The Selected Vendor shall be solely responsible for the new microwave backhaul system performing as specified in this RFP and to be compliant with all new or modified FCC radio station licenses.
- C. The microwave backhaul system shall:
 - 1. Utilize Multiprotocol Label Switching MPLS technology.
 - 2. Utilize Ethernet/IP-based connections that shall be transported end-to-end in its native format with no intermediate time division multiplex (TDM) conversion.
 - 3. Support a smooth transition from the existing systems to Ethernet/IP-based radio systems.
 - 4. Prioritize traffic and guarantee bandwidth for critical applications, as defined by the Commission.
- D. All microwave radio links on spur routes shall be monitored hot standby (MHSB) with full protection. MHSB is not required for links that are on a ring.
- E. All microwave links within a ring shall be configured for loop protection.

- F. Software and firmware updates must be thoroughly regression tested prior to release and implementation. Software updates must include release information identifying the changes made, either to repair a problem or enhancements made.

3.2 System Performance Requirements

- A. Microwave links shall be designed for a minimum two-way end-to-end annual availability of 99.999% at a bit error rate (BER) of 10^{-6} .
- B. The microwave backhaul system shall:
 - 1. Provide a capacity capable of supporting the proposed radio system plus 50% with a minimum capacity of 150 Mbps.
 - 2. Maintain a frame loss of less than 0.01%; this includes any packets out of order (see jitter below)
 - 3. Have a latency of less than 50 ms for all Ethernet circuits, including from an Ethernet port at one site to an Ethernet port at any other site.
 - 4. Have a jitter of less than 20 ms for all MPLS circuits, including all equipment from the end-user equipment on one end to the end-user equipment on the other end, and shall ensure that all packets arrive in order.
- C. The network shall support the following QoS techniques:
 - 1. Classification (Layer 1/Layer 2/Layer 2.5/Layer 3)
 - 2. Marking (Layer 2/ Layer 2.5/ Layer 3)
- D. The network shall honor incoming QoS settings throughout the packet transport network and ensure that the IP packet markings remain set when each packet reaches its destination and is delivered to the local network.
- E. QoS techniques shall be capable of dropping packets of a lower priority when required to maintain the throughput of the higher priority packets or designating traffic of different priorities to different or alternate paths through the network. The network shall ensure that the high priority traffic is transported should the throughput on a path drops below predetermined network thresholds due to a microwave path degradation or other interference.

3.3 Microwave Backhaul Equipment

3.3.1 Microwave Radios

3.3.1.1 General

A. All microwave radios shall:

1. Be 19" rack mountable
2. Be type accepted for licensing under Part 101 of the FCC Rules and Regulations
3. Utilize all-indoor or split-mount architecture. All-door and split-mount radios shall be fully compatible, allowing a split-mount radio on one end of a path and an all-indoor radio on the other end of the same path.
4. Support built-in error detection and correction
5. Be equipped for Adaptive Coding and Modulation (ACM) with a range of modulations from QPSK to 256QAM or higher, to allow the radios to automatically adjust the modulation during path fading to prevent total loss of communications. Switching between modulation rates shall be error-free for all traffic.
6. Support hot standby (HSB), space diversity (SD), combined HSB/SD, and frequency diversity (FD). Average transmitter switching times for HSB and SD shall be not more than 50 ms, and receiver path switching shall be errorless.
7. Be equipped for -48 VDC operation and have redundant power supply cards
8. Have a minimum mean time between failure (MTBF) of 20 years
9. Support the following management techniques and standards:
 - a. Command line interface for configuration, management, and troubleshooting
 - b. Secure Shell (SSH, SSHv2) and Telnet for remote configuration and management
 - c. Remote Authentication Dial-In User Service (RADIUS) authentication services
 - d. Terminal Access Controller Access Control System (TACACS) authentication services

- e. Syslog for remote logging
- 10. Support Simple Network Management Protocol (SNMP v2c, SNMP v3) for remote monitoring via common network management tools
- 11. Provide sufficient transmit output power to meet the requirements of each link and comply with frequency coordination limitations and applicable FCC rules
- 12. In HSB mode, a fault detected in the online transmitter shall cause that transmitter to mute and the standby transmitter to unmute.
- 13. Be designed to ensure that the receiver with the better performance is operational at any given moment
- 14. Automatically transfer from the main receiver to the standby receiver and back without introducing traffic errors (hitless/errorless switching)

3.3.1.2 All-Indoor Radios

A. All-Indoor radios shall:

- 1. Operate to specification from 23°F to +131°F, and 5% to 95% humidity (non-condensing)
- 2. Have an RF transmitter switch
- 3. Have a transmit monitor port for in-service maintenance
- 4. Provide built-in waveguide expansion ports to allow multiple RF signals to operate on a common waveguide/antenna.
- 5. Include a calibrated transmit monitor port on the antenna coupler unit (ACU) for power and spectrum measurement purposes
- 6. Include front-panel test points for received signal strength indication (RSSI) measurement

3.3.1.3 Split-Mount Radios

A. All split-mount radios shall:

- 1. Include an indoor unit (IDU) and one or more outdoor radio frequency outdoor units (ODU)

B. The connecting cable between the IDU and ODU shall be hardened for outdoor installations in a coastal environment.

- C. IDUs shall operate to specification from 14°F to 122°F, and 0% to 95% humidity (non-condensing).
- D. ODUs shall operate to specification from -25 °F to 155 °F, and 100% humidity.
- E. The ODU shall Incorporate an RSSI port for antenna alignment purposes.
- F. Split-mount radios shall have an indirect ODU mount option to allow the ODU to be mounted on the tower, either close to the antenna and connected to the antenna with flexible waveguide, or at the base of the tower and connected to the antenna with waveguide.

3.3.2 Microwave Radio Antennas

- A. Microwave radio antennas shall:
 - 1. Be compatible with the radio frequency bands used and conform to applicable FCC requirements
 - 2. Be solid, parabolic, Category A antennas with radomes in accordance with FCC Part 101.115. Shielded antennas shall be used as required by frequency coordination
 - 3. Be of size and type to meet the specified path availability requirements
 - 4. Shall be equipped with two azimuth/stabilization rods for 8-foot diameter antennas or larger and one for 6-foot diameter antennas, tying the antenna rim to the tower steel (not tower cross members). Azimuth/stabilization rods are not required for 4-foot diameter and smaller antennas.
- B. Microwave antenna systems shall utilize:
 - 1. Mounting hardware designed specifically for the size and type of antenna mount structure, and the type of antenna used. Make and model numbers for all antenna mount hardware shall be provided to Commission for approval prior to beginning installation.
 - 2. Pressurized elliptical waveguide for from the antenna to all indoor mount radios. Connectors shall be standard, premium type, and compatible with the antenna
 - 3. Solid corrugated copper outer conductor coaxial cable for split and all-outdoor mount radio configurations

- C. The Selected Vendor shall furnish a dehydrator/pressurization system at sites with full-indoor microwave radios that is:
1. Capable of maintaining at least 5 pounds per square inch gauge (psig) positive pressure of conditioned air in the elliptical waveguide. Individual pressure gauges with valves on a distribution manifold shall be provided for each transmission line.
 2. Manually adjustable without the need for software or removable media
 3. Equipped with a run alarm and high and low-pressure alarms
 4. For solar-powered sites, the Selected Vendor shall furnish a dehydrator with low duty cycle and power drain, to minimize power consumption

3.3.3 MPLS Routers

- A. MPLS routers shall support the following:
1. Support the management of traffic at each site
 2. Provide for provisioning of primary and secondary services for dedicated bandwidth and permit the remaining traffic to select the best route across the network
 3. Ensure that service is uninterrupted during link failures
 4. Be equipped with built-in redundancy capable of supporting transport media MHSB or loop protected ring microwave hops
 5. Be configured with dual -48 VDC power supplies for redundancy
 6. Be 19" rack mountable
 7. Reroute network traffic in less than 50 ms in response to a path or device failure or transport media throughput restriction
 8. Support Internet Protocol Version 4 (IPv4) with OSPFv2, and Version 6 (IPv6) with OSPFv3
 9. Shall utilize a dual controller/compact flash. This requirement can be met with a single shelf that has dual controller/flash or a dual shelf design that has a single controller/flash per shelf.
 10. Support the following interface types:
 - i. Sdf
 - ii. 10/100/1000 Ethernet (RJ45)

- iii. DS1 and DS3
 - iv. OC3
 - v. Small Form-Factor Pluggable (SFP) interfaces
11. Support the following IP network requirements when managing traffic:
- vi. Guaranteed and dedicated bandwidth
 - vii. Automatic reroute upon a physical path failure or restriction
 - viii. Provisioning of primary and alternative paths for high priority latency and jitter sensitive traffic
 - ix. Packet “switching” in place of hop-by-hop routing
 - x. Honor IP class of service marking for various priorities of traffic
 - xi. Overlapping IP addresses in different virtual networks
 - xii. The ability to provide Layer 3 VPN, VPLS, and pseudo-wire services that can support IP, ATM, and Ethernet connectivity

4. Network Management

4.1 Network Management System (NMS)

- A. The Selected Vendor shall use a single NMS for all equipment (i.e. P25, microwave backhaul and IP networking).
- B. The NMS shall be a hierarchical system, capable of incorporating multiple management systems into a high-level management system that provides a single point to manage multiple subsystems.
- C. The NMS shall monitor real time and ensure proper equipment configuration, operation, and integration of existing systems.
- D. The NMS shall monitor the following subsystems at a minimum:
 - 1. Simulcast and voting equipment
 - 2. RF Site equipment
 - 3. Dispatch console subsystem
 - 4. Logging recorder
 - 5. Transport Backhaul system
 - 6. Site alarms (environmental)
 - 7. Any other proposed subsystem
- E. The NMS shall display system status and alarm conditions.
- F. The NMS shall support Simple Network Management Protocol (SNMP) allowing interfaces with higher-level network management systems.
- G. The NMS shall provide Simple Mail Transfer Protocol (SMTP) and Short Message Service (SMS) support to allow for email and text notification of system issues and alarms.
- H. The NMS shall:
 - 1. Monitor the health of all networked devices
 - 2. Generate real-time system statistical reports including failure, usage and performance reports

3. Provide email and text notification functions based on multiple levels of fault configurations
- I. The NMS shall include storage to support no less than 6-months retention of all system data and reporting, without the need for removable or external archiving equipment.

4.2 Network Management Terminal (NMT)

- A. The Selected Vendor shall furnish three NMT's for the P25, microwave backhaul and IP network equipment. These terminals shall be located at the three dispatch centers within the City of Galax, Grayson County, and Carroll County.
- B. Each NMT shall include:
 1. Computer
 2. Display
 3. Keyboard, mouse, interfaces
 4. Networking equipment
- C. The NMT shall provide administrative and user profiles that set permissions for each set of user credentials.

4.3 Site Alarms/Environmental Alarms

- A. The Selected Vendor shall furnish all hardware and software to monitor, at a minimum, 20 conditions/points at each site (system control, simulcast/voting, dispatch, microwave backhaul and RF sites). At a minimum, the following alarms shall be monitored:
 1. Door open/close
 2. Temperature high/low
 3. Power failure (AC and DC)
 4. UPS failure, low battery and bypass
 5. Generator run
 6. Generator low fuel
 7. Generator failure alarms

- 8. Tower lights
 - 9. Smoke alarm
- B. The proposal shall assume existing sites to be reused in the system design will contain a punch block where existing environmental alarms shall be available.

5. Civil Development

5.1 Existing Site Improvements

5.1.1 General

- A. The Selected Vendor shall be responsible for site improvements based on deficiencies discovered through the site surveys.
- B. Refer to Appendix A for available information on existing sites. The Selected Vendor shall verify all data.
- C. The Selected Vendor shall verify that all sites selected for use have sufficient space available for antenna and ancillary equipment to be mounted on the tower/structure. If the Selected Vendor chooses a location on the tower/structure that is not available, the guarantee of coverage shall not change even though an alternative design may be required.
- D. The Selected Vendor shall perform structural analyses on all existing sites (towers and/or buildings) selected for their design. If no current drawings are available, the Selected Vendor shall provide all tower mapping services required for the structural analysis.
 - 1. Structural analysis shall be performed on existing towers according to the ANSI/TIA-222 standard, latest version applicable at time of structural analysis.
 - 2. Structural analysis shall include existing and proposed equipment; however, it is the Commission's intent that the Selected Vendor remove unused system equipment once cutover and acceptance of the new system is completed.
 - 3. Structural analysis reports shall be provided to the Commission upon completion of study or studies.
- E. If an existing commercial tower location is selected, the Selected Vendor shall provide the Commission with estimated lease costs for tower space and ground space required to support the new LMR system and microwave backhaul. Additionally, the Selected Vendor shall exercise due diligence to verify availability of the tower elevations proposed and that the tower can support the new equipment.

- F. The Selected Vendor shall identify and propose any additional work necessary to make existing Commission-owned and non-Commission-owned sites and infrastructure usable in the new LMR and microwave backhaul systems.
- G. The Selected Vendor shall be responsible for updating all existing sites that are part of the new LMR and microwave backhaul systems to be compliant with their selected grounding and lightning protection standards.
- H. The Selected Vendor shall be responsible for completing any studies and documents required by local, state and federal departments including, but not limited to environmental impacts, permitting documents and State Historic Preservation Office (SHPO) forms.
- I. The Selected Vendor shall be responsible for any issues related to site selection and will be responsible for resolving any issues related to site permitting or zoning.
- J. Code Compliance:
 - 1. Installation of all electrical equipment, power distribution, lighting assemblies and associated wiring shall comply with the most recent edition of the National Electric Code (NEC) and Occupational Safety and Health Administration (OSHA) regulations.
 - 2. All electrical equipment shall be listed or approved by Underwriters Laboratories (UL).
 - 3. The Selected Vendor shall comply with all applicable local codes as well as industry best practices and guidelines stipulated in Section 1.3, Standards and Guidelines.
- K. The Selected Vendor shall assume total responsibility for maintaining liability insurance covering the following items:
 - 1. Project design
 - 2. Implementation
 - 3. Licensing
 - 4. Shipping
 - 5. Receiving
 - 6. All site work required
 - 7. Any items required for the Selected Vendor or any required subcontractors

- L. The Selected Vendor shall coordinate with utility companies for all utility related items, such as electrical service hookups and disconnects.

5.2 Greenfield Sites

- A. Should greenfield sites be proposed, the Selected Vendor shall be responsible for development of raw land into a complete communications site. At a minimum, the following new equipment shall be provided for all greenfield sites:
 - 1. Self-Supporting tower
 - 2. Equipment shelter
 - 3. Site generator w/ fuel tank
 - 4. Site compound development
- B. The Selected Vendor shall be responsible for completing any studies and documents required by local, state and federal departments including, but not limited to environmental impacts, permitting documents and State Historic Preservation Office (SHPO) forms.

5.3 Self-Supporting / Monopole Tower

5.3.1 Design Criteria

- A. The tower design shall be based on the minimum wind and ice requirements as specified for Class III structures in TIA-222 Standard current revision.
- B. Each tower and foundation shall be designed for all equipment, appurtenances, ancillary equipment, antenna loading and include 25% future capacity.
- C. The tower shall be manufactured as a self-supporting lattice or a monopole design.
- D. All structural steel and hardware shall be galvanized after fabrication in accordance with the appropriate standards.
 - 1. All tower materials shall be hot dip galvanized after fabrication; with a minimum zinc coating of 2 oz. per sq. ft.
 - 2. Bolts shall be hot dip galvanized according to American Society for Testing and Materials (ASTM) A-325 or the latest version of this standard.

- E. The make, model, serial number, and height of the tower shall be clearly labeled at the base of the tower. Labeling shall be weatherproof and durable such as a stamped metal plate or equivalent.

5.3.2 Waveguide Support

- A. There shall be a ladder type support system associated with the tower to mount the transmission cables.
- B. In the case of a monopole, transmission lines will be routed internally. This support shall comply with tower and cable manufacturer's installation specifications.
- C. The support system shall accommodate cable or waveguide mounting hardware at the proper intervals.
- D. The support shall be equipped with precision punched or drilled holes to allow installation of snap-in type or bolt-in hangers.
- E. The support system shall be sized for 25% growth beyond initial system implementation.
- F. The support materials will be of similar construction as other tower materials to appear integral to the structure.
- G. The support shall be designed to meet rigidity specifications similar to the tower.

5.3.3 Waveguide Bridge

- A. The tower shall be equipped with a waveguide bridge with support posts spaced at intervals compliant to the wind loading specifications, but not more than 10 feet distant.
- B. There shall be posts placed on both lateral sides of the bridge to fully support the load.
- C. The bridge shall be designed to support all initial antenna transmission lines plus 25% growth capacity.
- D. The structure shall comply with the tower wind and ice requirements as specified in TIA-222 Standard current revision.
- E. The Selected Vendor shall furnish and install the waveguide bridge between the tower and equipment shelter.

- F. The following criteria shall govern the design of the waveguide bridge:
1. Structurally sturdy to support live and dead loads
 2. Free standing (i.e., not attached to the shelter or tower)
 3. Minimum width of 2 feet in width
 4. Length/height as required by the site specifics
 5. Bridge/ice shield material shall be fabricated from galvanized bar grating or approved equivalent
 6. All components of the waveguide bridge shall be hot-dipped galvanized after fabrication
 7. Posts shall have galvanized caps
 8. Posts shall be set in concrete foundations.
 9. Each post shall be separately grounded to the site ground system with 1/0 AWG stranded bare copper conductor
 10. Waveguide bridge shall be adjustable in height to allow interface with shelter waveguide entry ports
 11. Waveguide Bridge shall be effectively grounded to the external ground bar

5.3.4 Climbing Equipment

- A. The tower shall be equipped with an approved climbing ladder and safety device.
- B. There shall be a climbing safety system compliant to original manufacturer's specifications.
- C. The equipment shall comply with TIA-222 current revision.

5.3.5 Lighting System & Control

- A. The Selected Vendor shall furnish and install an obstruction lighting system approved by the FAA and compliant with applicable standards for any tower taller than 200', if required by the FAA due to proximity of the tower to nearby airport(s).
- B. The lighting system shall include:
1. Controller
 2. Lamps

3. Lightning protection
 4. Mounting hardware
 5. Service cabling and conduit
 6. Conduit drain-breather system
 7. Wiring
 8. Other material required for a complete installation
- C. The lighting system shall be controlled by a 120-volt AC, single-phase solid-state control unit and power supply.
- D. The control unit shall be installed within a NEMA 3R metal cabinet or a NEMA 4X cabinet. The control unit shall be mounted inside the equipment shelter.
- E. The lights shall be automatically controlled by means of a photoelectric unit. The control unit shall be designed with relays for:
1. ON-OFF status of lights
 2. Control unit failure
 3. Light failure
- F. The lighting system shall automatically revert to back-up power source upon loss of primary power. The lighting system shall automatically reset upon power restoration of primary power.
- G. The controller shall include a test switch allowing simulation of daytime and nighttime modes.
- H. All tower lighting wiring shall be contained within rigid galvanized conduit, junction boxes, and lighting equipment housings.
- I. Vertical conduit runs shall be adjacent to the tower waveguide supports.
- J. All levels of lighting shall be clearly visible from any direction of approach to the tower.
- K. The photoelectric unit shall be installed in a moisture-proof protective metal or high impact plastic housing.
- L. The photoelectric unit shall be installed on the building in an inconspicuous location and adjusted to attain an unobstructed view of the sky.

- M. The photocell shall be mounted such that it is not affected by artificial light.
- N. Photocell wiring shall be installed entirely within rigid galvanized conduit.
- O. Ice shields shall be installed for all lighting system fixtures except for the top most light.

5.4 Equipment Shelter

5.4.1 General

- A. The Selected Vendor may recommend re-use of existing shelters based on space availability and/or the ability to meet system requirements, as discovered through the mandatory site surveys. The Commission shall approve re-use of existing shelter(s).
- B. If required, the Selected Vendor shall supply a new equipment shelter for existing sites.
- C. The Selected Vendor shall supply a new equipment shelter for all new sites.
- D. Should a new equipment shelter be required at any site in the Selected Vendor's design, it shall comply with the requirements of this section.
- E. Where the Selected Vendor selects existing site(s), the requirements for the equipment rooms shall be functionally the same as for new equipment shelters and meet current industry standards for uninterruptible power supplies (UPS), lighting, HVAC, site alarms, grounding, backup power generator (or second source AC power), and security. The Selected Vendor shall describe where equipment rooms are included in their system and provide details on the equipment room design. The Selected Vendor shall describe how the equipment rooms in their design functionally meet the requirements as stated, as well as industry standards.
- F. For all sites where an existing equipment room is not sufficient to accommodate the new radio equipment in accordance with current industry site standards, the Selected Vendor shall provide new equipment shelters. The Selected Vendor shall describe where new equipment shelters are included in their design.

5.4.2 Shelter Size

- A. The minimum exterior shelter dimensions shall be 12' x 10'. Minimum interior height shall be 9', unless otherwise directed by the Commission.

5.4.3 Shelter Design and Construction Requirements

- A. Where possible, the shelter shall be a prefabricated, preassembled concrete shelter.
- B. The Selected Vendor is responsible for all costs, permits and approvals required to transport the shelter to the site and for assembling and constructing the shelter at the site.
- C. In addition to all applicable codes and standards, the Selected Vendor shall design the shelter to meet or exceed the following structure requirements:
 - 1. 200 pounds per square foot distributed floor loading while on foundation
 - 2. 125 pounds per square foot distributed floor loading while lifting
 - 3. 200 pounds per square foot minimum roof load and a concentrated load of at least 500 pounds per square foot
 - 4. Minimum wind requirements as specified in the Grayson and Carroll County zones in TIA 222 Standard current revision.
 - 5. Seismic Design Category [D]
 - 6. Vents and entryways shall be constructed to deter vandalism
 - 7. Vents and entryways shall be constructed to prevent entry of rodents
 - 8. Waterproof

5.4.4 Exterior Finish

- A. The exterior finish of the shelter shall be exposed aggregate.

5.4.5 Bullet Resistance

- A. Shelter walls shall be capable of stopping 30.06 rifle fires per UL 752 requirements.

5.4.6 Fire Rating

- A. Shelter walls must provide a two-hour fire rating.

5.4.7 Insulation and Interior Finish

- A. Walls and ceiling must be insulated to a minimum value of R-11.

- B. Interior walls and ceiling must be sheathed with ½ inch white Nu-Poly® or similar board.
- C. Shelter walls must be reinforced as required to support wall mounted equipment.
- D. Floor will be covered with light colored industrial grade vinyl tile floor covering.

5.4.8 Exterior Door

- A. The shelter shall be equipped with a 42 inch by 84 inch door.
- B. The door shall have a bullet resistance rating that complies with levels 1-4 of UL 752 ballistic standards.
- C. Door, frame and frame components shall be painted or otherwise treated to be rust-proof.
- D. Each door shall as a minimum be equipped with the following hardware and accessories:
 - 1. A continuous stainless-steel hinge the entire length of the door
 - 2. Neoprene weather strip
 - 3. High security locking cylinder latch set
 - 4. Mortised dead bolt
 - 5. Anti-pick plate on strike of door to restrict access to the latch and deadbolt
 - 6. Hydraulic closer
 - 7. An exterior mounted canopy to protect the door entry shall be designed to support a load of 100 pounds per square foot

5.4.9 Power Distribution

Power distribution shall include the following:

- A. One MOV/SAD only lightning arrestor, Type 1.
- B. One MOV lightning arrestor, Type 2.
- C. One (60 Amp) enclosed circuit breaker for safety disconnect of TVSS unit.

- D. One (200 Amp), 10,000 AIC, 120/240 VAC, single phase, 60 Hz, 30 space main breaker, snap-in utility power distribution panel, in a NEMA 1 surface mount enclosure.
- E. Circuit breakers for all communications system equipment and customer loads as specified.
- F. One (200 Amp), 240 VAC, fused, double pole, single throw safety switch.
- G. One (200 Amp), 240 VAC, non-fused, double pole, double throw manual transfer switch.
- H. One (200 Amp), four-pin, reversed service exterior power receptacle.
- I. Six 20 Amp specification grade duplex receptacles.
- J. One 20 Amp specification grade exterior ground fault duplex receptacle.
- K. Ten 20 Amp ceiling or cable tray mounted NEMA twist-lock receptacles with matching plugs.
- L. All wiring shall be installed in surface mounted conduit or NEMA wire ways and be in full compliance with ANSI/NFPA-70 - The National Electric Code, latest version.

5.4.10 Lighting

- A. Equipment shelter lighting shall be energy efficient and generate low heat levels. Acceptable lighting shall be long lasting energy efficient technologies, such as light emitting diodes (LED) or fluorescent.
- B. Equipment shelter lighting shall comply with the U.S. defense standard MIL-STD-461E or most current version for low radio frequency interference (RFI) lighting fixtures.
- C. There shall be sufficient interior lighting to provide a level of 540 Lux (50-foot candles at 1 meter (39.4 inches) above the equipment shelter floor. Refer to TIA-569-B or most current version standard for additional information.
- D. Placement of equipment shelter lighting shall assure illumination in front of and behind tall equipment racks (within aisle ways; not directly above equipment racks).
- E. Light fixtures shall employ earthquake bracing.

- F. Interior lighting control switches shall be located near the non-hinged side of the entrance door to the equipment shelter. One switch shall control a single lighting fixture and the second switch shall control the remaining lighting fixtures. Refer to NFPA, NEC 70-2011 (or latest edition) Article 410 - Luminaries, Lamp Holders, and Lamps for additional information.
- G. Interior emergency backup lighting units shall be installed and activate immediately upon failure of all AC power. The emergency backup lighting shall also be equipped with an illuminated "Exit" sign mounted above the exit door of the equipment shelter indicating exit locations in the equipment shelter during emergency evacuation.
- H. Exterior lighting shall illuminate points-of-exit and entry into the site compound and the equipment shelter and be located to the side of the entrance way and above door level.
- I. Each equipment shelter shall have light-emitting diode (LED) exterior lighting fixtures with cutoff housings that limit the beam top to 35° below horizontal, and protection from falling ice.
- J. Each shelter shall have a combination photoelectric/motion switch that provides for automatic illumination at sunrise or when motion is detected, and extinguishment of the exterior equipment shelter lights at twilight.
- K. Each exterior light equipped with a combination photoelectric/motion switch shall also have a photoelectric /motion bypass switch installed at the same location as the interior lighting control switches.

5.4.11 HVAC

- A. HVAC shall be redundant wall mount air conditioning units, with low ambient and compressor anti-cycle controls, integral 5 kW resistance heat strips and washable dust filters.
- B. Selected Vendor will ensure HVAC is sized correctly with equipment heat loads and include the following features:
 - 1. Redundant lead/lag controls allowing approximately equal operating time on each air conditioning unit
 - 2. Active dehumidification controls that modulate heat and air conditioning operation to control high humidity conditions

3. One 650 cfm at 0" of H2O static pressure exhaust fan system, including motorized intake and exhaust louvers, thermostat, fiberglass hoods, permanent expanded metal dust filter and exhaust insect screen

5.4.12 Site Alarms

- A. Any change in the state of site equipment shall induce an alarmed state.
- B. Equipment monitored shall include, but not be limited to the following:
 1. Surge arrestors
 2. Transfer switch (normal or bypass state)
 3. Power fail
 4. HVAC
 5. Smoke detector
 6. Intrusion detection
 7. High temperature
 8. Low temperature
 9. High humidity
 10. UPS/DC Power Plant fail
 11. UPS state (normal or bypass)
 12. Generator (including, e.g., generator run, low fuel, high temp, and fail)
 13. Generator not in auto
 14. Fuel level low
 15. Tower lighting alarms
 16. To reduce false alarms, all alarm contacts shall be normally closed when no alarm is present.

5.4.13 Grounding

- A. The Selected Vendor shall follow industry standard best practices for the grounding and bonding of the building, electrical service, tower, cable trays, transmission line entrance portal, and all equipment and other structures, that the Commission will pre-approve. The Selected Vendor shall provide the standards

documents to the Commission and include these documents in all site documentation.

- B. The required impedance of the ground system is 5-Ohms or less.

5.4.14 Entry Ports

- A. Cable entry ports shall consist of one – eight-port/waveguide entry panel with 4-inch sleeves and protective blank covers.

5.4.15 Cable Ladder

- A. The Selected Vendor shall supply and install an 18-inch-wide cable ladder/tray as required to route all cables between each equipment rack's location, entry panel, telco board and power distribution panel.

5.4.16 Telco Board

- A. The Selected Vendor shall supply one 4-foot x 6-foot x ¾ inch Telco board.

5.4.17 Accessories

- A. The Selected Vendor shall provide the following accessories:
 - 1. One portable fire extinguisher, FE-36 clean agent or equivalent
 - 2. One handheld emergency eye wash station
 - 3. One first aid kit
 - 4. One service manual
 - 5. One smoke detector

5.4.18 Drawings

- A. The Selected Vendor shall:
 - 1. Provide three sets of shelter drawings with each shelter.
 - 2. Supply typical foundation drawings based on Presumptive Soil Parameters specified in the TIA-222 Standard current revision.
 - 3. Validate all foundation design parameters and assumptions for the specific site prior to construction.

4. Supply support calculations for recommended building tie down locations.

5.4.19 Generator Plug

- A. The shelter shall include a wall penetration for exterior weatherproof generator plug, to accommodate the use of a mobile generator.
- B. The location of the penetration and the type of exterior generator plug that is to be installed in the penetration will be coordinated with the Commission prior to manufacture of the shelter.

5.5 Site Generator

5.5.1 General

- A. If required, the Selected Vendor shall supply a new site generator for new and/or existing sites.
- B. The Selected Vendor shall supply a new site generator for existing sites based on deficiencies discovered through their site surveys.
- C. The Selected Vendor shall supply and install new generators that comply with the Outdoor-Use Units specifications in UL 2200, latest edition.
- D. The Selected Vendor may recommend reuse of existing generators based on the site survey findings. The Commission shall approve reuse of any existing site generators.

5.5.2 Power and Electric Requirements

- A. Generator specifications shall include the following:
 1. Fuel: Liquid Propane (natural gas or diesel may be provided as an option)
 2. Output: 25 kW (minimum, and sized for the proposed system)
 3. Phase: Single
 4. Voltage: 120/240 VAC
 5. Frequency: 60 Hz

5.5.3 Enclosure

- A. The generator enclosure shall be outdoor weather protective and securely attached to a foundation designed to the generator manufacturer's specifications.

5.5.4 Muffler Type

- A. The generator muffler shall be of residential critical grade including flexible exhaust section.

5.5.5 Control Panel

- A. The generator control panel shall be either analog or digital and capable of displaying the following:
 - 1. Oil Pressure
 - 2. Coolant temperature
 - 3. Fuel level (where applicable)
 - 4. DC battery voltage
 - 5. Run time hours
 - 6. Alarm Status
- B. The generator shall be capable of providing, at a minimum, the following alarm status information:
 - 1. High or low AC voltage
 - 2. High or low battery voltage
 - 3. High or low frequency
 - 4. Low or pre-low oil pressure
 - 5. Low water level
 - 6. Low water temperature
 - 7. High and pre-high engine temperature
 - 8. High, low and critical low fuel levels (where applicable)
 - 9. Over crank
 - 10. Over speed
 - 11. Unit not in "Automatic Mode"

5.5.6 Miscellaneous

- A. Generator will be supplied with block heater, battery charger, and meet NFPA99 and 110 requirements.
- B. Fuel tanks shall be sized to accommodate for a 7-day run time with a minimum size of 500 gallons.
- C. The Selected Vendor shall be responsible for generator installation, test, and first fill of all fuel tanks.
- D. Fuel tanks shall be equipped with monitoring device capable of triggering an alarm contact upon low fuel. Low full threshold shall be programmable.
- E. Fuel tanks shall be securely attached to a poured concrete foundation.

5.5.7 Automatic Transfer Switch (ATS)

- A. The Selected Vendor shall install the ATS in the shelter prior to shelter shipment.
- B. ATS shall include a programmable exerciser capable of automatic starting and shutdown of generator on a weekly basis.
- C. ATS shall have a 200 Amp rating and enclosed in NEMA 1 enclosure.

5.6 Power Systems

5.6.1 DC Power Requirements

- A. The Selected Vendor shall provide new DC power systems for all radio frequency (RF) equipment sites.
- B. The DC power system shall be designed to meet the specific load requirements for all system equipment at each site and include enough capacity for an additional future load of 25% of the equipment furnished under this contract.
- C. The DC power system shall provide the following alarms to the NMS alarm system:
 - 1. Rectifier failure
 - 2. AC power failure
 - 3. Low current
 - 4. Battery low voltage

5. DC breaker

- D. The DC power system shall perform as specified herein when housed with or adjacent to other radio transmitters operating in accordance with FCC regulations.
- E. All load current shall pass through a single main distribution breaker prior to sub-panel breaker/fuses and individual load breaker/fuses. An individual assigned breaker/fuse shall be employed for each specific communication device powered.
- F. The power supply/charger shall meet the following requirements:
 - 1. Input Voltage: single phase, 120 VAC +/- 10%
 - 2. Frequency: 60 Hz +/- 5%
 - 3. Output Voltage Range: -42 to -56 VDC (positive ground)
 - 4. Float Voltage: 50.9 - 54.0 VDC
 - 5. Equalize Voltage: 54.2 - 57.6 VDC
 - 6. DC Output Voltage Regulation: +/- 1/2% from no load to full load
 - 7. Output Current: As calculated to support load requirements
 - a. Minimum 12 amps
 - b. Full recharge of batteries shall be accomplished within eight hours
 - 8. Output noise shall not degrade the performance of LMR and microwave radio equipment in the vicinity of the power supply/charger
 - 9. AC to DC conversion efficiency shall not be less than 75%
 - 10. Shall include equalize circuitry and controls for periodic manual equalization of batteries as needed
 - 11. Shall be 19-inch rack mountable
 - 12. Shall be equipped with an input power AC circuit breaker, output power DC circuit breaker, DC current meter and DC voltage meter
 - 13. Shall be initially configured for independent operation, however, shall be capable of operating in parallel with another power supply/charger in the future, without damage to either unit
 - 14. Shall provide separate adjustable voltages for floating and equalizing of the batteries, with the voltages initially adjusted to accommodate the batteries provided

15. Shall include short circuit current protection and high voltage shutdown circuitry
16. Each alarm shall include a Form "C" contact for connection to an external alarm, and the alarm status shall be displayed on the front panel of the power supply/charger.

G. The 48-volt batteries shall:

1. Be designed for float connection in support of continuous steady current loads with battery discharge only during loss of charger/power-supply output
2. Be sized to support full load operation during an AC power failure for a minimum of 8 hours
3. Include support trays for installation inside the communication cabinets
4. Include all cell interconnect bus pieces and hardware
5. Be sealed, lead acid batteries requiring no maintenance
6. Have a minimum service life of 10 years, defined as the time in which the battery capacity drops below 80% of the original capacity

H. Other DC Power System Components:

1. Load distribution/disconnect panels shall:
 - a. Include individual 100A circuit breakers for protecting and/or disconnecting each charger/battery bank from the load
 - b. Include a front panel LED display indicating whether a breaker has been tripped
 - c. Include a Form "C" relay for connection to an external alarm panel. The relay shall be activated if any breaker trips or is shut off
 - d. Be 19-inch rack mountable
2. Circuit breaker panels shall:
 - a. Include circuit breakers, appropriately sized for disconnecting the individual loads
 - b. Be 19-inch rack mountable
 - c. Include a minimum of five spare circuit breakers, with a minimum current rating equal to the circuit breaker for the installed load

3. The negative and positive bus bars shall:
 - a. Be 19-inch rack mountable
 - b. Be equipped with standoffs that will electrically isolate it from the mounting rack inside the cabinet
 - c. Be solid copper, sized to handle the required current capacity
4. DC power cables shall be of appropriate size to handle the load current requirements, as specified

5.6.2 Uninterruptible Power Supply Requirements

- A. The Selected Vendor shall provide a new Uninterruptible Power Supply (UPS) for all non-RF sites.
- B. The UPS shall be a single phase, online, double conversion, static type with the following features:
 1. Direct dedicated connection to main panel
 2. Surge suppression
 3. Input harmonics reduction
 4. Rectifier / charger
 5. Inverter
 6. Static bypass transfer switch
 7. Battery and battery disconnect device
 8. Internal maintenance bypass / isolation switch
 9. Output isolation transformer
 10. Remote UPS monitoring provisions
 11. Battery monitoring
 12. UPS output shall be connected to a dedicated subpanel feeding quad 20A twist lock outlets to be installed on the overhead cable tray.
- C. Operational Requirements:
 1. Automatic operation includes the following:
 - a. Normal Conditions - Load is supplied with power flowing from the normal power input terminals, through the rectifier-charger and

inverter, with the battery connected in parallel with the rectifier-charger output.

- b. Abnormal Supply Conditions - If normal supply deviates from specified and adjustable voltage, voltage waveform, or frequency limits, the battery supplies energy to maintain constant, regulated inverter power output to the load without switching or disturbance.
- c. If normal power fails, energy supplied by the battery through the inverter shall continue to supply regulated power to the load without switching or disturbance.
- d. When power is restored at the normal supply terminals of the system, controls automatically synchronize the inverter with the external source before transferring the load. The rectifier-charger then supplies power to the load through the inverter and simultaneously recharges the battery.
- e. If the battery becomes discharged and normal supply is available, the rectifier-charger charges the battery. On reaching full charge, the rectifier-charger automatically shifts to float-charge mode.
- f. If any element of the UPS system fails and power is available at the normal supply terminals of the system, the static bypass transfer switch switches the load to the normal AC supply circuit without disturbance or interruption.
- g. If a fault occurs in the system supplied by the UPS, and current flows in excess of the overload rating of the UPS system, the static bypass transfer switch operates to bypass the fault current to the normal AC supply circuit for fault clearing.
- h. When the fault has cleared, the static bypass transfer switch returns the load to the UPS system.
- i. If the battery is disconnected, the UPS continues to supply power to the load with no degradation of its regulation of voltage and frequency of the output bus.

2. Manual operation includes the following:

- a. Turning the inverter off causes the static bypass transfer switch to transfer the load directly to the normal AC supply circuit without disturbance or interruption.
- b. Turning the inverter on causes the static bypass transfer switch to transfer the load to the inverter.

3. Controls and Indications:

- a. Basic system controls shall be accessible on a common control panel on the front of the UPS enclosure.

D. Performance Requirements:

1. Input:

- a. Single phase, three-wire
- b. Voltage: 120/240V Nominal
- c. Frequency: 50/60 Hz +/- 3 Hz

2. Output:

- a. Voltage: 120/240V
- b. Frequency: 60 Hz, +/- 3 Hz
- c. Maximum Voltage Distortion: 5% at full load
- d. Two-hour battery operation

6. System Implementation, Test, and Acceptance

6.1 Project Management

- A. The Selected Vendor shall attend project and construction meetings as deemed necessary by the Commission prior to and during installation. Additional meetings may be scheduled at the discretion of the Commission.
- B. If any changes in the overall timeline occur, the Selected Vendor shall update the project schedule for discussion during these project meetings.
- C. The Selected Vendor shall provide written minutes of all meetings no later than five business days after the meeting.

6.1.1 Project Staffing

- A. The Selected Vendor shall provide the appropriate project staff based on workload and the level of effort required throughout the implementation/installation process.
- B. The staff identified in the Selected Vendor's proposal shall serve the duration of the project unless the Selected Vendor proposes an alternative plan to the Commission for consideration and gains approval. The Commission reserves the right to accept or reject any proposed staffing changes.
- C. The Selected Vendor's project manager shall be:
 - 1. The primary point of contact for the Commission
 - 2. Fully responsible for supervising and coordinating the installation and deployment of the communications system including:
 - a. Development and acceptance of the project management plan
 - b. Managing the execution of the project against that plan
 - c. Overseeing the day-to-day project activities, deliverables, and milestone completion
 - d. Coordinating, and facilitating weekly status meetings
- D. The Selected Vendor's project engineer shall:
 - 1. Have the primary responsibility for managing the system design and ensuring system installation in accordance with the approved system design. Any deviation from the proposed system design shall be subject to project change

- control procedures and will not be undertaken until approved by the Commission.
- 2. Ensure the accurate development of block diagrams, system-level diagrams, and rack diagrams.
- 3. Supervise the development and execution of:
 - a. Acceptance Test Plan (ATP)
 - b. Coverage Acceptance Test Plan (CATP)
- 4. Guide the project team through the processes and procedures necessary to prove that the system performs as specified in the contract.
- 5. The Commission shall approve all test plans prior to execution.

6.1.2 Scheduling

- A. The Selected Vendor shall develop and maintain a project schedule including tasks, milestones, start and end dates, task predecessors, and task owners based on an approved WBS.
- B. The schedule shall represent tasks associated with completing work on all items identified in the WBS.
- C. The Selected Vendor shall update the project schedule with actual dates as tasks are completed.
- D. The Selected Vendor shall present all schedule updates to the Commission during the weekly status meetings.
- E. The schedule shall address the following at a minimum:
 - 1. Site surveys
 - 2. Detailed design review
 - 3. Site preparation
 - 4. Equipment order and manufacturing
 - 5. Factory acceptance test
 - 6. Equipment delivery
 - 7. System installation
 - 8. System configuration

9. System optimization
10. Acceptance testing
11. Coverage testing
12. User training
13. System cutover
14. System documentation development and delivery
15. System and equipment warranty

6.1.3 Project Meetings

- A. The Selected Vendor shall schedule a project kickoff meeting prior to the beginning of the project.
- B. The Selected Vendor shall schedule weekly project status meetings following contract award and the initial kickoff meeting.
- C. Weekly status meetings shall continue throughout the duration of the project until the Commission issues final system acceptance.
- D. The Selected Vendor shall be responsible for facilitating the weekly status meetings.
- E. The Selected Vendor shall prepare and distribute meeting agendas and minutes to the Commission via e-mail on a weekly basis at least 24-hours prior to each scheduled meeting.
- F. Meeting agenda items shall include, as a minimum, the following items:
 1. Schedule review
 2. Status of deliverables
 3. Risk items and planned responses
 4. Proposed changes
 5. Plans for the next period
 6. Action item assignments
 7. Punch list review

6.1.4 QA/QC Plan

- A. The Selected Vendor shall submit a QA/QC plan as described in this section.
- B. The QA/QC plan shall address all stages of the project, including, but not limited to:
 - 1. Procurement
 - 2. System design
 - 3. Installation
 - 4. Implementation
 - 5. Testing
 - 6. Cutover
- C. The QA/QC plan shall:
 - 1. Describe the plans and procedures that ensure compliance of the proposed system design with the RFP requirements.
 - 2. Be included in the project management plan developed by the Selected Vendor's project manager
 - 3. Be an integral part of the project
 - 4. Include the Commission personnel as part of the review and approval process for all deliverables and submittals
 - 5. Address the following project tasks at a minimum:
 - a. Design analysis and verification
 - b. RF coverage analysis and verification
 - c. Design changes and document control
 - d. Material ordering, shipping, receiving, and storage
 - e. Site preparation (if required)
 - f. Field installation and inspection
 - g. Equipment inventory and tracking
 - h. System testing and validation
 - i. Software regression testing
 - j. Deficiency reporting and correction

- k. Implementation and cutover
- l. Training and certification

6.1.5 Project Punch List

- A. The Selected Vendor shall establish and maintain a punch list, as mutually agreed to with the Commission. The punch list shall be maintained in real time.
- B. The punch list shall address all open issues including those related to sites, facilities, equipment, and acceptance tests.
- C. The Selected Vendor shall distribute the punch list to the Commission weekly via e-mail.
- D. The punch list shall include the following at a minimum:
 - 1. Sequential punch list item number
 - 2. Date identified
 - 3. Item description
 - 4. The party responsible for resolution
 - 5. Expected resolution date
 - 6. Resolution date
 - 7. Details about how each punch list item was resolved and tested
 - 8. Notes about the item
- E. If the Selected Vendor receives written permission from the Commission to transfer the responsibility of an item to another person or group, the Selected Vendor shall add a new entry to the punch list and appropriately note the original entry.
- F. The Selected Vendor shall be responsible for reviewing each punch list item and advising the Commission of any changes.
- G. The Selected Vendor shall update the status of punch list items during each weekly status meeting.

6.2 Frequency Coordination and Licensing

- A. The Commission currently operates in VHF and will provide all current licensing information to the Selected Vendor following contract award.

- B. The Commission anticipates remaining on the same frequency band and/or channels for the proposed system.
- C. Prior to submitting proposals, Offeror shall evaluate the viability of licensing the required amount of VHF channels within their proposed design at the proposed sites. If Offerors determine sufficient VHF channels are not licensable, Offerors should propose a design that uses an alternate frequency band, while also maintaining the interoperability requirements for the Commission.
- D. The Selected Vendor shall:
 - 1. Provide all FCC and frequency coordination modifications and applicable forms to the Commission for review and approval following approval of the preliminary design
 - 2. Complete all engineering tasks required for channel search/identification, coordination, and licensing of all new LMR and microwave channels and the modification of existing licenses, which are required for the new system, including the completion of all forms and submission of license applications to the FCC
 - 3. Track all applications and filings with the selected frequency coordinator and/or the FCC
 - 4. Respond to any questions by the selected frequency coordinator and/or the FCC regarding all applications and filings
 - 5. Correct and resubmit any applications or filings by the selected frequency coordinator and/or the FCC for the modification of licenses or re-licensing of existing channels at no additional cost
 - 6. Complete Federal Aviation Administration (FAA) forms as necessary
 - 7. Complete all required FCC construction deadline notifications
 - 8. Ensure compliance with the FCC's Maximum Permissible Exposure (MPE) requirements
 - 9. Provide copies of each license to the Commission

6.2.1 Intermodulation Interference

- A. The Selected Vendor shall analyze all transmitters at each site for intermodulation interference, considering transmitting equipment from all tenants located at the sites as identified in FCC license information.

- B. If the Selected Vendor identifies an intermodulation problem prior to, during, or following implementation, the Selected Vendor shall resolve the issue without degrading system coverage or performance for a period of up to 12 months after System Acceptance and at no cost to the Commission.

6.2.2 Electromagnetic Exposure

- A. Transmitters at each site shall meet FCC Maximum Permissible Exposure (MPE) standards (per latest revision of FCC Office of Engineering and Technology (OET) Bulletin 65).
 - 1. Evaluations for MPE standards shall consider all transmit signals from all tenants located at the site, per FCC licensed information
- B. The Selected Vendor shall mitigate causal and occupational exposure at locations that exceed MPE standards.

6.3 Site Surveys

- A. The Selected Vendor shall participate in a mandatory site survey with the Commission, at each location where equipment is being installed, to confirm actual equipment location within each space prior to the start of the system installation.
- B. During the mandatory site survey, the Selected Vendor shall determine and document any changes needed to the detailed design installation drawings. All detailed design drawings and documents requiring changes shall be revised prior to installation.
- C. The Selected Vendor shall visit all sites to:
 - 1. Assess site, safety, and access conditions
 - 2. Verify work to be completed, including location of equipment and installation requirements
 - 3. Assess the condition of existing radio shelters, radio towers, power systems, standby power systems, cable and waveguide routing, earthquake bracing, site grounding and lightning protection systems, and all other installation practices, to assure that they adhere to industry standard(s) listed in Section 1.3
 - 4. Identify existing Commission equipment that can be reused on the new system

- D. The Selected Vendor shall produce a Site Survey report for each site, including, at a minimum:
1. Cover page with site name, date of survey, survey team member(s), and general site description
 2. Accurate site coordinates (latitude/longitude) using Datum WGS84, preferably near the tower or antenna structure of interest
 3. Photographs (submitted in .jpg format using the naming convention "site name photo description date.jpg") of:
 - a. Overall site, showing location of radio tower(s) and equipment shelter(s)
 - b. The radio tower(s)
 - c. Antennas to be used for this project or location for new antennas
 - d. Radio shelter exterior
 - e. Inside of equipment shelter, including front and rear of existing radio equipment to be removed
 - f. Coaxial cable and waveguide routes
 - g. Rack location and position(s) where new equipment will be installed
 - h. DC panel indicating breakers to be used
 - i. Dehydrator unit and distribution manifold
 - j. Feedline entry (inside and outside of shelter)
 - k. Grounding and lightning protection systems
 4. Potential obstructions at or near the site that could impede radio paths and/or radio coverage, including type, and approximate azimuth and height
 5. A list of existing equipment that can be reused for the new system
 6. A list of issues encountered or identified and proposed solution(s) for each deficiency
 7. A statement of the work to be completed for system implementation and the method to complete the work
 8. Recommended site upgrades, including, but not limited to equipment shelter, radio tower, antenna, waveguide, AC or DC power system, backup generator(s), UPS system(s), site access and physical site security

9. Accurate drawings of the shelter/equipment room in Microsoft Visio native format or equivalent
 10. Tower mapping with complete inventory of tower appurtenances, including antenna type, manufacturer, model number, height, weight, tower leg, azimuth, and transmission line type and size
- E. The Selected Vendor shall produce a Grounding Assessment report for each site, based on the standard(s) selected in Section 1.3. The report shall include at a minimum:
1. Cover page with site name, date of survey, survey team member(s), general site description, and selected standard(s) name and revision
 2. Accurate site coordinates (latitude/longitude) using Datum WGS84, preferably near the tower or antenna structure of interest
 3. Photographs (submitted in .jpg format using the naming convention "site name photo description date.jpg") of:
 - a. AC utility service grounding
 - b. Site ground ring (tower and shelter)
 - c. Ground rod test well(s)
 - d. Tower grounding (each leg)
 - e. Tower ground bar(s)
 - f. Tower guy wires
 - g. Transmission line grounding kits
 - h. Ice bridge grounding (all sections and legs)
 - i. Exterior ground bar(s)
 - j. Exterior RF entry port grounding
 - k. Interior RF entry port grounding
 - l. Interior halo grounding
 - m. Interior master ground bar(s)
 - n. Secondary ground bar(s)
 - o. RF surge suppressor grounding
 - p. Equipment rack grounding
 - q. Cable ladders and trays

- r. DC power systems
 - s. AC surge suppressors
 - t. Generator grounding
 - u. Fuel tank grounding
 - v. Fence(s) and gate(s)
 - w. Other nearby metal objects
- 4. Clamp-on meter measurements (in ohms) for each component assessed per the selected standard(s)
- 5. A list of existing grounding equipment that can be reused for the new system
- 6. A list of issues encountered or identified and proposed solution(s) for each deficiency
- 7. A statement of the work to be completed for system implementation and the method to complete the work
- 8. List of site upgrades, including recommended or optional requirements specified in the selected standard(s) for compliance with industry best practices

6.4 Microwave Path Design

- A. The Selected Vendor shall conduct physical path surveys to identify type, location and height of potential path obstructions for verifying path clearance and performing path calculations.
- B. The Selected Vendor shall perform an independent analysis of all radio paths to ensure that all radio paths will meet the path availability requirements.

6.5 Detailed Design

- A. The Selected Vendor shall submit the Detailed Design package within 60 days after contract award, which shall include the following:
 - 1. Any updates to previously submitted design information
 - 2. A detailed description of the new LMR and microwave backhaul systems, including the function of all equipment and how they interact to meet the requirements of this RFP

3. System block diagrams
4. Radio channel/frequency plan(s)
5. Radio coverage maps
6. Bandwidth requirements and calculations
7. IP addressing scheme and plan
8. Microwave path analysis results:
 - a. Path profiles
 - b. Path calculations, showing capacity, RSL, fade margin and availability
 - c. Recommended antenna mount location and height
9. Microwave backhaul architecture diagram showing the physical relationship and connectivity between the sites, and the frequency band of each link.
10. Migration/Cutover plan:
 - a. A preliminary cutover plan describing how the radio system will be phased over into a fully operational system
 - b. The Selected Vendor shall successfully complete all tests and training prior to the actual cutover of systems.
 - c. The Selected Vendor shall provide the necessary labor to cutover from existing systems to the proposed system.
 - d. The plan shall include the schedule and procedures associated with the transition of each operational user group. The plan shall specifically address how the existing users will begin using the new system with minimal operational impact.
 - e. The plan shall provide detailed component or subsystem cutover plans, and specifically delineate between systems that affect and do not affect ongoing operations.
 - f. The Commission reserves the right to approve and change the cutover plan as it relates to any or all system components.
11. Coverage Acceptance Test Plan (CATP), complete with coverage overview, service area definitions and grid structures, talk-in and talk-out test procedures, Commission and Selected Vendor responsibilities, and sample pass/fail sheet

12. Sample factory testing documentation for each piece of equipment
13. System installation, optimization, operation, and maintenance manuals for all equipment
14. Blank site installation, grounding remediation, and optimization documents to be completed during and after installation and provided with as-built documentation
15. Tower structural analyses, based on TIA-222 latest revision, showing results of passing or failed tower and/or foundation with existing and proposed antenna(s)
 - a. Structural analysis for failed tower and/or foundation shall detail the required or recommended modifications for tower and/or foundation remediation
 - b. Sites without a completed structural analysis, tower mapping, and/or remediation pricing shall not be presented at Detailed Design Review.
16. Structural analyses for any buildings/rooftops which will support proposed antennas and/or other system equipment
17. Complete Detailed Design package for each site, consisting at a minimum the following content:
 - a. Cover page with site name, site type (control, multicast, simulcast, etc.), simulcast cell name (if applicable), technology (Conventional, P25 Phase 1, etc.), frequency band, number of channels, and other pertinent site data if applicable (region, site ID, etc.), aerial imagery-based site photo, accurate site coordinates, elevation, county name, ownership (land, tower, shelter)
 - b. Index page with sheet titles, drawing descriptions, drawing versions, and page numbers
 - c. Block diagram(s) showing entire network and any region- or subsystem-specific diagram
 - d. Mobile and Portable Talk-in and Talk-out coverage maps
 - e. Site plan showing existing and/or proposed site compound, tower(s), and shelter(s), all to scale and orientation
 - f. Tower drawings (to scale and different elevations as needed) including tower type and height, number of legs, existing and proposed antenna and coaxial cable loading information, antenna center line heights, and any other equipment mounted on the tower

- g. For any rooftops/buildings supporting antennas, drawings (to scale and different elevations as needed) including structure type and height, existing and proposed antenna and coaxial cable loading information, antenna center line heights, and any other equipment mounted on the structure
- h. Transitional and final floor plan drawings, including room layouts with doorways, existing and proposed rack location(s), cable trays, RF entry port(s), power system(s), HVAC unit(s), generator room(s), all to scale with interior and exterior dimensions and measurements of rack(s) to room/shelter walls and/or other surrounding equipment
- i. Equipment rack/cabinet elevation diagrams for radio/backhaul rack(s), combiner rack(s), and any DC power rack(s), with dimensions and rack unit locations
- j. Equipment room/shelter power drawing(s) showing how new equipment connects to AC or DC power systems, as well as backup generator and UPS systems
- k. Detailed electrical loading for AC and/or DC power systems (itemized by equipment types and quantities), as well as UPS and generator sizing and BTUs for HVAC for the entire site
- l. Detailed antenna system drawings for proposed base station transmit and receive antennas, TTAs, GPS, and/or microwave dishes, complete with quantities, model numbers, and configuration/interconnection
- m. RF entry port drawing(s) showing existing and/or proposed entry ports, labels for existing and proposed transmission lines (color-coded by size), and quantity and types of lightning protection devices for
- n. Interior and exterior site grounding system drawings
- o. Site-specific frequency and combiner plans
- p. Network equipment interconnection drawings showing router and switch connections, with cables and port numbers labeled and color-coded
- q. Site-specific IP addressing scheme, showing host names, host addresses, subnet mask, equipment use/description, and configuration-specific notes

- r. Patching schedules and termination details for all cabling necessary for a complete record of the installation
 - s. Location of demarcation points for any items to be provided by the Commission
 - t. Site-specific bill of materials for all new equipment to be installed at the site
 - u. Site remediation summary (with pricing) based on results from Site Survey report, Grounding Assessment report, and Structural Analysis report
18. Draft Factory Acceptance Test Plan (FATP) outlining a comprehensive series of tests that will demonstrate proof of performance and readiness for shipment
19. Draft System Acceptance Test Plan (SATP) outlining a comprehensive series of tests that will demonstrate proof of performance after installation and optimization is complete
20. The Final FATP and Final SATP shall be submitted no later than 15 business days before the testing starts and shall be approved no later than five business days before the testing starts.
21. Any other items as required or requested by the Commission prior to Detailed Design Review
22. All items required for detail design shall be submitted to the Commission 10 business days prior to the detailed design review meeting.
23. A detailed design review meeting shall be conducted to allow the Selected Vendor to present the system detailed design for review and approval.
24. The detailed design review shall be considered the last step prior to ordering and/or manufacturing of equipment. Upon approval of the detailed design by the Commission, the Selected Vendor may begin the ordering and manufacturing of system equipment. The Commission shall not be held liable for any equipment ordered or manufactured prior to approval of the detailed design.

6.6 Staging

- A. Each individual assembly or equipment unit for the LMR and microwave backhaul systems shall undergo factory testing prior to shipment.

- B. The Selected Vendor shall submit standard factory test documentation, documenting the tests performed and indicating successful completion of testing to the Commission.
- C. System staging:
 - 1. The Selected Vendor shall perform system staging and testing on the complete system at a location in the United States.
 - 2. The intent of the staging tests is to demonstrate to the Commission that the system is ready for shipment and installation.
 - 3. The Selected Vendor shall provide all necessary technical personnel, and test equipment to conduct staging tests.
 - 4. All deviations, anomalies, and test failures shall be resolved at the Selected Vendor's expense.
 - 5. The Selected Vendor shall use an approved staging acceptance test plan (SATP).
 - 6. The Selected Vendor shall successfully perform all tests before the Commission witnesses the official SATP and provide a copy of the test results.
 - 7. The Selected Vendor shall provide a detailed agenda for the SATP one week before the Commission is onsite to witness the testing.
 - 8. The Selected Vendor and the Commission shall jointly execute and date the SATP following completion of all tests.
 - 9. All tests in the SATP shall be marked as either pass or fail.
 - 10. The Selected Vendor shall document all failed components.
 - 11. The Selected Vendor shall correct and retest all failed components.
 - 12. The Selected Vendor shall replace at its own expense failed components that are not repairable.
 - 13. The decision to retest an individual failed SATP tests or the entire plan shall be at the Commission's discretion.
 - 14. The Selected Vendor shall provide the Commission with the fully executed and complete SATP document.
 - 15. There shall be no deemed acceptance of the SATP.

6.7 Shipping and Warehousing

- A. The Selected Vendor shall ship and warehouse all equipment and materials at its own expense. The Commission will not store equipment.
- B. The Selected Vendor shall be responsible for transporting LMR and backhaul equipment to and from the Selected Vendor's warehouse(s) and the Commission sites.
- C. The Selected Vendor maintains all liability and risk for all equipment until it has been installed at the site.

6.8 Tower Installation

6.8.1 General

- A. The Selected Vendor shall:
 - 1. Furnish all materials, labor, equipment, and mounting hardware to provide a complete functional tower installation.
 - 2. Perform all operations required for the installation
 - 3. Be responsible for all concrete work and excavation
- B. All concrete work shall comply with manufacturer's recommendations, including temperature, slump and air content.
- C. Two sets of fresh field concrete specimens shall be taken for each concrete pour.
 - 1. One set of field-cured concrete specimens shall be tested for weight.
 - 2. One set of specimens shall be tested for compressive strength with the tests to be taken at 7 days and at 28 days.
 - 3. The results of these tests will be presented to the Commission.
 - 4. The compressive strength test shall be the average of the two specimens from the same composite sample.
- D. Tower documentation shall include construction, installation, and maintenance drawings.
- E. All drawings shall be approved by a Virginia registered Professional Engineer (PE).

6.8.2 Tower Erection

- A. The foundation shall be allowed to cure for at least 7 days before erecting the tower.
- B. Manufacturer recommended bolts shall be used for all connections in accordance with the installation documentation.
- C. Bolts should be of such lengths as to protrude beyond the nuts a minimum of 1/4 inch and a maximum of 1/2 inch.
- D. All bolts shall be equipped with self-locking nuts.
- E. Field reaming of coated metal components will be acceptable only upon determining there is no structural damage to the tower.
- F. Field remanufactured holes must be hot stick galvanized as specified and completely filled by the use of a larger diameter bolt.
- G. All bolts placed through slotted holes shall be equipped with flat washers.
- H. Mud, dirt, and other foreign matter shall be removed from the tower sections before erection. Special attention shall be given to cleaning the contact surfaces at joints before they are bolted together.
- I. When portions of the tower are ground assembled, such assembly shall be on rigid surfaces or blocking, which will provide support to prevent distortion of tower steel and damage to surface finish.
 - 1. All bolts shall be installed in all connections of ground assembled portions of the tower.
 - 2. Temporary bracing of tower members shall be used to avoid overstressing or distortion.
- J. The structure shall be erected plumb.
- K. The method of assembling and erecting shall be such that no member will be subjected to a load in excess of that for which it was designed.
- L. Extreme care shall be taken to establish and maintain the true geometric shape of the portion of the tower assembled.
 - 1. All connections must lie flat where bolted together.

2. No gaps between butt flanges or connections are acceptable after the bolts are tensioned.
- M. Slings or other equipment used for picking up members or portions of the tower shall be of such material or protected in such a way as to not damage the tower section, the finish, or distort or overstress the tower when lifts are made.
- N. Portions of the tower shall be raised in such a manner that no dragging on the ground or against other hard surfaces occurs.
- O. Damaged tower sections can be used if properly repaired.
1. If a damaged portion cannot be repaired to the satisfaction of the Commission, it shall be replaced.
 2. For any galvanized surfaces, damaged for any reason, zinc-based solder repair shall be used.
 - a. Solders in a rod form or a powder may be used.
 - b. Surfaces must be cleaned using a wire brush or a light grinding action.
 - c. Surface preparation shall extend into the surrounding undamaged galvanized coating.
 - d. The thickness of zinc solder repair shall be equivalent to the originally specified hot dip galvanizing process.
 - e. Repairs shall be performed in accordance with the solder manufacturer's instructions.
- P. Only wrenches of proper size, which will not deform the nuts, nor damage the surface finish, are to be used.
- Q. Standard ironworkers' 12-inch spud or 12-inch socket wrenches shall be used.
- R. Pipe extenders will not be permitted.
- S. During construction of the tower where required, the obstruction lighting fixtures shall be installed and operated at each required level as each such level is exceeded in height during construction.

6.8.3 Grounding

- A. The tower and all appurtenances shall be installed in accordance with Motorola R56, Harris 4Z/LZT 123 4618/1 R3A or MIL-STD-188-124B.

- B. All equipment mounted on the tower shall be properly bonded/grounded to the tower.
- C. All antenna systems shall be effectively grounded and provide surge protection to all equipment.
- D. All antenna transmission lines shall be properly bonded/grounded to the tower.
 - 1. At a minimum, transmission lines shall be bonded/grounded at the antenna base, at the base of the tower, and at the exterior ground bar located at the entry to the building.
 - 2. Additionally, transmission lines shall be bonded/grounded to the tower or cable ladders at intervals recommended by the manufacturer.
 - 3. Antenna transmission line ground conductors shall be bonded to the tower in compliance with standards.
- E. The site installation should have less than 5 ohms resistance between any connected point on the ground bus and earth ground.
- F. The Selected Vendor shall test ground resistivity using the four-point method.
- G. The Selected Vendor shall supply a ground test report that fully describes the testing method used.

6.9 System Installation

- A. Installation shall consist of a complete tested system to include placement of associated cabling, appropriate system layout, and terminal connections.
- B. The Selected Vendor shall provide associated power supplies and any other hardware, adapters, and/ or connections to deliver a complete operable system to the Commission.
- C. The Selected Vendor shall participate in a mandatory project site survey with the Commission to confirm actual equipment location within each space Prior to the start of the system installation.
- D. During the mandatory project site survey, the Selected Vendor shall determine and document any exact locations that differ from the detailed design installation drawings.

- E. All detailed design drawings and documents requiring changes shall be revised prior to installation.
- F. The Selected Vendor shall coordinate with others, as appropriate, to confirm that any preparatory work that affects the installation of the base station equipment, such as tower work, coring, bracing, conduit, and electrical, is complete before final inspection.
- G. The Selected Vendor shall provide and pay for all materials necessary for the execution and completion of all work.
- H. Unless otherwise specified, all materials incorporated into the permanent work shall be new and shall meet the requirements of this specification document and RFP.
- I. All materials furnished and work completed shall be subject to inspection by the Commission.
- J. The Selected Vendor shall be responsible for preparing and submitting the necessary applications for site permissions/access to install system equipment at non-Commission owned sites.
- K. The Selected Vendor shall be responsible for any leases at non-Commission owned sites for temporary space needed during installation and cutover to the new system.
- L. The Selected Vendor is responsible at all space-limited sites (not just leased sites) for planning, coordinating, supplying temporary shelter or site-on-wheels, moving/installing of existing and new equipment, and decommissioning of old equipment.
- M. Qualified, trained personnel experienced with this type of work, shall perform all installations.
- N. Equipment installation will be compliant with all applicable standards for seismic bracing.
 - 1. Equipment placement in racks or cabinets shall be such that heavier items are lower in the racks while lighter items are higher in the racks to minimize the effect of centrifugal forces and swaying during an earthquake.
 - 2. Bracing of equipment is required during unattended periods of construction.

- O. The Selected Vendor shall not use equipment supplied as spares for installation of the proposed system.
- P. The Selected Vendor shall supply all spare equipment in new condition.
- Q. The Selected Vendor shall clean all equipment and devices and repair all damaged finishes.
- R. The Selected Vendor shall leave sites neat and broom swept upon completion of work each day.
- S. The Selected Vendor shall thoroughly clean all equipment shelter and building floors and remove all scuff marks and abrasions prior to acceptance.
- T. The Selected Vendor shall remove all trash weekly.
- U. Inspection:
 - 1. The Commission shall conduct an inspection of the installations upon substantial completion.
 - 2. The Commission shall document any deficiencies on a single punch list and provide the punch list to the Selected Vendor for resolution.
 - 3. Final acceptance testing shall not commence until all punch list items are resolved.
- V. The Selected Vendor shall provide the Commission with all programming cables required for the programming or configuring of any provided piece of equipment.

6.10 Acceptance Testing

6.10.1 General

- A. Prior to testing, the Selected Vendor shall:
 - 1. Verify and document that all equipment, hardware, and software are upgraded to the latest factory revision. Multiple revision levels among same equipment types are not acceptable.
 - 2. Provide two weeks written notice to the Commission that the system is ready.
 - 3. Submit a Test Plan for review and approval by the Commission

- B. The Selected Vendor shall provide all test equipment and miscellaneous cables, adapters and parts required to perform all testing specified in this specification document and RFP. All test equipment shall be calibrated prior to testing.
- C. The Selected Vendor shall utilize quality instruments in proper condition for all tests. Calibration records for all instruments shall be available at the site during all testing.
- D. The Selected Vendor shall perform all tests in the presence of Commission or a Commission-approved representative.
- E. The Selected Vendor shall submit all test schedules to the Commission for approval.

6.10.2 LMR Acceptance Testing

- A. The Selected Vendor shall use the completed and approved FATP.
- B. The Selected Vendor shall successfully perform all FATP tests before the Commission witnesses the official FATP.
- C. The Selected Vendor and the Commission representatives shall jointly execute and date the FATP following completion of all tests.
- D. All tests in the FATP shall be marked as either pass or fail.
- E. The Selected Vendor shall provide all necessary technical personnel and test equipment to conduct FATP tests.
- F. All deviations, anomalies, and test failures shall be resolved at the Selected Vendor's expense.
- G. The Selected Vendor shall document, correct, and retest all failed components.
- H. The Selected Vendor shall replace at its own expense any failed component that is not repairable.
- I. Retest of individual failed FATP tests or the entire plan shall be at the Commission's discretion.
- J. The Selected Vendor shall provide the Commission with the fully executed and completed FATP document.
- K. There shall be no deemed acceptance of the FATP.

6.10.3 Microwave Backhaul Acceptance Testing

6.10.3.1 Antenna System Tests

- A. The Selected Vendor shall conduct return loss (RL) testing on all microwave antenna systems. The antenna system includes the antenna, waveguide and connectors.
- B. The measured return loss of the antenna system shall be 21 dB or greater over the specified frequency range of the antenna.
- C. For RL testing the Selected Vendor shall:
 - 1. Perform RL tests after the antenna system has been installed, and prior to antenna alignment
 - 2. Include a copy of the RL trace in the Test Report
 - 3. Perform a distance to fault (DTF) measurement to identify fault area(s) if the RL of the antenna system is < 21 dB
 - 4. Make any repair or replacement required and repeat testing until a 21 dB RL is achieved over the specified frequency range of the antenna

6.10.3.2 Microwave Radio Path Tests

- A. The Selected Vendor shall perform the following tests for each radio path.
 - 1. Transmitter
 - a. Measure and record the microwave radio transmit power at the center frequency of each radio at each modulation rate and verify it is within the expected tolerance.
 - b. Measure and record the output frequency of each radio transmitter and verify it is within the specified limits.
 - c. If either the transmit power or frequency are not within expected limits, investigate and correct the issue before beginning the tests described below.
 - 2. Receive Signal Strength
 - a. For each radio link, measure the RSL under no-fade conditions and verify that it is within 2 dB of the expected value. If the RSL is not

within 2 dB of the expected value, investigate and correct the issue before beginning the remaining tests described below.

3. Thermal Fade Margin (to confirm that the calculated fade margin matches actual performance)
 - a. Conduct this test after it has been verified that the expected RSL for normal link operation is present at both ends of the link.
 - b. Fade the receiver using an external continuously variable vane attenuator (0 to 60 dB) in series with the receiver.
 - c. Apply attenuation using the vane attenuator until the receiver reaches the 10-6 and 10-3 BER thresholds.
 - d. The fade margin is equal to the amount of attenuation that was required to reduce the received signal level to the 10-6 and 10-3 thresholds. Record both values. The fade margin shall be no less than 2 dB lower than the calculated value.
 - e. The Selected Vendor shall remedy the source of degradation if the fade margin does not meet this requirement.
4. Far-End Transmit Fade Test:
 - a. Fade the far end transmitter using a continuously variable vane attenuator and record the fade margin at the 10-6 and 10-3 BER thresholds. Note the difference between these fade margins and those achieved during the Thermal Fade Margin Test.
 - b. Results for Thermal Fade and the Far-End Transmit Fade that differ by 3 dB or more may indicate possible interference or presence of dribbling errors emanating from the far end transmitter. If transmit dribbling errors are suspected, reduce the transmit power of the Power Amplifier (or bypass the PA) and repeat Far-End Fade Test. If the difference is 3 dB or more, remedy the source of the degradation and retest.

6.10.3.3 Packet Internet Payload Performance

- A. Long-term Ethernet Test - after successfully completing the Radio Path Tests, Selected Vendor shall perform an RFC 2544 test, with the radio link at nominal RSL.

1. Begin generating Ethernet traffic at 100 Mbps, increasing the data rate until the test set indicates dropped packets, then reduce data rate until no packets are dropped for 10 minutes.
2. Continue generating Ethernet traffic across the radio path for a minimum of 12 hours and show that there was no packet loss.
3. If there is packet loss, identify and resolve the issue, and then repeat the test until there is no packet loss.

6.10.3.4 MPLS Testing

- A. Selected Vendor shall demonstrate operation of all features of the MPLS routers, testing equipment operation in accordance with the manufacturer's recommended test procedures.
 1. Demonstrate access and administration of MPLS router lookup tables
 2. Demonstrate the proposed MPLS system will meet or exceed latency and jitter requirements specified in this RFP
 3. Demonstrate the priority packets provisioned with a primary and alternative route do switch to the alternate route in 20 milliseconds or less when the primary route fails
 4. Demonstrate packets with no provisioned route are successfully rerouted in 50 milliseconds or less when the microwave route is restricted or failed due to a microwave path fade
 5. Route/system tests shall be performed to demonstrate the correct operation of all functions of the MPLS routers operating over the microwave radios and fiber optic route closures. The results from the route and systems tests shall be recorded and presented to the Commission for review and approval.

6.11 Coverage Testing

- A. The Selected Vendor shall submit a Coverage Acceptance Test Plan (CATP) that will validate the coverage requirements defined in Section 2.3.
- B. CATP:
 1. The CATP shall be consistent with the procedures and guidelines outlined in TIA TSB-88 (current version).

2. Coverage testing shall commence only after the radio system is fully optimized, tested and aligned.
 3. Significant changes to the system will require retesting of coverage at the Commission's discretion.
 4. The CATP shall be conducted when trees are in full foliage, typically between April 1 and September 30.
 5. The Selected Vendor shall perform the following types of coverage testing:
 - a. Automated talk-out and talk-in objective BER drive testing
 - b. Subjective talk-out and talk-in DAQ testing
 - c. In-Building talk-out and talk-in DAQ Testing for those buildings contained within Appendix B
- C. Objective and subjective testing shall be complementary and serve to fully verify that coverage requirements are met both technically and operationally. The BER and DAQ test results shall be the determining factor for pass/fail of the P25 system coverage. Should either the BER or DAQ testing not pass using the criteria outlined, at the system-wide level, the system will not pass the acceptance testing.
- D. Test configurations:
1. Test configurations shall represent typical operating configurations to the greatest extent possible, using portable and mobile radio equipment (including the proper microphones) that will be used with the system. In addition, the proper subscriber antenna location (e.g., roof-mounted, hip-level, etc.) should be simulated during the testing, and the attenuator values required to simulate those locations shall be submitted to the Commission for their review and approval prior to testing.
 2. Automated objective drive testing:
 - a. The Selected Vendor shall test on-street BER and signal level, using a portable to be used on the system.
 - b. The Selected Vendor shall test at a statistically significant number of test locations throughout EACH of the three Jurisdictions. Methods for determining the minimum number of tiles are provided in TSB-88.
 - c. The Selected Vendor shall test both talk-out and talk-in BER, and talk-out RSSI, as applicable.
 - d. Testing will be conducted in FDMA mode (i.e., P25 Phase 1), and operating in the simulcast mode, as applicable.

3. Non-automated subjective DAQ testing:
 - a. The Selected Vendor shall perform non-automated subjective DAQ coverage testing using portable radios typical of the system, in their proper configuration (e.g., shoulder-mounted antenna, Bluetooth speaker mic, etc.).
 - b. Voice quality testing (DAQ) will be sampled at 100% of the total number of accessible tiles across the coverage area.
4. In-Building DAQ Testing:
 - a. In-Building DAQ testing shall be performed at all Critical Buildings listed in Appendix B in both the talk-out and talk-in direction.
 - b. If specific areas of any particular building are listed as required, DAQ testing must occur in those areas, at a minimum. For remaining sections of buildings, and for those buildings which do not have required areas listed, the following locations shall be tested:
 - 1) Small commercial building (single story, open floor plan). Five test locations, one in each corner and one in center.
 - 2) Medium building (small school, light industrial, medical office). Twenty test locations uniformly distributed on the ground floor.
 - 3) Large building (Shopping malls, factories, buildings over 5 stories). Multiple test points uniformly distributed on the ground floor.
 - c. Buildings are considered “passed” if 95% or more of the tested locations pass the DAQ test, in both directions, and if all listed required areas pass the DAQ test in both directions.
- E. For testing purposes, EACH of the three Jurisdictions shall be divided into 1/4-mile square test tiles (i.e., .25-mile x .25-mile).
 1. The Selected Vendor may subdivide test tiles if necessary.
- F. The Selected Vendor shall not count inaccessible test tiles as either a pass or fail in the statistical analysis.
- G. Should the coverage test fail, the Selected Vendor shall correct the cause of the failure and re-conduct the coverage test in its entirety.

- H. The Selected Vendor shall measure talk-out and talk-in performance separately for each test tile (i.e., BER and DAQ shall be measured in both directions in each test tile), and the overall subsystem pass/fail percentages shall be calculated for each direction distinctly.
- I. The Selected Vendor shall provide a standardized test form for testing.

6.12 Training

6.12.1 Training Programs

The Selected Vendor shall develop and conduct training programs to allow the Commission personnel to become knowledgeable with the system, subsystems, and individual equipment.

- A. The Selected Vendor shall provide:
 - 1. Subscriber device training
 - 2. Console operation training
 - 3. Training shall cover all features, operation, and special care associated with the equipment supplied.
- B. Operational training shall include the following categories:
 - 1. APCO P25 Fundamentals
 - 2. P25 Portable Unit Operation
 - 3. P25 Mobile Unit Operation
 - 4. P25 IP Console Operation
- C. The Selected Vendor shall provide technical/system management training, including:
 - 1. Complete and comprehensive technical training as applicable to the system design
 - 2. This training shall include:
 - a. System theory
 - b. Troubleshooting
 - c. Repair

- d. Servicing techniques
3. Technical training shall include the following categories:
- a. P25 Systems Operations
 - b. P25 Base Station Programming and Maintenance
 - c. P25 Fleetmapping, Radio Programming, and Maintenance
 - d. P25 IP Console Maintenance
 - e. P25 Control Site Design
 - f. P25 Repeater Site Design
 - g. P25 Digital Simulcast Design
 - h. Interference Analysis
 - i. P25 system troubleshooting
 - j. Coverage Mapping Tools, Propagation Analysis & Prediction Modeling
 - k. NMS maintenance, configuration, troubleshooting and report generation
 - l. Microwave radio maintenance, configuration, and troubleshooting
 - m. Optical Fiber transmission systems, if applicable
 - n. Router maintenance, configuration, and troubleshooting
 - o. Logging Recorder
- D. The Selected Vendor shall provide system management training for technical staff responsible for managing the system.
- E. System management training shall include, but is not limited to:
- 1. Planning and setting up the system and network
 - 2. Building and implementing system and network profiles and configurations
 - 3. Performing database management functions
 - 4. Monitoring and managing the system's performance
 - 5. Writing and printing system reports
- F. The Selected Vendor shall:

1. Conduct all training at a location where duplication of system operation will not impact daily operations
 2. Coordinate with the Commission regarding number of attendees, schedule, and training location
 3. Schedule classes as close to system cutover as possible
 4. Train Commission employees or designated individuals
- G. For console and subscriber operator training, the Selected Vendor shall provide "train-the-trainer" courses to selected Commission personnel.

6.12.2 Training Materials

- A. The Selected Vendor shall provide all instructional material, for all technical and operational training classes for the exact model and series of equipment delivered, including:
1. Printed manuals
 2. Audio, video, interactive self-paced personal computer programs
 3. Complete equipment operating instructions
- B. All instructional material shall be subject to the approval of the Commission and shall become property of the Commission.
- C. Training materials shall be professionally produced and provided in binders.
1. Loose leaf materials are not permitted.
 2. Paper shall be 8 ½ x 11" whenever possible.
 3. If larger paper is utilized it must be professionally incorporated into the document.
 4. Binders shall be color coded where it will provide an organizational benefit.
 5. Illustrations and photographs, where provided, shall be specific to the Commission installation.
 6. Color photos must be provided where detail or clarity is supported by use of color.
 7. Black and white photocopying of color materials is unacceptable.

- D. The Selected Vendor shall provide fully editable (softcopy) versions of all training materials so that the Commission trainers can update the course materials.
- E. The Selected Vendor shall provide unit pricing for all media (e.g., DVDs, flash drives, external hard drives, manuals) used for training.

6.13 System Cutover

6.13.1 Cutover Plan

- A. The Selected Vendor shall develop a Cutover Plan for review and approval by the Commission. The Commission reserves the right to approve and change the cutover plan as it relates to any or all system components. The Cutover Plan shall be logical and must consider every facet of the existing and new networks. Key objectives of the Cutover Plan are:
 - 1. Ensure that new systems are brought online with minimum interruption to all existing systems and communications
 - 2. The Selected Vendor shall be responsible for planning and coordinating the implementation of all equipment, subsystems, and the overall system.
 - 3. The Selected Vendor shall:
 - a. Be responsible for any costs associated with their proposed cutover plan.
 - b. Program the users' existing and/or new radios
 - c. Identify the cutover of individual circuits
 - d. Identify temporary alternate routing of critical circuits
 - e. Include fallback, recovery, and contingency plans to mitigate the risk of circuit failure during cutover
 - f. Maintain reliable and stable communications
 - g. Ensure the timely deployment of a complete and functional network
 - h. Identify physical and technical constraints that must be considered for successful implementation planning such as site ownership, site access, shelter space, tower loading and availability and electrical load limitations
 - i. Ensure successful integration with all legacy systems, including a smooth transition from existing operations

4. Clearly defined roles and responsibilities between the Selected Vendor and the Commission.
- B. The Cutover Plan shall demonstrate that it meets the following requirements:
1. Supports the operational requirements of each participating agency including
 2. Ensures users and technical staff are prepared for the migration to the new network
 3. Mitigates risk
 4. Does not exceed maximum outage times
 5. Considers site access issues, such as sites that are inaccessible during winter months
- C. During detailed design, the Selected Vendor shall deliver a draft Cutover Plan describing how the existing radio systems will be migrated to the new system.
- D. The Cutover Plan shall:
1. Include the schedule and procedures associated with the transition of each operational user group
 2. Specifically address how the existing users will begin using the new system with minimal operational impact
 3. Provide detailed component or subsystem cutover plans, and specifically delineate between systems that affect and do not affect ongoing operations
- E. The Commission reserves the right to approve and change the Cutover Plan as it relates to any or all system components.

6.13.2 Cutover Execution

- A. After successful completion of all tests and training, the Selected Vendor shall execute the system cutover according to the approved Cutover Plan.
- B. Any modifications to the plan shall be proposed to and approved by the Commission at least ten business days prior to execution.
- C. The Selected Vendor shall provide 5 business days advance notice for required outages of the existing system during the cutover. All planned outages require approval of the Commission.

- D. The Selected Vendor shall provide the necessary labor to cutover from existing systems to the new system.

6.14 30-Day Operational Verification Period

- A. The Selected Vendor shall plan a 30 calendar-day operational burn-in period for EACH of the three Jurisdictions, in addition to the entire system.
- B. The conditions of the test shall be determined during Final Design with plans including loading the system as fully as approved by the Commission.
- C. Technical staff from the Commission shall monitor the burn-in period.
- D. The Selected Vendor shall demonstrate the integrated operation, reliability, long-term stability, and maintainability of the system during this period.
- E. System must be fully loaded (all users must be fully migrated).
- F. A Critical failure of the system during this test will cause the 30-day burn-in period and warranty to reset and restart from the beginning after completion of the repair. A Critical Failure is defined as follows:
 - 1. Any failure which causes a loss of 15% or more in capacity or coverage in any cell
 - 2. Any failure which causes a loss of the primary system control
 - 3. Any failure which causes a loss of simulcast capability
 - 4. The concurrent failure of two or more repeaters
 - 5. Concurrent failure of two or more switches and/or routers
 - 6. Any system failure that causes the loss of two or more console positions
 - 7. Any failure that renders the logging recorder inoperable or caused the irretrievable loss of recorded audio
 - 8. Failure of the receiver voting system
- G. A minor failure will cause the burn-in period to temporarily hold until the issue has been fully resolved to the Commission satisfaction.
- H. After resolution of the failure, and with Commission approval, the burn-in period will continue.

- I. Two or more repetitive minor failures of the same functionality with or without the same root cause shall be defined as a major failure.
- J. Two or more repetitive minor failures of the same piece of hardware with or without the same root cause shall be defined as a major failure.
- K. Two or more repetitive minor failures with the same root cause shall be defined as a major failure.
- L. Two or more similar minor failures without the determination of cause will temporarily hold the burn-in test until a cause is found and corrected, or the Commission is satisfied there is little likelihood of a systemic recurring issue.

6.15 Decommissioning, Removal, and Disposal of Legacy Equipment

- A. The Selected Vendor shall remove existing equipment (e.g., transmitters, consoles, mobiles, cables, and antenna systems) not being reused in the new system or identified for future use by Commission.
 - 1. Equipment purchased by the Selected Vendor as Trade-In shall be removed and handled according to the terms of any applicable Trade-in agreement.
- B. The Selected Vendor shall maintain a detailed inventory of all equipment removed, listing the following at a minimum:
 - 1. The owning agency
 - 2. Model numbers
 - 3. Serial numbers
 - 4. Asset numbers
 - 5. Location removed from
 - 6. Location within the warehouse
 - 7. Trade-in or disposition value
- C. The Selected Vendor, at its sole expense, shall warehouse, as necessary, removed equipment prior to disposal.
- D. The Selected Vendor, at its sole expense, shall transport all removed equipment to the Commission-specified disposal location.

6.16 As-Built Documentation

- A. At the completion of each implementation phase, the Selected Vendor shall provide complete as-built documentation as outlined below:
 - 1. Equipment provided
 - 2. Plan and elevation drawings of all equipment including antennas on towers
 - 3. Shelter floor plans
 - 4. Cabling and terminations
 - 5. Block and level diagrams
 - 6. Fleet mapping and programming
 - 7. Setup, configuration, and alignment information, to include commissioning, provisioning, test and turn-up
 - 8. Successfully completed, signed, and dated Coverage and Final Acceptance Test Plans
- B. The Selected Vendor shall provide final documentation in printed form:
 - 1. Six bound, hard copy, printed sets
 - a. Hand modified drawings are not acceptable.
 - b. Hard copies of all drawings shall be 11" x 17".
- C. The Selected Vendor shall provide final documentation on DVD in electronic form:
 - 1. All drawings provided in MS-Visio native format
 - 2. All other documentation provided in MS-Word or MS-Excel native format
 - 3. A copy of all drawings and documentation in Adobe Portable Document Format (PDF)

6.17 System Acceptance

- A. The Commission shall deem the system ready for final acceptance following successful completion and approval of the following:
 - 1. Final Detailed Design
 - 2. Staging Acceptance Test

3. All contracted installation completed
 4. Final inspection and punch list resolution
 5. As-built documentation
 6. Coverage Acceptance Test
 7. Final Acceptance Test
 8. Delivery of final documentation
 9. Successful completion of (30)-Day Burn-in test for EACH Jurisdiction and entire system
 10. Training completed
- B. No conditional acceptances will be granted.

7. Warranty, Maintenance, and Support

- A. Selected Vendor support includes the initial 3-year warranty, software and firmware upgrade support, maintenance, and spare parts and equipment.
- B. Should the Selected Vendor be a system integrator, they will provide pricing and discounts per the final contract throughout the term of the final contract.

7.1 Warranty Requirements

- A. All equipment provided shall be new and covered by a full manufacturer's warranty for 3 years, commencing with Commission final acceptance.
- B. System performance, installation, and all hardware, parts, software, and materials (including third-party equipment) shall be warranted for a period of 3 years.
- C. Warranty coverage shall include all related return and delivery fees.
- D. The Selected Vendor shall provide a single toll-free telephone number staffed and available 24 hours a day, 7 days a week, 365 days a year, for service requests and warranty claims.
- E. During the warranty period, maintenance service and repair shall be performed 24 hours a day, 7 days a week, 365 days a year.
 - 1. There shall be no additional charges for work outside of normal Selected Vendor business hours.
- F. If Selected Vendor level support is required, the following repair response time and repair-completed time criteria shall be in effect:
 - 1. The Selected Vendor shall contact the Commission within 30 minutes of telephone notification for a Critical Service issue.
 - 2. The Commission defines Critical Service issue as any one or more of the following events that results in a loss of voice traffic on the system:
 - a. Any failure which causes a loss of 15% or more in capacity or coverage in any cell
 - b. Any failure which causes a loss of simulcast capability
 - c. Any failure which causes a loss of the primary system control (assuming a primary/secondary architecture)

- d. Any system failure that causes the loss of two or more console positions
 - e. Any failure that renders any logging recorder inoperable or causes a loss of recorded audio
 - f. The failure of two or more repeaters
 - g. Concurrent failure of two or more switches and/or routers
 - h. Failure of the receiver voting system(s)
- 3. The Selected Vendor's qualified service representative and the Commission's representative shall attempt to resolve the Critical Service issue over the phone or via remote network management.
- 4. If the Selected Vendor's qualified service representative and the Commission's representative cannot resolve the issue remotely or over the phone, then the Commission shall make the determination regarding the criticality of the service issue.
 - a. If determined to be critical the Selected Vendor shall dispatch a qualified service representative to the site experiencing the service issue.
- 5. The Selected Vendor's qualified service representative shall be physically present at the site that requires service within 4 hours of Commission's decision to escalate the call to on-site service.
- 6. On-site Selected Vendor's service representative shall make every effort to resolve the Critical Service issue within 12 hours from the time the critical service issue was reported.
- G. The Selected Vendor shall repair all equipment, hardware, and software throughout the implementation, cutover and warranty periods.
- H. The following procedures shall be followed during the warranty period:
 - 1. The Selected Vendor shall provide the Commission with written documentation indicating:
 - a. The cause of the service outage
 - b. The resolution
 - c. All post-repair testing procedures to ensure proper operation

2. In the event the Selected Vendor uses Commission-owned spares to complete a repair, the documentation shall include the model and serial number of both the defective unit and the spare.
3. Hardware:
 - a. For all equipment needing factory or depot repairs, the Selected Vendor shall maintain a comprehensive tracking system to track units to and from the factory/depot.
- I. Replacement parts shall be new or original repaired parts only.
- J. Fixed equipment mail-in board repair shall be completed within seven calendar days of receipt.
- K. Equipment must be returned to the Commission via second-day shipping, with tracking number provided to the Commission.
- L. Serialized units sent in for depot repair must not be exchanged unless specifically authorized by the Commission.
- M. The original unit must be repaired and returned unless specifically authorized by the Commission.
- N. Software and Firmware:
 1. The Selected Vendor shall warrant all software and firmware.
- O. During the installation, warranty, and extended warranty periods, the Selected Vendor shall provide, at no additional cost, commercially available upgrades of all software and firmware originally sold to the Commission.
- P. The frequency and timing of installation of upgrades during this period shall be at the sole discretion of the Commission based on availability by the Selected Vendor.
- Q. The Selected Vendor shall provide all back-up media and revised software manuals to the Commission at the time of any software revisions at no cost.
- R. The Selected Vendor shall update all devices to the same and latest release level prior to the conclusion of the warranty period at no additional cost to the Commission.
- S. Recurring Failures and Manufacturer Defects:

1. Any fixed equipment or fixed equipment module that fails twice during the acceptance test or twice during the first 12 months after System Acceptance shall be indicative of a recurring or systemic failure or defect that warrants further investigation by the Selected Vendor and Commission.
 - a. If the defect is deemed by the Commission to be systemic after the investigation is completed, the Selected Vendor shall then be responsible for replacing at no additional cost to the Commission all equipment and/or equipment modules related to the recurring or systemic failure, not only the specific equipment affected.
- T. The Selected Vendor, at no additional cost to the Commission, shall correct latent design defects or recurring problems relating to software, firmware, hardware, or overall system design, during the warranty period.
- U. During the warranty period, the Selected Vendor shall correct all system malfunctions due to software at no additional cost to the Commission.

7.2 Warranty Services

- A. Network Monitoring: The Selected Vendor shall remotely monitor all components provided as part of this procurement. Monitoring shall be performed 24 hours a day 7 days a week from a remote location specifically staffed with personnel performing monitoring duties for other systems throughout the United States. Any connectivity required for network monitoring shall be provided and paid for by the Selected Vendor. Any and all network monitored events shall be logged by the Selected Vendor and a report shall be provided to the Commission on an agreed upon schedule.
- B. Dispatch Services: The Selected Vendor shall notify the appropriate personnel in the event of a system event detected through the network monitoring service. Any events requiring notification of maintenance personnel shall be logged and provided to the Commission on a monthly basis, or as requested.
- C. On-Site Repair: The Selected Vendor shall supply the appropriate personnel to provide on-site repair of any failed system components or ancillary equipment. All components provided through this procurement shall be repaired by the Selected Vendor or their subcontractors. System components shall be returned to a fully functional state via direct on-site repair, replacement of faulty module, or replacement of entire component.

- D. Depot Repair: The Selected Vendor shall provide for depot repair of any components found to be defective, or not within factory specifications.
- E. Software Services: The Selected Vendor shall provide and install any software patches, anti-virus definitions, or other software as needed to any provided networking and/or system devices.
- F. Information Security Services: The Selected Vendor shall monitor the network architecture to detect and respond to security related incidents, manage system firewalls, update anti-virus software, test, and update security patches, and proactively manage the security of the radio system network.
- G. Software Refresh: The Selected Vendor shall install all software updates that have been released and are applicable to the provided system and its components. The Selected Vendor shall provide all labor and software. Prior to expiration of the warranty period, all system software shall be updated to the latest software revision shipping on the end of warranty date. Commission owned spare parts shall be included in software update process.
- H. Hardware Refresh: The Selected Vendor shall replace any hardware that is not compatible with the latest revision software. In addition, all system components shall be replaced with the then current versions shipping on the warranty expiration date. This ensures system components are not at end of life upon expiration of the warranty period. Commission owned spare parts that become obsolete will also be replaced with upgraded model.
- I. System Manager: The Selected Vendor shall provide system management functions by an individual that has been factory trained and is competent to monitor and change network settings as required by the Commission. These services shall be available during the system warranty period on an as needed basis and will not be limited to alias database changes, usage, and alarm reports. If any changes to the system cannot be performed by the provided system manager, the Selected Vendor shall provide the appropriate personnel to meet the request of the Commission.
- J. Spare parts: The Selected Vendor shall maintain a sufficient quantity of spare parts to maintain 24/7 operation of the provided system and subsystems. As an OPTION the Commission may purchase spare parts. Restoration times shall not be dependent upon the Commission's decision to purchase spares.
- K. Preventive Maintenance: The Selected Vendor shall provide annual preventive maintenance checks and services to all provided equipment, including

infrastructure and subscriber units. Any component found to be out of spec will be realigned or repaired as needed to bring unit back into specifications. Included will be software audit services where each component's software revision will be recorded. Antennas and dishes will be swept and the results compared to system as-built records for any deficiencies or anomalies.

7.3 Parts Availability

- A. The Selected Vendor shall certify that replacement parts for all delivered equipment shall be available for a period of at least 10 years after the last date of production.
- B. In the event the Selected Vendor plans to discontinue manufacture of any product-line or stocking any part required for maintenance in the system, the Selected Vendor shall send written notice to the Commission 24 months prior to the date of discontinuance to allow for last-time buys and spares replenishment.

7.4 Spare Equipment

- A. The Selected Vendor shall include recommended initial spare parts and equipment to be procured as part of the initial contract. The Commission is required to maintain the necessary spares on hand to repair the LMR systems to provide timely restoration of the system.
- B. The initial spare parts and equipment shall include, but is not limited to, the following:
 - 1. All Selected Vendor identified Field Replaceable Units (FRUs)
 - 2. All infrastructure components having no FRUs, but that can cause a critical failure (e.g., antenna systems, other non-modular components), including all third-party equipment items
 - 3. Power supplies
 - 4. Required and/or recommended test, measurement, calibration equipment, and repair kits
 - 5. Recommended diagnostic equipment to support the Commission's maintenance activities
- C. Initial spares for less critical items shall also be enumerated

- D. The spare parts and equipment shall include items that will rapidly and completely restore all critical system functionality with the least amount of effort (e.g., board replacement instead of troubleshooting to component level when a critical unit fails).
- E. The Selected Vendor shall determine the types and quantities of spares based on their proposed system size and design.
- F. The Selected Vendor shall define the primary equipment category each spare kit supports (e.g., transceiver board for a base radio or interface board for a router).

7.5 Lifecycle Support

- A. System(s) shall not be accepted with components or equipment at the end of their respective lifecycles.
 - 1. Selected Vendor shall provide a roadmap for end-of-life dates on existing and/or proposed products.
- B. A product for which development and/or distribution will be discontinued within the next 5 years shall be considered "end of lifecycle" products.
- C. The Commission shall have the option to purchase post-warranty service for the system.
- D. The Selected Vendor shall:
 - 1. Provide spare parts and equipment at a discounted rate for the life of the contract.
 - 2. Provide technical support at a discounted rate for the life of the contract.
 - 3. Provide engineering services at a discounted rate for the life of the contract.
 - 4. Offer OPTIONAL service tier(s) for the system.
 - 5. Provide discounted software support and upgrades for the system.
 - 6. Offer extended warranty for all supplied equipment for up to an additional seven years in 1-year increments.

7.6 Post-Warranty Support

- A. As an option, the Selected Vendor shall provide their top tier of 24 hours a day, 7 days a week, 365 days a year on-site support (i.e. all services described in Section

- 7.2) for annual increments (years 4-10) following expiration of warranty. The Offeror shall provide pricing for this in accordance with the Pricing Form.
- B. During a Post-Warranty period, all third-party services and equipment provided as part of the initial system and warrantied during the initial warranty period shall be covered in a similar fashion.
 - C. The Commission shall have the option to purchase post-warranty service for the system.
 - D. The Offeror shall offer OPTIONAL service tier(s) for the system.
 - E. The Selected Vendor shall provide discounted software support and upgrades for the system.

8. Options

8.1 Interoperability Requirements

- A. As an option, the system shall include all new hardware and software to support three Inter-RF-SubSystem Interface (ISSI) connections to P25 radio systems in the vicinity with the capacity for 10 concurrent conversations.
- B. The Offeror shall fully describe the features and capabilities provided through the implementation of the ISSI connection to external P25 systems.
- C. The proposed system shall allow a talkgroup from a system that is interconnected to the proposed system via ISSI to be patched via a console-initiated patch to a talkgroup on the proposed system.
- D. The proposed system shall also allow a talkgroup from a system that is interconnected to the proposed system via ISSI to be patched via a console RFP initiated patch to another talkgroup from a system that is interconnected to the proposed system via ISSI.

8.2 Optional Vehicular Extender

- A. Vehicular Extenders shall be of high quality and provide high reliability in severe environments.
- B. Vehicular Extender Equipment shall comply with applicable requirements of Part 90 and Part 15 of the FCC Rules and Regulations, as well as appropriate TIA/EIA and similar standards and shall be FCC type accepted in accordance with FCC Part 90 rules and regulations for the specific application.
- C. The Vehicular Extender shall interface to a P25 Phase 1 mobile unit, providing connection to radio frequency (or pair) separate from the network, allowing voice traffic to be exchanged between the P25 Phase 1 network and subscriber radio units in the vicinity of the Vehicular Extender.
- D. The Vehicular Extender shall operate on public safety radio bands.
- E. The Vehicular Extender shall operate in the following modes:
 - 1. On simplex channels in conventional mode
 - 2. On duplex channels in conventional mode

3. On both simplex and duplex channels in conventional mode
 4. In analog conventional mode
 5. In P25 conventional mode
 6. Selectable in both analog and P25 mode.
- F. The Vehicular Extender shall provide a minimum of 2 Watts RF output.
- G. The Vehicular Extender shall have receiver sensitivity appropriate for balanced operation with a portable radio of similar power.
- H. The Vehicular Extender shall be provided as a fully functional package with antenna, mounting, all interface cables and ancillary equipment required.
- I. The Vehicular Extender shall be provided with all programming software and cables equipment required to program from a standard PC or laptop.

Appendix A - Site Information

Table A.1 lists sites currently used by the Commission in existing radio systems. These site locations should be considered as highly preferable when designing the new radio system.

Table A.1 – Existing Commission Radio Site Locations

Site ID	Owner	Structure Type	ASR #	Latitude (WGS84)	Longitude WGS84	Structure Height (ft AGL)
Beamer's Knob	Carroll County	SST	N/A	36.675741	-80.744056	80
Carroll County Complex	Carroll County	Building	N/A	36.768159	-80.73483	80
Fisher's Peak	Blue Ridge Radio Corp.	SST	1005294	36.559952	-80.823247	240
Fries (US Cellular)	US Cellular	SST	1250511	36.711086	-80.978905	195
Hillsville PD Rptr	Crown Castle	Guyed	1018218	36.741998	-80.739989	400
Indian Ridge	Crown Castle	SST	N/A	36.828912	-80.573736	180
Laurel Fork Fire Tower	Laurel Fork VFD	SST	N/A	36.715454	-80.526599	100
Laurel Rescue	Laurel Rescue Squad	SST	N/A	36.797484	-80.850299	60
Mt Rogers/Whitetop*	Grayson County	SST	N/A	36.638935	-81.605466	60
Point Lookout	Grayson County	SST	N/A	36.669494	-81.161973	120
Pop's Peak	Carroll County	SST	N/A	36.646056	-80.679862	120
Route 100 Water Tank	Carroll County	Water Tank	N/A	36.829546	-80.730809	100
Twin County Regional Healthcare	TCRH	Building	N/A	36.670774	-80.923786	70
Ward's Knob (Carroll)	Carroll County	SST	N/A	36.657653	-80.904891	120
Ward's Knob (Galax)	City of Galax	SST	N/A	36.658011	-80.906278	160
Wolf Knob	American Tower	SST	1245995	36.616567	-81.144251	195
York Ridge/Rugby Fire	Grayson County	SST	N/A	36.607339	-81.427404	40
York Ridge/Rugby SO	GC Sheriff's Office	Guyed	N/A	36.604971	-81.407862	110

**This tower has a structural issue - it should be prioritized lower than other Commission sites, as a new tower may be required at this location.*

Table A.2 lists additional candidate sites for a proposed radio system.

Table A.2 – Additional Radio Site Candidate Locations

Site ID / Address	Owner / Description	Structure Type	ASR #	Latitude (WGS84)	Longitude WGS84	Structure Height (ft AGL)
App Co Tower	Appalachian Power Co.	SST	1247165	36.750028	-81.328917	330
Troutdale Tower	WideOpen Networks	SST	N/A	36.699830	-81.438719	120
Cana Fire Bldg.	Cana VFD	Building	N/A	36.601565	-80.684970	40
Cana Rescue Squad Bldg.	Cana Rescue Squad	Building	N/A	36.570118	-80.655777	40
829 FRIES RD	US Cellular	Monopole	1250518	36.673662	-80.936294	190
478 CEMETERY RD	US Cellular	SST	1041270	36.644995	-80.705593	190
945 HALL HOLLOW RD	CELLULAR TOWER	SST	1041271	36.853114	-80.813359	285
1689 COON RIDGE RD	SBA	SST	N/A	36.775755	-80.793327	183
311 ROCK CHIMNEY RD	US Cellular	SST	1241654	36.619863	-81.017373	300
5069 ELLIOTT PL	US Cellular	Guyed	1044059	36.645413	-81.208253	400
21 GOODSPUR RD	US Cellular	Monopole	1233424	36.771342	-80.805370	135
492 CEMETERY RD	Unknown	Monopole	N/A	36.643700	-80.704405	100
10991 GRAYSON PKWY	US Cellular	SST	1246099	36.636532	-80.975946	195
5031 COULSON CHURCH RD	Laurel Water Tank	Water Tank	N/A	36.779989	-80.837665	80
195 N A LINEBERRY DR	US Cellular	Monopole	1266065	36.695077	-80.886544	150
106 CITY VIEW ST	US Cellular	Monopole	1264579	36.659002	-80.934163	115
943 RESCUE RD	American Tower	SST	1244607	36.799193	-80.843625	224
2134 PLEASANT VIEW RD	CINGULAR BLUE	SST	N/A	36.826492	-80.854153	120
774 CEDAR LN	CINGULAR BLUE	SST	N/A	36.599811	-80.736958	120
298 SYLVATUS HWY	US Cellular	SST	1262105	36.784224	-80.707806	245
2073 ELLIOTT PL	VIRGINIA STATE POLICE	SST	1268310	36.645469	-81.208714	180
775 CARROLLVIEW RD	AFTON COMMUNICATIONS	SST	N/A	36.682268	-80.746522	80
729 COMMONWEALTH RD	VERIZON WIRELESS	Pole	1286528	36.717312	-80.852053	290
348 LOUISVILLE LN	US Cellular	Pole	N/A	36.604132	-80.934886	150
2136 BEAR BRANCH RD	US Cellular	Pole	1284110	36.614187	-81.388560	195
1078 BRIAR PATCH MTN RD	Unknown	SST	N/A	36.710379	-81.081714	100
264 CHERRY ST	PARALLEL INFRASTRUCTURE	Monopole	1293690	36.764870	-80.741309	195
196 SENIOR RD	Apex Towers	SST	1295211	36.742920	-80.799439	195
229 OLD PIPERS GAP RD	Towercom VI, LLC	Pole	1297458	36.582246	-80.741017	195
607 SUGAR SHACK RD	Apex Towers	SST	1302021	36.629913	-81.079515	195
9732 POPLAR CAMP RD	Unknown	Guyed	N/A	36.844592	-80.847274	312
320 CARDINAL CIR	Apex Towers	SST	1301873	36.715960	-80.529482	150
8891 DANVILLE PIKE	Apex Towers	SST	1317397	36.720267	-80.603607	300
1311 DUGSPUR RD	Apex Towers	SST	1300678	36.825926	-80.586076	199

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Site ID / Address	Owner / Description	Structure Type	ASR #	Latitude (WGS84)	Longitude WGS84	Structure Height (ft AGL)
179 VALLEY ST	SWITZER,EMILEE	Monopole	N/A	36.675191	-80.918413	60
13785 FANCY GAP HWY	Unknown	Monopole	N/A	36.589614	-80.671132	80



Appendix B - Critical Buildings Requiring Coverage

For the Critical Buildings listed in Table B.1, indoor testing must be performed, as part of the Coverage Acceptance Test Plan, inside the listed buildings in accordance with the requirements outlined in Section 6.11 of this document. For some buildings, required rooms/areas of the buildings are identified in the “Required Rooms/Areas” column of the table. In those rooms/areas, the required levels of coverage must be demonstrated as part of the testing (i.e., these areas cannot fail coverage testing), as these are locations where people may congregate in the emergency situations.

Table B.1 - Critical Buildings Requiring Coverage

Buildings Requiring RF Coverage			
Critical Building	Street Address	Type of Structure	Required Rooms/Areas
Twin County Regional Healthcare	200 Hospital Drive Galax, VA 24333	Healthcare / Hospital	To be provided as addendum
Waddell Nursing Home	202 W. Stuart Drive Galax, VA 24333	Nursing Home	To be provided as addendum
Galax Health And Rehab	836 Glendale Drive Galax, VA 24333	Healthcare / Hospital	To be provided as addendum
City Of Galax Head Start	105 Rosenwald Felts Drive Galax, VA 24333	School	To be provided as addendum
Galax Vocational Building	204 Maroon Tide Drive Galax, VA 24333	School	To be provided as addendum
Galax Middle School	202 Maroon Tide Drive Galax, VA 24333	School	To be provided as addendum
Galax High School	200 Maroon Tide Drive Galax, VA 24333	School	To be provided as addendum
Galax Elementary School	300 Mcarthur Street Galax, VA 24333	School	To be provided as addendum
Crossroads Institute (Wcc)	1117 E. Stuart Drive Galax, VA 24333	Community / Conference Center	To be provided as addendum
Albany Industries	626 Creekview Drive Galax, VA 24333	Business	To be provided as addendum
Boss Lumber	47 Poplar Knob Road Galax, VA 24333	Business	To be provided as addendum
Consolidated Glass	110 Jack Guynn Drive Galax, VA 24333	Business	To be provided as addendum
Vaughan-Bassett Furniture	400 Railroad Avenue Galax, VA 24333	Business	To be provided as addendum
Walmart	1140 E. Stuart Drive Galax, VA 24333	Business	To be provided as addendum
Carroll County Middle School	1036 N. Main Street Hillsville, VA 24343	School	To be provided as addendum
Carroll County Complex	601 Pine Street Hillsville, VA 24343	Government	To be provided as addendum

Buildings Requiring RF Coverage			
Critical Building	Street Address	Type of Structure	Required Rooms/Areas
Carroll County High School	100 Cavs Lane Hillsville, VA 24343	School	To be provided as addendum
St Paul School	231 Flower Gap Road Cana, VA 24317	School	To be provided as addendum
Carroll County Child Care Ctr	564 Industrial Park Drive Hillsville, VA 24343	Child Care	To be provided as addendum
Island Creek Mennonite Church	894 Island Creek Drive Hillsville, VA 24343	Church	To be provided as addendum
Lambsburg Community Center	130 Learning Lane Lambsburg, VA 24351	Community / Conference Center	To be provided as addendum
Hillsville Elementary School	90 Patriot Lane Hillsville, VA 24343	School	To be provided as addendum
Oakland Elementary School	4930 Pipers Gap Road Galax, VA 24333	School	To be provided as addendum
Laurel Elementary School	26 Pleasant View Road Austinville, VA 24312	School	To be provided as addendum
Gladesboro Elementary School	7845 Snake Creek Road Hillsville, VA 24343	School	To be provided as addendum
Fancy Gap Elementary School	63 Winding Ridge Road Fancy Gap, VA 24328	School	To be provided as addendum
Carroll County Education Ctr Apartments	787 Woodlawn Road Woodlawn, VA 24381	Housing	To be provided as addendum
Laurel Meadows Nursing Home	16600 Danville Pike Laurel Fork, VA 24352	Nursing Home	To be provided as addendum
Lowes Hardware	8417 Carrollton Pike Galax, VA 24333	Business	To be provided as addendum
Fries Middle School	130 E. Main Street Fries, VA 24330	School	To be provided as addendum
Independence Middle School	100 Blue Devil Drive Independence, VA 24348	School	To be provided as addendum
Grayson County High School	110 Blue Devil Drive Independence, VA 24348	School	To be provided as addendum
Vocational School	112 Blue Devil Drive Independence, VA 24348	School	To be provided as addendum
Independence Elementary School	915 E. Main Street Independence, VA 24348	School	To be provided as addendum
Grayson County Administration/Court	129 Davis Street Independence, VA 24348	Government	To be provided as addendum
Grayson Health And Rehab	400 S. Independence Avenue Independence, VA 24348	Healthcare / Hospital	To be provided as addendum
Oak Hill Academy	65 Academy Circle Mouth Of Wilson, VA 24363	School	To be provided as addendum
Providence Elementary School	56 Bainbridge Road Fries, VA 24330	School	To be provided as addendum
Fairview Elementary School	2323 Fairview Road Galax, VA 24333	School	To be provided as addendum

Buildings Requiring RF Coverage			
Critical Building	Street Address	Type of Structure	Required Rooms/Areas
Flatridge Elem School	8496 Flatridge Road Troutdale, VA 24378	School	To be provided as addendum
Old Baywood School	247 Grammar Lane Galax, VA 24333	School	To be provided as addendum
Oak Hill Academy	116 Hash Lane Mouth Of Wilson, VA 24363	School	To be provided as addendum
Mount Rogers Combined School	11337 Highlands Parkway Whitetop, VA 24292	School	To be provided as addendum
Elk Creek Elementary School	57 School Lane Elk Creek, VA 24326	School	To be provided as addendum
Grayson Highlands School	6459 Troutdale Highway Troutdale, VA 24378	School	To be provided as addendum
Oak Hill Academy - Turner Gymnasium	65 Warrior Road Mouth Of Wilson, VA 24363	School	To be provided as addendum
Oak Hill Academy English Academic Building	65 Warrior Road Mouth Of Wilson, VA 24363	School	To be provided as addendum
Oak Hill Academy	75 Warrior Road Mouth Of Wilson, VA 24363	School	To be provided as addendum
Whitetop Community Center	51 Fire House Road Whitetop, VA 24292	Community / Conference Center	To be provided as addendum

Appendix C - Existing VHF Coverage Maps

The coverage maps in this appendix show the existing VHF LMR coverage for Carol County, Grayson County, and the City of Galax. The coverage layers depict mobile, on-street portable, and in-building portable radio talk-out and talk-in coverage.

The coverage maps use the following colors to model coverage:

- Green - areas where users should be able to communicate using their portable radios when inside light-density and/or residential buildings (13 dB of simulated building loss).
- Yellow - areas where users should be able to communicate using their portable radios on the street (on-street portable coverage should also exist in all green areas)
- Purple - areas where users should be able to communicate using their mobile radios (mobile coverage should also exist in all green and yellow areas)

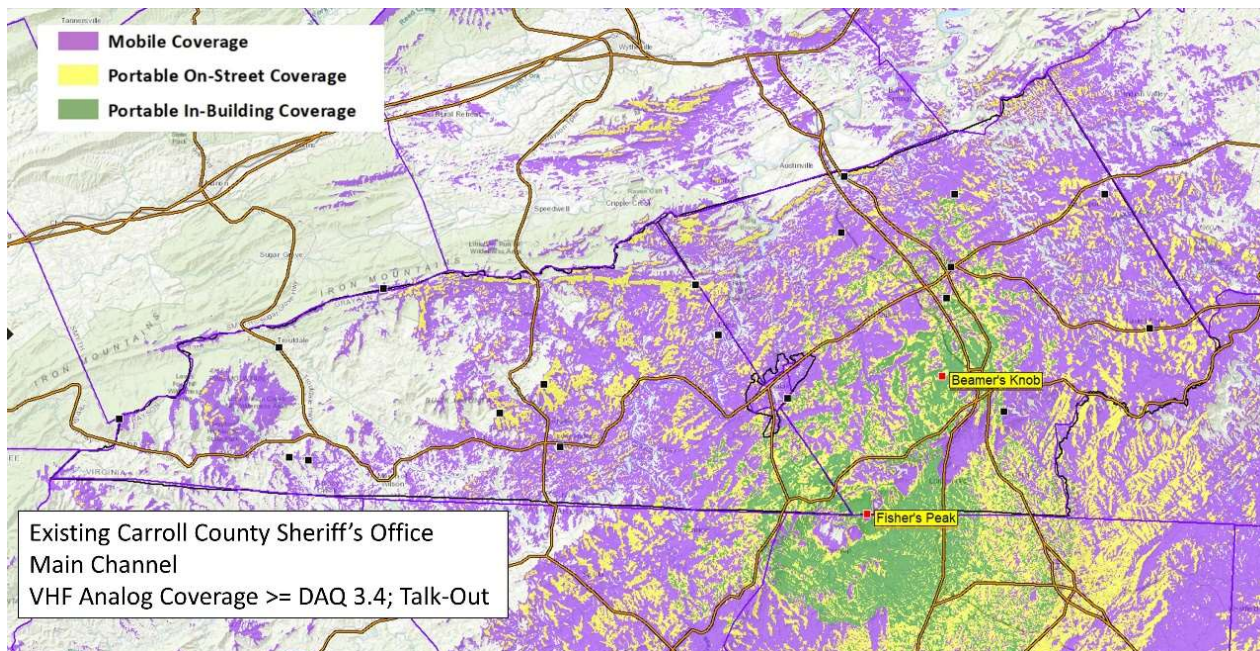


Figure C-1: Existing Carroll County Sheriff's Office Coverage – Analog VHF Composite Talk-Out

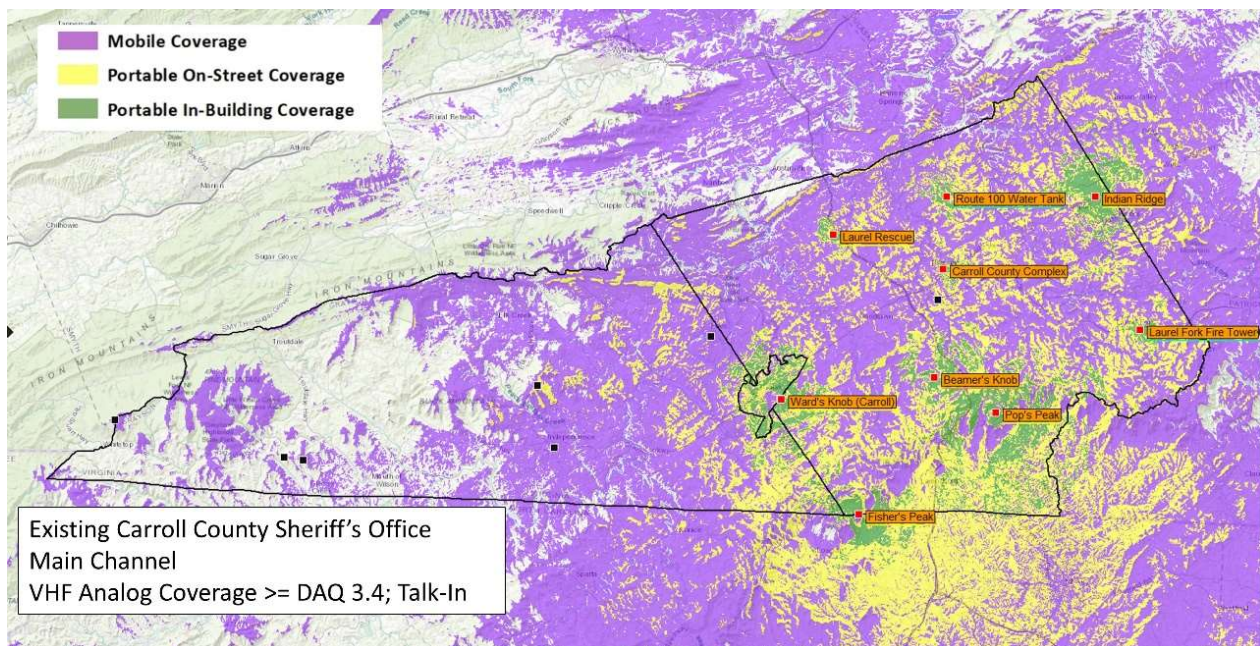


Figure C-2: Existing Carroll County Sheriff's Office Coverage – Analog VHF Composite Talk-In

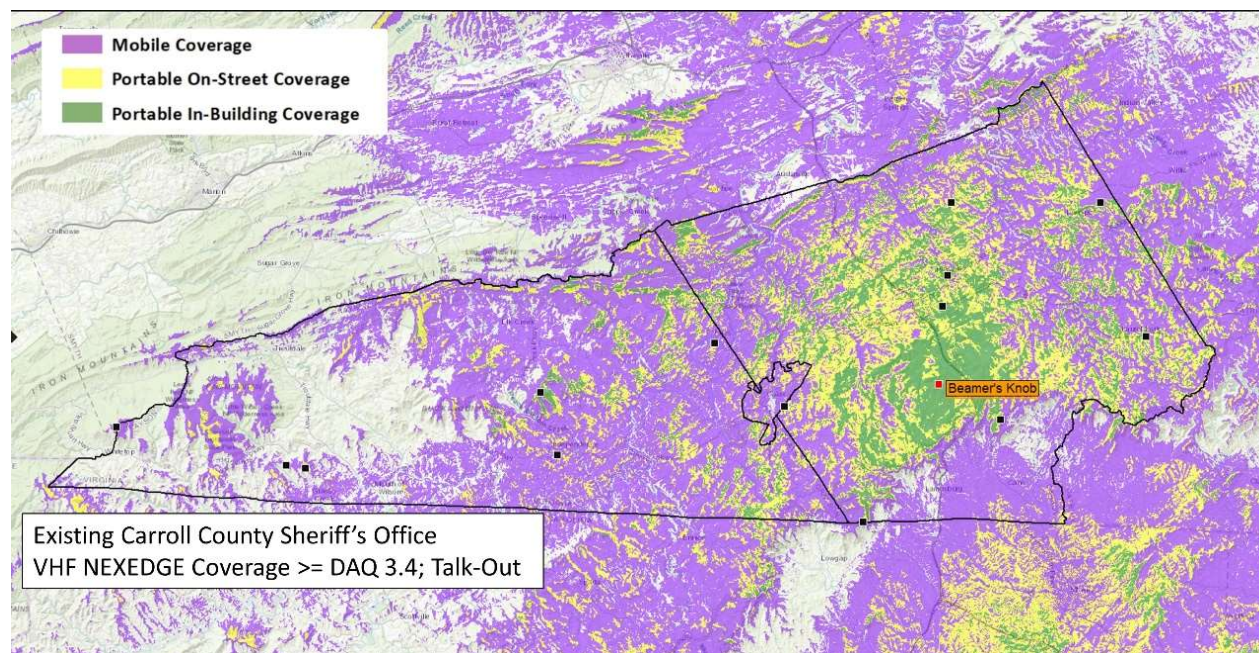


Figure C-3: Existing Carroll County Sheriff's Office Coverage – NEXEDGE VHF Talk-Out

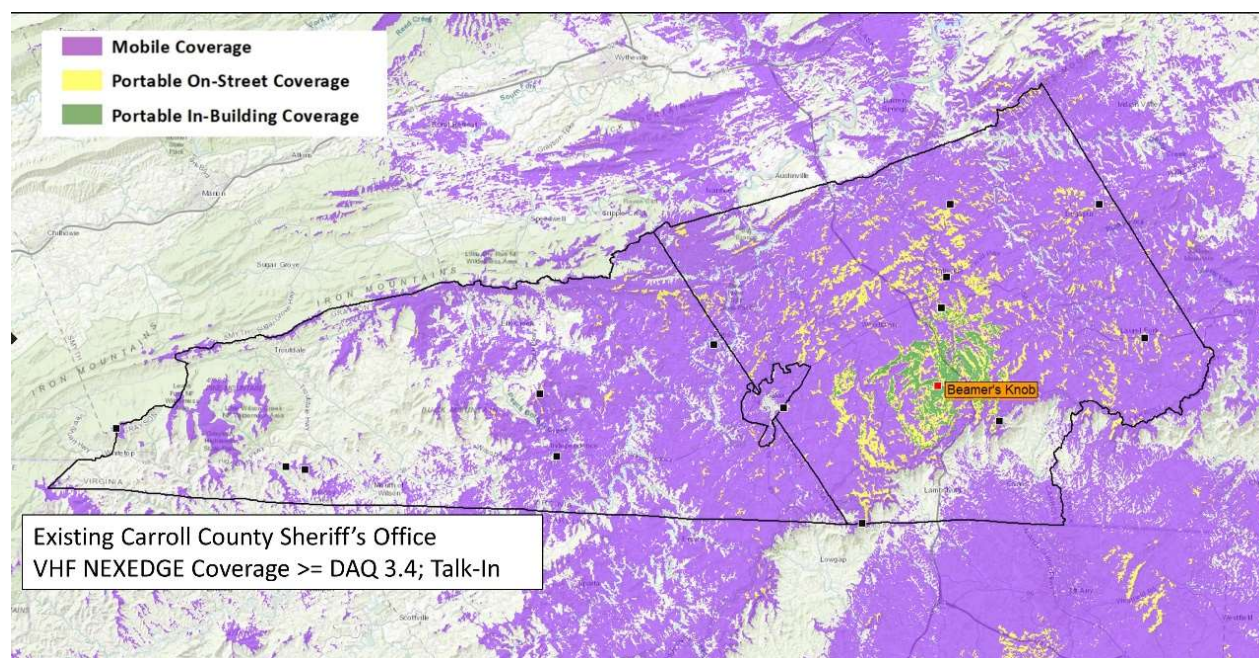


Figure C-4: Existing Carroll County Sheriff's Office Coverage – NEXEDGE VHF Talk-In

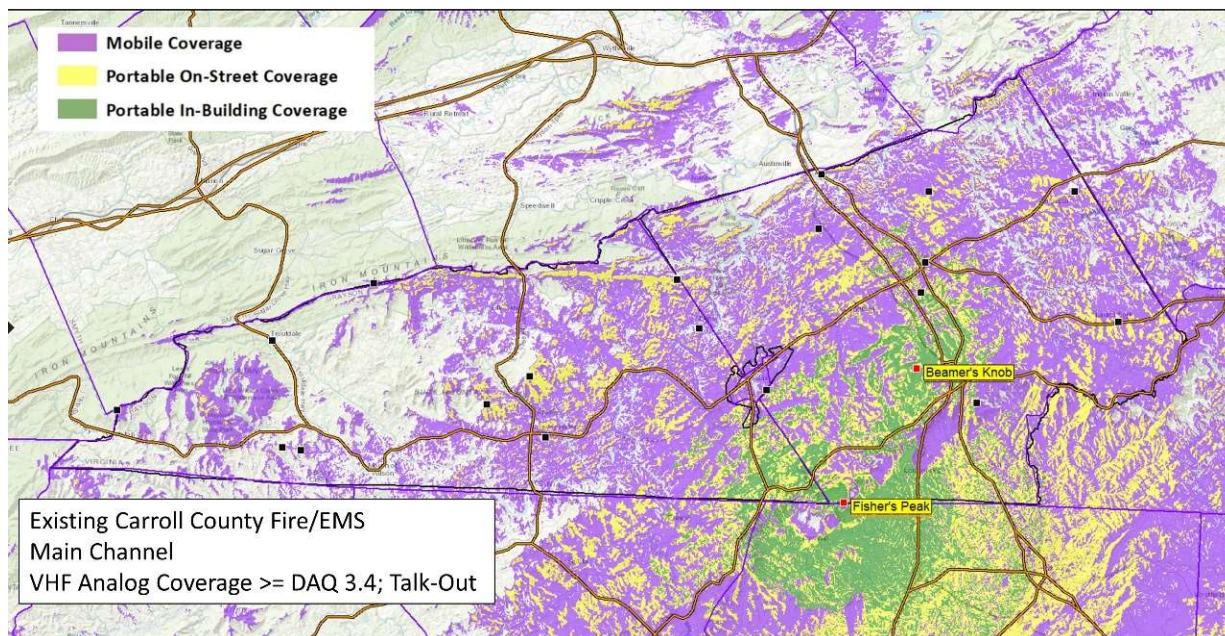


Figure C-5: Existing Carroll County Fire/EMS Coverage – Analog VHF Composite Talk-Out

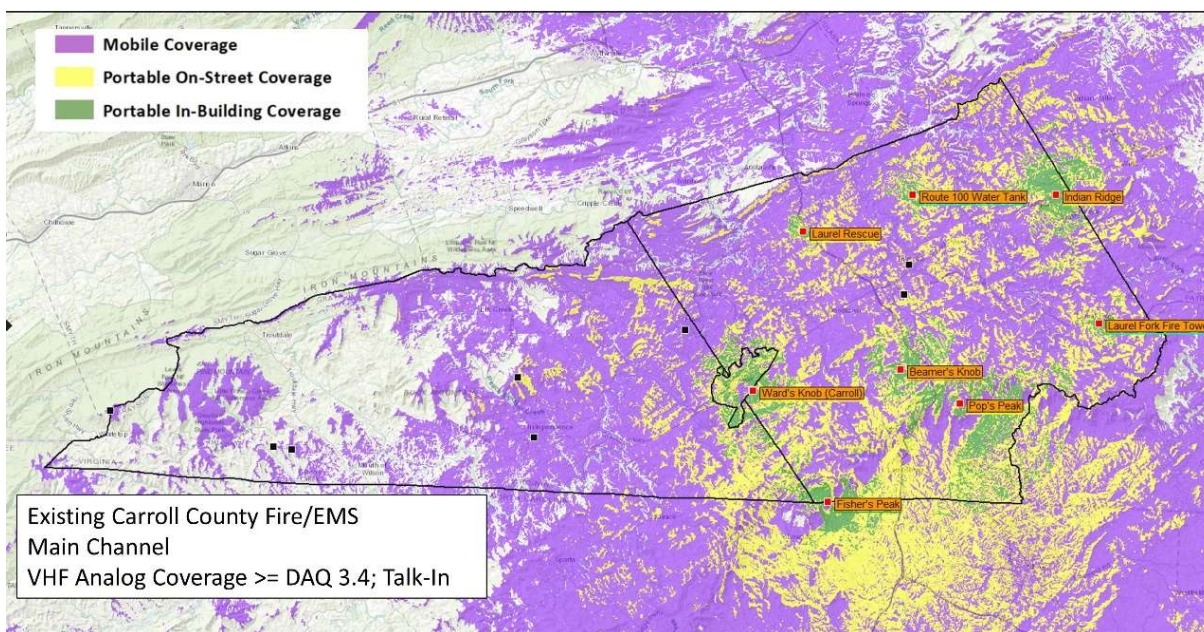


Figure C-6: Existing Carroll County Fire/EMS Coverage – Analog VHF Composite Talk-In

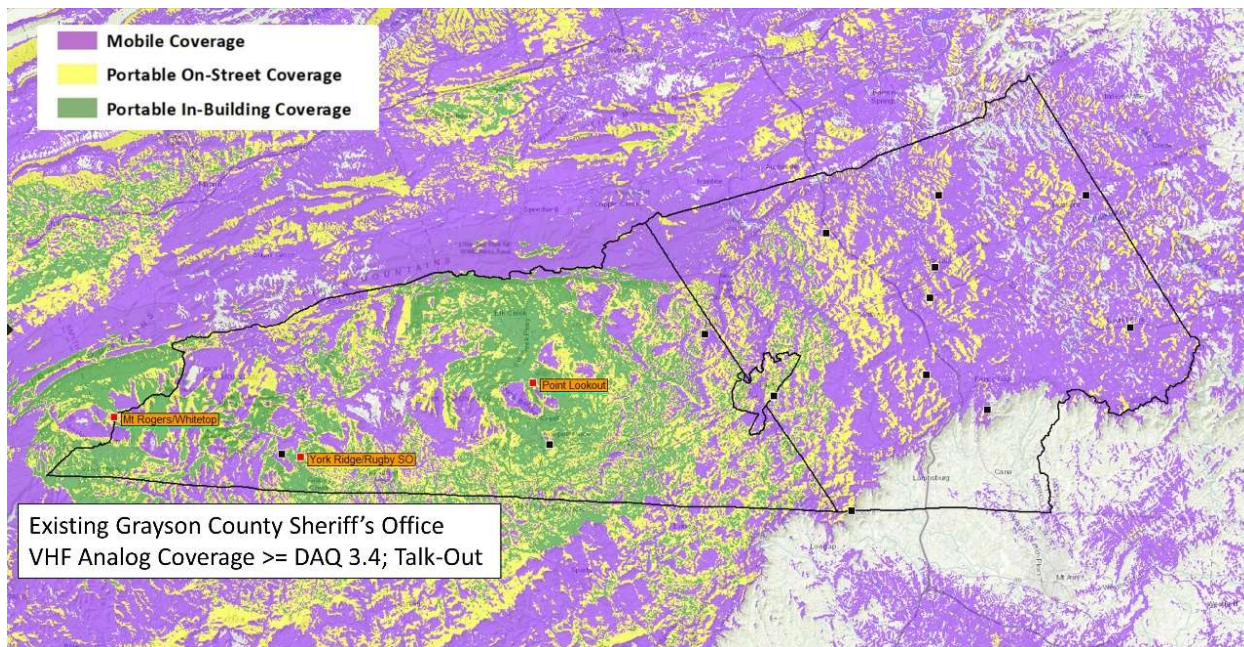


Figure C-7: Existing Grayson County Sheriff's Office Coverage – Analog VHF Composite Talk-Out

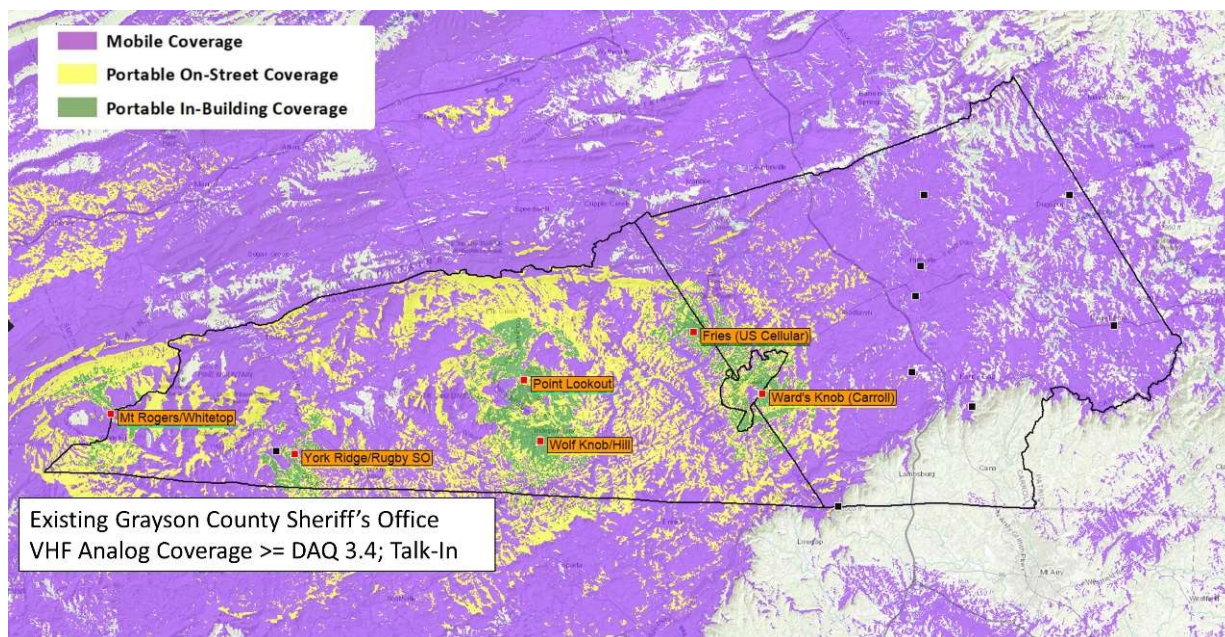


Figure C-8: Existing Grayson County Sheriff's Office Coverage – Analog VHF Composite Talk-In

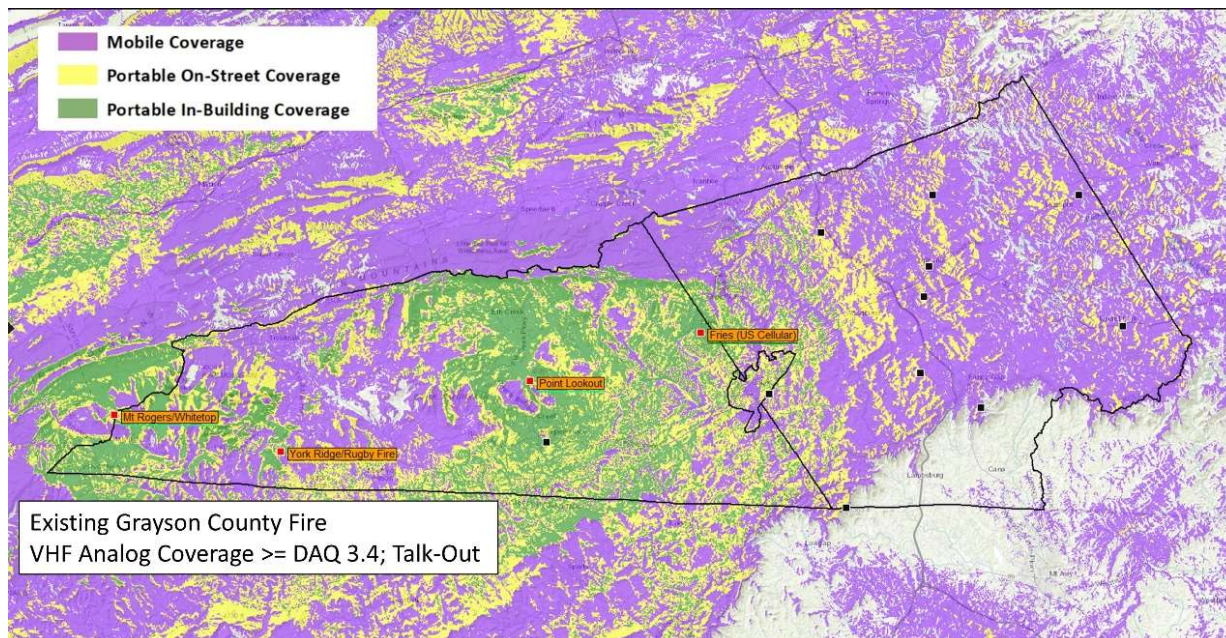


Figure C-9: Existing Grayson County Fire/EMS Coverage – Analog VHF Composite Talk-Out

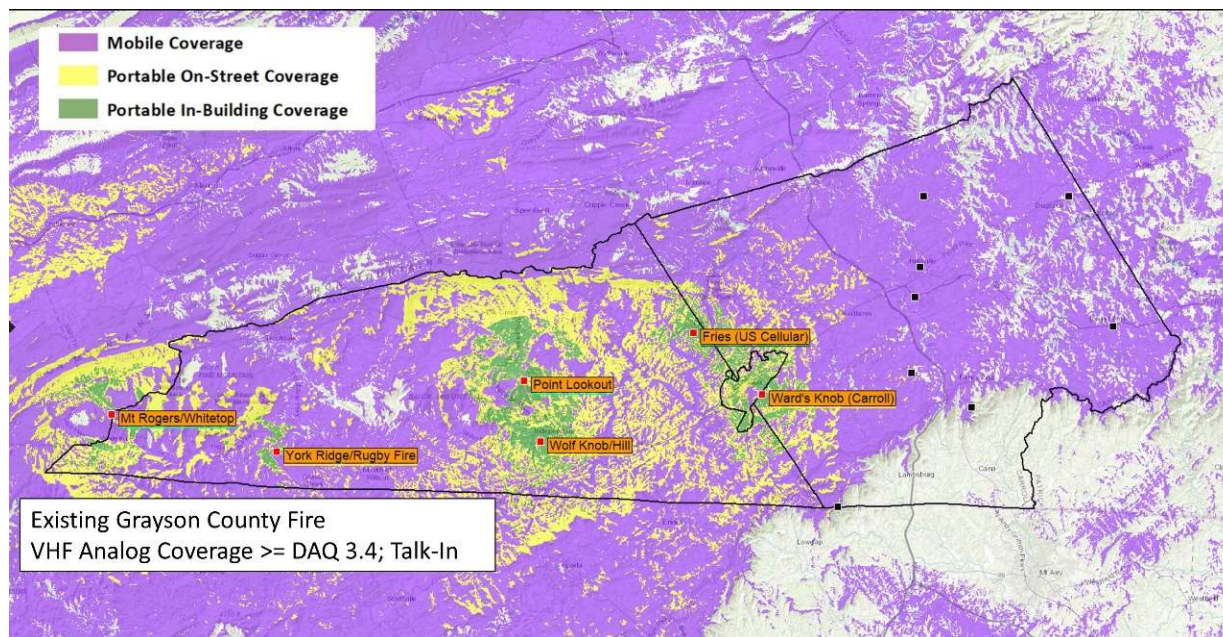


Figure C-10: Existing Grayson County Fire/EMS Coverage – Analog VHF Composite Talk-In

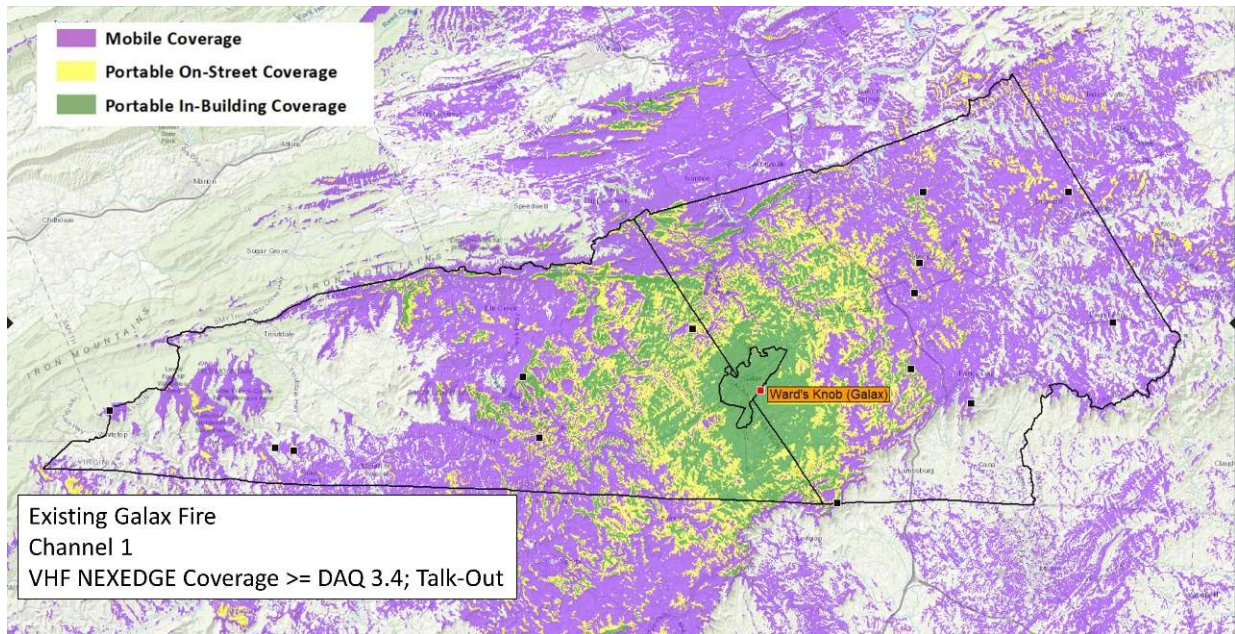


Figure C-11: Existing Galax Fire Coverage – NEXEDGE VHF Talk-Out

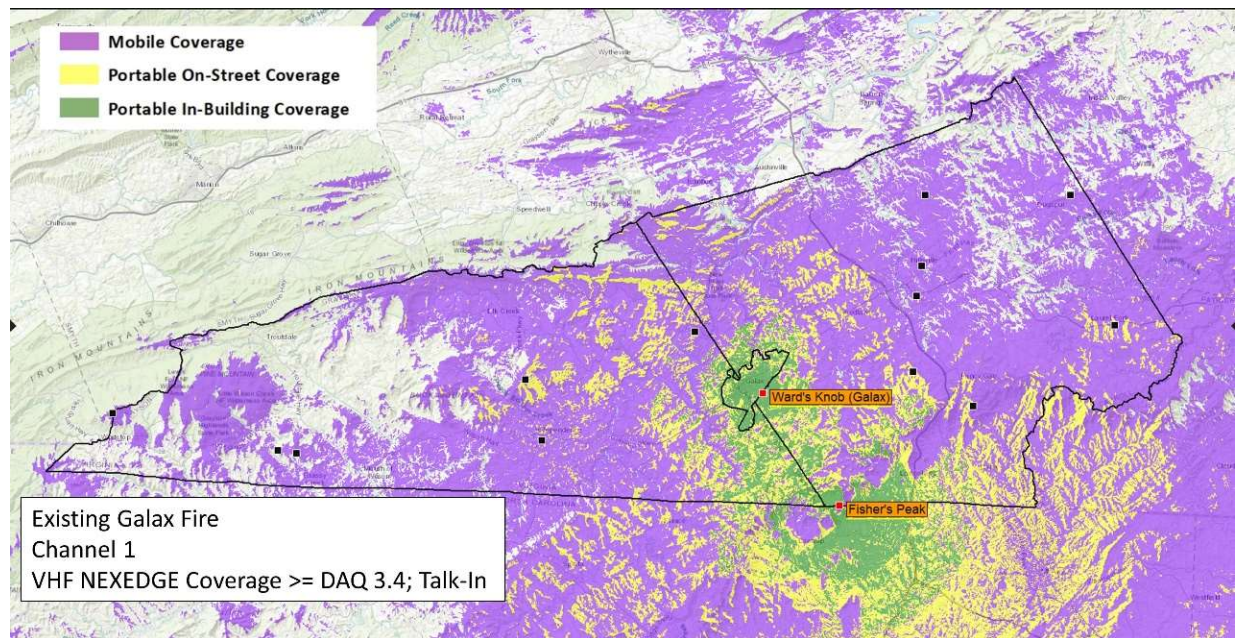


Figure C-12: Existing Galax Fire Coverage – NEXEDGE VHF Composite Talk-In

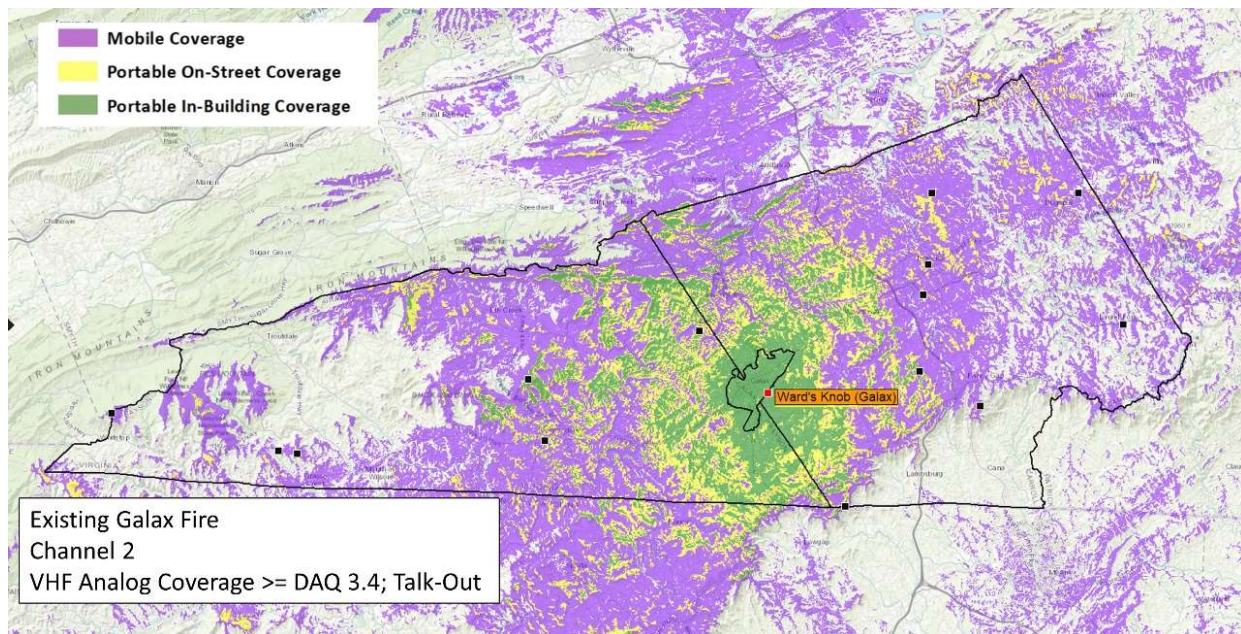


Figure C-13: Existing Galax Fire Coverage – Analog VHF Talk-Out

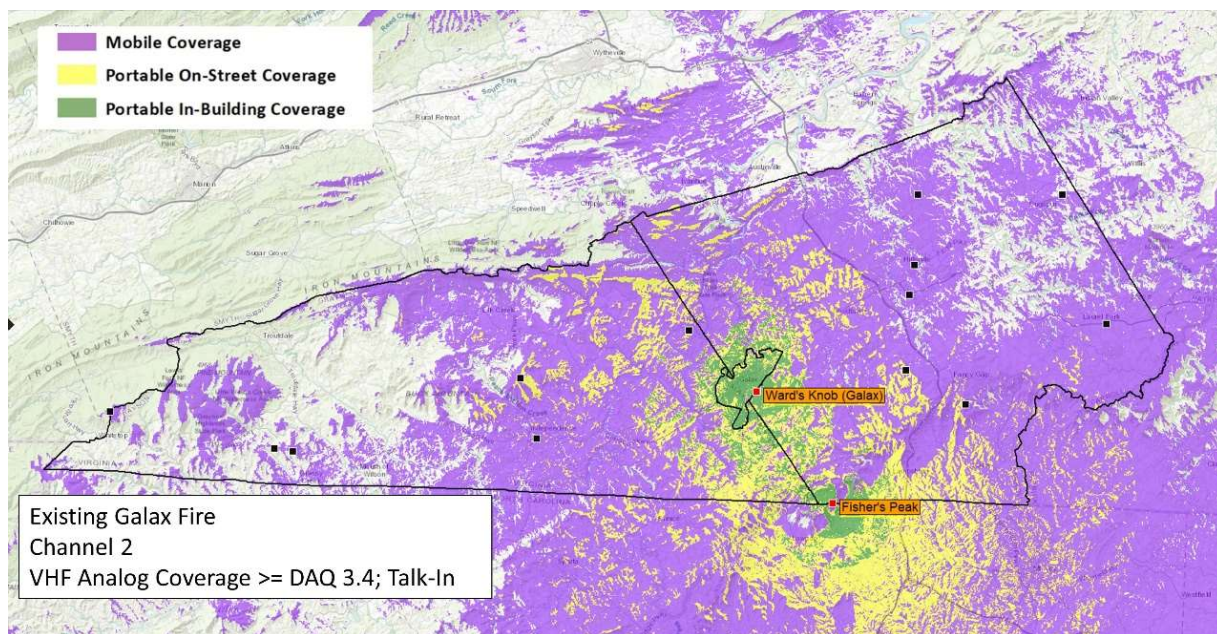


Figure C-14: Existing Galax Fire Coverage – Analog VHF Composite Talk-In

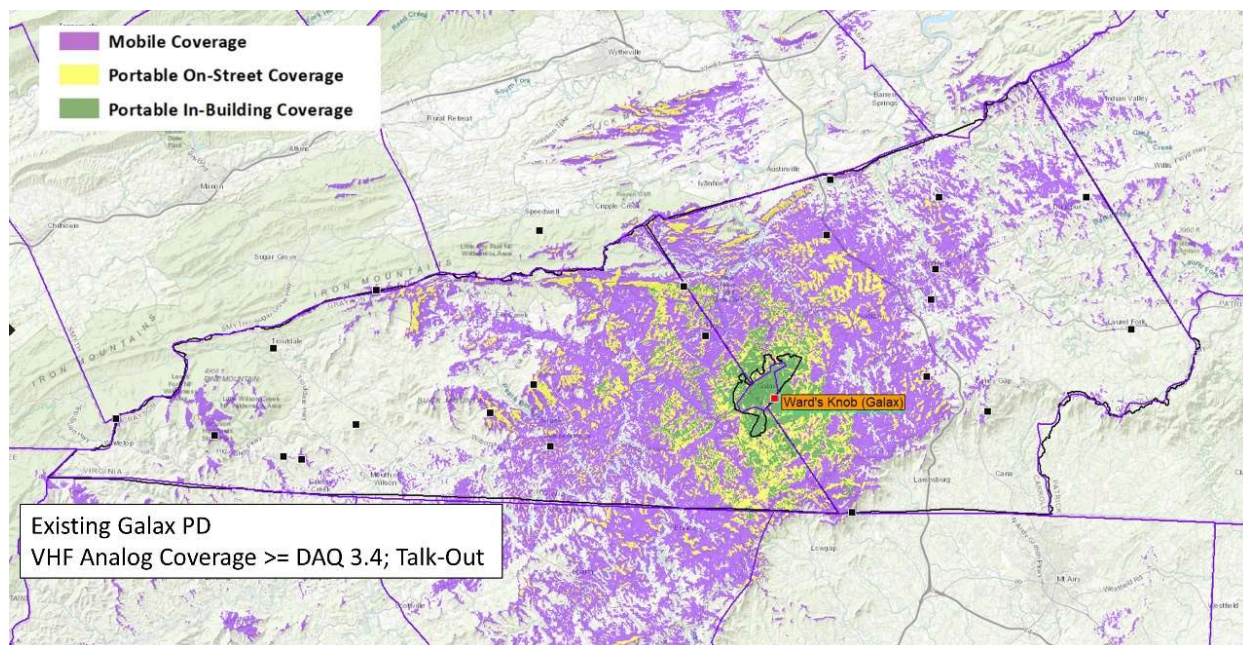


Figure C-15: Existing Galax PD Coverage – Analog VHF Talk-Out

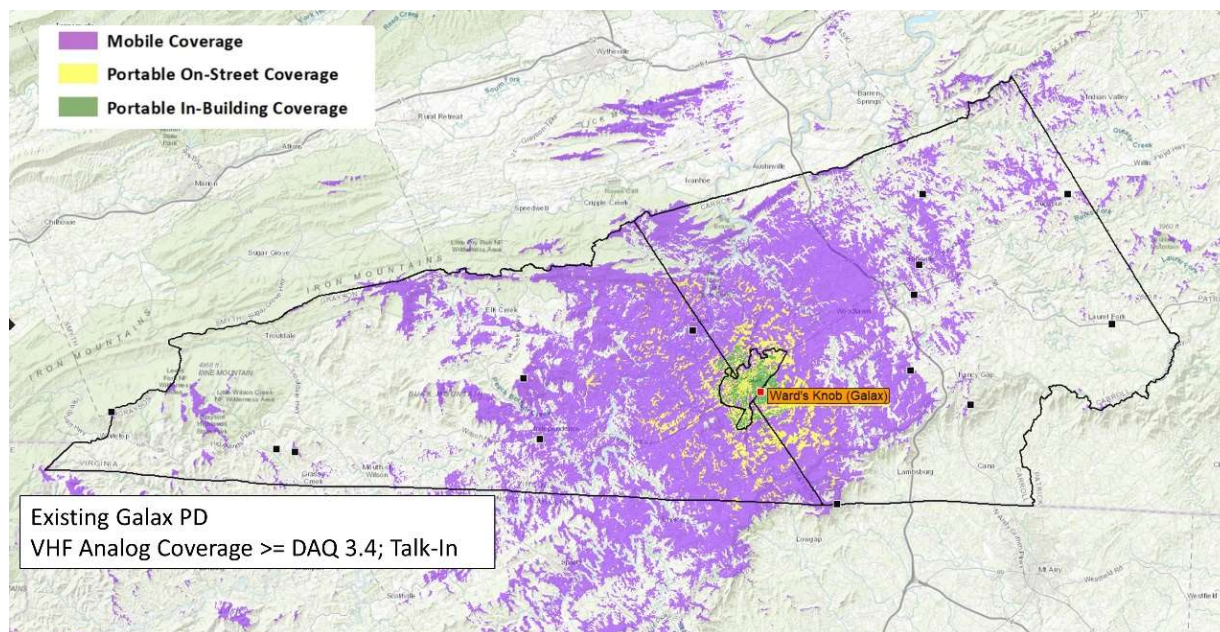


Figure C-16: Existing Galax PD Coverage – Analog VHF Talk-In

Appendix D - Existing Dispatch Centers and Consoles

Table D.1 - Existing Dispatch Centers

Name / Location	Address	Number of Consoles	Console Manufacturer
City of Galax Police Department Dispatch Center	353 N. Main Street, Galax, VA 24333	4	Avtec
Carroll County Sheriff's Office (CCSO) Dispatch Center	605 Pine Street, Hillsville, VA 24343	3	Telex
Grayson County Sheriff's Office (GCSO) Dispatch Center	304 Davis Street, Independence, VA 24348	2	Moducom

Appendix E - Commercial Fiber Assets

The Commission will provide Information on commercial fiber assets as an official addendum to the RFP.