

## SECTION 27 53 19

### DISTRIBUTED ANTENNA SYSTEM

#### Part 1 - GENERAL

##### 1.01 SUMMARY

- A. This Section includes technical and performance requirements for an In-building Wireless System (IWS) based upon active amplification and Distributed Antenna System (DAS) architecture to support Public Safety Radio Enhancement / Emergency Responder ("Public Safety1, "First Responder") Radio Coverage.
- B. The Contractor shall provide all system design, project management, coordination with the Owner Entities.
- C. The Contractor shall provide a turnkey Public Safety Radio Distributed Antenna System (DAS) including bidirectional amplifier, donor antenna, and distributed coverage antennas throughout the building to be in full compliance with both the International Fire Code (IFC) Section 510, National Fire Protection Association (NFPA) Section 1221, local Authority Having Jurisdiction (AHJ) requirements.
- D. This scope shall include all pathways and penetrations necessary for installation, including provisions for a roof penetration and weather head to provide a pathway to the donor antenna on the roof. Where existing support can be provided the Owner will have final approval of acceptable use.
- E. The Contractor shall coordinate required permits, submittals and approvals of the AHJ.
- F. This Contractor shall NOT be required to improve the existing Public Safety Communication System(s) outside of the building. Coverage within the building shall be contingent upon existing coverage levels at the exterior of the building.

##### 1.02 REFERENCE

- A. It is the Contractor's responsibility to ensure that the DAS system equipment complies with all codes, ordinances, and requirements established by the local AHJ.
- B. The equipment shall meet or exceed all current Electronics Industries Association (EIA) and Federal Communications Commission (FCC) standards and regulations applicable to the class of equipment proposed.
- C. Installation practices shall meet all building Owner requirements.
- D. The availability of existing dark fiber exists between MDF and IDF closets that may serve to support the DAS system.

##### 1.03 CODES AND STANDARDS

- A. In addition to requirements shown or specified, comply with applicable provisions of the following for design, materials, fabrication, and installation of component parts:
  - 1. FCC Rules and Regulations (47 CFR) Report and Order 87 112
  - 2. FCC Rules and Regulations 47 CFR Part 90.219

3. OSHA, Occupational Safety and Health Administration Recommendations
4. ANSI/TIA 603C, Land Mobile FM or PM -Communications Equipment -Measurement and
5. ANSI/TIA-222-G-1, Structural Standards for Steel Antenna Towers and Antenna Supporting
6. EIA/ECA-310E, Cabinets, Racks, Panels and Associated Equipment
7. TIA-329-C, Minimum Standards for Communication Antennas, Part 1: Base Station
8. ANSI/TIA-569 Telecommunications Pathways and Spaces
9. BOCA, Building Officials & Code Administrators, National Building Code
10. NFPA 78 Lightning Protection Code, National Fire Protection Association.
11. IBC, International Building Code
12. IFC Chapter 5 Section 510 Emergency Responder Radio Coverage, International Fire Code
13. NEC, National Electric Code.
14. ASTM, American Society for Testing Materials
15. NEMA, National Electrical Manufacturers Association
16. NESC, National Electrical Safety Code (ANSI C2)
17. MIL-STD, MIL-STD-810 Shock, Vibration and Environmental Standards

#### 1.04 ABBREVIATIONS AND ACRONYMS

##### A. The following abbreviations apply:

1. ACG: Automatic Gain Control
2. AHJ: Authority Having Jurisdiction
3. ATP: Acceptance Test Plan
4. BDA: Bi-Direction Amplifier
5. BOM: Bill-of-Material
6. BTS: Base Transceiver Station
7. CFR: Code of Federal Regulations
8. EBS: Educational Broadband Service
9. ESMR: Enhanced Specialized Mobile Radio
10. FCC: Federal Communications Commission

11. FHU: Fiber Head Unit
12. FRU: Fiber Remote Unit
13. IBC: International Building Code
14. IDF: Intermediate Distribution Frame
15. IFC: International Fire Code
16. MDF: Main Distribution Frame
17. MTBF: Mean Time Between Failure
18. NFPA: National Fire Protection Association
19. PIM: Passive Intermodulation
20. PSN: Public Safety Network
21. RSL: Received Signal Level
22. SNIR: Signal-to-Noise Interference Ratio
23. SOW: Statement of Work
24. UPS: Uninterruptable Power Supply
25. WSP: Wireless Service Provider
26. VSWR: Voltage Standing Wave Ratio

#### 1.01 SYSTEM DESCRIPTION

- B. The in-building wireless system, herein referred to as 'System' shall be a distributed antenna system. The System shall reliably distribute RF signals and wireless services throughout the specified frequency ranges and throughout the specified coverage spaces.
- C. The System shall be implemented based on proven state-of-the-art technology that can seamlessly integrate with the rapid evolution of wireless technologies and business applications.
- D. All active elements shall be located in telecom or equipment rooms to simplify maintenance and increase security. Locating active elements in or above ceilings is not acceptable. Locations for active equipment shall be approved by the Engineer.
- E. Radiating coax or "leaky" coax systems are not acceptable.

#### 1.02 SUBMITTALS

- F. Preconstruction Submittal Requirements – Provide the following:
  1. Technical data sheets for all equipment including amplifiers, cabling, connectors, splitters, antennas, etc.

2. Evidence that the proposed solution is approved by the Authority Having Jurisdiction (AHJ) and meets or exceeds all local requirements prior to any work being done.
  3. Certificate(s) from the manufacturers of the proposed system stating that the vendor has the necessary training and qualifications to install the equipment.
  4. Specific detail(s)/shop drawings of any roof penetrations.
  5. Detail drawings for the mounting and installation of donor antenna, distributed antennas, bidirectional amplifier, and all ancillary equipment.
  6. Coordinate co-location and interconnection with fire alarm control panel (FACP), annunciator, and remote annunciator locations.
  7. Electronic floor plan drawings indicating the locations of equipment and cabling pathways between them.
  8. Schematic diagram showing the complete system connectivity. This must be specific to the project and installation indicating operational details, and locations of devices as depicted on floor plan drawings.
- G. Close-out Submittals – Provide the following:
1. Submit the operation and maintenance manuals for any and all components of the DAS system in hard copy format in front & spline labeled three ring binders (two copies required), as well as in electronic PDF Format on USB jump drives.
  2. Submit a record of Owner's equipment programming options setup.
  3. Submit as-built drawings indicating a final, updated copy of all previously submitted documents reflecting the final, as-built representation, equipment used, and details.
    - a. Include donor antenna, grounding and lightning protection details.
    - b. Include cable routing, splitter, couplers, and coverage antenna final locations.
    - c. Include active component locations, layout, configuration, and programmed parameters
  4. Submit Test Reports:
    - a. Submit sweep-testing results for all cable runs.
    - b. Submit evidence of compliance with the requirements of the governing authorities, and, where applicable, copies of Certificates of Inspection.
  5. Submit Manufacturer's Equipment Warranty detail.
    - a. Splitters, Couplers and Antennas:
    - b. Coaxial Cable and Connectors:
    - c. Active Components:
  6. Contractor Warranty: Contractor shall warrant the system installation work as installed for 1-year from date of system acceptance.

## 1.05 CONTRACTOR QUALIFICATIONS

- A. The Contractor shall be a manufacturer authorized reseller of the proposed BDA devices.
- B. The Contractor shall have a minimum of five (5) years of experience in In-Building Systems executing work of similar scope and complexity.
- C. The Contractor shall provide a minimum of three (3) projects as references to similar size and scope.
- D. The DAS designer and installation team shall hold license and the certifications as listed below.
  - 1. Certification of in-building system training issued by a nationally recognized organization, school.
  - 2. A valid FCC-issued general radio operators license.
  - 3. Certificate issued by the manufacturer of the equipment being installed.

## 1.06 PERFORMANCE REQUIREMENTS

- A. In-building coverage improvements shall be provided that enhances the P25 RF communication system indoor coverage.
- B. Coverage shall be acceptable when the above requirements are met and measured in 95% of all areas on each floor and 99% in critical areas as defined in NFPA 72.
  - 1. Minimum signal strength receivable within the building is to be measured at no less than -95 dBm in acceptable locations.
  - 2. Minimum signal strength receivable by the public safety radio system when transmitted from within the building is to be measured at no less than -95 dBm in acceptable locations.
- C. On a per-channel basis, the Delivered Audio Quality (DAQ) of 3.0 with a 90% reliability factor for emergency personnel using radio communication in buildings and structures shall be guaranteed by Contractor.
- D. DAQ test shall be performed as per the NFPA requirement in a grid pattern. On a per-channel basis, the downlink and uplink RSL for each frequency shall meet or exceed the criteria.
- E. Prior to installation, the Contractor shall confirm the channel count, loading, and frequencies used in the service area, and shall guarantee coverage for these channels per the criteria.
- F. The DAS shall be capable of modifications and upgrades, without the need to replace the proposed hardware or software, to allow for changes and additions to system frequencies within the deployed frequency band in order to maintain radio system coverage as originally designed.
- G. The DAS shall provide alarming capabilities and be integrated into building alarm systems.
- H. The DAS shall have network access to allow remote monitoring and access.

- I. The DAS system shall be equipped to provide independent power backup unit sized to handle the system operation at full capacity for a minimum of twelve (12) hours.
- J. The Contractor shall explain the method used to avoid downlink and uplink interference.

**Part 2 - MATERIALS**

**2.01 MANUFACTURERS**

- A. Contractor shall propose all equipment in a complete system solution and all equipment shall meet or exceed requirement of IFC, NFPA, and local AHJ standards.
- B. Components utilized in the installation of the public safety radio enhancement system, such as repeaters, transmitters, receivers, signal boosters, cabling, and fiber-distributed antenna systems, shall be approved and shall be compatible with the public safety radio system.
- C. All system equipment shall provide a minimum full coverage warranty period of 1 year from the date of acceptance.

**2.02 COMPONENTS**

**A. Bi-Directional Amplifier (BDA):**

**1. Characteristics:**

- a. Gain: 45-90 dB as required by the design, with the ability to provide programmable attenuation at lower values
- b. Channelized 700/800 MHz operation
- c. Capable of battery backup operation
- d. Dry Contact Alarming
- e. Maximum Output Power: + 32 dBm
- f. Maximum Noise Figure: 8 dB
- g. Minimum -50 dB 3rd order intermodulation rejection
- h. Operating Temperature Range: -20 °C to +50 °C
- i. Mounting Options: Shall be capable of wall mounting in a NEMA Type 4 or 4X enclosure as required by the design.
- j. FCC: Shall be FCC type certified.

**B. Donor Antennas:**

**1. Electrical:**

- a. VSWR  $\leq$  1.5:1
- b. Maximum input power: 100 watts
- c. Front-to-back ratio:  $\geq$  15 dB
- d. Polarization: Vertical

- e. Impedance: 50  $\Omega$
  - f. Azimuth Pattern: As proposed by the manufacturer to meet the performance specifications
2. Mechanical:
- a. Connector: 50  $\Omega$  N Type
  - b. Mounting: Pole or wall
3. Environmental:
- a. Lighting protection: Direct ground or manufacturer provided
  - b. Minimum wind rating (w/o ice): 100 mph
- C. Distributed Antennas
1. Electrical:
- a. Frequency Bands Supported: 698 - 2700 MHz
  - b. VSWR:  $\leq 2.1:1$
  - c. Impedance: 50  $\Omega$
  - d. Beamwidth, Horizontal: 360° omnidirectional
  - e. Polarization: Vertical
  - f. PIM rated
2. Mechanical:
- a. Mounting: Through-hole ceiling mount
  - b. Pigtail cable: Plenum rated
3. Environmental:
- a. Operating Temperature: 40°F to 140°F
  - b. Relative Humidity: Up to 100%
- D. Cabling Systems
- Air Dielectric, Plenum Rated Cable:
1. Material Characteristics:
- a. Jacket: Halogenated, Fire-Retardant, Plenum rated Outer Conductor
  - b. Material: Corrugated Aluminum or Corrugated Copper Inner
  - c. Conductor Material: Copper-Clad Aluminum Wire

2. Electrical Characteristics:
  - a. Impedance:  $50 \pm 2.0 \Omega$
  - b. Frequency Bands Supported: 698-2700 MHz

3. Mechanical Characteristics:
  - a. Diameter Over Jacket:  $\leq .627$  in
  - b. Minimum Bending Radius:  $\leq 5$  in

Foam Dielectric Cable:

1. Material Characteristics:
  - c. Jacket: Non-halogenated, Fire-Retardant Polyolefin
  - d. Outer Conductor Material: Corrugated Copper
  - e. Inner Conductor Material: Copper-Clad Aluminum Wire or Copper Tube
4. Electrical Characteristics:
  - a. Impedance:  $50 \pm 1.0 \Omega$
  - b. Frequency Band: 1/2" Nominal: 698-2700 MHz
5. Mechanical Characteristics:
  - a. Diameter Over Jacket: 1/2" Nominal:  $\leq .630$  in, 7/8" Nominal:  $\leq 1.1$  in
  - b. Minimum Bending Radius: 1/2" Nominal:  $\leq 5$  in, 7/8" Nominal:  $\leq 10$  in
  - c. One Time Minimum Bending Radius: 1/2" Nominal:  $\leq 2$  in, 7/8" Nominal:  $\leq 5$  in

E. Ancillary Components

1. Splitters, combiners, couplers, taps, connectors, jumpers

2.03 SECONDARY POWER

- A. The system shall be provided with an approved secondary source of power. This secondary power supply shall be capable of operating the system for a period of at least 12 hours. When primary power is lost, the power supply to this system shall automatically transfer to the secondary power supply.

2.04 SYSTEM MONITORING

- A. Active devices shall provide monitoring outputs to the Fire Alarm System that trigger a signal in the event of any issue that would inhibit the system from meeting the operational requirements, including the following scenarios:
  1. Loss of primary power
  2. Donor antenna malfunction
  3. Distributed antenna malfunctions



4. Signal failure

**Part 3 - EXECUTION**

3.01 PRE-INSTALLATION

- A. The Contractor, prior to beginning the on-site installation, is required to submit, for approval by the Owner, the following information:
1. Shop Drawings: After receiving acceptance from the Owner and/or authorized representative for the materials and equipment list, and before ordering, purchasing, fabricating, or installing any materials or equipment, the Contractor shall submit schematic design drawings of the systems to demonstrate compliance with the construction documents.
  2. Functional system block diagrams showing single line interconnection of all integrated systems and the major components of each system and methods of integration.
  3. System theory of operations, that clearly defines the operating parameters of all systems being supplied.
  4. Acceptance Test Plan (ATP) shall be submitted to and approved by the Owner. The ATP shall include Isolation Testing for all BDAs.
  5. Detailed Statement of Work that includes a project schedule.
  6. Evidence that the proposed solution is approved by the Authority Having Jurisdiction (AHJ) and meets or exceeds all local requirements.

3.02 COORDINATION

- A. Contractor shall field coordinate the installation of all DAS equipment with other trades – particularly the Electrical Contractor and Structured Cabling Contractor – to ensure that each device location is provided with the necessary infrastructure.
- B. Contractor shall coordinate installation work with Owner.

3.03 INSTALLATION

- A. The Contractor shall be responsible for following all manufacturer's instructions and recommendations with respect to the system design, installation, commissioning, and testing.
- B. Installation shall include the delivery, unloading, setting in place, fastening to walls, floors, ceiling, or other structures and where required, penetration fire-stop, interconnecting wiring of the system components, equipment alignment and adjustments, and all other work whether or not expressly required herein which is necessary to result in complete operational DAS.
- C. All installation practices shall be in accordance with, but not limited to, these specifications. Installation shall be performed in accordance with the applicable standards, requirements and recommendations of National, State, and Local Authorities having jurisdiction. All distributed antenna cables shall be installed such that the cables are as straight as possible.
- D. During the installation, and up to the date of final acceptance, the Contractor shall be under obligation to protect his finished and unfinished work against damage and loss. In the event of such damage or loss, he shall replace or repair such work at no cost to the Owner.

- E. All cabling shall be concealed from view with the exception of cabling running in communication closets (IDF and MDF spaces), and/or Mechanical and/or Electrical rooms or mezzanines.
- F. Cables shall be properly supported with dedicated hangers or brackets. Cable trays may be used only if they are dedicated divided low voltage trays and only with approval from the owner. E. Fastenings and supports shall be adequate to support their loads with a safety factor of at least three.
- G. All boxes, equipment, etc. shall be secured plumb, level and square.
- H. In the installation of equipment and cable, consideration shall be given to operational efficiency and overall aesthetic factors. Antennas shall be centered and in-line with other ceiling mounted devices.
- I. All cables the Contractor installs shall be handled in accordance with the manufacturer's guidelines. Transmission line cables have minimum bending radius specifications that shall be followed. In the event a cable is kinked or bent excessively during installation, that section of cable cannot be used, even if subsequently straightened. The damaged area of the cable shall be removed, and a new section installed using correct splice methods. Ultimately, the cable shall pass the testing and meet the manufacturers requirements.
- J. Radio communications cabling shall not be grouped with electrical cabling. It can only share sleeves and raceways with other low voltage data and communications cables.
- K. Connection between cables and other antenna components shall use 4.3-Type premium connectors. No splicing is permitted.
- L. All power dividers shall be securely mounted in place either by bolting the mount to a solid surface or securing each by suspension on the cables within 4 inches of each connector termination at the power divider. The transmission lines connecting to the device shall be routed in the shortest possible path.

#### 3.04 GROUNDING

- A. In order to minimize problems resulting from improper grounding, and to achieve maximum signal-to-noise ratios, the following grounding procedures shall be adhered to:
  - 1. System ground: a single primary "system ground" shall be established for the system. All grounding conductors in that area shall connect to this primary system ground. The system ground shall consist of a copper bar of sufficient size to accommodate all secondary ground conductors.
  - 2. A copper conductor, having a maximum of 0.1 ohms total resistance, shall connect the primary system ground bar to the primary system active components.
  - 3. Under no conditions shall the ac neutral conductor, either in the power panel or in receptacle outlets, be used for a DAS component ground.
- B. Because of the great number of possible variations in grounding systems, it shall be the responsibility of the Contractor to follow good engineering practice, as outlined above, and to deviate from these practices only when necessary to minimize crosstalk and to maximize signal-to-noise ratios and reduce interference in the radio systems.

### 3.05 INTERFERENCE ANALYSIS

- A. No amplification system capable of operating on frequencies or causing interference on frequencies assigned to the jurisdiction by the FCC shall be installed without prior coordination and approval of the authority having jurisdiction. The building manager/owner shall suspend and correct other equipment installations that degrade the performance of the public safety radio system or public safety radio enhancement system.
- B. The Contractor shall cooperate to resolve reports of interference to or from collocated equipment where the following criteria are met:
  - 1. The interference shall be reported within one year following final system acceptance.
  - 2. The collocated equipment shall have been licensed, installed, and operational prior to the start of on-site installation.
  - 3. The collocated equipment shall be operating within the bounds of its license, FCC regulations, and published equipment specifications.
- C. The Contractor shall resolve any interference that meets the above criteria at no cost to the Owner. This may require furnishing and installing additional filtering or other equipment, but is not intended to include research and development of new equipment.
- D. Isolation testing shall be performed to ensure the DAS does not interfere with the PSN network. Isolation shall be maintained between the donor antenna and all inside antennas and shall be a minimum of 15 dB above the signal booster gain under all operating conditions.

### 3.06 ACCEPTANCE TESTING

- A. Acceptance testing shall be performed conforming to the requirements of this Section by a Certified Technician.
- B. Testing shall meet all requirements in IFC 510, NFPA 72, and other applicable codes.
- C. The Contractor shall complete the acceptance testing as prescribed in the approved Acceptance Test Plan (ATP) submittal. Testing shall be witnessed by the AHJ or their representative.
- D. Prior to start of testing, provide a list to Consultant of test equipment make, model numbers and calibration dates that will be used.
- E. Interference performance is the measure of the effects of the DAS on other co-located equipment, and of other equipment on the DAS. The Contractor shall complete interference performance testing to verify the DAS does not interfere with the co-located equipment and the co-located equipment does not interfere with the DAS.
- F. Each floor of the building shall be divided into a grid of approximately twenty (20) equal areas. Each area shall be tested for two-way audio communications and RSSI. An area shall be considered to have failed if DAQ in one or more directions (talk-in or talk-out) is below 3.0, or if the RSSI is below -95 dBm. A maximum of two (2) nonadjacent areas shall be permitted to fail the test on each floor. In the event that three (3) of the areas fail the test, and to provide greater statistical accuracy, the floor may be divided into forty (40) equal areas. In such an event, a maximum of four (4) nonadjacent areas shall be permitted to fail the test.

- G. Transmissions originating from the DAS shall be received by the PSN with a minimum Receive Signal Strength of -95 dBm.
- H. The Contractor may be required to coordinate this testing with entities other than the AHJ.

### 3.07 TRAINING

- A. Contractor is required to provide comprehensive training covering system design and equipment operations in a single process.
  - 1. Equipment operations and failure indications shall be provided to the Owner.
  - 2. Alarm logging systems operational training shall be provided to the Owner.
  - 3. Equipment layout and location detail shall be reviewed with the Owner.
- B. Training shall be coordinated with Owner's schedule, and Contractor personnel who provide training are subject to Owner's approval.

### 3.08 PROJECT ACCEPTANCE

- A. System shall be considered complete when all of the following has occurred:
  - 1. Testing has been completed to the satisfaction of Owner and Consultant.
  - 2. Punch-listed items have been addressed to the satisfaction of Owner.
  - 3. As-built drawings and system documentation has been turned over to Owner and Consultant.
  - 4. Complete operational training has been conducted with Owner's staff.
  - 5. System Commissioning Process has been completed.
  - 6. The AHJ has tested the signal strength throughout the building and provided a Certificate of Approval.
- B. Upon completion the Contractor shall secure written Acceptance of systems in the form of authorized Owner signature on Acceptance Document. This shall constitute the date of Acceptance.

**END OF SECTION**