Distributed Antenna Systems (DAS)
Competency requirements

This competency listing is an identification of individual topics in which Distributed Antenna Systems (DAS) technicians and installers are expected to obtain knowledge to prepare for the DAS certification examination. This includes basic knowledge concepts of distributed antenna systems and antenna installation including carrier and public safety applications. This also includes service and skills applicable to all of the functions required to safely and completely install, maintain, troubleshoot and provide support of in-building distributed antenna systems, communications and electronic equipment.

Distributed Antenna Systems technicians must be knowledgeable in the following technical areas:

1.0 Distributed Antenna Systems Fundamentals

- 1.1. Define Distributed Antenna System (DAS)
  - 1.1.1. Types of DAS including:
    - 1.1.1.1. Active
      - 1.1.1.1.1. Hybrid fiber-coax
      - 1.1.1.1.2. Actives at the edge (fiber or category cable fed)
    - 1.1.1.2. BDA (bi-directional amplifiers) fed passive
    - 1.1.1.3. Fully passive
    - 1.1.1.4. In-building
    - 1.1.1.5. Outdoor
- 1.2. Describe DAS fundamentals
  - 1.2.1. Define wireless coverage
- 1.3. Define the DAS life cycle, differentiating:
  - 1.3.1. Public safety
  - 1.3.2. Cellular carrier
- 1.4. Describe the In-building role of a DAS to include:
  - 1.4.1. Public Safety
    - 1.4.1.1. Radio Frequencies (Public Safety Spectrum – FCC)(47 CFR § 90.20 table)
      - 1.4.1.1.1. VHF Low Band (25-50 MHz = 6.3 MHz available)
      - 1.4.1.1.2. VHF High Band (150-174 MHz = 3.6 MHz available)
      - 1.4.1.1.3. 220 MHz Band (220-222 MHz = 0.1 MHz available)
      - 1.4.1.1.4. UHF Band (450-470 MHz = 3.7 MHz available)
      - 1.4.1.1.5. T-Band (470-512 MHz = 6-12 MHz blocks, see FCC new page)
      - 1.4.1.1.6. 700 Broadband (758-769/788-799 MHz = 22 MHz available), First Responder Network Authority (FirstNET)
      - 1.4.1.1.7. 700 Narrowband (768-775/798-805 MHz = 14 MHz available)
      - 1.4.1.1.8. NPSPAC Band (806-809/851-854 MHz = 6 MHz available), plans per 55 Reg. Planning Committees (RPCs)
      - 1.4.1.1.9. 800 MHz Band (809-815/854-860 MHz = 3.5 MHz available)
      - 1.4.1.1.10. 4.9 GHz Band (4940-4990 MHz = 50 MHz available)
      - 1.4.1.1.11. 5.9 GHz Band (5850-5925 MHz = 75 MHz available), Dedicated Short Range Comm. Service (DSRCS)
    - 1.4.1.2. Describe radio system fundamentals:
      - 1.4.1.2.1. Simplex
      - 1.4.1.2.2. Half-Duplex
      - 1.4.1.2.3. Trunked radio
  - 1.4.2. Cellular carrier
    - 1.4.2.1. List frequency bands for 3G, 4G, FirstNet, and 5G
    - 1.4.2.2. Describe modulation technologies:
      - 1.4.2.2.1. GSM including GPRS/EDGE
      - 1.4.2.2.2. CDMA including UMTS
      - 1.4.2.2.3. WCDMA including related HSPA protocols
      - 1.4.2.2.4. LTE
    - 1.4.2.3. Differentiate between SISO (single input-single output) and MIMO (multiple input-multiple output) antenna systems
- 1.5. List Federal Communications Commission (FCC) directives:
  - 1.5.1. Rules and Regulations governing DAS / Signal Booster systems

1.5.1.1. Receive written permission from FCC licensee to legally rebroadcast their frequencies in building's DAS/BDA
1.5.1.2. Legal signal (and interference) responsibility (remains with the licensee, not with the DAS owner/designer)
1.5.2. Part 90 services for public safety and private mobile
1.5.3. Roll of U.S. CFR 47 § 90.219 (Use of signal boosters)
1.5.4. Rules concerning commercial versus consumer grade cellular signal boosters

2.0 Safety

2.1. List Occupational Safety and Health Administration (OSHA) requirements for In-building DAS:
2.1.1. Personal Protection Equipment (PPE)
2.1.2. earthquake remediation
2.1.3. weather contingencies
2.2. List safety requirements of working with Radio Frequency (RF) energy:
2.2.1. maximum permissible exposure (MPE) to RF per OSHA; FCC OET Bulletin 65, sup.A-KDB; and IEEE/ANSI C-95 standard (C95.1-2019)
2.3. Explain how to safely handle and dispose of fiber optic cable and optical fiber debris

3.0 Building Codes

3.1. Describe the National Fire Protection Association (NFPA) safety guidelines related to DAS
3.1.1. List the National Electrical Codes (NEC®) as they apply to In-building DAS
3.1.2. Describe the role of NFPA 72, Chapt.24 and NFPA 1221 in public safety DAS
3.1.3. Describe the International Code Council (ICC) guidelines on fire safety found in IFC-510 Emergency Responder Radio Coverage (ERRC) for public safety DAS
3.2. Describe DAS detail content from above codes for:
3.2.1. Enclosures (NEMA4, UL50E)
3.2.2. Alarms
3.2.3. Battery Backup
3.2.4. Protected cable paths
3.2.5. Coverage requirements
3.2.6. Testing
3.2.7. System/designer requirements (IFC minimum personnel requirements)
3.3. Describe where and how to find local municipality building (AHJ) codes
3.3.1. Differentiate versions of specific codes referenced and enforced by AHJs
3.4. Define codes that apply to cellular DAS installations

4.0 Radio Frequency (RF) Signal Characteristics and Requirements

4.1. Define DAS coverage needs and measurement methods:
4.1.1. Public Safety RSSI (received signal strength indicator)
4.1.2. Public Safety DAQ (delivered audio quality)
4.1.3. Cellular RSSI
4.1.4. Cellular RSCP (received signal code power)
4.1.5. Cellular RSRP (reference signals received power)
4.1.6. Cellular SINR (signal-to-interference-plus-noise ratio)
4.2. Describe RF characteristics:
4.2.1. Decibels (dB)
4.2.1.1. In reference to milliwatt(s) (dBm)
4.2.1.2. Rule of Three (3dB Rule)
4.2.2. Wavelength
4.2.3. Amplitude
4.2.4. Free space path loss (FSPL)
4.2.5. Fast Fading / Margins
4.2.6. Multipath
4.2.7. Reflection
4.2.8. Absorption
4.2.9. Diffraction
4.2.10. Scattering
4.2.11. Isolation
4.3. Describe Noise characteristics:
4.3.1. Noise floor measurements
4.3.2. Noise figure of amplifiers

4.3.3. Noise rise at donor site due to BDAs

5.0 Site Surveys

5.1. Describe donor signal measurement methods and tools:
- 5.1.1. Interference and mitigation

5.2. Explain RF characterization of indoor environments

5.3. Describe indoor macro signal measurements and concerns of:
- 5.3.1. Public Safety
- 5.3.2. Cellular

5.4. Explain equipment location best practices, clearances

5.5. Explain antenna locations best practices

5.6. Describe cable routing best practices

6.0 Equipment

6.1. Discuss DAS signal source(s):
- 6.1.1. off-air signal booster
- 6.1.2. small cell
- 6.1.3. eNodeB

6.2. Describe components in an active DAS:
- 6.2.1. DAS interference panel, attenuation tray
- 6.2.2. Head-end
- 6.2.3. Remote(s)

6.3. Describe how to evaluate schematics, wiring and diagrams:
- 6.3.1. Component access and locating
- 6.3.2. Testing of wiring and circuits
- 6.3.3. Common connection types
- 6.3.4. Low current terminations (low voltage)

6.4. Describe the different choices of off-air signal boosting used in a DAS
- 6.4.1. Repeaters / Signal Booster(s) / bi-directional amplifiers(BDAs) limited to 5 watts/channel
  - 6.4.1.1. Class A Signal Booster / Channelized BDAs
    - 6.4.1.1.1. Single channel amplification
  - 6.4.1.2. Class B Signal Booster / Non-channelized BDAs
    - 6.4.1.2.1. Broadband capable amplification

6.5. Describe equipment mounting:
- 6.5.1. Grounding and bonding (refer to the NEC®)
- 6.5.2. Access (present and future)

6.6. List installation test equipment:
- 6.6.1. Digital Multimeter (DMM)
- 6.6.2. Spectrum Analyzer
- 6.6.3. cable sweep, fault locator (sweep testing can cause interference)
- 6.6.4. continuous wave (CW) signal generator
- 6.6.5. test 2-way radios
- 6.6.6. Test for Mobile Systems or other cellular survey equipment

6.7. Describe tools used on DAS:
- 6.7.1. Common
- 6.7.2. Special Purpose

6.8. Explain why labeling is required using TIA 606B standards and labeling per drawings of:
- 6.8.1. Equipment
- 6.8.2. Racks
- 6.8.3. Bays
- 6.8.4. Mounts
- 6.8.5. Cables
  - 6.8.5.1. Coaxial
  - 6.8.5.2. Optical Fiber
  - 6.8.5.3. Twisted Pair (Cat 5e, 6, etc.)
  - 6.8.5.4. Other copper
- 6.8.6. Connectors
- 6.8.7. Splitters
- 6.8.8. Couplers
- 6.8.9. Filters and chassis per engineering drawings
- 6.8.10. Bill of Material (BOM)

- 6.8.11. Method of Procedure (MOP)
- 6.9. Explain commissioning of equipment factors:
  - 6.9.1. Power up / Green light system(s)
  - 6.9.2. Baseline measurements
    - 6.9.2.1. Antenna isolation (including single frequency testing)
    - 6.9.2.2. Donor interference on distribution
  - 6.9.3. Gain settings (AGC = automatic gain control)
  - 6.9.4. Noise power

7.0 Antennas, Transmission Lines and Connectivity

- 7.1. Describe the different antennas used in DAS
  - 7.1.1. Donor system (antenna, protectors, cabling, connectors/combiners)
  - 7.1.2. Server / Distribution
- 7.2. Describe antenna gain
- 7.3. Describe the function and use of transmission lines
  - 7.3.1. Types
    - 7.3.1.1. Coaxial cables
    - 7.3.1.2. “Leaky” coax
    - 7.3.1.3. Optical fiber
    - 7.3.1.4. Twisted Pair (Cat 5e, 6, etc.)
  - 7.3.2. Explain Bend Radius
  - 7.3.3. Explain Data grade testing
  - 7.3.4. Discuss Measurements
    - 7.3.4.1. Optical time-domain reflectometer (OTDR) for fiber
    - 7.3.4.2. Return Loss for coax
    - 7.3.4.3. Baseline recording
  - 7.3.5. Conformance testing
- 7.4. Describe the different DAS terminations/connectors for the 7.3.1 cabling types
  - 7.4.1. Explain how cable preparation, including labeling, for connectors is required
- 7.5. Explain the use of splitters, couplers, tappers, and/or hybrid combiners
  - 7.5.1. Explain insertion loss testing for correct ratios
- 7.6. Describe how harnesses/hangers can and must be used for cabling
- 7.7. Explain how connectivity must be maintained
  - 7.7.1. Describe coaxial connectivity mechanics
  - 7.7.2. Describe installation procedures, including:
    - 7.7.2.1. Proofing line performance quality
      - 7.7.2.1.1. Tamper resistance and vermin protection
      - 7.7.2.1.2. Water
    - 7.7.2.2. Explain splicing procedures

8.0 Testing and Troubleshooting

- 8.1. Explain Antenna Line Sweep Testing:
  - 8.1.1. Return loss (RL)
  - 8.1.2. Insertion loss (IL)
  - 8.1.3. Distance-to-Fault (DTF)
- 8.2. Explain Passive Intermodulation (PIM) testing
  - 8.2.1. Describe other intermodulation testing
- 8.3. Describe the need for coverage surveys and link budget calculations:
  - 8.3.1. Shadowing / Fading
  - 8.3.2. Waveguide effects
  - 8.3.3. Grid testing for public safety
  - 8.3.4. KPI (key performance indicators) testing for cellular
    - 8.3.4.1. Speeds (RSRP, RSCP, SINR, UL/DL {Uplink/Downlink})
- 8.4. Explain post installation quality assessment:
  - 8.4.1. Reconnecting power
  - 8.4.2. Resetting devices
- 8.5. Describe how to make received signal strength indicator (RSSI) calculations
  - 8.5.1. Antenna versus actual
  - 8.5.2. Each antenna (integrity testing) by:
    - 8.5.2.1. Spectrum Analyzer (Spec An, Spec A, etc.)
    - 8.5.2.2. Power meter

9.0 Documentation

9.1. Define 'As Built' documentation
9.2. Explain "Walk-Test" documentation
9.3. Describe the 'Post install checklist'
9.4. Explain Building Codes documentation
9.5. Describe permits and why they are required
9.6. Explain 'Proof labeling per drawings'

End of Distributed Antenna Systems Competencies

Find An ETA Test Site: **http://www.eta-i.org/testing.html**

Suggested Study Material and Resources:

Useful DAS courses, white papers, discussion and videos can be found at the following web sites: https://www.waveform.com/pages/public-safety-das-and-bdas-for-nfpa; www.txrx.com; https://www.waveform.com/pages/das-distributed-antenna-systems; www.birdrf.com; http://danebrockmillerconsulting.com/ (dBc, LLC); www.doverts.com (Dover Telecom); www.iwatsi.com (IWA Technical Services); https://www.dhs.gov/publication/fog-documents, www.iccsafe.org/codes-tech-support/codes/the-i-codes/; www.nfpa.org/Codes-and-Standards; www.nfpa.org/nec; https://www.pctel.com/public-safety-testing-solution/; http://motodas.com/; https://harriscommunications.com/public-safety-das; or by contacting ETA® International for other DAS resources: www.eta-i.org and 1-800-288-3824

Distributed Antenna Systems Fundamentals, 2E; Tom Dover, Dane Brockmiller, FOI, LAS, PIM, DAS CTT authors, Ken Law, illustrator and Jay Thompson, editor; ISBN 978-1940429-98-4; Dover Telecommunications, Inc; 2015; pp. 135; Kindle Ed on Amazon.com (2017); also on www.doverts.com or call 800-360-1425

Wiring for Wireless Sites; Ira Wiesenfeld, P.E.; ISBN 978-1401810375; Thompson Delmar Learning; 2002; pp. 260

Practical Antenna Handbook, 5E; Joseph Carr & George (Bud) W. Hippisley; ISBN 978-0071639583; McGraw-Hill/Tab Electronics; 2011; pp.784

Modern Electronic Communication, 9E; Jeff Beasley & Gary M. Miller; ISBN 978-0132251136; Prentice Hall; 2007; pp.992

Handbook of Radio & Wireless Technology; Sam Gibilisco; ISBN 978-0070230248; McGraw-Hill Professional; 1998; pp.640

Basic Radio, Principles & Technology; Ian Poole; ISBN 978-0750626323; Newnes; 1994; pp.224

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