



CONNECTICUT LAND MOBILE RADIO NETWORK

Technical Advisory Bulletin

SUBJECT:***INTERIM EMERGENCY RESPONDER RADIO
COVERAGE ENHANCEMENT***

DISCUSSION:

The Connecticut Land Mobile Radio Network (CLMRN) is primarily a 7/800 Mhz, digital/TDMA based system. The system is designed and tested to provide certain levels of coverage. Despite prudent design, there are occasions where additional in building coverage is either desired or required. In-building systems require careful design, on-going maintenance, annual testing, and a means of alarming should the system be impaired.

While the Bi-Directional Amplifiers (BDA), Distributed Antennas Systems (DAS), or Signal Boosters that make up in-building radio systems can effectively enhance coverage, they also have the potential to negatively affect both in-building and overall radio network coverage if not properly designed, installed, and maintained. Furthermore, without proper BDA/DAS records management, locating in-building systems that interfere with the network can be very challenging. Further challenging the installation of the BDA/DAS/SB may be the requirement to support both CLMRN and locally used systems, both with potentially different engineering parameters.

The purpose of this document is to serve as a reference guide to outline how in-building BDA and DAS Systems shall be designed and deployed to provide emergency responders radio coverage in buildings for locations served by CLMRN. The contents of these documents are made available to relevant organizations to facilitate the process of implementing and operating BDAs and DAS that will provide the required radio services and not adversely affect the mission critical radio network that CLMRN or locally used systems provide the State of Connecticut and local jurisdiction.

REFERENCE:

2022 Connecticut Fire Safety Code

Section 510, International Fire Code[®], Emergency Responder Radio Coverage

NFPA 1225

Washington, DC Office of Unified Communications, OUC's Public Safety In-Building Radio System Requirements¹

APPLICABILITY:

Emergency responder radio coverage shall be provided in all new buildings.

Buildings shall have approved radio coverage for public safety officials within the building based on levels sufficient to provide communications as noted in this document. This shall not require improvement of the existing CLMRN network.

¹ <https://ouc.dc.gov/page/oucs-public-safety-building-radio-systems-requirements>

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Exceptions:

The Connecticut amended model code references all new and existing buildings other than r-3, undergoing an addition, alteration, renovation, or change of use that do not have two-way radio coverage that may be required by the Authority Having Jurisdiction (AHJ).

- A) Where approved by the building official and the fire code official, a wired communication system in accordance with Section 907.2.13.2 shall be permitted to be installed or maintained instead of an approved radio coverage system.
- B) Where it is determined by the fire code official that the radio coverage system is not needed.
- C) In facilities where emergency responder radio coverage is required and such systems, components or equipment required could have a negative impact on the normal operations of that facility, the fire code official shall have the authority to accept an automatically activated emergency responder radio coverage systems.

Buildings and structures that cannot support the required level of radio coverage shall be equipped with a system that could include bi-directional amplifier(s) or other distributed antenna systems to achieve the required level of radio coverage.

RF emitting devices and cabling used in the installation of the BDA system shall be approved by the Connecticut Telecommunications System (CTS) Unit of the Division of Statewide Emergency Telecommunications (DSET), Department of Emergency Services and Public Protection. The only acceptable system shall be a "Class A" device.² All RF emitting devices shall have the certification of the FCC and be suitable for public safety use prior to installation.

The system, including any emitting devices, antennas, etc. must, at a minimum, be suitable for use from at least 769-862 Mhz and may require other bands as well.

The system must provide protection to and from adjacent Commercial wireless operations, unless such operations are specifically part of the design of the system.

WAIVER:

Buildings that have sufficient levels of radio coverage to satisfy the requirements may request a waiver by submitting survey evidence that sufficient levels of radio coverage are present. Coverage will be verified by the AHJ with CTS Engineers/and or designee.

Waivers are valid for 5 years, or a change in building construction, and must be renewed.

At any time it is determined by the AHJ or CTS that radio coverage is not adequate, the waiver will be revoked.

² See Appendix A

BUILDING OWNERS/REPRESENTATIVES RESPONSIBILITY:

The owner of the building is responsible for:

- Fund the procurement of the repeater system and ancillary components and its installation.
- Equipment and system performances shall meet CTS requirements.
- Contract with a qualified vendor to perform the acceptance testing when implementation complete
- Schedule with a qualified vendor and CTS the acceptance testing itself
- Provide required documentation according the CTS requirements
- Provide the contact information for the building manager and a 24x7 emergency contact no later than acceptance testing time. The building manager will receive from CTS the authorization to transmit on CLMRN licensed frequencies. Local authorization from a designated local AHJ will also be provided by the local AHJ.
- Contract a vendor to maintain the equipment
- Provide advance notice to CTS of any equipment or parameter changes;
- Contract one a qualified vendor to perform annual testing
- Share the testing results with CTS. If CTS identifies any issues you shall make necessary adjustments within one (1) week of the date of the notification from CTS;
- If at any time, if the BDA/DAS system causes degradation to CLMRN or local systems, immediately shut down the system and provide CTS with plans to remedy the issue within 24 hours.
- Fund additional testing and any troubleshooting and repairs costs if necessary
- Fix deficient equipment or configurations until meeting requirements.

Also, please note that:

A number of buildings are built to be occupied by offices or for commercial use. It might take a few months, sometimes years to rent all floors out. Meanwhile, some of the building interiors might not be completed when coming to perform a Public safety DAS test (floors without interior walls, no ceilings, etc.)

In that case the building is not complete i.e. the whole building still needs to be tested. The testing staff shall note which floors are not physically complete.

The transmission authorization letter sent by the CTS will specifically include which floors were complete when testing occurred and which floors were not. The letter will also explain that when significant modification will be made to the building affecting radio waves propagation and/or levels of interference, the building owner shall perform again a public safety BDA/DAS test at their cost using a qualified vendor. A non-exhaustive list of modifications affecting radio propagation includes:

- adding interior/exterior walls, ceiling, partitions,
- extending the Distributed Antennas System
- implementing additional wireless systems (internal systems or cellular systems for instance)

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The extent of the test will depend on the modifications made to the building. It will be determined on a per case basis.

PLAN APPROVAL:

The process to approve an Enhanced In-Building Coverage Enhancement System is multifaceted and requires several steps.

Entities looking to install such a System are encouraged to contact the CTS Unit at p25@ct.gov as soon as practical to obtain information on the frequencies required, general distance and heading to the closest appropriate CLMRN site, and site Effective Radiated Power (ERP). The address/location of the building must be supplied.

Prior to the installation of an enhanced In-Building Coverage Enhancement System, an application for the installation of an engineered system must be submitted for review to p25@ct.gov.

A non-exhaustive list of the information required includes:

- The name of the building and its address
- The room number the BDA and DAS Head-end equipment are located in
- The name of the personnel designing the system and a copy of professional certifications
- The name of the personnel installing/integrating the BDA and DAS and the corresponding vendor certifications, the vendors being those whose equipment are deployed
- A softcopy, in PDF format, of the floor plans indicating:
 - the location of the donor antennas
 - the name of the donor site
 - the location of the distributed antennas
 - the location of the headend and room number
 - the location of remote units as applicable
 - the cable path
 - a ruler that will allow to scale the plan
- A layout of the DAS architecture (riser diagram)
- A Bill of Materials (BDA, cables, surge arrestor, connectors, splitters, antennas) along with their technical specifications
- If the building is already existing (not a building in construction), the radio signal strength indicator measurements (RSSI – in dbm) that demonstrate that an in-building radio system is necessary
- All submitted plans and drawings will clearly show in-building client antennas with accurate antenna labels.
- The link budgets and technical information listed in here: including
 - The CLMRN uplink evaluation spreadsheet found on the DSET/CTS web page
 - The calculations showing that the battery back-up selected solution configuration meets the Code requirements
- Coverage plots for all floors of the building (not only those where antennas are installed)

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- If other radio systems DAS are present, intermodulation studies or demonstration that the bandpass filters will protect the public safety DAS from adjacent cellular carriers
- Manufacturer's data sheets on all equipment to be installed
- Detailed proposed test plan

Upon submission of the required information, a project number will be assigned.

Any field changes that occur during construction shall be incorporated into new As-Built plans, including any manufacturer's data sheets for any equipment changes not submitted in the original submittal. Any changes as the result of construction shall be submitted for approval.

EQUIPMENT REQUIREMENTS:

The in-building radio system shall use a channelized BDA. The BDA shall be certified Class A³ by the FCC. The system must also be compatible and fully operational with both P25 Phase 1 and P25 phase 2 for all CLMRN and required local channels. The BDA shall also provide a squelch capability for uplink. NOTE: Some of those BDAs meet the requirements only when the relevant features are configured appropriately, so the vendor will ensure that if required that these features are configured and will document the relevant configuration in as built documentation. More than one BDA maybe coupled to support ALL CLMRN and locally required frequencies.

PERFORMANCE REQUIREMENTS:

Link budgets shall assume the use of a 3W portable for buildings and for the areas a vehicle can access (tunnels, garage) shall support both portables and 35 W mobile devices. Talk-out link budgets shall assume the radio at hip level and talk-in at hip level. Talk-out link budget and Talk-in link budgets shall be balanced.

The minimum downlink coverage requirement is -95 dBm. Additionally, the building shall be considered to have acceptable emergency responder radio coverage when signal strength measurements in 95 percent of all areas on each floor of the building, and 99% of critical areas such as emergency and standby power rooms, elevator lobbies, areas of refuge, exit stairs and exit passage ways and elevator machine rooms, achieve the Delivered Audio Quality (DAQ) score of 3.0 (or 3.4 if adopted for the community of installation) for voice quality for Talk-Out. For Talk-In, the required level is a minimum of -95 dBm or 18 dB above the noise floor, whichever is more stringent.

BDA systems should target a signal received at the host site receiver equal to the noise floor plus 18 dB when transmitted from the edge of the cell (lowest received signal in the targeted area).

A significant risk is presented by BDA sites transmitting signals received at CLMRN host sites at overly high levels. All BDA transmissions must be limited to be received at CLMRN sites below -55 dBm. Appropriate adjustments to the design to accommodate the adjusted gain values are the responsibility of the vendor and shall be documented in any as-built documentation.

³ See Appendix A

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The signal level received at the input of the BDA and transmitted by the user device (portable or mobile) shall be at least 5dB below the max operating power of the BDA and at least 10 dB lower than the max damaging threshold of the BDA in particular when transmitted in close proximity of a DAS antenna (“hot signal” or “Near Test”).

The same applies to Fiber DAS Head-end if used.

Host site ERP will be provided by CTS during the review process. The vendor shall use those values to make a first estimate of the required BDA gains or attenuation. Link budgets shall be detailed and show losses for each DAS antenna, donor antenna, coupler, splitter, cable, as well as the gains of active components, both in the uplink (talk-in) and the downlink (talk-out). The link budgets shall be detailed enough that CTS Engineering can check that the signals at the inputs of the BDA and if applicable the DAS fiber Head-end and remote units are within the equipment vendor(s) specifications both on the uplink and the downlink.

The system must be able to successfully operate to the voice quality standards in the presence of multiple simultaneous public safety portable radio transmissions (operating in “worst-case” locations). In particular, the system shall be balanced such that any negative “near-far” effect is avoided. Downlink coverage maps shall show coverage for 1 frequency assuming at least 12 frequencies transmitting simultaneously in each band (the number may vary depending on the CLMRN system involved as well as local resources required) Uplink shall assume simultaneous channels. All provided maps shall have a scale (ruler).

INTERFERENCE MANAGEMENT:

The in-building radio repeater system must be able to withstand and maintain compliance with voice quality requirements with any other licensed system (other than CLMRN) with signal transmitting into the DAS antenna that would produce the highest signal level.

A significant risk of in-building radio repeater system is to raise the level of noise at donor site(s) receiver(s), damaging therefore the coverage of the public safety system beyond the targeted building. In order to minimize that risk, the system shall be designed such that the contribution of the BDA to the noise at the receiver of the host site(s) will be 15 dB below the noise floor of the receiver of the host site prior to the installation of the BDA. During acceptance test CTS Engineering and the vendor will optimize the gain of the BDA to ensure that it is the case.

The uplink squelch threshold shall be set 5 dB above the noise measured at the uplink input of the BDA and coming from the DAS. The measurement of the noise shall be done as per the “Acceptance Procedure” document describes.

CLMRN utilizes 2.5/3 W portables and 35 W mobiles. The vendor is responsible for ensuring proper BDA protection (manufacturer operating specifications plus 5 dB) in all regularly accessible areas for mobile (where it makes sense) and portable users.

CLMRN is a, primarily, TDMA based system. Significant effort must be made to minimize to the greatest extent possible time-domain-interference (TDI).

OTHER RADIO SYSTEMS:

The building owner shall notify CTS if any other radio system is located in the building. A non-exhaustive list of other radio systems includes internal radio communications systems used by the building engineering team, building security or others, as well as cellular Distributed Antennas Systems. If such systems are deployed, the designer shall provide intermodulation studies with the design. Depending on the results of those intermodulation studies, CTS might require the vendor to perform PIM testing while installing the system. If such systems are installed after the public safety DAS is designed or accepted, the building owner will notify CTS and provide appropriate intermodulation studies.

ISOLATION:

The DAS system isolation shall be greater than 20db.

BACKUP POWER REQUIREMENTS:

The emergency responder radio coverage system shall be equipped with a secondary source of power. The secondary power supply shall supply power automatically when the primary power source is lost. The secondary source of power shall be capable of operating the emergency responder radio coverage system for the period of time specified in the Fire Code (IFC 2022). The active components of the installed system or systems shall be capable of operating on an independent battery system for a period as specified in the IFC without external power input. The battery system shall automatically charge in the presence of external power input. Where the building is provided with a standby or emergency generator, the emergency responder radio system shall be connected to the building emergency power circuit. The vendor shall provide documentation attesting the emergency power solution is designed to support necessary operations and has been tested.

SYSTEM MONITORING AND CONTROL:

The DAS shall have a network management system (NMS) capable of alarm, monitor, configuration, and control of all active components. The NMS shall be accessible via local and remote access. Local indication of the in-building radio system status to the Fire Alarm system shall include the BDA (and fiber DAS if applicable) system component malfunction summary alarms visible at the fire alarm annunciator panel.

In accordance with NFPA requirements, the alarms visible in the Fire Control Center shall include the following:

- Normal AC Power
- Loss of Normal AC Power
- Battery Charger Failure
- Low Battery capacity (to 70 percent depletion)
- Active RF emitting device malfunction
- System component malfunction
- Donor antenna malfunction (VSWR)

When alarms are detected, the Building Manager(s) shall be notified of the alarm condition as well and the appropriate vendor must be responsive within 4 hours.

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The Building Manager(s) must immediately notify CLMRN Network Control Center (NCC) of any system outage. The NCC will then notify radio system users of the outage.

The System shall allow a firefighter or a CTS Engineer or designee to shut down the BDA from the fire control center via a simple key switch, button or equivalent. That switch shall turn all amplifiers off and cause an appropriate alarm condition to be sent.

INSTALLATION REQUIREMENTS:

The installation of the equipment for the public safety/emergency responder radio coverage enhancement equipment shall be in accordance with applicable codes.

ENCLOSURE:

All signal booster/BDA components shall be contained in a NEMA4-type waterproof cabinet and installed in a climate-controlled room as specified in NFPA 72. Those components will include the BDA, the DAS Head-end and the active components of the battery charging/maintenance system. The cabinet shall be sized to permit adequate heat dissipation without vents.

Batteries may be stored in a vented cabinet.

SIGNAGE:

Proper signage for all DAS/BDA NEMA4-type cabinets shall be of fire engine red color, and bear the following in bright yellow lettering:

**CLMRN/(INSERT LOCAL JURISDICTION)
(INSERT ASSIGNED BDA NUMBER)
NOTIFY 860-685-8008 FOR ANY ISSUES
AC BREAKER: (INSERT LOCATION OF BREAKER)**

All cables associated with the DAS/BDA (Fiber/Coax/AC, etc) shall be clearly marked and identified for troubleshooting and upgrade purposes.

SHARING COMPONENTS WITH COMMERCIAL SYSTEMS:

For buildings where, in addition to the public safety in-building system, commercial and/or other wireless systems will be installed

- No active components shall be shared between the public safety system and the commercial or other wireless system
- The BDA enclosure hosting public safety system(s) shall solely host public safety components
- Passive components may be shared

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FIBER OPTIC CABLE INSTALLATION:

Cable management will provide strain relief for each optical fiber strand and its connectors.

Connectors will be equipped with protective dust covers on each end. The dust covers will be left in place after testing is complete.

Fiber optic cable will be installed such that the cable is protected from accidental damage.

COAXIAL CABLE INSTALLATION:

Coaxial cables will be Plenum rated and have a low PIM rating. Vertical cables shall be in conduits or riser with survivability in accordance with the building and fire codes.

All coaxial cables will be installed in accordance with the manufacturer's specifications.

All coaxial connectors will be shielded type and installed in accordance with manufacturer's specifications. All coaxial connectors shall exhibit low PIM.

EQUIPMENT AND ANTENNAS:

Installation will be in accordance with the final design document, Cable FAQs and all other requirements contained in this document.

HEAD END EQUIPMENT:

The equipment will be installed in a temperature-controlled space.

The installer will ground all equipment in accordance with all manufacturer specifications and applicable codes

All equipment will be connected in accordance with approved plans, all manufacturer specifications, and applicable standards and codes.

REMOTE EQUIPMENT:

All equipment will be connected in accordance with approved plans, all manufacturer specifications, and applicable standards and codes.

ANTENNAS:

Antennas will be installed in accordance with manufacturer's specification in locations noted on the final approved plans.

Any antenna that requires painting will be painted with a non-metallic paint that is approved by the antenna manufacturer.

All donor antennas mounted outside will follow manufacturers recommendations.

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GROUNDING AND BONDING:

Equipment grounding (at HE and RHUs) will be with #6 AWG/green-jacketed/grounding wires to the nearest ground bus bar.

All equipment will be grounded in accordance with manufacturer specifications to existing ground bus bars located in the telecom rooms or at the head-end.

Donor Antenna, Mount, and Coax shall be grounded and bonded on the roof, to suitable building ground.

Surge arrester shall be installed at building entrance and grounded & bonded to suitable building ground.

LABELING:

All cables will be at every end in accordance with the approved labeling plan.

Installation contractor will tag and label all coax, CAT5e, Fiber or braided coaxial cables at both ends indicating the active device, antenna number and any other required information.

Installation contractor will label all antennae with the assigned antenna number provided in the approved construction drawings. Label will be applied to outer diameter edge of the base plate on an omnidirectional antenna or on the side edge of a panel and be visible from the ground.

All cable ID labels will be machine-generated, non-metallic, fade-resistant and designed for communication cable application. P-Touch or similar labeling device will be used to generate the labels unless otherwise stated in the approved plans.

All items labeled will be recorded and provided to the Customer or its agent in the form of a Microsoft Excel spreadsheet and documented in the required as-built plans.

DOCUMENTATION:

Design vendors and installation vendors shall provide all necessary design and installation documentation to the CTS Engineering Unit.

DOCUMENTATION REQUIRED WITH DESIGN SUBMITTAL:

In order to facilitate a timely review of the design(s), the vendor shall provide all the documentation included in the checklist spreadsheet described in the "DesignCheckList.xlsx" document available on the DESPP/DSET/CTS webpage. Each item shall be provided in a separate document and in the format specified in the document

The checklist is provided as a separate document on the DESPP/DSET/CTS web page.

No proposed design review will be initiated until all the requested documentation listed in that checklist is provided.

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ACCEPTANCE TESTING SUBSCRIBERS:

The subscriber units used by both DESPP and the local jurisdiction will be used for any acceptance testing in a manner typically used by DESPP and the local jurisdiction.

ACCEPTANCE TESTING:

During acceptance testing, only two adjacent grid squares are allowed to fail, even if 95% or 99% area, respectively, is achieved. If more than two adjacent grid squares fail, the test is failed.

DOCUMENTATION REQUIRED TO SCHEDULE ACCEPTANCE TESTING:

In order to ensure an efficient acceptance test, prior to scheduling the test, the vendor shall provide all the documentation included in the checklist spreadsheet described in the “CTS Pre-testing CheckList.xlsx” document available on the DESPP/DSET/CTS webpage. Each item shall be provided in a separate document and in the format specified.

ACCEPTANCE TESTING DOCUMENTATION:

The vendor shall provide the CTS acceptance testing report and an updated uplink link budget spreadsheet.

FCC REGISTRATION:

Although not required by the FCC for Class A BDA devices, all such devices used for CLMRN will be registered with the FCC. The device must be registered for the system to be accepted. This may require the owner or representative to obtain a FCC FRN. The registration number must be provided for the system to be accepted.

EXPRESSED CONSENT:

Upon successful final acceptance testing and system acceptance, an express letter of consent allowing the BDA/Signal Booster to amplify and retransmit frequencies licensed under applicable CLMRN call signs will be provided. The letter is required to be maintained by the BDA/Signal Booster operator and presented to a FCC representative or the licensee investigating interference.

ANNUAL TEST:

All active components of the in-building radio system, including but not limited to amplifier, power supplies, and battery systems shall be inspected a minimum of once every twelve (12) months. If communications appear to have degraded or if the tests fail to demonstrate adequate system performance, the owner of the building or structure is required to remedy the problem and restore the system in a manner consistent with the original approval criteria.

Any testing or re-testing shall be done at no expense to the municipality or DESPP.

FIVE YEAR SURVEY:

A RF survey consistent with the acceptance testing outlined in this TAB shall be conducted every five (5) years to ensure that the radio system continues to provide the required level of radio coverage.

MAINTENANCE AND SERVICING:

At final acceptance, the building owner shall supply a letter to both the local or State fire marshal and the CTS Unit accepting the property owners' responsibilities. These responsibilities include:

- Upgrades to the system as directed by the CTS Unit
- Maintenance contract is in place with the name of the authorized company who will provide 24x7x365 emergency response within two (2) hours of notification. The system shall be maintained in accordance with FCC requirements
- Maintain a list of all contact personnel with phone numbers at the BDA cabinet. The contact personnel shall have knowledge of the building and the BDA system and be available to respond to the building in the case of an emergency.
- Commitment to maintaining a maintenance contract with appropriate and qualified servicing company
- Annual inspections
- Five (5) year RF Surveys

This letter shall be on company letter head signed by the property owner or designee

MODIFICATION:

Modification of an existing BDA system requires prior approval by the CTS Unit.

An application shall be submitted which includes a description of the work to be performed and drawing showing intended modification.

Modification must not degrade radio coverage at any time.

A RF survey must be completed and submitted after any modification to an existing BDA system.

INSPECTION: The local or State fire marshal and/or CTS Engineering personnel, after providing reasonable notice to the owner or owners representative, shall have the right to enter onto the property and conduct field testing to ensure proper operation of the system.

DISCLAIMER: The State of Connecticut does not endorse, recommend, or specify any specific product, service provider, or configuration as a means to comply with this TAB.

APPENDIX A

The requirement under this TAB is for a Class A BDA/DAS/SB device.

The Federal Communications Commission defines a Class A device as: *“Class A signal booster. A signal booster designed to retransmit signals on one or more specific channels. A signal booster is deemed to be a Class A signal booster if none of its passbands exceed 75 kHz”*⁴

While CLMRN is a statewide system, the host site can vary in channel capacity from two to (currently) twelve. Concurrently, CLMRN often works in conjunction with local jurisdictions who may have their own system(s) that may need signal enhancement. These local systems may vary in engineering requirements (different host sites, frequency ranges, signal levels, etc) from CLMRN. Additionally, there may be use cases where ONLY specific frequencies are to be retransmitted in certain areas.

Class A BDA/DAS/SB devices allow for configuration of each individual channel rather than one configuration for all channels utilized. The use of “uplink squelch” will help with the mitigation of potential interference to CLMRN.

While a Class B system may be easier to implement, the technical advantages of a Class A system are required in a system that is as complex as is found in the CLMRN environment.

⁴ <https://www.fcc.gov/wireless/bureau-divisions/mobility-division/signal-boosters/part-90-signal-boosters>