SAN FRANCISCO
DEPARTMENT OF
TECHNOLOGY

Emergency Responder Radio Communications Systems (ERRCS) Technical Requirements

Version 2.0

Effective January 1st, 2024

CITY AND COUNTY OF SAN FRANCISCO

Department of Technology, San Francisco, CA

Background and Purpose

Public safety radio communications are critical to emergency responders. As a result, San Francisco Fire Codes require sufficient radio coverage to be maintained in various types of buildings. Some applicable codes in San Francisco include: *2022 CFC Section 510*, *2022 SFFC*, *2022 SFFD AB # 2.01 Addendum G*, *2022 SFFD AB # 3.04*, *2022 NFPA 1225*. When public safety radio coverage in specified buildings fails to meet code requirements, building owners may be required to install an Emergency Responder Radio Communications System (ERRCS), which typically implement a Bi-Directional Amplifier (BDA) with a Distributed Antenna System (DAS).

While these ERRCS can improve coverage inside of buildings, they can also degrade or even disable public safety radio communications in the "macro" environment outside the building and are a known source of interference problems for public safety radio systems.

Note that FCC rules supersede any fire codes or building codes requiring the use of ERRCS. FCC CF 47 Part 90.219 states the following:

> *"(b) CONSENT REQUIREMENT*
> *Although building codes or other regulations may require installation of Part 90 signal boosters, they do not authorize non-licensee building owners or others to operate them. Commission rules prohibit Part 90 booster operation unless the proposed operator has obtained the express written consent of the licensee(s) whose signals are to be re-transmitted. …"*

San Francisco Department of Technology Radio Services is the FCC Licensee for the City and County of San Francisco and sets forth specifications and requirements on ERRCS installations and associated equipment, devices, and components. The overall purpose of these requirements is to:

1) Ensure that uplink and downlink radio communications retransmitted by ERRCS in to and out of buildings remain compatible with existing SF Public Safety radio communications infrastructure.

2) Minimize the potential for ERRCS to cause harmful interference, noise, degradation, or any other negative impacts to Public Safety radio communications.

3) Enable SFDT Radio Services to quickly identify, locate, respond to, and resolve harmful interference or any other negative impacts from ERRCS to Public Safety radio communications.

4) Keep accurate records of ERRCS locations, equipment, designs, inspections, and authorizations.

5) Maintain a standard of quality in ERRCS installations and equipment.

Most of the following requirements are directly related to at least one of these principles.

All ERRCS installed in San Francisco shall meet or exceed the following requirements:

1 Reporting to System Watch

1.1 Anytime that any ERRCS is turned on or off, or adjusted in any way (including settings changes), even if it is only for installation testing purposes, commissioning, or coverage testing, SFDT System Watch *must* be notified immediately prior to the system being turned on, off, or adjusted. System Watch is available 24/7/365 by calling: **(415) 558-3884**

1.2 The technician present on site shall provide a contact number where they will be available to immediately disable the ERRCS if requested by the System Watch or SFDT Radio Services.

1.3 If SFDT Radio Services receives reports of interference problems which may occur while the BDA is active, System Watch or DT Radio Services may contact the on-site technician and they shall immediately comply with any request to disable the ERRCS BDA equipment.

1.4 Failure to comply with any of these reporting requirements may result in revocation of the FCC Licensee "authorization to operate" for that building or other enforcement actions.

2 Design

2.1 Design Files and Drawings

2.1.1 The following ERRCS design documents/files shall be submitted to SFDT Radio Services:

2.1.1.1 Design drawings
2.1.1.2 One-line diagram or "Label diagram" (see Exhibit C)
2.1.1.3 Link budget diagram (see Exhibit D)
2.1.1.4 Coverage projections ("heatmaps") (see Exhibit E)
2.1.1.5 Pre-design coverage test results

2.1.2 All the above required documents shall be submitted as directed by SFDT (email, etc.)

2.1.3 ERRCS Design documents shall be submitted in native file format and .PDF format.

2.1.4 SFDT Radio Services' receipt of design documents is not an assurance that an ERRCS will meet coverage expectations or pass an SFDT Radio Services inspection. NOTE: SFFD Bureau of Fire Prevention & Inspection and SF-DBI Electrical Inspection Department (EID) perform plan-review and inspections regarding each field of jurisdiction.

2.1.5 ERRCS design documents shall include all ERRCS equipment and components which carry, convert, amplify, or attenuate RF signals, including but not limited to: All BDA headend equipment, fiber optic distribution equipment, monitoring devices, BDA remotes, cables, directional couplers, tappers, donor antenna and service antennas.

2.1.6 ERRCS design drawings submittals shall identify the "make and model" for each individual component and shall be accompanied by specification sheets from the Original Equipment Manufacturer (OEM) for each component.

2.1.7 All ERRCS design documents shall include and account for all exterior and interior walls, and any significant objects that could affect the radio coverage within the building.

2.1.8 ERRCS design documents shall include the planned roof location for the donor antenna.

2.1.9 ERRCS design documents shall identify the primary donor site location that the donor antenna will be directed towards, and the approximate azimuth relative to true north.

2.1.10 ERRCS designs shall specify the distance (within 0.1 miles) to the expected donor site(s).

2.2 One-line diagrams and link budget diagrams

2.2.1 One-Line drawings and link budget documents shall include the following:

2.2.1.1 Lengths of each cable segment shall be specified (in feet).

2.2.1.2 The calculated loss, attenuation and gain values (in dB), for all ERRCS components, devices and segments, shall be specified next to each symbol for that device or segment, including, but not limited to: donor antenna, BDA inputs and outputs, coaxial cables, directional couplers, tappers, splitters, service antennas, attenuators, etc. (See Exhibit D)

2.2.1.3 The calculated RF signal input power and output power figures (in dBm), for all ERRCS components, devices and segments, shall be specified next to each symbol for that device or segment, including, but not limited to: donor antenna, BDA inputs/outputs, coaxial/feeder cables, directional couplers, tappers, splitters, service antennas, attenuators, etc. (See Exhibit D)

2.2.1.4 The service antenna with least path loss to the BDA which will emit the highest RF power ("hot antenna") shall be identified and its location clearly marked.

2.3 ERRCS RF Coverage Projections

2.3.1 ERRCS RF coverage projections shall be provided to SFDT Radio Services

2.3.2 Projections shall be submitted in native file format (iBwave, etc.) and .PDF format.

2.3.3 Coverage projections shall clearly indicate the expected signal strength level.

2.3.4 Differences between passing signal level coverage areas (>-95dBm) and failing signal level coverage areas (<-95dBm) shall be clearly identifiable by color gradation (Exhibit E)

2.3.5 Coverage projections shall include and account for all interior and exterior walls, and any significant objects that could affect the expected RF coverage within the building.

2.4 Design Considerations

2.4.1 The ERRCS shall be designed to provide sufficient radio coverage with minimal use of BDA gain while meeting all SFDT Radio Services requirements and shall not transmit excessive RF noise. This includes selection of appropriate equipment for the application.

2.4.2 The ERRCS should be designed to generate a variance between minimum and maximum uplink input signal levels of less than **30dB**. For example, a typical uplink input range to the BDA from the strongest and weakest areas might be from -35dBm to -65dBm.

2.4.3 Subscribers should not be able to exceed **30 feet** distance from a service antenna, unless RF propagation software analysis shows this is not necessary (large open spaces, etc.). Thus, spacing between neighboring indoor service antennas should not exceed **60 feet**.

2.4.4 The ERRCS shall not transmit signal outputs that will cause any other nearby ERRCS to retransmit the same signal (**> -75dBm** BDA squelch thresholds). (See Sections 9 and 10)

2.4.5 ERRCS designs shall account for the differences in path loss between the selected 700 MHz and 800 MHz collocated “donor Rx site” and any other 800MHz only sites which may reside within the transmit path of the donor antenna. (See Exhibit A)

2.4.6 ERRCS designs shall account for nearby RF signals or operators, cell sites, base stations, antennas, and any co-located cellular BDAs or services within the same building.

2.4.7 ERRCS shall be designed with sufficient dominance of the indoor signal over the outdoor/macro signal that the “delivered audio quality” (DAQ) inside the building is not significantly degraded to less than 3.0 DAQ by Time Delay Interference (TDI) effects.

2.4.8 ERRCS shall be designed to minimize “leakage” of the indoor signal from inside the building to the outdoor environment. Sufficient “dominance” of the outdoor/macro signal over any indoor signal leakage shall be maintained to prevent the DAQ of the outdoor/macro signal in the area immediately surrounding the building from being degraded to less than 3.4 DAQ by TDI effects.

2.4.9 Designs shall account for typical indoor coverage variables such as closed fire-doors, room partitions, stocked inventory shelves, vehicles in garages, and similar variables.

3 ERRCS Management Form

3.1 All ERRCS submittals shall include an SFDT Radio Services ERRCS Management Form.

3.2 The ERRCS Management Form can be requested from System Watch at 415-558-3884

3.3 The document shall have all required fields completed.

3.4 The document shall include all the following information:

- 3.4.1 BDA / Signal booster specifications
  - 3.4.1.1 Original Equipment Manufacturer (OEM)
  - 3.4.1.2 Model #
  - 3.4.1.3 Firmware Version(s)
  - 3.4.1.4 FCC ID#
  - 3.4.1.5 Max UL RF input power before overdrive/wideband AGC or equivalent.
  - 3.4.1.6 Active/Fiber remote BDAs, if any (make & model)
    - 3.4.1.6.1 Number of Remotes, if any (including OEM/Model #s for each)
  - 3.4.1.7 Number of indoor service antennas
- 3.4.2 BDA Settings
  - 3.4.2.1 Highest uplink gain setting used (800 MHz band)
  - 3.4.2.2 Highest uplink gain setting used (700 MHz band)
  - 3.4.2.3 Uplink max/target power setting, composite (800 MHz band)
  - 3.4.2.4 Uplink max/target power setting, composite (700 MHz band)
  - 3.4.2.5 Uplink max/target power setting, per channel (800 MHz band)
  - 3.4.2.6 Uplink max/target power setting, per channel (700 MHz band)
  - 3.4.2.7 Uplink squelch threshold setting used (same for all filters)
  - 3.4.2.8 Any enabled settings or features which are unique to the specific BDA OEM (i.e. Comba “Net Protect”, “Mode 1”, etc.)
- 3.4.3 Pre-commissioning test results:
  - 3.4.3.1 Raw Isolation test results (excluding attenuators)
  - 3.4.3.2 Effective Isolation (including attenuators)
  - 3.4.3.3 UL cross-isolation test results (See Section 10)
- 3.4.4 UL Input Variables
  - 3.4.4.1 Nearest distance a portable radio (worn on hip) can approach a service antenna
  - 3.4.4.2 Nearest distance a vehicle can approach a service antenna with a mobile radio
  - 3.4.4.3 The minimum DAS path loss to any service antenna (“hot” antenna)
  - 3.4.4.4 Peak uplink input power to the BDA. This shall be measured with a portable radio (worn on hip) transmitting 10’ away from the “hot” antenna

3.4.4.5 Attenuator values applied to BDA inputs or outputs shall be listed, including:
- 3.4.4.5.1 Uplink output
- 3.4.4.5.2 Downlink input
- 3.4.4.5.3 Uplink input
- 3.4.4.5.4 Downlink output
- 3.4.4.5.5 Attenuators on fiber optic distribution inputs or outputs

3.4.5 Uplink (UL) Outputs
- 3.4.5.1 Peak uplink power output per channel/filter from BDA (before attenuators)
- 3.4.5.2 Peak squelched/muted uplink noise from BDA (before attenuators)
- 3.4.5.3 Peak unsquelched/unmuted uplink noise from BDA (before attenuators)

3.4.6 UL Output Variables
- 3.4.6.1 All external uplink output attenuators (dB)
- 3.4.6.2 Donor cable length
- 3.4.6.3 Donor cable loss/100 ft specification (from OEM)
- 3.4.6.4 Measured donor cable loss (dB)
- 3.4.6.5 Donor antenna gain (dBd)

3.4.7 Expected ERP
- 3.4.7.1 Expected ERP per channel at the donor antenna
- 3.4.7.2 Expected squelched/muted noise ERP at the donor antenna
- 3.4.7.3 Expected unsquelched/unmuted noise ERP at the donor antenna
- 3.4.7.4 GPS coordinates of donor antenna location on roof

3.4.8 Other Installation Variables
- 3.4.8.1 Donor Rx site and azimuth (true north) in relation to donor antenna placement
- 3.4.8.2 Distance from the donor antenna to the selected donor site
- 3.4.8.3 Measured uplink path loss for both 700 and 800 MHz systems (See Section 10)

3.4.9 Expected Donor Site Rx Levels
- 3.4.9.1 Expected Peak UL Rx level at donor site (from “hot” ERRCS service antenna)
- 3.4.9.2 Expected Min UL Rx level at donor site (from “weakest” ERRCS coverage area)
- 3.4.9.3 Expected peak UL Rx noise power level (unsquelched/unmuted) at donor site
- 3.4.9.4 Expected peak UL Rx noise power level (squelched/muted) at donor site

4 ERRCS Equipment Specifications Requirements

4.1 Bi-Directional Amplifier (BDA) / Signal Booster specifications

4.1.1 All BDA equipment shall be fully compliant with all FCC CF 47 Part 90.219 regulations.

4.1.2 All BDA equipment shall be UL 2524 listed.

4.1.3 BDA shall be a fully "Channelized" signal booster (typically FCC "Class A" or "Class A/B").

4.1.4 BDA shall be compatible with both P25 Phase 1 (FDMA) and P25 Phase 2 (TDMA) signals.

4.1.5 BDA shall support all CCSF 700 MHz and 800 MHz frequencies (See Exhibit B).

4.1.6 BDA shall be capable of having at least 24 filters per each band (700MHz and 800MHz).

4.1.7 BDA shall be capable of the following filter widths: 12.5kHz, 25khz, and 75kHz.

4.1.8 BDA filters shall not exceed a maximum filter group delay of 20µs on 75kHz filters.

4.1.9 BDA shall provide uplink and downlink squelch capabilities.

4.1.9.1 Squelch thresholds shall be adjustable up to at least -75dBm or higher.

4.1.10 AGC/ALC shall operate discretely for each filter ("channelized AGC/ALC").

4.1.10.1 Channelized AGC/ALC shall operate per each TDMA timeslot. Transmitting or receiving on one TDMA timeslot shall not interfere with simultaneous uplink or downlink signals or affect available gain on the other paired TDMA timeslot.

4.1.11 Uplink gain settings shall be independently adjustable from downlink gain (not linked).

4.1.12 Uplink target power shall be independently adjustable from downlink target power.

4.1.13 Settings for uplink gain, downlink gain, uplink target power, and downlink target power shall be independently adjustable for each band (700 MHz and 800MHz).

4.1.14 The headend BDA and/or BDA remotes should permit the placement of separate physical attenuators (SMA or N type) for each of the following: uplink input, downlink output, uplink output, and downlink input.

4.1.15 ERRCS (BDA) shall be capable of supplying sufficient uplink / downlink power during full loading conditions, all filters transmitting or receiving simultaneously. (See Section 6.9)

4.1.16 The BDA shall have a network (ethernet) port for configuring system settings and shall have capability to be remotely powered off and powered on, and to independently power off and power on the uplink and downlink power amplifiers, through a remote connection to this port.

4.1.17 Remote connections shall be compatible with SFDT's remote monitoring and control system and shall be compliant with SFDT Cybersecurity requirements. (See Appendix B)

4.1.18 The BDA shall have a general-purpose input-output (GPIO) connection capable of being configured to shut down the BDA's RF outputs (ULPA/DLPA) by means of a simple "open/short" input.

4.1.19 New ERRCS installations shall not include BDA equipment, fiber distribution systems, remotes, or any other major components with active electronics, which have exceeded the "End of Life Announcement" (EOLA) or "Last Order Date" (LOD) from the OEM.

4.1.20 For BDAs used in conjunction with remote BDAs over fiber, the headend BDA equipment should have fully accessible RF connections that allow for monitoring and measurement of composite signals from service antennas and the donor antenna, as well as signal injection for manual isolation tests to be performed without the need to access each remote BDA location separately.

5 BDA Installation Requirements

5.1 In addition to any fire code, electrical code, or other building codes and structural installation requirements, all ERRCS equipment and system components shall be installed per OEM requirements and recommendations, including grounding requirements, environmental operating conditions, signal level input thresholds, structural requirements, etc.

5.2 The top of the headend BDA equipment should be installed at a height less than 6 feet.

5.3 The placement of the BDA headend should be selected so that access to the BDA, its connector ports, and opening BDA doors or compartments is unrestricted.

5.4 There shall only be one headend BDA connected to a donor antenna feedline. To supply more power which may be required to provide sufficient in-building coverage, an “active” BDA system may be used with fiber optic distribution to feed one or more “remote” BDAs that are subordinate to the headend BDA.

5.5 ERRCS designs which elect to use “active” BDA systems implementing BDA remotes connected over fiber optic cables to a headend BDA shall account for any additional time delay introduced by the fiber optic links and remotes by designing for coverage with sufficient dominance of the indoor signal over macro (outdoor) signal to nullify any TDI effects that may be introduced by the additional time delay.

6 BDA / Signal Booster settings

6.1 All BDA filters shall be centered on the frequencies defined by the table provided in **Exhibit B.**

6.2 All BDA filter bandwidths shall be set to **75kHz** (see Exhibit B).

6.3 If the 75kHz filters have an adjustable filter group delay, they shall all be set to **20µs** or less.

6.4 Uplink and downlink gain settings shall not exceed **80dB**.

6.5 Uplink and downlink squelch shall be set at **-75dBm**.

6.6 Settings that cause the BDA to fail any FCC CF 47 Part 90.219 regulations shall not be used.

For example, if certain gain settings or features are available that result in a noise figure >9dB, those gain settings or features shall not be used.

6.7 Some BDA OEMs (i.e. Comba) have "modes" of AGC/ALC operation available which allow for more power per channel to be available when only one filter is active than compared to when multiple filters are active simultaneously. The BDA shall be set to a "mode" where the available power is derated to be equal for all filters, even if all filters are active simultaneously ("full loading" conditions). If no AGC/ALC setting is available that automatically derates the UL and DL output power per channel according to the number of filters, then the UL and DL output target power per channel shall be calculated and derated manually (see **Section 6.9**).

6.8 Manual Derating calculations:

6.8.1 800 MHz PS band UL and DL output power shall be derated by **12.5dBm** per channel.

6.8.2 700 MHz PS band UL and DL output power shall be derated by **8dB** per channel.

EXAMPLE:
BDA has +24dBm of available *composite* UL output power for *each* individual band. Therefore, *after derating* there will be **+11.5dBm** of available UL output power per channel in the 800 MHz PS band (+24dBm – 12.5dB = +11.5dBm), and **+16dBm** on the 700 MHz PS band (+24dBm – 8dB = +16dBm).

6.8.3 AGC/ALC. The BDA shall not be set to overdrive any AGC/ALC capabilities that may result in an abnormal UL output or DL output from the BDA.

7 Donor Antenna Technical Specifications

7.1 Donor antenna frequency range shall include the 700MHz and 800 MHz public safety bands:

700 Public Safety Downlink band = 769 – 775 MHz
700 Public Safety Uplink band = 799 – 805 MHz
800 Public Safety Uplink band = 806 – 816 MHz
800 Public Safety Downlink band = 851 – 861 MHz

7.2 The donor antenna shall be directional.

7.2.1 The donor antenna horizontal beamwidth shall be less than or equal to 30˚.

7.2.2 The donor antenna vertical beamwidth shall be less than or equal to 30˚.

7.2.3 The donor antenna front-to-back ratio shall be greater than or equal to 27dB.

8 Donor Antenna Installation Requirements

8.1 ERRCS designs should implement the use of only one donor antenna.

8.2 The planned location for the donor antenna shall provide a clear line of sight path to the primary donor site, free of obstruction by any objects on the roof of the building that are within the beamwidth of the donor antenna (30 degrees vertically and horizontally).

Donor antenna placement should account for other buildings which may present an obstruction to the line-of sight path.

NOTE: In some cases, placing the donor antenna on or near a corner of the building roof may provide greater range of movement for the antenna to be directed to an alternate donor site.

8.3 The donor antenna shall point to a donor site that transmits all required CCSF 700 MHz and 800 MHz frequencies (see Exhibit B).

8.4 In the direction the donor antenna is pointing, the donor antenna shall be installed within 10 feet from the roof edge or roof wall/parapet.

8.5 Based on the distance from the roof edge or parapet that the donor antenna is placed, the bottom of the donor antenna shall be installed at the minimum height in the following chart:

Distance from Roof Edge / Parapet	Minimum Height above roof edge, or any other obstruction
0 – 3 feet	1 foot
3 – 6 feet	2 feet
6 – 10 feet	3 feet

8.6 Donor antenna mounting devices shall permit 360˚ of horizontal rotational adjustment.

8.7 Donor antenna mounting devices should allow for vertical adjustment.

9 ERRCS Signal Levels, Metrics and Thresholds

9.1 It is the ERRCS integrator's responsibility to design an ERRCS system that will pass all SFDT Radio Services requirements and still be compliant with any coverage or installation requirements from the AHJ, SFFD Bureau of Fire Prevention Inspection team, SF-DBI Electrical Inspection Department (EID), and any other applicable Fire Codes or other regulations.

9.2 If any of SFDT Radio Services required signal level thresholds are not met or are exceeded, they shall be adjusted to be passing by adding physical attenuation to the applicable input or output and/or by reducing the BDA gain or power settings.

SFDT Radio Services shall not be responsible for the coverage impacts of any adjustments to gain, power, attenuation, or configuration which may be required to meet the thresholds.

NOTE: Adding attenuation may reduce the input or output power and negatively impact the expected ERRCS coverage test results. For this reason, it may be advisable to install BDA equipment which allows for physical attenuators to be added to inputs or outputs.

As an alternative, the installer may elect to instead add or remove, move, modify or replace antennas, tappers/directional couplers, or other components to alter the input and output levels. When an installer makes this election, the inspection is "failed", and the installer shall reschedule the inspection for another date after the modification work is completed.

9.3 ISOLATION

9.3.1 The minimum isolation between the donor antenna and the DAS service antennas shall be **20dB** greater than the highest gain setting used in the BDA.

EXAMPLE:
If isolation is 90dB, then the highest BDA gain setting permitted is 70dB (90 - 20 = 70).

9.4 BDA Input thresholds

9.4.1 Uplink Input
The peak uplink input level to the BDA shall not exceed the BDA's overdrive* threshold *minus* a **10dB** safety margin. Tests shall be performed with an SFDT approved portable radio model worn on hip at a distance of 10 feet from the "hot antenna".
* Some OEMs may refer to this as "maximum RF input power, normal operation".

Example: If a BDA "overdrive" threshold is -30dBm, then the uplink input level shall not exceed -40dBm (-30dBm - 10dB safety margin). If uplink input power is -20dBm, then 20dB external attenuation shall be added to the uplink input (-20dbm -20dB = -40dbm).

9.4.2 Downlink Input

Composite Downlink Input power shall not exceed the OEM's specified composite downlink power input overdrive* threshold minus a **10dB** safety margin.
*OEMs may use other terms such as "clip-level" or "non-linear operation level"

9.4.3 Public Safety Band Filters

If uplink or downlink input signal level limits are exceeded, then external attenuation shall be added until the input level meets the required level. If the source of the high signal is from outside the 700 MHz and 800 MHz public safety bands (i.e. cellular operator) a public safety band filter shall be installed to reduce the signal to acceptable levels instead of an attenuator.

9.5 BDA Output Thresholds and Donor Antenna ERP Thresholds

9.5.1 All BDA outputs shall be compliant with all FCC CFR 47 § 90.219 regulations.

9.5.2 Abnormal uplink output or downlink output signals, as identified by SFDT Radio Services, shall not be permitted. If adjustments do not correct abnormal signals, the BDA OEM should be consulted or the BDA should be replaced with one generating normal outputs.

9.5.3 Uplink Output (ERP)

9.5.3.1 BDA uplink output levels shall not cause the uplink **ERP** at the donor antenna to exceed **+24dBm <u>per channel</u>**.

To find max uplink output per channel from the BDA, apply the following formula:
+24dBm – Donor Ant. Gain + Donor Cable Loss = BDA Max UL Output per channel

EXAMPLE:
If donor antenna gain is 13dBd and donor cable path loss is 1dB, then:
+24dBm – 13dBd + 1dB = +12dBm Max uplink output per channel from BDA

9.5.3.2 Squelched* uplink noise ERP at the donor antenna shall not exceed **-43dBm****

9.5.3.3 Unsquelched* uplink noise ERP at the donor antenna shall not exceed **-43dBm****

* Some OEMs may use the term "mute/unmute" instead of squelch/unsquelched.
** Noise shall be measured at 10kHz RBW

9.5.4 Downlink Output

9.5.4.1 Peak Downlink Composite power shall not exceed **5W (+37dBm)**

9.6 Donor Site Receive Level Thresholds

The following thresholds supersede all others and may require BDA output power levels and donor antenna ERP levels to be even lower than the limits defined in the previous sections of this document:

9.6.1 Maximum Uplink receive levels at the donor site base radio shall not exceed **-70dBm***

9.6.2 Minimum Uplink receive levels at the donor site base radio equipment shall be **-95dBm***

* Measured at the donor receive site. For these tests, the uplink signals shall be generated by a portable radio worn on the hip within 10 feet of the "hot" antenna.

9.6.3 Peak uplink noise when the BDA is idle and unsquelched* shall not exceed **-137dBm****

9.6.4 Peak uplink noise when the BDA is idle and squelched* shall not exceed **-154dBm*****

** The BDA squelched/muted state does *not* include power amplifier shut down or "sleep" states used by some OEM specific features (i.e. Comba "Net Protect", etc.)

*** Peak uplink noise contribution level can be calculated by the following formula: Donor Site Noise = BDA Uplink Noise – Path Loss to Donor Site. (See Section 10.1)

EXAMPLE:
If the peak BDA uplink noise (squelched) is measured to be -65dBm, and the path loss is measured to be 85dB, then the donor site noise contribution level is -150dBm (-65dBm - 85dB = -150dBm). SFDT will require attenuation to be added to the BDA UL output until the UL noise contribution level at the donor Rx site meets requirements (-154dBm).

9.7 No Changes After SFDT Inspection

After any SFDT Radio Services inspection has been completed and passed, the ERRCS and its components shall not be adjusted, moved, or removed without consent of SFDT Radio Services, including but not limited to: the headend BDA and BDA remotes and all settings, attenuators, splitters, tappers, directional couplers, cable segments, donor or service antennas, or the physical placement and or angle of any antennas.

9.7.1 If any adjustments or modifications are made to any RF components of the ERRCS after an SFDT inspection is passed, the previous SFDT inspection results are invalidated and the SFDT's authorization to operate the ERRCS shall be immediately revoked until the ERRCS can be re-inspected by SFDT Radio Services and pass again.

10 Pre-Commissioning Tests

The following pre-commissioning tests shall be performed prior to scheduling an inspection:

10.1 Measured Uplink Path Loss

10.1.1

An uplink path loss test should be performed. The downlink and uplink paths at radio sites are separate with different antennas at different positions and heights on the donor site building or tower. Thus, Tx and Rx signals have different total path loss values in relation to the position and height of a building and its donor antenna.

Uplink Path Loss measurement:

(1) Contact DT Radio Services system Watch to schedule a test time and reserve a test radio (+35dBm Tx output). Alternatively, a signal generator may be used.
(2) Schedule a time with SFDT Radio Infrastructure to measure donor site Rx levels.
(3) Set-up a soft donor antenna installation at the expected roof location and use the portable radio to inject a signal directly to the donor antenna back to SF site(s). SFDT Radio Services can read back to the tester what the Rx level the donor site is, which can be used to calculate the estimated path loss to our Rx system.
(4) Uplink path loss for each band can be calculated by the formula:

Uplink path loss = +35dBm – received signal level at donor site (dBm)

EXAMPLE:
Test radio transmits +35dBm and -55dBm is received by our system, then:
Uplink path loss = +35dBm – (-55dBm) = 90dB

NOTE: Installers should use this UL Path Loss to estimate donor site Rx and noise levels.

10.2 Minimum Distance to other ERRCS/BDA/Signal Boosters

Any building with an ERRCS installation that is located within 300 feet of any other existing building with an ERRCS shall be considered a “nearby ERRCS”. A cross-isolation test shall be performed between the new ERRCS and any other “nearby ERRCS” within 300 feet. The distance shall be measured between the location of donor antenna and the closest exterior wall of each building, and vice versa.

10.3 Cross-Isolation

There shall be at least **100dB** isolation between any ERRCS output and any other nearby ERRCS input. If isolation is less than 100dB, the new ERRCS installation shall be modified until the cross-isolation between ERRCS is within spec. Relocating or adjusting a poorly positioned donor antenna or service antenna(s), or to replace omni-directional service antennas near exterior walls with directional antennas is preferred. Attenuators at the new ERRCS installation headend may be used to increase isolation.

10.4 Uplink cross-isolation test

(1) At any other nearby ERRCS, a test signal shall be injected* at the BDA uplink input that is sufficient to drive the uplink output to its peak ERP (**+24dBm** per channel).
*An approved test radio may be keyed within 10 feet of the hot antenna of nearby ERRCS.

(2) At the new ERRCS headend, the uplink input signal level to the BDA shall be measured.

(3) If the uplink input signal received at the new ERRCS exceeds the required uplink squelch level (**>-75dBm**), then the installer at the new ERRCS location shall modify the service antenna or donor antenna configuration or add external attenuation to the UL input until the signal received at the new ERRCS is below **-75dBm**.

EXAMPLE:
At Building A (pre-existing "nearby ERRCS"), the installer injects a signal into its uplink input (user keys a portable within 10 feet of the "hot antenna"). Building B (a new ERRCS) receives a signal of -70dBm at its uplink input (from Building A), which exceeds the required squelch level (-75dBm). At Building B, the installer reconfigures the location of several service antennas placed near windows or adds 10dB of attenuation to its uplink input. On retest, Building B now receives a signal of -80dBm, which is below the required uplink squelch threshold (-75dBm). Building B now complies with the cross-isolation requirement.

11 ERRCS Inspection Scheduling

11.1 To receive an "Authorization to Operate" letter from SFDT Radio Services (FCC Licensee), all new completed ERRCS projects shall be inspected and receive a PASS approval.

11.2 To renew or extend a Letter of Authorization to Operate, all pre-existing ERRCS installations shall be reinspected annually by SFDT Radio Services and upon receiving a PASS approval, may receive a renewed or extended letter of Authorization to Operate for an additional year.

11.3 Vendors that wish to schedule an inspection of completed ERRCS projects shall submit a completed ERRCS management form.

11.4 Only completed ERRCS projects which have submitted a completed and approved ERRCS Management Form will receive a response to schedule an inspection appointment. If any relevant fields are not completed an inspection may not be scheduled.

12 Inspection requirements

12.1 The technician that commissioned and tuned the ERRCS shall be present for the inspection.

12.2 The technician present shall have all equipment and tools (laptop, cables, etc.), including BDA login access credentials, required to be capable of making any BDA settings adjustments requested by the SFDT Radio Services ERRCS Inspection Team.

12.3 The commissioning technician shall have the following information and documents available:

- 12.3.1 Contact info, including cell phone number
- 12.3.2 Documentation of Underwriters Laboratories vendor certification with UUKF Category
- 12.3.3 Documentation of FCC GROL license
- 12.3.4 Documentation of OEM specific training for the installed BDA equipment and remotes
- 12.3.5 Documentation of any other certification (NICET, etc.) which SFDT may require
- 12.3.6 Manuals and spec sheets for all ERRCS equipment
- 12.3.7 Technical support phone number for the BDA OEM

12.4 The commissioning technician shall have the following attenuator values available:

3dB (x2)
6dB (x2)
10dB (x2)
20dB (x2)
30dB (x2)

- 12.4.1 The attenuators shall be rated for at least 5W.
- 12.4.2 The attenuator connector types (SMA, N) shall be compatible with the installed BDA.

13 ERRCS Installer/Servicer Requirements

13.1 ERRCS installers and maintenance providers shall provide 24/7/365 availability for ERRCS shut down requests and shall furnish a contact phone number where SFDT Radio Services can reach them at any time in response to interference events.

13.2 Any ERRCS Service Technician performing system commissioning or that will access the BDA to adjust any settings, either locally or remotely, shall have at a minimum, the following:

13.2.1 Underwriters Laboratories vendor certification with UUKF Category
13.2.2 FCC General Radiotelephone Operator License (GROL)
13.2.3 Completed Certificate of Training from the OEM of the installed ERRCS equipment
13.2.4 Any other industry certification (NICET, etc.) which SFDT may require

14 Coverage Testing

14.1 All officially required coverage testing (aka “20 grid testing”, DAQ testing, etc.) shall only be performed after the SFDT Radio Services inspections of the ERRCS have been passed.

14.2 Copies of all coverage test results shall be submitted as directed by SFDT (email, etc.)

14.3 ERRCS coverage test documents shall be submitted in their native file format and .PDF format

14.4 Separate downlink coverage tests shall be performed with the BDA off, and with the BDA on.

14.5 Inside the building there shall be sufficient dominance of the indoor signal over the outdoor (“macro”) signal that the DAQ is not degraded by the effects of TDI.

14.6 Coverage test reports shall include the following metrics:

14.6.1 Downlink testing:

14.6.1.1 DAQ (Delivered Audio Quality): > 3.0 DAQ = PASS
14.6.1.2 Received Signal Strength, in dBm: > -95dBm = PASS
14.6.1.3 BER (Bit-Error-Rate): < 2% = PASS
14.6.1.4 SINR (Signal-to-Interference-plus-Noise-Ratio), in dB: > 20dB = PASS

14.6.2 Uplink testing (after testing capability is implemented by SFDT):

14.6.2.1 DAQ (Delivered Audio Quality): > 3.0 = PASS
14.6.2.2 Received Signal Strength, in dBm: > -95dBm = PASS
14.6.2.3 BER (Bit-Error-Rate): < 2% = PASS
14.6.2.4 SINR (Signal-to-Interference-plus-Noise-Ratio), in dB: > 20dB = PASS

14.6.3 Leakage Testing:

14.6.3.1 Whenever an ERRCS implements fiber remotes: Signal strength testing shall be performed outside the perimeter of the building to a width of at least 10’ or to the edge of the street. The signal strength of the indoor ERRCS signal shall be measured and compared with the outdoor (“macro”) signal, preferably the control channel. The ERRCS signal leakage measured outside the building shall not exceed -95dBm or 16dBm less than the macro signal, whichever is lower.

14.6.3.2 Along the perimeter of the building there shall be sufficient dominance of the outdoor (“macro”) radio system signal over the indoor ERRCS signal that DAQ is not degraded to less than 3.4 DAQ by effects of TDI.

15 Documentation

15.1 The following documents shall be kept with the BDA at the headend location:

15.1.1 Letter of "Authorization to Operate"

15.1.1.1 Alternatively, an official SFDT sticker or seal shall be displayed and clearly visible at the BDA headend, if provided by SFDT.

15.1.2 Contact info for the ERRCS vendor

15.1.3 Contact information for the building owner, building management, or access provider

15.1.4 User manuals for the headend BDA, BDA remotes, and fiber distribution system equipment

15.1.5 Design Drawings

For questions about this document, contact: michael.proscia@sfgov.org

Exhibit A – Public Safety Donor Radio Site Map

700 MHz & 800 MHz Collocated sites (Target these)	**Latitude**	**Longitude**	**Tx ERP (dBm)**	**Tx Antenna Elevation (Est)**
Twin Peaks (this is ***NOT*** Sutro Tower)	37.7545°	-122.4467°	47.71	954'
One Market	37.7932°	-122.3945°	48.39	586'
Forest Hill	37.7485°	-122.4673°	48.18	808'
South Hill	37.7041°	-122.4303°	48.89	750'
800 MHz ONLY Sites (Avoid high noise)				
Clay Jones	37.7931°	-122.4142°	48.60	572'
Bernal Heights	37.7431°	-122.4149°	47.61	485'
Fort Miley	37.7826°	-122.5073°	48.21	400'
SFSU	37.7236°	-122.4766°	45.91	230'
Bayview	37.7164°	-122.3950°	48.75	348'

Exhibit B – BDA Filter Frequencies and Bandwidths

	Uplink Frequency (MHz)	Downlink Frequency (MHz)	Filter #	Filter Bandwidth (kHz)
800 MHz PS Band	806.12500	851.12500	F1	75
	806.25000	851.25000	F2	75
	806.40000	851.40000	F3	75
	806.61250	851.61250	F4	75
	806.81250	851.81250	F5	75
	807.06250	852.06250	F6	75
	807.21250	852.21250	F7	75
	807.38750	852.38750	F8	75
	807.67500	852.67500	F9	75
	807.86250	852.86250	F10	75
	808.08750	853.08750	F11	75
	808.25000	853.25000	F12	75
	808.43750	853.43750	F13	75
	808.65000	853.65000	F14	75
	808.78750	853.78750	F15	75
	808.88750	853.88750	F16	75
	811.23750	856.23750	F17	75
	812.23750	857.23750	F18	75
700 MHz PS Band	799.26875	769.26875	F1	75
	799.53125	769.53125	F2	75
	799.84375	769.84375	F3	75
	800.10625	770.10625	F4	75
	801.13125	771.13125	F5	75
	803.68125	773.68125	F6	75

Exhibit C – One-Line Diagram Example (Label diagram)

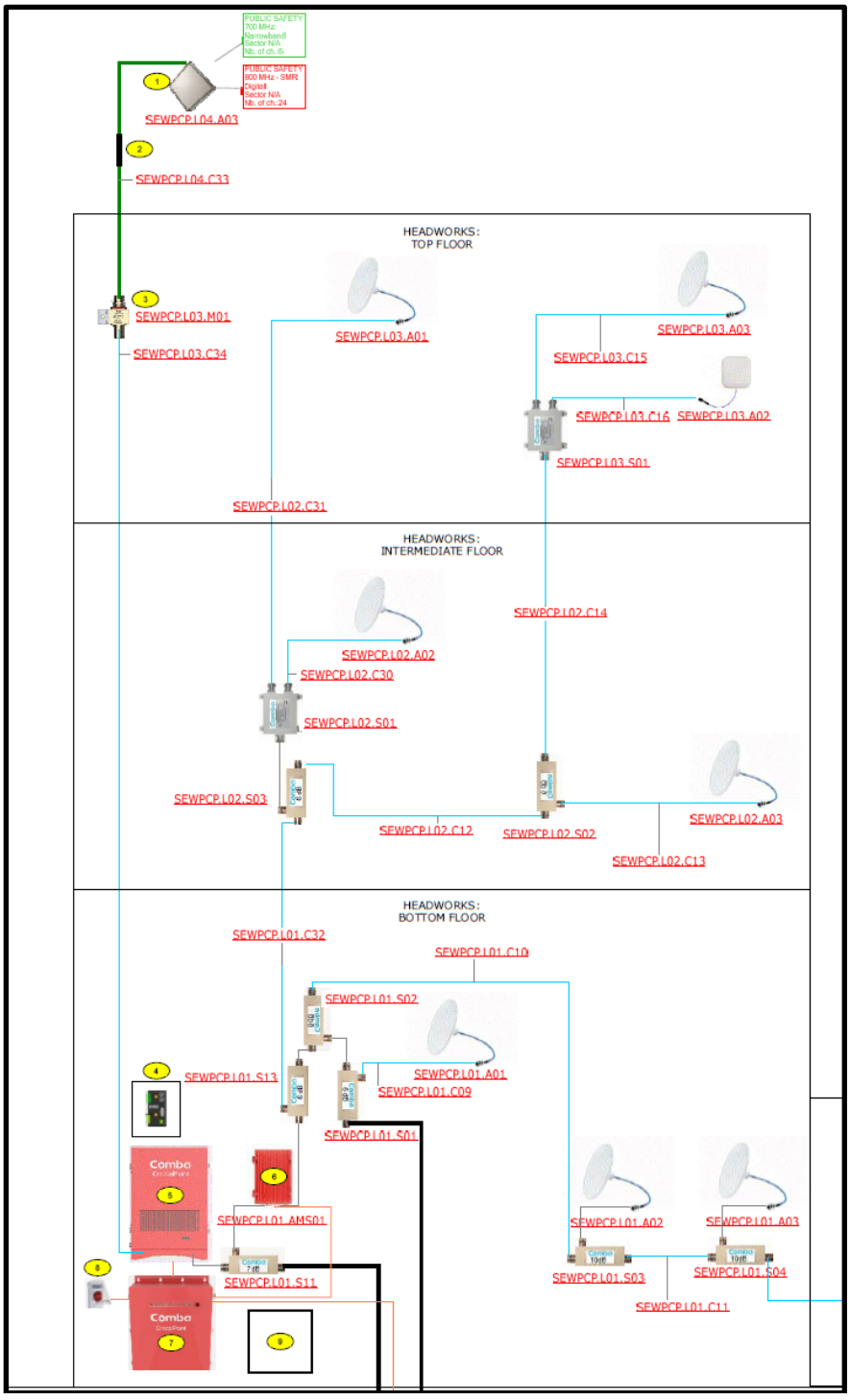


Exhibit D – Link Budget Diagram Example

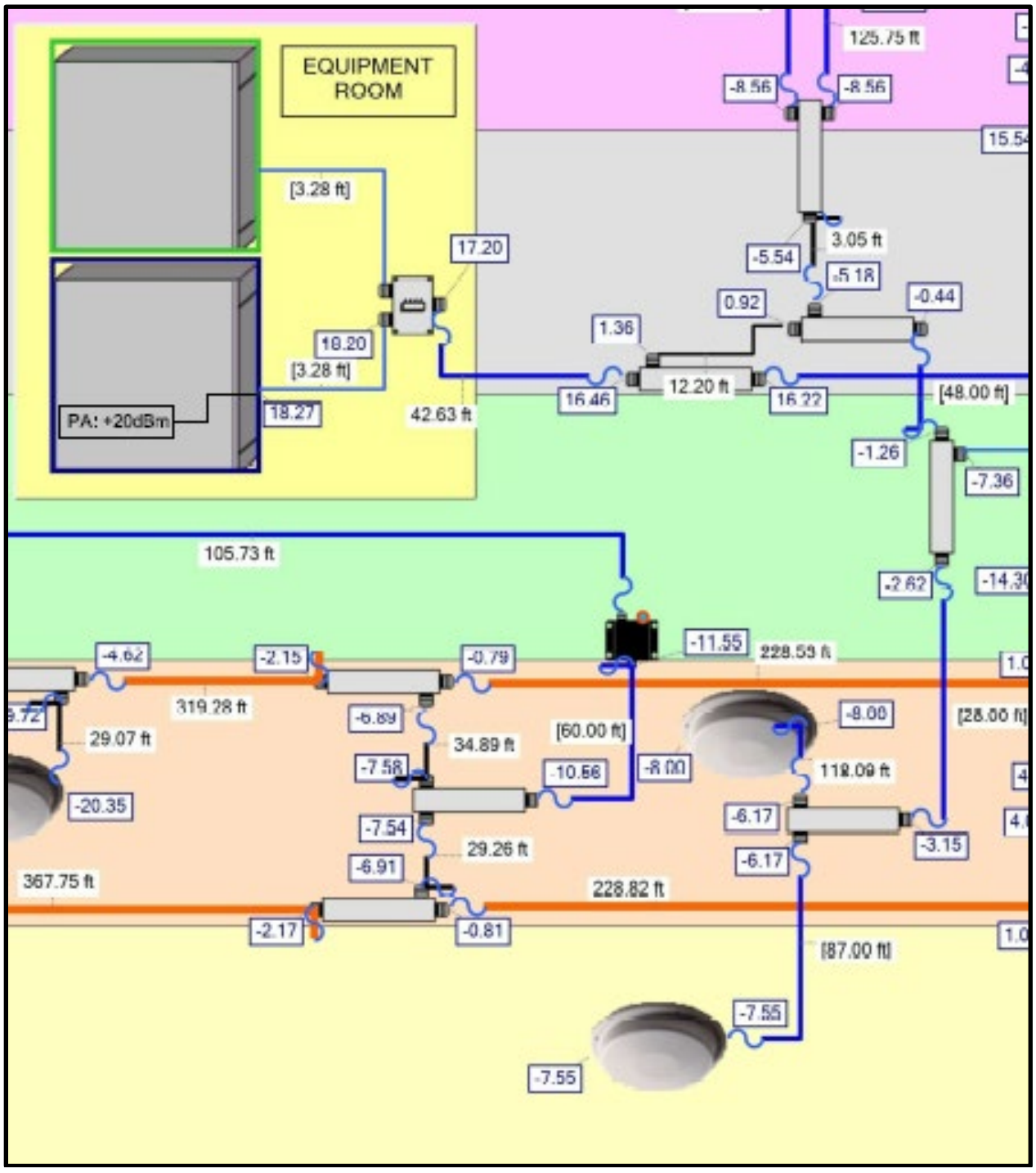
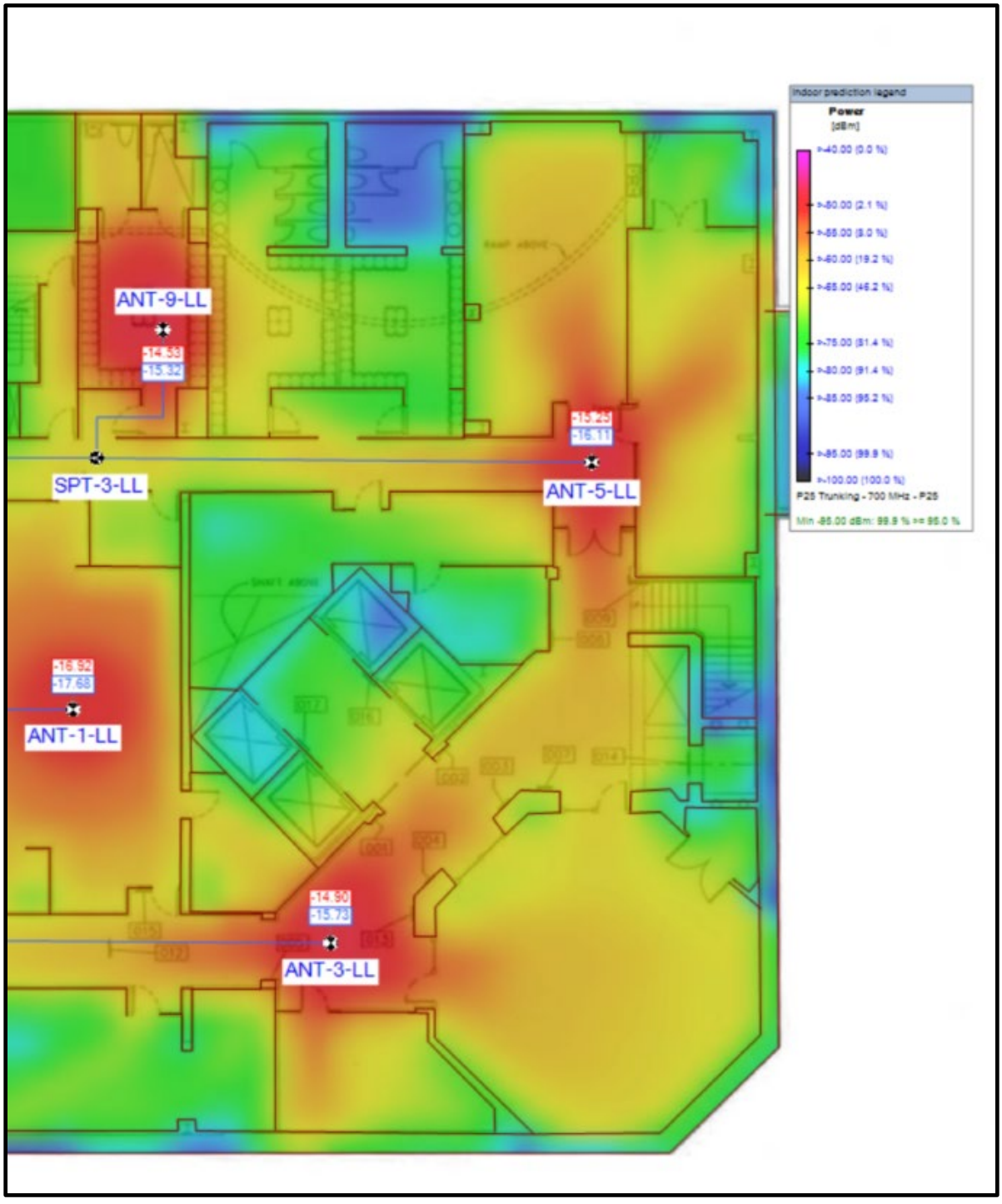


Exhibit E – Coverage Projection (Heatmap) Example



Appendix A – Glossary of Acronyms and Terms

AGC – Automatic Gain Control
ALC – Automatic Level Control
BDA – Bi-Directional Amplifier
BER – Bit Error Rate
CCSF – City and County of San Francisco
CFC – California Fire Code
CNR – Carrier to Noise Ratio
DAQ – Delivered Audio Quality
DAS – Distributed Antenna System
dB – Decibel(s)
dBm – decibel(s) relative to milliwatt
dBd – decibel(s) relative to dipole antenna
DL – Down Link
DLPA – Downlink Power Amplifier
EOL – End of Life
ERRCS – Emergency Responder Radio Communications System
ERCES – Emergency Responder Communications Enhancement System
ERP – Effective Radiated Power
FCC – Federal Communications Commission
GROL – General Radiotelephone Operators License
Hz – Hertz
IFC – International Fire Code
kHz – Kilohertz
LOD – Last Order Date
MHz – Megahertz
µs – microsecond(s)
NFPA – National Fire Protection Association
NICET – National Institute for Certification in Engineering Technologies
OEM – Original Equipment Manufacturer
PA – Power Amplifier
P25 – Project 25
RF – Radio Frequency
RFI – Radio Frequency Interference
Rx – Receive
SFDT – San Francisco Department of Technology
SFFC – San Francisco Fire Code
SINR – Signal to Interference plus Noise Ratio
TDMA – Time Division Multiple Access
TDI – Time Delay Interference
Tx – Transmit
UL – Up Link
ULPA – Uplink Power Amplifier
VNA – Vector Network Analyzer
W – Watt(s)

Appendix B – SFDT ERRCS Cybersecurity Requirements

B Cybersecurity Requirements

B.1 Scope - Remote Access Connections to BDA: ERRCS installers and maintenance providers shall ensure all remote connections used as gateways to the BDA are following the defined security standards 24/7/365. All guidelines are in adherence to CISA Cybersecurity Performance Goals and NIST Cybersecurity Framework 2.0 specifications.

B.1.1 Identify: ERRCS installers and maintenance providers shall identify and document all internet accessible devices and networks used to remotely connect to the BDA. They shall identify and mitigate any known vulnerabilities used to exploit and breach any network connected to the BDA.

B.1.2 Protect: Any ERRCS installer or service technician who will access the BDA via logical interface to adjust any settings, either locally or remotely, must use an active account of least privilege with a strong password and two-factor authentication enabled over an encrypted connection.

B.1.2.1 User accounts will use a strong password or passphrase with a minimum of 8 characters.

B.1.2.2 Two-Factor Authentication enabled for all user accounts.

B.1.2.3 User accounts should only have access to the applications needed to complete the required task. Restrict administrator privileges to dedicated administrator accounts.

B.1.2.4 Disable all dormant accounts.

B.1.2.5 Enable transport Layer security (TLS) to protect data in transit, when technically feasible.

B.1.2.6 Use AES-256 encryption of configurations and data-at-rest when technically feasible.

B.1.3 Detect: ERRCS installers and maintenance providers must document and maintain a list of Tactics, Techniques, Procedures (TTPs) and a list of threats that are relevant to exploiting remote access to BDAs.

B.1.4 Respond: ERRCS installers and maintenance providers shall maintain policy and procedures on to whom to and how to report all confirmed BDA cybersecurity incidents to appropriate external entities and regulators as required.

B.1.5 Recover: ERRCS installers and maintenance providers shall develop, maintain, and execute plans to restore access to BDA in case of access impacted by a cybersecurity incident.