Design Considerations for Florida County EOC Backup Radio Rooms

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Our Alachua County volunteer group learned the hard way that an Emergency Operations Center can be a difficult place to have optimal backup radio communications. This article is an attempt to provide opinions and options to help new designs or remodeling efforts.

PRIORITIES

County Emergency Managers likely prioritize the abilities to (a) reach the State of Florida FDEM with traffic if normal communications fail; (b) reach deployed locations such as shelters or points of distribution; and (c) reach nearby county or city EOC groups where mutual aid or other communications might be needed.

SYSTEMS

The typical radio systems available to meet these needs include:

1) Florida Statewide Law Enforcement Radio System[1], a 700/800 MHz repeater-based system connecting key assets for law enforcement as well as emergency manager (and potentially other) use.
2) Federal DHS/CISA SHARES[2] Automatic Link Establishment system, which allows for automatic choice of HF frequencies and alerting for voice or small message delivery. FDEM is actively encouraging this system and participating in exercises of this system.
3) SHARES Winlink radio email.[3] FDEM not only maintains a continuous Radio Message Server, but there are multiple others within the state which makes logistical communications easy in our area.
4) Satellite telephone -- noting that portable systems require a view of the sky, which may be difficult during a weather event sufficient to activate an EOC..
5) Amateur SARNET[4] UHF communications. A very easy-to-use system that is tested weekly, but has some unique fragilities as a "serial" connected system.
6) Amateur voice and WINLINK[5] HF radio communications (particularly since at the Winlink CMS, the Florida FDEM can be addressed easily from a message originated on a ham radio callsign.

Note that these system span the frequency range from low megahertz all the way to gigahertz, and from point-to-point direct line of sight communications through variable ionospheric refraction techniques.

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1 See: https://www.dms.myflorida.com/business_operations/telecommunications/public_safety_communications/radio_communications_services/statewide_law_enforcement_radio_system_slers

2 See: https://www.cisa.gov/shares-program-information Information about this program is intentionally limited. The SHARES program makes many federal HF frequencies and radio assets available for counties/states to utilize, and ham radio volunteers can serve their local EOC using these frequencies once the EOC is enrolled in the program, which is free and has no obligations. No risk, high benefit option for EOCs.

3 WINLINK is a software system connected to radio assets which allows the sending and receiving of emails, including attachments (such as small photos, documents, spreadsheets) over radio, without any requirement for a functioning Internet. Originally developed for ocean-going mariners, it has grown significantly with volunteer assets all over the world, and has been adopted and adapted to federal frequencies in the SHARES program, which maintains their own volunteer radio system assets available 24/7/365 all over the USA. This system allows EOCs to communicate by email to other counties or state agencies in the program, without need for Internet or satellites.

4 See: http://www.sarnetfl.com/ In Florida, the SARNET is a Florida DOT-based system using the decommissioned motorist assistance microwave system to allow ham radio UHF repeaters to operate like a "party line" telephone all over the state of Florida. Florida FDEM is involved and supports the use of this simple system for limited disaster tactical communications.

5 See: https://winlink.org/

PROBLEMS

The key hindrances to good performance include:

A) Excessive coaxial cable runs causing crushing losses of signal. At UHF frequencies, one can expect 4dB or more per 100 feet even with expensive LMR-400 cable. A 300-foot run can reduce the signal to less than 10% of the original power.
B) Damaging wide bandwidth RF interference noise from unfiltered backup power systems and computers, particularly high-power uninterruptible power supplies. These may add as much as 20dB to the noise floor and effectively wipe out most HF communications systems.

> At one Florida EOC, the installed computer and backup power systems generated very significant wideband radio frequency interference into the AC power wiring of the building. This allowed for radiation of the radio frequency energy all throughout and around the building for about 30 yards. This wideband RF "hash" interference made the use of crucial frequency bands, that are normally optimal for contacting the State EOC, unusable, because the interference was strong enough to wipe out most normal radio signals on those bands. Correcting these kinds of problems after construction is difficult and expensive.

C) Lack of adequate number of cable penetrations of the facility to allow for simultaneous antenna use on multiple bands. Having only one or two antennas for VHF/UHF, or HF communications can mean that you cannot monitor more than a couple of systems.

> Florida FDEM encourages county EOCs to participate in both the SHARES ALE (automatic link establishment) program and the SHARES WINLINK radio email system. The ALE system is similar to widely utilized military systems, and constantly switches between more than dozen HF frequencies, listening for a call. It is able to quickly make a connection to any involved county or state agency. However, this requires a dedicated, wide-band antenna dedicated to this purpose. Other voice communications or data communications will require an additional radio and antenna. Similarly, VHF/UHF voice & data communication options generally require more than one system to be monitored for optimal information flow.

D) Lack of sufficient height for any of these antenna systems -- Florida foliage losses and ground losses from our low-conductivity soil can be very significant. At UHF the losses through Florida tree growth can be 20dB per mile, effectively turning even a powerful station into a 3-mile radius performer.
E) Lack of adequate physical space to allow 3 or 4 volunteers to operate simultaneously without serious compromise. (Remember the COVID limitations?)
F) LIGHTNING Protection - EOC antennas may end up connected to 24/7 radios that must continue to work even in bad weather, including thunderstorms. Grounding and lightning arrester choices are important. Gas discharge tubes (the active component in a modern lightning arrestor) do degrade over time and recent commercial products make replacement with a new "button" easy and cheap. The correct power and frequency range must be selected for these components.[6] Providing a good "ground" for the radio room is also important.

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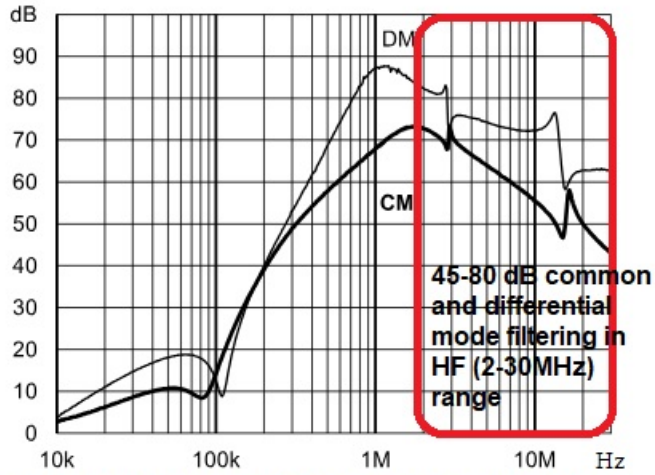
6 Attempting to push 400W of HF through a 50W VHF/UHF lightning arrester has an interesting outcome, based on sad experience.

CONCRETE SUGGESTIONS

Some suggestions to obtain optimum backup performance based on these systems, communications goals and typical problems include:

- Encourage volunteer communicators--or even a suitably qualified RF engineer--to be involved throughout the design, remodeling or construction process, as they can help make measurements and tests that will more likely result in an on-time success, rather than problematic "fixes."
- Provide industrial quality line filtering against radio frequency interference if there will be significant switched-mode power systems as part of the facility. It is much cheaper to provide this from the start than to have to re-build high power AC systems afterwards. The usual FCC limits are **not adequate** to protect the capabilities of high performance HF receivers. Industrial filters installed by electricians near the noise-producing power systems can significantly reduce the damaging RF power that flows into the building wiring system, acting as a huge, enclosing antenna system if these interfering currents aren't blocked. Factories using pulse-width-controlled motors and data centers are familiar with these solutions. The Shaffner FN2520-32 (32 Amp) AC line filter is just one example, which provides 45-80 dB isolation in crucial HF frequency ranges.[7] Correcting noise problems potentially involving both conducted and radiated noise is a significant RF engineering skill; be sure to enlist professionals or volunteers with expertise in this area.



Example Industrial EMC Line Filter - Shaffner FN2520-32 (32Amp)

- **Measure and then correct high ambient RF noise** (e.g. from data center or power line arcing) in the areas where antennas will be placed. Our local group has authored an example of a Protocol for easy measurement with a simple spectrum analyzer, and provided baseline comparison benchmarks.[8]

  Power line loose connections that radiate interference can be mitigated by the local power company. Wideband RF interference from installed computer systems can be more easily addressed at the initial construction than later. RF interference from poorly operating systems in neighboring residential or commercial establishment can be identified and owners assisted to correct issues.

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7 This particular filter is only one example of industrial common- and differential-mode AC line filters. See: https://www.schaffner.com/article/fn2520-32-07-c1111

8 Ambient HF Radiated Noise Measurement Protocol, 2019. Accessed at: https://qsl.net/nf4rc/2019/AmbientNoiseMeasurementProtocol.pdf

- Position the radio room within the building such that it will be near to exit points/walls closest to towers and substantial trees that provide mounting points for HF/VHF/UHF antennas. This will reduce cable runs and losses.[9]
- Provide a **very low resistance ground system** at the entry point of antenna cables, suitable for lightning protection (where currents may reach tens of thousands of amperes). Suitable systems often bond more than one ground rod together.[10] Run a short, heavy wire from this ground into the radio room without sharp turns or coils to avoid inductance.
- **Lightning Protection.** Either right outside, or right inside the building penetration, provide adequate gas-discharge-tube lightning arrestors for every coaxial cable. Each device must be properly chosen for the frequency range and power level to be utilized. VHF/UHF systems typically will be up to 100 watts. HF (3-30 MHz) cables should be protected for up to 1 kilowatt if possible, to allow for the use of amplifiers in the 400-1000 watt range. Some systems are rated for both HF and VHF/UHF. Choose commercial devices that allow for easy replacement of the internal gas discharge tube.[11]
- Provide high quality coaxial cable, particularly if any runs will be in physical situations that might become waterlogged. Direct Burial rated cable should be used for any of those, and in general, cable of RG-213 or LMR-400 size should be the minimum where possible

  An infamous historical example involved an important agency whose coaxial cables were said to have been "drowned" in runs underneath a parking lot. Water penetrates the coaxial cable jacket and corrodes the braid and wiring of susceptible cable.

- Provide a suitable antenna to reach preferably two potential SLERS repeaters. Cable length and antenna height will be important for that UHF system.
- Provide multiple VHF/UHF antennas (3 is a good number) to allow reaching multiple repeaters, including SARNET. Since one SARNET connection point may be turned off or disabled, attempt to have adequate antenna height to reach a secondary system as well. Omnidirectional vertical antennas are generally the easiest to mount on towers, and the goal should be to at least reach local foliage height to reduce immediate losses during leafy seasons.[12]
- For HF, our needs for reaching State and other assets generally are better served by Near Vertical Incidence Skywaves, rather than low-angle of radiation antennas favored for "chasing DX stations" (distant stations in other nations). As a result, in general, aesthetically pleasing vertical HF antennas are a **distinctly inferior choice** to low-loss multi-band **horizontal** HF antennas that work well on a wide range of frequencies. Wire antennas can be almost invisible and can be installed to survive high winds if suitable supports are available Our group favors Off Center Fed Dipoles driven with low-loss Guanella-type 4:1 baluns and of sufficient length so that their fundamental working frequency is the 160 meter band (e.g. 270 feet). A backup antenna is a very important item, and having a separate coaxial cable for that is very important. We avoid "voltage-baluns" because of the risk of radio frequency interference within the building from common mode currents on the coaxial cable.

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9 An example of a cable run loss calculator: https://timesmicrowave.com/calculator/

10 Paper explaining some of the options: https://topbandhams.com/tech-page/83-proper-grounding-for-safety-and-lightning-protection

11 For example, an HF/VHF/UHF 2kW-rated arrestor with replaceable cartridge and SO-239 connectors: https://www.dxengineering.com/parts/alf-att3g50uhp; with N-connectors: https://www.dxengineering.com/parts/alf-att3g50hp; replacement cartridge: https://www.dxengineering.com/parts/alf-3g50hp. This type device can be used for virtually all our frequencies.

12 One antenna for connection to SARNET, one antenna for local communications to deployed volunteers or personnel, and one as a backup.

- Provide a backup radio room that has adequate space for 4 older volunteers to work simultaneously.