Potential Antennas for Backup Radio Communications for New Alachua County Emergency Operations Center

Report Prepared for The Emergency Manager,
Alachua County
by the Alachua County ARES(R) Volunteers

EXECUTIVE SUMMARY

The Emergency Operations Center tasks local volunteers with providing emergency backup communications with local Shelters or other deployed volunteers, and with the Florida State Division of Emergency Management, as well as nearby counties. These volunteers generate quite significant Federal "match" dollars through their volunteer service both at the EOC and at Shelters, during declared emergencies. Volunteers maintain a significant number of redundant system and test them very frequently. **Since these systems depend on eight current external antennas at the present EOC including 4 that connect to the 90-foot EOC tower** for radio wave transmission and reception, **multiple external antennas will need to be reconstructed for all these systems at the new location of the EOC**. This document is designed to explain the needs and constraints, potential solutions, recommended solutions, and to provide a rough estimate of costs for materials.

The entire cost of materials for the complete multi-radio and multi-band antenna system proposed ranges from < $11,000 to approximately $17,000 depending on whether the EOC can utilize an existing crank-up /tilt-over tower that appears unused. These costs are approximate, and do not include labor. Our local volunteers are happy to help, but heavy installation steps would be better done by county employees or contracted professionals.

Avoiding destructive RF Noise (RFI):
It is also very important that installation of any high power system using switching power or control systems (such as mains-based uninterruptible power systems, or pulse-width-modulated HVAC systems) include suitable AC line common- and differential-mode filtering. This is a niche and esoteric part of electrical engineering that can require professionals to achieve low-noise systems. Our volunteers have some practical experience and also suitable measurement equipment and are happy to assist.

INTRODUCTION

Volunteers using appropriate FCC or NTIA[1] licensure provide, maintain, and provide recurrent testing for at least 6 emergency backup communications techniques at the EOC. Eight external antennas serve these backup functions, *four of which depend on the existing 90-foot tower*. Figure 1 is a sketch to show approximately where all of these antennas are located, including those on county-owned land south of the rear fence of the EOC. Placing all these antennas took years of experimentation and effort by our volunteers and county and contracted personnel.

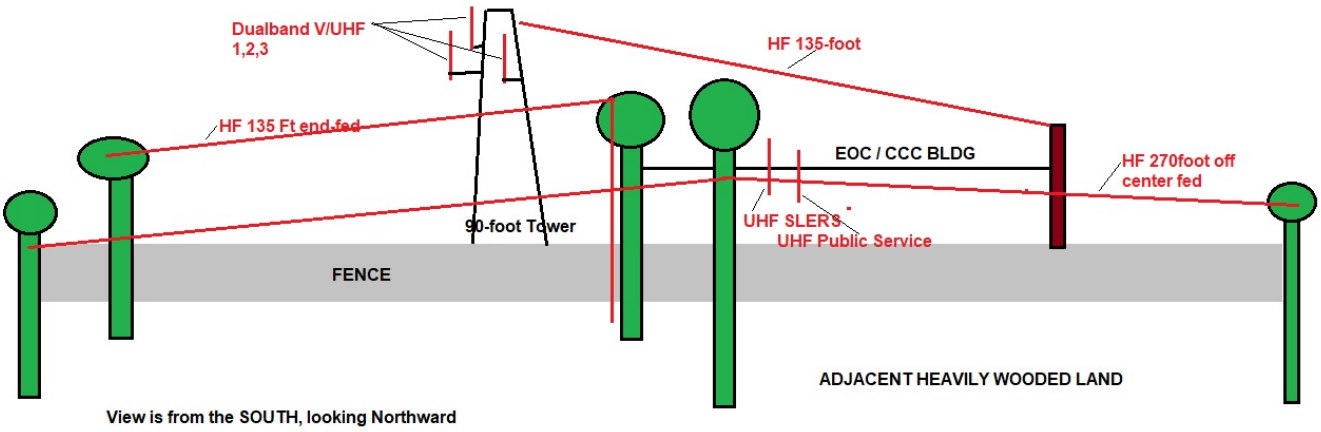

Figure 1: Existing EOC backup antennas at current location, installed over a period of years.

Table 1: Antennas and Functions

Antenna	Serves Function	Comment
Dual-band antenna at 60 feet on tower	Communications to shelters, and via SARNET to other counties and to Tallahassee FDEM	Good height, but close proximity of three antennas on the same tower caused interference problems.
Dual-band antenna at 60 feet on tower	Communications to shelters, and via SARNET to other counties and to Tallahassee FDEM	Good height, but close proximity of three antennas caused interference problems.
Dual-band antenna at 60 feet on tower	Communications to shelters, and via SARNET to other counties and to Tallahassee FDEM	Good height, but close proximity of three antennas caused interference problems.
270-foot off center fed dipole at 20-50 feet in woods	Data/Voice/ALE to State FDEM Alternate connection to local volunteers and	Constructed and maintained by our volunteers at no cost to county other than feedline extension

1 Our station at the EOC has federal licensure designated by NCS181, and FCC licensure designated as NF4AC.

	nearby counties / federal agencies	
130 foot end fed HF antenna	Backup antenna for the 270-foot off center fed dipole	Constructed & maintained by volunteers at no expense to the County. Shares single feedline.
130 foot off center fed (top of roof, from telephone pole to Tower)	Consensus-developed antenna that unfortunately experiences unremitting NOISE from EOC building	Constructed at great expense by EOC. Not able to be used at present due to radio frequency NOISE created by systems inside the EOC.
UHF SLERS antenna	SLERS comms to FDEM	Antenna provided and managed by Sheriff Radio Room
UHF Public Service antenna	Police/Fire monitoring	Antenna provided and managed by Sheriff Radio Room

Table 2 provides data on these techniques, and which of the current eight external antennas are used to make them successful.

Table 2: Current Backup Communications Techniques & their Antennae

No.	Description	Comment	ANTENNA UTILIZED
1	SHARES High Frequency (HF) voice and data channels	Florida DEM lists SHARES Data (technique: WINLINK) as a preferred backup technique to reach them. Some nearby counties also have this capability. SHARES Voice nets are also available on frequencies that are relatively clear at most times. This technique requires an antenna that can operate on multiple frequencies, but each for several seconds to minutes. We exercise these techniques weekly.	Two volunteer-created wire antennas at approximately 45-50 feet AGL in the woods south of the building and one commercial antenna stretched between the current EOC Tower and a specially placed telephone pole.
2	SHARES Automatic Link Establishment data channels (ALE)	Florida DEM lists SHARES ALE as the alternate preferred backup technique to be reached, or reach them. This technique requires an antenna that can operate on any of 10+ channels every second or so. We exercise these techniques several times each month.	Same three wire antennas as (1)

3	FCC Part 97 Amateur HF voice and data channels	During emergencies, one or more representatives including FDEM and nearby counties participate in a shared meeting ("net") on amateur frequencies on a continuous basis. This technique requires a multiband antenna, typical on the 3.5 and 7 MHz bands. In addition, this technique is applicable to reaching distant volunteer stations, POD's or shelters when VHF communications / radio assets are not successful. We exercise these techniques weekly.	Same three wire antennas as (1)
4	FCC Part 97 Amateur VHF/UHF voice and data channels	The traditional technique for communications between the Alachua County EOC and shelters, via privately provided VHF/UHF repeaters. This technique also allows for reaching representatives of FDEM via a series-microwave-linked repeater system known as SARNET, which is independent of the Internet, but somewhat fragile. We exercise these techniques weekly.	Three commercial dual band sturdy antennas at the 60 foot level of the current EOC tower, supported on side-masts and connected to the radio room by 300 feet of coaxial cable.
5	SLERS (Statewide Law Enforcement Radio System)	This UHF P25 technique based on proprietary radios, relies on interconnected repeater towers and is private for EM and LEO usage. We exercise this technique monthly.	Believed to be one of the array of antennas at the SW back corner of the EOC building by the loading dock.
6	Public Service UHF	Utilizing P25 radios on private channels for local law enforcement, when authorized we can reach city and county dispatchers. We do not typical exercise this technique.	Believed to be another of the array of antennas at the SW back corner of the EOC building by the loading dock.

For Reference when considering how these antennas will be replicated or even extended, a satellite view of the proposed new location, looking from the South:

FIGURE 2: View of the new location, from the south. 8th Avenue is the street to the north of the building. There is a metal fence around the facility. Reserve Park is immediately adjacent to the south. There is a high voltage power line running along the south edge of 8th Avenue. The power transformer for the building is at the immediate center right hand side of the building.

ANTENNA EMPLACEMENT CONSTRAINTS

Volunteers have conducted an assessment of the proposed EOC site and have cataloged the constraints on potential antennas ranging from high frequency (HF) to very high frequency (VHF) and ultra high frequency (UHF). Table 3 provides information on constraints that must be considered in any systems antenna design:

Table 3: Constraints on Antenna Emplacements

No.	Description	Comment
1	High Voltage Power Line	The high voltage power line running along the northern property border prevents antennas nearby that could potentially break or fall into contact with the line, of where the breakage of the line could contact the antenna, for extreme safety hazard. This is also a potential noise source, particularly if connections are damaged by high winds. At

		the moment, it seems quiet. (See Appendix for measurements.)
2	High voltage transformer power supply on a pole on the eastern border of the property.	No antenna can be near enough to this hazard to potentially break and contact the power lines. This is also a potential noise source, particularly if connections are damaged by high winds. At the moment, it seems quiet.
3	Potential difficulties with tower placement.	**The new location does not appear to be within any known historic district.** The building is outside the Duckpond historic district. (See confirmatory map below.) Local city ordinances (see Sec. 30-5.33 (H). - Wireless communication facilities and antenna regulations located within https://library.municode.com/fl/gainesville/codes/code_of_ordinances?nodeId=PTIICOOR_CH30LADECO_ARTVUSST_DIV2ACUSST_S30-5.34GE)) appear only to address **residential** amateur radio towers (not EOC governmental towers) but even in that instance, allow for a) towers up to 80 feet (more than we need) b) in rear yards c) approved by the appropriate engineer and designed to fall within property lines in the event of failure d) protected by fencing or alternately climb-proofed
4	Need to avoid antenna-antenna interference	Because of our need to be able to communicate and monitor on multiple systems simultaneously, it is important to provide separation between antenna systems. Our current set of 3 antennas on one tower cause very problematic VHF interference between data and voice channels, preventing simultaneous usage, until we worked our a very complicated duplexer-can filtering system. Our FIELD DAY 2022 and 2023 exercise experience has shown that antennas with center-to-center differences of <100 feet have significant power transfer which can result in damage to simultaneously operating systems if not protected by suitable filtering. The need to potentially operate wide-ranging ALE systems

		is a significant concern for this. As a result of these issues we encourage: a) At least ONE VHF/UHF antenna separated from others by 50+ feet[2] b) At least TWO HF multiband antennas with center-to-center distances maximized, but at least 100 feet.
5	Feedline protection	To avoid galvanic interactions on multiband HF antenna used for multiple transceivers using filter-based multiplexer systems, **feedlines combining aluminum and copper braiding should be avoided**. [3] Specifically LMR-400 should be avoided for all HF antennas and for at least one VHF/UHF antenna. To avoid wind-damage during hurricanes, and eventual sun-damage to PVC jackets, we recommend placing coax cables in underground waterproof PVC electrical conduit, of sufficient side that the cables can be serviced without having to dig up the entire conduit.[4] Also the use of pre-tinned copper braid can significantly reduce oxidation and rusting of the copper braid; for this reason, marine wires are almost exclusively tinned wires.

2 Our proposed design splits VHF/UHF antennas into two separated groups, and provides for 4 total VHF/UHF antennas providing significant redundancy.

3 See, for example: https://www.repeater-builder.com/antenna/ant-sys-coax.html and https://forums.radioreference.com/threads/lmr-400.320370/

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

Figure 3: The proposed new EOC does not lie within the NE Gainesville Historic District, which is the shaded area marked "1" well to the west of the large structure.[5]

5 Map from page 23, https://www.gainesvillefl.gov/files/assets/public/v/1/sustainable-development/planning-department/documents/historicpreservation_rehabilitationndesignguidelines.pdf

PROPOSED ANTENNA DESIGN

With considerable discussion, local volunteers with years of experience and engineering background have provided a potential sketch of an array of antenna and feedline systems that would provide for a range of replacement backup communications techniques, and provide flexibility for new techniques that may be requested in the future by FDEM.

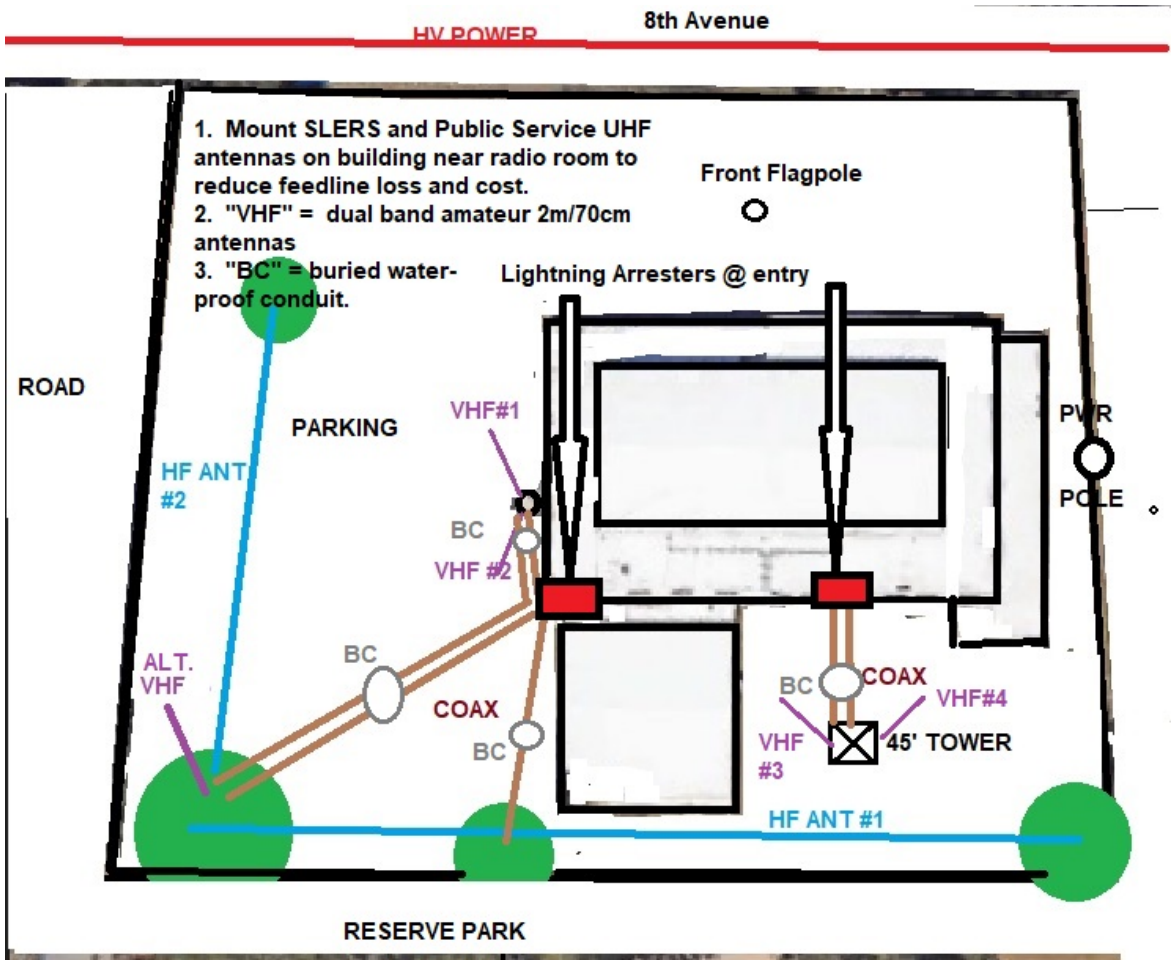

FIGURE 4: Sketch of proposed antenna placements.

SUPPORTING STRUCTURES

Table 4: Supporting Structures Assumed

No.	Description	Comment
1	45' crank-up nested (collapsible) tower[6]	We strongly suggest for cost-containment, that the county place a tower at the new facility that is of crank-up and tilting design. With fixed towers (such as the current EOC tower) every coaxial cable failure or antenna failure requires an expensive climber to go up the tower.[7] A crank-up tower can be "nested" during a hurricane, and tilted over so that ground personnel can make repairs. This will save the county a lot of expense over the lifetime of the tower. **All of the state's MARC trailers are equipped with a tilting, crank up tower.**  Figure 5: Photo of the MARC Unit #3 tilting, crank up tower being raised at our group's 2023 Field Day exercise, with multiple VHF/UHF and

6 Gainesville's topography includes a "ridge" that runs roughly through the center of Gainesville North/South, and is roughly 75 feet higher than the MSL altitude of the current EOC on Hawthorne Road. This poses a very significant problem in signal paths to the west of our County since radio waves do not go through dirt. The choice of 45 feet was made because the proposed new EOC's ground height (in MSL altitude) is 45 feet above that of the existing EOC, whose antennas at the 60-foot mark on the associated tower have relatively little margin for reaching Shelters in Hawthorne and Archer. The nearby buildings and foliage will exert loss on 144 MHz radio systems at both locations. Making the antennas at the new location 45 feet AGL (above ground level) will make them 90 feet MSL higher than the antennas at the prior EOC and increase the probabilities that we can have direct communication with even the distant edges of the county.

7 Typical climber fees are on the order of $3000 per day.

HF antennas attached. Without guys the tower can be extended to 50 feet; with guys, to 100 feet.

The County already owns a 100-foot tilting / crank-up tower of exactly this type, that is trailer mounted and has been stored by the Sheriff's office, but to our knowledge had moved infrequently in > 6 years.[8] This generally unused asset could be placed at the new EOC in usable condition and extended to 45 feet easily. Guy wires are not considered necessary at that height. The tower could be positioned on its existing trailer or removed and **hinged to a short supporting tower (even taken from the existing trailer supports) to allow the crucial tilt function to operate properly**.

Figure 6: The county-owned tower looks similar to this stock photo from the manufacturer, AlumaTower (see: https://www.alumatower.com/products/trailers/)

Additional surplus crank-up-tilting towers may be available from government sources. *These towers will dramatically reduce life-time maintenance costs, obviating the need for tower climbers.*

An estimated price for a steel retail crank-up nesting tower (not on a trailer) is in the range of $6-8,000.00 For Example the nested US Tower TMM-541SS 41-foot, 13-foot nested: https://www.hamradio.com/detail.cfm?pid=H0-002356

8 However, the week of September 18th -- it was no longer present behind the EOC building.

		This tower can support multiple VHF/UHF antennas, and also provide pulleys for supporting HF wire antennas. Base Kit for that Tower: $1800 https://www.hamradio.com/detail.cfm?pid=H0-015546 Towers of these types have a long track record of providing flexible supports for a wide array of antenna types. It could be hinged to a short support structure to become even more accessible. Aluma Tower provided a price list for their non-heavy-duty crank-up aluminum towers: ALUMA TOWER COMPANY **Aluma Tower Telescoping Towers** **Tower Models and Pricing** | Tower Model	Max Height (Feet)	Retracted Length (Feet)	Max Top Load (lbs.)	Wind Max Speed (MPH)	Sail Area (Sq Ft.)	Price Per Unit
---	---	---	---	---	---	---
T-35HN	32	12.75	125	70	18	$5,850
T-50HN	50	20.5	125	70	18	$6,350
T-75HN	71	25.75	125	70	18	$7,500
T-100HN	92	26	125	70	18	$9,850
T-35XHD	32	12.75	200	70	18	$6,500
T-50XHD	50	20.5	200	70	25	$7,200
T-50XXHD	50	25.5	300	70	25	$7,850
T-75XHD	71	25.75	200	70	25	$9,250	 • Mounting Pole (MP-2) can be added to any tower for an additional charge of $2,250 • All towers come standard with manual crank winch • All towers come standard with combo rotor plate • Guy kits, anchors, electric winches and other accessories sold separately • Crating and shipping not included in base pricing Figure 7: Aluma tower crank-up tower price list. These prices do not include a hinge mechanism nor a standing section on which to tilt, which can be assumed to be in the range of $2,000.
2	NW Oak Tree	The oak tree at the NW edge of the existing pavement can be utilized to help support an HF wire antenna with suitable sun-resistant nylon rope, emplaced pulleys and suitable weights.

3	SW Oak Tree	The oak tree at the SW edge of the existing property can be utilized to help support an HF wire antenna, and could, if other supports are not available, have a VHF antenna bolted or strapped to a branch or the trunk.
4	South Oak Tree	This smaller oak tree can support center- or off-center fed Baluns and feedlines.
5	South East Oak Tree	This oak tree can support the ends of HF wire antennas, with suitably emplaced pulley, nylon rope and weight.[9]
6	West Flagpole	The West Flagpole (assuming flags are placed on the North, street-facing pole) can have brackets installed at the top to support two VHF/UHF antennas. This is an unusual support, but it can be an economical one.
7	Building	The building's 2nd floor can have SLERS and Public Safety antennas (700/800 MHz) antennas mounted on it. Using a mast to help them clear obstructions may be helpful. Additionally, we would recommend the satellite antennas for low earth orbiting internet service be mounted on the building

For maximum lifespan, eye-bolts should be placed in trees by climbers or via boom lift[10], pulleys installed, and weighted lines used to maintain tension on wire antennas. Estimated weight required if the feedline of a center- or off-center fed antenna (possibly with Balun) is already supported, is in the range of 30 lbs and can be protected in PVC piping. The proposed end-fed north-south antenna does not have significant mass to be supported other than the wire itself and is also easily tensioned.

9 The purpose of pulleys and weights is to reduce the damage to the nylon ropes from friction as the trees sway in winds and rub the ropes. At one volunteer's house, ropes break approximately every 2 years and have to be replaced because pulleys aren't able to be placed. At another volunteer's house, where pulleys and weights are used, much better outcomes have been noted.

10 One of our members had this done by a tree surgeon at a cost of $25 per eye-bolt installed.

RECOMMENDED REPLACEMENT ANTENNAS

Table 5: Recommended Antennas

No.	Antenna description	Comment Coax cable treatment
VHF/UHF #1	Dual band antenna mounted on top of flagpole	A suitable example is the Diamond X-200A https://www.dxengineering.com/parts/dmn-x200a $130 Estimate $100 for suitable standoff hardware[11]
VHF/UHF #2	Dual band antenna mounted on top of flagpole	A suitable example is the Diamond X-200A https://www.dxengineering.com/parts/dmn-x200a $130 Estimate $100 for suitable standoff hardware
VHF/UHF #3	Dual band antenna mounted on tower	A suitable example is the Diamond X-200A https://www.dxengineering.com/parts/dmn-x200a $130 Estimate $100 for suitable standoff hardware
VHF/UHF #4	Dual band antenna mounted on tower	A suitable example is the Diamond X-200A https://www.dxengineering.com/parts/dmn-x200a $130 Estimate $100 for suitable standoff hardware
HF #1	Multiband HF antenna suitable for amateur and SHARES frequencies	The existing BUCKMASTER $300 off center fed antenna stretched over the EOC building from the tower to the telephone pole should be taken down and made available either for continuous use at the new EOC or as a spare. It can be taken down without difficulty since it is supported by ropes through pulleys. **Our current primary antenna was constructed by our volunteers at their cost**, 270 feet long off-center-fed dipole with 4:1 Balun. ***This antenna was chosen specifically to allow access to all federal frequencies for communications to the State EOC.*** It could be replaced using the

11 It is true that antennas and hardware could be retrieved from the 90-foot EOC tower, however unless the county has its own tower-climber personnel, the costs to retrieve these antennas might exceed their value.

		removed $300 commercial BUCKMASTER from the current EOC, or replaced using one of the following options under study:[12] • Delta-loop full wave loop version using same Balun • Commercial product parallel dipole Alpha Delta DX-CC $190, https://www.amazon.com/DX-CC-Parallel-Dipole-Alpha-Delta/dp/B00CUFIABY No matter which antenna is the final solution, the same type supports in the available trees will be utilized.
HF #2 (backup and flexibility)	End Fed antenna between Oak Trees	Current antenna was constructed by our volunteers at their cost, 130-foot end fed half wave dipole with ground rot. This antenna is still suitable, but will require the installation of a 6 foot ground rod at the base of the southwest oak tree. An alternative may be to use the BUCKMASTER to replace this antenna.
SLERS	Commercial antenna	Use suitable commercial 700/800 MHz antenna similar to that at current EOC.
Public Service	Commercial Antenna	Use suitable vertical or directional Yagi antenna, aimed at nearest P25 trunked repeater tower

12 The reason we are studying possible new antennas is that we have successfully created, using volunteer labor and parts, an **antenna multiplexer** that allows us to use multiple radios on one antenna, allowing us to monitor the State at the same time we monitor local volunteers or other counties on HF. This is a recent and surprising development and the implications are not yet completely clear.

FEEDLINE CONDUITS

To avoid corrosion damage, we ***strongly recommend*** that all coaxial cable feedlines

1. use corrosion-resistant solder-tinned braid (no bare copper braid),
2. be enclosed within conduit, underground where appropriate, with significant spare space to allow addition or replacement.

While typical low-loss modestly-priced coaxial cables have an outer jacket diameter < 0.5", the outer diameter of a PL-259 connector is 0.705". If it is necessary to pull an installed cable out of a conduit, it may be advisable to remove the connector first to avoid the risk of getting trapped.

Three coaxial cables in a conduit demand at least 1.5" internal diameter with no snags. *Friction can be considerable on a longer length.* We recommend **minimum 3" conduit** to provide for lower risk of entrapment and the possibility of additional cables (such as antenna switch cabling, rotator cabling) in the future.

Table 6: Estimates of Conduit Requirements for protected coaxial cable

No.	Description	Comment
1	To west flagpole	Above or below existing pavement. Estimated 45 feet to SW corner of building. If buried, recommend 3" PVC conduit.
2	To SW tree	Buried 3" PVC conduit, estimate 165 feet to SW corner of building
3	To S tree	Buried 3" PVC conduit, estimate 125 feet to SW corner of building
4	To Tower	(Depends on exact placement of tower) Estimate 50 feet to nearest building wall. Strongly recommend 3" PVC conduit and likely providing a spare coaxial cable at the initial install, particularly since this is only approximately 50 feet.

ENTRY PENETRATION

The ENTRY PENETRATION of these coaxial cables into the building should be built with the provision for future additions of cabling as technology changes the requirements for backup and monitoring radio communications. LIGHTNING PROTECTION is specified on every coaxial cable at

the point of entry (preferred) or immediately inside (sub-optimal). **We recommend a series of eight ground rods linearly between the SW corner entrance, the South wall entrance, and at the tower base, all connected by #4AWG wire.** The ground rods with bonding clamps for the ground cable can be sunk below the ground level and accessible via 6" irrigation cans. We recommend the application of a modest amount of dielectric grease on each bonding connection at installation. We recommend that the #4 AWG bonding wire between grounding rods and lightning arrestors be buried in the trench with conduit but (if permitted by code) be outside the conduit.

INITIAL BILL OF MATERIALS & ESTIMATED PARTS COSTS

Table 7: Estimated Costs of Materials (does not include labor)

Line No.	Item, description	Estimated Cost
1	Amateur Radio/SHARES HF/VHF/UHF coaxial cable. RG-213 solder-tinned copper braid, estimate total 1400 feet @ $1.25/foot There are a finite and limited number of choices in manufactured coaxial cables. Obtaining every possible desirable attribute is not always possible. We would recommend the following specifications: 1) RG-214 cable (which is tinned), or RG-213 with tinned braid 2) Tinned copper braid; ***does NOT have to be silver***; plain tin is fine. Tinning significantly reduces corrosion of coaxial cable braids.[13] Although Belden and other manufacturers produce tinned (or even silvered!) braid cables, it appears that one manufacturer, Ancor, a Wisconsin-headquartered company, appears to have the primary market share of this industry. Their catalog can be downloaded here: http://www.delzer.com/oneasg/ANC_CAT_003/16/; pages 16-17 provide some information on their various grades of tinned marine coaxial cable.	$1,750.00

13 See the detailed discussion here: https://nassaunationalcable.com/blogs/blog/tinned-copper-wire-vs-bare-copper-wire-when-is-it-best-to-use-each-in-cable-conductors Tinned marine wire (pioneered by Ancor) is all that I allow on my saltwater boat.

Wire Type	RG58C/U	RG59U	RG8X	RG213
Insulation Material	PVC*	PVC	PVC	PVC*
Nominal O.D.	3/16" 4.8 mm	1/4" 6.4 mm	1/4" 6.4 mm	13/32" 10.3 mm
AWG	20	23	16	13
Conductor Stranding	19/33	Solid**	19/29	7/21
Braid Coverage	96%	96%	96%	96%
Wt. per 1000'	26 lbs 11.8 kg	36 lbs 16.3 kg	40 lbs 18.1 kg	110 lbs 50 kg
Impedance (Ohms)	50	75	50	50
Capacitance/Ft.	30.8 pF	20.5 pF	26.0 pF	30.8pF
Attenuation/100'				
@50MHz	3.3db	2.4db	2.5db	1.3db
@100MHz	4.9db	3.4db	3.7db	1.9db
@1000MHz	21.5db	12.0db	13.5db	8.0db
Velocity of Propagation	66%	66%	78%	66%

* non-contaminating insulation ** copperweld

FIGURE 8: available information on Ancor marine coaxial cables.

The loss characteristics of coaxial cable are primarily determined by
a) size
b) dielectric content of AIR.

Foamed dielectrics have lower losses than the original polyethylene, but are not as sturdy against impressed loads and can short out as the center conductor can slice through the foam under heating conditions.

Available prices for Ancor marine-grade coaxial cable in the RG-231 size suitable for VHF/UHF:

> Anchor RG213 tinned braid & center -- as low as $1.25/foot
>
> https://www.anchorexpress.com/ancor-white-rg-213-tinned-coaxial-cable-250-151725
> https://www.westmarine.com/ancor-rg-213-129876.html

3) This assumes placement in a sealed waterproof chaise underground, with inverted U's at the ends and a way to blow compressed air through the chaise to remove collected water from time to time.
4) Direct burial cable recommended if buried without conduit for an attempt at water protection.[14]

2	Various termination connectors (PL-259, possibly N connectors, estimate)[15]	$ 100.00
	LMR-400 equivalent for SLERS & Public Service Antenna feedlines (mounted on building and thus not buried) Estimate 50-75 feet each	$ 150.00
	Estimate for N-connector terminations	$ 50.00
3	Lightning arrestors, quantity 10, suitable for HF or VHF / UHF up to 1kW. Strongly suggest models allowing replacement of inexpensive gas discharge tube for lowest life cycle costs. Example: https://www.dxengineering.com/parts/alf-att3g50uhp	$ 550.00
4	3" PVC waterproof conduit, estimate 400 feet (Approx $7/foot in small quantity; county may be able to get a discount on 400 feet. See: https://www.lowes.com/pd/CANTEX-Common-3-in-Actual-3-in-Non-Metal-PVC-10-ft-Conduit/1002431310	$2,800
5	Dual band fiberglass VHF/UHF amateur vertical antennas suitable for tower mount. Qty 4. Example: https://www.dxengineering.com/parts/dmn-x200a	$ 520.00
6	HF#1 and HF#2 antennas, including using existing materials and donations from volunteers	$ 200.00
7	SLERS antenna (commercial) Unknown, estimate $200 (mounted on building)	$ 200.00
8	Public Service Antenna (commercial) Unknown, estimate $200 (mounted on building)	$ 200.00
9	Additional internal coax, to reach from entry to radio room; presuming backup radio room positioned as close as possible to entry point of feedlines. Estimate 9 antennas x 50 feet @ $1.25/ft for RG-213 cable	$ 560.00
10	45 foot crank-up tower - assuming existing county-owned tower can be utilized (Replace with $6-10,000 if commercial tower has to be purchased)	FREE
11	Estimate of cost for tower mounting on concrete base / fixed tower section for tilting, if desired	$1500.00

14 "Direct Burial" may only mean that there are much fewer defects in the jacketing material. If there is a single defect, it can allow electrolytic damage to the cable through the movement of electrons.

15 While PL-259 (male) / SO-239 (female) connectors do cause an "impedance bump" and are NOT optimal for UHF they have the advantage of positive mechanical connection that will survive loading. The center connector of N-connectors (much smoother impedance continuance) has been known to pull out of the female connector when a dereccho damaged antennas in Iowa, leading to loss of communications. N connectors should not be left under strain.

12	8 ground rods, NEC-compliant; 8 foot (Lowes price: see https://www.lowes.com/pd/Galvan-0-625-in-x-8-ft-Copper-Grounding-Rods/3446270)	$ 144.00
13	Ground Rod Clamps (either 1 or 2 on each ground rod) see: https://www.lowes.com/pd/Sigma-Electric-ProConnex-5-8-in-Grounding-Clamp-Conduit-Fitting/1099921	$ 53.00
14	#4 AWG Bare ground wire, solid, to interconnect 8 ground rods and tower and lightning arrestors in entire group. Estimate 125 feet https://www.lowes.com/pd/4-Gauge-Solid-Soft-Drawn-Copper-Bare-Wire-By-the-Foot/3345460	$ 250.00
15	6" buried irrigation access box for sunk ground rod access. Qty 8 https://www.lowes.com/pd/NDS-0-in-L-x-6-in-W-x-8-38-in-H-Round-Irrigation-Valve-Box/1060257	$ 80.00
16	Dielectric Grease for preserving electrical connections (ground wire bonding; coaxial cable connections). Qty 2. https://www.lowes.com/pd/GUNK-Outdoor-Gunk-Outdoor-Anti-Seize-Lube/5000877061	$ 14.00
17	Estimate for 4 pulleys for HF antennas, nylon rope, weights, eye-bolts	$ 150.00
ESTIMATED MATERIALS TOTAL IF EXISTING TOWER UTILIZED		$10, 670
ESTIMATED MATERIALS TOTAL IF NEW TOWER PURCHASED[16]		$17,000-$21,000

16 In a single multi-day deployment of our volunteers to shelters, Federal match of this amount or greater can be justified merely by our volunteer hours.

APPENDIX:
VALIDATING RADIO FREQUENCY NOISE LEVEL OF SITE

Background: After HF antenna installations at the existing EOC, costing thousands of dollars, **were stymied by enormous, wide-band radio "hash"** produced (presumably) by backup-switching-power systems at the EOC/CCC, our group became much more cognizant of the due diligence requirement to vet the background RF noise level of any proposed installation.

We therefore created and published a standardized background noise measurement technique.[17] This technique was validated by demonstrating that it showed background noise levels at the EOC roof to be great than 1,000 times greater (30dB) than those at a residential amateur radio station.

On Tuesday, September 12, 2023, with assistance from the current owner of the property in question, standardized measurements using the published procedure were made both at the back, and front of the building.

Figure 9: RF background measurement equipment, including Siglent Spectrum Analyzer, standardized test antenna, battery and inverter power supply.

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

The measurements indicated that the noise level at the site is very low, indistinguishable from the baseline "quiet residential" setting, and 1,000 times quieter than the current Alachua County EOC. This indicates that it is reasonable to install and provide backup radio services at the proposed location.

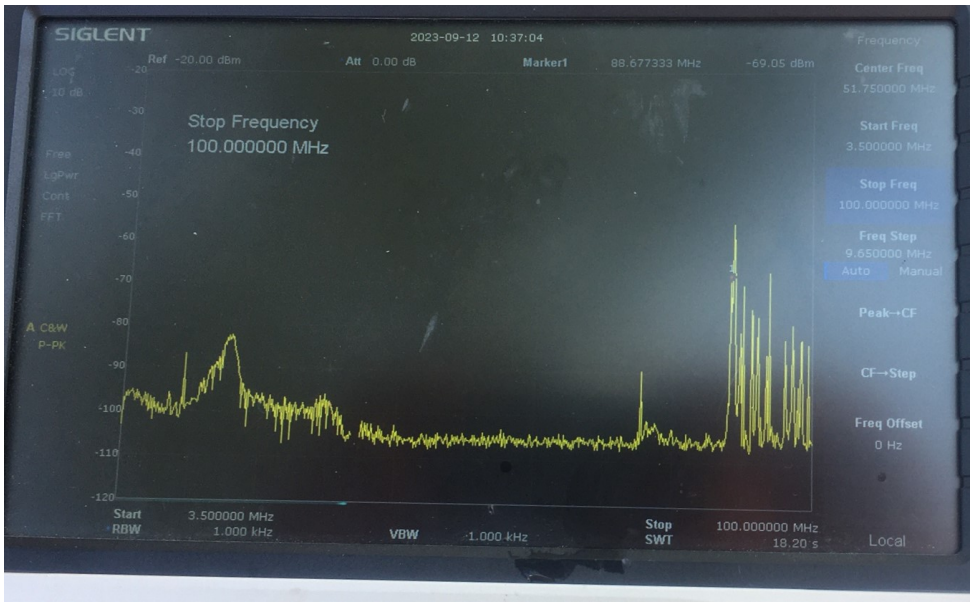

Figure 10: *3.5-100 MHz measurements, SW corner of property. . RBW = 1kHz (quite narrow, improving the sensitivity of the device). The bump in the noise floor at the left end of the spectrum at approximately 18MHz comes from the battery-inverter power system utilized, and the baseline system noise sensitivity of approximately -95dBm is limited also by that same sensitivity. The measurement demonstrated the background noise is at or below -95 dBm in the crucial HF frequency range used to reach local counties and the Tallahassee FDEM.* ***By contrast, measurements at roof level of the current EOC were often as strong as -60dBm, or > 1000 times as much noise.***

Commercial FM stations are visible in the upper end of the spectrum for comparison, between -60dBm and -70 dBm on the measurement system.

CAVEAT: **This happy finding can be destroyed by purchasing and installing high power noise-making switching systems in the new EOC <u>without proper filtering</u>.** Our baseline measurements will assist in detecting if new noise generators are installed.

It is very important that the designers of HVAC, power and backup power systems at the new facility pay very careful attention to both radiated and conducted RF noise generation by switching power supplies at lease in the range of 3-30 MHz.

Part 15 requirements are *quite loose*, and do *not* provide a guarantee that our ability to reach Tallahassee FDEM will be unhindered by noise emanations from high power switching power systems.

Designers are encouraged to use the same techniques utilized by industrial power engineers to provide high quality line-filtering as close as possible to high level noise producing devices, particularly

- **Pulse width modulated HVAC systems**
- High power backup uninterruptible power supplies (UPS)
- High power modified sine wave or pure sine wave alternators or inverters, such as from solar or backup power system
- High power charger controllers typically utilized in solar power systems

All of these systems are FREQUENT radio frequency noise polluters even when they ostensibly meet Part 15 regulations. Proper metallic shielding and high quality line-noise filtering will solve these problems, but are much cheaper to insert at the start of design, than after construction is finished.

The filter specifications of a typical industrial EMC line filter in graphical form are demonstrated in Figure 11, with reduction in common and different mode filtering of 50-80 dB in the crucial 3-30 MHz range. The example filter is rated at 32A RMS @ 240VAC or > 7.5 kW. Such filters are very available and very commonly used in factory installations.

The proper installation and usage of such filters close to conducted and radiating noise generators can be an important part of a design that reduces RF noise generation to maintain the ability of our backup radio communications gear to perform to its inherent potential.[18]

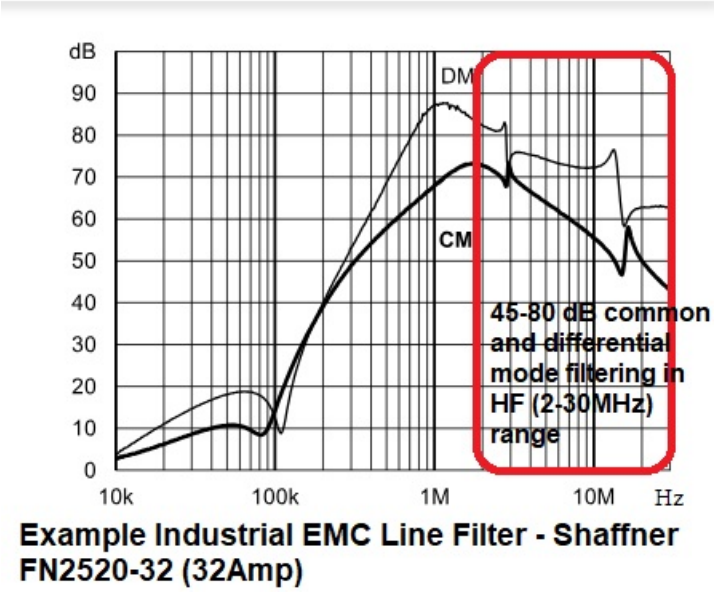

Figure 11: Example of filtering specifications for industrial line filter

18 Tutorials on EMI design: https://www.ato.com/power-line-filter-basics-working-principle; https://interferencetechnology.com/emi-filtering-101-understanding-the-basics/