ALACHUA COUNTY BACKUP RADIO ANTENNA REQUIREMENTS

Justifications

Alachua County Amateur Radio Emergency Service (ARES(R)) Volunteers
North Florida Amateur Radio Club
Alachua EOC Radio Club

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December 11, 2023

INTRODUCTION

Alachua County radio volunteers[1] have made significant gains in proficiency and professionalism over the past 5 years. Our current Integrated Preparedness Plan[2] is now expiring and will need to be reviewed and updated. We have a written emergency communications plan for coordinated response.[3] We have nearly 2-dozen badged volunteers[4] in compliance with State Statutes designed to protect vulnerable citizenry.[5] During declared disasters, our deployed volunteers provide ICS-214 documentation, suitable for gaining the county very significant Federal Match reimbursement, often reaching tens of thousands of dollars per incident.[6] Training level data are maintained and available on our volunteers.[7] We carry out multiple annual exercises and events,[8] and have typically planned those using the Incident Command System and documented written After Action Report/Improvement Plans. Our group is nationally recognized as a leader in this area, and was selected to provide leadership for the American Radio Relay League 2022 National Convention Emergency Communications training. Here are just the documentation for events and incidents of the past few years:

Exercise or Event	Exercise Plan or other Planning	AAR/IP
Jan 27-28 2024 Winter Field Day	See document embedded within: https://www.nf4rc.club/winter-field-day-2024-signup-docuent/	
Hurricane Idalia	-- (utilized communications plan)	https://qsl.net/nf4rc/2023/AARIPHurricaneIdalia.pdf
2023 (summer) Field Day	https://qsl.net/nf4rc/2023/FieldDay2023/ICS201GLG2023.pdf (includes multiple separate sub-documents)	https://qsl.net/nf4rc/2023/FieldDay2023/2023FieldDayAARIP.pdf
2022 Ian & Nicole	--	https://www.nf4rc.club/historical-exercises/2022-alachua-county-auxcomm-volunteersresponse-to-hurricane-ian-ts-nicole/

1 Web page: https://www.nf4rc.club/ Legacy web page: https://qsl.net/nf4rc/ (Non-WordPress site)
2 Integrated Preparedness Plan: https://qsl.net/nf4rc/2022/DraftAlachuaCountyARESIntegratedPreparednessPlanning.pdf.
3 Backup radio communications plan: https://qsl.net/nf4rc/AlachuaCountyCommsPlan2022.pdf
4 Badged volunteers: https://www.nf4rc.club/how-to-docs/county-ares-docs/badging-list/
5 https://www.nf4rc.club/how-to-docs/county-ares-docs/state-volunteers-legal-docs/
6 Federal Match: https://www.fema.gov/hmgp-appeal-categories/cost-sharing
7 https://www.nf4rc.club/how-to-docs/county-ares-docs/training-level-data/ Taskbooks: https://www.nf4rc.club/how-to-docs/county-ares-docs/fl-ares-taskbook/ and specific to our County: https://www.nf4rc.club/how-to-docs/county-ares-docs/alachua-county-comms-taskbook/
8 For example, 2023 Activities: https://www.nf4rc.club/club-history/2023-year-in-review/; 2022 Activities: https://www.nf4rc.club/club-history/2022-accomplishments/

Exercise or Event	Exercise Plan or other Planning	AAR/IP
2021 Exercise Whirlwind Boom	Documents at: https://www.nf4rc.club/historical-exercises/2021-whirlwind-boom/	AARIP state and local at: https://www.nf4rc.club/historical-exercises/2021-whirlwind-boom/
2021 (summer) Field Day	https://qsl.net/nf4rc/2021/NFARCDraftICS201.pdf	https://www.nf4rc.club/historical-exercises/2021-field-day-after-action-report/
2021 Simulated Emergency Test		https://qsl.net/nf4rc/2021/2021SET AAR BRW Edit 21 10 08.pdf
2020 (summer) Field Day		https://qsl.net/nf4rc/2020/AlachuaCountyARES2020FIELDDAYAfterActionReport.pdf
2020 Exercise Hot and Cold		https://qsl.net/nf4rc/2020Conference/CreateSpaceHotColdAARIPBlackInk.pdf

Our communications capabilities **depend on radio** since we are a backup for public switched networking systems. Radio communications depend on suitable and effective antennas. This document will provide details of antenna justifications.

RADIO BACKUP SYSTEMS

Modern public-switched networks are extremely well-developed redundant data systems that move huge amounts of data continuously. However, they depend on copper, fiber, or rarely microwave connections, and complex switching/routing systems. These are targets for malicious damage by state or non-state actors, as well as at risk due to weather. [9] [10] While generally reliable, failure modes are known. The communications failures of Katrina are legendary, with police almost without working radio systems, and "running to the sound of gunfire" -- as documented in a Congressional report.[11]

Cable breaks can occur due to construction accidents.[12] Cell towers without power function only for a limited number of hours, and Florida has experienced inaccessible towers due to flooding, where refueling trucks simply can't make it to the tower. Tennessee has had famous outages due to icing, which misaligned microwave antennas, and due to domestic terrorism bombing. Iowa has experienced high strength dereccho winds that completely isolated a major city -- loss of almost all normal communications systems. The 2020 Cedar Rapids, Iowa dereccho left the city virtually without working communications, and state offices were unaware for many hours that there was a need for help.

> *A key focus of the IDHSEM report is the communications breakdown: massive phone and internet outages led to strained resources, duplicated efforts, and a lack of support for vulnerable populations like immigrants and refugees.*
>
> *"There was not a backup process for communication and coordination for long-term power and cellular outages. For the 14 days following the storm, communication capabilities throughout the state varied, and in some areas, there was consistent conflict of information," the report reads.*
>
> *Examples of communication failures include accounts of semi-trucks full of ice arriving in local communities unprompted and Department of Transportation workers arriving at dump sites only to discover they been given inaccurate operating hours.*[13]

As a result of these known threats and hazards, Florida Division of Emergency Management has encouraged counties to have backup radio communications systems. Alachua county radio volunteers participate with several nearby counties and with the Florida Division of Emergency Management in multiple backup radio communications systems, each with unique advantages, disadvantages and limitations.

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9 https://www.cisa.gov/news-events/cybersecurity-advisories/aa23-215a
10 https://nap.nationalacademies.org/read/10330/chapter/3
11 https://www.qsl.net/nf4rc/KatrinaComms.pdf
12 Florida Panhandle hurricane response experience was that heavy equipment would re-break freshly repaired fiber, over and over again.
13 State analysis of 2020's dereccho response highlights communications breakdowns, coordination issues. https://www.iowapublicradio.org/ipr-news/2021-11-17/state-analysis-of-2020s-derecho-response-highlights-communications-breakdowns-coordination-issues

At the time of this writing, FDEM maintained a horizontal HF loop antenna as well as a rotatable HF log-periodic antenna.

FDEM HF log-periodic antenna

Alachua County Backup Long Distance Backup Radio Systems

No.	Backup Radio System	Frequency(ies)	Modulations / Bandwidth	Limitations	Advantages	Disadvantages
1	Amateur Radio voice "nets"	Published frequencies on the 3.5 MHz and 7MHz bands	3kHz SSB	Varying propagation, accidental and malicious interference	Simple technology requiring only wire antennas	Low throughput, varying reliability, interference
2	Amateur Radio digital radio-networked email (WINLINK[14])	Published data frequencies	Advanced VARA[15] and PACTOR[16] 2.7kHz data streams approaching Shannon limit	Varying propagation, overloading in emergency / disaster scenarios	Inexpensive, daily usage, large number of volunteer relay stations, 35,000+ monthly message usages[17]	Limited national throughput in time of disaster due to limited spectrum
3	DHS SHARES[18] voice nets using NTIA-allocated frequencies. (licensed as NCS181)	Unpublished frequencies throughout shortwave spectrum	3kHz SSB	Varying propagation, limited planning for usage	Simple technology	Lack of realistic stressed exercises

14 WINLINK system: https://winlink.org/
15 VARA: https://www.sigidwiki.com/wiki/VARA_HF
16 PACTOR 3: https://www.sigidwiki.com/wiki/PACTOR_III
17 TOOLS: https://winlink.org/RMSChannels; click on "TOOLS" tab to find monthly traffic totals by various means.
18 SHARES, an office of CISA/DHS: https://www.cisa.gov/resources-tools/programs/shared-resources-shares-high-frequency-hf-radio-program

4	DHS SHARES radio email network (SHARES WINLINK)[19] [20]	Unpublished frequencies throughout shortwave spectrum	Advanced VARA and PACTOR III/IV data modulations[21]	Varying propagation	Sparse usage provides significant availability for disaster service. FDEM maintains their own node server	Not suitable for megabyte sized files, but useful for Resource Requests, modest spreadsheets.
5	DHS SHARES Automatic Link Establishment (ALE)[22]	Unpublished frequencies throughout shortwave spectrum	Simple 2nd Generation ALE modulations	Limited data throughput	FDEM can provide monitoring and encourages county usage[23]	Modest throughput
6	Statewide Law Enforcement Radio System (SLERS)[24]	700/800 MHz voice (FM)	Voice FM	No data throughput	Little training required	Voice only; serial system easily overloaded
7	Handheld Satellite telephone system	Satellite frequencies	Advanced modulations	No data throughput	Commercial system	Not suitable for human use during dangerous weather, requires clear view of sky

Local Backup Radio Systems

Alachua county volunteers also maintain local short-distance radio systems that are independent of the computer/internet-dependent trunked systems used for public service. Our systems include amateur

19 Note that one of our badged members, Gordon Gibby MD, is separately licensed by DHS SHARES as NCS521/NND4FL and operates a 24/7/365 SHARES RMS radio email server.

20 State of Florida FDEM operates an internet-independent DHS/SHARES RMS radio email server. With our current systems and antennas, we can generally offer 24/7 connections directly to this server, completely independent of any network or Internet.

21 Encryption is an option, end to end.

22 ALE: https://en.wikipedia.org/wiki/Automatic_link_establishment Currently we use ION2G software on an ICOM 7300 transceiver with good success on our NVIS antennas. https://ion2g.app/

23 When FDEM is activated, with our current systems and antennas, we can generally offer 24/7 direct radio contact, independent of any network or Internet system.

24 https://www.dms.myflorida.com/business_operations/telecommunications/public_safety_communications/radio_communications_services/statewide_law_enforcement_radio_system_slers; currently we gain access through the Payne's Prairie tower.

radio voice repeaters, direct (simplex) point-to-point communications to radio antennas affixed to 14 shelters and at a modest number of Fire Stations. In addition, we have developed a significant data communications system including both ancient AX.25 modulation and newer, higher-speed VARA-FM OFDM multi-carrier data modulations. We have a modest number of low-height AX.25 digipeaters and WINLINK internet-gateways, and one 500-foot elevation VARA-FM digipeater.

Using these local backup radio systems we normally provide backup direct, or repeater-dependent communications to all normally chosen Alachua County shelters[25], and with deployed, badged personnel, should be able to provide emergency communication to most or all Fire Stations if required, as well as "points of distribution." Our volunteers are experienced in short time frame deployment of emergency antennas, battery power systems, and portable radio systems.

25 Alachua County radio antenna-equipped shelters: https://qsl.net/nf4rc/Alachua County Emergency Shelters MASTER 08-27-2020.pdf

ANTENNA JUSTIFICATIONS

Our current antennas at the existing Alachua County Emergency Operations Center, and our requests for antennas at the proposed new Emergency Operations Center, are designed to accomplish the missions which we have been assigned for which we train, within the constraints within which we operate.

VHF/UHF MISSIONS

No.	Description
1	Direct or repeater connection to deployed volunteers at Shelters, Points of Distribution, or Fire Stations
2	Incoming data transmissions of logistical information from deployed volunteers
3	Over-watch of the statewide SARNET
4	Ability to respond to the SLERS system calls
5	Ability to communicate / respond on public service channels

Current VHF/UHF Antennas

Current 2meter/70cm Antennas	3 vertical co linear antennas at the 60-foot level of the existing EOC tower
700/800 SLERS	?Yagi back of EOC facility
Public Service	Additional 700/800 MHz back of EOC facility

Our short-range VHF/UHF antennas are designed to allow us to maintain **concurrent voice and data connectivity to local shelters, points of distribution or Fire Stations**, to which suitably trained volunteers have been deployed, with or without the 14 portable radio boxes provided by the Office of the Sheriff in addition to monitoring of the SLERS and Alachua County/Gainesville public service frequencies. Voice communications can be carried out either direct (point to point) or via relay or repeater, using FM voice over FCC amateur frequencies.

Simultaneously, we can provide immediate reception of incoming data messages via our peer-to-peer WINLINK capability, which does not require immediate human operation, but will capture incoming messages for review whenever possible. We have utilized duplexer-can notch filtering to allow both voice and data communications simultaneously on typical frequencies despite our antennas being co-located on the same tower at the 60-foot level.

We have one remaining redundant VHF/UHF antenna at the current location, which can be utilized to maintain a watch over the state SARNET connected UHF repeater network, or used as a backup in the event of failure of one of the other two antennas.

In our proposed design, we provided an additional redundant antenna and we separated the VHF/UHF antennas into groups with lateral physical separation to reduce the need for complicated duplexer can notch filtering for simultaneous operation.

PROPOSED VHF/UHF ANTENNAS

Ant	Type/Task	Comment
1	Dual Band (2meter / 70 cm) Vertical #1: Voice watch over deployed locations, either direct or via repeater	Separated physically from the data incoming antenna
2	Dual Band (2meter / 70 cm) Vertical #2: Data watch (does not require human over-watch, to reduce the number of volunteers required)	Separated physically from the voice watch antenna
3	Dual Band (2meter / 70 cm) Vertical #3: UHF monitoring of the SARNET frequency for nearby counties or State of Florida information	
4	Dual Band (2meter / 70 cm) Vertical #4	**Redundant** in case of failure
5	SLERS	700/800 MHz Pointed at suitable SLERS tower
6	Public Service	700/800 MHz pointed at suitable Alachua County tower

VHF/UHF connectivity (absent repeaters) is generally point-to-point space wave. Local foliage, buildings, etc provide considerable absorption (published values as much as 20dB/mile). The radius of coverage (to ground penetration) of a single VHF/UHF antenna, measured in statute miles, is approximately 10-20% greater than the square root of the height of the antenna in feet.[26] Alachua county has a rolling topography with a general higher point in the middle of the city of Gainesville. The current EOC is located roughly 40-50 feet lower than that peak elevation. As a result, even with our 60-foot antennas on a fixed tower, we cannot provide reliable backup direct radio communication to the farthest shelters (Archer, High Springs, likely Hawthorne). Relays are required in the absence of repeaters to reach those locations.

26 This range estimate is determined by the rate of curvature of the earth and a modest amount of diffraction of radio waves. More in depth information can be found at: https://en.wikipedia.org/wiki/Line-of-sight_propagation

MSL (Mean Sea Level) Elevations

Site	MSL Elevation (Google Earth)
Existing EOC 1100 SE 27th St	126 feet
Proposed EOC 1125 NE 8th Ave	171 feet

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The proposed new EOC is located on somewhat higher ground. Making reasonable engineering assumptions, we believe we can have substantially equal communications connections with multiple antennas at roughly the 45 foot level due to the higher location (MSL) of the proposed EOC. Due to the significant absorption of the tree canopy in Gainesville, we would not recommend reducing this height significantly.

HF MISSIONS

Practical Objectives During Disaster

No.	Mission (Objective)	Antenna Requirement
1	**Direct or relayed radio connections to the State of Florida FDEM radio systems in Tallahassee Florida.** a) Continuous ALE scanning during disaster for connection to FDEM. b) Alternate with discontinuance of that service to send/receive radio email via public or SHARES Winlink system.)	Requires a large number of separated frequencies from 2-25 MHz; antenna must be separate from other antenna; impossible to multiplex when the transmitter can hop through ten frequencies in seconds. Low loss is highly desirable, hence tilted multi-wire terminated antennas have been avoided in favor of longer off-center fed antennas which have given us good service.
2	**Simultaneously**: Direct or indirect (relayed) *radio* connections to nearby counties with potential for mutual aid, completely independent of wired networks a) Watch over Florida HF voice communications nets b) Alternate with as needed: Ability to connect by *radio* to nationwide volunteer or DHS SHARES Winlink radio email systems, as well as DHS SHARES voice nets	Typical frequency bands, 3.5, 7 MHz, 14 MHz. For optimal performance, need a physically 130-foot antenna at 30+ feed AGL.

Compromise Due To Electromagnetic Interference

Our current shortwave (HF) antennas are a considerable *compromise* designed to meet our operational needs in spite of very significant obstacles. Expensive and well-planned shortwave antenna installations at the current Alachua County EOC[27] have **failed** due to radiated and conducted wide-band electromagnetic interference (EMI, in simple terms, *noise*) from switching power systems provided for computer and backup systems at the building. About two year of documentation and study went into discovering the cause and solving these issues. The wideband noise picked up by normal antennas at the current location is roughly 20 dB (100 times) stronger than that at typical residential volunteer housing locations.[28] [29] This level of EMI noise made inter-county and county-to-State communications very nearly impossible for several years.

Our research and testing indicated that the noise from the switching systems had a "near field" quality and a falloff with distance that was considerably faster than the r^2 spatial weakening of a theoretical point source of RF energy.[30] Experiments conducted on June 29, 2019, showed that we could mitigate the EMI noise by moving our antennas 100-200 yards away from the building, despite increased RF losses in the required coaxial cable to reach those antennas.[31]

As a result, our volunteers constructed a primary and backup HF (shortwave) antennas within a wooded property lot purchased by the County just south of the current EOC building.[32] **These antennas demonstrated much more normal noise levels and have been successful for our missions.**

Importance of Significant HF Antenna Height Above Florida Soil

27 Including a multi-thousand dollar wire antenna installation (https://qsl.net/nf4ac/2018/AntennaConsensusDocumentation.pdf) stretching over the roof of the current EOC from the fixed tower to an emplaced telephone pole at the southeast end of the building -- unusable due to EMI.

28 Residential noise documentation: https://qsl.net/nf4ac/2019/GibbyAntennaBaselines042232019/GibbyHouseAntenna181540metertune04232019.jpg; same test at EOC showing 20dB more noise: https://qsl.net/nf4ac/2019/EOCResults04232019/EOCAntennacs40mtune.jpg

29 Interior of home residence noise measurements https://qsl.net/nf4ac/2019/GibbyEFieldBaseline042232019/GLGHouseE-Field2ftwand10AM04232019.jpg @ -115dB using specific sensing antenna; same measurements inside EOC at -84 dB (30 dB more intense) https://qsl.net/nf4ac/2019/EOCResults04232019/EfieldAntennaEOC151604232019.jpg

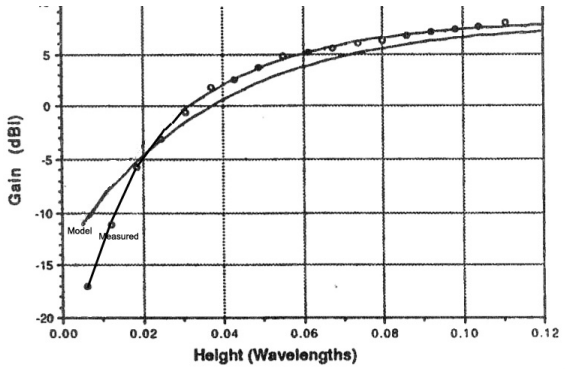
30 Near-field type falloff: https://qsl.net/nf4ac/2019/May18Investigations.pdf

31 Farther-away antenna successful test: https://qsl.net/nf4ac/2019/OakTreeAntennaData.pdf

32 An example of a report of work on these volunteer-funded and installed antennas: https://qsl.net/nf4ac/2021/AARJan262021AntennaWork.pdf

Florida soil, sandy in nature, is of particularly low conductivity, especially when compared to rich farming soil of the Midwest.[33] Radio wave propagation from HF antennas is a complex combination of direct radiation and reflection/absorption by the ground beneath the antenna.[34] In order to carry out our missions, we need strong radiation at relative high angles of radiation, to make the geometry of Near Vertical Incidence Sky wave (NVIS) reflection from F1, F2 ionospheric layers to Tallahassee, the site of the Florida Division of Emergency Management.[35]

As a result of those mission requirements, we have attempted to place horizontal or sloping dipole type antennas, at heights between 30-50 feet.



Comparison between measured (data points plotted as an open circle) and calculated gains for a 6 MHz horizontal dipole vs height of the dipole (h/λ). The curves are the theoretical gains (according to NEC-3) for two ground conductivities, measured by the authors at the test site where they made their their gain measurements, on two different occasions [Hagn and Barker, 1970]. The conductivity corresponding to the lower curve was 24 mS/m (ε_r= 51); for the upper curve 58 mS/m (ε_r= 53).

From https://www.w8ji.com/nvis_n_v_i_s_antenna.htm

Vertical antennas, while aesthetically popular have a **very low-angle elevation radiation**, suitable for long-distance communication, but at a *very significant disadvantage* for communications to Tallahassee, Ocala, or Miami. Nearby counties with vertical antenna systems have consistently shown poorer success rates in mission-oriented communications in monthly tests.

Horizontal antennas at a height of 1/4-1/2 wavelength are considered optimal for our intra-state communications. Raising the antenna to this 30-50 chosen height has the effect of significantly reducing ground losses in Florida low-conductivity soil. Antennas at low height (such as used in Vietnam warfare) will have far higher radiation losses above Florida soil, and thus we have avoided them.

An advantage of this 30-50 foot horizontal antenna height is that for higher frequencies (such as 14, 21 or 28 MHz) the height in wavelengths of the antenna becomes greater, and the elevation angle of maximum radiation lowers, allowing a geometry suitable for longer-distance communications. Our volunteers have leveraged this into quite successful radio email connections to volunteer and DHS SHARES radio-email servers throughout the Midwest, Canada and the Caribbean, such as providing communications or relay possibilities for Puerto Rico.

Optimal HF Antenna Solutions

Our current HF antenna systems are a compromise. We have only ONE HF coaxial line. Our antennas, by necessity to escape the high EMI (noise) environment, are located within a wooded area via 300 feet of coaxial cable, and are at considerable risk for damage due to high winds causing limbs or trees to fall and damage our wires. As a result, we created two antennas, using one as a backup. At the proposed EOC location we have requested similar antennas to provide the same level of service and backup. The MSL height advantage of the proposed new location does not provide any significant HF

33 Official FCC estimates for our area are between 2-4 millimho per meter. See: https://www.ecfr.gov/current/title-47/chapter-I/subchapter-C/part-73/subpart-A/section-73.190

34 See the disastrous effect of placing an antenna too close to the ground in the chart here: https://www.w8ji.com/nvis_n_v_i_s_antenna.htm

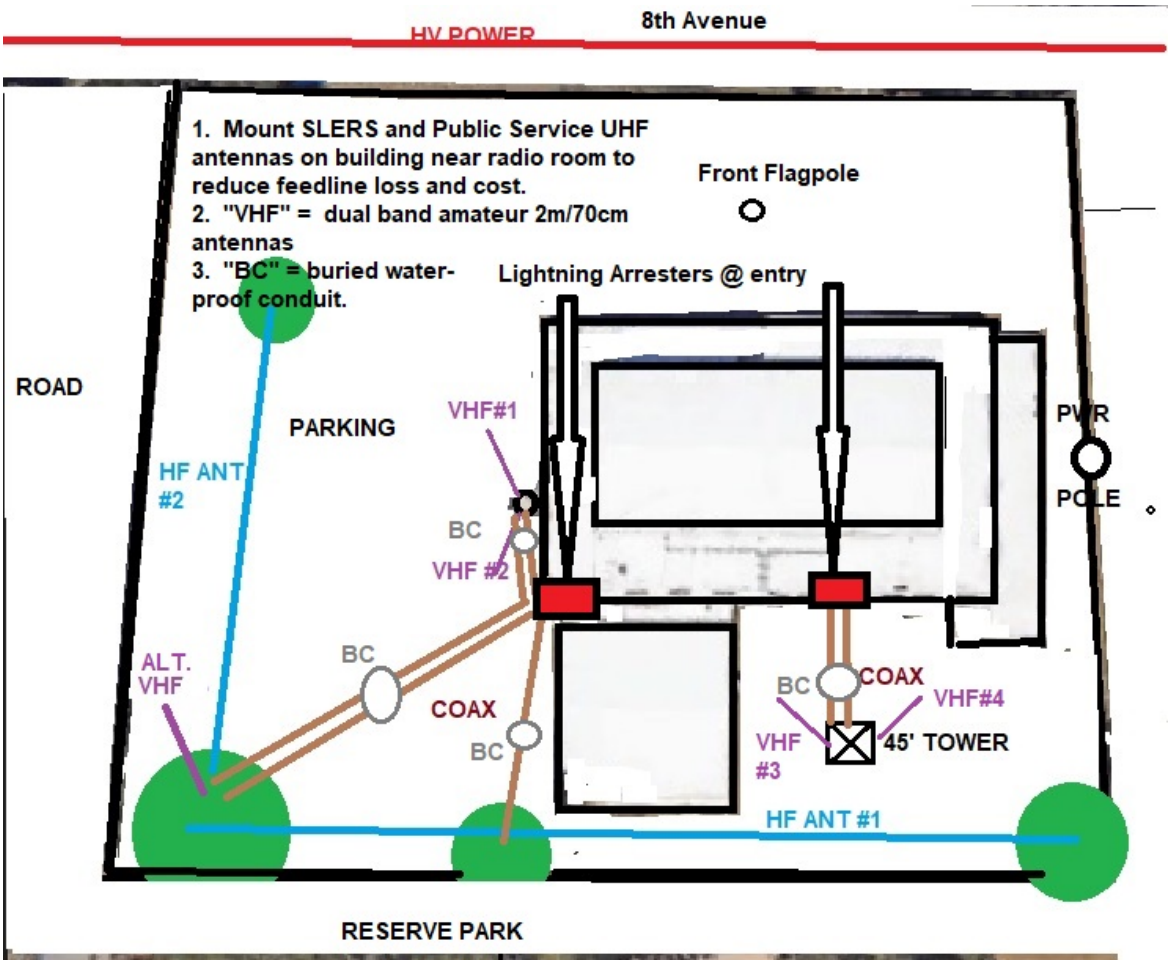
35 https://en.wikipedia.org/wiki/Near_vertical_incidence_skywave

advantages, different from the situation at VHF/UHF. We are unable with our single coaxial cable system, able to connect to only one antenna at a time, to optimally carry out our HF objectives.

Because our team may need to utilize almost any frequency of HF communications between 3-30 MHz, we have developed inexpensive multi-band antennas. One of our antennas is a compromise off-center fed dipole which provides reasonable matching across a wide swath of frequencies; the other is an end-fed half-wave antenna which is more suitable for harmonically related frequencies.

Objective Improvement Proposal

We propose two separate HF antennas, at right angles to each other for minimal coupling.[36] While the proposed property location (with a high tension wire along the northern boundary) is not large enough to support optimal separation of antennas, we have a modes amount of experience with right-angle antennas and suggest this is the optimal compromise.



Proposed Antenna Installations, showing HF Antenna #1 and HF Antenna #2 with separate feed lines. Available at: https://qsl.net/nf4rc/2023/AntennaProposal4.pdf

36 New EOC Antenna Proposals: https://www.nf4rc.club/how-to-docs/county-ares-docs/2024-new-eoc-antenna-proposals/, also available at: https://qsl.net/nf4rc/2023/AntennaProposal4.pdf

SUMMARY

Our volunteer backup radio group has multiple objectives to provide both local and distant radio communications that are completely independent of wired networking systems. Our short-range VHF/UHF objectives are considerable:

VHF/UHF MISSIONS

No.	Description
1	Direct or repeater connection to deployed volunteers at Shelters, Points of Distribution, or Fire Stations
2	Incoming data transmissions of logistical information from deployed volunteers
3	Over-watch of the statewide SARNET
4	Ability to respond to the SLERS system calls
5	Ability to communicate / respond on public service channels

In order to meet those simultaneous objectives, we have proposed installation of multiple antennas with simultaneous access (multiple feed lines):

PROPOSED VHF/UHF ANTENNAS

No.	Task	Comment
1	Dual Band (2meter / 70 cm) Vertical #1: Voice watch over deployed locations, either direct or via repeater	Separated physically from the data incoming antenna
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3	Dual Band (2meter / 70 cm) Vertical #3: UHF monitoring of the SARNET frequency for nearby counties or State of Florida information	
4	Dual Band (2meter / 70 cm) Vertical #4	**Redundant** in case of failure
5	SLERS	700/800 MHz Pointed at suitable SLERS tower
6	Public Service	700/800 MHz pointed at suitable Alachua County tower

Our longer-range (HF) communications goals are also multiple:

Practical Objectives During Disaster

No.	HF Mission (Objective)	HF Antenna Requirement
1	**Direct or relayed radio connections to the State of Florida FDEM radio systems in Tallahassee Florida.** a) Continuous ALE scanning during disaster for connection to FDEM. b) Alternate with discontinuance of that service to send/receive radio email via public or SHARES Winlink system.)	Requires a large number of separated frequencies from 2-25 MHz; antenna must be separate from other antenna; impossible to multiplex when the transmitter can hop through ten frequencies in seconds. Low loss is highly desirable, hence tilted multi-wire terminated antennas have been avoided in favor of longer off-center fed antennas which have given us good service.
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In order to meet those simultaneous objectives, we have proposed installation of multiple antennas with simultaneous access (multiple feed lines):

No.	Antenna
1	Multiband HF Wire Antenna suitable for use on both Federal and Amateur Frequencies; multiband with usable performance on most or all frequencies 2-30 MHz with low loss
2	End Fed Half Wave type antenna at right angles to HF Antenna #1 for minimum coupling.

Much more complete technical details can be found in our 24-page antenna proposal document, https://qsl.net/nf4rc/2023/AntennaProposal4.pdf