NEW ALACHUA COUNTY EOC BUILDING RADIO TOWER RECOMMENDATION EMPIRICAL TESTING RESULTS OCT 12, 2024

Alachua County ARES(R) Volunteers
October 12, 2024

Executive Summary

Our local ARES(R) Emergency Management-affiliated volunteer group has made a recommendation for a 50-foot telescoping/tilting radio tower at the new EOC location. However, we lacked experimental proof that this height would be sufficient for communication to local shelters by VHF radio. Although the new EOC location is on ground that is 43 feet higher than the elevation of the current EOC, a 50 foot tower is *shorter* than the current placement of VHF/UHF antennas on the massive tower at the current EOC, and this results in more tree/vegetative absorption of radio signals. We lacked proof that the increased ground elevation would overcome the disadvantage of the lower proposed tower height relative to tree canopy.

Therefore, on October 12, 2024, our group carried out a validation experiment using an available tower which was even shorter -- only 34 feet height. At the same time, we were able to test a newly recognized option of 50MHz (6 meter) single sideband (SSB) communications.

FINDINGS

(1) **Our recommendation for a 50-foot tower is validated as adequate for our local communications on 2 meters (144 MHz) FM.**

Our findings conclusively validated that despite tree canopy absorption, a tower height of 50 feet would provide adequate direct radio coverage using 2-meter (144 MHz) FM widely-available communications to most of the county. However, in this test, we were unable to prove that we would be able to directly reach the often-used Easton-Newberry shelter, on 2-meter (144 MHz) FM, but it appeared possible.

(2) **A recently recognized option for 6-meter (50 MHz) single sideband was validated as potentially even better.**

Our findings also surprisingly showed that a previously un-utilized option of 6-meter (50 MHz) SSB communications could provide clear county-wide direct radio backup communications given adequate antennas. This is of interest to us because moderately-priced transceivers with this capability are now becoming much more widely available in the amateur radio community. We should add a 50 MHz simple, modest-cost antenna to our plans for the new tower at the new EOC. As more volunteers acquire transceivers capable of this operation, this will become more and more useful to the county.

NOTE: file location c:\...\Projects\REDCROSSHAMCLUB\2024\NewEOC\TowerTest\SimulatedTowerRadioTest.odt

INTRODUCTION

The Alachua County Emergency Operations Center will move from its hardened concrete location on Hawthorne Road (135 ft MSL) , to the renovated Army Reserve center from World War II on significantly higher ground (178 ft MSL), on 8th Avenue NE. This move will provide much larger space and Alachua County Fire Rescue Headquarters is expected to move into this facility as well.

Alachua County ARES(R) has requested multiple antennas to replace and enlarge upon the two high frequency (HF) antennas, 3 VHF/UHF antennas, and 800MHz public safety antennas that we utilized at the previous EOC site.

Among those requests was a 50-foot telescoping, tilting tower that could support HF, VHF and UHF antennas. We theorized that due to the higher elevation of the newer site, the reduction in tower height from 60 feet to 50 feet would be acceptable. The lower tower height likely results in increased VHF/UHF losses in radio waves traveling through vegetation and tree canopy, but we suspected the farther distance to contact with ground due to the higher ground elevation would adequately or more than adequately compensate.

This radio range test, conducted in early October before most of the vegetation cover is lost, was designed to test that theory and assess whether a shorter tower would provide sufficient backup radio coverage to shelters and citizens of Alachua County.

METHODS

On Saturday, October 12, 2024 a small contingent of our volunteer crew[1] deployed our portable, trailered 34 foot telescoping, tilting Aluma Tower to the Reserve Park adjacent to the new EOC location. We attached a commercially available 2-meter (144 MHz)[2] high quality FM vertical antenna to the mast atop the tower, rotated the tilting-tower to vertical and extended it to approximately 34 feet length. 75 feet of high quality LMR400 coaxial feedline connected this antenna to a 50-watt ICOM 5100 2-meter FM transceiver.

Using the small sidearm, previously attached to the tower, and a rope, we elevated a homemade 6-meter (50 MHz) inverted vee antenna to approximately 25 feet, using a second rope to keep it clear of the tower to avoid being tangled in the tower. 100 feet of RG8X coaxial cable connected this modest antenna to an ICOM 7300 transceiver capable of 100 watts output.

1 David Huckstep W4JIR, Eric Pleace KO4ZSD, Manish Sahni KZ4KC, Gordon Gibby KX4Z

2 Because wavelength and frequency are interrelated by the equation wavelength x frequency = speed of light, it is common for amateur radio operators to refer to "bands" of frequencies by their approximate wavelength, as well as by frequencies.

Figure 1: Attaching the 2-meter vertical antenna to the top of the mast.

Figure 2: The completed antenna installation including vertical 2-meter antenna and homemade inverted V 6-meter antenna suspended by rope.

Figure 3. Operation of test transceivers in the back of an SUV, David Huckstep W4JIR shown at the controls (center).

Beginning at 0900 Local we conducted the following tests:

No.	Test	Time allotment	Power Level
1	Announcement on local 146.820 repeater, then connect to as many stations on 2-meters (146.550 MHz FM simplex) as possible, making notations of approximate signal strength in both directions	30 minutes	50 watts output
2	Connect to as many stations on 6-meters (50.135 MHz upper side band simplex (USB)) as possible and make notations of S-meter readings in both directions	10 minutes	*Inadvertently conducted at 3 W output*
3	Continued connections at 50.135MHz asking stations to give us updated strength measurements.	20 minutes	Conducted at 100W upper sideband

Table 1: Tests Conducted

RESULTS

TWO-METER FM TESTS

In Test #1, on 2 meters (146.550 MHz FM) we were able to reach across large amounts of the County as shown by selected successful connections shown in Figure 4. The connections shown were of sufficient strength and clarity to be usable for communications. Connections where only portions of words were intelligible are omitted. Because signal strengths on 2-meter radios are often not easily quantified, we do not have quantified strengths. A total of at least 18 voice stations were able to make contact. Additionally we tested contact to several automated digital data stations, with results shown in Table 1.

Station	Description	Result	Comment
KX4Z-12	VARA radio message server on the other side of ridge line running through Alachua County	Direct connection successful with good data throughput (failed to record signal to noise ratio)	Would allow send/receive of radio email.
W4DAK-7 DARK	Automated AX.25 digipeater in Trenton, FL on 100+ foot tower	Partial connection. Not good enough for data throughput	We are used to successful connections from current EOC antennas.
NF4CA-11	Automated VARA digipeater in south Columbia county on tower	Direct connection with good data throughput, +12 dB Signal to Noise ratios reported in both directions in a "ping" test	Provides access to amateur radio data assets in Columbia County
NF4CA-10	Automated VARA digipeater in south Columbia county at a home location.	Unsuccessful connection, but owner reported our signal was received successfully	

Table 2: Data Stations Connections on 2 meters

Two data points on 2 meters deserve special mention:

1. WB2FKO (High Springs) reported he could just hear us, and our reception of him was marginal as well
2. WA4AMY (Trenton) could not be received by our test station, but was copied by KG4VWI (SW Gainesville) and by W4UFL (NW Gainesville at 170 ft MSL elevation)

SIX-METER SSB TESTS

In Test #2 we inadvertently had set the transmitter output power to only 3 watts, which is below what most handheld walkie-talkies produce. Nevertheless we were making connections to stations in all directions and most distances later completed at 100watts. Upon discovering the mistake, we corrected the power level to 100W and collected final data of signal strengths. Stations reported that our signal strength had increased by notable amounts, and in several cases our signal had become very easily readable. Figure 5 demonstrates that with this level of power output, we were reaching stations at the east edge of the county (station using a non-optimal antenna) and beyond the northwest edge of the county (station using an optimized 6-meter Yagi beam antenna). The station on the east edge of the county reported that our intelligibility on the 6-meter frequency was better than on the 2-meter frequency.

Receiver gain and background noise levels: In all of the 6-meter tests we utilized "preamp #1" on the ICOM 7300 transceiver. This increases the gain of the receiver and increases the resulting signal strength meter (S-meter) readings.

NOTE: Background noise levels on the 6-meter (50.135MHz) frequency were undetectable on the S-meter readout. Stations with as little as S-1 displayed signal level were clearly and plainly audible.

No.	Station	Location	Their report of our signal strength when transmitting only 3 Watts voice	Their report of our signal strength when transmitting 100W voice
1	KG4VWI	SW Gainesville	S-8	S-9
2	K9RFT	Melrose	"barely hearing us"	S-3
3	KK6BS	CR 241 area, NW	"barely hearing us"	S-5 "full quieting"
4	WB2FKO	High Springs	S-1 to S-2	10 over S-9
5	W4GHP	NW Gainesville, near TV-5 tower	S-9	S9 + 10dB
6	K4ZSW	39th Ave just inside I-75	"barely hearing us"	S-2
7	W4IT	Ft White, FL	S-2	S-2

Table 3: Significant Reception Reports on 6 meters using low and high power

A comparison of communications on 6 meters to that on 2 meters was possible for 3 stations at considerable distances. In two out of three cases, signals on 6 meters were considerably better than on 2 meters.

No.	Station	LOCATION	Result on 2 meters	Result on 6 meters @ 100W
1	K9RFT	Melrose (eastern county border) using makeshift 6-meter antenna	"close to noise"	S-3; intelligibility notably better than on 2 meters
2	WB2FKO	High Springs	Heard his callsign but unable to make contact	We heard him as S2 (easily readable) and he heard us as extremely strong, 10dB over S9
3	KZ4JN	Keystone Heights	We heard him easily, "loud and clear"	He heard us S1 and we heard him S1, both readable signals

Table 4: Selected comparisons of 2 meter versus 6 meter communications results at great distances

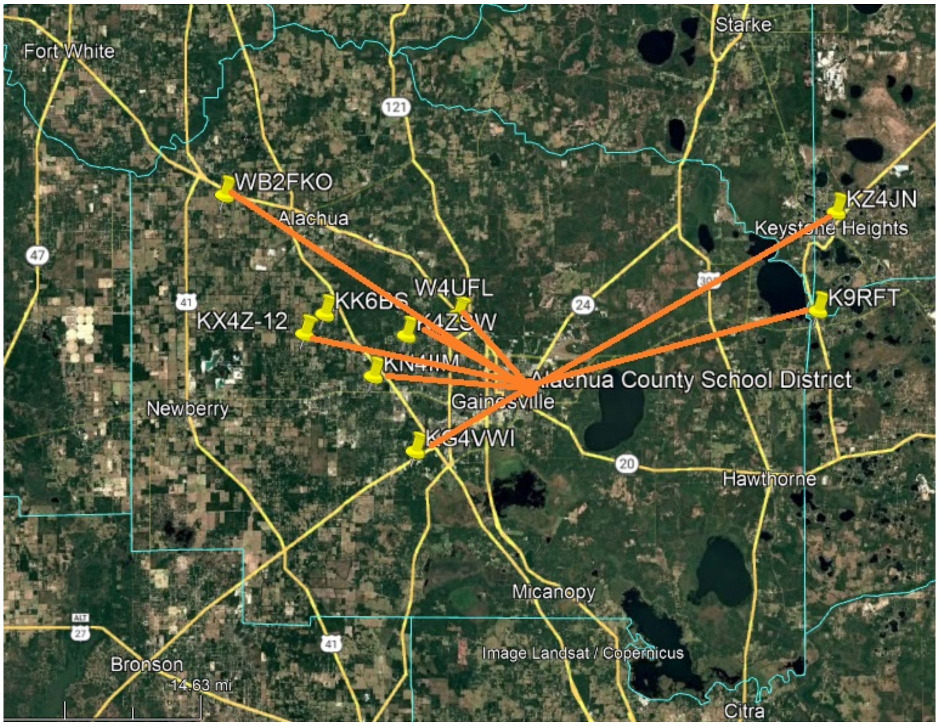

Figure 4: Important 2-meter (144 MHz) direct radio communications demonstrated during the test. (Additional, shorter-distance, communications are not shown for clarity).

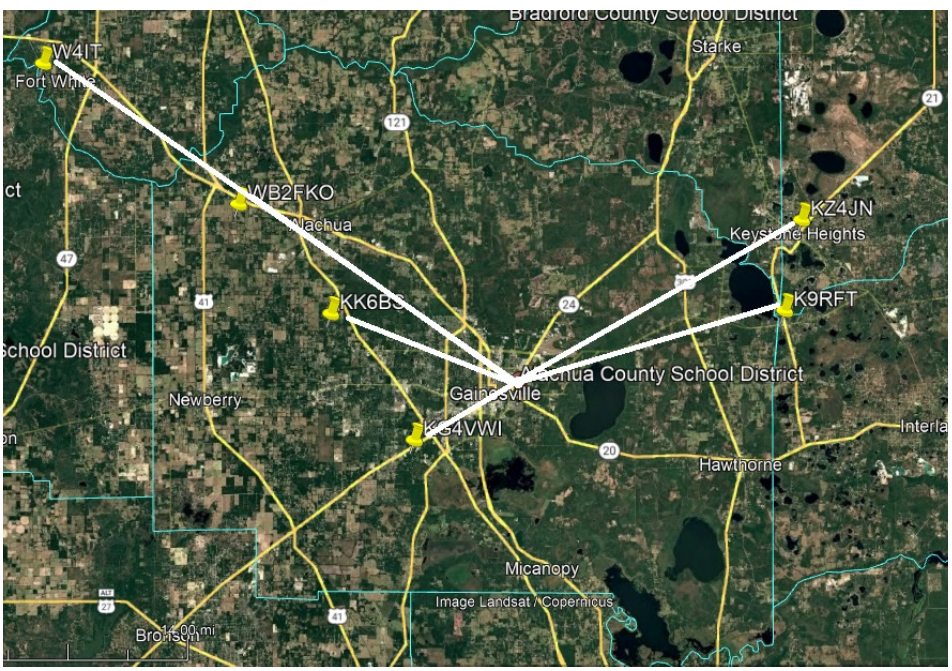

Figure 5. Important 6-meter (50 MHz) direct single sideband radio communications demonstrated during the test. Note that our communications reached and even exceeded the limits of Alachua County.

DISCUSSION

Our tests on 2-meters are likely comparable to the outcomes we could expect during a hurricane rainstorm with an antenna at 50-feet. These tests validate that such a tower height with 2-meter vertical antenna will provide substantial backup communications capabilities. While we were unable to test communications to the often-utilized Easton-Newberry sports complex shelter, it appears likely that we would be able to contact that shelter directly, without requiring a repeater using a 50-foot tall tower.

Our tests on 6-meters (50.135 MHz), using the more efficient single sideband voice technique[3], were very surprising and indicated that communications on this band to suitably equipped stations will be even more successful. The community prevalence of transceivers with this capability is not as great as that of 2-meter FM, but it is increasing. We believe that pursuing this as a longer-term solution to backup communications would be a wise plan for Alachua county volunteers. The antennas are of modest size (10 feet or less total dimension) and can be more easily managed by older volunteers.

Based on these tests we are now confident that recommending a 50-foot aluminum telescoping, tiling tower for the new Emergency Operations Center will provide excellent backup emergency communications throughout the county, and that simple antennas mounted on that tower will perform adequately.

Such a tower will give us the ability to support *multiple* antennas, assisting us in monitoring multiple different radio communications including:

3-element high frequency multi-band directional YAGI beam and wire dipole antennas:

- FDEM SHARES Voice high frequency (HF) communications
- FDEM ALE (automatic link establishment) data high frequency (HF) communications
- FDEM WINLINK data high frequency (HF) communications

Vertical 2-meter (144 MHz) antennas mounted on top and sides of extendable portion

- Alachua County shelters and residents
- Volunteer WINLINK VHF Alachua county data radio message servers
- Volunteer WINLINK VHF Columbia county data radio message digipeater

Dipole or Halo 6-meter (50 MHz) antennas mounted near top of extendable portion

- Alachua County shelters and amateur radio operators operating from their homes.

VHF Weather Radio antenna / Simple UHF TV Antenna

- Weather Radio alerts
- Available broadcast TV stations with weather and other information sources

3 A technical explanation of the advantages of single sideband communication for distant, weak-signal stations, compared to FM, is given in the Appendix.

APPENDIX: Theoretical Explanation of SSB Advantage over FM

For strong signals, wideband FM delivers excellent signal-to-noise results, and great (audio) frequency response. The use of signal limiters before the FM demodulator largely eliminate the impact of typical noise such as lightning noise etc. Thus with strong transmitters and short paths, FM is preferred for reception of symphonies and other musical programming.

However, for weak signals, FM is not as effective as single sideband, and even suffers the penalty of "capture effect." When two stations transmit simultaneously using single sideband, those receiving hear both of them simultaneously and can often effective process the majority of information from both. On FM, the stronger of the two "captures" the FM detector in the receiver, and the weaker signal's information is simply lost.

There are at least two theoretical explanations of the weak-signal advantages of single sideband modulation over FM, making single sideband attractive for maximum coverage of a geographical area during disasters.

The first is energy density. The typical bandwidth of a single sideband signal is approximately 2.5-2.8 kHz. The typical width of an amateur FM signal can be as much as 15 kHz. (Other services have long since been mandated to use narrower FM modulation.) Since noise is modeled as "white" -- equal noise in each Hz of bandwidth, the FM signal of 535% width of a single sideband signal **experiences much more white noise in the receiver bandpass**-- an advantage of 7.28 dB for the narrower SSB signal.

The second explanation deals with the need for an FM detector to have access to a constant amplitude signal, which is often obtained by operating a **limiter** on the received signal. The Figure below attempts to represent the relative performance of FM versus SSB detectors in the face of various levels of input signal. FM clearly wins at stronger signal levels. Weak signals may not meet the requirement to be correctly limited by this circuitry, leading to difficulties for the frequency-based demodulator. The inefficiencies of this process add additional dB losses compared to single sideband, which actually uses the amplitude changes to create the received signal. It is difficult to specify the exact penalty for this, but the graph in Figure 6 below suggests that it can easily exceed 10dB!

Figure 7 below, from Electrical Engineering lecture notes of L. H. Charles Lee PhD, shows a similar catastrophic decline in FM detector output signal to noise ratio for weak input signals (low input signal to noise ratio).

Thus the advantage of SSB over FM can be in the range of 15-20dB -- equivalent to the impact of an amplifier of 31 to 100 times the original power! For our purposes of maximum geographical area coverage, SSB has a significant advantage. However, 2-meter (144 MHz) single sideband equipment has been scarce and expensive, though certainly available to the higher-end user. With the advent of the Yaesu FT-991 and even more the ICOM 7300 transceiver, more and more of our volunteers in the Alachua County area have equipment capable of 6-meter SSB. The number with efficient antennas for this band is less, but since the simplest dipole for this band is less than 10 feet long, they can be inexpensively constructed.

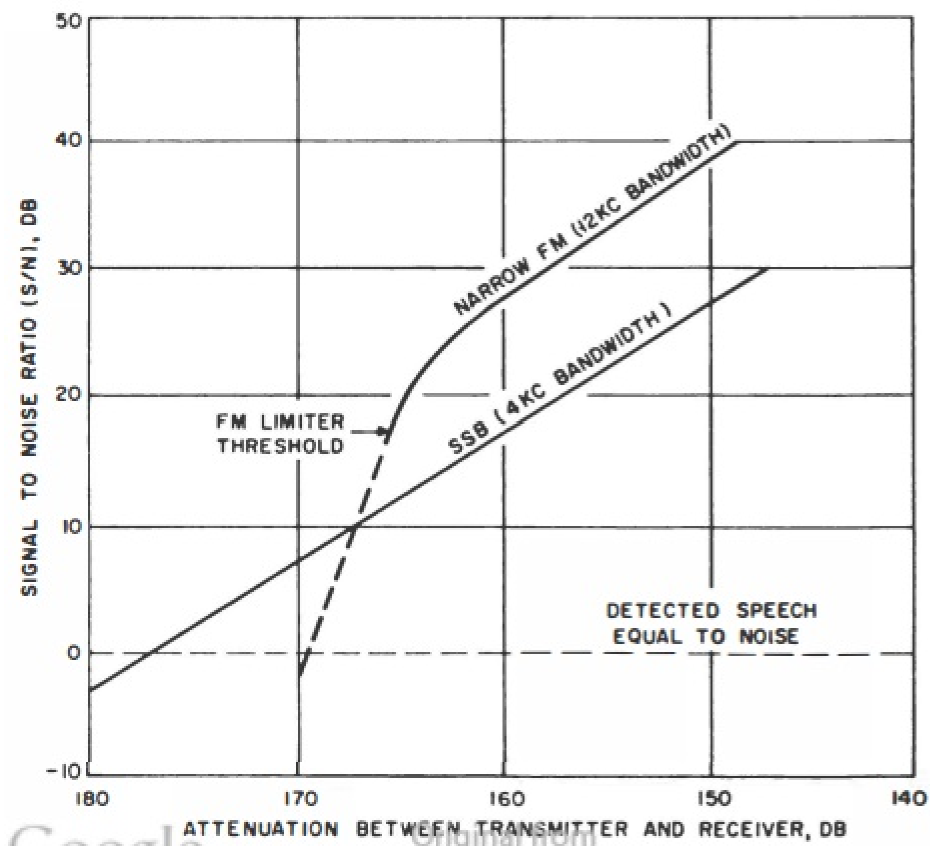

Figure 6. Approximate comparison of single sideband versus FM resulting signal to noise ratio for various levels of signal input (presented as related path loss). Ref: Collins Radio Company, SSB--comparison with AM and FM Systems, Part 2, BuShips Journal, April 1958, pp. 29-34. Accessed 10/14/2024: https://www.navy-radio.com/journal/journal-5804-ssb.pdf

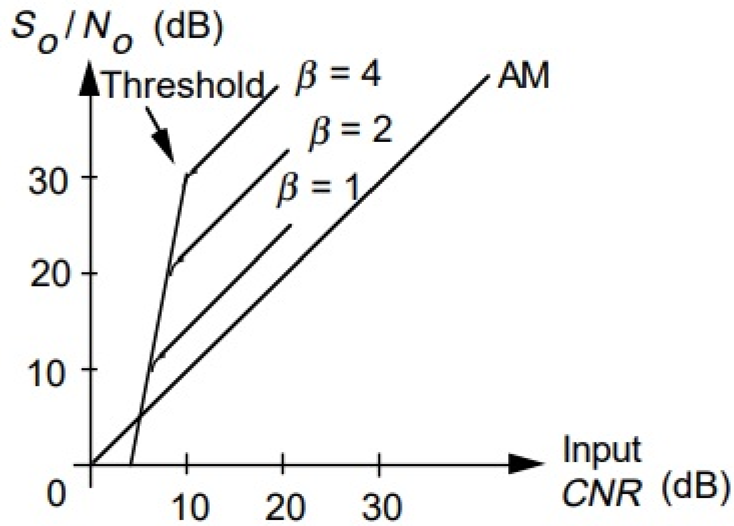

Figure 7: Taken from Figure 29.8 "Signal-to-noise characteristics for frequency discriminator" presented in lecture notes designated *29. Output Signal-to-Noise Ratios in AM and FM*, available at: https://charleslee.yolasite.com/resources/elec321/lect_snr_afm.pdf