NEW EOC ANTENNAS INITIAL EVALUATION

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ANTENNA	TEST RESULT	STATUS
X50 #2	Excellent VHF / UHF performance	**Excellent**
X50 #3	Excellent VHF / UHF performance	**Excellent**
VHF/ UHF SW antenna	Poor performance both VHF and UHF	**Not usable**
HF Antenna (Buckmaster commercial)	Sub-optimal performance on 3.5, 7, 10 MHz bands*; Adequate performance on 14 MHz band * Although not ideal, performance was much improved over the prior existing vertical HF antenna	**Needs further adjustment & evaluation.**

INTRODUCTION

After excellent work to install three new VHF/UHF antennas at a much higher height on the EOC tower, and to install a completely new HF horizontal Buckmaster antenna, by the EOC and outside tower crew, a group of volunteer hams traveled to the EOC on Saturday September 29 to become familiarized with the new antennas.

This is probably the best new communications development in our history, for backup amateur radio citizen volunteer communications efforts. Local volunteers are extremely grateful for ALL the work that was done in erecting the new antennas, new transceivers, new AGM high capacity batteries, and all the wiring and cables that went with this.

We were able to bring all the new VHF/UHF transceivers up and were able to test all three new VHF/UHF antennas, and we were able to spend multiple hours testing the new HF antenna.

RESULTS

VHF/UHF: We aren't completely sure exactly what frequency bands all the antennas represent. Standing in front of the table and looking at the row of SO-239 bulkhead connectors, we thought they were arranged from Left to Right as follows:

HF Ant	SW VHF/UHF #1	Other VHF/UHF #2	OtherVHF/UHF #3

#2 and #3 of the VHF/UHF antennas had excellent SWR readings and were used successfully to connect to local repeaters, including the local UHF repeater that connects to the SARNET. However, one cable, marked "SW VHF/UHF" (#1 in the listing above) had a poor SWR (5:1) on VHF, a good SWR on UHF, but was unable to contact the SARNET connected repeater on UHF. We suspect there is some problem with that feedline or antenna. Or possibly it was intended for a different frequency band altogether. The other two represent huge improvements for local VHF/UHF communications.

HF:

Initial inspection of the installed antenna indicated that the installation put the antenna wire too close to the supporting rope, because both were installed on the same pulley.. Two lines close to each other will often twirl and become intertwined in the wind, making it impossible for them to move through the double pulley..   The SE (longer) end of the antenna assembly we were able to disentangle, but the ropes for the NE (shorter) end are tied off within the fenced-in enclosure and we were unable to reach them.   That end appears intertwined.   Because they are that way, when we applied tension to the supporting rope on the SE telephone pole, the antenna WIRE (not the supporting rope) took the tension on the NE (tower) end --- an unwelcome finding.   For testing, we pensioned the system to an estimate 50-75 lbs of tension on the upper rope at the telephone pole, and allowed the antenna wire on the telephone pole end to droop approximately 3 feet below the tension wire.

Here is a drawing of the suggested initial installation, showing that the antenna and supporting ropes were to be on separate pulleys.   A separate "safety rope" was to be installed on the tension pulleys but both ends of that were to be directed elsewhere.   (Reference; original suggested installation instructions: https://www.qsl.net/nf4rc/2018/AntennaConsensusDocumentation.pdf)

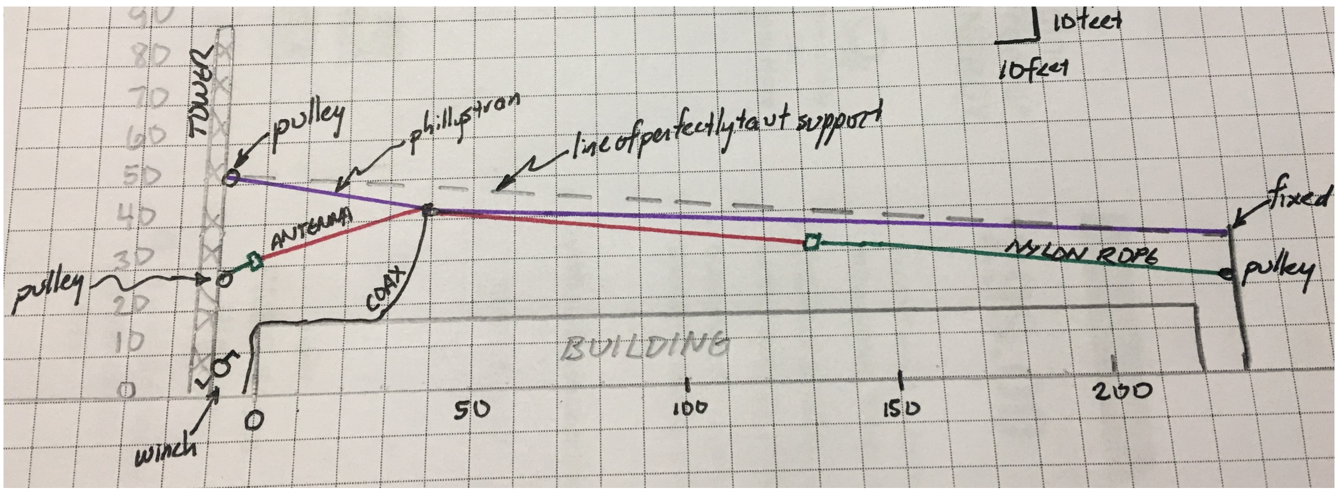

Figure 1.   Scale drawing of suggested initial installation.

Below is an altered drawing to explain what we believe was actually installed:

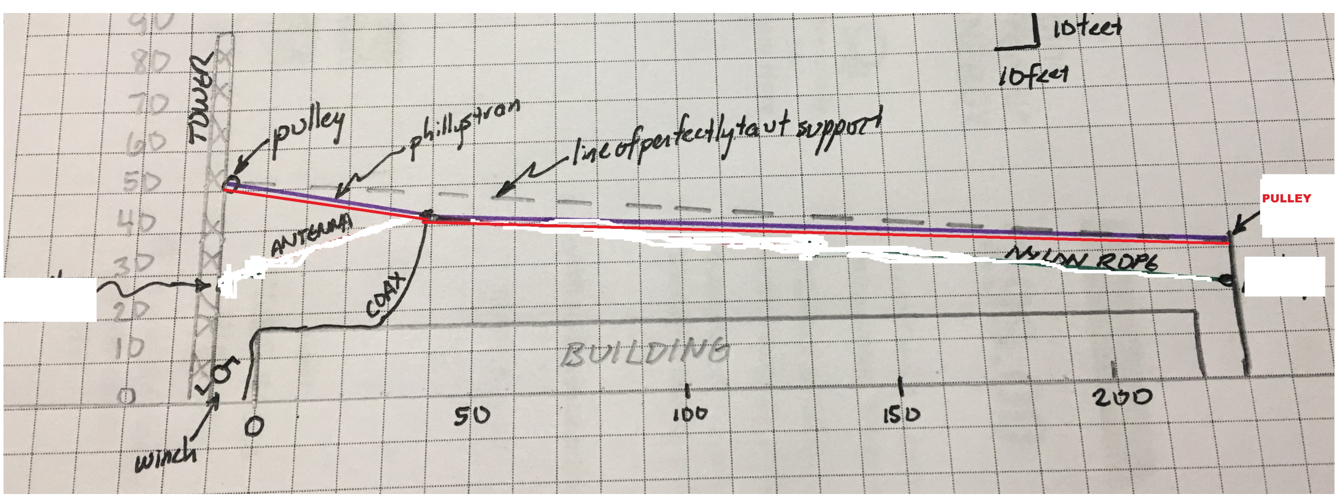

Figure 2:   Drawing of what appears to have been installed.

STANDING WAVE RATIO TESTING:

Standing wave ratio is an easily measured, objective way of quantifying how closely the antenna and feedline system produce the desired 50-ohm, non-reactive impedance. Due to complex transmission line effects beyond the scope of this paper, a mismatched antenna will present a complexly changing impedance at different portions along the (mismatched) transmission line --- but the standing wave ratio (SWR) remains the same at all points on the transmission line (except that due to excessive losses, it may appear "better" the farther one gets from the antenna.

A standing wave ratio of higher than about 2.5 is potentially injurious to modern solid station radio equipment (Many modern radios automatically reduce their output power when such an SWR is sensed, to prevent damage.). A standing wave ratio of 2.0 means the impedance can be considered as "twice" or "half" the desired 50 ohms. A standing wave ratio of 4.0 means the impedance can be considered "four times" or "one fourth" the desired 50 ohms. By itself, the SWR does not tell you which way, or with how much reactance the impedance diverges from the desired 50 ohms, it merely gives you a ratio of how far off it is. A more comprehensive explanation is beyond the scope of this paper.

Suffice it to say that if the SWR is worse than 3, a tuner will be required. Furthermore, with increasingly large SWR readings, more and more of the transmitted and received energy never makes it to the antenna or to the receiver – it is wasted in losses within the coaxial cable. So most engineers prefer to operate coaxial cable at an SWR less than 2 whenever possible.

Amateur radio bands of high interest to emergency communicators include:

3.5-4.0 MHz
7 - 7.3 MHz
10.1-10.15 MHz
14.0-14.35 MHz.

There are SHARES (federal) frequencies of interest to emergency communicators in the 3, 4, 5, 6, 9, 13 MHz ranges....exact numbers are not published in publicly available media.

The following handwritten graph demonstrates the measured SWR (black line) of a homemade Buckmaster-type antenna built by a local volunteer (we built 11 of the guts of these antennas in a local project party) and also the results measured (in **RED**) from the newly installed EOC commercially made Buckmaster antenna. Both are measured at the end of a fairly long stretch of coaxial cable:

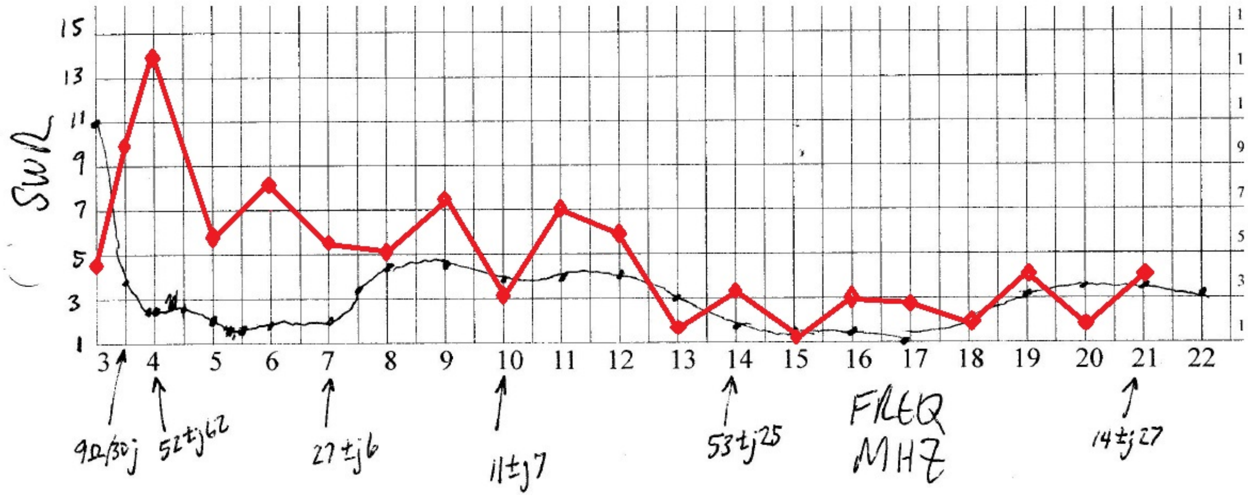

Figure 3: measured SWR from homemade Buckmaster clone (black line, measurements of 2/28/2018 hung in an oak tree at 15216 NW 41st Avenue) and the commercial Buckmaster installed at the EOC (RED, measurements made on 2/29/2018).

A comparison of these two graphs can be tallied as follows:

Band (MHz)	Homemade Antenna	EOC antenna
3.5-4.0	acceptable SWR	very poor SWR requiring a tuner and higher losses in coax
7.0-7.3	good SWR	usable SWR requiring a tuner
10.1-10.15	usable SWR requiring a tuner	usable SWR requiring a tuner
14-14.35	excellent SWR	good SWR but likely requiring a tuner

One can't simply "do without" various bands because of the characteristics of the ionosphere, which change with the daily movements of the sun, favoring different frequencies from hour to hour to reach critical distances such as to Miami, Tallahassee, Atlanta, etc.

PERFORMANCE EVALUATION

We re-inserted the EOC's auto-tuner into the system to attempt to "tune" the feedline/antenna HF combination. While this makes the apparent SWR far more acceptable to the commercial transceiver owned by the EOC, it doesn't change the losses in the feedline if there are high SWRs. However, it makes the system safe to utilize.

Subjective and semi-objective evaluations were carried out: **In general, the antenna is a BIG improvement over the previous short vertical antenna for HF.** We were able to make at least one voice contact, and after gaining some experience we were able to make digital (WINLINK) connections to stations 300-700 miles away. This was greatly facilitated because we have succeeded in making the commercial Yaesu transceiver's frequency be digitally controlled automatically from the WINLINK software using a USB-cable which we fabricated specifically for the EOC Yaesu transceiver.

We were not able to make 3.595 MHz connections to KX4Z in Jonesville. We were not able to make other 3.5 MHz digital connections and due to time issues, we were not able to test whether we can be heard by others around the state on the 3.950 emergency training net, which meets at 9AM Monday - Saturday.

We heard FAR more stations than we ever heard with the previous antenna. I estimate that we are now able to make many more digital and voice connections that we ever were in the past with the previous antenna, for which I wrote a detailed and objective report previously.

Using an online coax cable loss calculator and estimating that you have 150 feet of high quality coaxial cable, we estimate that the power losses are as much as 20-35% of the transceiver power, and one might speculate an additional 10-20% losses in the tuner and Balun. (see: https://www.qsl.net/co8tw/Coax_Calculator.htm) These are not huge losses, but if we are able to improve the performance of the antenna, they can be substantially reduced. The normal expected performance of a commercial Buckmaster antenna is more like that of our homemade clone....the results obtained at the EOC are distinctly abnormal.

One of our volunteers requested that I put in a table of the components of the suggested HF antenna components and portray how we think this has turned out, as follows:

HF Antenna Component	**Suggested installation**	**Actual Installation**	**Possible outcome**
Support rope	Phillystran	large diameter Dacron	Appears to be functioning well.
Buckmaster inverted vee	Inverted Vee	Sloping dipole intertwined on short side with Dacron rope	Unclear but this may cause the effective antenna wire length on the short side to be changed, altering the resonance point and impedance results of the antenna, likely more with the rope is WET than when Dry. The rope additional affects the dielectric constant of the surrounding space around the entangled short antenna wire.
Lower pulleys at each end to allow antenna wire to separate from support rope	Installed several feet below the upper pulley	Not installed	Running the ropes for both support and antenna through the same pulley results in the ropes/antenna becoming entangled due to twirling due to wind. It is possible that they

			may then become unable to be let down because you then cant get anything to pass through the double-pulleys
Higher pulleys at each end	Installed, with a safety rope (unused) for possible later use if the main rope separates and can't be retrieved.	Instead of the unused safety rope, that slot in the double pulleys was used to pass the rope from the antenna.	Entanglements.
Clevis / winch	Installed	Clevis installed And they are VERY NICE large clevises also! Thanks!	We found that we could manually pull the tension rope to a pretty reasonable tension ourselves. Would significantly benefit from a separate clevis on each side for the ANTENNA rope, which doesn't have to have a large clevis because it shouldn't be under much tension We were not able to reach the ropes for the NE (short) end because they are within the fenced area. We would suggest loosening the antenna rope there to allow a release of tension in the antenna wire --- and then potentially the antenna will disentangle by itself and droop downwards. If not -- someone will have to go on the roof to reach the center Balun and begin to disentangle them. It should be be very difficult as all, as every clockwise rotation should be accompanied by one counterclockwise rotation and both the rope and the antenna are new and free of much foreign object debris.

SUGGESTIONS

We don't have any real suggestions for the South West VHF/UHF antenna other than testing it with a time domain reflectometer -- and I believe Ryan has one of those wonderful devices. Otherwise, our Saturday crew may simply have mistaken which antenna is on which cable.

For the HF antenna, improving the SWR would make some useful improvement to the antenna, making our modest 100-watt station more effective and potentially reducing the dependence on the auto-tuner. We do not know the relative contributions to the SWR difficulties from

a) entangled Dacron rope
b) possible re-bar and other metal in the building construction of the EOC.

Positioning an antenna near a building that has significant metal in it is always a risk, and the general recommendations are to provide significant spacing between the antenna and the building. The Shands Dental tower has extreme metal in its roof due to railings, fences, and weather protection of the brick facades. This played havoc with a multi-band resonant antenna design that volunteers attempted to install there. So we have some experience with nearby metallic issues.

We would suggest that the first goal should be to disentangle the short (NW) antenna wire from the Dacron rope by adjusting the tension on the antenna by letting out a little rope on the NW (tower) antenna end, so that the antenna/rope becomes longer than the Dacron supporting rope and should be able to droop down by 5 feet or so from the supporting, higher, Dacron rope. At that point, it may possibly disentangle itself by itself. A person on the roof may be required to disentangle the antenna from the supporting, higher Dacron rope if this doesn't occur naturally.

Then the supporting Dacron rope can be appropriately tensioned on the SE (telephone pole) end to approximately 60-75 lbs tension, and the antenna end on that side adjusted for approximately a 5 foot droop. This should still have all of the antenna well above the EOC building.

At that point, the SWR measurements can be easily repeated with an antenna analyzer in a matter of 10 minutes.. We will then know how much improvement can be had by simple measures, even without any further adjustment of the antenna.

That some potential adjustment of this antenna (even though it is a commercially available product) might be required, should not be a surprise. We have consistently explained that constructing high frequency antennas often requires a bit of adjustment, and even with a commercially produced antenna like the high quality Buckmaster, some adjustment of length due to local environmental factors may be required to obtain optimal performance.

Should the separation of the antenna from the supporting Dacron rope create recognizable SWR dips in the 3.5 and 7 MHz range (as desired) then minor adjustments from that point should put the resonances at optimal positions --- we have a lot of experience at that sort of "tuning" an HF antenna.

MOVING TOWARD PERMANENT SEPARATION OF THE ANTENNA FROM THE SUPPORT ROPE:

At that point, a second pulley can be arranged on both sides, as in the original design suggestion, so that the antenna will not become entangled in the support rope due to high wind effects. It is possible that the second pulley can be added on both sides by clever usage of the existing 2nd rope through the double pulley. By allowing that rope to droop all the way down to a height where a person can snag it, we may be able to separate the antenna rope on each side into two parts, and hoist a separate pulley using the rope, and extending the antenna side of the parted rope through that new pulley so that we can separately control both the height and the tension on the antenna.. Drawing that is a little more difficult but we believe it is possible to secure separation of the antenna without requiring new tower work.