SUMMARIZATION OF HF ANTENNA DESIGN CONSENSUS DESIGN PER FEBRUARY 2, 2018 JOINT MEETING BETWEEN SHANNON BOAL, LARRY ROVAK, PETE WINTERS and GORDON GIBBY

Created 5/19/2018

Purpose	Complete the documentation of a consensus designed that was developed on February 2nd 2018.
Background:	Documentation of EOC amateur antenna difficulties http://www.qsl.net/nf4rc/EOCHFAntennaPerformance.pdf Work done May 2016 Note that it is quite possible that the buried coaxial cable between the radio room and the exterior antenna has been water-logged and destroyed through pinholes in the years since it was installed. I am unaware of any loss measurements made to date on this section of coax. Documentation of EOC amateur antenna initial suggestion http://qsl.net/nf4rc/EOCHFAntennaRecommendations.pdf July 2017 Antenna Recommendations: http://qsl.net/nf4rc/July2017EOCAntennaRecommendations.pdf Consensus redesign accomplished at Feb 2nd 2018 meeting, Peter Winters, Larry Rovak, Shannon Boal, Gordon Gibby present, Country Foodly.

CONSENSUS DESIGN

The Initial design of non-resonant balanced-line feed dipole (http://qsl.net/nf4rc/July2017EOCAntennaRecommendations.pdf) was replaced with an improved design at a meeting of Jeff Capehart, Larry Rovak and Shannon Boal. Concerns were reported to include the home-made construction. A proposal for purchase of a BUCKMASTER OFF CENTER FED DIPOLE was made with a supporting high wire made of out synthetic non-metallic material to

maintain the strain necessary to hold up the heavy center balun of this successful commercial antenna.

On February 2nd, 2018, a consensus design meeting was held that included Larry Rovak, Shannon Boal, Gordon Gibby and Pete Winters. Review of the recent design indicated that there would not be a way to access one or both ends of the antenna as drawn without a climber. This was rectified by adding two additional pulleys so that the antenna could be fully lowered, with the assumption being that work on the center balun could be accomplished from the roof of the building by authorized personnel without requiring a climber.

A napkin drawing of the consensus design was created, shown below:

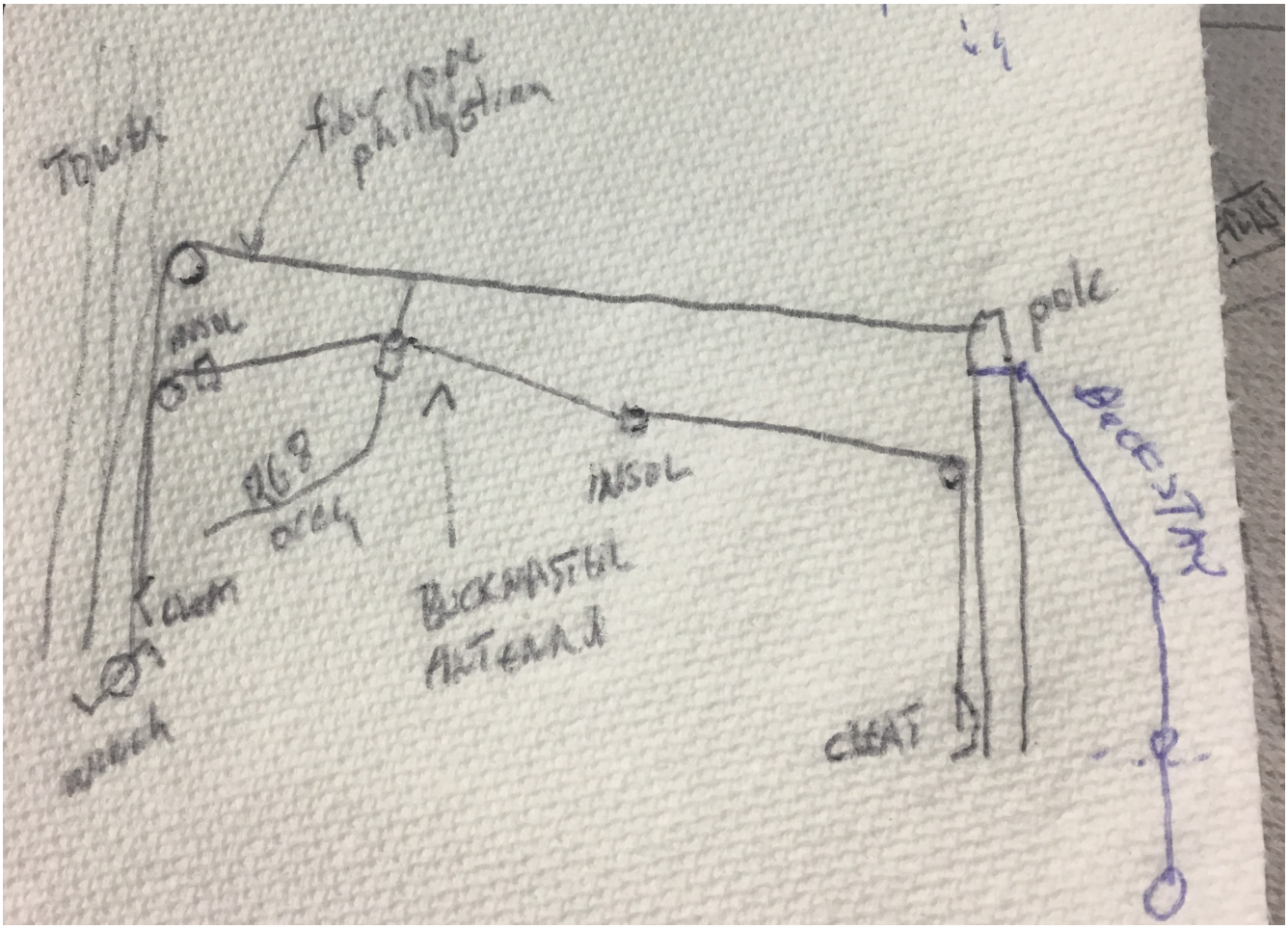
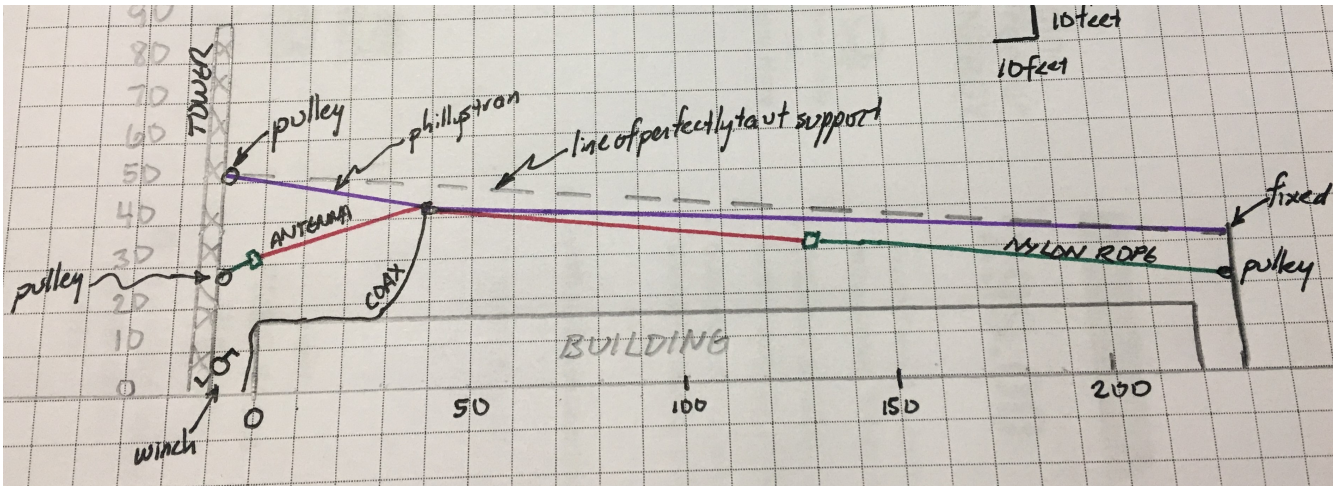


Figure: Napkin design of complete antenna system

Figure: Photo of commercial Buckmaster Antenna

Approximate Scale Drawing of Antenna Installation



LEGEND

dashed pencil line	Perfectly straight extended line of "perfect" support rope
purple line	Estimated straight line "sag" of actual phillystran rope
red line	Buckmaster antenna
green line	Nylon supporting rope for buckmaster antenna (under low tension)
black ink	Coax dropping to roof, running along roof to west end of building

Design notes:

- The Buckmaster central balun is a significant weight, on the order of 5-6 lbs and will additionally support the weight of RG8 or RG8X coaxial cable, estimated at another 1-2 lbs or so.

- The Buckmaster off center fed antenna is intended to be erected with the center high point suspended, and the ends dropping down in an inverted Vee format. An instruction manual for the installation can be viewed here: https://static.dxengineering.com/global/images/instructions/bmt-dx-ocf.pdf

- As intended to be installed, there is not a need for a large amount of tension on the buckmaster assymetrical wires (90 feet and 35 feet).

- The tension in the phillystran supporting non-conductive rope supports the weight of the buckmaster center insulator. A modest amount of droop in this rope will allow for significant load to be supported. It is suggested the the tension in this line be in the 100 lbs range, to allow for increased loads during high winds.

- The backstay in the napkin diagram above may not be necessary if the support is a telephone pole.

This document is intended to provide additional details that have apparently gone missing from previous documentation.

Presumed Dimensions

Item	**Estimated dimension**
Building Roof Height	18 feet
Lamppost height	25 feet
Estimated height of standard utility pole above ground	30 feet
Estimated height of standard utillity pole above roof height	12 feet
Top attachment height of pulley for supporting wire on tower	50 feet AGL, equivalent to 32 feet above roof height
Estimated span of building to be crossed	230 feet
Estimated droop of supporting phillystran from straight line	5-10 feet (depends on tension in phillystran supporting wire)
Distance from antenna end to tower	Set at approximately 10 feet

Weight of RG-8 sized cable	0.07-0.1 lb/foot
Weight of RG-8X sized cable	0.04 lb/foot
Weight of Buckmaster center balun	Estimated 4.5 lbs
Estimated height of buckmaster center balun above roof	20 feet
Estimated weight of buckmaster center balun + RG8 style coax to the roof	6.5 lbs

Utility Pole Background Information: https://en.wikipedia.org/wiki/Utility_pole A 40-foot pole is typically buried approximately 6 feet, leaving 34 feet above ground. I might guess that locally they are buried somewhat deeper, leaving approximately 30 feet above ground.

Coaxial Cable Background Information:
https://www.timesmicrowave.com/products/tl14/downloads/76.pdf

BILL OF MATERIALS

Item	Possible Source	Cost or Estimate
Buckmaster commercially available antenna	https://www.dxengineering.com/parts/bmt-dx-ocf 135 foot antenna for 80/75/40/20/17/10/6 meter bands. Includes end-insulators	$241.99
Coaxial cable for replacement of buried cable	https://www.pasternack.com/50-ohm-low-loss-flexible-lmr400db-pe-jacket-double-shielded-black-lmr-400-db-p.aspx $1.33/foot	As required to replace buried coaxial cable
Exterior Coaxial Cable from Antenna to ground	Choose any quality RG-8 / RG-213 / or even RG-8X cable as desired.	
Double fixed pulley, sailboat, weatherproof	https://www.amazon.com/Nautos-92324-Classic-DOUBLE-FIXED-characteristics-Sailboat/dp/B007ZVPUM0 ONE REQUIRED for the phillystran cable 50 foot up the tower, and a safety rope. Each accepts up to 2 3/8" lines, working load 600 lbs, breaking load 1700 lbs.	EACH $28.62 (1 required)
Single fixed pulley, sailboat, weatherproof	https://www.amazon.com/Nautos-92310-Classic-SINGLE-sheave-long-characteristics-	EACH $18.55

	Sailboat/dp/B007ZI30DO Single pulley, TWO REQUIRED, to handle nylon rope securing the ends of the Buckmaster antenna	(two required)
Phillystran 0.3 inch dia.	https://www.dxengineering.com/parts/phi-hptg-4000i Guy Line, Aramid Fiber, Polyurethane Coating 4,000 lbs. Breaking Strength, 0.30 in. Diameter, Per ft. Estimate of 230(building length) +20 (to account for droop) +80 (up tower and to allow for raising/lowering) = 330 feet required to allow dropping and raising of antenna. Strap on winch adds another twenty feet. Alternative (not nearly as useful) is 5/16 DOUBLE braided nylon rope: $176 for 600 feet. https://www.bulkropes.com/double-braid-nylon-rope-5-16/	$1.39/foot x 330 feet =
Winch	https://www.amazon.com/Driver-Recovery-Manual-Crank-Trailer/dp/B0742NVN8B	$32.49
3/8” nylon braided rope 100 foot length (4 required)	https://www.amazon.com/Amarine-made-Premium-Anchor-Braided-Thimble/dp/B074HRF9JN	$20.99 each (4 required)
Cleats for nylon braided rope	Two required, one at each end. Two additional to handle safety ropes from 50 foot pulley on tower. Package includes two cleats: https://www.amazon.com/MxEol-Cleat-Marine-Stainless-Steel/dp/B071CJTVLP	$15.99 2 packages required.
1/2” nylon braided rope for attachments.	http://www.knotandrope.com/store/pc/1-2-quot-Double-Braid-Nylon-p663.htm Approximately 10 feet required. 0.67 / foot.	
Eyebolts for phillystran and pulley on telepone pole	(drill straight through utility pole, choose length based on top dia. of utility pole – see table below.) https://www.amazon.com/12-Eye-Bolt-Galvanized-Steel/dp/B00LGYWZN4 5/8” x 12” $7.25 + shipping https://www.amazon.com/10-Eye-Bolt-Galvanized-Steel/dp/B00LGYVCJC 1/2” x 10” $4.82+shipping Note the top diameter for various classes of Telephone	2 required

	utility poles (inches) <table><tr><td>Class</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>H1</td></tr><tr><td>Min. Top</td><td>4.77</td><td>5.41</td><td>6.05</td><td>6.68</td><td>7.32</td><td>7.96</td><td>8.59</td><td>9.23</td></tr></table>	
Lightning Arrester	https://www.dxengineering.com/parts/ppr-is-50ux-c0	$70.00

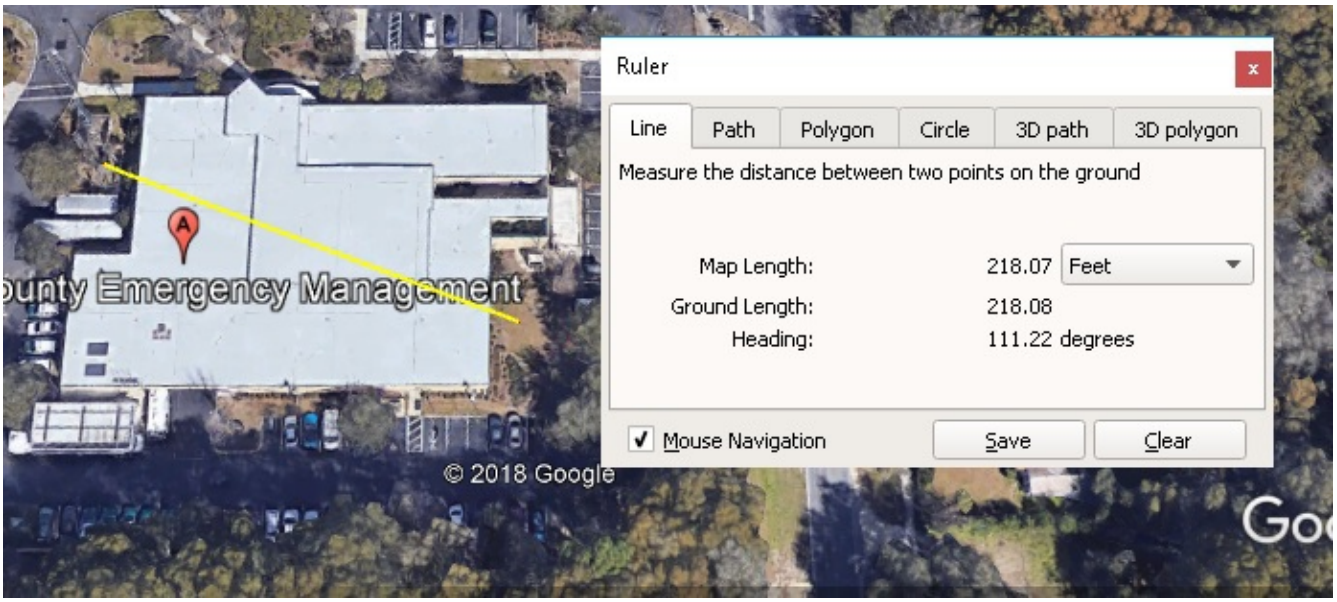


Figure: While this may not be the exact planned location of the Telephone Pole South East support, it gives a rough idea of the span across the building roof. The antenna is only 135 feet long, or about 65% of this distance. By positioning the SHORT end of the off center fed dipole toward the tower, the length of coax required (to the ground) can be reduced. That length (from center of antenna to ground level) can be approximated as about 70 feet.

ANTENNA & SUPPORT INSTALLATION

1. Install an eyebolt or other suitable connection very securely near the top of the telephone pole, attach the phillystran to this, by a secure method. Loop a security rope around the telephone pole in case the eye bolt fails.
2. Lay the antenna length draped along the roof, longer end toward the telephone pole and shorter end toward the tower.
3. Run the 0.3" phillystran through the top eyebolt of the buckmaster center balun. Ensure that the inner surface of the eyebolt is smooth so that it will not damage the phillystran; if not, smooth with steel wool/sandpaper. Secure with a single hitch, at a point chosen so that there will be approximately a 10 foot gap at the tower side for nylon rope.
4. Using dielectric grease on center conductor and on threads of SO-239, connect the coaxial cable PL259 to the buckmaster radio connection and waterproof using suitable materials. Ensure that the PL259 is securely bonded to the shield of the coaxial cable as it will have to support the cable.
5. Securely mount the winch for the phillystran at the bottom of the tower to a suitable structure, using suitable screw/bolt hardware.
6. Install a pulley for the phillystran supporting rope at approximately 50 feet height above ground level on the tower. This may be done with 1/2" nylon rope or with a suitable fitting. Thread the 0.3" phillystran through this pulley and down to the winch near ground level; connect to the strap on the winch. Tighten the winch to approximately 50-75 lb tension which should lift the buckmaster & coax off the roof.
7. Thread a security rope of 5/16" nylon through the remaining portion of the double pulley and secure both lines of that rope lower on the tower just above ground level, in such a way that they will not become entwined with the phillystran. The purpose of this rope is to avoid the need for additional tower work should the phillystan break.
8. On the telephone pole, at about 5 feet above the height of the roofline, install a pulley for the 3/8" nylon braided rope (to the end insulator on the longer side of the antenna); pass 3/8" nylon rope from the longer end buckmaster end insulator through and down to a cleat mounted approximately 7 foot above ground height on the telephone pole, so that people will not walk into the rope.
9. Install the final 3rd pulley on the tower for the 3/8" nylon braided rope to the buckmaster at approximately 10 feet higher than the roofheight of the building. Run 3/8" nylon braided rope to the end insulator of the buckmaster and to a cleat suitable attached at chest height within the fenced in enclosure.
10. Tighten all the lines so that the phillystran sags between 5-10 feet (max), with a tension of <= 150 lbs, and the ropes to the antenna ends have a tension of approximately 25-50 lbs.
11. VERY IMPORTANT: Replace the buried coax under the building with a length of DIRECT BURIAL LMR400DB or equivalent coaxial cable with waterproof exterior and gel protection.
12. Lightning Protection: Install suitable Polyphaser or equivalent lightning protection at a suitable exterior point on the cable and provide a large, straight wire to ground.

APPENDIX: ROPE INFORMATION

Braided rope safe working limits:
http://www.boatsafe.com/marlinespike/safeload.htm

American Boat and Yacht Council Safe Working Load (in pounds)

3 strand twisted line and single braid line

Diameter	Circumference	Manila	Nylon	Dacron	Polypropylene
1/4	3/4	120	182	182	213
5/16	1	160	281	281	232
3/8	1 1/8	216	407	407	459
1/2	1 1/2	424	704	704	714
5/8	2	704	1144	1100	1054
3/4	2 1/4	864	1562	1375	1445
7/8	2 3/4	1232	2200	1980	1955
1	3	1440	2750	2420	2380

American Boat and Yacht Council Safe Working Load (in pounds)

Double braided line

Diameter	Circumference	Nylon	Dacron
1/4	3/4	420	350
5/16	1	680	560

3/8	1 1/8	960	750
1/2	1 1/2	1630	1400
5/8	2	2800	2400
3/4	2 1/4	3600	3000
7/8	2 3/4	5300	4800
1	3	6260	5600

APPENDIX: UTILITY POLE INFORMATION

Standard Telephone Pole Dimensions: http://www.ldm.com/docs/dimensiontables_df_sp.pdf

McFarland Cascade®

STANDARD DIMENSIONS FOR DOUGLAS FIR AND SOUTHERN YELLOW PINE POLES

Class	7	6	5	4	3	2	1	H1	H2	H3	H4	H5	H6
Min. Top	4.77	5.41	6.05	6.68	7.32	7.96	8.59	9.23	9.87	10.50	11.14	11.78	12.41
Length of Pole		Minimum Diameter at 6 Feet from Butt (Inches)											
20	6.21	6.68	7.32	7.96	8.59	9.23	9.87						
25	6.84	7.32	8.12	8.75	9.39	10.03	10.66						
30	7.48	7.96	8.75	9.39	10.19	10.82	11.62						
35	7.96	8.59	9.23	10.03	10.82	11.62	12.41	13.21	13.85				
40		9.07	9.87	10.66	11.46	12.25	13.05	13.85	14.64	15.44	16.23		
45		9.55	10.35	11.14	11.94	12.89	13.69	14.48	15.44	16.23	17.03	17.83	18.62
50			10.82	11.62	12.41	13.37	14.32	15.12	16.07	16.87	17.67	18.62	19.42
55				12.10	12.89	13.85	14.80	15.76	16.55	17.51	18.46	19.26	20.21
60				12.41	13.37	14.32	15.28	16.23	17.19	18.14	18.94	19.89	20.85
65				12.89	13.85	14.80	15.76	16.71	17.67	18.62	19.58	20.53	21.49
70				13.21	14.32	15.28	16.23	17.19	18.14	19.26	20.21	21.17	21.96

APPENDIX

ESTIMATING EFFECT OF SAG IN SUPPORTING PHILLYSTRAN ROPE

As a very crude estimation, if a central load of L lbs has to be supported by a straight suspended rope making an angle theta to the horizontal, the ratio of the vertical lift provided by one side to the tension in that side is approximated by

sin (theta) = vertical lift / tension

If we allow a sag of 10 feet in a 170 foot long suspended rope, the theta is arcsin (10/85) = 6.75 deg

With an assumed weight of 6 lbs, 3 lbs must be supported by each end of the supporting rope.

10/85 = 3/tension or tension = 26 lbs

So a crude estimation suggests we can easily achieve less than 10 foot drop.