HF Balloon Antenna

Radio on the Square Antenna Prototyping

May 17, 2011

The Villages Amateur RADIO Club

Need better Antennas for ROS

- Radio on the Square (ROS) has experienced low signal strength and poor signal reports
- Better performing antenna(s) are needed that can be setup on the town square
- Supports are limited to a few trees and lamp posts
- Tiedowns are limited by concrete and trip hazard concerns
- Counterpoise limited to flowers beds at band stand, everything is concrete and bricks

Operations

- ROS mainly a 40M and 20M operation
- ROS is a SSB & CW event (desire to add PSK)
- ROS will be using a Band Plan to help QRM
  - 200 KHz between SSB & CW address QRM
  - CW & PSK too close on 20M & 40M…
    - Solution CW & PSK not in same band at same time

11/26/2011 | 16th Annual Radio-on-the-Square
Nov 26-Nov 27, 1400Z-2000Z, K4VRC, The Villages, FL. The Villages Amateur Radio Club.
SSB 14.266 & 7.255, CW 7.033 & 14.066, PSK-31 14.072 & 7.036. QSL and Certificates requests email info@k4vrc.org or Dennis Hardoin, 602 Lacy Pl., The Villages, FL 32162. The TVARC Radio-on-the-Square (ROS) is held on the Sumter Landing town square in The Villages, Florida held every year on the Saturday & Sunday after Thanksgiving. This is a great public education event about HAM radio. We send Radio Grams to family members around the world and sign up a dozen students for our January Technician Class every year. www.k4vrc.org

Antenna Requirements

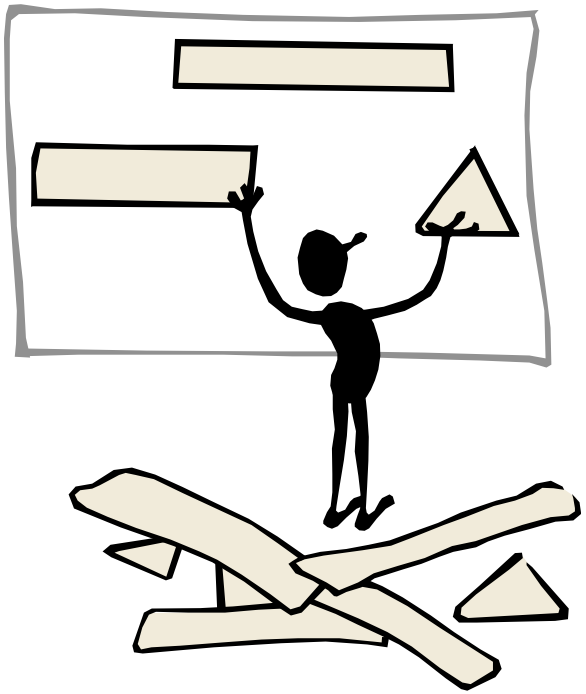
- Best DX performance is objective
  - Maximum radiation at 0 to 15 Degrees Elevation
- Bands are not used at the same time CW & PSK antennas can be swapped
- Antennas can be tuned to Tx Frequency
  - Single band solutions for 40M and 20M
  - Allows optimum performance without compromises

Operating Stations

- Two SSB RIGS
  - 14.266 MHz Balloon Antenna #1
  - 7.255 MHz Cushcraft R7 Antenna
- CW RIG
  - Primary 7.033 MHz Balloon Antenna #2
  - Secondary 14.066 MHz Balloon Antenna #3
- PSK RIG
  - Primary 14.072 MHz Balloon Antenna #3
  - Secondary 7.036 MHz Balloon Antenna #2
- VHF/UHF RIG(s)
  - Not addressed in this report

Antenna Requirements

- Club owns Cushcraft R7 Antenna (7.255 MHz)
- Need to build three tuned antennas for ROS
  - Antenna #1 tuned to 14.266 MHz
  - Antenna #2 tuned to 7.035 MHz
  - Antenna #3 tuned to 14.069 MHz



Design Approach

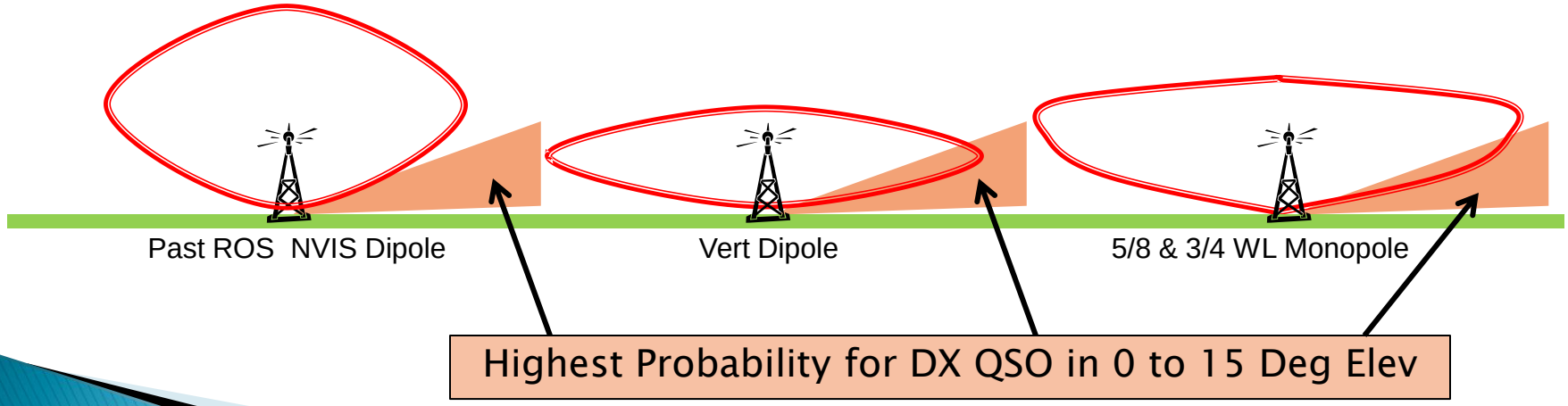
- What Dennis was thinking

Design Approach

- What Brad was thinking

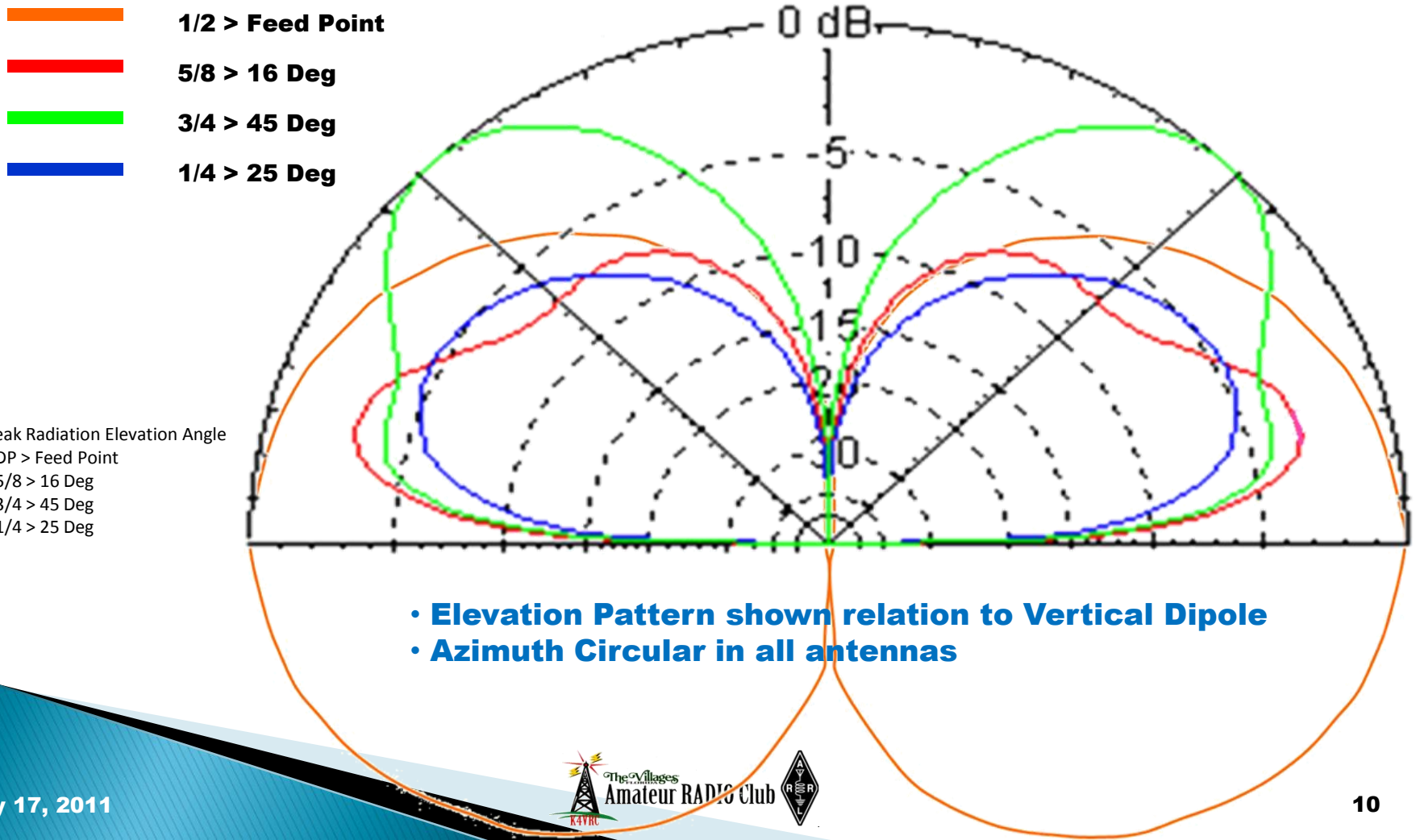
Design Approach

- Obtain best radiation in 0 to 15 Degrees elevation for greatest range / hops.
  - Best Antennas for 0-15 Degree vs dB Radiated
    1. Vertical Dipole
    2. 5/8 Monopole
    3. 3/4 Monopole
    4. 1/4 Monopole



Design Approach

- Res Freq Ant with perfect Ground Plane

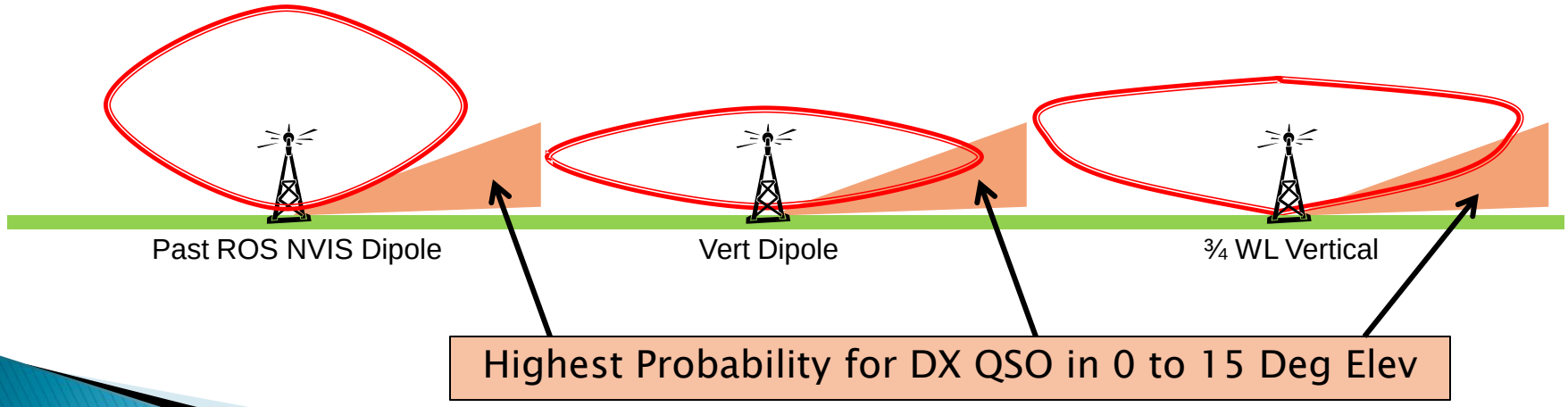


Peak Radiation Elevation Angle
- DP > Feed Point
- 5/8 > 16 Deg
- 3/4 > 45 Deg
- 1/4 > 25 Deg

- **Elevation Pattern shown relation to Vertical Dipole**
- **Azimuth Circular in all antennas**

Design Approach

- 40M Natural Selection always dominates
  - CON–50 Ft Mast for 40M Dipole too tall (34 FT + Clearance)
  - CON– 5/8 WL Monopole 40M requires Match* at Base
  - PRO–¾ WL Monopole 40M 3nd Best Pattern (100 Ft)
    - PRO–55 Ohm good match to 50 Ohm RG–58
    - PRO–No mast required

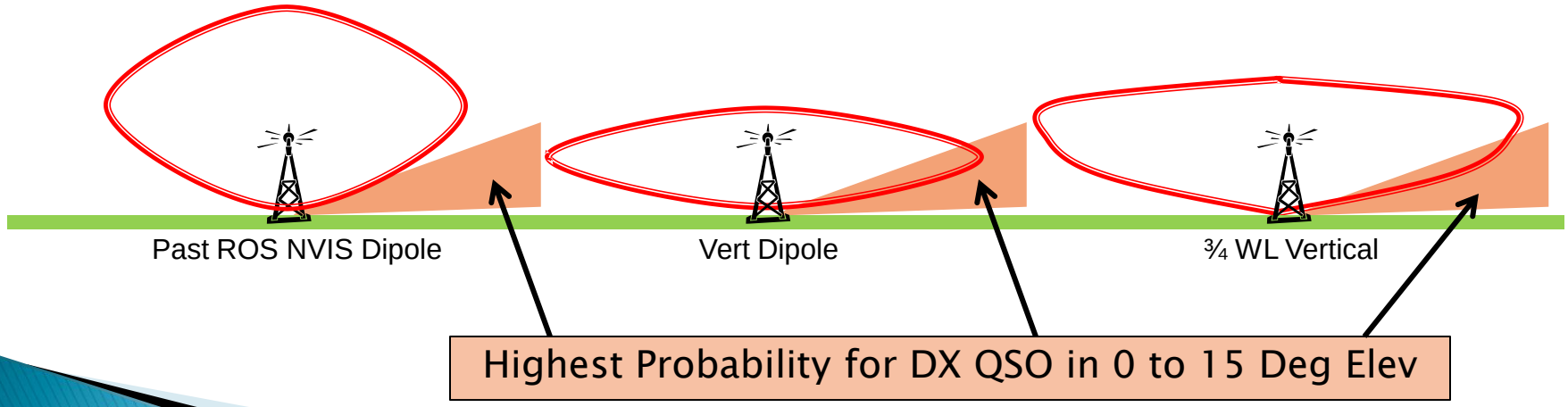


•L network: ~20pF shunt capacitor between antenna feedpoint and ground, and 9uH inductor in series with the feedline = 50 R

• 5/8 WL Monopole = 120 R - 500 j

Design Approach

- 20M Natural Selection always dominates
  - PRO–Vertical Dipole is #1 for pattern
    - PRO–No ground plane
    - PRO–72 Ohm good match to 75 Ohm RG–59
    - PRO & CON– 25 Ft Mast practical (16 FT + Clearance)



Design Approach

- ¾ WL Vertical 40M Wire (7.035 MHz) into a 99.8 Ft Vertical nominal 55 Ohms assume ground rod at gazebo
- Vertical 20M Dipole (14.069) with on 16.6 Ft Pole and 16.6 Ft via Balloon nominal 72 Ohms
- Only 40M using gazebo ground minimizes ground loops, coupling & RFI between RIGs

Test Plan

- Select Wire, Balloons and Helium
- Select insulator & leader
- Balloon lift tests with real wire
- Balloon lift vs. time tests need ~8 Hours
- Several overnight fatigue test of balloon, wire and insulator (try normal and windy)
- Test 3/4 WL vs. reference dipole on 40M

Experiments

- Lab work is never done!
- Was it 2 parts blue or red?
- Was that my Ice Tea?

Wire

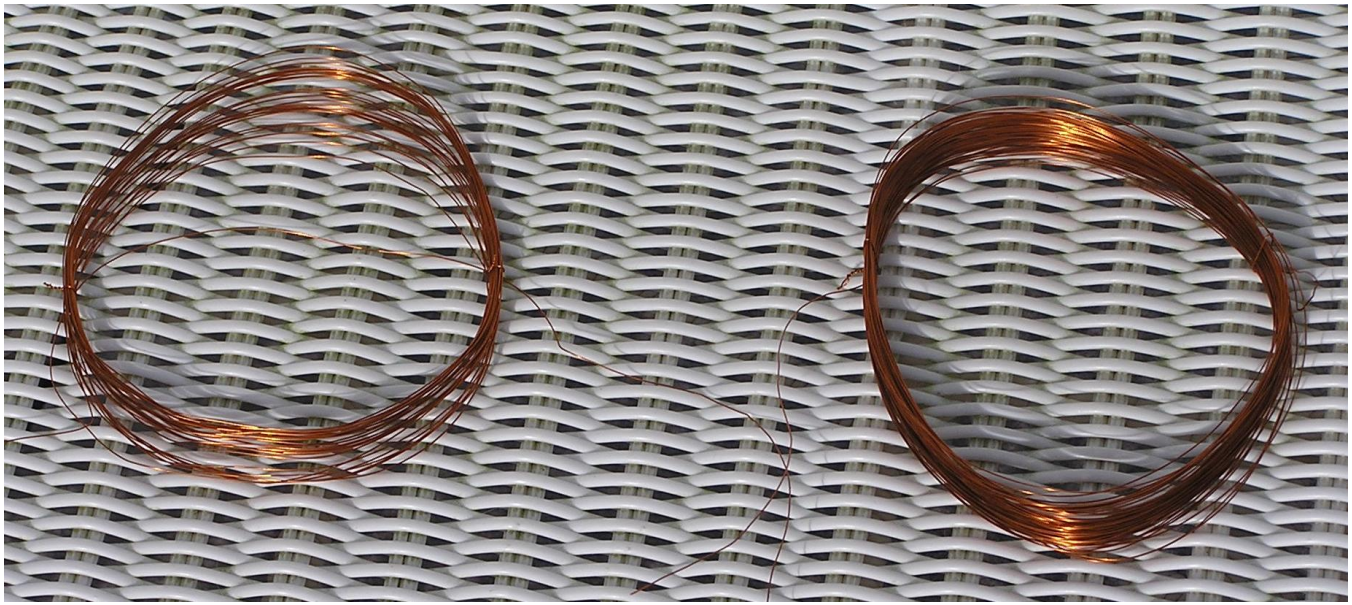
- Wire needs low Ohms vs. weight
  - Must fly to work
  - Lowest weight is more important
  - Allowed 0.5 dB loss to resistance ~ 5 Ohms
- #28 AWG = 6 Ohm/100 Ft
- #28 AWG X 100 Ft ~ 0.768 Oz
- 1 Cu Ft Helium will lift ~ 1 Oz
  - Helium sold in 15 Cu Ft ($20)

Balloons

- Helium balloons come in many sizes, shapes & materials
- Latex balloons are locally available normally used for advertizing
- Local retail = 9, 11, 12 Inch balloons
- Selected 12 Inch Latex ~ 0.4 Cu Ft

Lift Tests

- Prepared 33 Ft & 100 Ft coils of #28 AWG
- Estimated two 12 Inch Balloons for 100 Ft of wire lift (1 Balloon should lift 33 Ft)



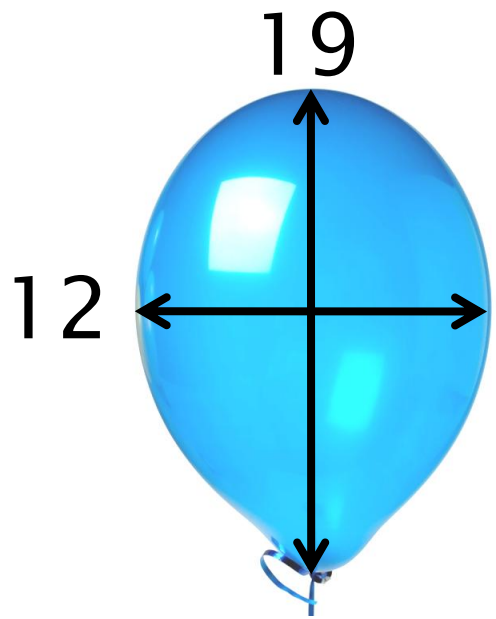
33 Feet 100 Feet

Lift Tests

- Determined a 9 Inch Balloon = 33 Ft #28 AWG
- 6 Inch did not lift 33 Ft coil
- Measured size as diameter

Lift Tests

- Three 12 Inch balloons = 100 Ft coil lift with margin
  - Line is tight and secure by weight
- 12 Inch balloon = 12 X 19 Inches

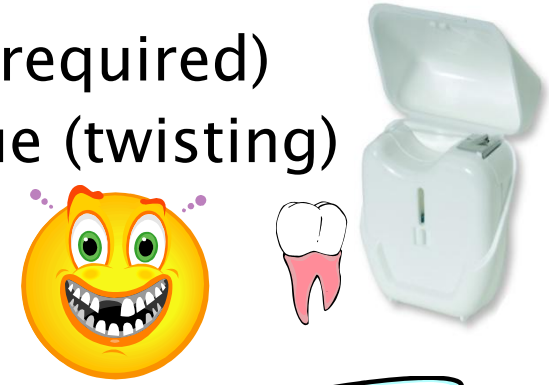


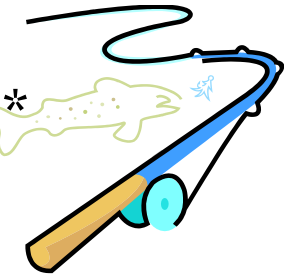
Lift Tests

- Latex balloons lift for less than 12 hours
- Lift is 2/3 original capacity after 8 Hours
- Lift is 1/10 original capacity after 24 Hours
- Decided to exceed equilibrium by 50%

Insulator & Messenger

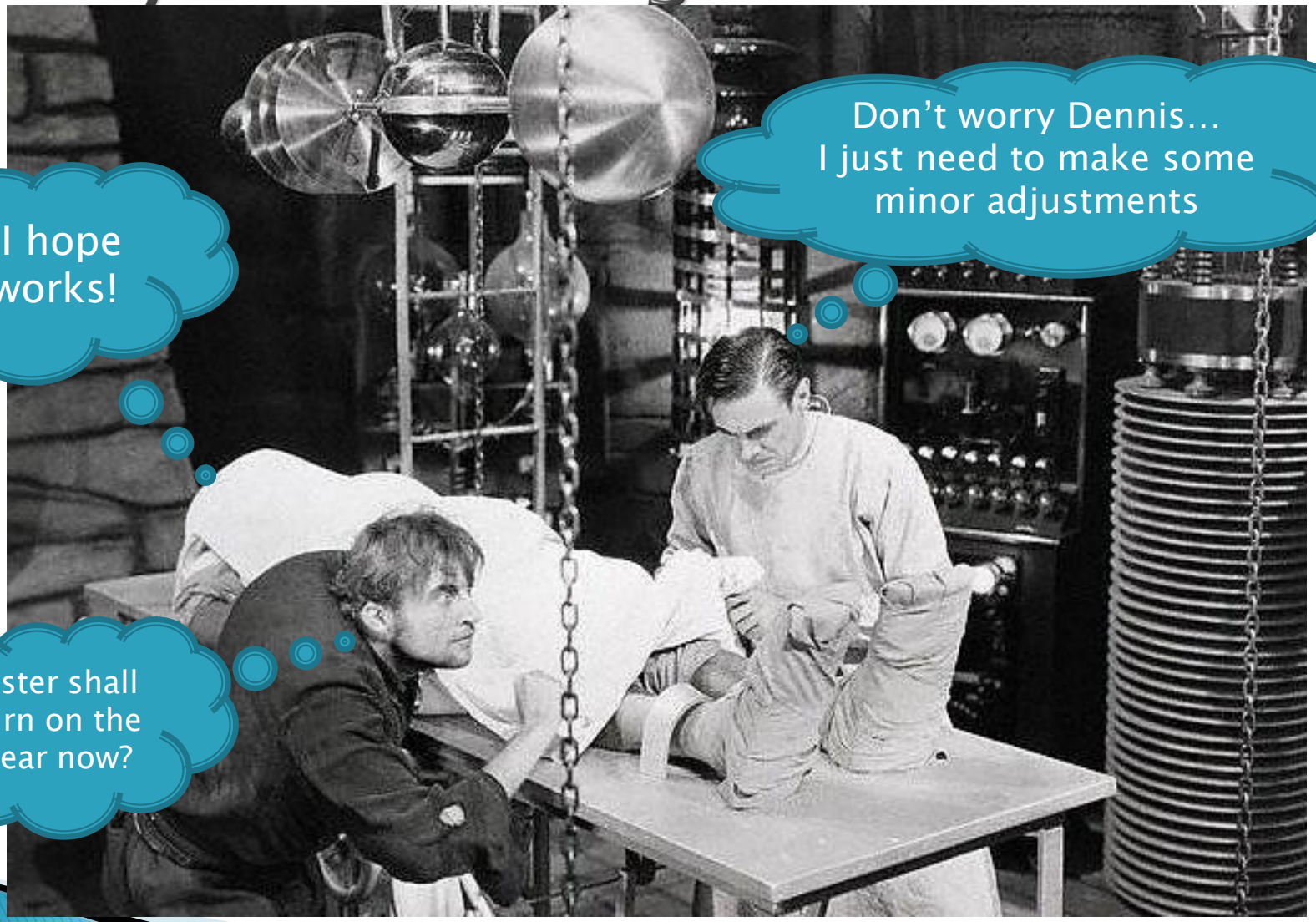
- Messenger vs. weight
  - Must fly to work
  - #28 AWG Copper tensile strength ~ 22 LBS
  - ~ 2 Oz load on 22 LB line
  - 800:1 Safety Factor (messenger not required)
  - 12 Inch dental floss leader for fatigue (twisting)
- Insulator
  - 30 LB Monofilament X 5 Ft
  - Measured greater than 10 Meg-Ohms
  - Measured less than 1 Micro-Amp at 200 VDC*





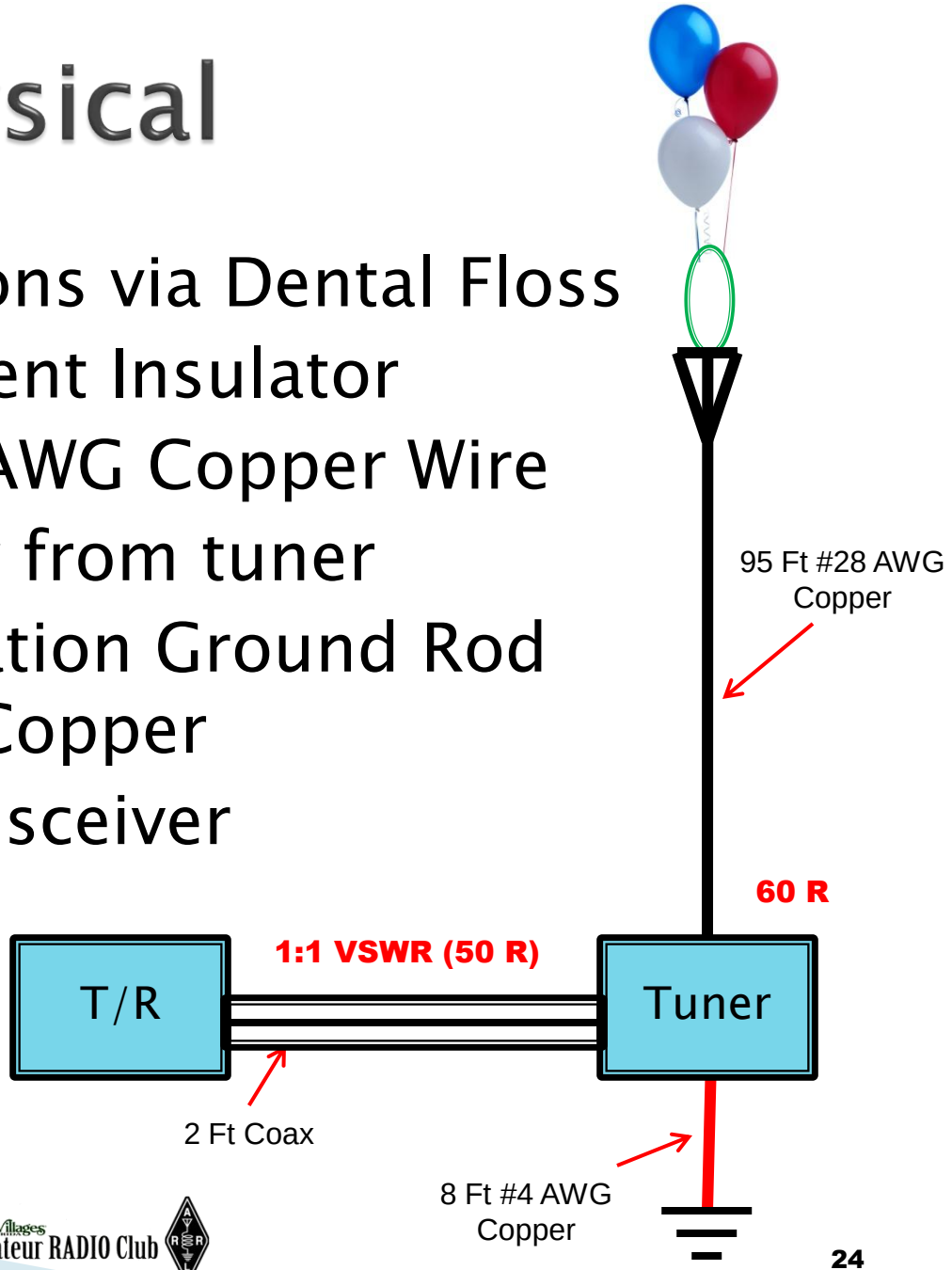
* Lowest reading on DVM

Ready for Testing!



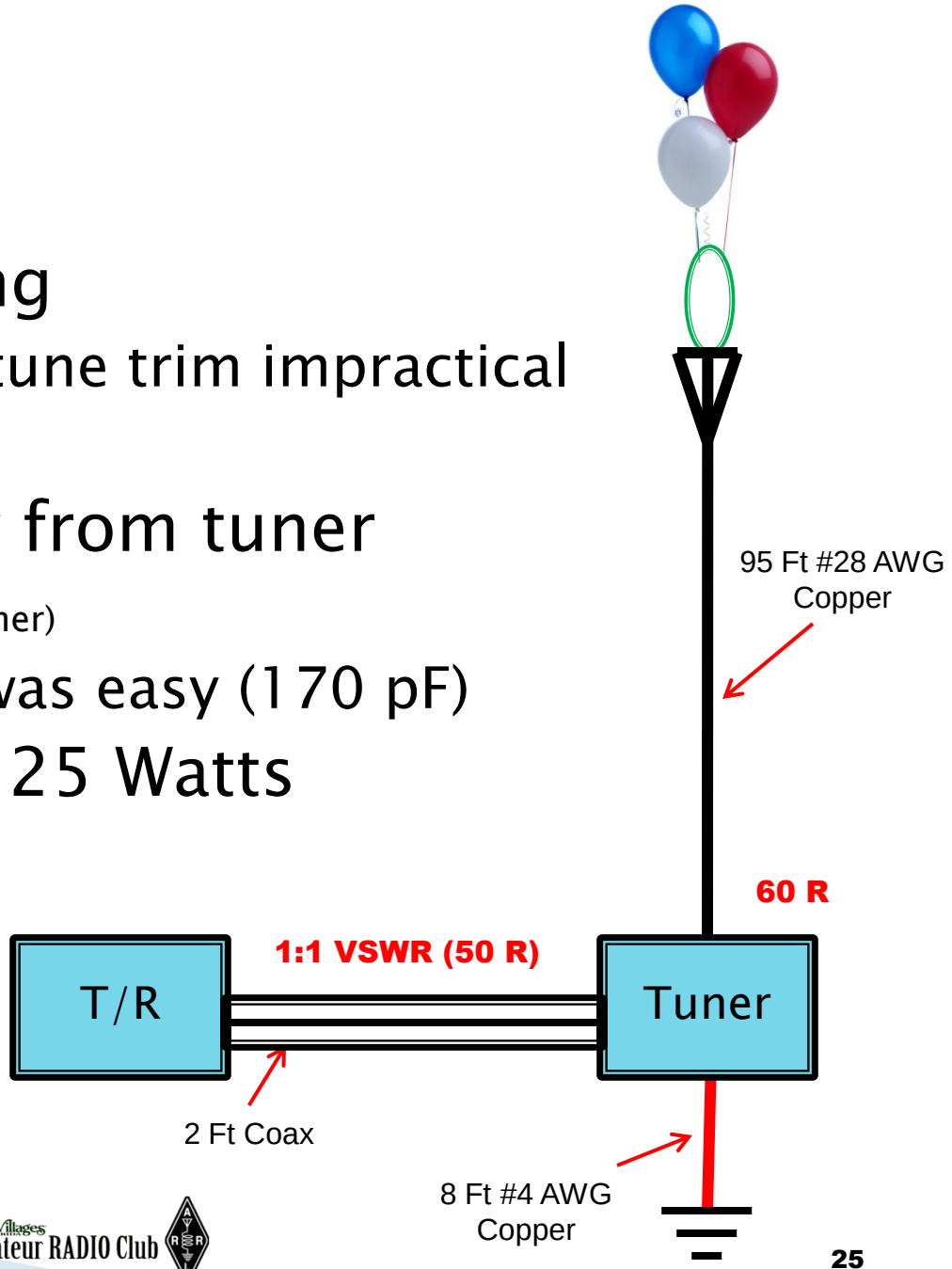
Test Setup Physical

- Three 12 Inch Balloons via Dental Floss
- 5 Ft #30 Monofilament Insulator
- Antenna 95 Ft #28 AWG Copper Wire
- Antenna fed directly from tuner
- Tuner Ground to Station Ground Rod via 8 Ft of #4 AWG Copper
- 2 Ft RG-213 to Transceiver
- No Radials



Test Setup RF

- Antenna was too long
  - Covert flight made retune trim impractical
  - ~ 6.9 MHz Resonance
- Antenna fed directly from tuner
  - ~ 60 Ohms (1.4 SWR w/o tuner)
  - Match at 7.035 MHz was easy (170 pF)
- Transmit tests used 25 Watts
- Ground Rod
  - No Radials

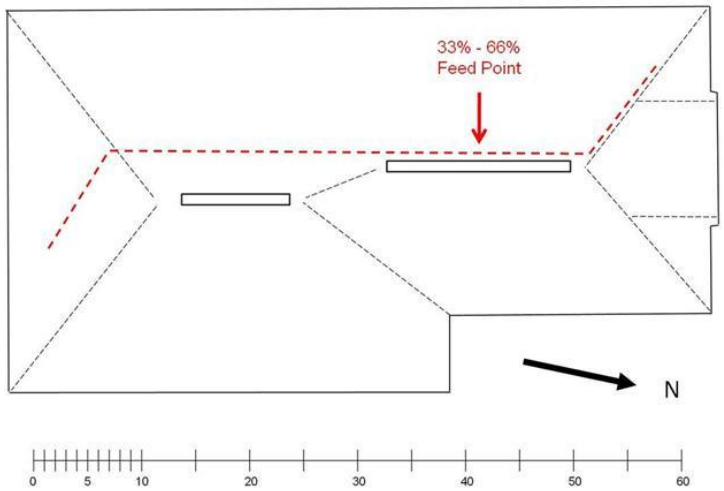


Test Procedure

- Tests are by comparison to reference antenna
- Transmit tests used www.reversebeacon.net
  - CQ calls are logged to database by stations
  - Reports Rx QTH, SNR, Frequency, Time/Date
  - Antenna ID by Tx Frequency
  - SNR compared for same QTH & Time Rx for both Ant
  - Distance / HOPs compared for same Tx Time
- Received tests used HRD Panadapter
  - AGC Off, Preamp Off, 100 dB scale
  - Antenna switched during Rx of CW & PSK DX Stations
  - Peak Signals were compared
  - QSB Stations not used

Reference Antenna Physical

- 40 M Horizontal Dipole
- 68 Ft in Length
- 13 Ft above ground
- Resonance at 7.020 MHz
- Very similar to ROS antenna

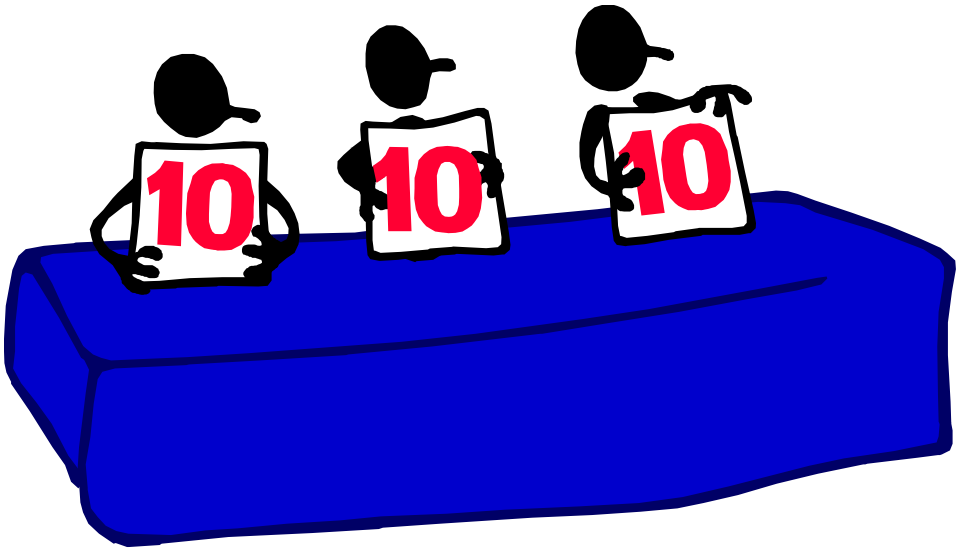


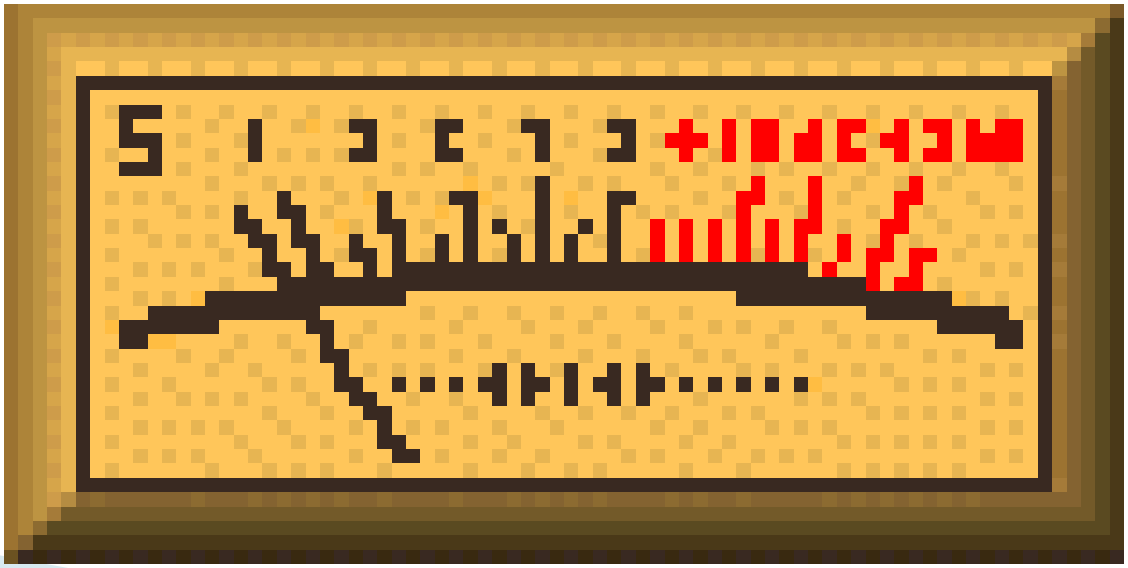
Reference Antenna on the Air

- Not an S9 + 20 dB
- Equal to 22 Ft Flagpole
- 40 M NVIS Dipole with circular Pattern
- QSOs for Feb, Mar & Apr 2011
  - Worked All Continents
  - Worked 50 Countries
  - Worked 45 States
    - Missing Alaska, Hawaii, Nevada, South Dakota & Wyoming

Test Results

- It works real good!

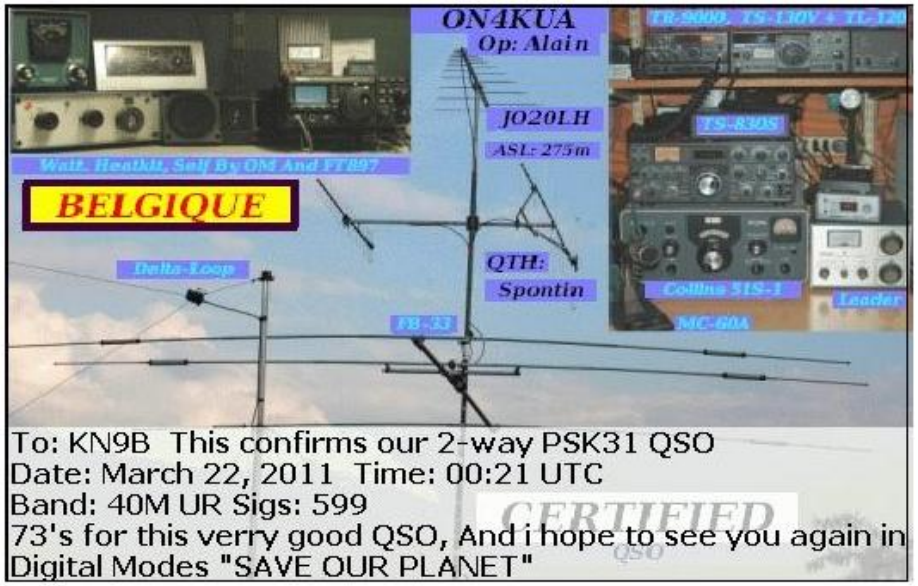


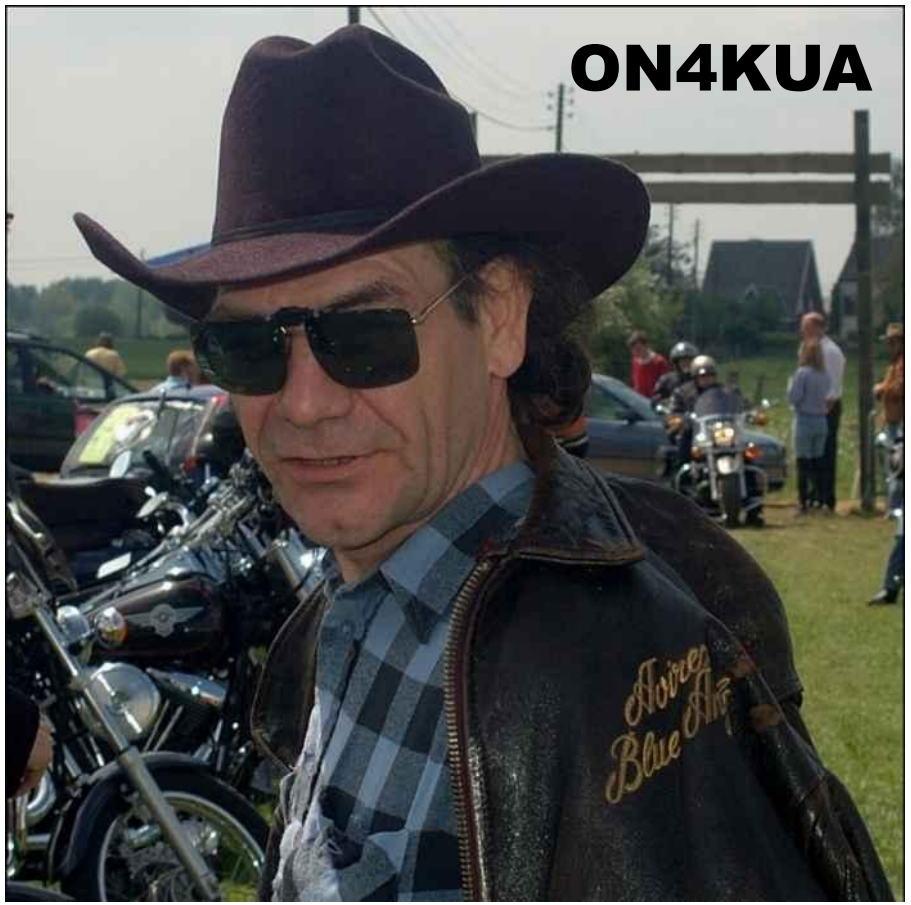


Subjective Results

- First transmission on Balloon 3/4 WL Vertical

Alain Muno
Rue Haie Collaux, 40 Spontin (YVOIR), NR 5530, Belgium
Report : 599 S/N:13 dB
Locator jo2Ølh >> 44.1° 4,587.0 Miles





Subjective Results

- Balloon 3/4 WL Vertical superior to Reference
  - Pulled hidden signals out of noise floor
  - Doubled the number of carriers on Panadapter
  - +20 dB Average Rx Gain Increase
  - CQ at 25W got Belgium on first call
  - CQ at 5W to adjust SWR got immediate SC RST Rpt
  - In the first Hour worked at 25W;

Belgium	Ontario Canada
Martinique	European Russia
Venezuela	Italy
Odessa Ukraine	

Objective Results*

- Sent 270 CW CQs
- Got 55 Reverse Beacon Hits
- Balloon 3/4 Vert average distance 1699 Miles
- 40M NVIS Dipole average distance 732 Miles
- +12 dB Average Tx Gain Increase **
  - All logs where increases for ¾ WL Monopole
  - Maximum was 18 dB increase
  - Minimum was 8 dB increase

* www.reversebeacon.net
** Conservative due to tree snag

Objective Results*

	de	dx	freq	cq/dx	snr	speed	time-date	ant	Miles	Zip	City-State-Zip	40M	Balloon	Balloon
Ref	N4ZR	KN9B	7029.50	CQ	7 dB	35 wpm	0242z 27 Mar	40m	756.8	25430	KEARNEYSVILLE, WV 25430	756.8		
Ref	K3MM	KN9B	7029.50	CQ	5 dB	35 wpm	0240z 27 Mar	40m	766.4	20872	DAMASCUS MD 20872	766.4		
Ref	WZ7I	KN9B	7029.50	CQ	4 dB	36 wpm	0240z 27 Mar	40m	884.9	18947	PIPERSVILLE PA 18947	884.9		
	N7TR	KN9B	7025.00	CQ	11 dB	34 wpm	0238z 27 Mar	Balloon	2,285.10	89506	RENO, NV 89506		2,285.1	
11 dB	N4ZR	KN9B	7025.00	CQ	18 dB	34 wpm	0238z 27 Mar	Balloon	756.8	25430	KEARNEYSVILLE, WV 25430		756.8	11
	LA5EKA	KN9B	7025.10	CQ	3 dB	35 wpm	0237z 27 Mar	Balloon	3854.4		Norway		3854.4	
	S50ARX	KN9B	7025.00	CQ	5 dB	35 wpm	0237z 27 Mar	Balloon	4397.22		Slovenia		4,397.2	
	W3LPL	KN9B	7025.00	CQ	11 dB	35 wpm	0237z 27 Mar	Balloon	770.3	21738	Glenwood, MD 21738		770.3	
12 dB	K3MM	KN9B	7025.00	CQ	17 dB	35 wpm	0236z 27 Mar	Balloon	766.4	20872	DAMASCUS MD 20872		766.4	12
9 dB	WZ7I	KN9B	7025.00	CQ	13 dB	36 wpm	0236z 27 Mar	Balloon	884.9	18947	PIPERSVILLE PA 18947		884.9	9
	AB1HL	KN9B	7025.00	CQ	7 dB	35 wpm	0236z 27 Mar	Balloon	1049.8	01240	CAMBRIDGE, MA 02140		1,049.8	
	WA7LNW	KN9B	7025.00	CQ	17 dB	35 wpm	0236z 27 Mar	Balloon	1,911.60	84780	WASHINGTON, UT 84780		1,911.6	
	N4ZR	KN9B	7025.50	CQ	16 dB	36 wpm	0257z 27 Mar	Balloon	756.8	25430	KEARNEYSVILLE, WV 25430		756.8	
	WA7LNW	KN9B	7025.50	CQ	19 dB	36 wpm	0256z 27 Mar	Balloon	1,911.60	84780	WASHINGTON, UT 84780		1,911.6	
	K3MM	KN9B	7025.50	CQ	20 dB	35 wpm	0256z 27 Mar	Balloon	766.4	20872	DAMASCUS MD 20872		766.4	
	WZ7I	KN9B	7025.50	CQ	7 dB	35 wpm	0256z 27 Mar	Balloon	884.9	18947	PIPERSVILLE PA 18947		884.9	
Ref	N4ZR	KN9B	7029.50	CQ	6 dB	35 wpm	0346z 27 Mar	40m	756.8	25430	KEARNEYSVILLE, WV 25430	756.8		
	NC7J	KN9B	7025.20	CQ	7 dB	35 wpm	0342z 27 Mar	Balloon	1,893.80	84041	LAYTON, UT 84041		1,893.8	
	N7TR	KN9B	7025.20	CQ	12 dB	35 wpm	0342z 27 Mar	Balloon	2285.1	89506	RENO, NV 89506		2,285.1	
	S50ARX	KN9B	7025.20	CQ	3 dB	35 wpm	0342z 27 Mar	Balloon	4397.22		Slovenia		4,397.2	
	WZ7I	KN9B	7025.20	CQ	10 dB	35 wpm	0342z 27 Mar	Balloon	884.9	18947	PIPERSVILLE PA 18947		884.9	
	DK9IP	KN9B	7025.20	CQ	3 dB	35 wpm	0342z 27 Mar	Balloon	4733.84		Germany		4,733.8	
	OL5Q	KN9B	7025.20	CQ	3 dB	35 wpm	0342z 27 Mar	Balloon	4980.18		Czech Republic		4,980.2	
	WA7LNW	KN9B	7025.20	CQ	13 dB	35 wpm	0342z 27 Mar	Balloon	1,911.60	84780	WASHINGTON, UT 84780		1,911.6	
11 dB	N4ZR	KN9B	7025.20	CQ	17 dB	35 wpm	0342z 27 Mar	Balloon	756.8	25430	KEARNEYSVILLE, WV 25430		756.8	11
	K3MM	KN9B	7025.20	CQ	14 dB	35 wpm	0342z 27 Mar	Balloon	766.4	20872	DAMASCUS MD 20872		766.4	

Reverse Beacon logged 55 of the 270 CW CQs sent	Total	10,977.6	50,955.7	80
+12 dB Average Tx Gain Increase for sample of 7 that logged multiple sites for the same CQ	# Samples	15.0	30.0	7
40M NVIS Dipole average CQ Report distance 732 Miles for sample of 15	Average	731.8	1,698.5	11.43
Balloon 3/4 WL Vertical average CQ Report distance 1699 Miles for sample of 30	units	Miles	Miles	dB

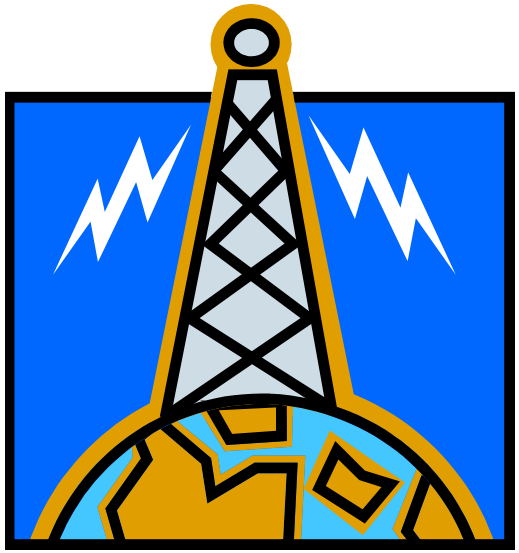
Not all 55 log items shown……

* www.reversebeacon.net

Conclusions

- It works real good!
- 12 dB or 20 dB is a gigantic improvement
- CQ results are conservative due to tree snag
  - Rx and first Tx tests were 20 dB
  - Covert night-time deployment prevent wire from reaching full altitude during measurements

Antenna Height Matters!



Why does it work?

- Approaching Wavelength Radiator
  - More radiation at angles below 30 Degrees
- Height Gain or Clear Sky Effect
  - Fewer obstructions means an increase in radiation at lower angles

Problems

- Unless you are 007 working at night is a bad idea

Picture of balloon launch

Problems

- Safety and Site Plan for Wind Changes
  - Wind will take the antenna into trees or worst even power lines
  - Wind direction will change during operations

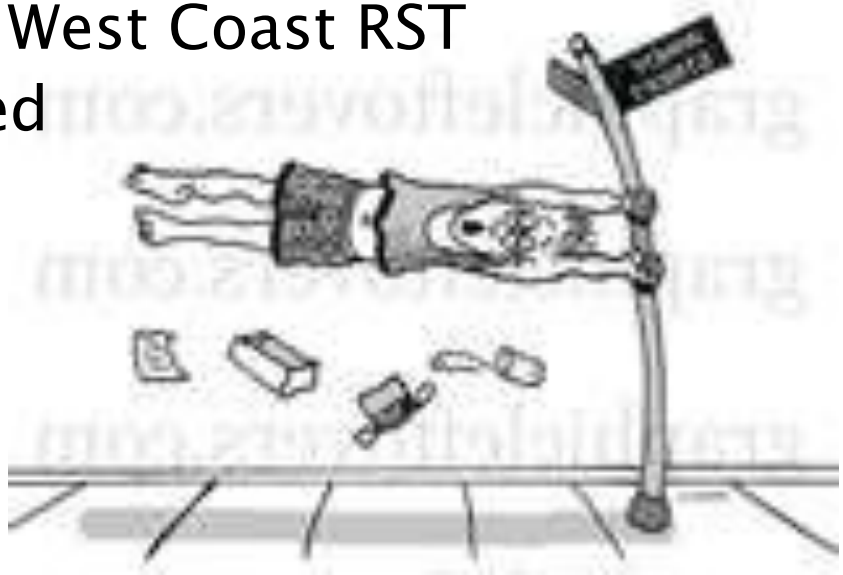
Problems

- RFI from Mis-Match on “perfect match”
  - Running directly unbalanced out on tuner
  - Measured 0 to 0.4 W Reflected on 25 W Forward
  - Still SWR was always 1:1.0
  - RFI was noticeable in shack

Need to Use Current BALUN

Problems (maybe not)

- Wind has big influence on antenna angle
  - 5 – 8 MPH resulted in 45 Degree Angle
  - 15 – 18 MPH resulted in 30 Degree Angle
- Mechanical Issue Only
  - Experienced both East and West Wind Slopping without change in EU or West Coast RST
  - No QSB could be detected
- No RF Issues

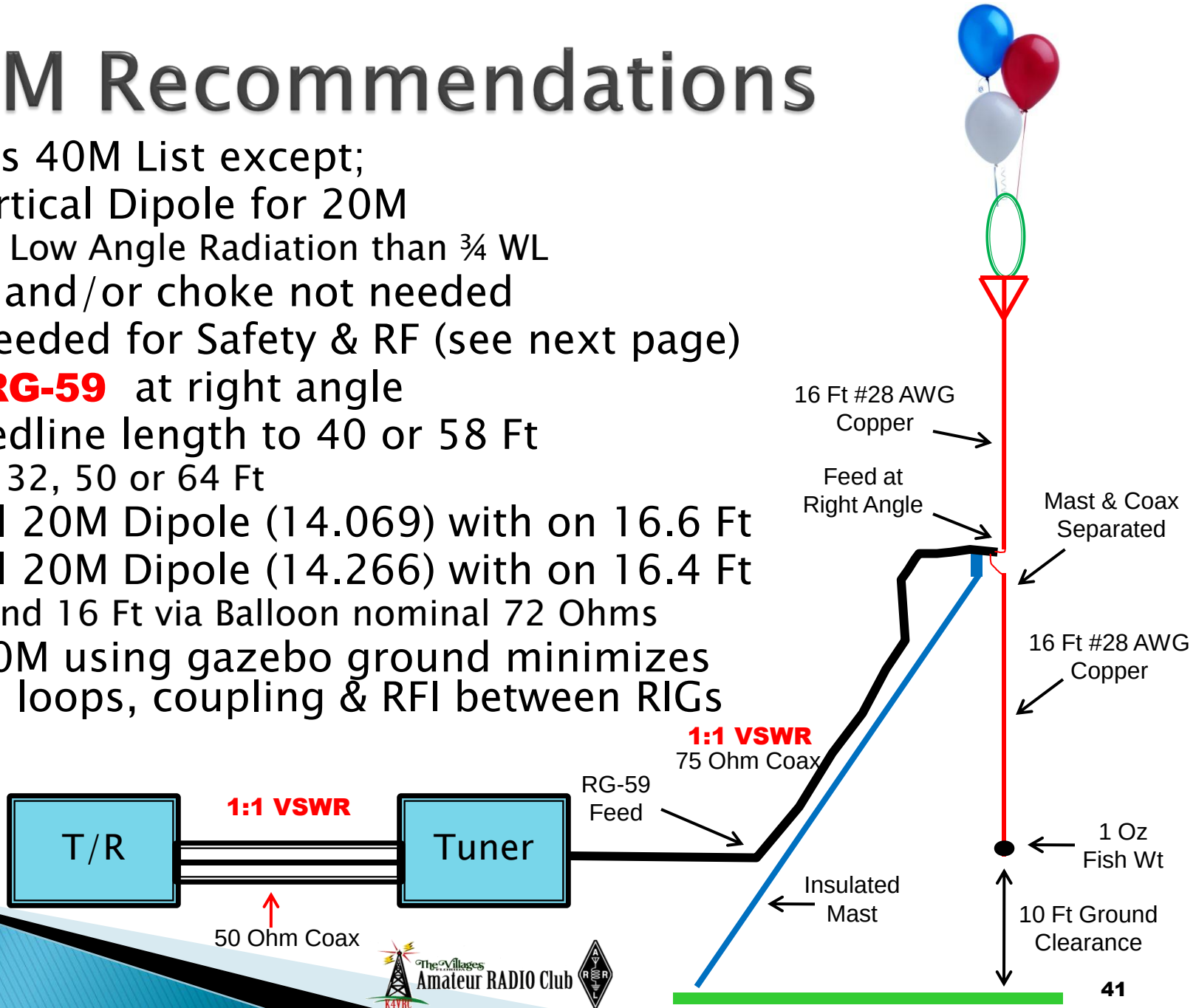


40 M Recommendations

- Mast for public issue at ROS not needed at FD
  - Mast required for safety (wind vs. people/structures)
  - Do not worry about wind drift angle vs. RF
- Do not kink antenna #28 AWG wire
  - ¾ WL Vertical 40M Wire (7.035 MHz) into a 99.8 Ft Vertical nominal 55 Ohms assume 4 radials (#22 AWG X 35 Ft) at gazebo
  - Use new wire and be careful during reeling
  - Length Tune for R + 0j vs. lowest VSWR
  - Take any ground with 3/4 WL
  - Use true Current BALUN on ¾ WL (BAL on Ant end)
- RG-58 OK as 0.5 dB not noticed with +20 dB
- Use Feedline length of 50 Ft or 75 Ft
  - Avoid 32 Ft or 64 Ft
- Use Dental Floss to secure balloons with 2 Ft
- Use Five Foot 30# Monofilament Leader Isolator
- Only 40M using gazebo ground minimizes ground loops, coupling & RFI between RIGs

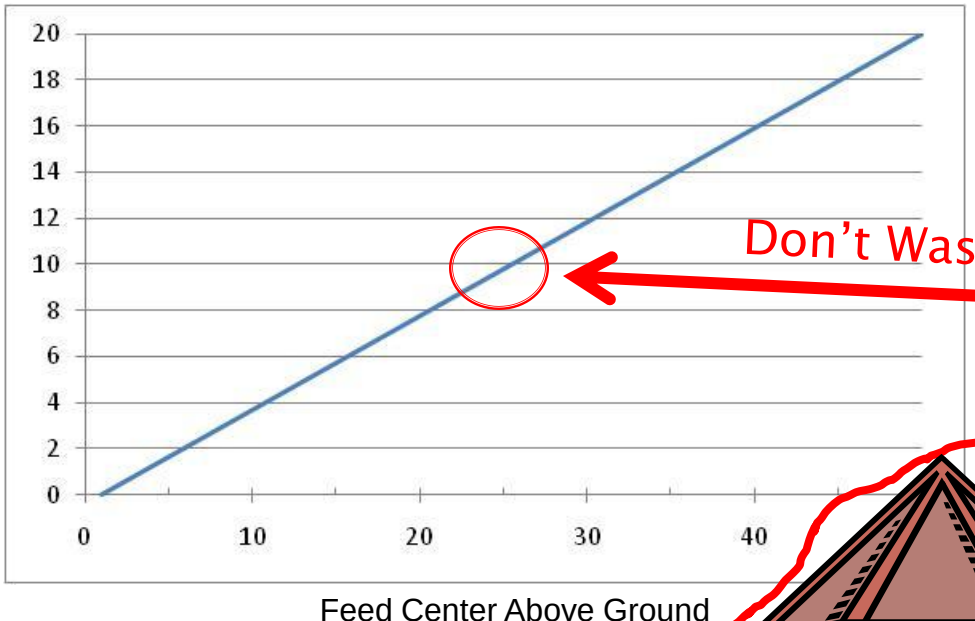
20 M Recommendations

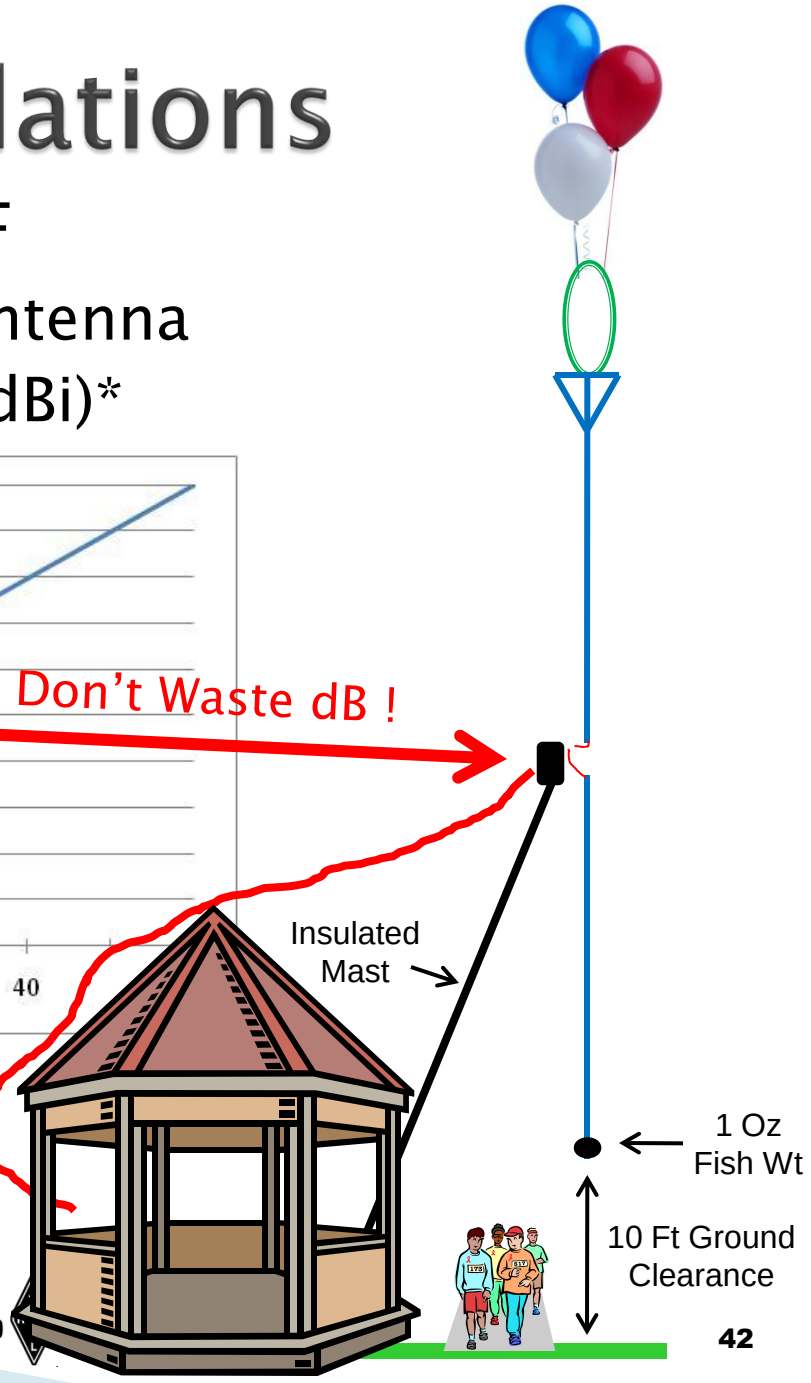
- Same as 40M List except;
- Use Vertical Dipole for 20M
  - Better Low Angle Radiation than ¾ WL
- BALUN and/or choke not needed
- Mast needed for Safety & RF (see next page)
- Feed **RG-59** at right angle
- Cut Feedline length to 40 or 58 Ft
  - Avoid 32, 50 or 64 Ft
- Vertical 20M Dipole (14.069) with on 16.6 Ft
- Vertical 20M Dipole (14.266) with on 16.4 Ft
  - Pole and 16 Ft via Balloon nominal 72 Ohms
- Only 40M using gazebo ground minimizes ground loops, coupling & RFI between RIGs



20 M Recommendations

- Mast needed for Safety & RF
  - Keeps people from touching antenna
  - Improves RF Gain (25 Ft = 10 dBi)*





* http://ham-radio.com/k6sti/height.htm

20 M Recommendations

- 20M Vertical Dipole featured in April QST
  - Fishing poles used for Masts
  - 5 Gallon buckets of Sand are only supports

Supporting Portable Antennas Without Guy Wires

A handy antenna — perhaps just right for your Field Day station.

Dave Fisher, KG0D/7

Look Mom, No guy wires! There are plenty of papers on designing antennas. This is more about supporting those antennas — without guy wires. Helping the grandkids build sand castles with small buckets on the beach triggered the idea. The materials for construction are simple — 33 foot fiberglass poles, 5 gallon plastic buckets with snapping lids and sand. These components make it easy to build a four element 20 meter monoband Yagi vertical without those messy guy wires.

I've been operating portable for several years now. This was caused by my proximity to a 50 kW AM station compounded by electronic noise from the neighbors. My portable operating locations needed to be near trees for antenna supports. This limited my operating locations. Using guy wires for support avoided the need for trees but these were a hassle to install and move.

A Better Way

This easy to duplicate antenna solved all my problems at once. The configuration I chose offers a four element 20 meter vertical Yagi of half wave dimensions that can be readily steered in multiple directions. The same materials can be used to construct similar antennas for other bands (see Table 1 for

Table 1
Element Wire Lengths and Interelement Spacing (feet) for Five DX Bands

Frequency (MHz)	Reflector (+5%)	Driver (468/MHz)	First Director (–5%)	Second Director (–10%)	Element Spacing
14.16	34.7	33.0	31.4	29.8	9.2
18.10	27.1	25.9	24.6	23.3	7.2
21.30	23.1	22.0	20.9	19.8	6.2
24.91	19.7	18.8	17.8	17.0	5.3
28.85	17.0	16.2	15.4	14.6	4.5

Figure 1 — Antenna construction starts with the driven element.

Figure 2 — Detailed view of the antenna feed connections. Vinyl electrical tape is used to secure the wire, pole sections and commercial 1:1 balun.

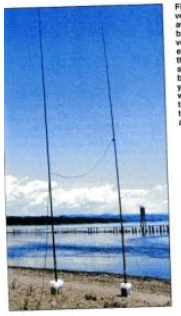


Figure 3 — The coax support vertical is built next. It gets the coax away from the driven element's bottom section. The coax support vertical is built just like the driven element. Each section is raised in three foot increments, taping each section as they are extended, until both are at full height. At this point you have an omnidirectional half wave vertical dipole. This is a good time to hook up the radio and check the band to see where you want to aim the antenna.

Figure 5 — The cat was kind enough to empty several more buckets of litter so more elements can be added. Using 20 meter data from Table 1, I measured and cut the wires needed for a reflector and two directors. I've included additional data for other bands these verticals could support. Part of the 20 meter reflector wire is extended above the pole and the other couple inches hangs down toward the ground.

dimensions), or base fed monopoles for lower bands. The base fed antennas require ground radials, making them more difficult to move, but they can still be effective choices if those are the bands you want to use.

The wire antenna elements are supported by 33 foot telescoping fiberglass poles that are available from a couple sources. The ones I use collapse to 45½ inches. Each weighs about 3½ pounds. The plastic buckets I use originally held cat litter. A nested stack of five buckets weighs 10 pounds and measures 27 × 12 × 10 inches — easy to manage. It is important to use buckets with lids that snap in place. There are many choices for buckets. Some large hardware stores sell them already empty. This is the best source. Others contain products such as soap, paint, swimming pool chlorine and cat litter that must be used first.

Figure 1 shows a bucket partially full of sand with the fiberglass pole in place. You can use sand, dirt or rocks dug from almost any operating location. These will make a bucket weigh 40 to 60 pounds depending on material density. Another option is bolting a PVC cap on the bucket's bottom. This will hold the bottom of your pole in place when you use water, rocks or snow/ice for wintertime operations. A 5 gallon bucket of water will weigh about 40 pounds. Two 20 pound bags of rice per bucket could also be used instead of sand. Long grain brown rice is said to lower the radiation angle and increase operating range. The lid snaps in place over the filled bucket and helps keep the pole stable.

The center fed driven element will be most effective if the coax to element transition is through a 1:1 balun or common mode choke. I used a commercial balun, but your favorite technique should be suitable. The coax should be routed as close to perpendicular to both the element and antenna axis as feasible. Figure 2 shows the details of the coax support system. At this point you have an effective 20 meter vertical dipole (see Figure 3).

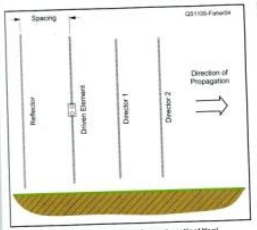


Figure 4 — Configuration of four element vertical Yagi. Dimensions are in Table 1.

Add Some Gain with a Little More Stuff

Now that the technique is proven, it is easy to make a top notch antenna array. I added a reflector and two directors resulting in a four element 20 meter vertical monoband Yagi. The configuration is shown in Figure 4. While somewhat stationary, it doesn't take much to pick up and move the parasitic elements to steer the antenna to other directions. If you will be in the same spot for a while, take the time to precompute and mark the bucket locations for directions you think you will want. Figure 5 shows the antenna looking north to Europe. Figure 6 is a side view.

The *EZNEC* predicted elevation and azimuth patterns are shown in Figures 7 and 8. This antenna provides a lot of gain for the investment.[1]

[1]J. Devoldere, *ON4UN's Low-Band DXing: 25 Years of Low Band Success*, Fifth Edition. Available from your ARRL dealer or the ARRL Bookstore. ARRL order no. 8560. Telephone 860-594-0355, or toll-free in the US 888-277-5289; **www.arrl.org/shop/**; **pubsales@arrl.org**. Data included with the provided CD includes many other multielement Yagi antennas with element quantity, length and spacing recipes.

Other Balloon HAMs in the Air

- Field Day using balloons on 160 Meters
- Small balloons are very effective HF antennas

Filling 18 Inch Balloon from $20 Helium Tank

Airborne at 200 Feet

SWR 1:1 at 1.825 MHz

Good Information

- Anyone with a remote tuner can try this on 40M using a 5/8 WL (83.1 Ft) should be super
- Mylar (foil) balloons good for 4 days, while latex balloons provide lift for only 10 hours
- Roll you #28 AWG on an empty 2-Liter bottle, after tying the coil open the bottle cap and squeeze to shrink the bottle for coil removal
- Wal-Mart has 15 Cu Ft Helium for $20
- Do not try a 5/4 or 7/4 WL on 20M the low angle radiation will be lost to upper lobes