HF Balloon Antenna

Radio on the Square Antenna Prototyping
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
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

Highest Probability for DX QSO in 0 to 15 Deg Elev
Design Approach

- Res Freq Ant with perfect Ground Plane

- 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 3rd Best Pattern (100 Ft)
    - PRO–55 Ohm good match to 50 Ohm RG–58
    - PRO–No mast required

Past ROS NVIS Dipole
Vert Dipole
¾ WL Vertical

Highest Probability for DX QSO in 0 to 15 Deg Elev

• 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
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)
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!

Don’t worry Dennis... I just need to make some minor adjustments.

Brad I hope this works!

Master shall I turn on the linear now?
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

Diagram:
- T/R
- Tuner
- 1:1 VSWR (50 R)
- 2 Ft Coax
- 95 Ft #28 AWG Copper
- 60 R
- 8 Ft #4 AWG Copper
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](http://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

To: KN9B This confirms our 2-way PSK31 QSO
Date: March 22, 2011 Time: 00:21 UTC
Band: 40M UR Sigs: 599
73's for this very good QSO, And I hope to see you again in Digital Modes "SAVE OUR PLANET"
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;

<table>
<thead>
<tr>
<th>Country</th>
<th>Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>Ontario Canada</td>
</tr>
<tr>
<td>Martinique</td>
<td>European Russia</td>
</tr>
<tr>
<td>Venezuela</td>
<td>Italy</td>
</tr>
<tr>
<td>Odessa Ukraine</td>
<td></td>
</tr>
</tbody>
</table>
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 3/4 WL Monopole
  - Maximum was 18 dB increase
  - Minimum was 8 dB increase

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

<table>
<thead>
<tr>
<th>de</th>
<th>dx</th>
<th>freq</th>
<th>cq/dx</th>
<th>snr</th>
<th>speed</th>
<th>time-date</th>
<th>ant</th>
<th>Miles</th>
<th>Zip</th>
<th>City-State-Zip</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ref</td>
<td>N4ZR</td>
<td>KN9B</td>
<td>7029.50</td>
<td>CQ</td>
<td>7 dB</td>
<td>35 wpm</td>
<td>0242z 27 Mar</td>
<td>40m</td>
<td>756.8</td>
<td>25430</td>
</tr>
<tr>
<td></td>
<td>K3MM</td>
<td>KN9B</td>
<td>7029.50</td>
<td>CQ</td>
<td>5 dB</td>
<td>35 wpm</td>
<td>0240z 27 Mar</td>
<td>40m</td>
<td>766.4</td>
<td>20872</td>
</tr>
<tr>
<td></td>
<td>W7ZI</td>
<td>KN9B</td>
<td>7029.50</td>
<td>CQ</td>
<td>4 dB</td>
<td>36 wpm</td>
<td>0240z 27 Mar</td>
<td>40m</td>
<td>884.9</td>
<td>18947</td>
</tr>
<tr>
<td></td>
<td>N7TR</td>
<td>KN9B</td>
<td>7025.00</td>
<td>CQ</td>
<td>11 dB</td>
<td>34 wpm</td>
<td>0238z 27 Mar</td>
<td>Balloon</td>
<td>2,285.1</td>
<td>89506</td>
</tr>
<tr>
<td>11 dB</td>
<td>N4ZR</td>
<td>KN9B</td>
<td>7025.00</td>
<td>CQ</td>
<td>18 dB</td>
<td>34 wpm</td>
<td>0238z 27 Mar</td>
<td>Balloon</td>
<td>756.8</td>
<td>25430</td>
</tr>
<tr>
<td></td>
<td>L5EKA</td>
<td>KN9B</td>
<td>7025.10</td>
<td>CQ</td>
<td>3 dB</td>
<td>35 wpm</td>
<td>0237z 27 Mar</td>
<td>Balloon</td>
<td>3854.4</td>
<td>Norway</td>
</tr>
<tr>
<td></td>
<td>S50ARX</td>
<td>KN9B</td>
<td>7025.00</td>
<td>CQ</td>
<td>5 dB</td>
<td>35 wpm</td>
<td>0237z 27 Mar</td>
<td>Balloon</td>
<td>4397.2</td>
<td>Slovenia</td>
</tr>
<tr>
<td></td>
<td>W3PL</td>
<td>KN9B</td>
<td>7025.00</td>
<td>CQ</td>
<td>11 dB</td>
<td>35 wpm</td>
<td>0237z 27 Mar</td>
<td>Balloon</td>
<td>770.3</td>
<td>21738</td>
</tr>
<tr>
<td>12 dB</td>
<td>K3MM</td>
<td>KN9B</td>
<td>7025.00</td>
<td>CQ</td>
<td>17 dB</td>
<td>35 wpm</td>
<td>0236z 27 Mar</td>
<td>Balloon</td>
<td>766.4</td>
<td>20872</td>
</tr>
<tr>
<td></td>
<td>W7ZI</td>
<td>KN9B</td>
<td>7025.00</td>
<td>CQ</td>
<td>13 dB</td>
<td>36 wpm</td>
<td>0236z 27 Mar</td>
<td>Balloon</td>
<td>884.9</td>
<td>18947</td>
</tr>
<tr>
<td></td>
<td>AB1HL</td>
<td>KN9B</td>
<td>7025.00</td>
<td>CQ</td>
<td>7 dB</td>
<td>35 wpm</td>
<td>0236z 27 Mar</td>
<td>Balloon</td>
<td>1049.8</td>
<td>01240</td>
</tr>
<tr>
<td></td>
<td>WA7LNW</td>
<td>KN9B</td>
<td>7025.00</td>
<td>CQ</td>
<td>17 dB</td>
<td>35 wpm</td>
<td>0236z 27 Mar</td>
<td>Balloon</td>
<td>1,911.60</td>
<td>84780</td>
</tr>
<tr>
<td>Ref</td>
<td>N4ZR</td>
<td>KN9B</td>
<td>7025.20</td>
<td>CQ</td>
<td>6 dB</td>
<td>35 wpm</td>
<td>0346z 27 Mar</td>
<td>Balloon</td>
<td>756.8</td>
<td>25430</td>
</tr>
<tr>
<td></td>
<td>WC7L</td>
<td>KN9B</td>
<td>7025.20</td>
<td>CQ</td>
<td>19 dB</td>
<td>36 wpm</td>
<td>0356z 27 Mar</td>
<td>Balloon</td>
<td>1,911.60</td>
<td>84780</td>
</tr>
<tr>
<td></td>
<td>K3MM</td>
<td>KN9B</td>
<td>7025.20</td>
<td>CQ</td>
<td>20 dB</td>
<td>35 wpm</td>
<td>0326z 27 Mar</td>
<td>Balloon</td>
<td>766.4</td>
<td>20872</td>
</tr>
<tr>
<td></td>
<td>W7ZI</td>
<td>KN9B</td>
<td>7025.20</td>
<td>CQ</td>
<td>7 dB</td>
<td>35 wpm</td>
<td>0326z 27 Mar</td>
<td>Balloon</td>
<td>884.9</td>
<td>18947</td>
</tr>
<tr>
<td></td>
<td>NC7J</td>
<td>KN9B</td>
<td>7025.20</td>
<td>CQ</td>
<td>12 dB</td>
<td>35 wpm</td>
<td>0342z 27 Mar</td>
<td>Balloon</td>
<td>1,893.80</td>
<td>84041</td>
</tr>
<tr>
<td></td>
<td>N7TR</td>
<td>KN9B</td>
<td>7025.20</td>
<td>CQ</td>
<td>10 dB</td>
<td>35 wpm</td>
<td>0342z 27 Mar</td>
<td>Balloon</td>
<td>2285.1</td>
<td>89506</td>
</tr>
<tr>
<td></td>
<td>S50ARX</td>
<td>KN9B</td>
<td>7025.20</td>
<td>CQ</td>
<td>3 dB</td>
<td>35 wpm</td>
<td>0342z 27 Mar</td>
<td>Balloon</td>
<td>4397.22</td>
<td>Slovenia</td>
</tr>
<tr>
<td></td>
<td>W7ZI</td>
<td>KN9B</td>
<td>7025.20</td>
<td>CQ</td>
<td>10 dB</td>
<td>35 wpm</td>
<td>0342z 27 Mar</td>
<td>Balloon</td>
<td>884.9</td>
<td>18947</td>
</tr>
<tr>
<td></td>
<td>DK9IP</td>
<td>KN9B</td>
<td>7025.20</td>
<td>CQ</td>
<td>3 dB</td>
<td>35 wpm</td>
<td>0342z 27 Mar</td>
<td>Balloon</td>
<td>4733.84</td>
<td>Germany</td>
</tr>
<tr>
<td></td>
<td>OL5SQ</td>
<td>KN9B</td>
<td>7025.20</td>
<td>CQ</td>
<td>3 dB</td>
<td>35 wpm</td>
<td>0342z 27 Mar</td>
<td>Balloon</td>
<td>4980.18</td>
<td>Czech Republic</td>
</tr>
<tr>
<td></td>
<td>WA7LNW</td>
<td>KN9B</td>
<td>7025.20</td>
<td>CQ</td>
<td>13 dB</td>
<td>35 wpm</td>
<td>0342z 27 Mar</td>
<td>Balloon</td>
<td>1,911.60</td>
<td>84780</td>
</tr>
<tr>
<td>11 dB</td>
<td>N4ZR</td>
<td>KN9B</td>
<td>7025.20</td>
<td>CQ</td>
<td>17 dB</td>
<td>35 wpm</td>
<td>0342z 27 Mar</td>
<td>Balloon</td>
<td>756.8</td>
<td>25430</td>
</tr>
<tr>
<td></td>
<td>DK9IP</td>
<td>KN9B</td>
<td>7025.20</td>
<td>CQ</td>
<td>14 dB</td>
<td>35 wpm</td>
<td>0342z 27 Mar</td>
<td>Balloon</td>
<td>766.4</td>
<td>20872</td>
</tr>
</tbody>
</table>

Reverse Beacon logged 55 of the 270 CW CQs sent
+12 dB Average Tx Gain Increase for sample of 7 that logged multiple sites for the same CQ
40M NVIS Dipole average CQ Report distance 732 Miles for sample of 15
Balloon 3/4 WL Vertical average CQ Report distance 1699 Miles for sample of 30

Not all 55 log items shown............
* www.reversebeacon.net

May 17, 2011
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
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 $\frac{3}{4}$ 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
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