WSPR Antenna and Propagation Experiment: Preliminary Results

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Update May 20, 2016 by Charles Preston, now K7TAA
Recent controlled experiments with WSPR have validated the use of WSPR to make accurate and reliable measurements of comparative antenna performance with ionospheric or local, non-ionospheric propagation. A report of the results has been accepted for publication.

Summary
The WSPR protocol and network are tremendous aids to rapid antenna/propagation data collection. Two transmitters or receivers can be operated simultaneously with two antennas at the same location. The resulting measurements reduce some of the variables that make reliable antenna comparisons so difficult when using ionospheric propagation.

Introduction
The Weak Signal Propagation Reporter (WSPR) software and reporting network can be a big help in getting enough measurement data points to increase the reliability of HF antenna/propagation measurements.
http://wsprnet.org/drupal/wsprnet/map

The most important antenna question for some is not absolute performance, like stated or measured gain. It is how actual Antenna 1 works compared with actual Antenna 2, both being antennas usable in a certain location, and having different characteristics.

Making simultaneous measurements from more than one antenna to multiple points when transmitting, or simultaneous antenna/receiver measurements from multiple points should overcome some of the difficulty of making valid comparisons with rapidly changing ionospheric conditions.

Being able to make measurements, especially multiple measurements, every two minutes, can accomplish in hours what would otherwise take days to weeks. The high sensitivity of the WSPR protocol means more opportunities to make measurements when conditions aren't very good. The signal to noise ratio in the local WSPR log and online database lets you know whether other modes, at higher power levels, would be possible. Having the data logged automatically saves clerical errors that may otherwise cause confusion when analyzing data.

Using a number of efficiently obtained data points from different locations and stations should provide useful conclusions about the relative effectiveness of Antenna 1 vs Antenna 2. The data is likely to be more accurate than other methods of measurement. Except in rare cases, each pair of transmissions is being received on a single antenna at the same moment, and since the transmissions are less than 200 Hz apart, any existing or changing local or atmospheric noise levels should be greatly reduced as an error factor. Strong interference causing AGC gain changes from one second to the next should be the same for both received signals throughout each transmission period.

Except for those antennas that have current flow in ground radials, the actual ground characteristics directly under the antenna are less important than the ground and terrain for 10 wavelengths or more surrounding the antennas being compared. This means the antennas can be somewhat isolated electromagnetically from each other while still being close enough for both to be subject to the same far field ground conductivity and terrain.

Initial results
This preliminary report is mainly to suggest a testing method for antenna effectiveness, and does not have highly reliable data on Buddipole vs horizontal loop due to the physical proximity of the two antennas.

Testing on the 30 meter band, a Buddipole dipole configuration at about 16 feet in height was approximately as effective for DX as a 300 foot loop at an average 25 foot height.

While I found these initial results surprising, they shouldn't be considered the last word in Buddipole or loop performance. The Buddipole configuration was not isolated from the horizontal loop, but was actually inside the loop due to residential lot size in this first experiment. This undoubtedly had an effect on both antennas.

What these measurements can't do
Since WSPR reports signal to noise ratio, if the antennas are picking up different amounts of noise, which they were in this case, received signal measurements don't allow direct comparison of received signal strength. Equal SNR reports tell you that each antenna would be equally effective receiving those stations at a certain time. If you're going to use the antennas as transmitting antennas it's important to have both test stations also transmitting part of the time, to compare performance at different receiving sites with different antennas. Since there may be multiple signal components arriving at different elevation or azimuth angles at any instant at each site, this doesn't answer the question of how much total signal each antenna produces for a given amount of transmitter power.

Equipment configuration
The antenna configuration for KL7JES was a 300 foot horizontal rectangular loop, with the long side E/W, at an average height of about 25 feet. It is fed at a corner by 30' of ladder line, matched by an SGC SG-237 coupler.

The antenna configuration for KL7OA was a Buddipole dipole on the Buddipole 16 foot mast and tripod. Dipole length was about 22 feet. Each side had 2 Buddipole accessory antenna arms, 1 low band coil, and 5 sections of Buddipole military style shock-corded whip. A triple ratio switch balun was used to feed the dipole. The dipole ends were aligned NNE/SSW.

Coax losses from each antenna should have been 1 dB or less.

Each transceiver was a Yaesu FT-817ND, set for 2 watts (33 dBm) output.

Since signals reported by WSPR are in dB, different transmitter output powers could be used and easily allowed for in the results, as long as the WSPR reported output power is correct for each transmitter.

Result summary

KL7JES and KL7OA were both at the same location in Anchorage, Alaska, in grid square BP51. Considering all the locations, the performance of the two antennas was similar. The Buddipole had the weaker signal at the greatest distance, in Japan, but there are too few measurements to tell whether the orientation of the dipole might have been a factor.

The data in the table below was accumulated in less than 20 minutes. There were pairs of reports from 7 unique stations, in 5 general locations.

PM95so Japan
PM95wr

CN84px western Oregon
CN87to western Washington
CN89dk western British Columbia
DM43ci southern Arizona
CN87xo

Distances ranged from 2304 km to 5580 km. Azimuths from Anchorage varied from 117 to 273 degrees, an arc of 156 degrees.

Result details
The reception reports are sorted by time of transmission. Note that at certain times, KL7JES (loop) was reported by stations that did not report KL7OA (Buddipole), but the same thing happened in reverse during this short series of transmissions. One possible explanation is that the signal from one antenna is too low at the receiving site. But since the two transmitters are on different frequencies, an alternate explanation is that another, locally stronger, signal was present on the exact frequency used by one or the other during that 2-minute period.

More negative SNR figures are weaker. A difference of 6 dB is often considered equivalent to 1 S unit. The signal to noise ratio is the signal strength compared to the noise in a 2500 Hz bandwidth, which is about the narrowest bandwidth used with SSB. That means this experiment could not have been conducted with low power using SSB under the existing band conditions.

Date-time UTC	Reporter Grid	SNR dB	Xmtr	Dist. Km	Az fm Xmtr
3/29/09 21:42	PM95so	-21	KL7JES	5580	273
3/29/09 21:42	PM95so	-25	KL7OA	5580	273
3/29/09 21:42	PM95wr	-20	KL7JES	5551	273
3/29/09 21:42	PM95wr	-26	KL7OA	5551	273
3/29/09 21:42	CN87to	-27	KL7JES	2304	118
3/29/09 21:42	CN84px	-7	KL7JES	2522	123
3/29/09 21:42	CN84px	-4	KL7OA	2522	123
3/29/09 21:42	CN89dk	-18	KL7JES	2085	117
3/29/09 21:42	DM43ci	-23	KL7JES	4114	121
3/29/09 21:44	PM95so	-26	KL7JES	5580	273
3/29/09 21:44	PM95wr	-26	KL7JES	5551	273
3/29/09 21:44	CN87to	-23	KL7JES	2304	118
3/29/09 21:44	CN87to	-28	KL7OA	2304	118

Date-time UTC	Reporter Grid	SNR dB	Xmtr	Dist. Km	Az fm Xmtr
3/29/09 21:44	CN84px	-5	KL7JES	2522	123
3/29/09 21:44	CN84px	-5	KL7OA	2522	123
3/29/09 21:44	CN89dk	-22	KL7JES	2085	117
3/29/09 21:44	CN89dk	-14	KL7OA	2085	117
3/29/09 21:56	PM95so	-22	KL7JES	5580	273
3/29/09 21:56	PM95so	-26	KL7OA	5580	273
3/29/09 21:56	PM95wr	-27	KL7OA	5551	273
3/29/09 21:56	CN87to	-23	KL7JES	2304	118
3/29/09 21:56	CN87to	-26	KL7OA	2304	118
3/29/09 21:56	CN84px	-13	KL7JES	2522	123
3/29/09 21:56	CN84px	-13	KL7OA	2522	123
3/29/09 21:56	CN89dk	-14	KL7JES	2085	117
3/29/09 21:56	CN89dk	-11	KL7OA	2085	117
3/29/09 21:56	DM43ci	-24	KL7JES	4114	121
3/29/09 21:56	DM43ci	-20	KL7OA	4114	121
3/29/09 21:56	CN87xo	-23	KL7JES	2320	118
3/29/09 21:56	CN87xo	-22	KL7OA	2320	118