The Reverse Beacon Network

A worldwide network of receivers monitors the amateur bands every day.

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Chances are you've heard of the Reverse Beacon Network (RBN) and probably used the data from it, reporting stations heard on the air. But did you know that ionospheric scientists have begun to make use of RBN data to better understand the Sun's interactions with radio propagation? And you can participate!

Most amateurs are familiar with beacons — automated stations that transmit from a known location so a receiving station can assess propagation between the two locations. A "reverse beacon" is a station that listens to many transmitting stations and reports what it hears as "spots" (see the sidebar, "The Anatomy of a Spot"). The RBN (**www.reversebeacon.net**) consists of many such stations, extending nearly worldwide and making their signal reports available over the Internet. This allows propagation to be evaluated over a wide area.

The success of the RBN has changed the face of Amateur Radio, particularly radiosport. Along with similar signal monitoring and reporting systems such as WSPRNet (**wsprnet.org**) and PSKReporter (**pskreporter.info**), it also provides amateurs with a means to measure and experiment with propagation and other natural phenomena alongside the scientific community. Figure 1 shows a screenshot of *CW Skimmer* software.

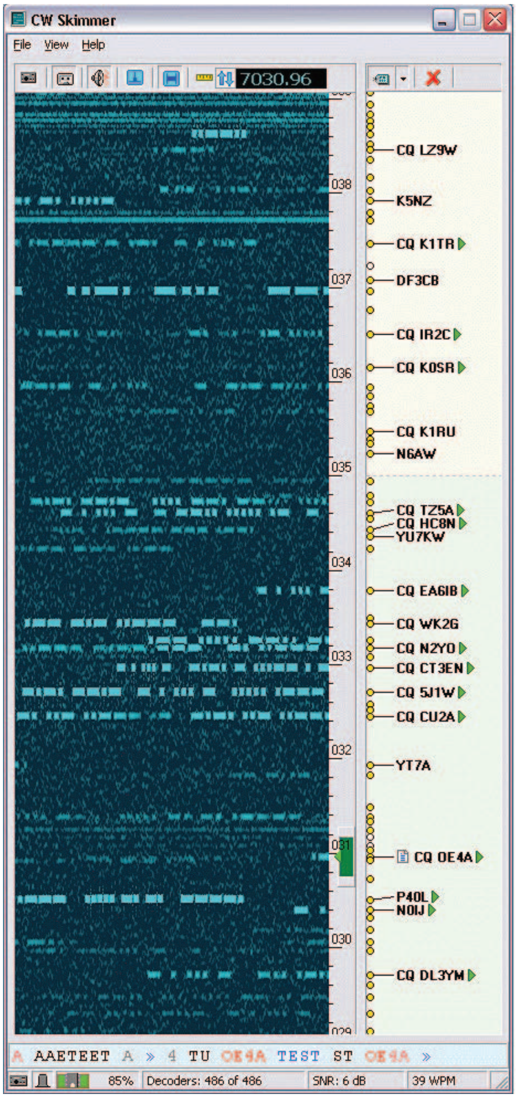

Figure 1 — A screenshot of *CW Skimmer* software. [Screenshot courtesy of Pete Smith, N4ZR]

In the Beginning

The RBN arose out of one seminal technological development — the release in early 2008 of *CW Skimmer* software by Alex Shovkoplyas, VE3NEA, which is capable of decoding many CW signals at once.

Starting with an e-mail exchange in March 2008 between Felipe, PY1NB, and Pete Smith, N4ZR, the RBN grew quickly over the next several years. They and the rest of the current RBN team — Nick, SV2SJ/F5VIH; Dave, KM3T; and Dick, W3OA — built a system of Telnet servers to supply RBN data worldwide.

VE3NEA released *RTTY Skimmer Server* in 2014 — again the first and only such program for amateur use — and the RBN has now become the predominant source of RTTY spots as well.

Today, the RBN provides more than 98% of all the CW and RTTY spots distributed by the worldwide DX spotting network. It has also archived every single spot made by any RBN node since February of 2009, together with information about the signal-to-noise ratio (SNR) and sending speed. During a single 48-hour contest weekend late in 2015, the

The Anatomy of a Spot

Ever since the release of *PacketCluster* software by AK1A in the late 1980s, stations have used digital networks to share reception reports. Typically, a DX station's call sign and frequency were reported along with a short comment. Initially, the networks used AX.25 packet radio, but today they are almost universally linked by the Internet, so the information is distributed worldwide at lightning speed.

Each traditional spot looks more or less like the following line of information:

DX de NØAX: 21046.5 W1AW Good signal today 1442Z

This means NØAX has received W1AW on 21.0465 MHz with a good signal and sent the report at 1442 UTC.

The *Skimmer* software for CW and RTTY watches for stations calling CQ or TEST and reports the signal's signal-to-noise ratio (SNR) and speed in WPM as the comments, along with whether the station is calling CQ or not. A typical Skimmer-generated spot looks like:

DX de NØAX-#: 21046.5 W1AW 38 dB 32 WPM CQ 1442Z

In this case, the hashtag (#) following the spotting station's call sign indicates the spot is Skimmer-generated. For obvious reasons, the RBN seeks to avoid spotting callers and stations in the middle of ragchews.

RBN recorded over 7 million spots from more than 140 nodes around the world (that's an average of more than 40 per second). Lee, VE7CC, programmed the RBN's relay servers, which are stripped down and optimized to handle this incredible throughput. Figure 2 shows a screenshot map of current Skimmer locations.

Using the RBN

All you need to begin using the RBN is a web browser connected to **www.reversebeacon.net**. The RBN web page offers several unique capabilities.

1. Station Testing

Call CQ or send TEST, followed by your call sign, several times on an open band and you will see a number of spots of your station appear. Want to compare antennas? Make a test transmission on the first antenna, change frequency slightly, and repeat with the second one. You can see immediately which antenna is better, over which paths.

2. Comparing Stations

The *Signal Comparison Tool*, accessible from the main web page menu under DX SPOTS, permits you to choose up to 10 stations and compare signals at a given RBN node over an entire day on all the HF bands. You can readily see who was heard more loudly and learn what improvements you need to make to compete more evenly.

3. Extracting Data

You can download each day's spots by RBN nodes worldwide in the widely used CSV (comma-separated values) format, which can be imported by Microsoft *Excel*, *Access*, and many other programs. Data is available from February 2009 until 1 day ago, and it's all free.

Becoming an RBN Node-Op

Suppose you want to become an RBN "node-op." Start by downloading a 30-day trial of *CW Skimmer* from VE3NEA's **DXAtlas.com** along with a copy of the user manual.

You can use the audio from your station transceiver, although that only gives you 3 kHz at a time. A separate SDR is a lot more fun. The cheapest approach is to build one of the Softrock SDR receiver kits available from **www.fivedash.com**. Get a Softrock that can be programmed to band-hop according to a programmed schedule. You can cover as much of each band as your sound card sampling rate can support.

As of early 2016, there are many RBN nodes using the QS1R receiver designed and built by Phil Covington, N8VB. A QS1R receiver can cover up to seven amateur bands at one time using VE3NEA's *Skimmer Server*, a multi-band adaptation of *CW Skimmer* (a successor to the QSR1 is currently under development).

To get your spots onto the RBN, you'll need to download the free *Aggregator* software from the RBN website and use it to connect your *CW Skimmer* to the Internet. The *Aggregator* forwards your spots to the RBN's server, which then archives them and forwards them to DX clusters around the world.

With a multiband node comes the requirement for a multiband antenna. Many RBN participants are using active vertical antennas and magnetic loops, or even their own transmitting antennas. Still others are using multiband dipoles. The important thing is to get an antenna on the air and start listening!

A relatively modern PC will suffice for all but the heaviest CW contest situations, and even then, the *CW Skimmer* software gracefully limits itself while continuing to decode as many streams as it can.

RTTY is a lot more computer-intensive, but again, the computer limits itself gracefully. Almost any Internet connection should be adequate.

HamSCI and the RBN

The RBN archive has already been used in a scientific article published in *Space Weather Quarterly* in late 2014, to provide data on HF propagation during a solar flare.[1] The study was held up as a prime example of how "citizen science" could contribute to ionospheric research. From this initial article came the HamSCI initiative announced in the August 2016 issue of *QST*.[2] A summary of the study, with a link to the full article, is available at **reversebeacon.blogspot.com/2015/06/rbn-entering-science-mainstream-who.html**.

Figure 3 shows maps of RBN data for three time spans (a) – (d), along with the Sun's X-ray output (irradiance) (e). There's no question that the volume of data available from the archive can be used to support similar research projects. One of the limitations of RBN data, however, is that there is no standard of comparison among RBN nodes worldwide — the nodes report signal-to-noise ratio (SNR) at each spot, but this value cannot be calibrated against any absolute standard. Antennas, local noise environments, and other factors all affect SNR, and a given station may perform very differently on 160 meters, for example, than on the higher-frequency bands.

One approach that has been suggested would be to collect data from many RBN nodes on the strength of one or more of the NCDXF beacons (**ncdxf.org/beacon**) or of other beacons on the lower bands. Many

Figure 2 — A screenshot map of current Skimmer locations generated from experimental software. [Screenshot courtesy of Pete Smith, N4ZR]

RBN and the 2017 Solar Eclipse

As reported in the August 2016 *QST* article, "HamSCI: Ham Radio Science Citizen Investigation," on the HamSCI initiative, the RBN will play a key role in collecting data during the eclipse. Amateur and professional observations of the eclipse are likely to generate the largest set of point-to-point propagation data ever recorded for a single event and amateurs will play a key role. You can participate by setting up an RBN node in your area, perhaps supporting a club project. Or you can participate simply by operating in the Solar Eclipse QSO Party and tailoring your transmissions to make it easy for the RBN to measure your signals. There will be additional *QST* articles about how to participate in this once-in-a-lifetime event.

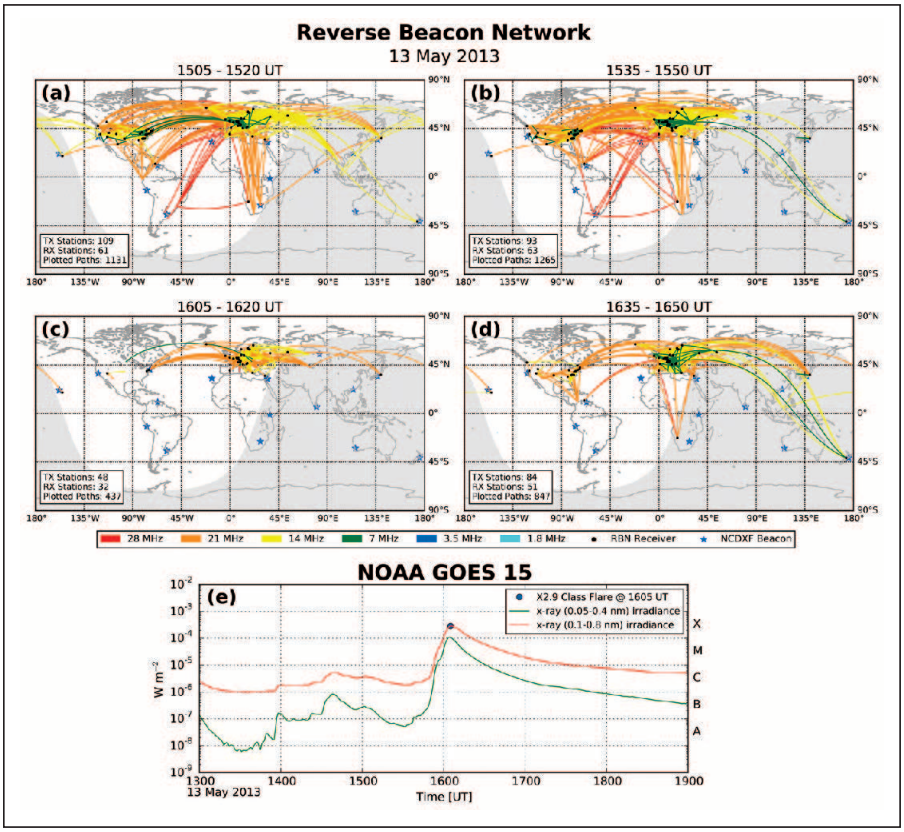

Figure 3 — HF communications before and after a solar flare. The figure shows signal paths during four time periods (a) – (d), and the Sun's X-ray output (irradiance) in (e).

details would need to be ironed out and stations wishing to participate would need to enable beacon reception on their nodes.

Another improvement that could provide scientific utility through direct comparison of data from the receivers at RBN nodes would be precise time and frequency calibration. In theory, this would enable measurements of the mode of propagation and the height of the relevant ionospheric layer. (The RBN archives time only to the nearest second and frequency to the nearest 0.1 kHz, for compatibility with the existing DX spotting network. Moreover, spots from each node are "batched" to reduce the communication workload on the servers. Precise time and frequency would only be available from GPSDO-controlled receivers themselves, not from the RBN.) Already, there are a dozen or so RBN nodes that use GPS-Disciplined Oscillators (GPSDOs) or similarly high quality time and frequency standards. One can imagine experiments on 160 meters, for example, with pairs of RBN nodes and co-located transmitters also referenced to GPS, collecting data on some of the unusual propagation modes present on that band.

Along with improving the time and frequency accuracy for the nodes, other aspects of the measurements are also important, including better-calibrated measurements of the received noise floor. This would allow signals from different transmitting stations to be compared more directly between the RBN node SNR reports. While the idea sounds great, achieving it in practice beyond very few nodes would take a lot of work.

The scientific potential of the RBN is just beginning to be tapped. *CW Skimmer*-equipped stations and the RBN have grown into a worldwide receiving network, continuously collecting and storing data from amateur stations worldwide. This type of data can be valuable for research into solar behavior, geophysical systems like the ionosphere and geomagnetic field, climate change, radio propagation, and other natural phenomena. Once again, Amateur Radio has the potential to fulfill its *Basis and Purpose* directive to "advance the radio art."

Notes

[1] *Space Weather Quarterly*, Volume 12, No. 1, 2015, pp 10 – 15

[2] Ward Silver, NØAX, "HamSCI: Ham Radio Science Citizen Investigation," *QST*, Aug 2011, pp 68 – 71.

Pete Smith, N4ZR, has been an ARRL member since he was first licensed in 1954 as WN8QZR. He has held an Amateur Extra class license and his current call since 1977. He served in the Foreign Service from 1964 to1979 and retired from NASA in 1996, where he was Director of International Relations. An active member, past Newsletter Editor, and Trustee of the Potomac Valley Radio Club, he's co-founder of the Reverse Beacon Network and a longtime member of the N1MM Logger+ team. You can reach Pete at 3 Windemere Pkwy, Phoenix, MD 21131 or by e-mail to **n4zr@comcast.net**.

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