Amateur Radio: Science in Action

Galen Burrell, a graduate student from Scott Bergeson's lab, using radio to conduct bat telemetry research in northeastern Indiana. [Deanne Jensen, photo]

Ham radio operators join forces with researchers for a wildlife telemetry experiment.

Andrew "Jim" Danielson, AC9EZ; Jordan Marshall, NM9L, and Scott Bergeson

The Amateur Radio Service, and by extension amateur radio operators, have a long and proud history of pushing the envelope when it comes to the science of radio communications. From medical devices to satellites, the Amateur Radio Service continues to be involved in a variety of fields and interests, including scientific research and public service.

How Researchers Can Use Ham Radio

One clear example of the overlap between the amateur radio hobby and scientific research is the practice of wildlife radio telemetry (see the lead photo). Since the 1950s to 1960s, radio telemetry has been used by scientific researchers as a means of tracking radio-tagged wildlife. Radio telemetry allows scientists to trace or track the movements of an animal without needing to be physically present and within eyesight of it.

The practice of tracking radio signals using a small receiver and handheld antenna is better known in amateur radio circles as *foxhunting* — an operating activity that involves hams splitting into two groups: a fox and its hunters. The fox transmits a signal from an undisclosed location for a set period, while the hunters attempt to locate it using only amateur radio direction finding (radio telemetry) techniques. Once the fox has been located, some participants take the hunt a step further by tasking hunters with finding a micro fox — an even smaller, low-power transmitter hidden somewhere near the main fox.

The biggest difference between researchers tracking wildlife using radio telemetry and radio amateurs tracking a fox transmitter is that the transmitter isn't moving, whereas wildlife is. The techniques and equipment used for these two practices are similar. A large number of amateur radio foxhunts use a signal on the 2-meter band, and many wildlife telemetry researchers use transmitters in the VHF or UHF region, with frequencies extending from just above the 2-meter band (approximately 150 MHz), all the way past the 70-centimeter band. Similar antennas (usually portable directional Yagis) are also used.

Merging Radio and Science

In the summer of 2022, Jim Danielson, AC9EZ, conducted a wildlife telemetry research project with Jordan Marshall, NM9L, and Scott Bergeson, both of whom are faculty members of the Department of Biological Sciences at Purdue University Fort Wayne (PFW). This project was inspired by the academic work of Scott, who uses wildlife telemetry to study several species of bats in the Midwest. As part of his research, Scott utilizes small transmitters (with frequencies in the 150 MHz range) that are attached to the backs of captured bats. These bats are released and then tracked by Scott and his students, identifying the bats' habitats and areas of activity.

The tracking equipment that's used consists of several commercially made portable Yagi antennas, as well as a commercial receiver. The wildlife transmitters' signals usually consist of a simple carrier emitted at regular intervals (again, similar to a micro fox transmitter in a foxhunt).

Jim's research project had two main goals: analyze the performance of homebrew Yagi-Uda antennas and their use for receiving telemetry signals, and analyze the performance of an inexpensive, software-defined radio (SDR) dongle and its possible utility by wildlife telemetry researchers. The SDR used was a popular model sold online for $25 to $30.

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For the first research goal, we constructed multiple Yagi-Uda antennas. The first Yagi was made out of aluminum tubing purchased at a local big-box home improvement store, and the antenna dimensions were calculated using the free antenna modeling program *4NEC2*. It had custom-designed, 3D-printed brackets made of polylactic acid-style material. We built the second and third Yagis following the traditional tape-measure construction, and they consisted of ½-inch PVC tubing and a 1-inch-diameter tape measure. The only differences between Yagis two and three were the length of the elements and the spacing between the elements. We determined the element lengths and spacing by using *4NEC2*.

For testing purposes, we placed a small beacon transmitter in different locations near the PFW campus to simulate a roosting bat. We connected the different homebrew Yagis to the commercial telemetry receiver and were able to record some approximate signal strength readings. The results were promising, with the final tape-measure Yagi yielding the strongest signal receptions. This was an important result, as it indicated the possibilities of homebrew Yagis and their use by professional researchers.

One interesting design flaw that revealed itself during the experiment was the lack of any kind of homebrew baluns on the Yagis. During the course of testing the individual Yagi antennas, it became clear that the different feed-line lengths were affecting the tuning of the antennas. This was probably due to the fact that a Yagi antenna has a balanced feed point, whereas coaxial cable (which was used to feed each antenna) is an inherently unbalanced type of feed line. Because an imbalanced feed line was feeding a balanced feed point, there is a strong pos-

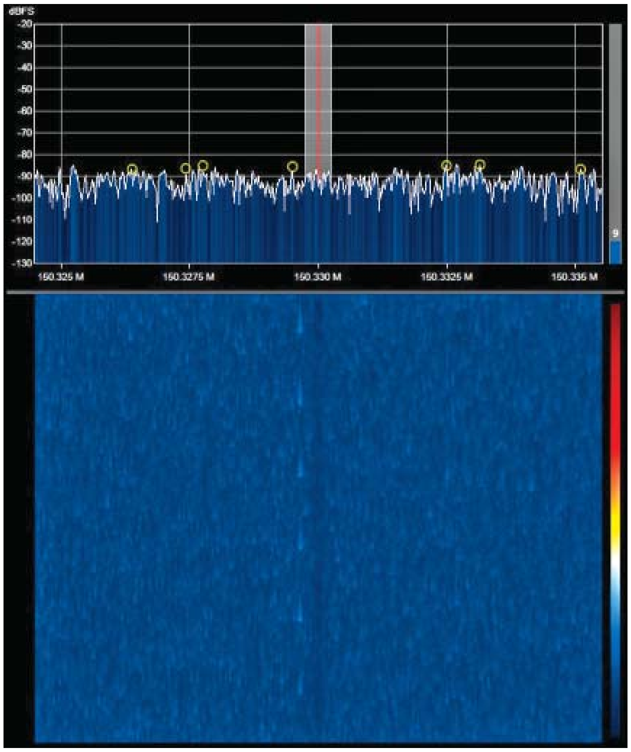

Figure 1 — A screenshot of the RTL-SDR dongle using SDR# software to receive the wildlife telemetry beacon from approximately 1 kilometer away. The SDR was set to CW mode with a 500 Hz filter. The frequency of the beacon was 153.330 MHz. Click here to hear a more detailed explanation of the results of AC9EZ's experiments. [Andrew "Jim" Danielson, AC9EZ, photo]

sibility that the radiation patterns and gain specifications for each Yagi design didn't match the calculated models, as the feed line was acting as part of the antenna. A balun at the feed point could improve the performance of each Yagi, although further research is required to see how much of an effect such a balun would have on the antennas.

For Jim's second research goal, the beacon transmitter was again placed at different locations off campus. At the receive site on campus, the SDR dongle was connected to a laptop. The main goal was to see how well the SDR dongle received the low-power beacon transmitter's signal, and determine to what extent the beacon's signal could be tracked visually. These tests yielded multiple results. The beacon's signal could be seen clearly on the software's waterfall display (similar to observing FT8 or other digital mode signals). Adjustment of the RF gain and waterfall frequency resolutions enabled the beacon's signal to be received visually, even if no audible signal was detectable (see Figure 1). It was determined that the utility of SDR technology, and its use in wildlife telemetry, is a possibility with a beacon's signal being received from distances above 2 kilometers.

Another factor to consider with the use of SDR technology in wildlife telemetry is that most researchers rely on audibly detecting a wildlife telemetry signal. This audio detection method has its drawbacks because it requires a telemetry signal powerful enough to be physically detected as audio. However, as demonstrated by amateur radio digital modes like FT8 and JT65, a radio signal can be detected visually before it is audible. For wildlife telemetry researchers, this could mean that wildlife telemetry signals could be visually detected by SDR receivers and software before audio detection methods are applied, possibly extending the range by which researchers can receive telemetry signals.

Looking Ahead

As Jim moves forward with his research, he hopes to continue applying the techniques and training he's received as an amateur radio operator to the research he conducts as a student.

Andrew "Jim" Danielson, AC9EZ, is a student at PFW. He's an Amateur Extra-class licensee and has been licensed since 2012. Jim received his WAS, DXCC, and WAC awards; served as a volunteer special event operator for SKCC, NAQCC, and CWops, and served as the youth/ATNO pilot station for the 2019 A35JT DXpedition to the Kingdom of Tonga. He is a proud member of ARRL, SKCC, NAQCC, CWops, Fort Wayne Radio Club, and Fort Wayne DX Association. Jim enjoys building antennas for his home and portable station, pursuing photography, reading books, and playing and writing music on the violin, piano, and pipe organ. Jim can be reached at **dfile13@hotmail.com**.

Jordan Marshall, NM9L, is a professor of plant biology at PFW, with research interests in forest structure and composition, disturbance ecology, and invasion biology. He is a member of ARRL and participates in POTA as a hunter and an activator. Jordan can be reached at **marshalj@pfw.edu**.

Scott Bergeson is an assistant professor of animal biology at PFW. His research interests focus on the impacts of disturbances on endangered and at-risk animals, such as bats, weasels, and alligator snapping turtles. Scott has used telemetry to study the spatial ecology of numerous bat species throughout the world. He can be reached at **bergesos@pfw.edu**.

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