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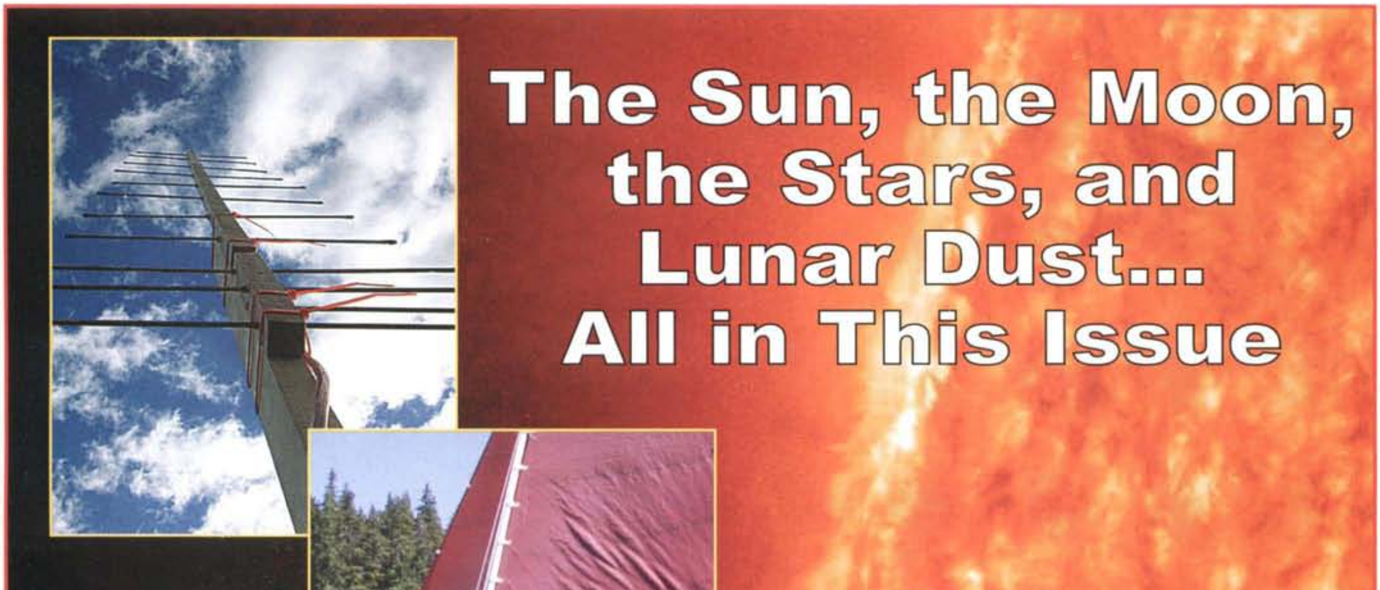

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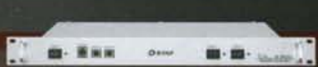

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Exit 1, I-93;
28 mi. No. of Boston
salem@hamradio.com

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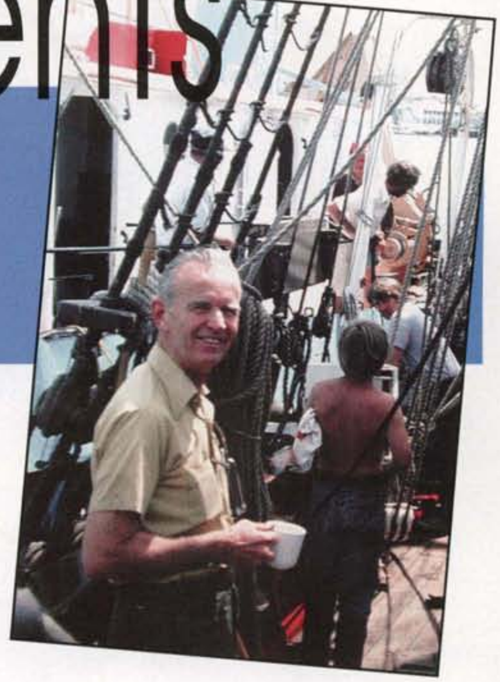


Fall 2010
Vol. 14 No. 3

FEATURES

COLUMNS

DEPARTMENTS

On The Cover: Arcs of solar plasma; see "VHF Propagation," by NW7US, p. 77. Top inset, W2VV's WA5VJB 432-MHz Yagi; see "Echoes of Apollo EME/Arecibo, Part 2," by AA6EG, p. 18. Middle inset, KK7B on Timothy Lake, OR; see "Beginning Experiments on the VHF Amateur Bands, Part 4," by KK7B, p. 26. Bottom inset, the first competition day of the 15th WC of ARDF; see "Homing In," by KØOV, p. 63.

CQ VHF Ham Radio Above 50 MHz

LINE OF SIGHT

A Message from the Editor

It's an Experiment

"An experiment is something interesting we try, not knowing ahead of time whether or not it will work." So writes Rick Campbell in Part 4 of his article "Beginning Experiments on the VHF Amateur Bands," which starts on page 26. Rick is onto something. For those of us who have followed his four-part series, we have learned how he puts into practice his words of trying something interesting while "not knowing ahead of time whether or not it will work."

Other authors in this issue also are experimenters. Let's take a look at a couple of them and see if we can learn something from them.

In order for the "something interesting we try" to be an experiment, we need to ask ourselves a series of questions. For example, Michael Helm, WC5Z, the author of "A Low-Cost 70-cm Tracking Beacon for Rocket or Balloon Payloads," probably asked himself the following question: "How can I make a 70-cm beacon that is light enough to be a payload on a small rocket or balloon and inexpensive enough to be expendable for our ham radio budgets?" From that initial question came other questions pertaining to what components to use, how to package the device, and most importantly, would it work? That last question brings us back to Campbell's second half his definition of an experiment: "not knowing ahead of time whether or not it will work."

You can go down the list of the table of contents in this issue and see how some of the authors have asked their particular questions. For example, "ATV" columnist Tom Dean, KB1JIJ, reports on he and his colleagues asking questions pertaining to a digital camera on board a balloonsat payload. Additionally, "Satellites" columnist Keith Pugh, W5IU, reports indirectly on his colleagues in AMSAT and ARISS asking questions pertaining to an amateur radio satellite that is deployable from the International Space Station (ISS).

To summarize: According to Campbell, we have an experiment when we try something interesting, not knowing whether or not it will work. In order to have an experiment, we need to ask questions. Our initial question is: "What is the experiment we are going to try?" Some of the follow-on questions include: "What are the components that make up the experiment?" "How do we assemble the experiment?" "What is the probability of the experiment being a success?" If you have an experiment that you would like to write about and have it published in this, your magazine, please contact me via e-mail at: <n6cl@sbcglobal.net>. Thank you.

The Cover Experiment

The purpose of the cover of a magazine is to sell the magazine off the shelf. It is to catch your eye so that you pick up the magazine and glance through it to see if you may want to purchase it. In order for the cover to do its job, its creator must have the eye of a true artist. Occasionally, the cover will stand on its own as a work of art.

Nearly the last task that CQ VHF's managing editor, Gail Sheehan, K2RED, and I perform on each issue is the cover. For that task, Gail turns to our art director, Elizabeth Ryan, for her input.

Liz goes through our photos and chooses something that she thinks will be appropriate for our readership. Many times, such as for this issue's cover, she produces a truly outstanding work of art. I am very proud of her excellent work on this cover. Not only does it have shelf appeal, but it also is very artistic. Thank you very much, Liz, for your excellent work.

Asking the Right Questions

Nearly 30 years ago I came across an article in *Science* magazine that intrigued me. Written by Kaufmann, Peter, V. L. R. Kuntz, N. M. Paes Leme, L. R. Piazza, J. W. S. Vilas Boas, K. Brecher, & J. Crouchley, and entitled "Effects of the Large June 1975 Meteoroid Storm on Earth's Ionosphere," it appeared in the November 10, 1989 issue. A couple of years later I wrote a paper on the article from an amateur radio perspective and presented it at the 1992 Central States VHF Society conference.

What puzzled me then was the lack of solid correlation between the "meteor storm" on the Moon and anything of significance on Earth. Without any way of understanding why there was little correlation, I kept my thoughts to myself.

A couple of years ago I learned about the effects of the Earth's magnetotail on the Moon. In particular, I learned that when the tail swept across the Moon, dust would rise up, sometimes to significant heights. That effect caused me to resurrect my concerns about the 1975 lunar meteor storm that Kaufmann, et al. described in their *Science* article. I asked myself a question: "Could their description of a lunar meteor storm instead be a lunar dust storm caused by the Earth's magnetotail?"

When researchers work on a problem, they ask a series of questions. Peer-reviewed research is when colleagues ask questions of the researchers. I ask you, my readers, to be my peer reviewers for my article, which begins on page 38. Did I ask the right question? Were my follow-on questions appropriate for my research? Are my findings and my predictions of future sand storms supportable?

Other Great Articles

As you flip through this issue, you will once again find great articles to read. Among them are the following: Both WB2AMU and NW7US discuss propagation, WB6NOA reports on microwave activity in southern California. WA2VVA continues his fascinating look back into our forefathers' contributions to so many different fields of research. AE3T reminisces about his experience of getting on EME after decades of being a ham radio operator. AA6EG gives us Part 2 of the EOA/Arecibo 2010 event. Also, our regular columnists add their usual great contributions to this issue.

Again, if you have something that you would like to have appear in the pages of this, your magazine, please let me know.

Until the next issue . . . 73 de Joe, N6CL

QUARTERLY CALENDAR OF EVENTS

Current Contests

January: The ARRL VHF Sweepstakes is scheduled for the weekend of January 22–24, 2011. For ARRL contest rules, see the issue of *QST* prior to the month of the contest or their URL: http://www.arrl.org.

Current Meteor Showers

November: The *Leonids:* is predicted to peak around 2115 UTC on November 17. As with last year's shower, this year's peak may go largely unnoticed.

December: Two showers occur this month. The first, the *Geminids*, is predicted to peak around 1100 UTC on 14 December. The actual peak can occur 2.5 hours before or after the predicted peak. It has a broad peak and is a good north-south shower, producing an average of 120 meteors per hour at its peak.

The second, the *Ursids*, is predicted to peak on 22 December. It is an east-west shower, producing an average of no more than 10 meteors per hour, with the very rare possibility of upwards of 90 meteors at its peak.

Quarterly Calendar

2010	
Nov. 3	Moon perigee
Nov. 6	New Moon
Nov. 13	First quarter Moon
Nov. 15	Moon apogee
Nov. 17	Leonids meteor shower
Nov. 21	Full Moon
Nov. 28	Last quarter Moon.
Nov. 30	Moon perigee.
Dec. 5	New Moon.
Dec. 13	First quarter Moon
Dec. 13	Moon apogee
Dec. 13	*Geminids* meteor shower
Dec. 21	Full Moon; Total eclipse of the Moon
Dec. 22	*Ursids* meteor shower
Dec. 25	Moon perigee
Dec. 28	Last quarter Moon

2011	
Jan. 4	*Quadrantids* meteor shower; New Moon; Partial eclipse of the Sun
Jan. 10	Moon apogee
Jan. 12	First quarter Moon
Jan. 19	Full Moon
Jan. 22	Moon perigee
Jan. 22–24	ARRL VHF Sweepstakes
Jan. 26	Last quarter Moon
Feb. 31	New Moon
Feb. 61	Moon apogee
Feb. 11	First quarter Moon
Feb. 18	Full Moon
Feb. 19	Moon perigee
Feb. 24	Last quarter Moon

—EME conditions courtesy W5LUU

January: The *Quadrantids*, or *Quads*, is a brief, but very active meteor shower. The expected peak is on 3–4 January, with up to 40 meteors per hour at its peak. The actual peak can occur three hours before or after the predicted peak. The best paths are north-south. Long-duration meteors can be expected about one hour after the predicted peak.

For details on these meteor showers see Tomas Hood, NW7US's "VHF Propagation" column in this issue, and visit the International Meteor Organization's website: <http://www.imo.net>.

Expectations for 6 Meters for Cycle 24

Solar Cycle 24 has been elusive and unpredictable. In this article WB2AMU gives his predictions of what to expect in the coming years of this solar cycle.

By Ken Neubeck,* WB2AMU

Sometimes, an article can be initiated by unexpected events. In preparation for writing this article, I was thinking in terms of general ideas as to what kind of 6-meter activity could be expected and when it would happen during the emerging solar cycle, Cycle 24. What occurred to intervene was an unexpected solar-flare, Earth-directed event that took place on August 1, 2010.

The impact of the solar flare with the Earth's ionosphere led to the aurora opening on 6 meters on August 3, where from my location on Long Island, New York I worked six stations on CW in Connecticut, Massachusetts, Maine, New Jersey, and as far south as K3ZO located in Maryland during the early evening hours on that day. The opening lasted for about an hour.

This was the first aurora opening that I have observed for the new cycle. At the same time the next night, I heard an aurora signal that sounded like VE3MMQ and called but with no response. Thus, in fact, there were openings for two days in a row, a good sign for the new cycle for 6-meter activity.

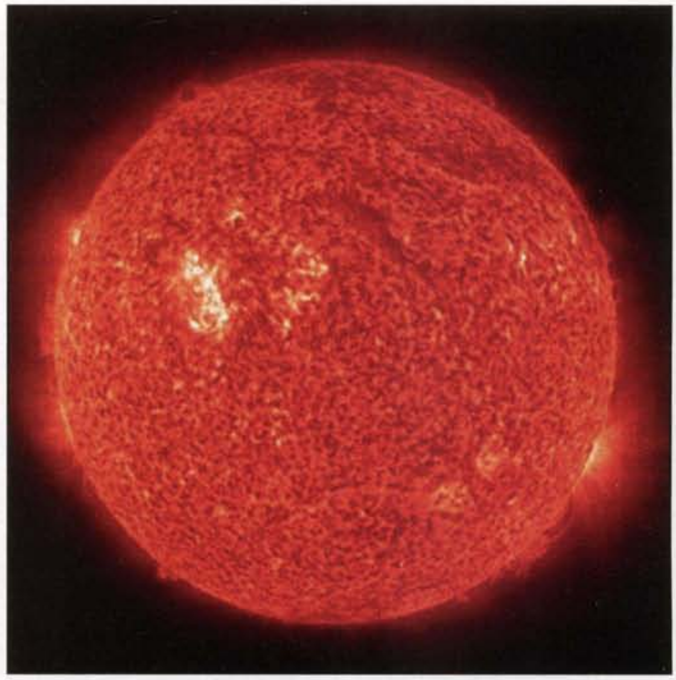
In looking back at my notes, the last aurora opening I observed on 6 meters happened on the tail end of Cycle 23 on August 19, 2006, when I worked two stations, K7BV/1 and WA1T in New England during the evening. This is a full four years to the aurora opening that occurred in August of this year, indicating the extreme depth of the recent solar minimum! To put this in perspective, the solar minimum between Cycle 22 and Cycle 23 was shorter, and I only observed an absence of aurora activity during the year 1996, with openings observed here in 1995 and 1997.

During Cycle 23 the first aurora opening took place in 1997, and subsequent aurora openings were observed each year up until 2006. The peak of the sunspot cycle occurred during 2000, but the cycle was a double-peak configuration where major solar flux values were observed in late October of 2001 into early February 2002, resulting in near-daily 6-meter *F2* openings during this time period. Sprinkled during this time were some significant aurora openings, as well.

Encouraging News!

The opening on August 3 is an encouraging sign that aurora events are starting pretty early in this new cycle. It cannot be understated as to how important this solar event is for hams, particularly VHFers. Since the beginning of 2010, the sunspots had been gradually increasing in numbers as the new cycle progressed. Things started to get really interesting as the sunspot level reached the intensity where solar eruptions occurred, resulting in solar flares that may be Earth-directed. It is a good sign for hams when flares are showing up more regularly because of the geomagnetic event which they induce.

**CQ VHF Features Editor, 1 Valley Road, Patchogue, NY 11772
e-mail: <wb2amu@cq-vhf.com>*



A significant solar flare took place on the sun on August 1, 2010. This photo shows the eruption just to the left of the center of the sun. The flare was Earth-directed and resulted in aurora activity on August 3 and 4. (Photo courtesy of NOAA)

When geomagnetic activity becomes more consistent, VHFers will observe the 6- and 2-meter bands opening about 30 days after a major flare occurs. This is because during the higher activity years, the same sunspot that yielded a solar flare or CME (coronal mass ejection) will often be active for a period of time, and it takes about 30 days for a full rotation of the sun with respect to the Earth. The event that occurred on August 3 of this year did not yield a subsequent event, so it is still early in the new cycle, as the activity of the sun is not yet at this consistent level for monthly occurrences.

Thus, with the appearance of solar flares and geomagnetic events, VHFers can start to see more aurora events occurring on 6 meters. Some of these possibly will reach the intensity during which 2-meter openings can occur. Then what about *F*-layer activity occurring on 6-meters, you may ask.

F-layer Activity on 6 meters

For sure, there will be occasional TEP events that will appear for those stations in the TEP zone, such as southern Florida and South American stations, as well as similar north-south events in Europe into parts of Africa. These events generally occur during October and November after the fall equinox and in April and May after the spring equinox. For the fall of 2010 and the spring of 2011, this should be an occasional occurrence.

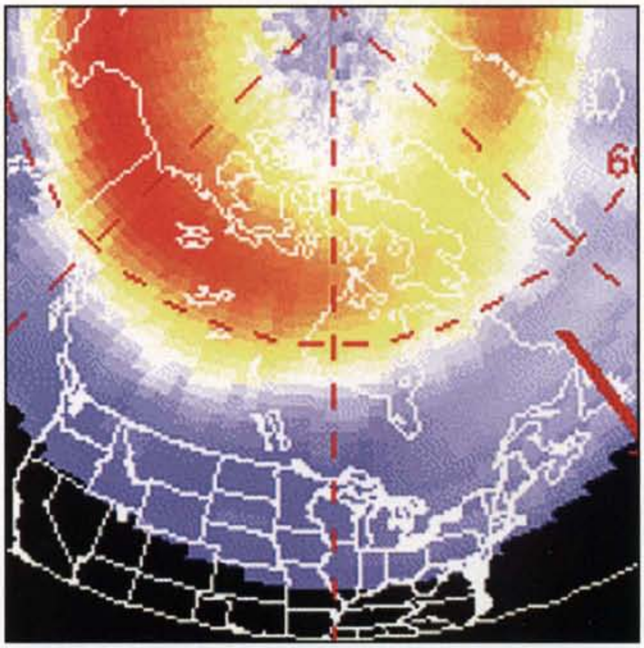
F2 openings have a possibility of occurring after a significant geomagnetic event. This type of event will usually start after major aurora activity has occurred during which north-south *F2* paths between the U.S. and South America can result. Past events saw such events after major aurora openings during Cycle 23 from 1999 through 2001, with middle-latitude U.S. stations working into the southern part of the Caribbean, Central America, and parts of South America. The signals may have some distortion when they first appear and may develop into very strong, stable signals as the opening gains strength. Usually north-south *F2* paths are the first *F*-layer paths to be heard on 6 meters as a new cycle gains strength. The question becomes: When will these openings occur during Cycle 24?"

A good guess as to the likelihood of north-south *F2* paths occurring soon in this cycle could be as soon as the late fall of 2010 or perhaps in the spring of 2011. Yet it is more likely that they will occur the fall of 2011. The reasoning for this prediction is that the sunspot cycle is still relatively young, and observations from the past show that regular occurrence of geomagnetic activity, coupled with a high solar flux, will be key to such events.

Predictions

An interesting prediction would be whether the appearance of east-west 6-meter activity will show up during Cycle 24 with the same force as it did in Cycle 23. During the fall of 2001 into early 2002, there were significant *F2* paths, eastern U.S. into Europe during the morning hours EST and eastern U.S. into West Coast of the U.S. during the afternoon hours of EST, along with West Coast U.S. into the Pacific area during the afternoon of PST. This activity was almost daily during the months of December 2001 and January 2002. A traditional 11-year peak-to-peak plot would put the next peak approximately in the fall of 2012 time frame, but because of the prolonged solar minimum at the end of Cycle 23, this will probably shift to forward by a year or two. Perhaps some east-west *F2* paths on 6 meters will show up in the fall of 2012, but most likely any significant activity will show up in the fall of 2013.

It is important to note that during the fall of 2001 the solar flux was reaching over the value of 200 for many days at a time, beginning in late September, which eventually resulted in east-west *F2* 6-meter activity beginning in early October. A consistent series of days when the solar flux values exceed 200 is critical for east-west *F2* activity to occur. For much of the summer of 2010, the solar flux value had been creeping up slightly due to the increased number of sunspot, with values hovering around 80. Thus, there is quite a way to go before the 200 solar-flux value is reached.



Daily sunspot activity information for the new cycle can be tracked on <http://www.spaceweather.com>. Information available includes the daily sunspot number, along with the current aurora imaging as captured by the NOAA POES satellite. This satellite makes a few passes over the poles each day. This particular plot was made midday on October 6, 2010. (Courtesy of NOAA/POES)

A good indicator for VHF hams is to listen to 10 meters on a daily basis, as well as monitoring 6-meter spotting sites on the internet. When 10 meters reaches the point of stable east-west paths, such as the eastern U.S. into Europe as early as October, there is some expectation of potential 6-meter paths occurring, as well. This is all a function of the MUF (maximum usable frequency) for the *F*-layer.

Conclusion

Will Cycle 24 be as good as Cycle 23 or some of the previous record-breaking solar cycles with regards to 6 meters? It is hard to tell because of the prolonged solar minimum that took place between the two cycles. However, the first step has occurred, with the first major aurora opening on 6 and 2 meters on August 3. There is no doubt that more aurora openings and TEP (trans-equatorial propagation) will become regular events. The question remains as to how much *F2* activity will show up in this cycle and in what year it will occur, if does appear.

The increase in aurora activity will help supplement 6- and 2-meter activity, most likely for the next five years. This past summer saw moderate levels of sporadic-*E* activity during May, June, and into the early part of July, with some transatlantic paths being observed between the east coast of the U.S. and Europe. Both the ARRL VHF contest in June and the CQ WW VHF contest in July saw significant amounts of sporadic-*E* activity of the single-hop variety that kept activity high during the contests. However, late July and the month of August saw reduced levels of sporadic-*E* activity and thus the appearance of aurora during August helped the activity levels on the VHF bands.

Amateur Radio and the Cosmos Part 6 – Signaling

What do the Boy Scouts, the Cosmos, and deep-sea hydrophones have in common? Leave it to WA2VVA to find a fanciful way to weave all of these topics together in this latest installment of his series of articles.

By Mark Morrison,* WA2VVA

This year marks the 100th anniversary of the Boy Scouts of America, and to mark the occasion, four badges are being brought out of retirement. One of these is Signaling, a badge that ran from 1910 through 1992 and demonstrated the ability of a Scout to communicate with International Morse Code using light waves, radio waves, or semaphores. That such a badge would be retired in the first place is a sign of our times. There just isn't as much interest in Morse code these days. *(However, even with the code requirement being withdrawn from the amateur radio licensing requirement, there still are many who choose to learn and use it because they want to do so—ed.)*

The Early Days of Radio

In the earliest days of the radio the ability to signal using Morse code was considered a valuable asset. In 1915, the ARRL was formed as a means of communicating messages across the nation using amateur wireless stations, and they were not alone. In 1920, the U.S. Navy, recognizing the Boy Scouts as a valuable resource of potential signalers, began transmitting messages in Morse code from its 1500-meter spark Naval Radio Station in New York (NAH) directly to Scouts across the nation. *Boy's Life* magazine, the official publication of the Boy Scouts of America, printed instructions for Scouts on when to listen for the signals, how to distribute them in their community, and encouraged them to team up with local amateur radio operators so that no messages would be missed.

In the early 1930s, when Bell Scientist Karl Jansky first discovered radio waves of extraterrestrial origin, the concept of signaling across the cosmos received new interest. In the decades that followed, man would actively listen for signs of intelligent life there. Assuming that other forms of intelligent life do exist that are capable of communicating across vast distances, how does one begin to look for such signals, distinguish them from similar signals of natural origin, and attempt to understand their meaning? Curiously, man already has some practice in this area.

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e-mail: <mark1home@aol.com>

Post WW II

In the years following World War II, scientists from Bell Laboratories and engineers from Western Electric began the installation of deep-sea hydrophones in the Atlantic Ocean. The idea was to listen for the sounds of enemy submarines, a form of underwater surveillance later called SOSUS, which stands for Sound Surveillance System. Originally operated by the U.S. Navy, SOSUS is a series of underwater listening posts that extends across the northern Atlantic Ocean.

To be certain, the SOSUS hydrophones picked up plenty of sounds associated with ships and submarines, but there were other sounds, too. Some were low-frequency rumbles. Others were clicks and pops. Still others were mysterious whistles and whooping sounds. Years later many of these sounds were identified as seismic in origin, but still others were signals of intelligent life, not of human origin!

The Story Begins . . . and Continues

Our story begins on the campus of Lehigh University in the 1930s, where geophysicist Maurice Ewing was a professor of geology and becoming well known for his work in reflection seismology, a technique that used sound waves to reveal features about the Earth below. In some ways, Ewing's work benefited from that of wireless pioneer Reginald Aubrey Fessenden (1XS), who in 1900 became the first person in history to transmit a human voice over radio and is widely recognized as the "father of broadcasting" for making the first AM radio broadcast in 1906. However, less well known are his many patents in reflection seismology (#1,240,328) and the field we now call sonar (#1,213,610).

The former (issued in 1917) used underground explosives to drive sound waves deep into the earth and nearby listening devices to monitor the sounds reaching different locations. By noting a difference in the sound arrival times it was possible to infer something about the location of valuable ore bodies hidden within the earth. The latter (also issued in 1917) described a low-frequency electromechanical device used to couple sound waves into a suitable plate, such as the walls of a submarine, driving low-frequency sound waves into the water and capable of listening for any reflected waves. Such a device proved useful not only for determining the depths of the oceans, but also for the detection of submerged objects, such as icebergs and submarines. This became of great importance with the sinking of the *Titanic* in 1912. It is interesting to note that the October 1920 issue of *Boys' Life* magazine included an article on early hydrophone work, apparently that of Fessenden. When Fessenden retired in 1928, he returned to the island of Bermuda, where he received a new callsign, VP9F.

No stranger to the ocean, Ewing him-

Photo 1. Geophysicist Maurice Ewing opened the Columbia University Geological Field Station (CUGFS) on the island of Bermuda, known later as the Bermuda SOFAR station. Shown here is the SOFAR station sitting on the edge of a bluff, facing the reef that signals the finish line of the Newport to Bermuda Yatch Race. Note the many aerials used for HF communications.

self became known for his pioneering studies of the Earth's gravity aboard the submarine *USS Barracuda*. Using a crystal chronometer on loan from Bell Labs, Ewing could time the period of a balanced pendulum and determine the acceleration due to gravity at different locations across the globe. Using this technique it was possible to learn something about the density of the earth beneath the submarine, and create detailed maps of the earth's crust otherwise invisible to terrestrial observers, and with 75-percent of the world covered with water, there was much to be learned.

While at Lehigh, Ewing had an eager following of bright young students. One was John Lamar Worzel, a mechanical wizard who accompanied Ewing on many sea-going ventures mapping the Atlantic Ocean. Borrowing the techniques developed for terrestrial exploration, Ewing and Worzel used explosives dropped into the ocean from one ship and hydrophones in a trailing vessel several miles behind to probe the ocean floor and its layers of sediment.

Another student at Lehigh during the late 1930s was Eagle Scout Harry Harchar, W2GND. It is not clear that Harry had any association with Ewing and Worzel, but being active with the school newspaper, he probably knew of them. As we shall soon see, Harry would later have a major influence on generations of future signalers.

In 1943 Ewing proved something that he had predicted at Lehigh in 1937—that the physical properties of the ocean's temperature and pressure would form refractive boundaries at certain depths, creating a natural sound channel. Sounds generated within this channel would propagate tremendous distances with little attenuation. Also, sounds launched from the surface at just the right angle and frequency could enter the channel and possibly never return to the surface.

The first practical application of this discovery was that shadow zones existed where submarines could escape detection from surface-generated sonar signals. Another practical use was signaling the location of downed aviators using a technique known as Sound Fixing and Ranging, or SOFAR. The idea was to drop a charge of TNT into the water set to go off within the sound channel, and for listening stations around the world to record the sounds of the explosion. By comparing the sound arrival times from at least three different stations, it would be possible to identify the exact location where the bomb had gone off, and thus locate the downed aviator. The big advantage to such a system was that the party in distress could be located without breaking radio silence. Although the use of SOFAR has long since been abandoned, an interesting example came to light just recently. When Gus Grissom's Liberty Bell 7 Mercury capsule was located off the coast of Florida in 1999, there were concerns about salvaging it due to the possibility of an unexploded SOFAR bomb aboard. Today, the listening techniques forged in the Cold War are being used to monitor the temperatures of the world's oceans and the effects of global warming.

In 1948 Ewing became the founder and first director of the Lamont-Doherty Earth Observatory. Located on an estate above the Hudson River in New York State, Ewing and several graduate students were wooed from Lehigh by Dwight D. Eisenhower, then President of Columbia University. It was there that Ewing and Worzel pursued their interest in the geology of the world's oceans. In 1949, Ewing opened the Columbia University Geological Field Station (CUGFS) on the island of Bermuda, known later as the Bermuda SOFAR station as shown in photo 1. This picture shows the SOFAR station sitting on the edge of a bluff, facing the reef that signals the finish line of the Newport to Bermuda Yatch Race. Note the many aerials used for HF communications.

A series of hydrophones would be placed offshore, far beyond the reef, and recordings made of the sounds picked up by them. This work was done for the U.S. Navy and highly classified at the time. In addition to explosive charges, these hydrophones detected low frequency signals, some at the limits of human hearing. For many years the source of these mysterious signals was unknown.

During the International Geophysical Year of 1957–58, Ewing presented a paper at the Harvard College Observatory overseen by Fred L. Whipple and Donald H. Menzel, W1JEX. Ewing's paper, entitled "Some Aspects of Physical Geodesy," described a network of hydrophones spread across the floor of the Atlantic Ocean and to be used for geodetic survey work. In those days there was great interest in the shape of the Earth, the structure of its crust, and the controversial theory of Plate Tectonics. Land-based surveys only covered a portion of the Earth's surface, and Ewing's idea was to attach hydrophones to the sea floor as a means of bridging the land-based surveys. The hydrophones would be placed in triangular patterns precisely centered on known geographic coordinates. These "benchmarks" would establish reference points from which to make the ocean-based surveys. Acoustic signals transmitted from surface vessels would be detected by these hydrophones and, in the fashion of a modern VHF repeater, an acoustic transponder would return a signal to the surface. Using the

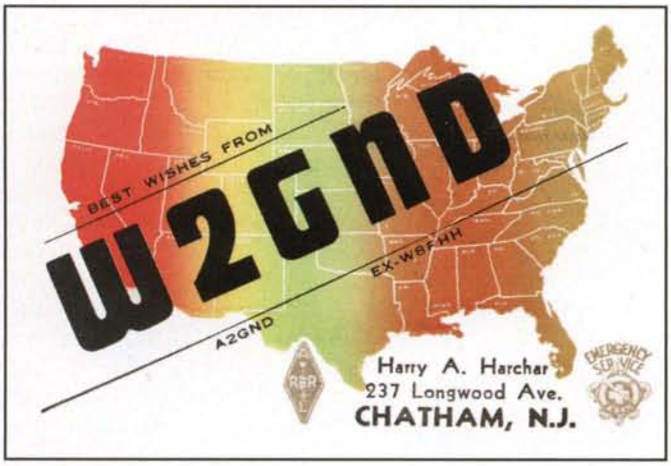

Photo 2. In 1957 the Scouts held their very first "Jamboree On The Air," or JOTA, something that gave many young Scouts an opportunity to earn the coveted Signaling badge. Harry Harchar, W2GND, was editor of Boys' Life *magazine and in the unique position of bringing the worlds of Scouting and amateur radio together. Harry also served as JOTA coordinator for many years and was an active signaler himself, as shown by this QSL.*

same techniques proposed for SOFAR, the arrival times from the different transponders could then be used to pinpoint the position of a ship with respect to the fixed benchmarks. Also present at this meeting were John A. O'Keefe, the man later credited with the discovery of the Earth's pear shape from satellite observations, and J. Allen Hynek, later to become a prominent figure in the study of UFOs.

It was also during the International Geophysical Year that the Boy Scouts of America held a very special kind of meeting, one that also fostered international cooperation. In 1957 the Scouts held their very first "Jamboree On The Air," or JOTA, something that gave many young Scouts an opportunity to earn the coveted Signaling badge. By this time Harry Harchar, W2GND, was editor of *Boys' Life* magazine and in the unique position of bringing the worlds of Scouting and amateur radio together. Harry also served as JOTA coordinator for many years and was an active signaler himself, as shown by the QSL card in photo 2.

With the success of Ewing and Worzel promoting the long-distance signaling capabilities of the deep-sea sound channel, and increasing concerns about the movement of Soviet submarines, the idea of placing hydrophones on the sea floor took on new interest. Although originally proposed for survey work and even studies of continental drift, the idea of a large hydrophone network such as that proposed by Ewing could also be used for underwater surveillance. Indeed, with the installation of strategically placed hydrophones inside the deep sound channel, it would be possible to monitor and locate any number of submarines that might otherwise go about their business in complete secrecy. Again, though, how does one distinguish the noise of a submarine from surface vessels, seismic activity, or even those mysterious low-frequency signals yet to be identified?

One answer may have come from Bell Laboratories with the invention of the sound spectrogram. Originally developed for the study of speech at Murray Hill, it was quickly realized that such a device could also characterize the low-frequency sounds being picked up by the hydrophones. Known as Low Frequency Analysis and Recording, or LOFAR, this device created a visual image of sounds, with frequency plotted against time. LOFAR gave trained operators the ability to identify signals of interest (Soviet submarines) and distinguish them from other sounds in the ocean deep.

While all this was going on, a scientist at the Bermuda SOFAR station, Frank Watlington, VP9N (ex-VP9NN), Silent Key, took what appears to be the first real interest in those strange unidentified signals coming off the hydrophones. According to Dr. Ray McAllister, who worked at the SOFAR station from 1958 to 1963, and now Professor of Ocean Engineering at Florida Atlantic University, Frank once had the following ghostly encounter that would change his life forever:

> Frank would go to SOFAR to work at odd hours if something was going on, acoustically, in the ocean. One day we finished installing the listening gear on some new hydrophones that we had just laid. Frank had purchased and just installed some magnificent and very expensive bass speakers in the recording room at SOFAR and was out there at midnight doing some work in his office. All of a sudden there were ghostly noises from the recording room. Moans of the most unearthly type were permeating the entire station. Frank listened with some trepidation, finally picking up a 15-inch-long experimental hydrophone and sneaking through the inky black corridors of the station toward the source of the sounds. He did not believe in ghosts, *but* the sounds were sure ghostly and he was sure he was the only person inside the gates at SOFAR! As he came cautiously around the corner into the recording room he discovered that the sounds were coming from the huge new speakers. What a relief! He was hearing the humpback whales singing to each other, in beautifully reproduced sound. We later made miles of tape of the whale sounds.

It's difficult to say with certainty that Frank was first to connect the whales passing his office window to those mysterious sounds coming out of the deep sound channel, but it does seem quite likely. Also, there is no doubt of his efforts to record those sounds and bring them to the attention of the scientific community. In a recent e-mail to this author, Frank's Bermudian friend Ed Kelly, VP9GE, commented how Frank had been hearing odd seasonal noise at SOFAR and even fixed a hydrophone to a small boat to record the whales as they passed.

In March 1960, the Bermuda SOFAR station participated in what may have been the greatest test of underwater sound transmission ever conducted, as described here by Dr. McAllister:

> The Royal Australian Navy frigate, *HMAS Diamantina* dropped three depth charges at sea off Perth, Australia, exactly 5 minutes apart. They were set to go off as deep as possible. We listened at the SOFAR station, in Bermuda, 10,000 miles away. We heard and recorded the incoming sounds filtered by seawater and by our filters to listen only to sounds below 400 Hertz. We heard a series of "crumps," each a bit louder than the one before it, and the last one the loudest and abruptly cut off. It was the sound that had traveled along the axis of the sound channel in the ocean, where the slowest sound was moving, and hence came in last. It gave us a very sharp cutoff that could be timed.
>
> Since sound travels about 20 minutes per 1000 miles, we heard the sounds 4 hours and 5 minutes after the *Diamantina* reported the detonations by radio. In addition, we heard, for some time afterward, the echo of the sound bouncing off Antarctica, then off South America and Africa, etc. It was a great demonstration that we (journalistic we) knew what we were doing! Furthermore, the ability to locate the source of the sound by time-difference-of-arrival helped us with another experiment. We proposed to locate downed ships and aircraft by acoustic means.

While scientists were busy putting together hydrophone listening stations around the world, Harry Harchar, W2GND,

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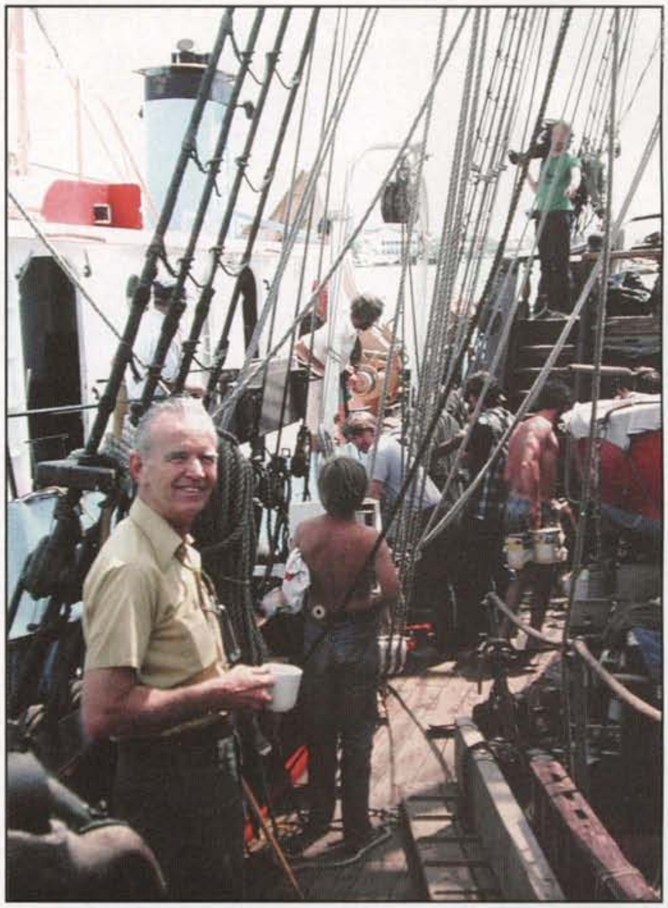

Photo 3. When Frank Watlington, VP9N, and I arrived at St. George's Harbor in 1977, we boarded the Barba Negra, *a three masted bark which only one year earlier had participated in the Bicentennial parade of Tall Ships in New York Harbor. This ship started out as a Norwegian whaling vessel in 1896 and then, some 80 years later, was chasing whales for a different purpose—to record their signals without the interference of engine noise. This photo shows Frank on the deck of the* Barba Negra.

Lloyd Everhart, K2CVT; and E. E. Hoisington, W4YTA (ex-K2GDR), all Boy Scout executives, were busy putting together the first amateur radio station for the Boy Scouts of America. Initially known as K2BFW, and later changed to K2BSA, the first Scout station went on the air in 1960 on the grounds of the new Boy Scout headquarters then located in New Brunswick, New Jersey. Harry would become one of the first trustees of the station.

In 1963, *Life* magazine published an article in its August 2 issue that hinted of a discovery made by "scientists" about the whales passing Bermuda. By 1964, scientists Roger Payne and Scott McVay would obtain one of the Frank's personal recordings for further study. It didn't happen right away, but after listening to the tape several times they came to recognize a pattern to the sounds. It was then that Payne and McVay realized that they had made an important discovery. More than simple sounds, these were actually songs! Payne later used one of Frank's recordings, and several of his own, in a record album entitled "The Songs of the Humpback Whale" that went on to become the best-selling natural history record of all time. When *National Geographic* magazine ordered 10.5-million

Photo 4. The Barba Negra *as it appeared in St. George's Harbor that day in 1977.*

copies of the album to be included with one of its issues, it became the largest single-print order in the history of the recording industry! You may think you've heard these songs before, but do yourself a favor and look for them on iTunes where you can hear a sample of what Frank and Roger heard and recorded so many years ago.

In the early 1970s, Columbia University experienced its share of anti-war protests and decided to distance itself from military work. Ewing, whose work had long been funded by the U.S. Navy, decided to create a separate organization known as the Palisades Geophysical Institute (PGI) as a way of continuing the undersea research so important to the Cold War, and the subject of underwater acoustics. Included in this transaction would be the Bermuda SOFAR station.

The PGI SOFAR station would eventually be run by Carl Hartdegen, yet another student who attended Lehigh University in the late 1930s, and the man who gave me my first job out of college. Hartdegen commanded the research vessel *Horace B. Lamb*, a converted WW II minesweeper (YMS-294). A total of 561 such vessels were built, the most famous being BYMS-26, commanded by Jacques Cousteau and known the world over as *Calypso*.

One day while working at the SOFAR station, Frank Watlington, VP9N, invited me to accompany him on a trip to St. George's Harbor, just a short distance from St. David's. I didn't know it at the time, but Frank had become something of a celebrity by this time. His recordings of humpback whales were used in the David Bowie movie *The Man Who Fell To Earth* and also appeared in Carl Sagan's book *Cosmos* (pg. 271). Curiously, whale recordings (I'm not sure whose) were even included on the gold record carried by the Voyager spacecraft, and in a strange twist, became central to the plot of the movie *Star Trek IV: the Voyage Home*.

When Frank and I arrived at the harbor we boarded the *Barba Negra*, a three masted bark which only one year earlier had participated in the Bicentennial parade of Tall Ships in New York Harbor. This ship started out as a Norwegian whaling vessel in 1896 and now, some 80 years later, was chasing whales for a different purpose—to record their signals without the interference of engine noise. Photo 3 shows Frank Watlington, VP9N, on the deck of the *Barba Negra* in 1977. Photo 4 shows the *Barba Negra* as it appeared in St. George's Harbor that day.

The Song of Whales

The first signals picked up by Navy hydrophones in the 50s and 60s served to get our attention. The seasonal variations in those signals suggested some kind of natural phenomenon. When Frank Watlington, VP9N, recognized the relationship between those variations and the appearance of whales outside his office window, he no doubt concluded they were one source of these mysterious signals. When scientists later analyzed the recordings that Frank so prized, they still considered them some of the finest of their kind, and they further recognized distinct patterns that led to the conclusion that whales could sing.

Whales are now recognized as intelligent creatures, but for all the years that we've been recording and studying their songs we still don't know what they're singing about. Now whales are in danger, not only from whaling vessels that still actively hunt them, but from the interference man has created within the sound channel. What was once a clear channel carrying the voices and songs of whales

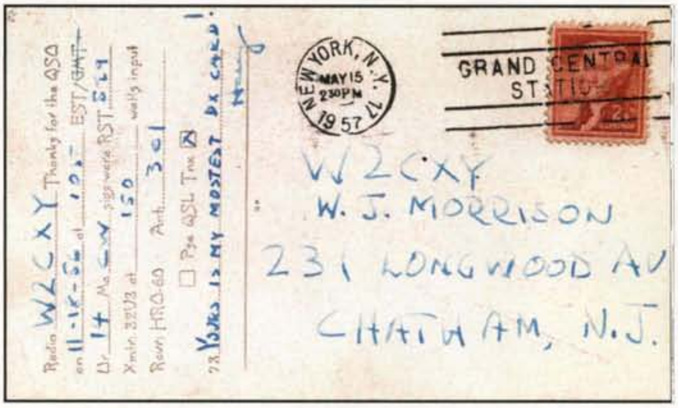

Photo 5. QSL card documenting a 1956 CW contact between Boys' Life *Editor W2GND and W2CXY.*

going about their business is now polluted by the noises of engines and propellers. Perhaps if we can learn the code behind their signals, we may one day help the whales, before it is too late. And should we be so lucky as to encounter other forms of intelligent life capable of communicating over vast distances, maybe the lessons we learn from the whales will help us "be prepared." After all, isn't that the Boy Scout motto?

By 1959, the requirement for the Signaling badge was to send and receive a message of 20 words over a distance of at least 100 yards using the international Morse code.

The QSL card in photo 5 documents a 1956 CW contact between *Boys' Life* Editor Harry Harchar, W2GND, and Walt Morrison, W2CXY, neighbors separated by roughly 100 yards.

Hmm . . . I guess that qualifies Harry for the Signaling badge! I wonder if he ever got one.

Feedback

Many years ago I had the good fortune of meeting or knowing many of the East Coast VHF pioneers, including Carl Scheideler, W2AZL; Bill Ashby, K2TKN; and Ralph Thomas , W2UK. In their day, these were the movers and shakers who appeared in almost every edition of *CQ* or *QST*. Yet for all their accomplishments, and the celebrity they once enjoyed, each has faded into obscurity. Although some people still recognize the calls, and what they accomplished, many more remember just the calls and little else. Three years ago I was given the opportunity to change all that by writing some articles for *CQ VHF* magazine. To make things more interesting I decided the articles should be more than a simple rehash of everything printed in back issues of *CQ* and *QST*. Rather, they should speak about the person, including not only what they did for ham radio, but what they did for a living, who they worked for, and what was important to them. In some cases this has been easy, because the people were personally known to me or my family. In others, it has proved more difficult because their work was shrouded in military secrecy, or concerns about divulging intellectual property. In some cases, information has come from unexpected sources, including readers of *CQ VHF* magazine who wrote to me after reading one of my stories. In such cases, I make every effort to include their part of the story in my articles, which can take a long time.

More recently, I received feedback of a different sort, something that I wanted to address right away, because it would be difficult to include in any planned future stories. Since my intention is to honor the many calls who paved the way for the rest of us, I also want the information to be as accurate as possible. Therefore, if you have any comments please write to me and I will make every effort to include your part of the story in a future issue of *CQ VHF*. Having said that, I would like to take this opportunity to make the following corrections to my article which appeared in the Summer 2010 issue of this magazine and to apologize to Gordon Pettengill, W1OUN, for any inconvenience it may have caused.

1. At the bottom of the right-hand column on p. 20 in the Summer 2010 issue, Gordon Pettengill's radar observations of Mercury in 1965 are discussed. It should be noted that these measurements led to the discovery that Mercury's rotation (i.e., spin on its axis) was not synchronous with its orbit of 88 days as had long been believed from blurry optical data (because of its inner orbit, Mercury always appears near the sun, which makes optical observation difficult), but was rather rotating with a 59-day sidereal period (two-thirds the synchronous value). Mercury's orbit around the sun remains at 88 days, as has been known for centuries.

2. At the bottom of the right-hand column on p. 21, I implied that Frank Drake was responsible for starting radio astronomy at Arecibo when he arrived in 1966. As it turns out, radio astronomy had always been a mainstay of Arecibo's operations from its very beginning in 1963. A typical observing schedule, then as now nearly 50 years later, gives about 5-percent of the available monthly time to planetary radar observations, another 10- to 20-percent to ionospheric radar operations, and the remainder to radio astronomy (less 5- to 10-percent for maintenance). Radio astronomy has always been the preponderant activity at Arecibo. Frank was, of course, a driving force behind the first upgrade of the facility in the early 1970s, which permitted its use at frequencies many times higher than in its early days, and deserves much credit for that.

Enhance /en-hans/ - *verb*

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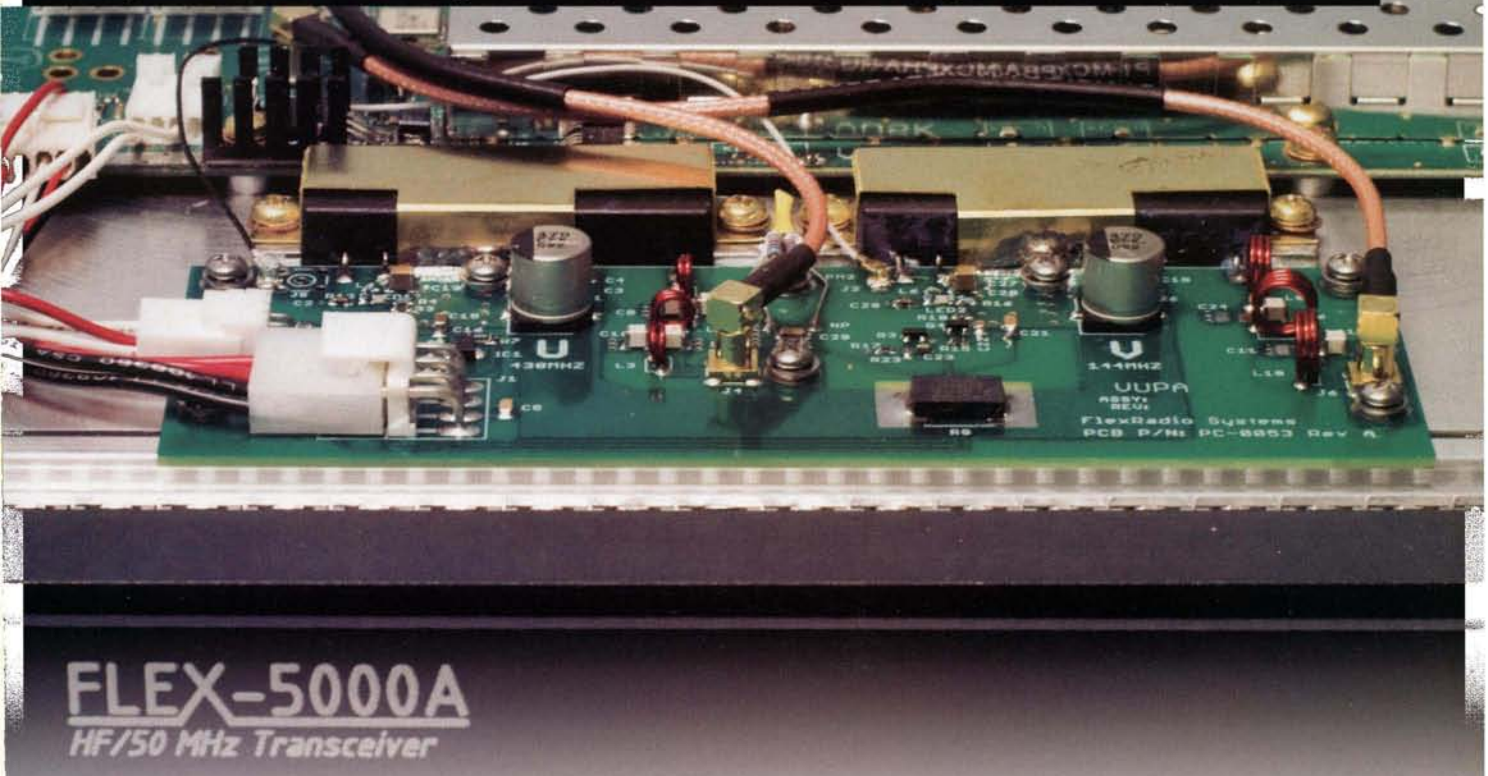

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Echoes of Apollo EME/Arecibo 2010 Part 2

Here AA6EG shares reflections of some of the participants in the April 2010 EOA Arecibo operation, along with future plans for Yuri's Night, and an announcement of Mexico's new space agency.

By Pat Barthelow,* AA6EG

The Echoes of Apollo/Arecibo KP4AO experience in April 2010 is still fresh in my mind, as if it were yesterday. In Part 2, I chose a selection of your stories from the other side of the 500K-mile path from Arecibo, along with some big-dish moonbounce ideas and some updates of what is next for EOA. See Part 1 in the Spring 2010 issue of *CQ VHF* magazine for an account of my personal experience while at that magical place, unique in all the world. Not only were the steel and waveguide magical and unique, but also were the people I met and experiences I shared.

I have to again give complete thanks and credit to the following: the NAIC Arecibo Observatory; Cornell University; NAIC (National Astronomy and Ionosphere Center) Director Dr. Mike Nolan and management; plus Joe Taylor, K1JT, Angel Vazquez, WP3R, Jim Breakall, WA3FET, and the whole rest of a sizeable on-site crew for their permissions and performance for and during the use and set up of the first Arecibo EME operation in decades.

Stories from the Field (Around the World)

Here are some stories and descriptions of EME activities on the other end of the Moon path. Thanks go to Joe Taylor, K1JT, for compiling a master file of these stories.

Photo 1 is the 4 × 19 EME Yagi array of Leo Fiskas, SV2DCD, who worked KP4AO on JT65 using 50 watts.

Here is a great story from Dave Olean, K1WHS:

*599 DX Drive, Marina, CA 93933
e-mail: <apolloeme@live.com>

Photo 1. The 4 × 19 EME array used by SV2DCD.

I worked KP4AO from my house on Friday as K1WHS. I was testing out the NEVHF Conference system (so there would be no surprises). The antenna was sort of large, 2 × 33-element Yagis with a preamp at the power divider. The same setup was used at W1RJA in Enfield, Connecticut at the conference. We were located in the parking lot, running on emergency power, batteries for the rig and exciter, and a 5-KW gas generator for the amplifier HV. I used my HB 8938 triode amp running 1200 watts peak. The interesting thing is that when I got home Sunday afternoon, I rigged up a short 11-element Yagi into a stock FT-817, and I could copy the JT65 tones so well that a CW QSO was entirely possible with that small antenna. The tones were Q5. I think the FT-817 NF is over 10 dB. At the conference, we tried several antennas and Dale Clement, AF1T, heard you pretty well on a 7-element Yagi (all with a low noise preamp). The signals were weak on a 3-element Yagi. He also could hear KP4AO very weakly on a single dipole. The kicker was that he also tried a second dipole using two pickles on either side of the feed point. They were stuck on some short rods to hold them up. There is a nice video of the W1RJA operation, and the pickle is featured near the end. See: <http://www.youtube.com/watch?v=ZutOfYLPIMY>.

I was very happy to have Gordon Pettengill, W1OUN, there. We tried to get him to make the QSO, but he did not really feel comfortable doing that. Part of the problem was that the repaired amplifier had croaked right there at the beginning, and the SSB from Arecibo was not very strong until the solid-state amp went online about 30 minutes into the Saturday operation. At 85, Dr. Pettengill's hearing is not what it used to be! (I hope I am in as good shape if and when I am 85.) I am sure you will get a report from Dale, AF1T, on the di-pickle experiment. He called it a dilly dipole. Thank you for the huge effort. It sure generated lots of excitement! *73 de Dave Olean, K1WHS*

Here is some detail from Tommy Henderson, WD5AGO, re his communi-

Month	Day	Call	Info
March	19	PY2ZX	15-ele K1FO/PY2NI, quad, ICR-7000, IC-706MKIIG
	19	LU7FIA	19-ele Yagi, 9-ele Yagi
	22	PY2ZX	15-ele K1FO/PY2NI, quad, ICR-7000, IC-706MKIIG
	22	PY4ZBZ	6-ele Yagi, FT100D
	22	PY2REK	28-ele K1FO/PY2NI pol H, FT-875D
	22	PY2RGR	5-ele Yagi, FT-817nd
	22	LU7DZ	8 x 21-ele. K1FO pol H, FT-847, 1 kW, LNA + splitter home made
	22	LU2DPW	10-ele. Yagi homemade, FT-726R
April	16	PY4ZBZ	2-ele. Yagi at TVRO Band C Dish, FT-100D
	16	LU7FIA	4 x 19-ele. Yagi, FT-736R, IC-910H, 70 W
	17	LU7DZ	8 x 21-ele. K1FO pol H, FT-847, 1 kW, LNA + splitter home made
	17 - 18	LU7FIA	4 × 19-ele. Yagi, FT-736R, IC-910H, 70 W
	17 - 18	PY2ZX	15-ele K1FO/PY2NI pol H, IC-706MKIIG
	17 - 18	PY2BS	4.6-meter dish, loop feeder, IC-910H
	17 - 18	PT2WWV - PP2RON	2 × Tonna 19-ele. pol H, IC-475, IC-7000, LNA, Mirage D-1010
	17 - 18	PY4AJ	2 × 16-ele. DK7ZB, FT847, home made amp 200 W 4CX250B
	17 - 18	PY3FF	12-ele. Yagi, 0.5 dB LNA, homebrew converter, SDR
	17 - 18	PS8RF	2 × 13-ele. Yagi, Mirage D-3010, high SWR
	17 - 18	PY2XS	(heard TX on QSX)
	17 - 18	LU8YD	Crossed Yagi 13- ele. homemade, FT-7000
	17 - 18	LU1UM	5-ele., FT-817, Daiwa 80 W, Radio Club St. Rosa
	17 - 18	LU8ENU	20-ele. crossed Yagi
	18	LU1C	4 × DJ9BV, ARR LNA, TS-2000, 100 W, hrd @ Arecibo but no QSO
	18	LU2D	PW10-ele. Yagi homemade, FT-726R
	18	PS8JN	5-ele. Yagi FT-817
	18	PY2OC	28-ele. K1FO/PY2NI pol H, FT-847
	18	PY5LF	Satellite setup
	18	CX1DDO	25-ele. pol H, IC-706MKIIG, GASFET LNA
	18	PY2NF	2 × 22-ele. K1FO/PY2NI pol V, TS2000

Figure 1. PY2ZX's list of mostly South American hams active during the EOA/Arecibo event.

ty college class EME projects, which earned a lot of coverage and photos in Part 1 of this article. Tommy wrote:

All of the class's antennas had to be built 1 meter or less in length, so the max number of elements was 7 to 8 to a minimum of 4 elements. With the lower power on Friday we were able to speaker copy the CW signal with all antennas on the test range. We did not try to hear the SSB mainly due to rain, but also the signal was weaker on the EME array during this period until about 1730 UTC, which was about the time signals were getting better and the switch to CW. An LNA was used; HB cavity measures 0.25 dB n/f and 32 dBg.

Figure 1 shows Flavio Archangel, PY2ZX's list of station setups of most South American stations of hams who lis-

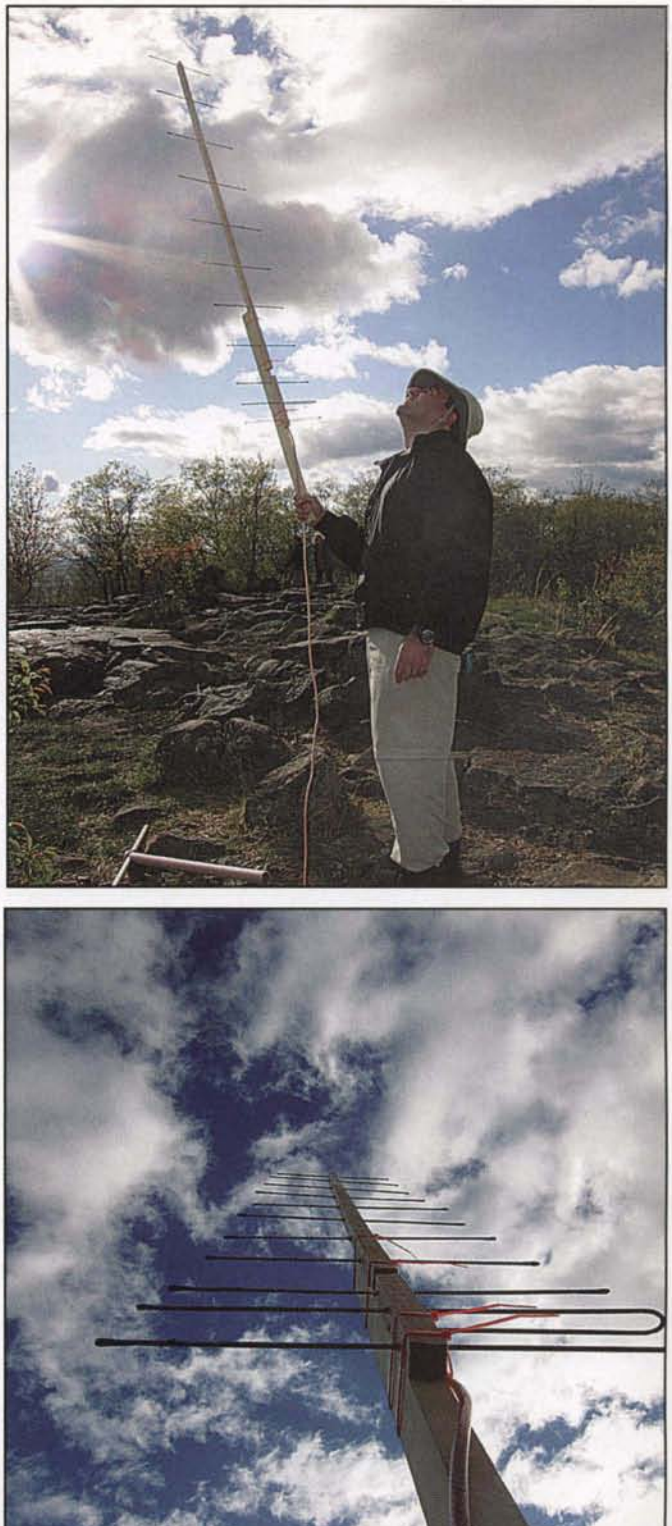
Photo 2. The 19-element Yagi used by F8ARR.

tened for or worked KP4AO (see: <http:// www.archangelo.net/misc/eme/arecibo/2010-04-18/stations.htm>).

Sean Michael Cavanaugh, VA5LF, in Saskatoon, Canada did an amazing job copying KP4AO CW using a 7-element WA5VJB Cheap Yagi, a mast-mounted preamp, and a Yaesu FT-847. It seems as though for any future EME events with Arecibo, one should plan for a larger, but manageable single Yagi of perhaps 20 elements to truly hear KP4AO well, particularly for SSB. Preamps were not always used, but should be considered a necessary RX system component. Take a look at Sean's You Tube video of his KP4AO EME experience at: <http://www.youtube.com/watch?v=FvYHP5q7R48>.

Photo 2 shows Guillaume Devoyon, F8ARR, in his back yard. He was successful with this borrowed 19-element Yagi, an FT-857D transceiver, and surprisingly with *no* preamp. Jacques Rambaud, F6BKI, loaned the Yagi to Guillaume. Guillaume kept to SWLing, because he did not have QRO. Even so, he had amazing success, with his wife and the neighbors abuzz, enjoying Guillaume's infectious excitement of witnessing moonbounce for the first time. Guillaume was quite the promoter of EME to his local neighborhood. He copied the CW solid. He also copied SSB, but at the noise margins.

Photos 3A and 3B show Dave Clausen, W2VV, on Hook Mountain, north of New York City along the Hudson River. He hand-pointed his Yagi for the EOA/Arecibo moonbounce event. Dave eventually had SWL success on JT65. There were so many NY stations participating near Hook Mountain that



Photos 3A and 3B. Dave Clausen, W2VV, with his EOA/Arecibo homemade WA5VJB 432-MHz Yagi.

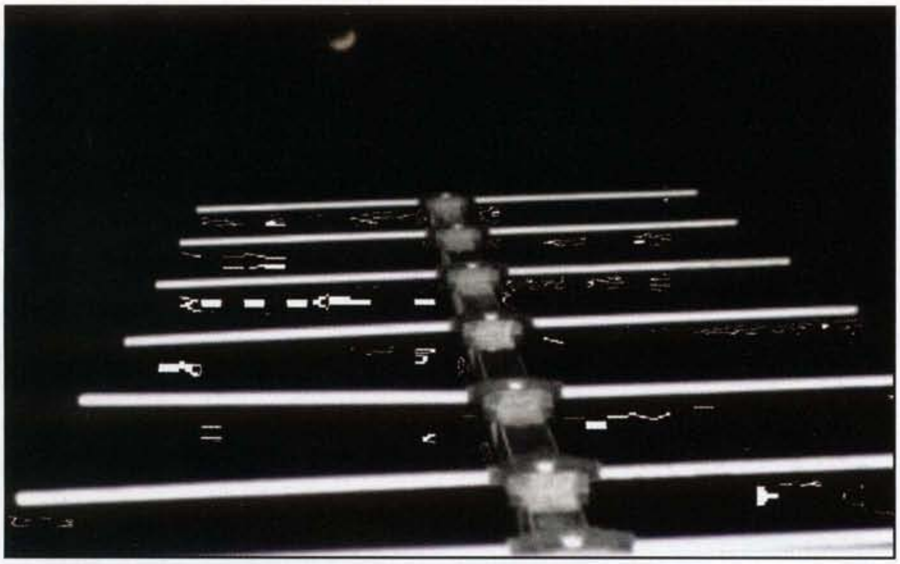


Photo 4. Isaac, IK3QLO, shooting the Moon.

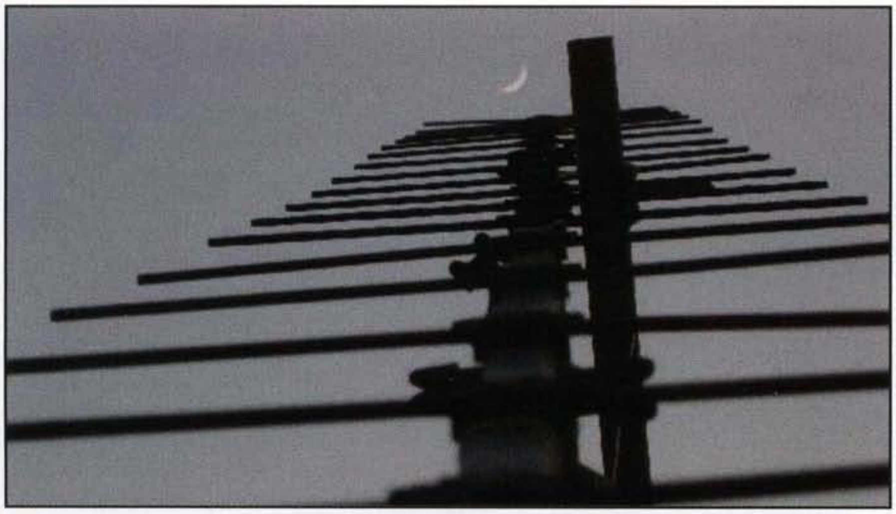


Photo 5. The Yagi used by DJ8FR.

Dave heard the direct transmissions from the ground, but with persistence copied and recorded JT65 off the Moon with this hand-held antenna. Dave wrote the following about his impressions of the EOA/Arecibo event: "In one weekend we went from having no digital or EME experience whatsoever to a having a working portable EME SWL station, and dreams of making two-way EME contacts from a summit."

Photo 4 shows Isaac, IK3QLO, shooting the moon during EOA/Arecibo while at the QTH of Andrea, IK5AMB. Isaac found that the EOA/Arecibo event brought together a lot of old ham friends, and some local amateur astronomers for the rare opportunity to receive Arecibo EME.

Photo 5 shows Juergen Friedrich, DJ8FR's Yagi on the Moon for EOA 2010/Arecibo event.

Summary and Future Activities

My goals for the operation were met and exceeded in spades. Like earlier Echoes of Apollo EME events, this one brought EME to the public view and attracted and introduced new folks, both hams and non-hams, to this very special part of the hobby. One of my goals was also to demonstrate to NASA, and other space agencies, that moonbounce is a natural for use in science outreach programs and as an all-encompassing intensive, hands-on experience that is difficult to create any other way for an upcoming space industry engineer or a space sciences student. This goal has proven to be very successful, with a recent new development—an invitation to present a case for EME at an international Space Conference in Mexico.

The Mexican Space Conference is also associated with the establishment of the first Mexican Government Space Agency, equivalent to our NASA, called AEXA. AEXA is just now being born, and will exploit the space sciences in every way possible to bring Mexico to being a productive player in space. AEXA's establishment includes the building of a space launch facility, probably not far from Cancun, and will probably have headquarters near Monterrey, Mexico. As it grows, AEXA will probably embrace EME on many levels. The conference is being coordinated with a mobilization of the amateur radio community in Mexico to support a major big-dish EME event presence on Yuri's Night (a yearly around-the-world event in honor of Russian Cosmonaut Yuri Gagarin, who embarked on the first manned space flight on April 12, 1961, and the U.S. first space shuttle launch on April 12, 1981) in April 2011. An e-mail to Luis Chartarifsky, XE1L, a well-known ham in Mexico, brought a powerful positive response. Luis has considerable talent for finding and gathering the right folks to get a Mexican EME project in gear. Thanks, Luis!

There are very few EMEers in Mexico at the present, Max, XE1XA, being one of the most well-known. However, there is a sizeable population of satellite operators who will no doubt be interested in the "Oscar Zero" project in Mexico *(see more about OSCAR Zero in this month's "Satellites" column by W5IU—ed.)*. We plan to work with the Mexican ham community to find a big dish somewhere in Mexico, along with the critical mass of hams needed to equip such a dish, in order to put an XE prefix on the Moon for Yuri's Night 2011. For more information about Yuri's Night, see: <http://www.yurisnight.net>.

Yuri's Night

The goals of Yuri's Night will be *to have fun* and to demonstrate EME to the non-EME community, both hams and non-hams. I don't know if Arecibo will be on, but I am hopeful that they will be. Arecibo is almost turnkey now on 432 MHz, but it is a challenge to authorize and implement a 1296-MHz station to be built. If management authorizes it, I am sure Angel, Jim, Joe, and the guys could figure out how to remote a 1296-MHz radio (1500 feet horizontally and 400 feet above the operating position) and squeeze in a horn on the crowded turntable of existing Arecibo horns and receivers. Other big guns' dishes, including Dwingeloo and HB9MOON, have been approached. An invitation will soon be sent to all of the EME community. This time the emphasis will be on 1296 MHz, in addition to 432 MHz.

Thanks to the efforts of the Arecibo event, many space enthusiasts, both hams and non-hams, have been introduced to and are following EME via various internet channels, and even Facebook, in recent times. Furthermore, moonbounce has caught the eye of leaders and future leaders of both NASA and AEXA. Preliminary discussions with NASA are under way on how to use the EME hobby pursuit in a productive way in NASA education and outreach.

Additionally, at Tulsa Community College, Tommy Henderson, WD5AGO, is already planning for a nice presence and participation on Yuri's night, with an inexpensive-to-make horn on 1296. Tommy plans to write an article about his efforts for a future issue of *CQ VHF* magazine. Best 73, and see you some day off the Moon!

10-GHz Tune-Up Party

This past July southern California hams enjoyed tremendous propagation. Dozens of contacts were made between the U.S. mainland and Hawaii on the lower VHF/UHF ham bands. Ever elusive, however, was the first California to Hawaii 10-GHz QSO. Even so, hams in southern California remain intrigued with 10-GHz and above activity. Here WB6NOA summarizes some of that activity.

By Gordon West,* WB6NOA

Southern California hams enjoyed nine straight days of Hawaii tropo, spanning 2500 miles over the Pacific during the third week of July this year. Chip Angle, N6CA, spent several afternoons on the Palos Verdes hill, attempting to work Paul Lieb, KH6HME, on 10 GHz.

"Unfortunately, the tropospheric ducting was not intense enough to bridge the Pacific," comments Paul Lieb, the dedicated Hawaii-based ham who makes the long haul trek up to the operating site on the Mauna Loa volcano. "But we sure worked hundreds of West Coast mainland stations on the other lower VHF/UHF bands, during this one week tropo period."

The 10-GHz path has eluded ham operators year after year. However, it is not without some very big efforts to ensure precise lateral alignment and elevation alignments, exact frequency tolerances, and, of course, a check of transmit power and receiver sensitivity.

At 10 GHz, testing for equipment performance requires specialized microwave skills and gear. A traveling, unique

*CQ VHF Features Editor, 2414 College Drive, Costa Mesa, CA 92626
e-mail: <wb6noa@cq-vhf.com>

Three photos of the San Bernardino Microwave Society's warm up event prior to the ARRL's Microwave contest this past August.

microwave test range, for both transmitting and receiving performance was developed by Kerry Banke, N6IZW, with the San Diego Microwave Group (SDMG) and the San Bernardino Microwave Society (SBMS). His traveling test range consists of a remote TX/RX transmitter sensor unit installed on a 15-foot pole at a distance of approximately 220 feet from the stations being tested.

"The remote transmitter produces a stable signal on the operating frequency, such as 10368.1 MHz, which we used for our recent tests in southern California," comments Ed, W6OYJ, working among the southern California microwave operators, one after another, for the sending and receiving measurements.

With the remote transmitter turned on, all operators tune in the signal with their

Wayne Yoshida, KH6WZ, playfully pulling a branch out of the way of the author's microwave signal so as to increase its strength at the other end of the QSO.

rigs, and peak their antennas. Gradually, the signal is reduced for the test. Then, one by one, each operator is judged for his ability to still hear the signal as it continues to be reduced (MDS, or Minimum Discernible Signal). Some operators swish their RIT and use digital signal processing to be able to hear the signal as it almost disappears into the noise. That signal level is then logged by one of the judges. Next, this same operator then transmits with maximum CW power, and the distant RX sensor power level is logged. Then on to the next operator.

A spread sheet is used for the log data, with information on each rig's measured antenna size and estimated transmit power level to allow comparison of measured versus expected performance. The results have been useful, not from an absolute basis, but by allowing operators to compare their rig's results against other amateurs' rigs, having similar antenna size TX and RX levels and antenna-feed techniques.

A major difference in performance can help to focus on unsuspected problems to be solved before upcoming contests events. During past tune-outs, operators have discovered problems with relays, cables, connectors, and even non-functioning power supplies.

"What operators should look for is receiving performance of their own rigs, marked in MDS Gen dBm," comments the San Diego test team. "You want the largest negative value compared to other stations having the same size or performance antenna on that frequency band," adds the judge.

Marked "Meas Calc," each operator's transmit ERP performance is shown. A zero means that your ERP (effective radiated power) came out exactly as expected, given the claimed transmitter power and antenna gain.

"If the operator has a positive number, then the ERP is better than expected by that many dB. If the number is negative, then your system measures less than expected," comments the judge.

As you can see by the photos, 15 operators tested their 10-GHz systems, and four tested their 24-GHz units.

It was fun to see the intense competition among the individual operators, each hoping for one of the overall best scores. Certainly, antenna size does make a difference:

12-inch dish = 27 calculated dB antenna gain
18-inch dish = 31 calculated dB antenna gain
24-inch dish = 33 calculated dB antenna gain
30-inch dish = 35 calculated dB antenna gain
36-inch dish = 37 calculated dB antenna gain

Up at 24 GHz:
12-inch dish = 35 calculated dB antenna gain
24-inch dish = 41 calculated dB antenna gain

It was educational to watch the microwavers poring over their transmit and receive measurements. I soon discovered why there was a concentration of dishes in a tight area, located within the distant setup's main lobe. I also discovered that trying to shoot a 10-GHz signal past the one and only tree in our test range put me many dB down in the pack. Nonetheless, it was fun to watch the distant signal fade in and out as the tree branches moved in the wind!

Best of all, we all came away knowing that our equipment was working well, or discovered it needed some additional tweaking at 10 GHz.

Beginning Experiments on the VHF Amateur Bands Part 4 – Conclusion

In this final installment, KK7B writes about how our experiments are guided by our interests, skills, and tools. He adds that an experiment is something interesting we try, not knowing its outcome ahead of time.

By Rick Campbell,* KK7B

The past three issues of this magazine described some specific VHF experiments involving stable VXO signal sources, receive converters, and low-power AM and CW transmitters. This time we'll step back and take in a larger view of experiments using basic radio hardware in the VHF bands. The topic for this issue's lesson is: Our experiments are guided by our own interests, skills, and tools. First, let's review what we mean by an experiment:

**e-mail: <ecekk7b@gmail.com>*

An Experiment

An experiment is something interesting we try, not knowing ahead of time whether or not it will work. That is fundamentally different from repair, tinkering, or duplicating someone else's design using either plans or a kit. Repair is both necessary and educational, and often provides the excuse to purchase a useful tool. Tinkering is enjoyable and highly educational, but without the goal of finding an answer to a specific question. Duplicating someone else's design can be challenging, time consuming, and expensive, but we want it to work as expected when the project is complete. Since the first requirement is that we don't know whether or not it will work, we prefer simple and inexpensive experiments. The risk of failure is high, but the cost of failure is low. One way to reduce the cost of failure is to design experiments so that

Photo 1. An historic VHF experimenter's station. From left to right are a home-built power supply, Johnson 6N2 transmitter, Drake 2A tunable IF receiver, and a pair of Ameco 6- and 2-meter Nuvistor converters sitting on top of the Drake 2AQ speaker Q-multiplier. (Photos courtesy of the author)

Photo 2. A complete low-power, 2-meter AM station using the 2-meter AM transmitter described in the last issue of this magazine and a modified portable AM aircraft receiver from the bargain table at the local RadioShack.

we can always take one step backward to something that works.

Consider the experimental amateur radio station. As we visit amateur radio stations we quickly notice some differences. Some operators are devoted to competition; everything is arranged to gain the maximum number of points in a contest and efficiently record everything in a computer log. Contest operators may forget that there are other approaches to amateur radio, particularly on VHF. Other stations are comfortable retreats where the operator spends a little daily time exercising basic radio skills while keeping in touch with new and old like-minded friends. These personal radio stations and the communities they foster are the heart and soul of amateur radio. The experimenter's station is an evening haunt for exploring interesting new ideas. We refer to our experimental spaces as "the bench" or "the lab." Sometimes the benches double as an operating position. They tend to be a bit cluttered, particularly when work is in progress. Looking back over decades of experiments, we can sketch some suggestions for experiments and experimental stations:

1. Build modular stations and laboratory benches.
2. Align experiments with our interests, skills, and tools
3. Keep an experiment simple.
4. Aim for useful results.
5. Make the work enjoyable and communicate interesting results.

If our stations are modular, we can experiment on one module at a time. This is the historic approach to a VHF station, as shown in photo 1. From left to right are a home-built power supply, Johnson 6N2 transmitter, Drake 2A tunable IF receiver, and a pair of Ameco 6- and 2-meter Nuvistor converters sitting on top of the Drake 2AQ speaker Q-multiplier. This station served as the experimental platform for developing the KK7B Rcx1 and Rcx2 receive converters available from Kanga US. Testing a converter was as simple as swapping cables between the new receive converter and the Ameco converter.

Interests, Tools, and Skills

We should choose projects that align with our interests, tools, and skills. Skills and tools include what we already have and those we are willing to invest time and money to acquire. The 6N2 power supply in photo 1 was also an experiment. It combines two junk-box transformers with high-voltage diodes and some large high-voltage capacitors from Surplus Gizmos. The basic principles were reviewed by studying the power-supply chapter in the 1967 *Radio Amateur Amateurs Handbook*. The goal of the experiment was to replace the Johnson Ranger power supply, and reduce CW chirp. VHF experiments often involve DC and mechanical skills. This is an important point: As amateur radio oper-

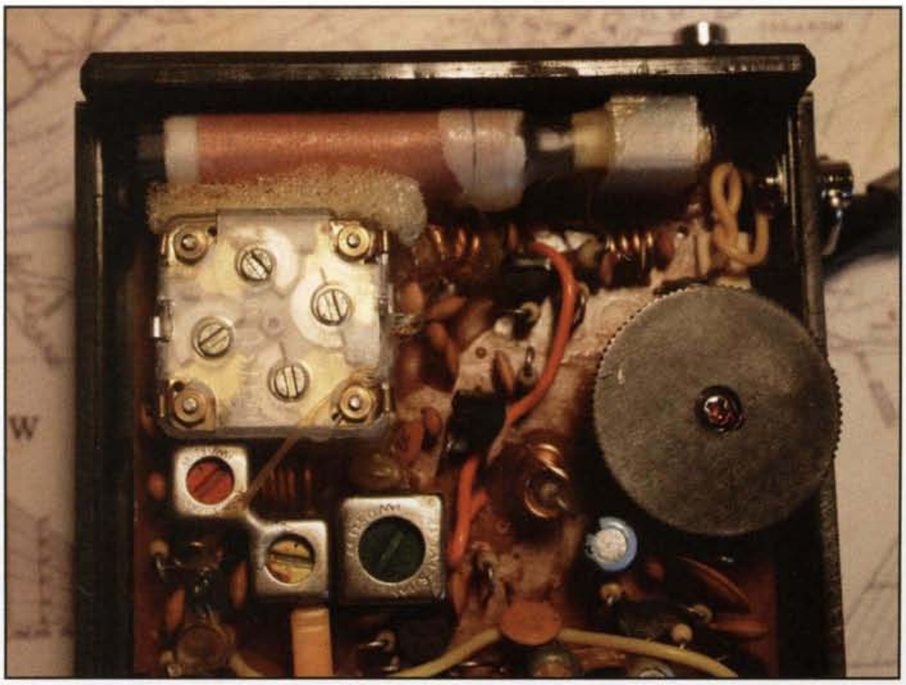


Photo 3. Inside of the radio. The RF and LO tuning inductors are just below and just to the right of the square plastic tuning capacitor. You can see that the turns have been spread a little.

Photo 4. KK7B heads out across Timothy Lake in the Oregon Cascades in search of a quiet portable QTH with a good view of Mt. Hood.

ators we are free to choose our projects, and each of us has a unique set of skills and tools.

The Fundamental Task

An experiment should be simple. The fundamental task is to define the experiment. By carefully using tried-and-tested hardware for everything but the unknown, we can quickly learn whether the experiment is a success, and how well it works. My own station is experimental, but not entirely homebuilt. I would rather use a piece of trusted, reliable commercial radio gear or laboratory equipment than spend my time duplicating someone else's design just so I can claim to have "built it all myself." Photo 2 shows a complete low-power 2-meter AM station using the 2-meter AM transmitter described in the last issue of *CQ VHF* and a portable AM aircraft receiver obtained from the bargain table at the local RadioShack store. The RadioShack radio originally covered 108 to 137 MHz, but the simple circuit, a schematic, is glued to the inside cover of the plastic case and shows that the tuning range is determined by only two inductors. Photo 3 shows the inside of the radio. The two inductors are just below and just to the right of the square plastic tuning capacitor. You can see that the turns have been spread a little. The receiver was converted to cover 118 to 149 MHz simply by spreading the turns of the two inductors using a toothpick. The inductors were modified while the radio was tuned to a signal generator by making small adjustments and then observing the new tuning range. Note that an old transistor FM radio can be moved to the 2-meter band using the same technique.

Useful Results

Results of experiments should be something we can use. A university "student lab experiment" only needs to teach a lesson. VHF experimenters have a different standard: We also want to use experiments to improve the performance of our stations in some way. The new power supply shown in photo 1 reduced CW chirp. A new power supply for the Ameco converters with zener diode regulation reduced receiver drift. The simple receiver in photo 2 has had the same 9-volt battery for years of casual listening on 2meters AM and the AM broadcast band, an obvious advantage to anyone who has ever taken an FT-817 away from AC power for a weekend. The Rcx1 and Rcx2 receive converters have already been used in a large number of applications in instrumentation and radio communications, and the VHF frequency sources have been widely applied to applications limited only by the remarkable imagination of the experimenting community. Experiments motivated by simple curiosity are valuable, but those fall into the category of "Basic Research." Our VHF experiments provide useful results that we incorporate into our stations and operating techniques. Finally, let's not forget the most basic and useful radio experiment of all: "Can You Hear Me Now?"

The Goal

I require my own amateur radio experiments to be both fun and cool. By definition, amateur experiments are done on our own time, without being paid. If they aren't fun, we won't finish the work. If they aren't cool, we won't be excited enough to tell anyone else about our results. Either way is a bit of a waste of time.

At the core of amateur radio is technical communication. One goal of our experiments is to generate results we can share with friends on the web, or by writing interesting articles for this magazine or a technical conference. If the experiments are enjoyable and the results are cool, next-generation experimenters will build on the work and take it to the next step. The history of VHF amateur radio in the 1950s and 1960s serves as a fascinating study of this process. These days we can inject a bit of fun into the experiments by combining cool vintage electronics with things we develop on the bench.

Operating via Our Results

The way we use our results is by operating our VHF stations. One reason we perform experiments is to develop stations for applications other than a traditional home or mobile operation. Home and mobile stations using common bands and modes are well served with commercial gear. We develop our own gear when we need something different.

My friend Wes Hayward has spent much of his amateur radio career designing, building, and operating rugged, ultra-light portable gear for operation from a small battery pack on HF CW. Wes typically operates from remote hilltops in the Pacific Northwest, miles from the nearest road and often more than a mile off the nearest marked trail. My own interests tend to involve unusual modes, beacon reception, and small boats.

Marine mobile operation from small

Photo 5. Experimenting with radios and boat rigs requires some tools and skills not often associated with radio. The author's bench in March 2010.

boats involves a number of tough challenges and two significant advantages. The first significant advantage is that VHF signals travel easily over water. In the Pacific Northwest, the path to the fixed station from a boat is often either line-of-sight or has to go through a mountain range. On line-of-sight paths 100 mW is enough, and 1 watt of CW and a small Yagi will do for bouncing signals off a mountain. We can sail or row the boat to a location with a good path. Most of the energy consumption in a portable station is used to transport it to the /7 location. I use wind power for that, and small batteries to power the radio gear.

The second advantage is that a boat takes us away from the local noise that plagues our bands. Radio gear for operation from a small boat doesn't need to be particularly light weight, but it does need to survive being knocked around and immersed in water. Listening for weak signals is incompatible with power-boat operation, and on my boats there is too much going on to try to make a contact while sailing. I often use a separate, rugged receiver with its own antenna for listening under way, and simple transmitters that I set up at anchor or when the boat is pulled up on a remote beach.

In photo 4 I am heading out across Timothy Lake in the Oregon Cascades in search of a quiet, portable VHF sight with a good view of Mt. Hood. The boat is experimental and home built, using a hull design by Phil Bolger. Experimenting with radios and boat rigs requires some tools and skills not often associated with radio. Sometimes my bench looks like photo 5.

Our experiments are unique because they are guided by our own interests, skills, and tools. A serious 6-meter CW station optimized for use in the boat is shown in photo 6. The handheld CW transmitter includes the key on top and batteries inside. The long, white, plastic lever is the T-R switch, operated by thumb. The receiver includes microR2 and Rcx1 kits from Kanga US, with a separate receiver battery pack and receive converter in the Otter waterproof plastic box from REI.

Outside the Limits

We don't have to limit our marine mobile operation to the lower VHF bands. Photo 7 shows a 5.8-GHz microwave station mounted in the stern of the sailboat for experiments with W7YOZ along Pickering Passage. A second 5.8-GHz SSB/CW station was designed and built for operation from a picnic table or deck.

The Summer 2010 issue of *CQ VHF* had interior photographs of the little experimental 6-meter SSB radio I built into an old Heathkit Q-Multiplier case. Photo 8 shows the little radio that rides in the boat with a battery pack, tucked in a soft, foam-lined lunch box. The foam lunch box was designed to keep a sandwich cool, but the foam also protects the radio as it gets knocked around in the boat, and it floats. The line was used to haul a 6-meter dipole up the mast. Heathkit offered 6- and 2-meter AM transceiver kits in a package a little larger than this, with a handle on top. They acquired the nickname "Benton Harbor Lunch Box" from Heathkit's home town of Benton Harbor, Michigan. I call this one the Dark Harbor Lunchbox. If you look closely you can see it's not an EF Johnson logo in the upper left corner; it's a Pirate, somehow appropriate, as I'm writing this on International Talk Like a Pirate Day, in Ireland, no less.

Conclusion

Thank you for sharing some of your time with me as we explored a few recent experiments on the VHF bands at KK7B. I hope some of them have been interesting and that you will be inspired to try a few of your own. Your experiments may

Photo 6. A serious 6-meter CW station optimized for use in the boat. The handheld CW transmitter includes the key on top and batteries inside. The long white plastic lever is the T-R switch, operated by thumb. The receiver is the Rcx1 and microR2 from Kanga US. The receiver battery pack and converter are in an Otter waterproof plastic box from REI.

Are You Moving?
Let us know.

Mail your subscription label along with your new address, to us, so you can be sure you don't miss a single issue.

Photo 7. A 5.8-GHz microwave station mounted in the stern of the sailboat for experiments with W7YOZ along Pickering Passage in Washington State.

be as simple as digging out an old FM transistor radio from the kitchen junk drawer and retuning it for the 2-meter band, or more complex, ultimately resulting in a high-performance modular VHF station.

The joy of experimenting means doing something different, modifying equipment and circuits to do something other than the original design. Experiments allow us to exercise our creativity, skills, and tools, and they give us something to do with the junk radios in the box in the garage. Have fun, and share your results with friends.

Photo 8. The Dark Harbor 6. The lunch box was designed to keep a sandwich cool, but the foam also protects the radio as it gets knocked around in the boat, and it floats.

A Low-Cost 70-cm Tracking Beacon for Rocket or Balloon Payloads

Because sometimes balloon-launched payloads are never recovered, one consideration for balloon launches is cost. Here WC5Z describes a low-cost tracking beacon for balloon launches.

By Michael Helm,* WC5Z

Amateurs flying high-altitude experimental balloon payloads and those flying large experimental rockets are often interested in simple and low-cost tracking beacons. Although both groups frequently fly sophisticated and expensive payloads including GPS/APRS tracking systems, it is useful to have backup tracking beacons in the event of failure of the more complex systems. I have participated in more than one balloon flight during which problems developed with sophisticated GPS/APRS systems and the simple tracking beacon of last resort led to the recovery of an expensive balloon payload. Usually the GPS/APRS equipment works well, but there are enough occasions to the contrary to make it worthwhile to include an alternate tracking signal source, particularly if it is lightweight, simple, and inexpensive.

I started developing simple tracking beacon transmitters about 15 years ago after getting introduced to ham radio high-altitude experimental ballooning by Jerome Doerrie, K5IS. Over the years I have designed and built numerous versions of beacons on 10, 6, and 2 meters. These all were designed around conventional circuitry, using frequency-multiplier stages where needed. I have found these designs to be robust even under temperature extremes. Some available designs using PLL technology have been shown to lose phase lock in temperature extremes. Hence, the simpler approach presented here, which has proven to be reliable in practice.

*190 Mason Road, Lubbock, TX 79407
e-mail: <michael.helm@ttu.edu>

Basic Design Goals

There were multiple goals of this design. It needed to be simple, low cost, rugged, have good signal purity and reasonable power level, produce an FM tone-modulated signal, and operate on 6 volts DC. The 6-volts requirement was needed to reduce battery weight in balloon or rocket payloads. The FM tone modulation makes it easier for trackers with commonly available FM transceivers to track the signal, and the signal has a pleasant audio sound. Harmonics need to be down by 40 dB or more below the carrier to meet FCC Part 97 requirements. Simplicity makes the beacons easier to build, robustness is simply a neces-

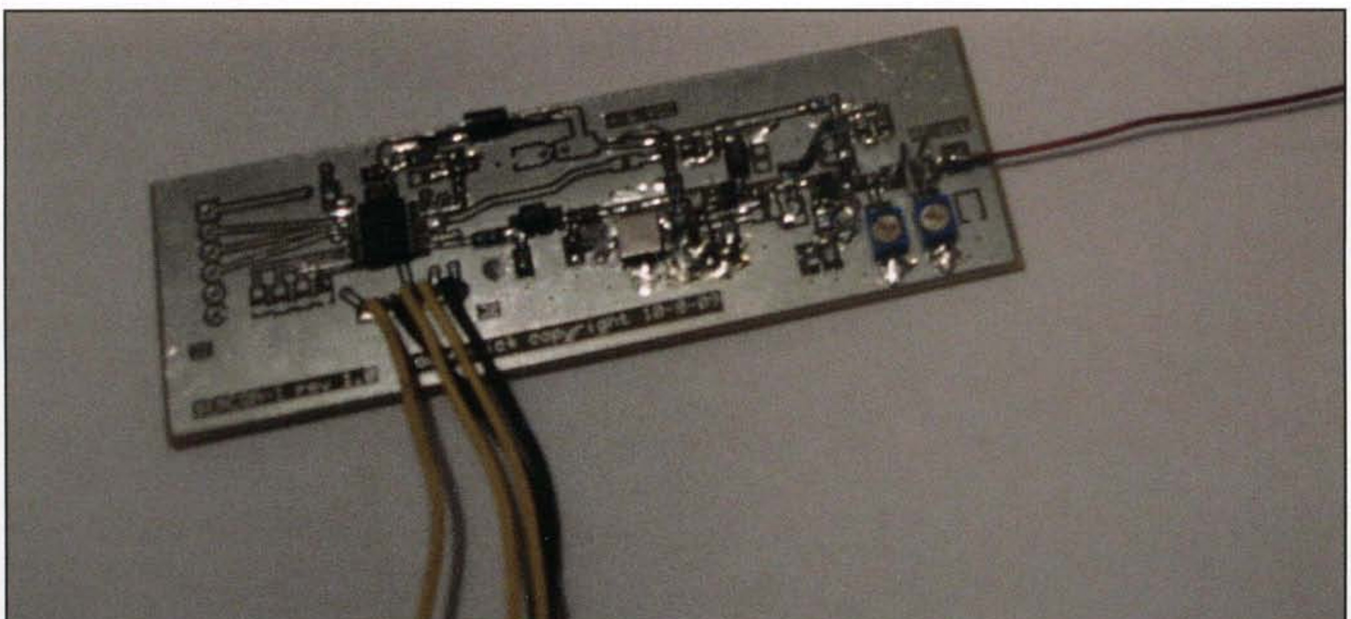


Photo A. Surface-mount PC-board version of the beacon transmitter including PIC IDer.

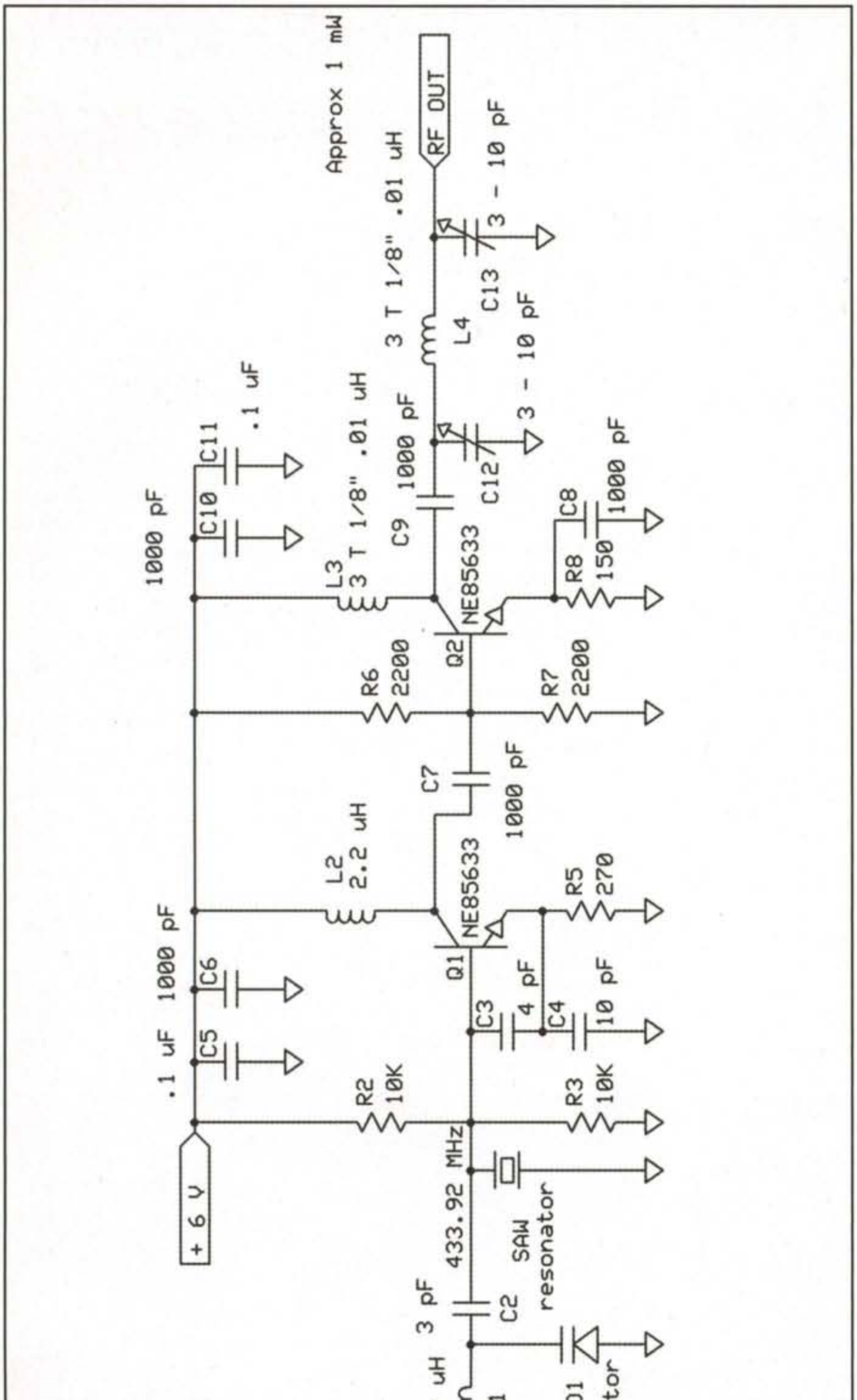


Figure 1. RF portion of the 433-MHz beacon transmitter.

sity of the application, particularly in rocketry, and low cost makes it more likely that we will never hesitate to include these in a payload as a backup.

I had tried several designs and prototypes for the 70-cm band, but had difficulty in meeting the goal of simplicity with frequency-multiplier designs. Then I found SAW resonators available inexpensively for several different frequencies in the 440-MHz ham bands. It is feasible to use a UHF SAW resonator in a Colpitts oscillator circuit much the same way you might use a quartz crystal. The SAW resonator will set and maintain the frequency within a fairly tight tolerance. The SAW resonators are not quite as frequency accurate as a quartz crystal, but they are inexpensive and eliminate the need for chains of frequency multipliers or somewhat complex PLL systems. The SAW resonators are available inexpensively from suppliers such as Mouser Electronics and Digi-Key.

Circuit Description

A basic version of the one of these beacons is shown in the schematic in figure 1. A Colpitts oscillator is built around Q1 and the SAW resonator sets the resonant frequency, in this case to 433.92 MHz. Frequency modulation can be achieved by providing a sine-wave input at the point labeled audio in. The modulation is achieved as the audio signal varies the reverse bias on D1, a varactor diode. Changing the capacitance of D1 changes the total capacitance in parallel with the SAW resonator, and achieves a limited amount of frequency modulation.

On my beacons, I have used a PIC microcontroller to generate a 1-kHz audio pattern of a Morse Code identifier to modulate the varactor. It is relatively easy to program a microcontroller to generate a square-wave audio signal, and a couple of sections of RC filtering can be used to take the edges off the square wave to provide a reasonably good-sounding audio signal for modulation. The amount of frequency modulation is dependent on the characteristics of the varactor diode, the value of C2, and the amplitude of the audio modulation. I was easily able to achieve about 1 kHz of FM deviation, and this sounds fine on an FM mobile transceiver.

Since the output power from Q1 is limited, Q2 is added as a class A buffer amplifier, followed by a low-pass filter and pi matching network formed from C12, L4, and C13. After tuning using a spectrum analyzer, all harmonics were down more than 45 dB below the carrier. The output power on the unit pictured in photo A was about 1 milliwatt. It is important to use transistors with a high Ft for both Q1 and Q2. If you are not interested in FM modulation on the beacon, you can leave out R1, C1, L1, C2, and D1. If you want to simply ON/OFF key the beacon with CW by keying the 6-volt supply voltage ON and OFF, you should reduce C5 and C11 to .01 µF.

It is possible to increase the power output of this basic beacon design by two different simple approaches. One approach is to increase the idle current in Q2 by reducing the value of R8. Care should be exercised with this approach and performance should be verified using a spectrum analyzer to ensure that the harmonics are sufficiently suppressed. A second approach which I have also used on various versions of this basic circuit is to add an additional amplifier stage at the output. This can just be a complete copy of the circuitry to the right of C7 in the diagram, inserted between junction of L4-C13 and the RF output connection. Using a second copy of the Q2 stage including the pi-network low-pass filter, I have been able to get 10 to 12 milliwatts of output power with good harmonic suppression.

Conclusion

Earlier versions of this design have been successfully flown on rocket and balloon payloads in 2008 and 2009, and this version was flown in May and July of 2010, for a total of five flights of this basic design. So far it has worked quite well and has provided a strong tracking signal. I did observe some frequency drift with temperature of the SAW resonator on one balloon flight at high altitude where the internal payload temperature dropped significantly due to some thermal insulation problems. The frequency stability characteristics of the SAW resonator are certainly not as good as a quartz crystal, but this design provides a very low-cost solution, so some frequency drift can be tolerated in this application, and can be minimized by keeping the beacon thermally insulated during flight.

This design has proven to work well in several flights and also during a recent foxhunt. The photo of the design shown uses all surface-mount components, and includes a programmed PIC microcontroller with a Morse Code identifier for the beacon. The PIC microcontroller also includes some limited status telemetry capability as part of the Morse Code message. Due to the power output level being far greater than what is allowed under FCC Part 15 license-free operation, this beacon can only be legally operated as part of an amateur radio station and only if it is identified using an amateur radio callsign. Those interested in a complete SMT board version of this design or other versions with higher power output can check my website <www.powerbrick.com> for details.

About the Author

WC5Z has been a ham since 1968. His interests are primarily in designing and building radio transmitters and receivers. He is interested in HF through microwave and has been involved in ham ballooning for about 15 years. He has gotten involved in designing and building payload beacon transmitters for local rocket teams in the past three years. After decades in the electronics industry, Michael is now teaching in the EE dept at Texas Tech University in Lubbock, Texas.

My Experience Getting Started on 2 Meters EME

Those of us who are old hands at EME, remember the first time we were on "the Moon." Here AE3T describes his experiences so we can reminisce. For those of us who have not yet tried EME, we can be challenged by his experiences to make our first attempt.

By Howard Sherer,* AE3T

Although I have been an active amateur for the past 46 years and have an interest in VHF, and propagation study, I have not had the opportunity to experience operating EME (Earth-Moon-Earth) moonbounce on 144 MHz until recently. This article is not going to discuss any of the operating procedures, or the basic physics, or the more technical aspects of EME operation, but will focus on my experiences as a small station getting started in this very exciting area of amateur radio. There are many excellent resources available to educate the amateur interested in this area. If you enjoy weak-signal operation, EME is the ultimate DX, very-weak-signal experience! Although you don't operate at QRP power levels, you can also relate EME operation to QRP operation.

From the 1970s through the 1990s I was active on the OSCAR amateur satellites and had a station equipped for the various modes of operation. In the late '90s during an EME activity weekend, I decided to spend some time to see if I could hear any of the big-gun stations off the moon. Using both my OSCAR array on an az/el mount, and my horizontal Yagi used for 2 meters SSB, I was able to copy four stations from the U.S. and Europe on CW and one station on SSB. I was amazed that this was possible, but realized that my 150 watts and single Yagi would not make the grade.

Fast forward nine years and the availability of digital communications using the WSJT modes, I rekindled my activity on 2-meter meteor scatter and realized how much easier it was to make contacts on any day using random meteor scatter and the WSJT FSK441 mode vs. only operating during the meteor showers using SSB. I continue to have great success on 2-meter meteor scatter, and am active on a regular basis.

I spent some time during the past year getting to know how to use WSJT, and began reading everything that I could find on EME operation with a focus on the digital modes. I quickly realized that with moderate power and a good single Yagi, EME contacts would be possible with large, well-equipped stations. I corresponded with a number of successful EME operators and listened very carefully to what they had to say about their experiences and station setups I decided to take the plunge during the October 2009 ARRL EME weekend. I was running 250 watts to a 13-element 13b2 at 35 feet with no elevation control. I don't have a clear horizon in any direction, so the possibility of using ground gain was in doubt, but that is what I had to work with. I watched for activity from well-equipped stations on the NØUK Ping Jockey internet reflector and requested some of the stations to try for a contact. It only took a short time and I had completed my first QSO with EA6VQ in the Balearic Islands. I was thrilled, and a short time later made my second contact. I was able to copy five other stations during the weekend, but did not make any additional QSOs for another week.

By learning more about the lunar propagation path and its many variables, I was better equipped to plan my limited access time with an antenna having no elevation control. I had what I thought was very good success, making 18 EME QSOs with my current station. I was bitten by the bug and wanted to improve my station, but realized that I would have to stay with a single Yagi due to space limitations. I made the following improvements to my station in short order:

I added 3 dB to my transmit signal by going to 500 watts with an old tube amplifier, changed my Yagi to a more effective 2.5-wl 12-element design with limited minor lobes, added elevation rotation to my Yagi, and finally moved my low-noise receive preamplifier up to the antenna.

These changes each made small incremental improvements, but together have made a big improvement in my success for competition for a QSO. I learned early on that patience was of great importance, and not to get frustrated by lack of success and the one-way propagation, which is a very big factor in EME operation. Many times I would be able to copy the other station very well, but it could see no sign of my signal, and yes there are times when I am being copied, but I cannot see the other station. Those well-equipped stations that have the ability to operate with either H or V antenna polarization, with independent switching for RX and TX which have a great advantage on EME to compensate for both the spatial offset in polarization, and the Faraday rotation, which is a major factor in EME communications.

The recent station improvement that made the greatest improvement was the addition of elevation control for the antenna. This resulted in two major advantages. First, the most obvious, was much greater access time for the moon. Also very beneficial was the great reduction in the terrestrial noise level when the antenna reached an elevation of 20 degrees and above the horizon. Due to the good pattern of the single Yagi, most of the noise sources on the ground were out of the radiation pattern of the antenna when elevated. My success rate for the competition for contacts when all of the required information is exchanged is still only about 30%, but I consider that to be very good for a station the size of mine.

*1481 Red Maple Lane, Allentown, PA 18104
e-mail: <howardms@lehigh.edu>

At the current time I have already completed over 140 EME QSOs with over 100 different "initial" stations. Most of these were stations running four Yagis or more and full power. I have also completed contacts with three stations that were only using two Yagis (2× 11 elements and 400 watts), and most recently with a station in Europe running a single 18-element H/V Yagi and 250 watts under the most ideal conditions. We both were very pleased to successfully complete this contact. I have not had good success in making contacts with a number of the recent EME DXpedition stations during the past year which typically were running large single or two Yagi stations.

Although DXCC is not feasible at the present time due to the lack of large station activity from all of the required countries, I have had great enjoyment operating EME and have met many very knowledgeable operators. I have completed my 2 meters Worked All Continents, and along with contacts using tropo and scatter on 2 meters have confirmed 46 U.S. states. The EME community is very helpful and has shown great patience in spending the sometimes great amount of time necessary (sometimes over a number of months) to complete contacts with small stations. There are many small stations like mine that have become active on EME with the development of WSJT, and we all share the same high level of excitement in completing every new contact. I have been pleased and actually quite surprised at the amount of success a small station can have on EME given sufficient time to plan time around the better lunar conditions.

My greatest thanks must be directed to K1JT, Joe Taylor, who has used some of his great knowledge to advance the state of the art for amateur radio communications.

The Meteor Shower Nobody Saw— Revisited

In 1975 seismometers on the Moon recorded what was first thought to be a lunar meteor shower. Here N6CL instead makes a case for a huge sand storm and predicts when the next similar storm may occur.

By: Joe Lynch,* N6CL

Photo A. Astronaut Buzz Aldrin deploys a seismometer in the Sea of Tranquility. (Courtesy NASA)

The placement of seismometers on the Moon's surface by the Apollo astronauts yielded evidence of a huge event during June 20–30, 1975. Previous research assumed that this event was a lunar meteor storm. In 1992 I presented a paper at the Central States VHF Society Conference on the supposed lunar meteor storm in which text from the "The World Above 50 MHz" column in the September 1975 issue of *QST* was used to determine whether or not there was support for the theory of a lunar meteor storm. Results of that examination were inconclusive.

Recent research into the Earth's magnetotail caused me to re-examine the original premise, that the seismometer activity of June 20–30, 1975 was a lunar meteor storm. This re-examination led me to form the hypothesis that this activity was not a lunar meteor storm after all, but rather a series of events—in particular, sandstorms—that were caused by the influence of the Earth's magnetotail on the Moon's surface. I have further hypothesized that certain events occurring at the same time were what exacerbated the effects of the magnetotail on the lunar surface, thereby contributing to the overall intensity of the sandstorms. Finally, I have hypothesized that these same events will occur at the same time during a similar period in June 2016. Should the resultant intense sandstorms occur as they did during June 20–30, 1975, it could be very problematic for any astronauts who might be on the lunar surface during that time frame.

*Editor, CQ VHF
e-mail: <n6cl@sbcglobal.net>

Introduction

Recent publications concerning the Earth's magnetotail's effect on the Moon caused me to revisit the paper that I presented at the 1992 Central States VHF Society Conference entitled "Historical Meteor Storms," which was published in the conference's *Proceedings*. Subsequently, I reprinted the essence of that paper in my "VHF Plus" column in the August 1992 issue of *CQ* magazine.

In that paper I discussed the historical October 9, 1946 Giacobinid-Zinner Comet and the November 17, 1966 *Leonids* meteor showers, along with a supposed meteor shower that affected the Moon during June 20–30, 1975. I titled that section of my paper "The Meteor Shower Nobody Saw." The following—with updated inclusions in brackets—is from that paper:

> While the Giacobinid-Zinner Comet meteor shower was spectacular in its effect on the 6-meter ham band and the *Leonids* storm displayed its wonder on the 2-meter ham band, they also were very visible showers. There was, however, a [supposed meteor] shower that apparently far surpassed these two, but that no one is known to have seen.
>
> Evidence of this supposed shower that nobody saw came by way of the Moon. The Apollo astronauts left seismometers on the Moon during their missions in the late 1960s [and early 1970s; please see photo A and sidebar "Bell-Ringing Moonquakes or Sandstorms?"].
>
> During June 1975 these seismometers detected [what seemed to be at the time] a very intense meteoroid onslaught that lasted for around ten days. A group of Brazilian astronomers, headed by Pierre Kaufmann, became aware of these reports and decided to examine VLF data for the same period. They published the results of their studies in an arti-

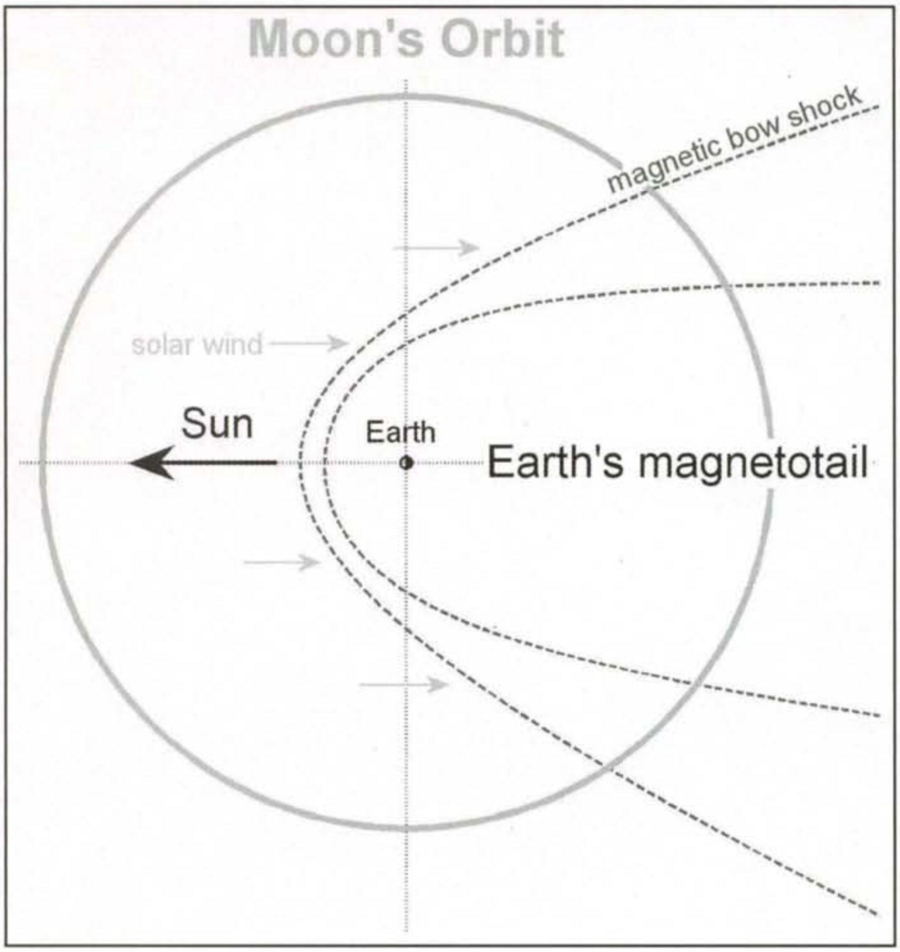


Figure 1. The Moon's orbit crosses Earth's magnetotail. (Courtesy NASA)

cle entitled "Effects of the Large June 1975 Meteoroid Storm on Earth's Ionosphere," which appeared in the November 10, 1989 issue of *Science* magazine (pages 787–790).

They decided to use the VLF data because of the known effects of meteor ionization on the *D*- and *E*-layers of the atmosphere. The *D*-layer forms a waveguide effect on signals within the VLF frequency range, transporting them for long distances across the Earth's surface. Meteoroid vaporization is known to cause phase shifts in the *D*- and *E*-layers of the atmosphere, and thus, phase shifts in the reception of the VLF signals. Therefore, examination of VLF reception records could reveal any meteor-caused detectable effects on these layers of the atmosphere.

First, by examining data from several different VLF transmitters, they concluded that [there was evidence of a radiant that] was low in the sky during the affected days, in the same general location of the Sun. [They also concluded that] because of the sunlight, the [so-called] shower was not visible. However, their examination of the [seismometer data caused them to conclude] that the shower was as much as three to nine times as intense as the Giacobinid-Zinner Comet caused shower.

Was this shower otherwise detected? While it occurred during a normal sporadic-*E* season, could there be any unusual events on VHF during that time frame, or did what were perceived to be normal sporadic-*E* events mask the effects of the shower?

Kaufmann[1] et al.'s research indicated that the [Earth] days of [lunar] activity were between June 20 and June 30, with the prime days being June 22–23 and June 26–27. An examination of Bill Tynan, W3XO's "The World Above 50 MHz" column in the September 1975 issue of *QST* (pages 78, 136, 138, and 140) showed that sporadic-*E* type propagation occurred during these days, with especially intense reports of events occurring on June 22 and June 30.

One of the most interesting reports (to me) was of a three-way QSO on June 22 that Bill (then located in Maryland) had with K3AAY, and K8CAY, the latter being only 280 miles away, in West Virginia. He convincingly concluded that the mode of propagation had to be sporadic-*E*. He went on to refer to other reports of very short-skip contacts during the same day. Oddly, this short-distance propagation was also cited as typical during the Giacobinid-Zinner Comet caused shower.

Bill also reported on receptions made by Pat, WA5IYX (near San Antonio, Texas) of numerous signals during the days indicated. Most notable were the receptions, on June 30, of many sporadic-*E* type signals throughout the FM broadcast band and the low-band VHF television band. These signals were being copied as early as 7:10 AM, Pat's local time. Pat also reported reception of several high-band VHF television stations east of him in Florida. These receptions lasted for as long as three minutes at a time. Additionally, on the same day Glenn Hauser, of Enid, Oklahoma, also reported reception of a high-band VHF television station from Florida. Glenn also reported reception of YVVK, a Caracas, Venezuela, Channel 3 television station. Although there was an increase in activity on June 30, there were not correlating data in the Kaufmann studies. It is possible that the data they examined were not complete on this day (a point they alluded to in their article).

Bill also quoted a report from W7NFC, in Athens, Oregon, that indicated contacts with all states in the W1, W4, and W5 call areas during the day of June 22. He went on to include other reports that specified that day and others during latter June and early July. Bill concluded these reports by observing that "the day-of-days was June 22, with QSOs all over the country [being reported]."

However, these days are during the sporadic-*E* time frame and any activity could have been (and was) easily interpreted as sporadic-*E* caused propagation. As stated, June 22 seemed to be a key day for both data. However, Bill does not report any correlating data on June 26. Could it be that many hams were on the air on Sunday, June 22, and that few hams were on the air on Thursday, June 26? Could it also be that most of the activity was overnight on June 26–27, whereby many [North American] hams were in bed, not expecting or suspecting anything out of the ordinary?

For as much meteor-shower activity, there seems to be little other correlating amateur radio VHF data (absence of 2-meter reports, for example). Again the question is, "Could the amateur radio observations be incomplete because 'nobody was on the air'?" In conducting unrelated research, I looked back into my 6-meter log for the last three years and found that each Memorial Day weekend the band had been open. No matter that the dates of the weekend have floated. Without exception, the band was open during some time of the weekend. Was the band open because people were home and on the air, or was the band being open and people being home coincidental?

Perhaps more study of pertinent log entries should be performed in order to see what effect this unknown June 1975 sporadic meteor storm had on VHF communications during the key days in late June.

Now, 18 years after I published my paper and presented it at the CSVHF Society Conference, I have come to believe that the supposed lunar meteor storm of June 20–30, 1975 was probably

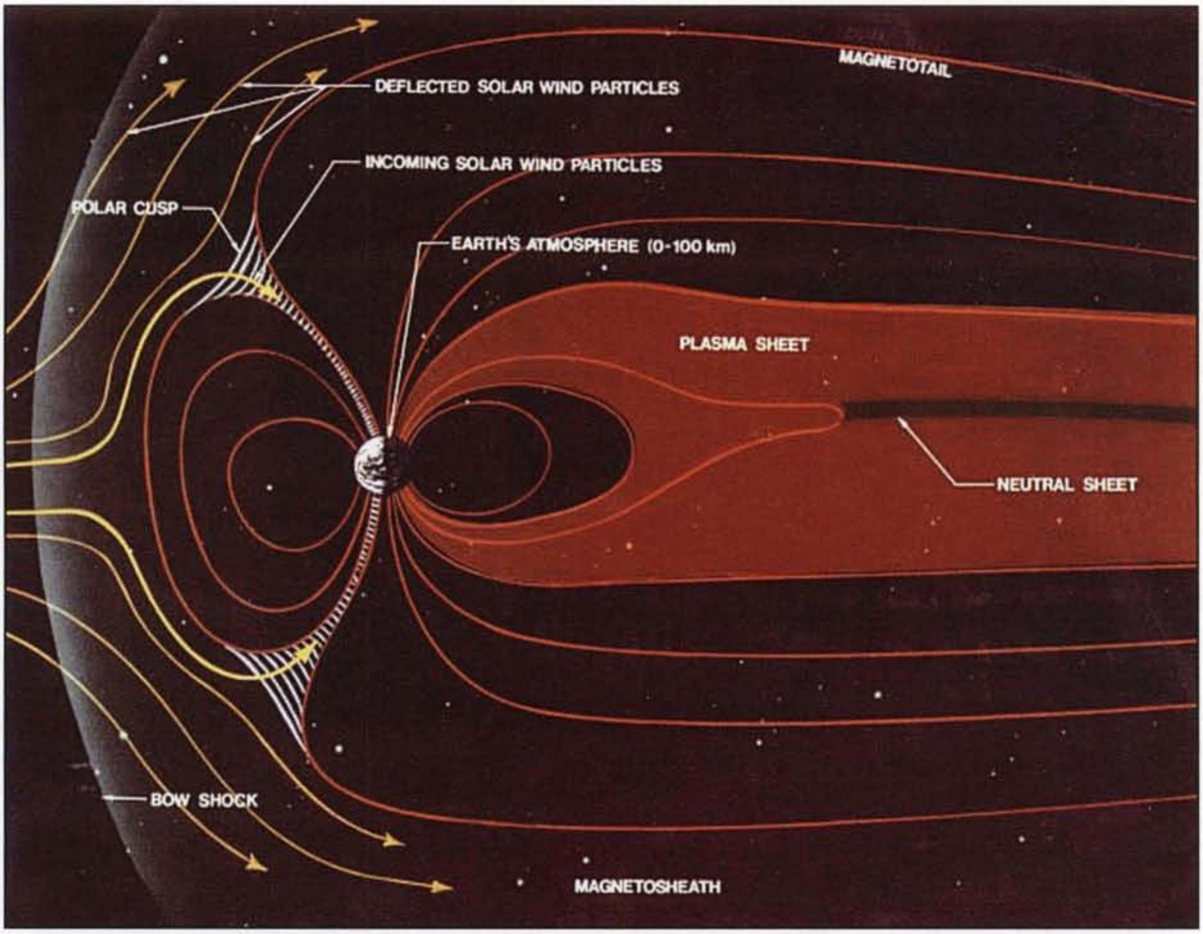


Figure 2. Detailed view of the Earth's magnetotail. (Courtesy NASA)

not a meteor storm after all, but rather successive sandstorms on the lunar surface caused by the Earth's magnetotail. Why have I come to believe this new hypothesis? What follows are what I identify as pieces of the puzzle that have led me to my hypothesis.

The first piece of the puzzle of my new hypothesis appears on page 790 of the Kaufmann, et al. paper: "However, the lack of strict day to day correlations between data from Earth and Moon suggest that the meteoroid stream was not homogeneous in space." Their concluding remark tells of their inability to tie what appeared to them to be a tremendous meteor storm on the Moon's surface to anything that occurred on Earth during the same timeframe.

I came to my next puzzle piece of my new hypothesis via reading a NASA report entitled "The Moon and the Magnetotail," which was published on the web on April 17, 2008.[2] In that article author Dr. Tony Phillips discussed the work of Dr. Tim Stubbs, a University of Maryland scientist working at the Goddard Space Flight Center. Phillips quotes Stubbs: "Earth's magnetotail extends well beyond the orbit of the Moon and, once a month, the Moon orbits through it [please see figures 1–3]. This can have consequences ranging from lunar 'dust storms' to electrostatic discharges. ... There is compelling evidence that fine particles of moon dust, when sufficiently charged-up, actually float above the lunar surface."

When I read Stubbs' and Phillips' comments, my mind flashed back to my 1992 CSVHFS paper and I wondered if what Kaufmann, et al. observed was not a meteor shower but rather a magnetotail-caused series of sandstorms. Phillips' next quote of Stubbs really got my attention: "If the Moon is full, it is inside the magnetotail. The Moon enters the magnetotail three days before it is full and takes about six days to cross and exit on the other side."

From that quote, I asked this question: "Was the phase of the Moon at full during June 20–30, 1975?" Indeed it was. Full Moon for 1975 was on June 23 at 1654 UTC. Going back to Kaufmann, et al., I noted that their evidence of the data from those seismometers indicated intense activity on the dates of June 22–23 and 26–27, 1975, which pretty much coincides with Stubbs' comments concerning the transition of the magnetotail across the Moon's surface.

A reservation that I had about my hypothesis was this: "What was special about those dates that the magnetotail would have a more intense influence over and related to other dates?" To answer my reservation, I first checked with solar records concerning Sun-caused events that might trigger a more elongated or more intense magnetotail. I found evidence of a minor solar flare on June 30, 1975 (which might explain the more intense sporadic-*E* amateur radio propagation reports on that date). However, in the absence of any other events, I concluded that the magnetotail was probably not abnormally influenced by the Sun during those critical days.

While it seemed that I had reached a dead end, my research did surface anoth-

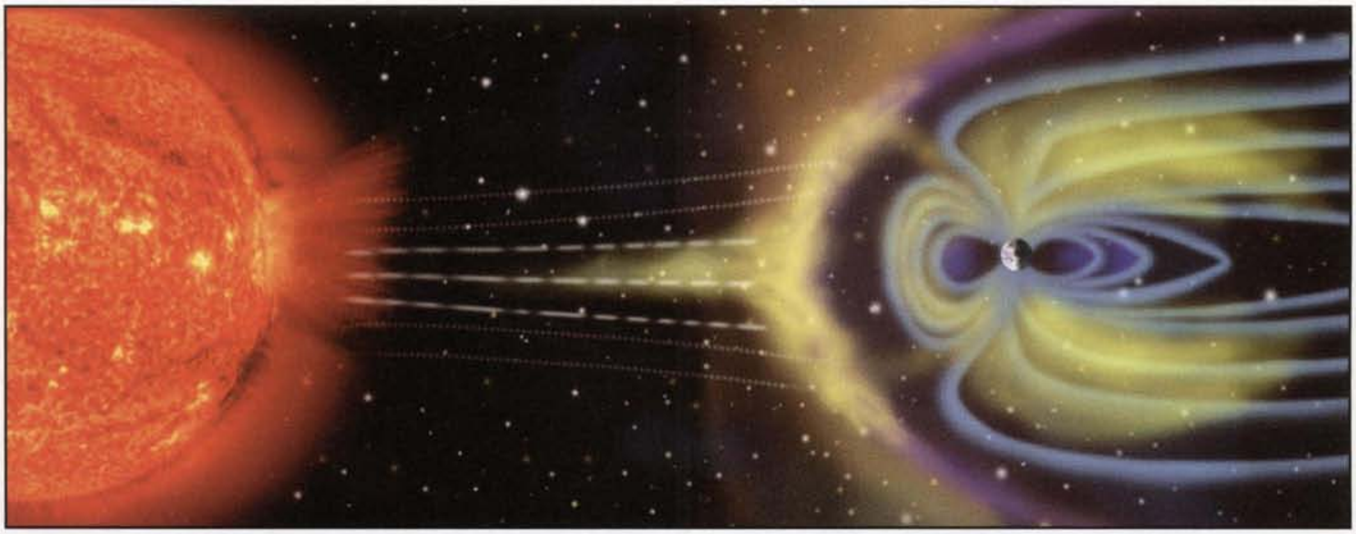


Figure 3. The Sun's influence on the Earth's magnetotail. (Courtesy NASA)

er paper, this one authored by Mike Hapgood[3] of the Rutherford Appleton Laboratory of Chilton, Didcot, Oxfordshire, UK. His paper is: "Modeling long-term trends in lunar exposure to the Earth's plasmasheet."

In Hapgood's paper he discusses how the magnetotail affects the Moon during its crossing the magnetotail at solstices—in particular the peaks and valleys associated with the Moon's approximate 18.6-year nodal period precessional orbit. At the vernal equinox of the precessional orbit, the lunar declination can reach 28° north or south each month. Around 9.3 years later (the next time being 2015) the declination reaches only 18° north or south each month.

Concerning the June 20–30, 1975 events, the summer solstice for 1975 was on June 22, at 0027 UTC. As it turns out, this particular crossing was during that time of the Moon's precessional orbit at the peak of the narrower (18°) declination (see figures 4 and 5).

For me, this third factor of the Moon's nodal period precessional orbit seems to be enough to support my new hypothesis that what happened on the Moon during June 20–30, 1975 was likely a series of sandstorms probably caused by the swath of the Earth's magnetotail across the Moon's surface.

Another piece of the puzzle can be found in the December 7, 2005 Science@NASA story entitled "Moon Storms."[4] In that article authors Trudy E. Bell and Dr. Tony Phillips write about the Lunar Ejecta and Meteorites (LEAM) experiment that was installed by the Apollo 17 astronauts in 1972. The purpose of the experiment was to look for dust kicked up by small meteoroids that would hit the Moon's surface. According to Hunt and Phillips:

> Apollo-era scientists wanted to know how much dust is ejected by daily impacts. And what are the properties of that dust? LEAM was to answer these questions using three sensors that could record the speed, energy, and direction of tiny particles: one each pointing up, east, and west.
>
> LEAM's three-decades-old data are so intriguing, they're now being re-examined by several independent groups of NASA and university scientists. Gary Olhoeft, professor of geophysics at the Colorado School of Mines in Golden, is one of them:
>
> "To everyone's surprise," says Olhoeft, "LEAM saw a large number of particles every morning, mostly coming from the east or west—rather than above or below—and mostly slower than speeds expected for lunar ejecta."
>
> What could cause this? Stubbs has an idea: "The dayside of the Moon is positively charged; the nightside is negatively charged." At the interface between night and day, he

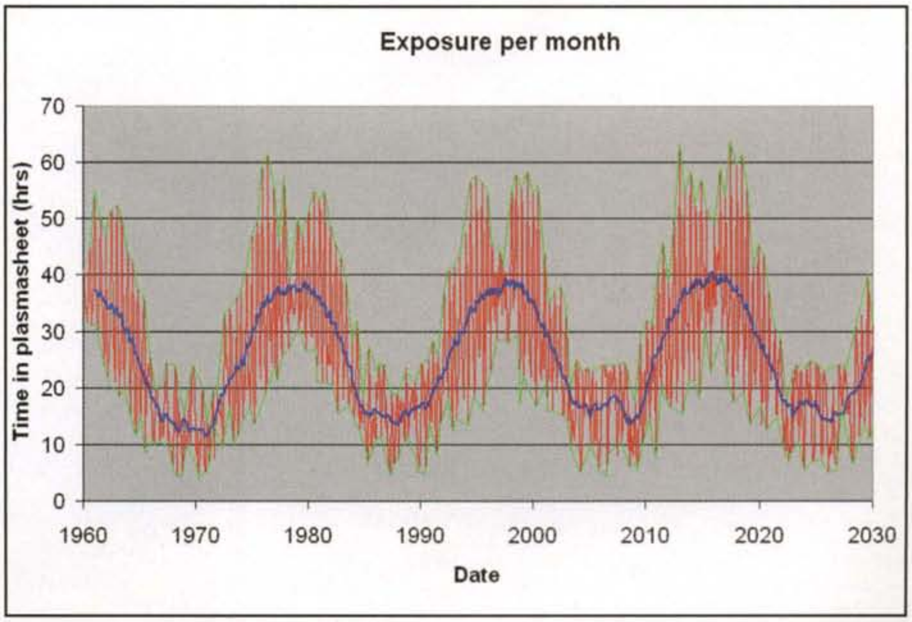


Figure 4. Predicted lunar exposure to the plasmasheet as a function of time over the period 1960 to 2030. The red curve shows the total exposure to the plasmasheet during each monthly crossing of the magnetotail. The blue curve shows the effect of smoothing the red curve with a 25-month running mean. The green curves show the maximum and minimum monthly exposures in half-yearly bins centered on the solstices. (Used by permission from Mike Hapgood)

explains, "electrostatically charged dust would be pushed across the terminator sideways," by horizontal electric fields.

Concerning the so-called lunar meteor storm hypotheses, while Kaufmann, et al. dealt with some aspects of them, it is necessary to mention two other theories concerning those hypotheses. First, in an article entitled "The Dark Ages: Were They Darker Than We Imagined?"[5] author Greg Bryant makes the following point concerning the annual *Beta Taurids* meteor shower and the June 20–30, 1975 lunar meteor storm:

> When the astronauts went to the Moon, they placed seismometers on the Moon's surface. At the end of June 1975, they registered their major series of lunar impacts. The impacts were detected only when the nearside of the Moon (where the astronauts landed) was facing the Beta Taurid radiant. At the same time, there was a lot of activity detected in Earth's ionosphere, which has been linked with meteor activity.

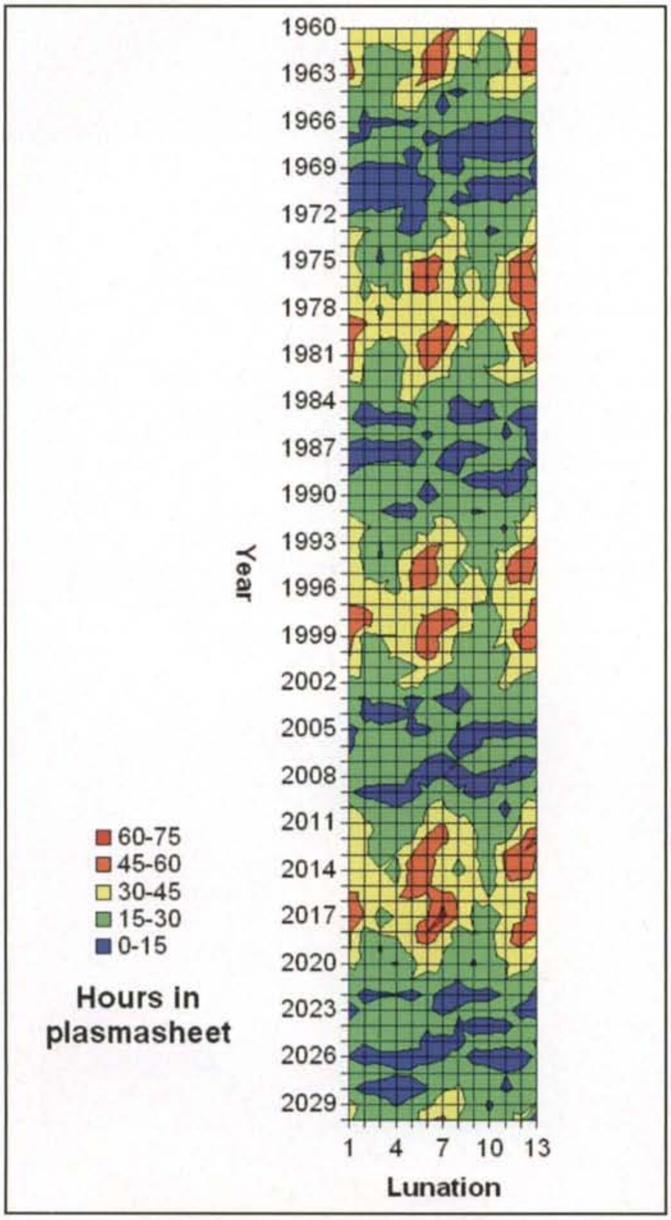


Figure 5. The short-term modulation in predicted lunar exposure to the plasmasheet. The red curve shows the difference between the half-yearly maxima and minima in monthly lunar exposure (as derived from figure 4). For reference, the blue curve shows the long-term modulation in the form of the 25-month running mean exposure. (Used by permission of Mike Hapgood)

Bryant is not unique in his suspecting the *Beta Taurids* meteor shower involvement. Kaufmann, et al. cite K. Brecher ("The Canterbury swarm: Ancient and modern observations of a new feature of the solar system," American Astronomical Society Bulletin 16, 476, 1984) and J. Dorman, S. Evans, Y. Nakamura, and G. V. Latham ("On the time-varying properties of the lunar seismic meteoroid population," *Proceedings* of the Lunar Planetary Science Conference 9, 3615-3626, 1978) as supporters of the *Beta Taurids* meteor shower theory.

Second, in an article entitled "Possible relationship between the Farmington meteorite and a seismically detected swarm of meteoroids impacting the Moon"[6] author Jürgen Oberst suggests a link between the Farmington meteorite[7] and the lunar meteor storm, while at the same time discounting the *Beta Taurids* meteor shower connection because that meteor shower does not show "swarming," which, according to Oberst, was necessary to explain the "observed large seismic signals." He further points out that "for objects in orbits of Taurid meteors, the longitude of the ascending node, Ω, shifts by about 35° on average during such a period (Jones, 1986)." Hence, the suggested association is quite unlikely, although it cannot be ruled out. It is also important to note concerning the *Beta Taurids* that their active dates are usually between June 5 and July 17, with a peak of June 28, which may or may not preclude their effect on the Moon during the peak days of June 22–23, and 25–26, 1975.

Finally, regarding the *Beta Taurids*, from their first discovery by Jodrell Bank observers during June 20–27, 1947, they have been consistently defined as a weak-stream meteor shower with no clear peak—particularly because it is a daytime shower that relies on radio observation reports for its definition. Ad-

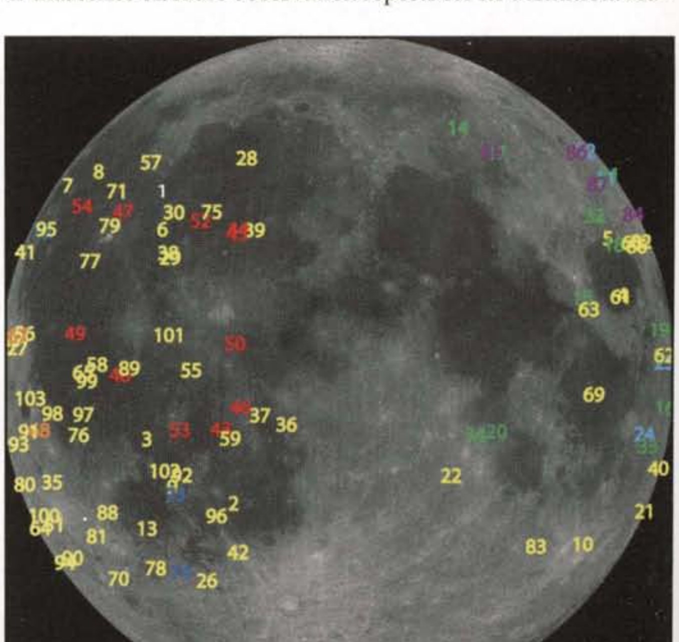


Figure 6. A map of the 100 explosions observed since late 2005. (Courtesy NASA)

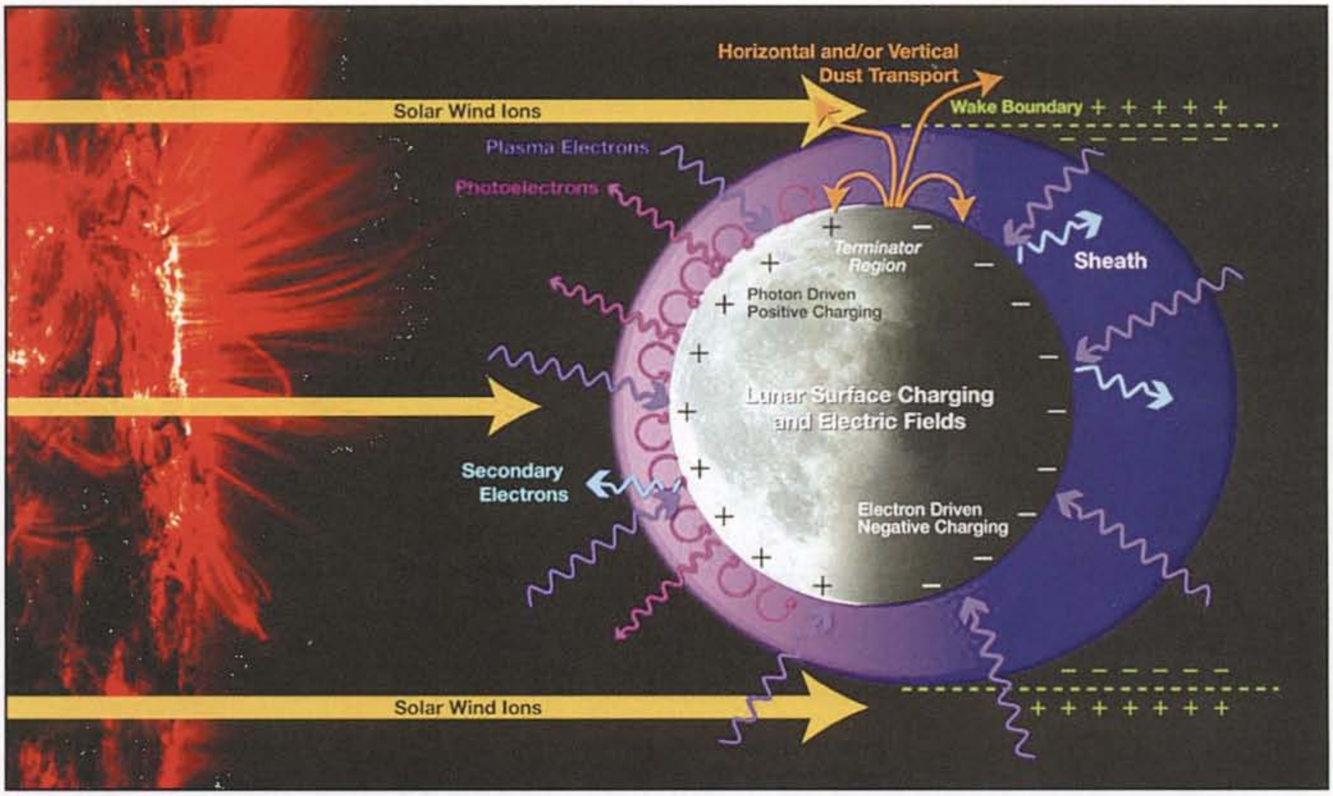


Figure 7. Lunar surface charging and electric fields caused by sunlight and solar wind. Credit: Jasper Halekas and Greg Delory of U.C. Berkeley, and Bill Farrell and Tim Stubbs of the Goddard Space Flight Center. (Courtesy NASA)

ditionally, the International Meteor Organization pointed out in its 2008 calendar of meteor showers that because of its proximity to other radiants, it is difficult to clearly define it from the other radiants.[8] Therefore, it is my opinion that to attribute such a massive lunar storm that, as Kaufmann, et al. noted was not homogenous to Earth, to the *Beta Taurids* is at least problematic. Furthermore, efforts to support the theory that the *Beta Taurids* shower could produce massive amounts of large boulders by way of linking it to the theory that the June 30, 1908 Tunguska explosion is also problematic because the Comet Encke hypothesis is one of many hypotheses that attempt to explain the Tunguska event.[9]

Recent observations[10] of explosions on the Moon's surface have tried to make a correlation between meteorites and such explosions. Commenting on the observations thus far, researchers have concluded that not all impacts are meteorites. Some may be sporadic meteorites; some may be space junk. In fact, the ratio of sporadic hits and other debris to known meteor showers is 2:1 in favor of the sporadic hits. Commenting on the research, Dr. Rob Suggs, KB5EZ, of the Marshall Space Flight Center stated: "That's an important finding [because] it means there's no time of year when the Moon is impact-free."[11]

What does not seem to be explored in their research is whether or not such sporadic impacts may in fact be moondust that has been excited by solar wind and thus caused to crash to the surface after such excitation.

Finally, I would like to add one more piece to the puzzle that might be significant to my hypothesis. That piece of the puzzle is the combined effect of the Moon's and Sun's gravitational pull on the Earth's magnetotail. While it has already been shown that the Moon gets a lashing from the Earth's magnetotail[12], because

Bell-Ringing Moonquakesor Sandstorms?

Between 1969 and 1972, Apollo astronauts placed seismometers at their landing sites at various locations around the Moon. For a number of years the Apollo 12, 14, 15, 16, and 17 instruments radioed data back to Earth until they were switched off in 1977.

In the March 15, 2006 Science@NASA article entitled "Moonquakes15," author Trudy E. Bell wrote about Clive R. Neal, associate professor of civil engineering and geological sciences at the University of Notre Dame, who, along with his 15-member team, spent considerable time identifying and categorizing the four types of moonquakes. Of importance to me was the identifying of moonquakes that were caused by meteors striking the Moon's surface. From Bell's article is the following excerpt:

> There are at least four different kinds of moonquakes: (1) deep moonquakes about 700 km below the surface, probably caused by tides; (2) vibrations from the impact of meteorites; (3) thermal quakes caused by the expansion of the frigid crust when first illuminated by the morning sun after two weeks of deep-freeze lunar night; and (4) shallow moonquakes only 20 or 30 kilometers below the surface.
>
> The first three were generally mild and harmless. Shallow moonquakes on the other hand were doozies. Between 1972 and 1977, the Apollo seismic network saw 28 of them; a few "registered up to 5.5 on the Richter scale," says Neal…
>
> Furthermore, shallow moonquakes lasted a remarkably long time. Once they got going, all continued more than 10 minutes. "The moon was ringing like a bell," Neal says.

In light of my hypothesis concerning the seismometers' recorded lunar activities of June 20–30, 1975, it is my suggestion that maybe some of the relative long-lasting shallow moonquakes were in reality the readings of the ongoing magnetotail-caused sandstorms rather than "bell ringing" moonquakes.

of this lashing it is also possible that during certain timeframes, such as during the days of June 20–30, 1975, with the Moon phase at full and the Earth being at summer solstice on nearly the same date, that this lashing is exacerbated by the influence of the Moon's gravity, combine with the Sun's gravity. Such combined gravity was exceptionally strong, thereby exerting an exceptional pull on the Earth's magnetotail onto the Moon's surface, which in turn resulted in an exceptionally strong sandstorm, the likes of which had not previously been recorded.

It is for this same reason that I am hypothesizing that another potential problematic timeframe could be the days immediately before and after June 20–21, 2016. Such sandstorms could be catastrophic for astronauts who are colonizing the Moon without the appropriate preparedness.

In summary, it is my hypothesis that what Kaufmann, et al. investigated as a meteor storm was more likely sandstorms caused by the Earth's magnetotail. The evidence I have found to support my hypothesis seems to indicate that Moon appears to have crossed through the Earth's magnetotail at the right timeframe (peak of the Moon's nodal period precessional orbit, during the summer solstice, and when the Moon was at full phase) for a series of sandstorms to have occurred that were detected by the seismometers left by the Apollo astronauts. While, as mentioned above, several have tried to tie the lunar events of June 20–30, 1975 to a meteor storm or storms or remnants of the Farmington meteorite (none more thoroughly than Kaufmann, et al.), it is my position that the evidence supports my hypothesis over and against these other hypotheses.

Concerning the significance to the amateur radio weak-signal community, in particular the significance to EMEers, there might be a possible influence on EME communication during these sandstorms. Knowing when they may occur might be important to predicting possible degradation in EME communication during such events.

Much more importantly, however, is the significance to NASA and its new lunar exploration program. The significance for NASA is that these sandstorms could be very problematic for the astronauts while on the Moon's surface, or even in orbit around the Moon. In particular, the experience of the Apollo astronauts with moondust provided some indication of the problems the dust posed to their exploration.

For example, NASA researcher Mian Abbas[13] commenting on the nuisances of moondust stated: "Moondust was a real nuisance for Apollo astronauts. It stuck to everything—spacesuits, equipment, instruments."

The sharp-edged grains of the moondust scratched faceplates, clogged joints, blackened surfaces, and made dials nearly unreadable. Abbas added, "The troublesome clinginess had a lot to do with moondust's electrostatic charge."

Regarding the possibility of a repeat of the possible magnetotail-caused sandstorms during the dates June 20–21, 2016, as well as June 20–21, 2035, the Moon's phase will be full the day before the summer solstice during the peak of the Moon's nodal period precessional orbit—such as was a very similar alignment of the Moon's phase, summer solstice, and the Moon's nodal period precessional orbit for the dates of June 20–30, 1975.

Notes

1. Kaufmann, Peter, V. L. R. Kuntz, N. M. Paes Leme, L. R. Piazza, J. W. S. Vilas Boas, K. Brecher, & J. Crouchley, "Effects of the Large June 1975 Meteoroid Storm on Earth's Ionosphere," *Science*, November 10, 1989, vol. 246, pages 787–790.

2. See: <http://science.nasa.gov/headlines/y2008/17apr_magnetotail.htm>.

3. This paper was published in the October 2, 2007 issue of *Annales Geophysicae* (vol. 25, pages 2037–2044), the journal of the European Geosciences Union.

4. See: <http://science.nasa.gov/headlines/y2005/07dec_moonstorms.htm>.

5. This article was originally published in the September 1999 *Universe* magazine and is now posted on the internet at: <http://gchbryant.tripod.com/Articles/darkages0999.htm>.

6. See *Meteoritics* 24, 23–28, 1989.

7. On June 25, 1890, at 1 PM local time a brilliant fireball was seen over the Midwest part of the United States. The resulting meteorite landed in Farmington, Kansas. The metal of the meteorite was later determined to be chondrite.

8. See: <http://www.imo.net/calendar/2008#spring>.

9. See: L'ubor Kresák, "The Tunguska object—A fragment of Comet Encke?" *Astronomical Institutes of Czechoslovakia, Bulletin*, vol. 29, no. 3, 1978, p. 129–134. An abstract is available online at: <http://adsabs.harvard.edu/abs/1978BAICz..29..129K>. A copy of the full text can also be accessed from this URL.

10. <http://science.nasa.gov/headlines/y2008/21may_100explosions.htm?list209719>.

11. Ibid.

12. See: <http://www.sciencedaily.com/releases/2008/04/080420123319.htm>.

13. <http://science.nasa.gov/headlines/y2008/10apr_moondustinthewind.htm>.

14. <http://science.nasa.gov/headlines/y2006/15mar_moonquakes.htm>.

CQ's 6 Meter and Satellite WAZ Awards

(As of October 1, 2010)

By Floyd Gerald,* N5FG, CQ WAZ Award Manager

6 Meter Worked All Zones

No.	Callsign	Zones needed to have all 40 confirmed
1	N4CH	16,17,18,19,20,21,22,23,24,25,26,28,29,34,39
2	N4MM	17,18,19,21,22,23,24,26.28,29,34
3	JI1CQA	2,18,34,40
4	K5UR	2,16,17,18,19,21,22,23,24,26,27,28,29,34,39
5	EH7KW	1,2,6,18,19,23
6	K6EID	17,18,19,21,22,23,24,26,28,29,34,39
7	KØFF	16,17,18,19,20,21,22,23,24,26,27,28,29,34
8	JF1IRW	2,40
9	K2ZD	2,16,17,18,19,21,22,23,24,26, 28,29,34
10	W4VHF	16,17,18,19,21,22,23,24,25,26,28,29,34,39
11	GØLCS	1,6,7,12,18,19,22,23,28,31
12	JR2AUE	2,18,34,40
13	K2MUB	16,17,18,19,21,22,23,24,26,28,29,34
14	AE4RO	16,17,18,19,21,22,23,24,26,28,29,34,37
15	DL3DXX	18,19,23,31,32
16	W5OZI	2,16,17,18,19,20,21,22,23,24,26,28,34,39,40
17	WA6PEV	3,4,16,17,18,19,20,21,22,23,24,26,29,34,39
18	9A8A	1,2,3,6,7,10,12,18,19,23,31
19	9A3JI	1,2,3,4,6,7,10,12,18,19,23,26,29,31,32
20	SP5EWY	1,2,3,4,6,9,10,12,18,19,23,26,31,32
21	W8PAT	16,17,18,19,20,21,22,23,24,26,28,29,30,34,39
22	K4CKS	16,17,18,19,21,22,23,24,26,28,29,34,36,39
23	HB9RUZ	1,2,3,6,7,9,10,18,19,23,31,32
24	JA3IW	2,5,18,34,40
25	IK1GPG	1,2,3,6,10,12,18,19,23,32
26	W1AIM	16,17,18,19,20,21,22,23,24,26,28,29,30,34
27	K1LPS	16,17,18,19,21,22,23,24,26,27,28,29,30,34,37
28	W3NZL	17,18,19,21,22,23,24,26,27,28,29,34
29	K1AE	2,16,17,18,19,21,22,23,24,25,26,28,29,30,34,36
30	IW9CER	1,2,6,18,19,23,26,29,32
31	IT9IPQ	1,2,3,6,18,19,23,26,29,32
32	G4BWP	1,2,3,6,12,18,19,22,23,24,30,31,32
33	LZ2CC	1
34	K6MIO/KH6	16,17,18,19,23,26,34,35,37,40
35	K3KYR	17,18,19,21,22,23,24,25,26,28,29,30,34
36	YV1DIG	1,2,17,18,19,21,23,24,26,27,29,34,40
37	KØAZ	16,17,18,19,21,22,23,24,26,28,29,34,39
38	WB8XX	17,18,19,21,22,23,24,26,28,29,34,37,39
39	K1MS	2,17,18,19,21,22,23,24,25,26,28,29,30,34
40	ES2RJ	1,2,3,10,12,13,19,23,32,39
41	NW5E	17,18,19,21,22,23,24,26,27,28,29,30,34,37,39
42	ON4AOI	1,18,19,23,32
43	N3DB	17,18,19,21,22,23,24,25,26,27,28,29,30,34,36
44	K4ZOO	2,16,17,18,19,21,22,23,24,25,26,27,28,29,34
45	G3VOF	1,3,12,18,19,23,28,29,31,32
46	ES2WX	1,2,3,10,12,13,19,31,32,39
47	IW2CAM	1,2,3,6,9,10,12,18,19,22,23,27,28,29,32
48	OE4WHG	1,2,3,6,7,10,12,13,18,19,23,28,32,40
49	TI5KD	2,17,18,19,21,22,23,26,27,34,35,37,38,39
50	W9RPM	2,17,18,19,21,22,23,24,26,29,34,37
51	N8KOL	17,18,19,21,22,23,24,26,28,29,30,34,35,39
52	K2YOF	17,18,19,21,22,23,24,25,26,28,29,30,32,34
53	WA1ECF	17,18,19,21,23,24,25,26,27,28,29,30,34,36
54	W4TJ	17,18,19,21,22,23,24,25,26,27,28,29,34,39
55	JM1SZY	2,18,34,40
56	SM6FHZ	1,2,3,6,12,18,19,23,31,32
57	N6KK	15,16,17,18,19,20,21,22,23,24,34,35,37,38,40
58	NH7RO	1,2,17,18,19,21,22,23,28,34,35,37,38,39,40
59	OK1MP	1,2,3,10,13,18,19,23,28,32
60	W9JUV	2,17,18,19,21,22,23,24,26,28,29,30,34
61	K9AB	2,16,17,18,19,21,22,23,24,26,28,29,30,34
62	W2MPK	2,12,17,18,19,21,22,23,24,26,28,29,30,34,36
63	K3XA	17,18,19,21,22,23,24,25,26,27,28,29,30,34,36
64	KB4CRT	2,17,18,19,21,22,23,24,26,28,29,34,36,37,39
65	JH7IFR	2,5,9,10,18,23,34,36,38,40
66	KØSQ	16,17,18,19,20,21,22,23,24,26,28,29,34
67	W3TC	17,18,19,21,22,23,24,26,28,29,30,34
68	IKØPEA	1,2,3,6,7,10,18,19,22,23,26,28,29,31,32
69	W4UDH	16,17,18,19,21,22,23,24,26,27,28,29,30,34,39
70	VR2XMT	2,5,6,9,18,23,40
71	EH9IB	1,2,3,6,10,17,18,19,23,27,28
72	K4MQG	17,18,19,21,22,23,24,25,26,28,29,30,34,39
73	JF6EZY	2,4,5,6,9,19,34,35,36,40
74	VE1YX	17,18,19,23,24,26,28,29,30,34
75	OK1VBN	1,2,3,6,7,10,12,18,19,22,23,24,32,34
76	UT7QF	1,2,3,6,10,12,13,19,24,26,30,31
77	K5NA	16,17,18,19,21,22,23,24,26,28,29,33,37,39
78	I4EAT	1,2,6,10,18,19,23,32
79	W3BTX	17,18,19,22,23,26,34,37,38
80	JH1HHC	2,5,7,9,18,34,35,37,40.
81	PY2RO	1,2,17,184OM,19,21,22,23,26,28,29,30,38,39,40
82	W4UM	18,19,21,22,23,24,26,27,28,29,34,37,39
83	I5KG	1,2,3,6,10,18,19,23,27,29,32.
84	DF3CB	1,2,12,18,19,32
85	K4PI	17,18,19,21,22,23,24,26,28,29,30,34,37,38,39.
86	WB8TGY	16,17,18,19,21,22,23,24,26.28.29,30,34,36,39
87	MUØFAL	1,2,12,18,19,22,23,24,26,27,28,29,30,31,32
88	PY2BW	1,2,17,18,19,22,23,26,28,29,30,38,39,40.
89	K4OM	17,18,19,21,22,23,24,26,28,29,32,34,36,38,39.
90	JHØBBE	2,33,34,40
91	K6QXY	17,18,19,21,22,23,34,37,39
92	JA8ISU	2,7,8,9,19,33,34,36,37,38,39,40
93	YO9HP	1,2,6,7,11,12,13,18,19,23,28,29,30,31,40
94	SV8CS	1,2,6,7,18,19,23,26,28,29
95	SM3NRY	1,6,10,12,13,19,23,25,26,29,30,31,32,39
96	VK3OT	2,10,11,12,16,34,35,37,39,40
97	UY1HY	1,2,3,6,7,9,12,18,19,23,26.28,31,32,36
98	JA7QVI	2,40
99	K1HTV	17,18,19,21,22,23,24,26,28,29,34

Satellite Worked All Zones

No.	Callsign	Issue date	Zones Needed to have all 40 confirmed
1	KL7GRF	8 Mar. 93	None
2	VE6LQ	31 Mar. 93	None
3	KD6PY	1 June 93	None
4	OH5LK	23 June 93	None
5	AA6PJ	21 July 93	None
6	K7HDK	9 Sept. 93	None
7	W1NU	13 Oct. 93	None
8	DC8TS	29 Oct. 93	None
9	DG2SBW	12 Jan. 94	None
10	N4SU	20 Jan. 94	None
11	PAØAND	17 Feb. 94	None
12	VE3NPC	16 Mar. 94	None
13	WB4MLE	31 Mar. 94	None
14	OE3JIS	28 Feb. 95	None
15	JA1BLC	10 Apr. 97	None
16	F5ETM	30 Oct. 97	None
17	KE4SCY	15 Apr. 01	10,18,19,22,23, 24,26,27,28, 29,34,35,37,39
18	N6KK	15 Dec. 02	None
19	DL2AYK	7 May 03	2,10,19,29,34
20	N1HOQ	31 Jan. 04	10,13,18,19,23, 24,26,27,28,29, 33,34,36,37,39
21	AA6NP	12 Feb. 04	None
22	9V1XE	14 Aug. 04	2,5,7,8,9,10,12,13, 23,34,35,36,37,40
23	VR2XMT	01 May 06	2,5,8,9,10,11,12,13,23,34,40
24	XE1MEX	19 Mar. 09	2,17,18,21,22,23,26,34,37,40

CQ offers the Satellite Work All Zones award for stations who confirm a minimum of 25 zones worked via amateur radio satellite. In 2001 we "lowered the bar" from the original 40 zone requirement to encourage participation in this very difficult award. A Satellite WAZ certificate will indicate the number of zones that are confirmed when the applicant first applies for the award.

Endorsement stickers are not offered for this award. However, an embossed, gold seal will be issued to you when you finally confirm that last zone.

Rules and applications for the WAZ program may be obtained by sending a large SAE with two units of postage or an address label and $1.00 to the WAZ Award Manager: Floyd Gerald, N5FG, P.O. Box 449, Wiggins, MS 39577-0449. The processing fee for all CQ awards is $6.00 for subscribers (please include your most recent *CQ* or *CQ VHF* mailing label or a copy) and $12.00 for nonsubscribers. Please make all checks payable to Floyd Gerald. Applicants sending QSL cards to a CQ Checkpoint or the Award Manager must include return postage. N5FG may also be reached via e-mail: <n5fg@cq-amateur-radio.com>.

**P.O. Box 449, Wiggins, MS 39577-0449; e-mail: <n5fg@cq-amateur-radio.com>*

By Kent Britain,* WA5VJB

ANTENNAS

Connecting the Radio to the Sky

Quads, Loops, and Polarization

This time we are discussing a topic that came indirectly from a reader. There has been a long history of quads and polarization, so this seems like a good time to cover some of the myths about quads.

Myth: Quads Have 2 dB More Gain Than Yagis

This is a "fact" going back over 50 years. I was able to dig up Clarence Moore, W9LZX's original work on quads vs. Yagis, and let me tell you that it was not a level playing field. Moore was comparing his carefully tweaked cubical quad with a Yagi that had all elements at the same spacing and all directors the same length. If Moore had put as much work into tweaking his Yagi as he had on his quad, the difference in their gain would have been immeasurable.

This is not to say that in some cases there aren't some good engineering reasons for a cubical quad. In Moore's case, the cubical quad was designed to solve an engineering problem. In 1942 Clarence visited the HCJB shortwave transmitters near Quito, Ecuador. In the high, thin air any high-voltage points on an antenna or a transmission line would ionize the air and arc. Classic collinear or dipole antennas tended to have corona off the tips that would, over a few weeks, actually eat away the ends of the antennas. As a continuous loop, the cubical quad avoided these voltage peaks and avoided the antenna damaging corona.

*1626 Vineyard, Grand Prairie, TX 75052
e-mail: <wa5vjb@cq-vhf.com>

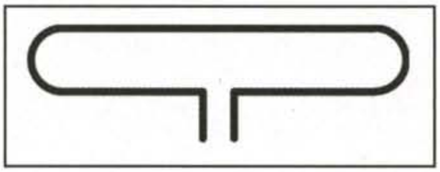


Figure 1. Horizontally polarized folded dipole.

A two-element quad has about 1 dB more gain than a two-element Yagi. Beyond three elements, a modern Yagi and a quad have the same gain, within measurement errors.

Myth: Quads Have More Capture Area

Capture area, or antenna factor, is a function of antenna gain. A quad and a Yagi with the same gain will have the same capture area once you reach three or more elements.

Myth: Quads Have All Polarizations

Now for the real reason why I wanted to expand on this reader's topic. In simple terms, it is *impossible* for an antenna to radiate vertical and horizontal polarization at the same time. Per Maxwell's Electromagnetic Equations, the E Field and the H Field of an antenna must always be 90 degrees out of phase. An antenna simply cannot radiate four fields, two E and two H, at the same time. Again, it is impossible for an antenna to be vertically and horizontally polarized at the same time.

I can see the mail starting now: "But what about circular polarization?!"

At any given instant, a circularly polarized antenna is linearly polarized just like a dipole. It's just that an instant later the linearly polarized antenna appears to be at a slightly different angle. Therefore, a circularly polarized antenna looks like a good old dipole antenna spinning at the same RPM as its frequency in Hz. However, again at any given instant, it's a linearly polarized antenna.

Loops and Polarization

I'm sure you have no problem with a simple folded dipole (as shown in figure 1) being a horizontally polarized antenna. As we make the folded dipole fatter and fatter, the impedance changes a bit, but the polarization is still the same—horizontal.

We can make the loop any shape, and polarization is determined by where the loop is fed, not the shape of the loop. All the commonly used, and one not commonly used, loops in figure 2 have the same horizontal polarization.

Of all the loops in figure 2, the circle is the most efficient. It encloses the most area with the smallest amount of wire. A good circle is a problem to build on HF, but a bit of strip metal becomes a practical loop element on the microwave bands. In photo A are some loop Yagis I have had in the air for many years. The wide loops make for low Q, or wide bandwidth elements, and thus are a bit more forgiving of construction tolerances than Yagis.

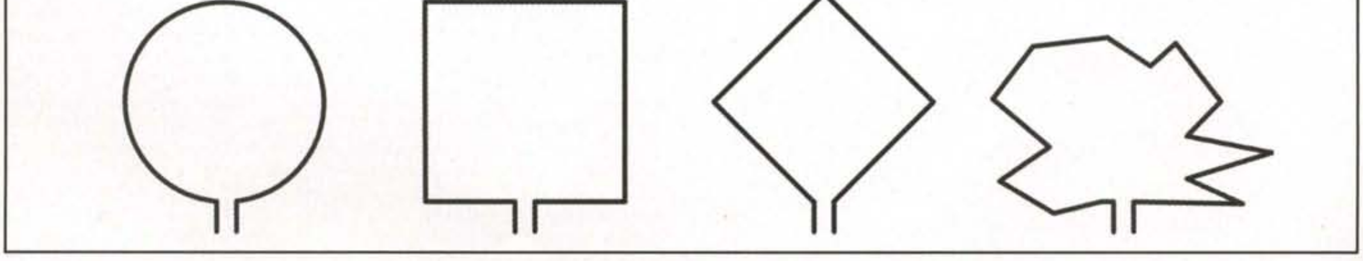


Figure 2. Horizontally polarized loop antennas.

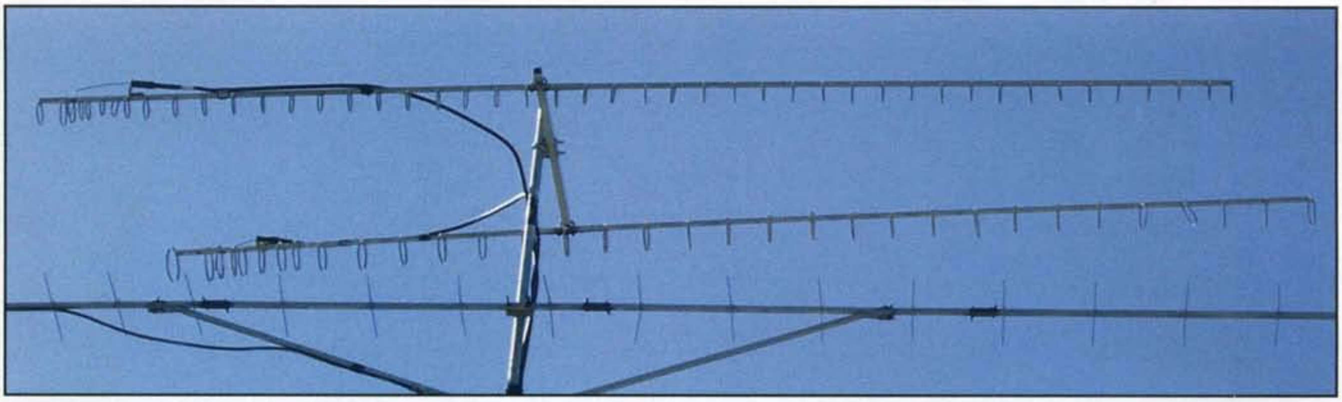


Photo A. Loop Yagis, which are electrically similar to cubical quads.

I have built loop Yagis from 900 MHz to 10.3 GHz. Yes, those were small elements at 10 GHz, but it worked.

You will note that the loop Yagi is mounted with the elements pointing downward. At first I mounted them with the loops pointing up, but the antennas kept getting damaged when large birds perched on them. As a side note, one evening I heard a horrible racket coming from the roof. A large owl had tried to land on the elements, and as the owl grasped the loops they crushed. Now the owl was hanging upside down from the antenna with its feet entrapped in the bent loops. I was glad to see the owl work itself loose after 10 minutes or so. It was a bit annoyed and wouldn't have appreciated my help if I had climbed up there!

Another reason to mount loop Yagis with the loops pointing downward.

Challenge for Readers

There are certainly a lot of claims and myths in the ham community about cubical quads and their performance. If quads are such great antennas, can you name one commercial application currently using cubical quads? I am unaware of any. Even HCJB has gone back to dipole-type antennas, but with very broad and rounded tips that look a lot like eggbeaters.

Future Projects

So don't expect any cubical quad projects in this column, or J-pole antennas either. J-poles are a project I consider more than well covered. However, I have it on good authority from Joe Taylor, K1JT, that there are plans to activate the Arecibo 1000-foot dish on 432 MHz again in a year or so. Therefore, I have a *long* 432-MHz Cheap Yagi in the works. Like the 435-MHz AMSAT versions, it will be easily changed from left-hand circular polarization to right-hand circular polarization to be used as linear polarization.

As always, our readers are one of the best sources of ideas for future antenna projects. Any antenna questions or antenna projects you would like to see in a future column, just drop me an e-mail to <wa5vjb@cq-vhf.com>. Or you can visit <www.wa5vjb.com> for additional antenna projects in the Reference Section.

73, Kent, WA5VJB

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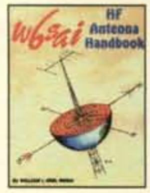

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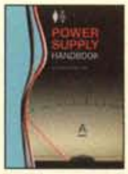

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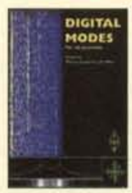

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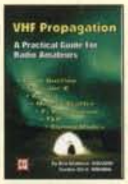

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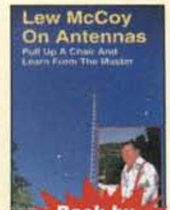

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By Mitch Gill, NA7US

EMERGENCY COMMUNICATIONS

The Role of VHF in EmComm

Lessons I Have Learned

I recently purchased a 25 foot sailboat. I had not sailed for over 30 years. They were smaller boats then, but again I just had the urge to sail. The reason I bring this up is that it opened a whole new venue of VHF communications that could be used in an emergency and brings with it some thoughts of how we could possible improve our abilities as amateur radio operators during emergencies.

Therefore, loyal readers, bear with me, as I know many of you do not live near a large body of water and need marine radio frequencies. I think you will find some good information that you can use, though, as well.

Maritime Radio

Today marine radio has technologically improved over the past few years. The radio now can be attached to your GPS, and if an emergency occurs it will automatically send your coordinates to the US Coast Guard and then automatically change your radio to Channel 16 (the emergency channel). At this point the US Coast Guard can obtain more information from you while they send out rescue craft to assist. It is a remarkable system of which I was not aware until I decided to sail on the Puget Sound, which is now known as the Salish Sea.

Via Ham Radio

Let's take a look at what we have done in the amateur radio world.

ICOM came out with the IC-92AD, which is D-Link capable and has an optional microphone with GPS built in. The IC-92AD and other radios have the capability to transmit GPS, and I know that many of you are using APRS with radios other than D-Link. The question I have is why can't we develop a system similar to what marine radio has? Here are my thoughts:

Since many hams monitor 146.52 as an emergency frequency, why not build a circuit with an emergency button for your mobile or hand-held radio? When the button is activated, it changes the frequency to 146.52, sends your GPS location, and then waits for someone to respond. On the receiving end we would have to be able to receive the GPS coordinates, which should not be a problem. Of course this is just a thought, as I am sure that some of you can expand on this and develop the circuits needed. I would be curious to hear from any of you who can come up with something similar and practical.

Suggested Programs

Nearly all of the digital programs out there can be effective during an emergency. The Military Auxiliary Radio System utilizes MT63. The Amateur Radio Emergency Service (ARES) uses PSK31 and/or MT63, although I am sure there are others. As for me, I believe that we should have one or two programs for emergency communications and not a whole group of them. Since PSK31 is the most popular digital program, would it

*29838 SE 285th Place, Ravensdale, WA 98051
e-mail: <na7us@arrl.net>

Photo 1. The author on his sailboat preparing to go out into the Salish Sea (formerly Puget Sound) with his marine radio system.

Photo 2. The West Marine VHF580 submersible VHF marine radio.

Photo 3. The Garmin GPSmap 498.

not be reasonable to assume that most people will use that type of communication in an emergency? What do you think? I have seen lots of ideas thrown around, but nothing seems to stick. Let me know.

Sailmail

A great program that has been around for years is WINLINK 2000. This program became very popular with boaters and was appropriately nicknamed *Sailmail.* It allowed them to send e-mail messages over HF, VHF, or UHF, and it was received and automatically sent over the internet. In addition, anyone who gets an e-mail, ham or not, can respond and send back a message. As time has gone by, this program has been used by hams traveling across the country, people living in remote countries, and for emergency communications.

My opinion is that everyone should have this loaded on their computer as one of the backups for emergency communications. I have used it and it worked well for me.

The Next Step

I have heard rumblings from some hams who want the Federal Communications Commission (FCC) to designate a 2-meter emergency frequency similar to Alaska's 5167.5. I am not an advocate of this, since hams have used 146.52 for years and many hams listen to it for just that reason. Now combining it with digital communications, as I suggested above, may not be the right way to go, but again I am hoping for input from any and all of you.

The main point we all have to all remember is that during an emergency, whatever works and whatever it takes!

73, Mitch, NA7US

By Rich Arland,* K7SZ

BEGINNER'S GUIDE

All you need to know but were afraid to ask . . .

Proper EmComm Training and Go-Kits

As this column is being written, we are rapidly approaching the time frame for the ARRL's Simulated Emergency Test (SET). Held in or about the first weeks of fall each year, the SET is a large-scale emergency communications (EmComm) exercise designed to test our abilities to respond to and support our local served agencies. Players include the American Red Cross, local/county/state Emergency Management Agencies (EMAs), The Salvation Army, etc. Our hobby is unique in that we, as ham radio operators, are in a position to give something back to our communities and our nation through the use of our time, communications skills, and equipment in support of various agencies that require our services. On a personal level, I feel that becoming involved in Amateur Radio Emergency Service (ARES) and/or Radio Amateur Civil Emergency Service (RACES) should be an individual commitment. Any time we can, as a group, make a difference in times of disaster or emergency by providing communications to the on-scene commander and/or disaster mitigators, we should avail ourselves of the opportunity.

Thankfully, the Federal Communications Commission (FCC) feels the same way. It recently has modified portions of Part 97 to allow hams to provide emergency communications for their respective employers during times of emergency. This, in itself, is a major change in policy and reflects the FCC's on-going efforts to make it easier for us hams to offer our communications skills to an ever-increasing number of relief agencies needing our services.

One of two Go-Boxes by Hal Collier, W4IGE. This is Hal's FM voice kit consisting of a dual-band VHF/UHF FM transceiver, 17-amp/hour battery supply, mic, and portable antenna. His other box (identical to this one) has a 2-meter rig and packet radio TNC for his portable packet station.

First Things First

EmComm has changed dramatically in the last 25 years. With the advent of new digital modes, including 1200-baud VHF packet, PSK31, BPSK, Olivia, and a host of others, ham radio operators not involved with these new modes encounter a severe technology handicap. Today's EmComm operators need all the tools at their disposal to provide the necessary communications coverage that our served agencies need or demand.

Therefore, the days of the ham radio operator showing up with an HT and a spare battery pack are long gone. Anyone desiring to enter into the disaster mitigation arena needs to be on the cutting edge, technology wise, to be a useful EmComm operator. It all boils down to training. I know, I know... many do not want to take the time to become trained, but in this instance, training is mandatory for a number of reasons.

Prior to September 11, 2001, ARES and RACES groups throughout the U.S. had very little in the way of realistic training on how to go about furnishing communications during and after a major disaster. Post 9-11 it became very apparent to many within the disaster-response community that ham radio operators, while having a lot of potential in the EmComm role, needed to become trained and gain realistic experience to be useful assets in times of emergency.

To its credit, the ARRL stepped forward and quickly organized some online emergency communications courses designed to take a newly assigned ARES member through the basics of structured communications networks, learning how to generate and receive message traffic, up through becoming a net control station (NCS) and on to the upper levels of EmComm planning and organization. By completing all three levels of the League's Amateur Radio Emergency Communications Courses, today's EmComm volunteer is much better suited to the demanding tasks of providing communications to disaster mitigaters. More importantly, the properly educated EmComm operator now has a good grasp of "how and why" things are done the way they are.

Online and/or structured classroom education only goes so far. What it takes to be a well-rounded EmComm operator is time in the field. Obviously, we cannot

*770 William St. SE, Dacula, GA 30019
e-mail: <k7sz@arrl.net>

Tim Blitch, N4EEE, uses a large roll-around box he found at an auto parts store as one of his three Go-Kits! This particular kit is his answer to long deployments, as it not only includes his radio gear, but also food, water, sleeping gear, extra clothes, etc.

conjure up an instant disaster several times per month, which is why the ARRL's annual SET and Field Day, along with monthly or quarterly EmComm training, are so important and necessary to ensure that the "edge" remains sharp. This "edge" is the ability of the EmComm operator to respond in a timely manner with the correct equipment and skills needed to do the job. This only comes with practice, practice, and more practice, all under the guise of having fun playing radio!

With my ongoing involvement in emergency communications via ARES and RACES over the years I thought I had a good working knowledge of the "how and why" of EmComm. When Pat, KB3MCT, and I moved from northeastern Pennsylvania to north Georgia and joined the Gwinnett Amateur Radio Society (GARS) and subsequently volunteered for the Gwinnett County ARES (G-ARES) program, we soon found that we were involved with a volunteer group that took training very seriously. They had developed their own separate qualification standards and tests, and required new EmComm volunteers to complete their training schedule, in addition to any other documented training they had undergone, before they could be certified for deployment. Wow! Thankfully, Pat and I both had the basics provided by the ARRL under our collective belts; however, we needed to take two Federal Emergency Management Agency (FEMA) training courses directly relating to disaster response and mitigation: ICS-100, Introduction to Incident Command System (ICS); and ICS-700, National Incident Management System (NIMS), an Introduction. These two courses are mandatory federal requirements for anyone involved with disaster response, so there is no use trying to buck the system. Just sign up online at <http://training.fema.gov/IS/crslist.asp> and get started. As an alternative, find out when your local ARES/RACES group has a class scheduled, sign up, and get educated. Pat and I took a locally held class on ICS-100 and 700 at a the Gwinnett County fire station. Thanks to the efforts of Dorothy Jubon, N2DLJ, our instructor, we received the training and passed the necessary tests to become deployable. Like I said, G-ARES takes training and qualification very, very seriously.

Yo-Yo 72

The creativity gene (I call it the "MacGyver Gene") is part of every ham radio operator (some more than others!). Innovation and the ability to "see" how everything works together and the ability to "work outside the box" are powerful tools well suited to the EmComm operator. With this in mind, we will now enter the world of the EmComm Go-Kit, Go-Bag, Bug-Out Bag, and G.O.O.D-Bag," all of which are as unique as the people who put them together.

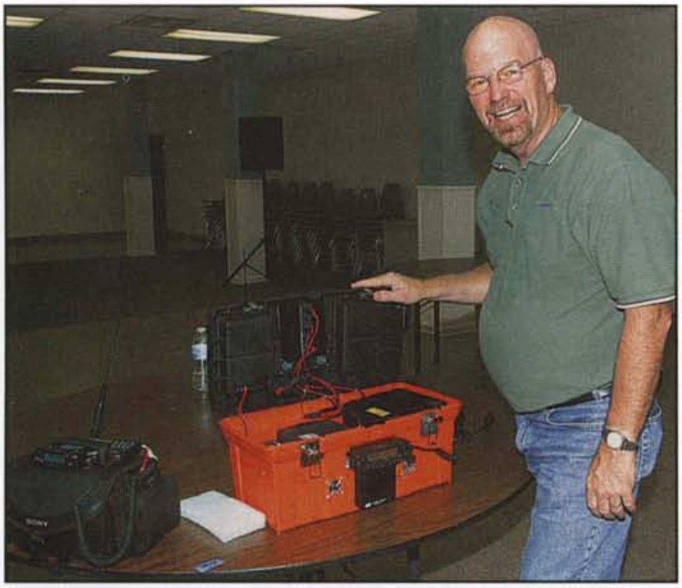
Exactly what is a Go-Kit? In keeping with brevity, it is the bag, box, backpack, duffle bag, roll-a-round toolkit-type container that an EmComm operator grabs as he/she goes out the door for an emergency deployment. It contains what the EmComm op needs to be do the job of providing communications to his/her served agency.

ARES members are encouraged to configure their Go-Kit to contain enough necessities to allow them to operate unaided for a minimum of 72 hours. I find this 72-hour timeframe a bit unrealistic. After several outings with various ARES groups, it became quite evident to me that 72 hours was a bit of "wishful thinking." In actuality, your ability to be self-sufficient for 72 hours (You are On Your Own for 72 hours, or "Yo-Yo 72") is a short-term goal and nothing more. It is designed to get you thinking about what you will need to be an effective communicator once you are in the field.

OK, we've identified the requirement for a Go-Kit, but what exactly is in there that makes these kits so valuable? Ask ten EmComm operators what is in their Go-Kits and you will get ten different answers. The one common thread is the radio gear, and here, too, you'll get a diversity of what individual operators think is needed and why. Suffice it to say that our Go-Kits are a direct reflection of ourselves, so variety is the name of the game. To get a feel for this diversity, check out these URLs:

- http://72hours.org/make_plan.html
- http://home.comcast.net/~buck0/hamgear.htm
- http://www.qsl.net/kc0nrk/go-bags.html
- http://journal.drfaulken.com/building-a-personal-emergency-bag/
- http://www.thegallos.com/gobag.htm

I have to stress that these five URLs are merely the tip of the proverbial iceberg. There are a ton of internet sites dedicated to preparedness and Go-Kits, so wander around cyberspace for a while and take copious notes. What follows is an encapsulated look at our ideas for a Go-Kit on a budget. With money becoming a rather scarce commodity these days, we have a personal goal of reusing as much gear that we have lying about the shack



David Adcock, KA4KKF, one of the "technical heavies" of the Gwinnett ARES group, has a small tool kit pressed into service for his Go-Kit. The kit contains a dual-band VHF/UHF radio, power supply, and packet radio gear for a portable FM voice and 1200-baud VHF packet station.

as we possibly can. After all, a good Go-Kit doesn't have to look pretty, but it has to be functional!

K7SZ's & KB3MCT's Personal Picks

Small 5-watt HTs are no longer the heart and soul of the Go-Kit. However, they still have a place in the kit, but they are relegated to portable, on-site work where small size and low power output fill the bill. On the other hand, a 25–50-watt dual-band (VHF/UHF) FM mobile unit, configured as a base station, is the main radio we now employ in place of our HTs. Why dual band? Simply put, this gives us a high-power radio that adds flexibility to our arsenal of communications equipment. In many instances during a disaster deployment, a resources net will be called up on VHF and additional nets will be set up as needed on UHF. The ability to cover both bands is a tremendous asset and greatly enhances the abilities of the EmComm volunteer to fulfill his/her duties.

My personal choice for radio gear for EmComm duties are driven by what I currently have on hand coupled with what I either can borrow or barter (trade) for among the local ham radio groups.

In addition to the radio, you will, of course, need coaxial cable (lots of it) along with a multi-band antenna, coaxial "tweenies," SWR/PWR meter, antenna base and supports, clock, message forms, binder with your ARES/RACES info, pencils, pens, paper, etc. A current listing of repeater and simplex frequencies is a must, and should be laminated in protective plastic. Don't forget the latest copy of the ARRL's EmComm handbook, a laminated copy of your license, along with your ARES/RACES identification. A copy of your local ARES/ RACES emergency plan, binder with additional info regarding EmComm, and a small notebook and pen to record events should also be included. This last tidbit sounds a bit like a "log book," and in fact, it is. Keeping an accurate record of things that happen during an EmComm deployment is critical. It serves to help identify problem areas and maintain accountability, and provides a chronological order of events as they transpire. The military has used this logbook method for decades, ditto fire, police, and emergency responders at every level. Having your own account of the happenings during and after an emergency deployment just makes sense. Don't forget a good watch or clock (we have both in our Go-Kits) accurately set to help with logging.

The aforementioned list is a basic starting point, and I am positive you can expand that list to include a whole lot more "stuff." You should also maintain a master list and an individual pack list of what is included in there so that everything returns from the field with you. Usually there is so much fever-pitch activity that you will most assuredly leave something out of the kit when you run out the door, unless your kit is inventoried and remains sealed until deployment time.

Returning to the radio equipment idea again, there is always the desire to dismantle the shack and take everything you can cram into your chosen container "just in case." Avoid that at all costs. In actuality, depending upon your geographical area, your radio requirements are pretty well defined by your local ARES group and its served agencies. The idea of taking extra gear can become dramatically escalated if you don't contain your desire to take it all with you. In most instances, a good dual-band HT and a dual-band mobile/base radio will be about all you really need. Of course, depending upon your location, these requirements will change. As an example, my good friend Frank Henrikson, KLØSW, told me that VHF/UHF gear in Alaska was not nearly as important as HF gear due to the lack of repeaters and repeater coverage in that state.

Power for the gear can take up an entire column, but briefly, Pat and I are big believers in the gelled electrolyte (gel-cells) batteries which are readily obtainable in the ham radio community. These small, lead-acid batteries have a relatively high power density and are rechargeable well over 500 times. They can be had for next to nothing if you know where to go. Hospitals and healthcare professionals are required to cycle out their old rechargeable gel-cell batteries on a regular basis to ensure that their emergency equipment will work properly without the use of AC mains power. That means that getting to know the electronics technicians who pull maintenance on these machines can lead to a very handy, almost inexhaustible supply of batteries for your EmComm gear. Pat and I have dual 20-amp/hr gel-cell batteries in our Go-Kit just to make sure that we have maximum power for the radio gear over an extended period. Add to this four 7-amp-hour gel-cells that are held in reserve, and we can operate for extended periods without fear of being short on radio power.

That is it for this session, gang. As you might be able to tell, I am a big believer in hams helping out their communities via ARES and RACES. If you want to get involved go to the ARRL website (www.arrl.org) and follow the links to the ARES page, find a local group, and join up. Your services will always be appreciated. But remember, before you jump in the car and hit the trail, you need training in order to be useful to the on-scene commander of an incident.

If you already have a Go-Kit or bag or whatever and are proud of your kit, drop me an e-mail at <k7sz@arrl.net> and tell me a bit about it. Send a picture (JPEG standard … no large files please) and you might just get featured in this column! Until next time remember: Preparedness is not optional!

73, Rich, K7SZ

By Bob Witte,* KØNR

Inside the D-STAR Protocol

My previous columns on D-STAR technology have focused mostly on the digital modulation characteristics of D-STAR. While it is important to understand how D-STAR modulation differs from the more familiar analog FM technology, the real power of D-STAR unfolds when we start looking at the bits. That is, much of D-STAR's capability is embodied in the digital format and protocol used. D-STAR transmissions include simultaneous voice and data, enabling features such as status messages, callsign-based squelch, digital code squelch, and GPS position reporting.

DV Protocol

At the simplest level, operating a D-STAR radio is very much like operating a conventional FM rig. You push the transmit button, start talking, and your voice appears at the other end of the QSO. What is fundamentally different is that your voice is being digitized and converted to a stream of bits, ones and zeros, that are transmitted over the air. In addition, other pieces of digital information are included in the transmission, most notably callsign routing information.

In this column, we'll focus on the Digital Voice (DV) modulation format, which is the lower speed and narrower bandwidth D-STAR format used on the 2-meter, 70-cm, and 23-cm bands. The Digital Data, or DD, format is the higher speed data format used only on the 23-cm band. For more background on these formats, you may want to review the *CQ VHF* "FM" columns from Winter 2006 and Winter 2009.

The DV data stream is 4800 bps, with half of that used for the voice information, encoded in AMBE[1] format. One fourth of the bits are used for Forward Error Correction of the voice information. This allows the D-STAR signal to drop a few bits here and there, but still has the recovered voice signal be understandable. Finally, one fourth of the bandwidth is reserved for data, including synchronization and (typically) simple text messages or position information.

*21060 Capella Drive, Monument, CO 80132
e-mail: <bob@k0nr.com>

Digital Voice (DV)

4800 bps data stream real time encoded with:
2400-bps voice (AMBE encoded)
1200 bps Forward Error Correction (FEC) for voice
1200-bps data (text messages, GPS, telemetry, etc.)

Graphically, the digital bit stream is shown in figure 1. The *Radio Header* contains some synchronization bits, a few flag bits, the *Radio ID* block, and a checksum (P_FCS). From a user's perspective, we are most interested in the *Radio ID* block, which is further broken down into four callsign fields and a comment field. This provides callsign routing and status information for each transmission.

The *Data Field* carries the main payload of the transmission, as shown in figure 2. This field has voice (audio) bits interleaved with data bits—72 bits for the Audio Frame, then 24 bits for the Data Frame, alternating back and forth. As shown, the final Data Frame is 48 bits, so each D-STAR transmission has both voice and data information interleaved in it.

Callsign Fields

In the *Radio ID* section of the DV protocol, there are four important callsign fields that determine how the transmitted signal is routed through the D-STAR system. We are into new territory, as conventional FM does not provide any kind of rout-

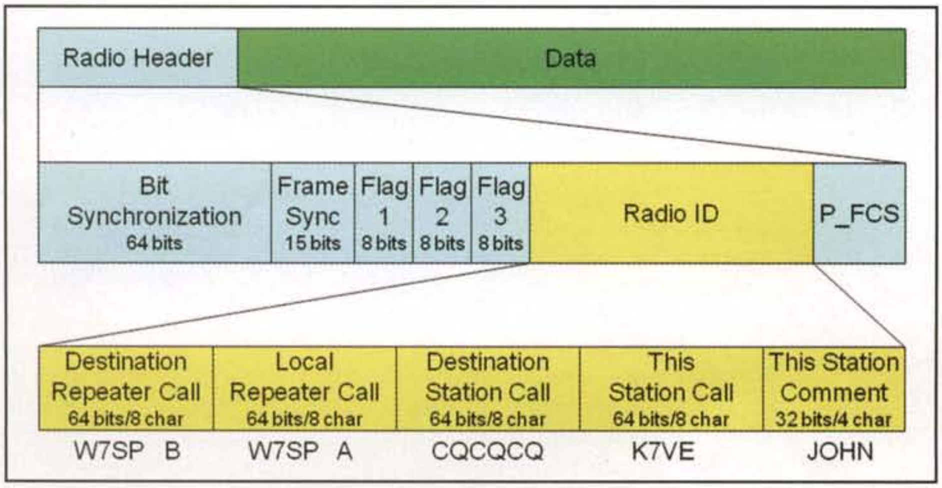


Figure 1. The DV Protocol includes callsign routing information embedded into the digital stream. (Courtesy of John Hays, K7VE)

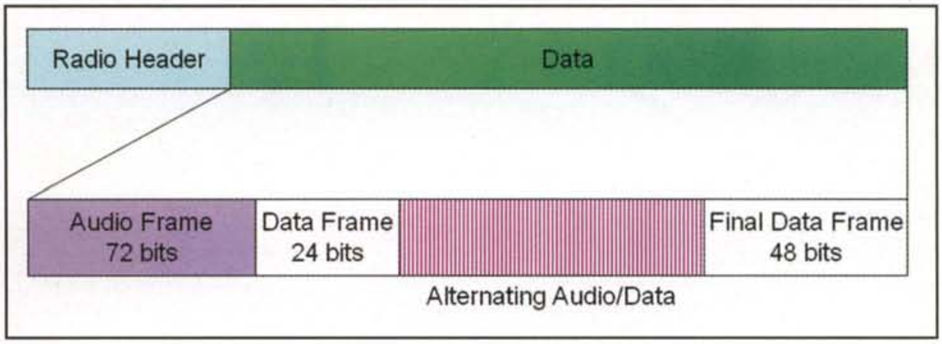


Figure 2. The Data Field contains the interleaved voice/audio information and data information. (Courtesy of John Hays, K7VE).

ing information. With D-STAR, the transmitting station determines the routing for each transmitted signal.

DV Field	Common Name	Description
This Station Callsign	MyCall (MY)	Callsign of the originating station
Destination Station Callsign	UrCall (UR, YOUR)	Default is CQCQCQ (call any station) or it can be the callsign of a specific station
Local Repeater Callsign	RPT 1 (R1)	Callsign of the repeater being accessed locally
Destination Repeater Callsign	RPT 2 (R2)	Callsign of the remote repeater or gateway

A D-STAR repeater should have its own unique callsign, often a club call, so there is no confusion between a user's callsign and the repeater callsign. In addition, a D-STAR repeater may have multiple frequency bands in the same system (referred to as "ports"). It is common for a D-STAR repeater to have a "full stack" of repeater ports: 2 meters, 70 cm, and 23 cm.

A single D-STAR repeater can have multiple ports (bands):

The A port is 1.2
The B port is 440 MHz (70 cm)
The C port is 146 MHz (2 meters)
The G port is the internet gateway

For example, "WØTLM B" is the 440-MHz port of the WØTLM repeater

Setting up the Radio

One thing that we won't cover in this column is how to program specific D-STAR radios. The user interfaces of the various radios are not the same, so you'll need to refer to your owner's manual to get the right key strokes. Due to the added complexity of callsign routine, most D-STAR users will opt for the programming software for their particular radio.

Let's work through a few specific examples of how the D-STAR callsign fields are used.

Example 1: Simplex Operation

Bob, KØNR, and Joyce, KØJJW, are going to operate simplex on 446.200 MHz. Both users set their radios to the desired simplex frequency (i.e., 446.200 MHz) and select DV mode.

Both users configure the callsign fields on their radios:

UrCall: CQCQCQ
RPT1: Not Used
RPT2: Not Used
MyCall: KØNR or KØJJW

This example is quite simple. Just set MyCall to the callsign of the person using the radio and set UrCall to CQCQCQ so anyone on the frequency can hear us. The repeater fields (RPT1 and RPT2) are not used because we are not going through a repeater. Note that unless a radio is changing hands between different operators, we'll usually just set MyCall once and leave it alone.

Example 2: Local Repeater Operation

Bob, KØNR, and Joyce, KØJJW, are going to make a contact via the WØTLM repeater using the 440-MHz band. Both stations set their radios to the WØTLM frequency, which is 446.8875 MHz, and the proper transmit offset of –5 MHz. They will use the B port on WØTLM, so the RPT1 is set to WØTLM B. The B *must be* the 8th character in the callsign field.

Both stations configure their radios:

UrCall: CQCQCQ
RPT1: WØTLM··B [the two dots ·· indicate spaces]
RPT2: Not Used
MyCall: KØNR or KØJJW

Compared to operating simplex, we need to have the right repeater frequency/offset *and* we have to program the repeater callsign and port in RPT1.

Example 3: Gateway Repeater Operation

Bob, KØNR, and Joyce, KØJJW, are going to make a contact via the WØTLM repeater using the 440-MHz band and they are going to make their transmissions available to the D-STAR network via the gateway. Again, both stations set their radios to the WØTLM frequency and –5 MHz offset. They will use the B port on WØTLM, so the RPT1 is set to WØTLM B. In addition, RPT2 will be set to the WØTLM gateway (WØTLM G). Again, the G must be in the 8th character space.

Both users configure their radios:

UrCall: CQCQCQ
RPT1: WØTLM··B [the two dots ·· indicate spaces]
RPT2: WØTLM··G [the two dots ·· indicate spaces]
MyCall: KØNR or KØJJW

This configuration is the most popular for using the WØTLM repeater, since it sets up the rig for working through the repeater and accessing the gateway. You'll probably want to duplicate this for your local repeater, changing the callsigns and port as required.

Before you can access the internet gateway (the D-STAR network), you'll need to register with your local repeater. You only register with one repeater, since your registration information is automatically shared across the D-STAR network. Do not register on multiple repeaters.

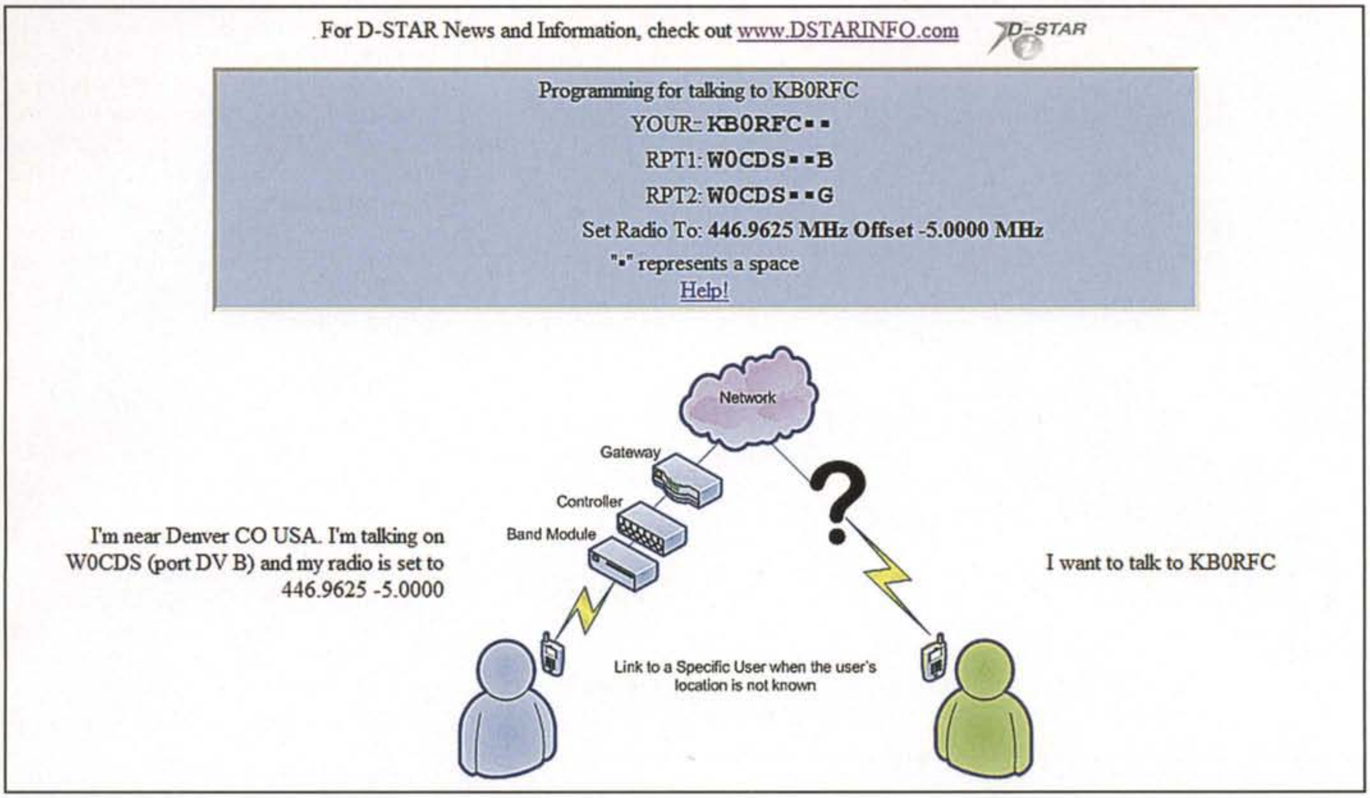


Figure 3. An example screen shot of the D-STAR calculator.

To find the registration page for your local machine, check out the repeater directory at dstarusers.org (see References). Clicking on the callsign of the repeater should eventually lead you to the registration page for that repeater. Otherwise, contact your local repeater trustee for information on how to register.

Example 4: Selective Call Gateway Operation

Using the WØTLM repeater, Joyce, KØJJW, is calling Bob, KØNR, somewhere on the D-STAR system, without knowing where KØNR is located. KØNR is visible to the D-STAR network if he has recently transmitted on any repeater in the system.

Joyce, KØJJW, sets her radio to the WØTLM frequency and offset. KØJJW configures the callsign fields on her radio:

UrCall: KØNR
RPT1: WØTLM··B [the two dots ·· indicate spaces]
RPT2: WØTLM··G [the two dots ·· indicate spaces]
MyCall: KØJJW

In this case, the UrCall field is used for selectively calling another station (not the general CQCQCQ). KØJJW's transmission will be picked up by the WØTLM repeater and routed via the gateway to the repeater where KØNR was last heard. How does KØNR configure his radio to reply to KØJJW? This can be tricky, One option is for KØNR to have already UrCall programmed to KØJJW. Alternatively, most D-STAR radios have a button labeled "RX-CS," which means "call the callsign that I just received." One push of the button should reconfigure your radio to get back to the calling station.

DPLUS Features

The D-STAR protocol was defined with selective calling and routing of radio signals in mind. One thing that was left out of the original system definition is the ability to link two repeaters together. This turns out to be really important for many types of amateur operating.

Fortunately, a software program called "DPLUS" was created by Robin Cutshaw, AA4RC. Most D-STAR machines in North America are running DPLUS, which provides additional features on top of the ICOM repeater gateway software. In particular, DPLUS allows repeaters to be linked together (everything heard on one repeater is also heard on the other). It also supports the use of "reflectors," which can link multiple repeaters together. When a repeater connects to a reflector, it is connected to all of the other repeaters using that reflector. This is a very powerful tool for providing nationwide and worldwide nets using D-STAR. DPLUS has some other fun features that we won't cover here now.

The UrCall field of the D-STAR protocol is used to activate DPLUS features.

The repeater linking command is:

UrCall: <repeater><port>L

Suppose I am using my local WØTLM repeater (with the configuration in example 3) and want to link it to the WØCDS repeater, which is about 80 miles to the north. I simply set the UrCall field to:

UrCall: WØCDS·BL

In this case, the L is the 8th character, so the port designator is in the 7th position.

I transmit once with the link command in the UrCall field and should hear a voice message that the systems are linked. Then I switch back to UrCall = CQCQCQ to actually make contacts.

References

JARL D-STAR Specification: <http://www.jarl.com/d-star/shogen.pdf>
D-STAR Uncovered, by Peter Loveall AE5PL: <https://www.tapr.org/pdf/DCC2008-D-STAR-AE5PL.pdf>
D-STAR Get-On-The-Air radio configuration, Alabama D-STAR, Greg Sarratt, W4OZK: <http://www.arrl-al.org/D-STAR_radio_setup6.pdf>
DSTAR Users Repeater Directory: <http://www.dstarusers.org/repeaters.php>
The D-STAR Calculator: <http://www.dstarinfo.com/Calculator/>

The unlink command is just the U character in the 8th space.

UrCall: ·······U [the dots · indicate spaces]

I set UrCall to the Unlink command, transmit once and get a voice response indicating that the repeater is unlinked. Linking and unlinking to a reflector is very similar to repeater linking. Reflectors have names such as "REF001C," so linking to a reflector uses this format:

UrCall: <reflector> L

To link to the REF001C reflector:

UrCall: REF001CL

Note that the reflector name is 7 characters and L is in the 8th position. The same Unlink command works for both repeaters and reflectors.

D-STAR Web Calculator

If all of this sounds complicated, well, it probably is. There is a very useful web page that can help sort this out (figure 3). The D-STAR Web Calculator (URL listed below) lets you enter the details of the D-STAR communication you are trying to accomplish. The calculator is very complete; it uses a database of all of the D-STAR repeaters worldwide, including what ports (bands) are available and the repeater frequencies. The calculator figures out the proper callsign fields that need to be programmed for your communication and gives you the right frequency information.

What Else?

Just to recap, then, whenever we use D-STAR, we have to configure the radio properly. Just like analog FM, we need to have the correct repeater frequency and transmit offset. We don't need to worry about CTCSS/tone access, as that concept does not apply to D-STAR repeaters. However, we do need to get the callsign fields programmed right so that our transmission goes to the intended place. Hopefully, this column will give you a start down that path.

Programming D-STAR radios is not completely obvious, so don't be afraid to try something and do expect to make a few mistakes. Most folks using D-STAR understand this and are happy to provide assistance. As you start to understand the programming techniques, you'll want to make use of the memory channels on your D-STAR radio, which will retain the callsign fields so they are preset and ready to go. You don't want to be fiddling with the callsign fields while driving down the highway.

The Alabama D-STAR "Get on the Air" page by Greg Sarratt, W4OZK, is good resource for getting started with D-STAR. If you want to dig deeper into the D-STAR protocol, take a look at the article by Pete Loveall, AE5PL, listed in the references section.

Tnx and 73

Thanks for taking the time to read another one of my columns on the *Utility Mode*. I always enjoy hearing from readers, so stop by my blog at <http://www.k0nr.com/blog> or drop me an e-mail at the address listed on the first page of this column. 73, Bob, KØNR

Note

1. Advanced Multi-Band Excitation (AMBE) is a proprietary speech coding standard developed by Digital Voice Systems, Inc.

By Joe Moell,* KØOV

HOMING IN

Radio Direction Finding for Fun and Public Service

ARDF Team USA Returns from Croatia with Three Medals

When I was a teenager and the space race was in full swing, it wasn't uncommon to hear someone ask, "How are we going to beat the Russians?" I hear the same question asked today, but in a much more friendly way.

Former Soviet nations still have a juggernaut when it comes to on-foot hidden transmitter hunting at international competitions. They helped write the rules for this worldwide sport, which is called foxtailing, radio-orienteering, and Amateur Radio Direction Finding (ARDF). Their best performers get regular training, supported by their governments and military. The Russian national anthem is heard most regularly at the medal podium, followed closely by the anthems of the Ukraine, the Czech Republic, Slovakia, Poland, Hungary, and so forth.

In about two dozen other nations, the radio-orienteers may not be as skilled or highly trained, and there may not be as many of them, but they are just as enthusiastic. That list of up-and-coming countries now includes two from North America: the USA and Canada. The rest of the world has welcomed them and recognizes them as serious contenders.

Team USA members are happy after the award ceremony for the first competition day. Kneeling in front are Lori Huberman and Jen Harker, W5JEN. Standing, left to right, are Marvin Johnston, KE6HTS; Harley Leach, KI7XF; Dick Arnett, WB4SUV; Ruth Bromer, WB4QZG; Jay Hennigan, WB6RDV; Alla Mezhevaya; Dennis Schwendtner, WB6OBB; Karla Leach, KC7BLA; Bob Cooley, KF6VSE; Ken Harker, WM5R; and George Neal, KF6YKN. Not pictured are Vadim Afonkin, KB1RLI; Jerry Boyd, WB8WFK; Dale Hunt, WB6BYU; and Kuon Hunt, KB7WRG. (Photo by Ken Harker, WM5R)

Friendly Competition on the Adriatic

The Fifteenth World Championships (WC) of ARDF took place near Opatija, Croatia from September 13 through 17, 2010. Fourteen people represented USA on the competitive courses, selected from the best performers at the USA ARDF Championships near Boston in 2009[1] and near Cincinnati in May of this year.[2] Through the summer, all of them continued to train and prepare. Some ran marathons, some went for map-and-compass orienteering sessions, and whenever they could, they all took opportunities to hunt radio transmitters in parks and forests. Two team "training camps" took place in the Los Padres National Forest north of Los Angeles, one in July and one in August. Each was two days long and included full ARDF courses on 2 meters and 80 meters, plus sprint courses in which the goal was to find each transmitter within 60 seconds.

Several of our team members arrived in Croatia during the week before the WC to take advantage of up to four days of field training offered by the event organizers. This was an opportunity to learn about the unique features of the Croatian coastal mountains, including their limestone deposits and depressions atop the hills that can't easily be discerned from the topographical orienteering maps that were provided.

There is a WC every even-numbered year in a country selected by a committee of the International Amateur Radio Union. Until 2000, most were headquartered on school campuses and participants were housed in dormitories. Because of the large number of participants nowadays and the limited number of suitable school facilities available in September, organizers now offer low-cost packages that include five hotel nights and all meals, buffet style.

By Monday evening, 386 competitors from 32 countries had arrived and were settled in about a dozen hotels around the historic seacoast resort town of Opatija—that is, all except one national team that

*P.O. Box 2508, Fullerton, CA 92837
e-mail: <k0ov@homingin.com>

didn't get its lodging requirements to the organizers on time and had to camp out on the first night.

Team USA members slept in the Hotel Kvarner. It was built in 1884, twelve years before electricity came to the town, and for decades it was a winter hideaway for Austrian nobility. It was not the headquarters hotel for these events, but its Crystal Ballroom with eight large chandeliers was the site of the opening ceremonies and medal presentations. There are many other historic locations in the area, including Lividraga, the favorite hunting lodge of Yugoslavia's Marshal Josip Tito, which was the finish point of the first day's competition.

On Tuesday, there was a two-hour bus ride to the Model Event. It was an opportunity to meet old friends, to make new acquaintances, and to test RDF equipment on very short courses. Before long, it was time to get back into the bus to return for dinner and pageantry.

At the opening ceremony, Dick Arnett, WB4SUV, and Lori Huberman represented the USA in the parade of nations. Lori went on to take 4th place in the W21 category on 2 meters. (Photo by WM5R)

Opening ceremonies of an ARDF WC are a miniature version of Olympic openings. Representatives of each country stand behind placards in a row as welcome speeches are given and local performers entertain. That night, they heard from the President of IARU Region 1, the head of the Croatian Amateur Radio Association, and the deputy Mayor of Opatija. Then everyone headed off for a good night's rest, because early the next day would be a two-hour bus ride to an unknown location near the Slovenian border for the first competition.

Two Courses in One

There is no "mass start" in championship ARDF. Each person is timed individually from start to finish. Groups of competitors take off at five-minute intervals that correspond to the times that transmitter #1 comes on the air.[3] With hundreds of WC competitors these days, the start would take most of the day under the old system of one band per course, so recently revised rules now allow dual courses on each competition day. Each morning, there is a set of five 2-meter transmitters and five 80-meter transmitters in different locations within the same forest, with start and finish points common to both.

On sunny competition day one, men ages 40 through 49 (M40) and all of the women hunted the 80-meter foxes, while all other men went after the 2-meter ones. As many as 11 runners in different age/gender categories started every 5 minutes, so everyone was onto the course in $3\frac{1}{2}$ hours.

Ruth Bromer, WB4QZG, and Karla Leach, KC7BLA, proudly stand on the podium after receiving silver medals for their team performance in the W60 category on 80 meters. (Photo by WM5R)

George Neal, KF6YKN, with his bronze medal in the M50 category on 80 meters. (Photo by WM5R)

The first competition day was sunny and pleasant. Jay Hennigan, WB6RDV, is racing to the finish on 2 meters. (Photo by WM5R)

More than one Team USA member recalls that the 2-meter course on day one was the most difficult ARDF challenge he had ever encountered because of the signal reflections. For all five foxes, it was 3.6 miles (5.3 km) from start to each fox in optimum order and then to the finish, but such a direct route was impossible. "The optimal first transmitter was behind a hill and was giving a very strong signal," says Jay Hennigan, WB6RDV, of Goleta, California.

"Its strong bearings were mostly from a reflector that was outside of the map boundaries. I persevered, but by the time I found it, it was time to go to the finish before I was overtime. I was using gear that I wasn't familiar with because I broke my antenna at the practice and wound up using someone's spare. It must have had more gain, because I was always farther from the transmitters than I thought I was."

Dale Hunt, WB6BYU, of Yamhill, Oregon had similar problems: "I should have run up to the top of the first hill for a better bearing but I didn't, so I spent the first half of my time chasing reflections around. When I was near the point of giving up, I figured I was within two cycles of one transmitter, but it had gotten no stronger than it was when I was a kilometer away on top of a ridge. There were lots of trails marked on the map in some places. It was hard to tell from the terrain which were major, which were minor, and which were unmapped logging spurs. It was really easy to miss trails because some were pretty faint, especially the ones that went through the limestone areas."

USA's best on 2 meters that day was George Neal, KF6YKN, who placed 8th out of 51 runners in the category for men ages 50 through 59 (M50). Gold medalist in M50 that day was Nikolay Ivanchihin, UR8UA, of the Ukraine, who had been a visiting competitor at the 2009 USA ARDF Championships and had won two gold medals there. In the category for men ages 60 through 69 (M60), Bob Cooley, KF6VSE, of Pleasanton, California placed 12th and Harley Leach, KI7SF, of Bozeman, Montana placed 15th out of 48. That put Team USA in 5th place out of 15 teams in M60.

It was better on 80 meters, where signal bounces are rare and bearings are usually very well-defined. The team of Karla Leach, KC7BLA, of Bozeman, Montana and Ruth Bromer, WB4QZG, of Raleigh, North Carolina received silver medals for being second only to the Russian team in the category for women over age 60 (W60).[4] KC7BLA has been participating in ARDF since 2000. This was her fourth time as a competitor in a WC and her first world medal. As a long-time member of Backwoods Orienteering Klub,[5] WB4QZG was an expert at running in the forest with map and compass when she went to her first ARDF event last year near Boston.

Among the individuals on 80 meters, Vadim Afonkin, KB1RLI, of Boston finished 12th out of 51 in the category for men ages 40 through 49 (M40). His course time was only 11 minutes longer than the Russian gold medalist's.

Then the Rains Came

It is a WC tradition that after the first day of competition, there is a day of rest and relaxation before the second day in the forest. It was an opportunity for yet another bus ride to tour the ancient city of Porec. That evening the rain began,

It was pouring throughout the second competition day. Vadim Afonkin, KB1RLI, was drenched as he approached the finish line after his 2-meter run. He was also disappointed because one of the transmitters failed while he was very close to finding it. (Photo by Dick Arnett, WB4SUV) continued all night, and became a downpour as buses arrived at the site of competition day two. Starts were delayed, with the first group not setting forth until 10:30 AM.

After standing in a crowded tent, it felt good to get out on the course, even if it meant getting drenched and trying to plot bearings on a wet map board. "The rain was horrible," WB6RDV recalled, "but once you had been running in for 5 minutes, you learned to just ignore it. The main problem I had was that Sharpie® pens don't write on clear-plastic map covers in the rain and my china marker wasn't much better. If I had been able to see the map marks well, I wouldn't have made a mistake that cost me a couple of transmitter cycles."

USA's best that day was KF6YKN, who captured a bronze medal in the M50 category on 80 meters. George found all of his required four transmitters in just under 55 minutes, which was 97 seconds longer than the Estonian M50 gold medalist took. In M60 category, KF6VSE was 7th in M60, also on 80 meters.

KF6YKN has been active in ARDF for much of his life. As HA3PA, George competed for his native Hungary. Then upon coming to the USA, he became a leader in developing the sport here by helping to train our team members. He was in the USA's first delegation to the WC in 1998. This was the second time he has captured a WC medal for the USA, the first being at the 2008 WC near Seoul, Korea.

Again, reflections plagued the 2-meter hunters. The five-fox 2-meter course was 10 percent longer than the 2-meter course on day one. Nevertheless, it was a good day for two women on our team. WB4QZG finished in 4th place in W60 on that band. Her time was 14 minutes shorter than the bronze medalist, but Ruth found one less fox. Only one person in W60 found all three of the required transmitters for that category. Lori Huberman, who is Ruth's daughter, finished in 4th place in W21 category. She was one of only six W21 competitors who succeeded in finding all five 2-meter foxes.

"I didn't trust most of my bearings," Lori reported. "I kept moving and only followed bearings that were consistent. I couldn't go to high places because there was only one big hill, out of the way on one corner of the map. The rest of the course was rolling hills and depressions. George and I had discussed where the transmitters might be before I went out, so I had a plan and I went to those areas. When I got to locations where I thought they might be close and signals were strong, I trusted the bearings more."

Some of the competitors in the First ARDF World Championships for the Blind pose for photos before their transmitter hunt. Dennis Schwendtner, WB6OBB, is on the left, wearing number 4. (Photo by Marvin Johnston, KE6HTS)

In M40, KB1RLI was the unfortunate victim of a technical problem. In the middle of the competition, as Vadim was closing in on it, 2-meter fox #3 failed and wasn't restored for more than 12 minutes. He then found it, but the extra course time pushed him down to 13th place. A protest was filed by USA co-captains Dale and Kuon Hunt, WB6BYU and KB7WRG, but the international jury determined that nothing could be done about it.

The jury and the organizers were kept busy with other problems and controversies. On both competition days, it was found that some Eastern European team members had maps of the courses already in their possession. Even worse, some of them had been in those forests for classic orienteering events this past summer. Because logging was taking place in parts of these venues and the mapping of minor trails was not entirely current, this gave a distinct advantage to those persons.

Official ARDF rules state that sites of future ARDF championships are embargoed once announced. That means that no competitors-to-be may set foot there, to avoid an unfair advantage of familiarity. However, those rules are unclear about whether the embargo is automatic or it must be announced, which it was not. Instead of disqualifying those who had maps in advance or who had been at the summer O-meets there, the organizers and jurors decided to post the maps in the waiting tents at the start to allow everyone to get a long advance look at them.

A WC jury has members from all IARU regions. Representing Region 2 (North and South America) was Marvin Johnston, KE6HTS, of Santa Barbara, California. Another juror familiar to stateside foxtailers was Per-Axel Nordwaeger, SMØBGU, of Bromma, Sweden, who was a visiting competitor at the last two USA national championships.

Some jury members were stationed out on the course to enforce the rule prohibiting fox-finding assistance and cooperation among team members. One Eastern European woman was disqualified when it was determined that she had asked a transmitter operator for directions and had acted on what the operator told her.

Team-Building in Boston

Lori Huberman's involvement in ARDF came about through an initiative of Vadim. Before he put on the 2009 USA ARDF Championships, he had visited a meeting of the Cambridge Sports Union (CSU)[6], which promotes orienteering, running, cross-country skiing, and racewalking in the Boston area. He told everyone about radio-orienteering and invited any CSU member to attend one of his ARDF practice sessions to try it. Vadim had enough receiver/antenna sets to supply all who came out.

Several CSU members took Vadim up on his invitation, including Lori Huberman, who went on to win medals at

Ian Smith heads down the starting corridor of his first formal ARDF competition in 2009. His rapid pace made him a USA medal hopeful, but he fractured his tibia four weeks before the 2010 World Championships. (Photo by Joe Moell, KØOV)

USA championships in 2009 and 2010. "Lori has always enjoyed sports and competition," Ruth recalled. "She was born the morning after an orienteering meet that I attended. I timed it that way. We had her out on string-O[7] when she was three years old. In the 9th grade, she was on an interscholastic orienteering team that we trained, and they were winners. Now she is a graduate student in cellular biology at Harvard."

Another CSU athlete who learned ARDF from Vadim is Ian Smith of Somerville, Massachusetts. Indeed, he learned it so well that he was second among all USA competitors in our national championships in 2009. A year later in Ohio, he had the fastest five-fox times of any USA competitor on both 2 meters and 80 meters. When he accepted the invitation to join ARDF Team USA 2010, I was sure that we had added another world medal winner.

It was not to be, at least not this year. In July, Ian sustained a leg injury that was diagnosed as a muscle strain and kept him inactive for a month. However, it was actually a stress fracture of his tibia. One day in August as Ian was rollerblading, he fell and the stress fracture became a complete breakage of the bone, which put him on crutches and ended his chances of competing in Croatia this year.

First WC for the Blind

In 1998, when the USA sent its first delegation to the ARDF WC, one of the six travelers was Dennis Schwendtner, WB6OBB, of Santa Barbara, California, who is blind. Dennis knew that he could not be in the competition at that time, but he was happy to cheer on our fledgling team and to be a tourist. As a professional piano tuner, he got a VIP tour of the Bosendorfer factory in Vienna, Austria on that trip.

Twelve years later, Dennis again went to the ARDF WC, but this time as a competitor. One of the activities in Opatija was the first ARDF WC for the Blind on September 14. Croatian hams are pioneers in the adaptation of radio-orienteering for sightless persons. In the last decade, a number of amateur radio clubs were formed at institutions for the blind in that country and a standard set of rules for this special sport was published.

A championship blind ARDF course has five transmitters in a flat grassy area such as a soccer field. They are on the 80-meter band, which is more suitable than 2 meters because receiver/antenna sets are smaller and signal reflections are usually non-existent. Competitors take on the course one at a time. When the start signal is given, fox #1 is already on the air and the competitor heads out to find it. There is an 8-foot (2.5-m) radius circle in chalk or tape around the vertical transmitting antenna. Stepping into this circle constitutes a "find."

In addition to Dennis, the competition field included 13 visually-impaired people from Croatia, three from Bosnia & Herzegovina, and one from Germany. Since some of them have a small amount of sight, all were required to wear opaque goggles.

WB6OBB placed 4th in the category for men over age 50, finding all five transmitters in less than 5 minutes. That was an excellent showing against the well-practiced Croatians. He credits it to his many years of experience in direction-finding, both in cars and on foot. He won the USA's first ARDF national championships for the blind at the Dayton Hamvention® in 2007.

The 2010 WC in Croatia provided a week of many firsts, including the first appearance of a team from Canada. That team included three people who have competed at events in the USA: Valeri Georgiev, VE2UMS, Nick Roethe, DF1FO, and Joe Young, VE7BFK.

Congratulations and thanks to everyone on Team USA who provided photos and narratives of their experiences. The location and dates of the 2011 USA and IARU Region 2 ARDF Championships are close to being announced. If radio-orienteering interests you, check for details at my website[8] and make plans to attend. All are welcome at our national championships, and you will have an excellent opportunity to learn from our nation's best. Perhaps you will become a candidate for ARDF Team USA at the next WC, in 2012.

73, Joe, KØOV

Notes

1. Detailed in "Homing In" for Summer 2009 *CQ VHF*.
2. Detailed in "Homing In" for Summer 2010 *CQ VHF*.
3. Transmitter #1 (sending MOE in Morse) is on for 60 seconds, then it goes off and #2 (MOI) comes on for a minute, then #3 (MOS) and so forth until the cycle repeats after #5 (MO5). Knowledge of the code is not necessary because the number of dits tells which transmitter is on. There is more about international ARDF rules at <http://www.homingin.com/intlfox.html>.
4. Team members are not permitted to help one another on the course. Their individual scores are added to determine team rankings.
5. <http://backwoodsok.org>
6. <http://www.cambridgesportsunion. org>
7. String-O is a simple form of orienteering for children. A long string or ribbon takes them from one control to another along a short course.
8. <http://www.homingin.com>>

By Thomas Dean, KB1JIJ

Amateur Television – Methods and Applications

W2KGY BalloonSat Payload

Recently, hobbyist Robert Harrison captured attention in the news by attaching a camera to a weather balloon and getting pictures of the Earth from high altitude. His project cost him about $750 and was the assembly was able to rise to an altitude of about 20 miles, which is classified as "near space." The idea of putting such a payload on a weather balloon is certainly not new and has been done by many hobbyists and universities for years. It is very common for hobbyists to rely on amateur radio for their telemetry; hence, the hobby is typically referred to as Amateur Radio High Altitude Ballooning (ARHAB). It can serve as an inexpensive way for students and hobbyists to prototype and test spacecraft or learn about space systems engineering without the overhead of coordinating and paying for a launch or dealing with difficulties such as launch survivability.

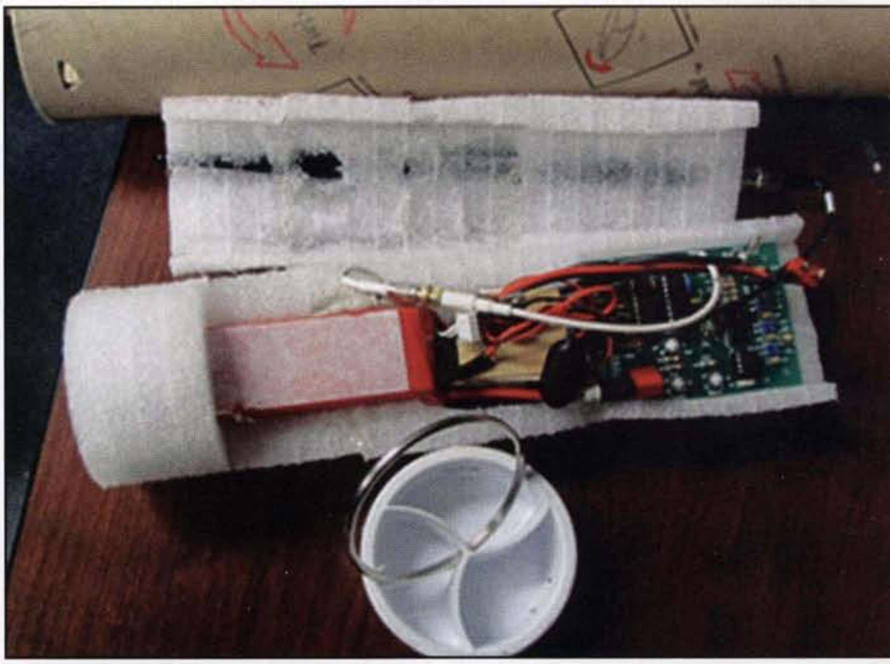


Photo 1. The nearly complete payload, prior to GPS integration and painting.

About the Project

This project had its origins in the beginning of the semester when West Point's Cadet Amateur Radio Club teamed up with the Astronomy and Electronics Experimenters' Clubs in an effort to create multiple payloads for a single weather balloon. In part, this project had the goal of inspiring cadets to take part in the developing space program of the academy and serve as future "space cadre." This project is shifting its focus to be developed this coming year, but Cadet Tom Dean, KB1JIJ, and Major Stephen Hamilton, KJ5HY, were still inspired to make an ATV payload to fly on a smaller tethered balloon.

Photo 2. The balloon flying over West Point. An extremely windy day proved to be a good stress test on the system.

The Payload

The heart of the payload is a Video-Lynx 434 transmitter module which provides a 50-mW SAW-stabilized NTSC output at 433.92 MHz. This is 50 kHz off CATV channel 59, close enough to be locked on by the PLLs of most analog televisions. The power level and antenna on board should be sufficient to allow recep-

*e-mail: <Thomas.Dean@usma.edu>

Photo 3. A view from the balloon. The academy's main academic building is to the right, and athletic fields are toward the top right. There is over 100 feet of elevation change between the two.

tion up to 1.5 miles unobstructed line-of-sight with a high-grade commercial antenna for reception. In order to comply with FCC regulations, the club's amateur callsign, W2KGY, is overlaid on the screen along with information from a GPS receiver. This is accomplished with an OSD-GPS (ID) module built and designed by Intuitive Circuits. The on-board GPS receiver is a module that is based on the SiRF Star III chipset. The entire payload is powered by an 11.1-volt 2200-mAh LiPo battery which is capable of powering the payload for approximately 5 hours.

Future Work

As it stands, the current payload could be flown on a weather balloon, rather than the current tethered balloon; however, there are several additions to the payload that should be added. A linear amplifier should be added to provide greater power output and ensure that the signal can be received when the payload is 20 miles in the air. There are several off-the-shelf ATV transmitters available with higher power outputs that could be used as well. The additional power consumption of the amplifier would also solve the issue of keeping the payload warm in the cold upper atmosphere. Work would have to be done to determine the proper balance among power, range, battery life, and weight. Range could also be extended by the use of a better antenna; the current payload uses a simple vertical antenna. This is not a good idea, as it provides a null towards the ground. A better solution would be a patch antenna or a small directional antenna such as a three-element Yagi. Additionally, recovery of the current payload would prove difficult, but could be accomplished through radio location and the use of the GPS data displayed on the screen. A better solution would be to incorporate an APRS transmitter on the band.

Additional Applications

This project was very simple to put together and had great results. It would serve as a good way to inspire new or young hams. The project could be put together with little technical knowledge and therefore would be an excellent project for any age group. Also, the project is a good introduction to many of the problems faced in space systems engineering, including considering system weight and power and survivability of the system.

In addition to providing educational value and inspirational results, the concept of producing small balloon- or rocket-based payloads such as this could be of tremendous utility to the military. A tethered balloon could afford a small area a rapidly redeployable solution to provide enhanced C4ISR (Command, Control, Communications, Computing, Intelligence, Surveillance, Reconnaissance) capabilities. Also, payloads released on weather balloons could provide similar short-term capabilities over an entire theater.

Types of payloads are only limited by one's imagination, and examples could include RADAR or optical imaging, communications relay, signal collection or surveying, or sampling atmospheric conditions. A similar concept, but on a larger scale, is currently being considered by the DoD (Department of Defense) through the development of Operationally Responsive Space, which is aimed at ensuring that our overhead assets are responsive to the needs of the military.

Acknowledgements

Many thanks go to Mr. Frank Blackman and Mr. Bob McKay for helping to package the system and clean up our connectors. Additionally, Cadet Josh Miles, KC2VDO, helped with making the power-distribution board. The project would not have gotten its start without the work and inspiration of Major Diana Loucks and the Astronomy Club.

73, Tom, KB1JIJ

By Keith Pugh,* W5IU

SATELLITES

Artificially Propagating Signals Through Space

Developing ARISSat-1, Working Astronauts on the ISS, and Working Our Oldest Satellite, OSCAR Zero

As we approach launch of ARISSat-1, first I would like to review the development process leading to such a launch. With a very active ham astronaut on board the ISS (International Space Station), what can you do to enhance your chances of a QSO? Last, we revisit our old friend OSCAR Zero.

Developing ARISSat-1

As I write this (20 September 2010), ARISSat-1 is in the final stages of vibration testing prior to shipping to Russia within the next week or two (photo 1). At this time I would like to review the steps in the development of this "bird." Many hams do not have an appreciation of the technical, political, and financial problems involved in an effort of this type. Most, if not all, of this process is common within the aerospace industry, except that it's usually done with paid employees.

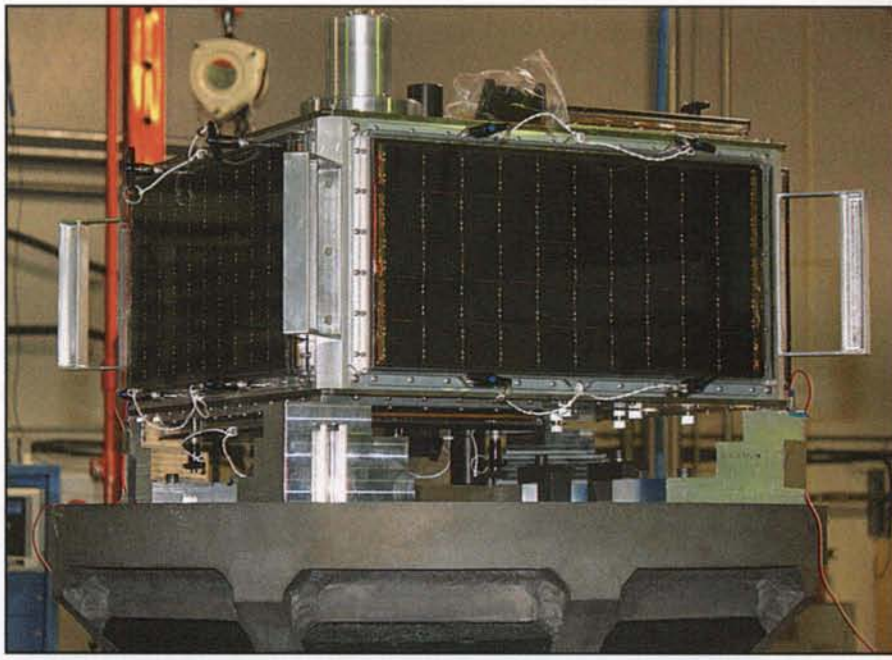


Photo 1. ARISSat-1 on a "shaker" during vibration testing.

First, a brief history. ARISSat-1 can trace its development back to SuitSat-1 – amateur radios in a Russian Orlan Space Suit thrown overboard from the ISS during a space walk (EVA). Building on this successful mission, SuitSat-2 development was started with greatly increased capabilities. Before SuitSat-2 could be completed, the Orlan Space Suit that had been reserved for use with SuitSat-2 was thrown away to provide needed space on board the ISS. This led to the development of ARISSat-1 in its own space frame. A new name, ARISSat-1, was coined and approved, since it no longer involved a space suit. Development of the electronic hardware and software was well under way at this time, but we now had to "shift gears" on the mechanical design and come up with a completely new structure and a plan for its deployment. Fortunately, the allocation for "up mass" (transportation of hardware) on a Russian Progress Supply Vehicle and a slot for training for and deployment during a Russian EVA were preserved; otherwise the launch opportunity would have evaporated with the Orlan Space Suit.

ARISS International immediately enlisted the assistance of the AMSAT-NA satellite builders, and they came up with plans for the structure, for a modular reusable design, and for completion of the satellite. Let me emphasize at this point that this was a large undertaking for a volunteer group, but similar to other programs successfully accomplished by the group. Let me further emphasize that another key to this project from the outset was incorporation of support for educational experiments into the design. This meant close association with Kursk Technical University in Russia, the only experiment builder to step forward, and close cooperation with NASA and the Russian Space Agency to understand the requirements for transporting and deploying such a satellite. Keep in mind that this equipment must not adversely impact the progress supply vehicle, the ISS, and the astronauts on board the ISS. Meanwhile, remember the international nature of the project—satisfying the international customs organizations, and just all of the complex, bilingual communications involved.

In the end, not only must the satellite work, but it must be well documented in a way that can be reproduced and understood by everyone – especially the safety review boards of NASA and the Russian Space Agency. By the way, there were exceptions noted at the first formal safety review and these must be resolved prior to the final review, which is now planned within the next couple of weeks after completion of all testing.

Now for some words about how the design process unfolds. Similar processes exist for four areas of the design: sys-

*3525 Winifred Drive, Fort Worth, TX 76133
e-mail: <w5iu@swbell.net>

Photo 2. NASA astronaut Doug Wheelock, KF5BOC, Expedition 24 flight engineer, uses a ham radio system in the Zvezda service module of the International Space Station.

tem design, electronic design, software design, and mechanical design.

System design is an operational concept for the satellite—what modes, frequencies, and functions it will perform. System design personnel also allocate the functions among electronic design, software design, and, to a lesser degree, mechanical design. System design controls and documents all interfaces, electrical, mechanical, software (communications between modules), and environmental among the various modules and components of the satellite. Design and fabrication of interconnect cabling comes under this function. System design is usually the overall "overseer" of the project. In addition to the flight hardware, system design defines any peculiar ground station equipment that may be required to operate with and gather telemetry from the satellite. Last but not least, system design defines how many prototypes, complete units, etc., are to be built to support the design and testing. In this case, two complete flight-ready units have been built, plus two more without solar panels. I don't have an accurate accounting of the prototype hardware; however, several modules and one complete prototype satellite were demonstrated at the Dayton Hamvention® 2010.

Electronic design creates the modules: housekeeping computer, RF (receive and transmit), power control, solar panels, batteries, processors, etc., that make up the satellite. It is responsible to see that the hardware works over the expected environment.

Software design, to a large extent, creates the functions of the satellite by coordinating the individual capabilities of the modules to create the overall functions of the satellite and to control the operation of the "bird." In this day and age of digital signal processing (DSP) and software defined transponders (SDXs) the software becomes an integral part of the design. Software design also gathers data on the status and functions of the satellite for inclusion in the satellite telemetry messages. Software design is the last to be

Memory No.	Downlink MHz	Uplink MHz	
1	145.8030	144.4870	AOS
2	145.8020	144.4880	
3	145.8010	144.4890	
4	145.8000	144.4900	TCA
5	145.7990	144.4910	
6	145.7980	144.4920	
7	145.7970	144.4930	LOS

AOS = Acquisition Of Signal
TCA = Time of Closest Approach
LOS = Loss of Signal

Table 1. You can increase your chances early and late in the ISS pass if you can correct for Doppler. This table assumes you can change your frequency in 1-kHz steps. If 5 kHz is your minimum step size, it may be worthwhile to change in just three steps instead of the seven steps as shown.

Photo 3. Paul Perryman, WA5WCP's portable 1296-MHz EME station.

completed and may be changed right up to flight date. Actually, changes will continue to be made even after the satellite is "on orbit." Many times software changes can create "workarounds" long after hardware changes are no longer possible.

Mechanical design defines the overall structure (the space frame of the satellite), sets construction requirements for the electronic components, defines mounting provisions for the modules /components, and handles provisions for carrying and launching the satellite. Mechanical design also usually takes the lead in conducting the environmental testing.

All elements of the design are important. Successful development and deployment of a satellite involve all of these elements regardless of the physical size of the satellite. ARISSat-1 has been through all stages of the design cycle and is now in the final environmental test process. See the photo of the complete, flight-ready, ARISSat-1 satellite installed on a vibration test fixture.

All that is now left is the packaging, shipping, and clearing of customs to transfer ARISSat-1 to Russia. Once there, the final Kursk experiment package must be integrated into the space frame and tested, final operational testing performed, crew training and deployment procedures developed, transport to the launch facility performed, and finally launch to the ISS aboard a Progress Supply Vehicle. Once on board the ISS, it will be made ready for the EVA, taken outside, and launched.

Current plans call for shipping two units—a flight unit and a backup—to Russia in October, final integration with the Kursk Experiment and other testing in November, followed by shipping to Baikinor. The EVA and final deployment are scheduled for early 2011. We all look forward to a successful launch and several interesting months of operation once it is "on orbit."

By the time you read this, complete review of all facets of ARISSat-1 complete with demonstration of actual hardware will have been presented at the AMSAT Space Symposium 2010 held in Chicago on 8–9 October. Hopefully, I can report on a successful deployment of this new "bird" in my next column.

Photo 4. The thermometer showing 103 degrees in the shade during the International EME Conference in Texas in August.

Working the Astronauts on the ISS

We recently have encountered an interesting development on the ISS. Col. Doug Wheelock, KF5BOC, has become very active in general contacts with hams all over the world (photo 2). We knew he would be active with school contacts before his trip to the ISS, but we didn't know how active he would become. In recent weeks, and probably for the remainder of his rotation, he has been *very* active. A picture of Doug "on orbit" is included in this column.

It actually takes very little equipment to work an astronaut on the ISS—in general, a 2-meter FM radio capable of at least 5 watts (or less, if you're lucky) and a simple antenna. Most anything above a standard "rubber ducky" will do the job,

Photo 5. Joe Taylor, K1JT, in the middle, at the EME conference in Texas.

but your chances go up a bunch if you have a simple directional antenna such as a hand-held "Cheap Yagi," an Arrow antenna, or an Elk antenna. Attention to the operating frequency also helps. The worldwide downlink frequency is 145.800 MHz. For IARU Region 1 (Europe and Africa) the uplink is 145.200 MHz. For IARU Regions 2 and 3 (U.S., Canada, and rest of world) the uplink is 144.49 MHz. No PL tone is required. Doppler is low enough on 2 meters (±3 kHz) that you can get by without any correction. However, you can increase your chances early and late in the pass if you can correct for Doppler. Table 1 assumes you can change your frequency in 1-kHz steps. If 5 kHz is your minimum step size, it may be worthwhile to change in just three steps instead of the seven steps as shown in the table. You can store this information in memory in your radio to make the process easy.

One last caution: Make sure your tracking program is up to date with the latest Keplerian data you can find. You never know when they might do a re-boost and throw off your tracking program. Also make sure your latitude and longitude are entered correctly and that your computer clock and time zone are correct. You can cross-check your predictions with the prediction tool at <http://www.amsat.org> or the NASA Human Spaceflight Page.

Revisiting OSCAR Zero

In August I had the opportunity to attend the 14th International EME Conference held in Dallas–Fort Worth, Texas, my back yard. This conference is held every other year somewhere in the world. Last time it was Italy; next time it will be Cambridge, UK. I highly recommend attending one of these if possible. Like many other conferences—AMSAT Space Symposium, Central States VHF Conference, and Microwave Update, to name a few—attending and listening will help. A little will "rub off" each time if you're not careful!

I know the common perception is that moonbounce, or EME, is only for the elite with lots of money, lots of power, and huge antennas. Yes, this is still one way to do EME, but it can now be done, even on 2 meters, with a long Yagi, 100 watts, processing power, and a program called WSJT developed by Joe Taylor, K1JT. This opens up the world to EME operation if you are willing to go digital. Joe spoke on this topic and the EME special event held at the Arecibo Radio Telescope, KP4AO, earlier this year. With one of these "big dishes" in the loop even very modest stations can work EME in both digital and analog modes.

I have included pictures of Paul Perryman, WA5WCP's portable 1296-MHz station in operation at the conference in Texas (photo 3). Please note photo 4, a picture of the thermometer, in the shade, at the time the photos were taken. I have also included a photo with Joe, K1JT, in the middle (photo 5).

Summary

I hope you have gained an appreciation of the tasks involved in the development of a new amateur radio satellite

Follow this column for up-to-date information on all of the amateur radio satellites and related topics. The AMSAT Space Symposium and General Meeting 2010 in the Chicago Area will be history by the time you read this, but I will report on this year's event in the next column. Now's the time to get ready to work ARISSat-1.

Please continue to support AMSATs plans for the future of the amateur radio satellites. AMSAT is now updating its web page at <http://www.amsat.org> on a much more regular basis. Satellite details are updated regularly at <http://www.amsat.org/amsat-new/satellites/status.php>. 'Til next time . . .

73, Keith, W5IU

By Bill Brown,* WB8ELK

UP IN THE AIR

New Heights for Amateur Radio

SpaceJam-4

This past August, over 300 Boy Scouts descended upon Chanute Air Museum in Rantoul, Illinois to attend SpaceJam-4. This was an event to learn about space, science, electronics, and amateur radio. Merit badges could be earned for a variety of topics, including an unofficial one for the most creative use of duct tape. After all, real science is not possible without duct tape!

The Scouts camped out along the runway at the Chanute Air Museum and were treated to some very special amateur radio events, which included making contacts through orbiting amateur radio satellites as well as a direct contact with the astronauts flying overhead on the International Space Station (ISS, see photo 1).

Thanks to Howard Brooks, KC9QBN, the Scouts were able to experience the thrill of flying their very own satellite into the stratosphere with the back-to-back launches of two high-altitude balloons. Howard is a professor of astronomy at DePauw University and runs the Balloon Assisted Stratospheric Experiments (BASE) high-altitude balloon program at DePauw.

The first balloon carried an APRS tracker and an Elktronics multi-mode transmitter sending down DominoEX data (N9QGS). In addition, I added my 1-watt Amateur Television (ATV) payload to the flight train to send down a live camera view of the very edge of space (see photos 2 and 3).

The second balloon launched within minutes of the first liftoff and carried another APRS tracker, a DominoEX multi-mode transmitter (W9YJ), as well as a crossband voice repeater (2 meters input/70 cm output).

The Scouts really loved the balloon missions. We had a large number of people helping with the inflation, the launch, and tracking the flight paths via laptops inside the tents.

The crossband balloon repeater provided amazing coverage with lots of QSOs over a large area of the Mid-west. At one point, a contact was made between stations in the Kansas City area (KDØFW) all the way to Ohio (N8WAC).

*12536 T 77, Findlay, OH 45840
e-mail: <wb8elk@aol.com>

Photo 1. The satellite-capable SpaceJam-4 amateur radio tent and towers.

Photo 2. Howard Brooks, KC9QBN, inflates a balloon with help from the Boy Scouts.

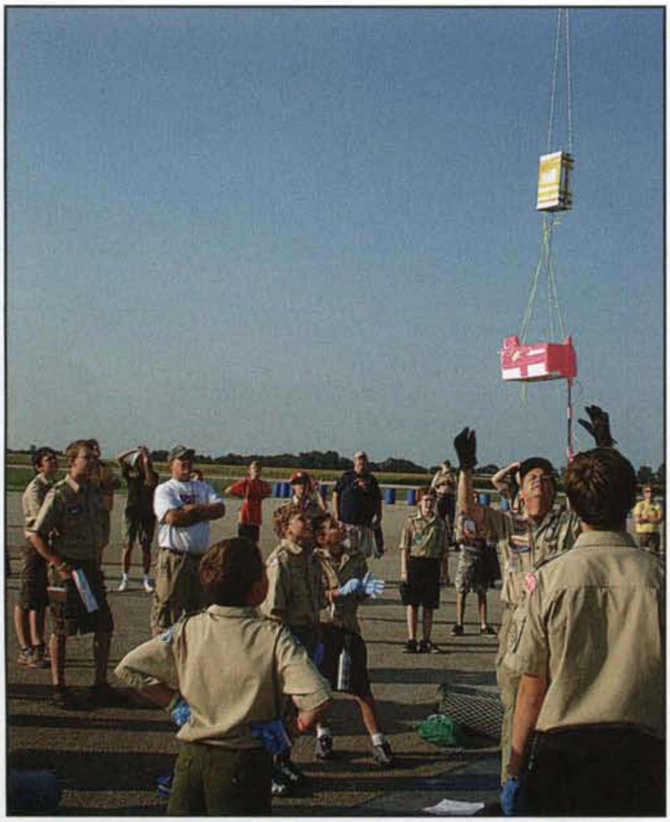


Photo 3. Liftoff of the first high-altitude balloon from SpaceJam-4.

Photo 4. The WB8ELK ATV payload is found inside the cornfield.

Photo 5. Al Wolfe, K9SI, discovers the N9QGS DominoEX payload draped across the corn rows.

The ATV signal was received as far away as lower Michigan by KC8LMI and several others in Ohio.

Since the balloons were going up at vastly different ascent rates, the landing spots ended up being about 20 miles apart. Mark, KA9SZX, and I set out in his truck filled with multiple radios and three netbooks hooked to the internet via a portable WiFi Hotspot unit on the dashboard (Verizon USB cellular modem with a Cradlepoint hotspot unit, similar to the new MiFi units). It took me some time to exit Mark's truck, as I had to extract myself from all the netbooks, radios, and cables piled up on my lap.

We were able to stream video of the chase from the camera in my netbook via the British Amateur Television Club's streaming video website as we bounced around the backroads of Illinois farmland. Mark and I got close enough during the chase to watch the first balloon parachute down and land about a thousand feet behind a large cornfield. It was a long and very hot hike to get to the payload, and it was found just 30 feet from the edge of the cornfield in chest-high soybeans.

The second balloon landed over 20 miles away and also appeared to have a cornfield magnet onboard. It landed inside an 8-foot tall corn only about 100 feet from the road. I figured that compared to the long hike and recovery for the first balloon, this was going to be a walk in the park. We quickly found out that you can't see a thing more than a few feet in front of you inside a tall cornfield. It took us 20 minutes to find the payloads. The ATV transmitter was hanging a foot off the ground dangling from an ear of corn (photo 4). The rest of the payloads were strung across the tops of the corn across several rows (photo 5).

It was a successful day and a great chance to introduce hundreds of Scouts to the excitement of amateur radio.

73, Bill, WB8ELK

By Tomas Hood,* NW7US

VHF PROPAGATION

The Science of Predicting VHF-and-Above Radio Conditions

Open Season for VHF Meteor Hunting

Even with the increase in sunspot activity, the Sun's activity is not yet high enough to energize the ionosphere to the level needed for VHF radio signal propagation. With the seasonal sporadic-*E* (*Es*) season behind us, what hope do we have during the fall season for long-distance VHF communications? Of course, we can try working an amateur radio satellite. However, there are a lot of exciting opportunities coming our way as we move into the yearly "meteor season."

Every year weak-signal VHF operators look forward to meteor showers, hoping that storm-level showers will provide exciting opportunities for bouncing their VHF signals off the plasma trails of burning-up meteors. Each year we hope that the November *Leonids* shower will yield a high rate of meteors per hour (the ZHR, or zenith hourly rate). Will this year yield a major VHF meteor-scatter event?

One of the largest yearly meteor showers occurs during November. Appearing to radiate out of the constellation of Leo from November 10 through November 23, the *Leonids* will peak on the night of November 17 at 2115 UTC. This shower is known to create intense meteor bursts.

The most recent perihelion passage (the date and time at which an object orbiting the Sun is at its closest to the Sun) of the *Leonids*' parent comet, the 55P/Tempel-Tuttle, occurred in 1998, over a decade ago. The *Leonids* yearly shower activity has been excitingly variable from year to year ever since. One of the greatest events was the peak in 1999 of roughly 3700 meteors per hour. While every year since has been significantly less spectacular, these showers have not been disappointing for the VHF weak-signal DXer.

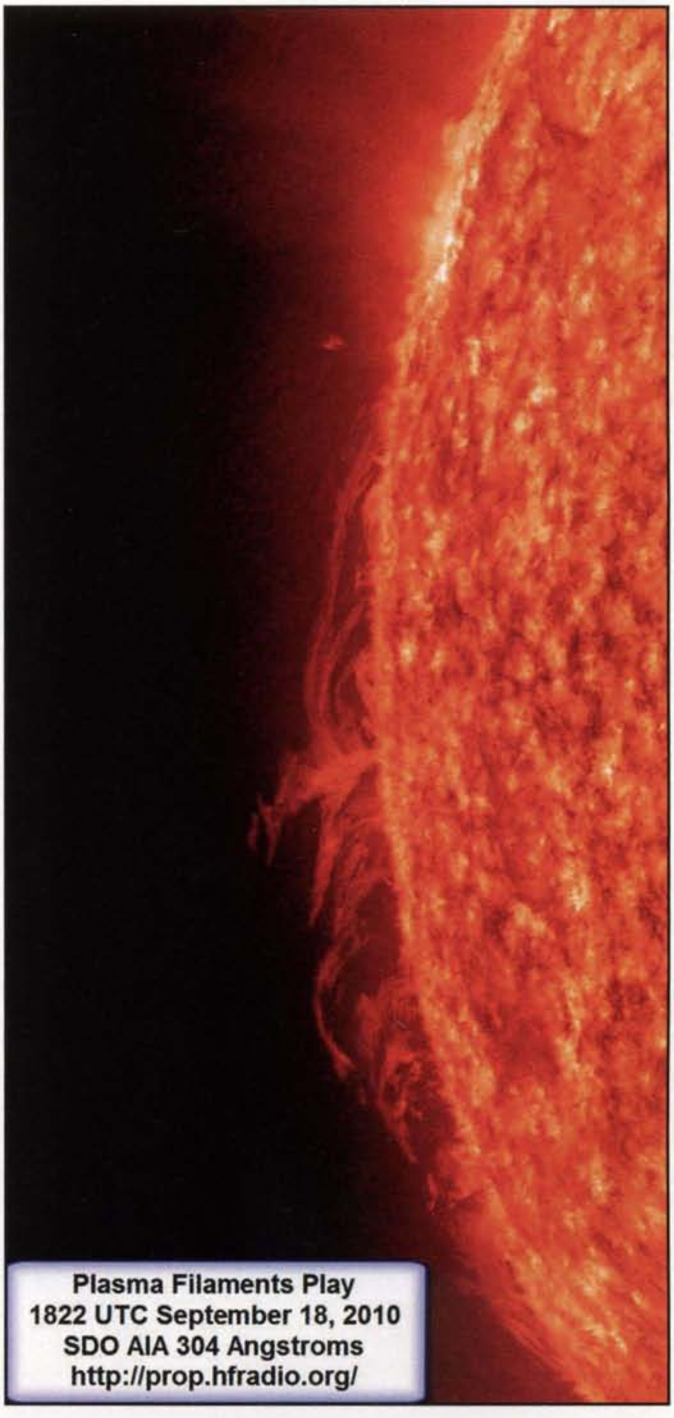
The best time to work meteor scatter off the *Leonids* is around 11:30 PM, local time, in the Northern Hemisphere. The shower should increase in rate the closer you get to midnight, and then move toward pre-dawn. Remember, though, that when we are talking about meteor-scatter radio propagation, we count any meteor-formed plasma clouds that will support VHF radio signals.

This year, as Earth passes through the stream of debris left by comet 55P/ Tempel-Tuttle, we can expect at least moderate meteor activity. Predictions are for the low rate of 20 meteors per hour, but there are theoretical forecasts for a possible 100 to 200 per hour. Somewhere in that range is plenty of opportunity to work other VHF stations equipped to make quick contacts on the 6- and 2-meter VHF bands.

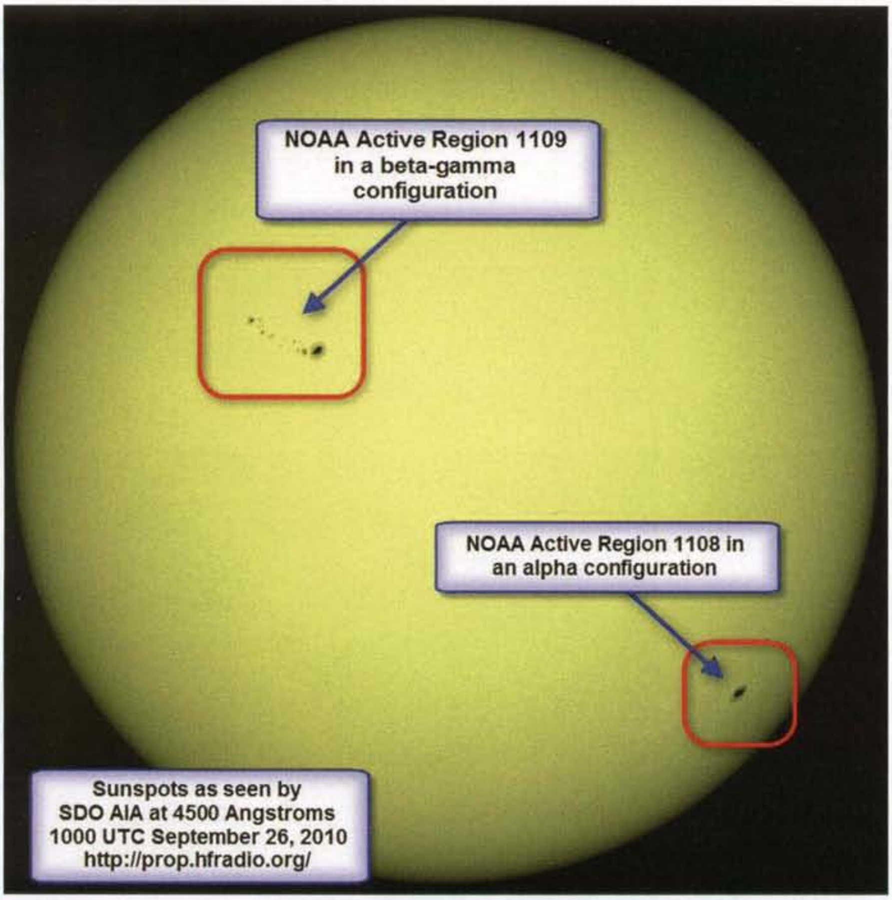
December and January Prospects

After November, the annual *Geminids* meteor shower from December 7 to December 17 will peak on December 14 at 1100 UTC. This is one of the better showers, since as many as 120 visual meteors per hour may occur. It is also one of the better showers for operators trying meteor-scatter propagation from

*PO Box 1980, Hamilton, Montana 59840
e-mail: <nw7us@arrl.net>



Amazing arcs of solar plasma seen through the 304-Angstrom wavelength filter by the Solar Dynamics Observatory (SDO) Atmospheric Imaging Assembly (AIA) at 1822 UTC, September 18, 2010. These plasma arcs are formed by the strong magnetic fields above the Sun's corona. (Source: SDO/AIA)



NOAA Active Region 1109 was a very large sunspot region. In this image, seen through the 4500-Angstrom wavelength filter by the Solar Dynamics Observatory Atmospheric Imaging Assembly at 1000 UTC, September 26, 2010, we see two regions, the large area 1108 and the string of sunspots in 1109. These two sunspot regions helped raise the 10.7-cm flux. (Source: SDO/AIA)

positions in North America. The *Geminids* is a great shower for those trying the meteor-scatter mode of propagation, since one doesn't have to wait until after midnight to catch this shower. The radiant rises early (starting at about 0200 UTC). This shower also boasts a broad maximum, lasting nearly one whole day, so no matter where you live you stand a decent chance of working some VHF/UHF signals off a meteor trail.

Finally, check out the *Quadrantids* from January 1 through January 5, 2011. This meteor shower is above average, with peaks expected of around 120 to 200 meteors per hour.

Check out <http://www.imo.net/calendar/> for a complete listing of meteor showers.

Working Meteor Scatter

Meteors are particles (debris from a passing comet) ranging in size from a speck of dust to a small pebble, and some move slowly while others move fast. When you view a meteor, you typically see a streak that persists for a little while after the meteor vanishes. This streak is called the "train" and is basically a trail of glowing plasma left in the wake of the meteor. These trains enter Earth's atmosphere traveling at speeds of over 158,000 miles per hour. Besides being fast, the *Leonids* usually contain a large number of very bright meteors. The trains of these bright meteors can last from several seconds to several minutes. It is typical for these trains to be created in the *E*-layer of the ionosphere.

Meteor-scatter propagation is a mode in which radio signals are refracted off these trains of ionized plasma. The ionized trail is produced by vaporization of the meteor. Meteors no larger than a pea can produce ionized trails up to 12 miles in length in the *E*-layer of the ionosphere. Because of the height of these plasma trains, the range of a meteor-scatter contact is between 500 and 1300 miles. The frequencies that are best refracted are between 30 and 100 MHz. However, with the development of new software and techniques, frequencies up to 440 MHz have been used to make successful radio contacts off these meteor trains.

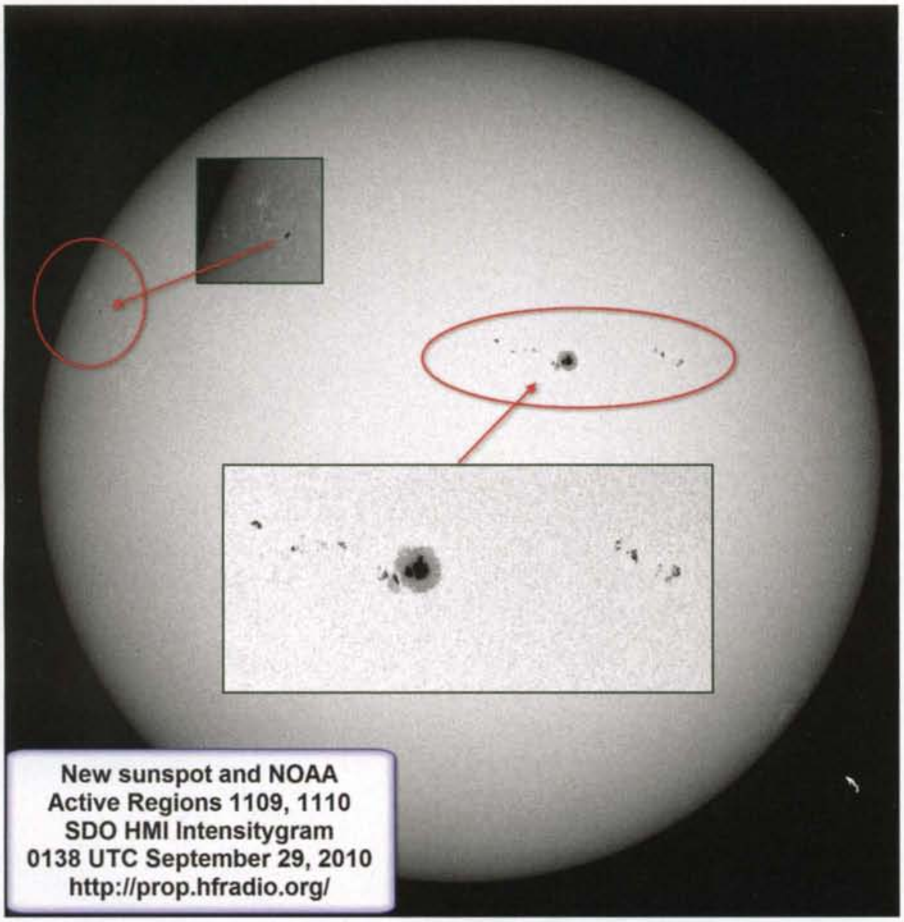
Lower VHF frequencies are more stable, and last longer, off these ionized trails. A 6-meter contact may last from a second to well over a minute. The lower the frequency, the longer the specific "opening" made by a single meteor train. Conversely, a meteor's ionized train that supports a 60-second refraction on 6 meters might only support 1-second refraction of a 2-meter signal. Special high-speed digital modulation modes are used on these higher frequencies to take advantage of the limited available time. This includes high-speed CW, in the neighborhood of hundreds of words per minute.

A great introduction by Shelby Ennis, W8WN, on working the high-speed meteor-scatter mode is found at <http://www.amt.org/Meteor_Scatter/shelbys_welcome.htm>. Ted Goldthorpe, W4VHF, has also created a good starting guide at <http://www.amt.org/Meteor_Scatter/letstalk-w4vhf.htm>. Links to various groups, resources, and software are found at <http://www.amt.org/Meteor_Scatter/default.htm>.

Outlook

November through January is a relatively quiet time period, with very little, if any, transequatorial propagation (TEP). TEP, which tends to occur most often during spring and fall, requires high solar activity which energizes the ionosphere enough to cause the *F*-layer over the equatorial region to support VHF propagation. The normal TEP signal path is between locations on each side of the equator. However, without the level of solar activity needed to keep the *F*-layer energized enough for VHF propagation, these paths don't materialize. The fall season of TEP usually tapers out by mid-November. This year, though, TEP will be rare, if it occurs at all.

Tropospheric-ducting propagation during this season is fairly non-existent, as the weather systems that spawn the inversions needed to create the duct are rare. On the other hand, using tropospheric-scatter-mode propagation is possible, but one needs to have very high-power, high-gain antenna systems.



NOAA Active Region 1109 seen in the intensitygram captured by the Solar Dynamics Observatory Helioseismic and Magnetic Imager (HMI) at 0138 UTC, September 29, 2010. A cluster of new sunspots appeared ahead of (left of) NOAA Active Region 1109. Another sunspot appeared near the eastern (left) limb of the solar disc. This is common now that sunspot Cycle 24 is slowly gaining energy. (Source: SDO/HMI)

" I suspect that within the next year we will see a significant increase in sunspot activity. "

Having dual receivers in a voting configuration would also help. The idea is to use brute force to scatter RF off water droplets and other airborne particles, and capture some of that signal at the far end with dual-diversity, high-gain receivers —not everyone's cup of tea.

Aurora-mode propagation is unlikely during this season. Even if there are periods when the solar wind speed is elevated and is magnetically oriented in a way to impact the geomagnetic field, this is the season when statistically we see very few aurora events.

A secondary seasonal peak in sporadic-*E* ionization should also result in some short-skip openings on low VHF bands between distances of about 800 to 1300 miles at the end of December and early in January. Reports even after the end of the 2010 summer *Es* season indicate surprise openings when no one expected them, so be vigilant and watch for 6-meter openings throughout November, December, and January.

The Solar Cycle Pulse

The observed sunspot numbers from June through August 2010 are 13.5, 16.1, and 19.6. The smoothed sunspot counts for December 2009 through February 2010 are 8.3, 9.3, and 10.6. This upward trend clearly indicates that sunspot Cycle 24 is now "awake" and moving (albeit slowly) toward a distant sunspot cycle maximum. I suspect that within the next year we will see a significant increase in sunspot activity.

The monthly 10.7-cm (preliminary) numbers from June through August 2010 are 72.6, 79.9, and 79.7. These numbers are higher than those of one year ago. The smoothed 10.7-cm radio flux for December 2009 through February 2010 are 74.9, 75.5, and 76.5. These indicate a level of solar energy not yet high enough to support *F*-region ionospheric propagation of VHF radio signals, but these monthly flux readings do show an upward trend.

The smoothed planetary *A*-index (*Ap*) numbers from December 2009 through February 2010 are 4.8, 5.0, and 5.1. The monthly readings from June through August 2010 are 7, 5, and 8. These numbers are pretty low, indicating a rather quiet Sun (very few coronal holes or coronal mass ejections, which would trigger geomagnetic storms). Expect the geomagnetic activity to increase early in 2011, however, if the new solar cycle picks up as we hope.

The monthly sunspot numbers forecast for November 2010 through January 2011 are 38, 42, and 46, while the monthly 10.7-cm flux forecast is 95, 98, and 101 for the same period. Give or take about eight points for all predictions.

(Note that these are preliminary figures. Solar scientists make minor adjustments after publishing, by careful review.)

Feedback, Comments, Observations Solicited!

I am looking forward to hearing from you about your observations of VHF and UHF propagation. Please send your reports to me via e-mail, or drop me a letter about your VHF/UHF experiences (sporadic-*E*, meteor scatter?). I'll create summaries and share them with the readership. Up-to-date propagation information is found at my propagation center, <http://prop.hfradio.org/>. If you are using Twitter, follow @hfradiospacewx for space-weather and propagation alerts, and follow @NW7US to hear from me about various space-weather and amateur radio news. Facebook members should check out the *CQ VHF* Magazine Fan Page at <http://tinyurl.com/cqvhffb>, and the Space Weather and Radio Propagation Page at <http://tinyurl.com/fbswx>. My personal amateur radio Facebook page is at <http://tinyurl.com/fb-nw7us>. Until the next issue, happy weak-signal DXing.

73 de Tomas, NW7US

By Dr. H. Paul Shuch,* N6TX

DR. SETI'S STARSHIP

Searching For The Ultimate DX

Remembering Project Ozma

It was an idea whose time had come, but nobody dared admit that out loud. Frank Drake, in particular, was keeping silent. Like many of his generation, he had long speculated about the existence of extraterrestrial life, and pondered how we humans might probe for direct evidence of our cosmic companions. Now, in 1959, the young astronomer was finally in a position to do more than ponder. At 29, he had just completed graduate school, the ink on his Harvard diploma as wet as he was behind the ears. As the new kid on the block at the National Radio Astronomy Observatory, he had access to the tools necessary to mount a credible search for radio evidence of distant technological civilizations. Drake knew enough to tread lightly; a publicly announced hunt for Little Green Men would be tantamount to professional suicide. Thus, he approached his superior with understandable trepidation.

*Executive Director Emeritus, The SETI League, Inc., <www.setileague.org>
e-mail: <n6tx@setileague.org>

Fortunately, NRAO director Otto Struve was sympathetic, even as he counseled caution. Having theorized that the slowed rotation rate of certain stars suggested that their angular momentum had been dissipated in the formation of planets, Struve himself speculated on the probable existence of extraterrestrial civilizations. Therefore, he authorized Drake to use the 85-foot diameter Howard Tatel telescope in his off-duty time to conduct what was to become the world's first observational SETI experiment. Only do so quietly, Struve warned; we don't want the word getting out that we're using a government facility to hunt for aliens.

Drake had already run the numbers. He knew the most likely frequency on which to search, and the best receiver circuitry to employ. He had picked his candidate

The 85-foot diameter Howard Tatel Telescope at the National Radio Astronomy Observatory, Green Bank, West Virginia, used by Frank Drake for his Project Ozma observations in April and May of 1960.

The seven agenda items for the Order of the Dolphin meeting. Strung together, they form the famous Drake Equation. This plaque graces the very wall on which the equation was originally scrawled on a chalkboard at NRAO Green Bank in 1961.

stars, two nearby sunlike ones which he reasoned were likely to harbor habitable planets. He had selected his research methodology and proceeded (very quietly) to assemble his listening station.

Then the *Nature* magazine article hit the newsstands. "Searching for Interstellar Communications" was written by two Cornell University professors, Giuseppe Cocconi and Philip Morrison (then W8FIS), and it proposed, in brief but clear detail the very experiment that Drake was preparing to conduct! This very first scientific article in the not-yet-named discipline of SETI was complete, down to the selection of frequencies and target stars, and it paralleled Drake's work exactly. Neither the team of Morrison and Cocconi, nor that of Drake and Struve, knew anything about the other's interest in this esoteric study. Both groups had arrived at the same crossroads in history, completely independently, in an elegant example of what I like to call the Parenthood Principle: When a great idea is ready to be born, it goes out in search of a parent. Sometimes, it finds more than one.

Now Schrodinger's "cat was out of the bag," and Drake had no choice but to go public. The publicity he received was widespread, and generally enthusiastic; the scientific community, it appeared, was ready to embrace the notion of SETI. Struve began writing about the possibility of extraterrestrial life: "An intrinsically improbable event may become highly probable if the number of events is very great … it is probable that a good many of the billions of planets in the Milky Way support intelligent forms of life. To me this conclusion is of great philosophical interest. I believe that science has reached the point where it is necessary to take into account the action of intelligent beings, in addition to the classical laws of physics."

His cover now blown, Drake soon found himself in the company of other open-minded scientists and technologists who collectively found themselves unwitting parents to a newly emerging scientific discipline. Among those contacting Drake after reading about his nascent experiment were microwave communications expert Bernard M. Oliver, then vice-president of engineering at Hewlett-Packard (and later president of the Institute of Electrical and Electronics Engineers); Dana Atchley, president of Microwave Associates in Massachusetts; and a young planetary scientist, Berkeley post-doctoral researcher Carl Sagan. These individuals, as well as Struve, Morrison, and a handful of others, were ultimately to become SETI's patriarchs. (Cocconi, though having co-authored the seminal SETI article with Morrison, went on to distinguish himself in particle physics research at CERN, never to return to the SETI fold.)

Drake named his search Project Ozma, after the Princess of Oz in the third book of the L. Frank Baum Oz series, as he saw his efforts leading humans to a far-off and exotic land. Launched in April of 1960, and running only through May of that year, Ozma searched but two stars, on a single frequency, for mere dozens of hours, but established the protocols and laid the groundwork for all subsequent SETI experiments. It was a paradigm-shifting endeavor, successful for its audacity, if not for its discoveries.

And yet for one brief moment early on, Frank Drake thought he had hit pay dirt. As he swung his antenna off Tau Ceti and onto Epsilon Eridani, he was greeted with a strong, periodic, pulsed signal on 1420 MHz, the hyperfine transition emission line of interstellar hydrogen atoms proposed by Cocconi and Morrison, and still favored as a promising hailing frequency for interstellar communications. "My god," Frank mused, "can it really be this easy?"

The next day, when the signal reappeared, Drake was ready with a second, low-gain antenna. The pulses were there as well, sadly disproving their extraterrestrial origin. However, they were not exactly terrestrial interference, either. The rate at which the phantom signal traversed the sky suggested that it was emanating from an aircraft cruising at unprecedented altitude, perhaps 80-thousand feet! Of course, in April of 1960, no known aircraft could reach the stratosphere. Such an aircraft, as it happened, didn't "come into existence" until the following month, when Francis Gary Powers was shot down over the Soviet Union. (Frank wisely decided to withhold publication of this positive result, so he never did receive proper credit for "discovering" the U-2.)

A year after Project Ozma's brief tenure, Drake convened at Green Bank the first scientific conference devoted to modern SETI. He gathered together ten scientists from disparate disciplines to spend a week contemplating areas from the physical, biological, and social sciences that had relevance to the question of extraterrestrial technological civilizations, and how to communicate with them. The assembly included the six SETI patriarchs already mentioned, along with J. Peter Pearman of the National Academy of Sciences' space science board, Su Shu Huang of NASA, University of California chemist Melvin Calvin (whose Nobel prize was to be announced during the Green Bank meeting), and neuroscientist John C. Lilly, who was then studying the language of dolphins and attempting to communicate with these intelligent Earth mammals. The group called themselves the Order of the Dolphin, a tribute to Lilly's studies of human-dolphin communication, which they deemed a worthy metaphor for the challenge of interspecies communications on a grander, cosmic scale.

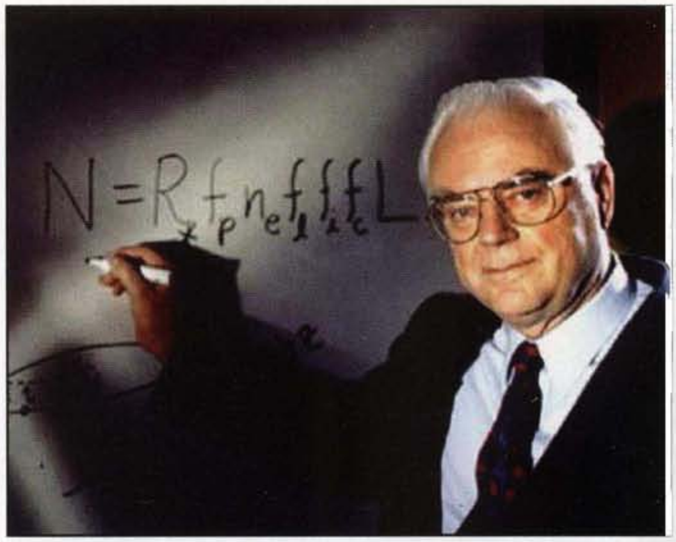
Drake chalked on a blackboard seven topics for discussion, which would comprise the agenda for the week-long meeting. They included stellar formation, planetary formation, the existence of planets within habitable zones, the emergence of life, the evolution of intelligence, communications technology, and the longevity of technological civilizations.

Having established that the emerging discipline of SETI was to encompass fields as diverse as stellar evolution, planetary astronomy, environmental science, biology, anthropology, engineering, and sociology, Drake next did something almost whimsical, which assured his lasting fame: He strung these seven factors together into an equation.

The idea was to multiply seven unknowns together, and in so doing, to estimate N, the number of communicative civilizations in our Milky Way galaxy. The Drake Equation, as it is now called, appears in every modern astronomy textbook. It is a marvelous tool for quantifying our ignorance, never intended for quantification, but quite useful in narrowing the search parameters. We still use it, not to seek a numerical solution, but rather to help us to focus our thinking in designing our searches for life.

Drake's seven factors are cleverly ordered, from solid to speculative. Today's astrobiology meetings are similarly structured. When the equation was first published, only the first factor (the rate of stellar formation) was known to any degree of certainty. In the intervening decades, Drake's equation has guided our research in an orderly manner, from left to right, so that today we have a pretty good handle on Drake factors two and three (planetary formation and habitable zones). The remaining four factors are still anybody's guess, and it may well take decades more before our research begins to quantify those areas of our ignorance. However, the Drake Equation is most valuable in guiding our research, because it asks the important questions. It is still up to us to answer them.

The lessons learned during the brief course of Project Ozma, amplified and expanded at the Order of the Dolphin meeting, have informed and enriched every subsequent SETI experiment. The interdisciplinary nature of the science now known as SETI was articulated at the outset. Drake's work clearly showed that Earth's technology was at last approaching the level at which a disciplined search for extraterrestrial microwave emissions was becoming feasible. The quietest part of the electromagnetic spectrum was explored then, as



In his rightful role as SETI Elder Statesman, Frank Drake still serves as keynote speaker at SETI conferences all over the world.

now. Highly directional, high-gain parabolic antennas, coupled to very low-noise microwave preamplifiers, remain our preferred observational tools. Although the advent of multi-channel spectrum analyzers means we no longer have to select a single channel to scan, SETI scientists continue to speculate as to universal calling frequencies that alien civilizations might employ to make their presence known. Concentrating our efforts on known, nearby sun-like stars remains an accepted technique for planning targeted searches, one of the two primary search modalities still practiced. (The other popular SETI research strategy, the all-sky survey, was long employed at the Ohio State University "Big Ear" radio telescope, and more recently forms the basis of The SETI League's Project Argus search.)

Most important, Frank Drake's early efforts began to lend legitimacy to an endeavor previously considered fringe science. Today, the preponderance of informed opinion holds that we inhabit a universe teeming with life. The only matter for speculation is whether we yet possess the technology necessary to detect it. The emphasis here is on *yet*. Most of us contemplating such a detection no longer argue "if," but rather "when."

Drake subsequently distinguished himself as Director of the famed Arecibo Observatory, from which he orchestrated the Arecibo Message, humankind's first deliberate microwave transmission to the stars. His astronomical research has led to important discoveries about pulsars and Jovian radio emissions. A retired academic, he is today recognized as the godfather of observational SETI. Much in demand as a speaker at scientific meetings, Frank remains deeply involved in SETI science fully a half-century after Project Ozma, serving as a Director of the SETI Institute in California, and on the scientific advisory board of the non-profit SETI League.

This, then, is Project Ozma's legacy: It, and Frank Drake, have turned science fiction into credible, respectable science.

73, Paul, N6TX

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