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Fall 2007

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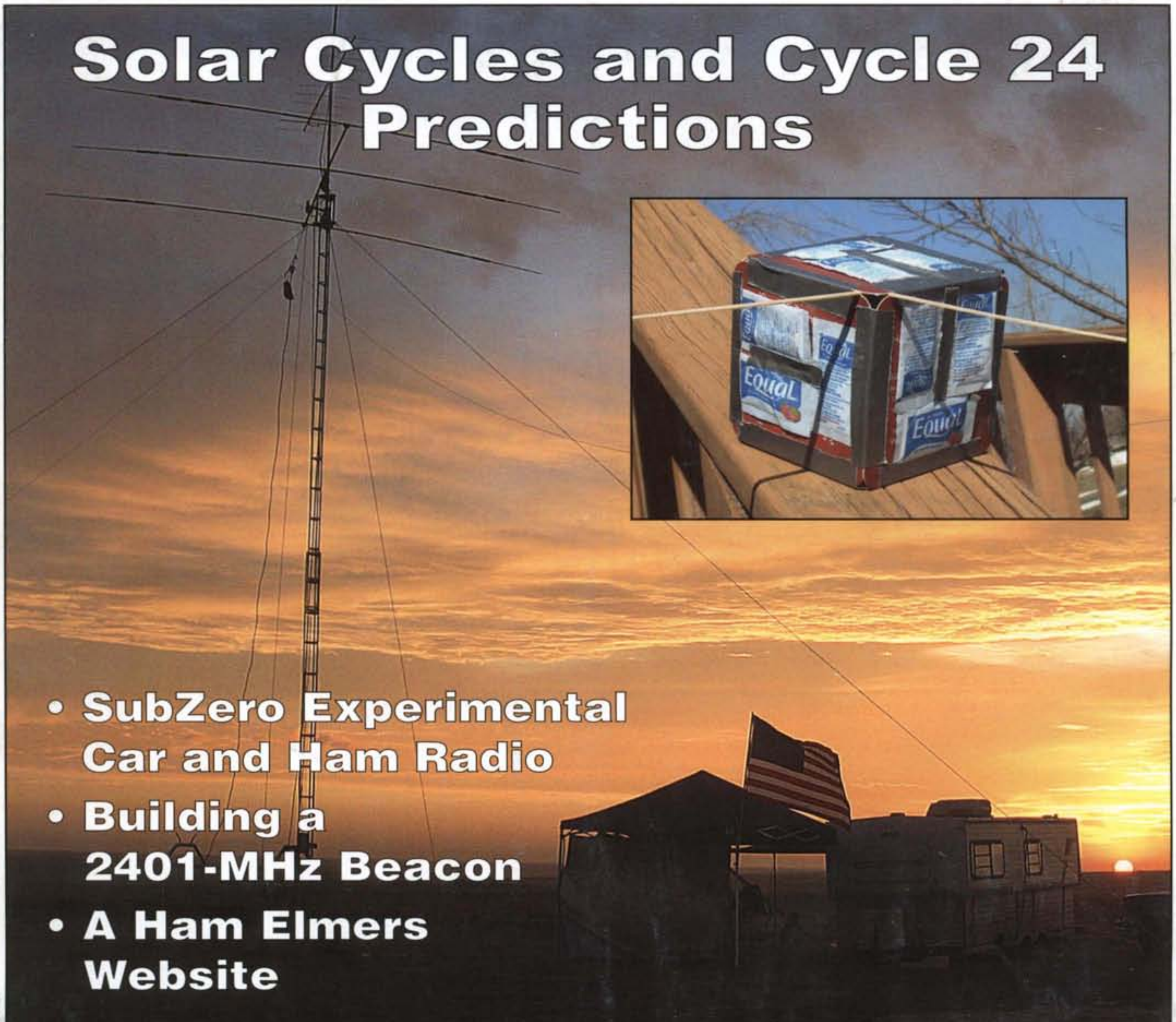

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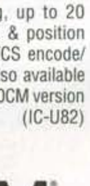

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contents

Fall 2007
Vol. 10 No. 3

FEATURES

COLUMNS

DEPARTMENTS

On The Cover: Sunset on Mount Sunflower, Kansas, at the site of the K4S effort in the 2007 14er event. For more information on the K4S operation and the one from atop Pikes Peak, Colorado, see the "FM" column on page 58. *(Photo by Bruce Frahm, KØBJ)* Inset: CoasterSat I, a new AMSAT lab's first "satellite." For details see Paul Shuch, N6TX's "Orbital Classroom" column on page 79. *(Photo courtesy of N6TX)*

CQ VHF Ham Radio Above 50 MHz

LINE OF SIGHT

A Message from the Editor

Doing a Better Job of Telling Our Stories

This past August 16–17, my wife Carol, W6CL, and I were among the nearly one hundred participants at the 2007 Global Amateur Radio Emergency Communications Conference (GAREC-07), which was held in Huntsville, Alabama during the run up to the Huntsville Hamfest. This was the third such conference, and the first one to be held in the U.S. (the other two were held in Europe). Among the participants were representatives from the IARU, the ARRL, Army MARS, American Red Cross, Southern Baptist Disaster Relief, Department of Homeland Security, The Salvation Army, a Coast Guard auxiliary, as well as many appointees from the ARRL field organization. International participants came from Ireland, France, Bulgaria, Finland, The Netherlands, South Africa, Brazil, Canada, and Trinidad and Tobago. I was fascinated by the various stories told of amateur radio involvement in emergency communications.

This past September 28–29, I attended the Western Region NASA Space Grant Consortium conference, which was held in Oklahoma City, Oklahoma. Participants included directors of most of the state NASA space-grant consortia west of the Mississippi River, along with Louisiana. Also participating were affiliates of these various space-grant consortia, as well as NASA officials and faculty fellows affiliated with NASA.

I again was fascinated by stories told by the various participants of student involvement and student-driven projects taking place throughout the country. One such story was told by Mike Voglewede, a teacher at Northwood Public School, in Northwood, North Dakota. Northwood was in the news recently because of the August 26, 2007 devastating category four tornado that nearly destroyed the town. In the aftermath of the tornado, Mike spoke of the past and the future for his school. The immediate future for the school is it was so totally destroyed that it will have to be completely torn down and a new school built in its place.

What was not destroyed, however, is the spirit of several of the students who have participated in Northwood's after-school program. Here is their story, thanks to the efforts of Mike, his wife, and others in the school and the community.

It was about a half dozen years ago when Mike had the idea to bring robotics to the classroom—after school. Robotics is the study and building of robots for various tasks. What is important about learning robotics is that robots increasingly are being used throughout industry to perform a variety of small and large tasks.

Robotics as a subject is one that both excites and educates youth. It excites youth because it is hands on. Young people build projects to accomplish tasks and in the process learn a number of skills, including creative thinking and working together in teams—in other words, learning how to cooperate with others in order to accomplish a task, something about which we adults sometimes need refresher lessons.

While robotics is an excellent teaching device, it is a non-traditional subject for many public K-12 schools that are constrained by the "no child left behind" mandate, with which most of today's public schools now must comply. Such was the case with Northwood Public School. Undaunted by this constraint, Mike and his friends decided to develop an after-school program centered on robotics. In time, the program almost took on a life of its own. The after-school program lasted from 3:30 in the afternoon to 9:30 at night. The parents got on board and began a rotational meal-serving program. The PTA went from a few in attendance to hundreds, and not all of them parents. Local industry got involved in the school, with businessmen and tradesmen becoming mentors for the students. At its peak, there were more Northwood students involved in the robotics after-school program than were on the football team.

Their hard work has paid off. Teaming with nearby Hatton Public School and entering multiple competitions, the robotics team has won many awards over the past several years.

While the tornado set back the program a bit, it has not stopped it nor kept outside sources from supporting it. For example, as demonstration of the faith it has in the robotics program, the North Dakota Space Grant Consortium awarded it a special $5,000 grant to rebuild the robotics library.

While the robotics story is not directly related to amateur radio, one can easily see that amateur radio could become a part of it, or a similar program that incorporates amateur radio could be started in another school. Perhaps Mike's story might inspire you to start one in your local school.

What I found to be in common between these two conferences was that while participants in both conferences were very good at telling each other their stories, they seemed to be unable to tell their stories to others outside of their peers. For example, apart from my mention of the GAREC-07 conference in my column in the November 2007 issue of *CQ* magazine and the article posted online at the ARRL's website (http://www.arrl.org/news/stories/2007/08/24/102/), very little publicity has been given to the many stories that have emerged from that conference. Furthermore, apart from its mention here, to date none of the other amateur radio media has covered the Western Region NASA Space Grant Consortium conference.

The tragedy of this lack of publicity is that both venues are sources of great stories concerning amateur radio or potential amateur radio involvement. Regarding GAREC-07, in the aftermath of 9/11 and Hurricane Katrina, one of the two emerging stories in amateur radio is the huge resources that its operators can commit to emergency communications—resources that heretofore have not been matched by the professionals at any level.

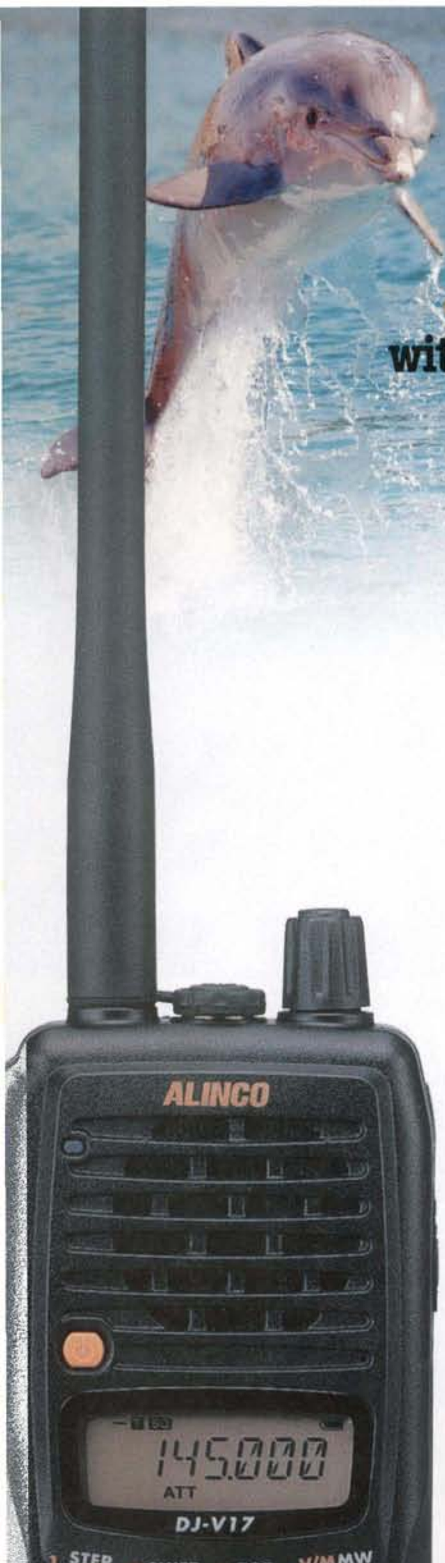
The other emerging story in amateur radio is education. Regarding amateur radio and education, the NASA Space Grant Consortium program is a very large source for such stories. You have already read stories of amateur radio involvement in the consortium in previous issues of *CQ VHF* magazine. One example is Professor Kevin Carr, KE7KVT's story "Through the Back Door: A Teacher's Journey into Amateur Radio," which appeared in the Spring 2007 issue. Kevin's employer, George Fox University, is an affiliate of the Oregon Space Grant Consortium. Ironically, when I showed Kevin's article to Jack Higginbotham, OSGC's director, he was totally unaware of the national publicity that GFU had received via this magazine.

My point in this editorial is that we need to do a better job of telling our amateur-radio-related stories. No one else is going to do it for us—except perhaps your doggedly persistent editor. Yet even with my single-handed efforts, I still cannot discover or uncover all of your stories. In order to do so, I need your input—either by way of an article in *CQ VHF* magazine or a few paragraphs in my column in *CQ* magazine.

Therefore, if you have a story to tell, then please write it and get it to me. If you have a story lead, then send it to me and I will track it down. Please contact me via my e-mail address (n6cl@sbcglobal.net) with your story or story idea. I look forward to hearing from you in the very near future.

Until the next issue…

73 de Joe, N6CL



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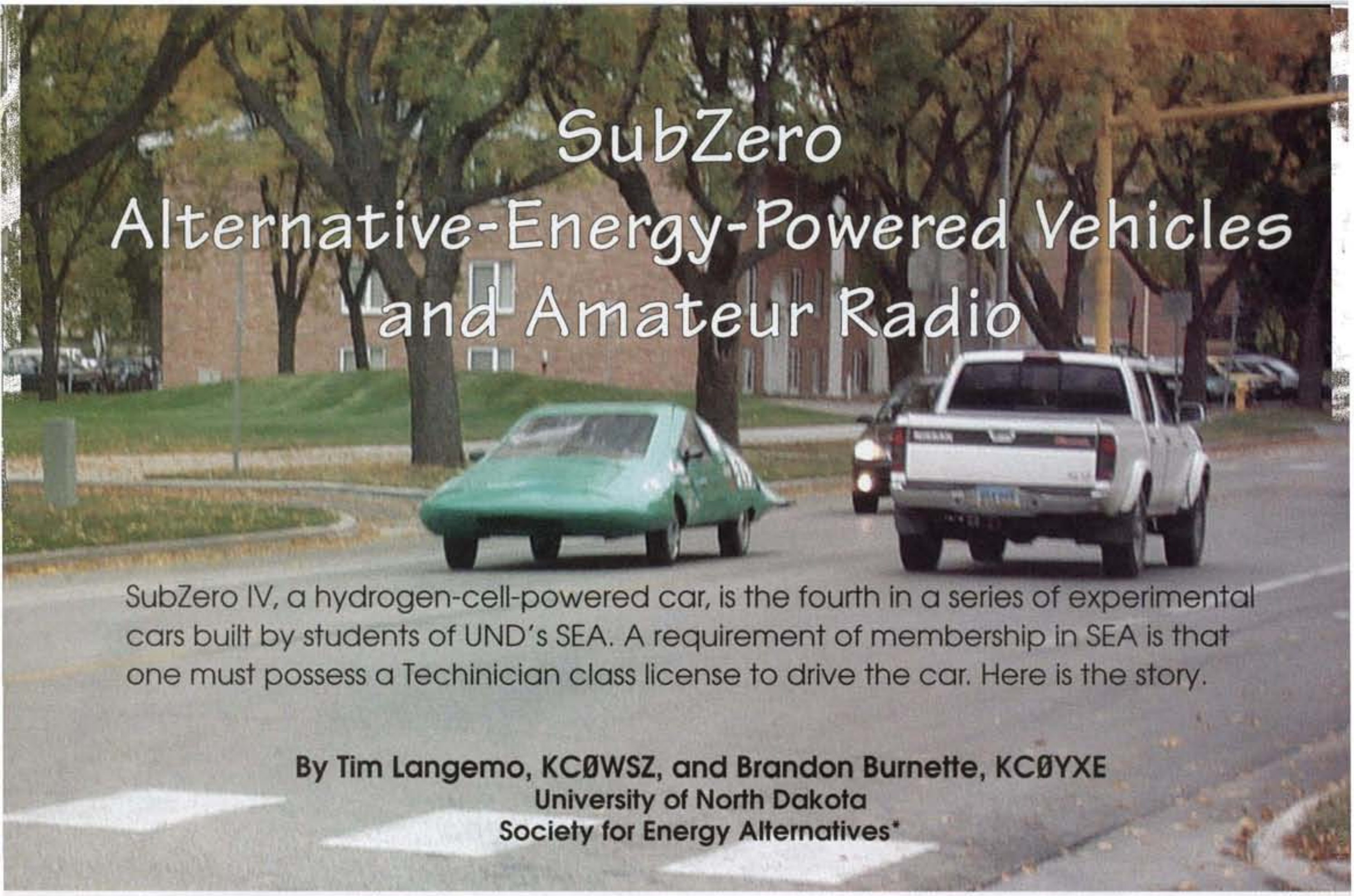
SubZero
Alternative-Energy-Powered Vehicles and Amateur Radio

SubZero IV, a hydrogen-cell-powered car, is the fourth in a series of experimental cars built by students of UND's SEA. A requirement of membership in SEA is that one must possess a Techinician class license to drive the car. Here is the story.

By Tim Langemo, KCØWSZ, and Brandon Burnette, KCØYXE
University of North Dakota
Society for Energy Alternatives*



SubZero IV H_2 travels down the road with a chase vehicle close behind.

Rising gas prices have been in the headlines for the past several years, and better gas mileage seems to be on almost everyone's mind. What can be done to reduce our dependence on foreign oil? While many theories on this subject exist, we have come across one in particular with which we agree—hydrogen.

The Society for Energy Alternatives (SEA) is a student organization at the University of North Dakota that includes students from every college on campus. Founded in 1996, our group has sought to utilize various alternative fuel sources, such as solar power and now hydrogen, in transportation applications. After building three solar cars (SubZero, SubZero 2, and SubZero 3) between 1996 and 2001, SEA began looking for a new, more viable fuel source for use in a transportation setting.

The sun does not always shine thanks to the rotation of the Earth, making solar-powered vehicles impractical. Clouds and rain can also affect the performance of solar cells. Add in the infant-like fragility, and it becomes fairly clear that a different direction is needed. Compressed hydrogen gas offers a solution to this problem. Hydrogen is very clean and contains a higher density of energy than gasoline or even ethanol at a given volume. When properly stored, it is no more dangerous than the gasoline or diesel fuel that powers almost every vehicle on the road today.

**The Society for Energy Alternatives, 243 Centennial Drive, Grand Forks, ND 58202*
phone: 701-777-4110
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website: <www.und.edu/org/sea>

Our group settled on the use of a hydrogen proton exchange membrane (PEM) fuel cell for our fourth alternatively fueled vehicle, SubZero IV H_2. The car, designed between 2002 and 2004 and built during the 2005 academic year, was the first fuel-cell powered vehicle to be built from the ground up by university students in the United States.

Powered by a 10-kilowatt Hydrogenics fuel cell, the drive train includes a bank of ultracapacitors and a 7-hp DC brushless motor. The single-wheel drive manages to propel SubZero IV H_2 to a blistering top speed of 45 mph. The ultracapacitors provide an electrical buffer for the fuel cell when the electric motor is engaged, as well as a source of emergency power so that the car may be pulled safely off the road should it become necessary to shut down the fuel cell while operating the car.

During July 2005, the team participated in the North American Solar Challenge. The race covered 2,500 miles of public highways between Austin, Texas and Calgary, Alberta, Canada. Seventeen solar-powered vehicles participated in two classes, along with one hydrogen fuel-cell car operating in a demonstration class. While our car did not finish the competition in first place overall, we managed to win our class in our first attempt with the fuel-cell car. Some will point out that we also finished last in our class. Overall, the vehicle placed 14th, beating four solar cars over the 2,500-mile competition.

Along the way, we achieved an observed highway fuel economy of 125 miles per kilogram. Hydrogen is measured in kilograms, where one kilogram of hydrogen has the approximate energy equivalency of one gallon of gasoline. With about 2 kg of on-board storage capacity, we were able to go 250 miles per fill, not much different than the average auto-

Local school children line up to sit in the driver's seat at an annual science day in Grand Forks, ND. The rig was turned off, so the repeated use of the push-to-talk button by the children did not produce any spurious transmissions.

mobile. If our team had access to a hydrogen compressor, we would be able to pressurize our tanks to their rated 5,000 psi and have an on-board storage capacity of about 4 kg, enough to travel about 500 miles.

When SubZero IV H_2 is being operated on public roads, the State of North Dakota requires that a "chase vehicle" follow it with flashing amber lights to warn other motorists of the presence of an experimental vehicle. In addition, our team uses a lead vehicle with flashing amber lights to lead the convoy around, and notify the driver of the fuel-cell vehicle about any changes in road conditions. All three vehicles keep in contact over the amateur radio bands. Over the years, our team has tried using FRS, GMRS, and CB for communications. We found that these systems just did not have the range and reliability that we demanded of them. We found that 2-meter simplex transmissions met our criteria quite well. Because we utilize the ham bands, in addition to needing a driver's license to operate SubZero IV H_2, a Technician class license is needed as well.

At the beginning of the fall 2007 semester, our team had over 80% of our members licensed to operate the Technician class bands. Our unlicensed team members who have joined the group this semester all are encouraged to obtain their Technician license. With a large pool of members, plenty of help is available to teach the principles that an operator needs to know to obtain a license. Also, with the recent elimination of the Morse code requirement, some of our members have expressed interest in upgrading to earn some HF privileges in addition to the frequencies available on the Technician bands.

Our team does not require the members to obtain their own rigs to operate on the bands. We have several mobile radios/antennas, as well as a couple of handhelds that our licensed members are welcome to check out at any time. This gives them a chance to learn to operate outside of the organization and make contacts with people they don't see at team meetings every week. Several members have gone on to purchase their own rigs, which in turn frees up other radios for other members to use.

Outside of the organization, many of our members have become more active with not only the local FORX radio club in Grand Forks, North Dakota, but clubs in their home towns when they are on summer break. Field Day 2006 was Tim's first exposure to the real world of amateur radio, only about a month after getting licensed as KCØWSZ. SubZero IV H_2 was hooked up to the SSB radio so the club could receive points for alternative-energy use. Watching Charlie, KIØLS, and Dick, KAØHDN, make five contacts in what seemed like the blink of an eye, he was "bitten by the bug." Field Day 2006 was cut short for Tim and a few others from the team when they needed to attend the wedding of two alumni from the team.

A few of our members got the chance to show SubZero IV H_2 at the Dayton Hamvention® in April this year. It was a great experience for us. We were able to share our experience with anyone who stopped to look at our car. The Hamvention® is the largest expo we have been to in terms of attendance. Because of that, we were exposed to a large variety of people from all over the country and the world. By nature, ham operators are innovative people. Our team requires innovation to be successful. People walked up to us and after getting the basic rundown

Brandon, KCØYXE (left), shares his experience with hydrogen fuel cells with North Dakota Congressman Earl Pomeroy (center).

Josh, KCØUBH (left), and Craig, KCØYXC (right), explain the operation of the car to tailgaters before a University of North Dakota football game.

on the project, started asking questions. Before the Hamvention®, we had never been asked a question about the project that we could not answer. Two questions were fielded to us that sent us home searching for answers. It felt great to ponder something about our car during the drive home.

Field Day 2007 was another great experience for some of our members. College students make good laborers for moving things such as generators, setting up the guy wires for the antennas, and hauling in the food after the grocery store run. After getting all set up, the real fun began. Tim, KCØWSZ, and Trent, KCØYXH, spent most of the day with Rod, KEØA, logging contacts at the CW station. Even though the FCC dropped the Morse code requirement for the General class license, we have members who have expressed an additional interest in learning code when they can get a break from their studies.

Late this summer, severe weather threatened the greater Grand Forks area. Tim, along with fellow team members Trent and Sarah, KCØUKW, went out to the National Weather Service and began to learn the procedures that are followed by the SKYWARN net control operator. When SKYWARN training rolls around in the spring, all of our members will be encouraged to attend.

This fall we are beginning work on our fifth car, SubZero V. This next vehicle will be a departure from some of our previous projects. However, this does not mean that we will be severing our connections to the ham radio community. Subzero V, like our previous vehicle, will use a power system to which we are not accustomed. It was decided that a hybrid drive system would be the power source for our next vehicle, incorporating and synchronizing two systems to create a drive train that is greater than the sum of its parts. We will use this vehicle to compete in the 2008 Society of Automotive Engineers (SAE) Formula Hybrid competition. The change of venue was brought on by several factors, but most of all we relish this opportunity to put our ham ingenuity to use towards the electrical system design.

Data acquisition has always been important to our program, as it is with any engineering endeavor. In the past, data has been extrapolated based upon vehicle performance and known input. For our newest vehicle we plan to use real-time electronic data acquisition over amateur radio frequencies. This will allow us to record vehicle metrics throughout the various events at the competition.

For those of you who are curious, or happened to ask us about it at the Hamvention®, APRS has not been utilized in any of our projects. This is an additional aspect of amateur radio that we are considering adding to our current project.

Upon graduation, our average member will have seven years left on his or her amateur radio license. We hope the skills learned operating amateur radio in our organization will carry through to our endeavors after we depart from the University of North Dakota.

Field Day 2006. Organization alumni Anna Vosgerau Severson, KCØNDB, and Keith Severson, KCØUIT, left the wedding chapel in the SubZero IV H_2.

Author Bios

Tim Langemo, KCØWSZ, from Minot, ND, earned his Technician license in May of 2006. He is a junior at UND and has been a member of SEA since the fall of 2005. Tim is the Project Manager for SubZero V. He will graduate in May 2009 with a B.B.A. degree in Information Systems.

Brandon Burnette, KCØYXE, from Minnetonka, MN, earned his Technician license in November 2006. He is a senior at UND and has been a member of SEA since the spring of 2005. Brandon is a past-president and acting vice president of the organization. He will graduate in December 2008 with a B.S. degree in Industrial Technology.

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Solar Cycles and Cycle 24 Predictions

Based on a paper presented at the 41st Central States VHF Society Conference in San Antonio, Texas on July 28–29, 2007, KH6/K6MIO begins this article with the *F*-layer and the Sun. He then discusses and summarizes the various predictions of solar Cycle 24 that have been made to date. Significant portions of this article also appeared in the *Proceedings* of the above-mentioned conference.

By Jim Kennedy,* KH6/K6MIO
Gemini Observatory, Hilo, Hawaii

On 6 meters, F_2 propagation can produce dramatic results. The *F*-layer is ionized primarily by extreme ultraviolet (EUV) radiation from the Sun. The intensity of solar EUV is strongly dependent on the phase of the solar activity cycle. Unfortunately, the average level of solar EUV is not sufficient to raise the maximum usable frequency (MUF) above 50 MHz. Consequently, 6-meter *F*-layer propagation is confined almost entirely to the *peak* years of the solar activity cycle.[1]

Managing radio propagation, satellite health, and power-grid issues all lead to an interest in predicting future solar activity, on both short and long time scales. There are actually two intimately related "solar cycles": the *activity* or "sunspot" cycle and the solar *magnetic* cycle.

Solar Activity Cycle

The sunspot cycle peaks roughly every 11 years. Sunspots are always found in pairs or groups. The spots and groups occur in two latitude bands, one north and the other south of the solar equator (Figure 1). They come and go within those latitude bands with end-to-end lifetimes of a few days to several weeks.

As will be shown in this article, sunspots are the visible effects of loops of powerful magnetic fields arising from within the Sun that have then floated up and bulged out above the Sun's visible surface (Figure 2).

The east-west leading spot(s) in a pair (or group) have the opposite magnetic polarity from that of the trailing spot(s). If the leading spots in the Southern Hemisphere band have one polarity, then the leading spots in the Northern Hemisphere band have the opposite polarity—that is, the direction of the field between the leading and following spots in the south are opposite of those in the north (Figure 3).

As the Sun rotates on its axis every 27 days or so, sunspot pairs and groups appear to march across the Sun from east to west, being visible for up to 14 days as they travel from limb to limb and then rotate out of sight around the far side. If they live long enough, they return to the near side about 14 days later.

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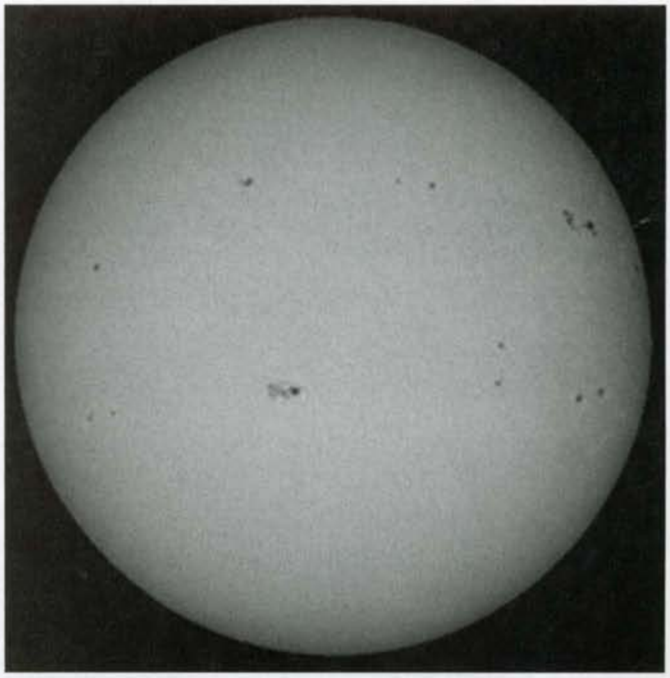


Figure 1. The Sun as seen by the National Solar Observatory (NSO) at Kitt Peak near Cycle 23 solar maximum on April 3, 2000. Note the two bands of sunspots north and south of the solar equator. (Credit: NSO/AURA/NSF)

Old Cycle, New Cycle

Each "new" activity cycle begins at the *minimum* after the preceding solar maximum. Near the minimum, the few remaining "old-cycle" spots are found in their two latitude bands, now very near the solar equator (about 5 degrees north and south).

On the almost spotless Sun, the new cycle begins when spots begin to appear in two *new* bands about 30 degrees north and

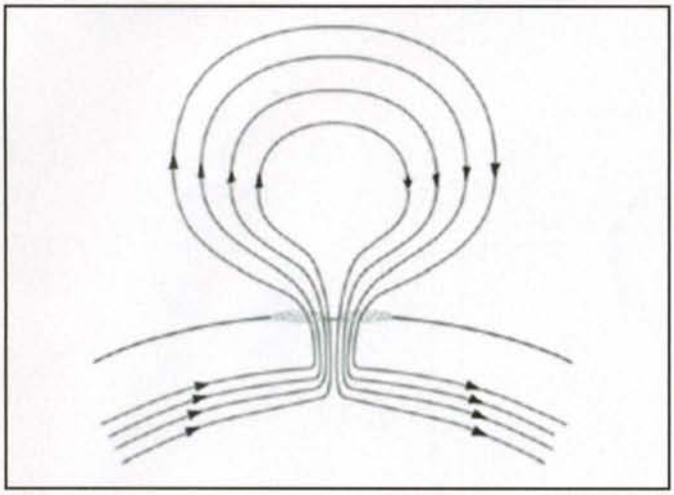


Figure 2. When magnetic-field lines within the Sun erupt through the surface, they form loops creating sunspot pairs. The leading spot at the surface has one polarity and the following surface spot has the other polarity, as indicated by the direction of the arrows.

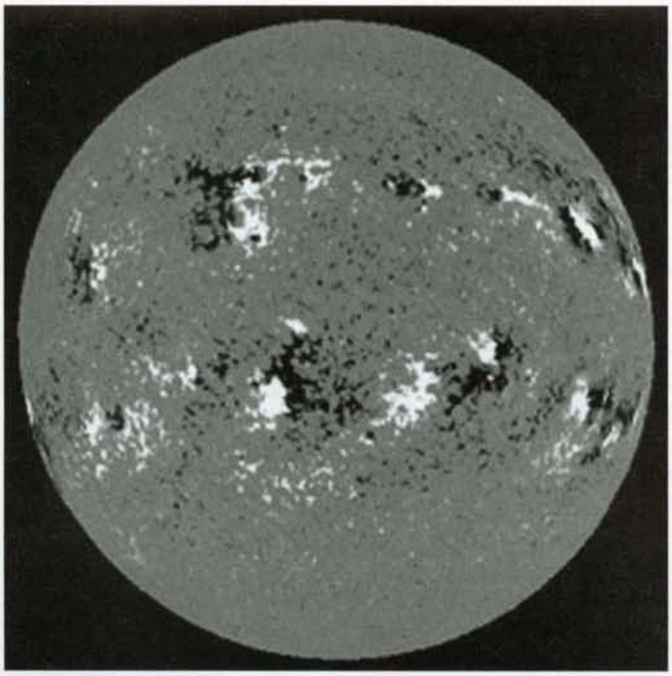


Figure 3. An NSO solar magnetogram, also from April 3, 2000. It shows the magnetic strength at the surface. White is polarity pointing out of the Sun, and black is pointing into the Sun. Note that the northern and southern leading-trailing patterns are reversed. (Credit: NSO/AURA/NSF)

south—with opposite polarities from the old-cycle spots. Thus, the old and new cycles actually overlap each other for a period of time. Their latitude bands and polarities distinguish between the old- and new-cycle spots. Curiously, new-cycle spots generally do *not* appear at the same time in both the Northern and Southern Hemispheres (more later).

As the cycle progresses, the new-cycle spots appear in increasing numbers, with their higher latitude bands slowly moving closer and closer to the equator. By solar maximum, the bands are centered on about 15 degrees north and south latitude. As the cycle wanes, the old-cycle spot count decreases and the two bands move to within about 5 degrees of the equator.

Cycle Strength

The amplitude of a cycle is measured by various indices. The most common one today is the international sunspot index[2], R_i. Another common index is the 10.7-cm radio flux, F10.7. Both indices are quite valid, but have different values. Only R_i will be discussed here, just to simplify the presentation.

Solar Magnetic Cycle

The *activity* cycle, with its sunspots, solar flares, and coronal mass ejections (CMEs) is the result of an underlying cycle of *magnetic* activity within the Sun. The period of the solar magnetic cycle averages about *22* years.

On very large scales, the Sun has a global average magnetic field of about 1 gauss. It is basically a *dipole with its axis passing through the poles.* During solar maximum, every 11 years or so, the polarity of the *polar* field flips direction. As a result, it goes through a complete cycle, pointing from north to south and then back to north again about every 22 years. Each *magnetic half-cycle* produces a peak in solar activity, producing the 11-year *activity* or sunspot cycle.

The magnetic cycle is the result of the recurring evolution of large-scale plasma flows inside the Sun. These flows of charged particles interact to produce a kind of *dynamo.* By concentrating the small overall magnetic field into relatively small volumes, the dynamo produces locally intense magnetic fields, typically a few thousand gauss and sometimes greater than 6,000 gauss. These strong local fields lead to solar activity in the form of sunspots, flares, and other particle and radiant emissions.

Understanding the details of these complex interactions and why they lead to cyclic solar activity has been a "holy grail" in solar physics for a long time. Thanks to the evolution of some very clever technologies, much progress has been made in the last two or three decades in shedding light on these mysterious processes. *Any successful solution to the problem must account for all the effects described above.*

Convection Zone

The outer 30% of the Sun is a seething convection layer. As heat moves up from the fusion core, it reaches a level where the gases are convectively unstable (like the hot air rising in a summer thunderstorm). Giant updrafts within the convection zone carry heat up to the surface of the Sun, where it is released into space. Then the cooled gas sinks back down, to be reheated and rise again.

Since the convection zone is gaseous, it does *not* rotate as if it were a solid object. The equatorial regions rotate faster than the polar regions. Thus, the gases at the equator take about 25 days to rotate all the way around the Sun, but it takes about 35 days near the poles. This effect is called *differential rotation.*

Rising Cycle

At the beginning of a cycle the Sun's whole magnetic field is essentially the polar dipole. However, the lines of force that flow through the Sun, from pole to pole, cannot remain long as simple straight north-south lines. Differential rotation in the convection zone drags the embedded magnetic fields in *equa-*

torial regions westward, out ahead of the same lines of force nearer the poles, eventually wrapping them around in the interior parallel to the equator, like string around an axle (Figure 4).

After a few months, this transforms the north-south polar magnetic field into two east-west *toroidal* field bands, one north and the other south of the equator (figure 4d). These two bands have opposite polarities: one is pointed around in an east-west direction and the other in a west-east direction.

Thus, the reason that the sunspots are found in two latitude bands is that they are spawned from the two toroidal fields that lie beneath the sunspot bands. Eventually, fragments of the toroidal fields float up and break out above the surface in big loops, as shown in Figures 2 and 5. At each foot of the loop is a sunspot, together forming a sunspot pair. Multiple fragments sometimes result in very complex sunspot groups.

Solar Maximum

As the cycle continues toward maximum, more and more of the polar field is converted into the two toroidal fields, and they and their sunspot bands move closer to the equator. When the toroidal field is at maximum strength, so also is the amount of energy "leaking" upwards into the sunspot-causing above-surface field loops.

Solar maximum occurs when all the available polar-field energy has been converted to the two toroidal fields. At this point, having been sucked down to zero, the polar field passes through zero and *reverses* its polarity to produce a very weak field in the opposite direction. Thus, the *polar-field reversal* is closely associated with the solar maximum.

North Cycle, South Cycle

The northern and the southern polar-field reversals can occur many months apart. The two hemispheres' toroids usually don't reach solar maximum at the same time. One hemisphere often leads the other (see figure 9). This is the reason why new-cycle spots don't appear at the same time in both hemispheres.

Therefore, each hemisphere has its own cycle and timetable. The periods are similar, but the phases are not exactly the same. The two phases shift in time, but they resynchronize from time to time, since they are coupled through their reliance on the same pool of total solar magnetic energy. When the time lag is long between the north and south peaks, a *double-peaked maximum* occurs.

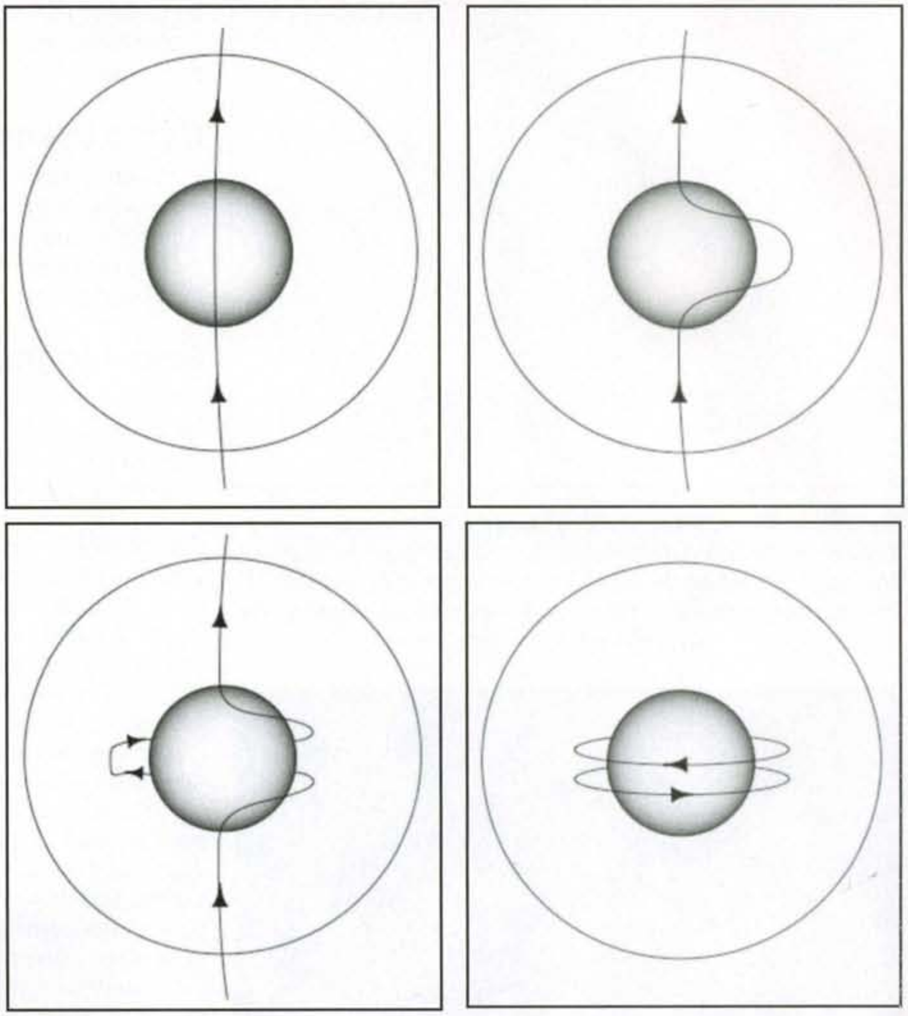


Figure 4. Frames "a" through "d" show how convection-zone differential rotation wraps the polar dipole magnetic-field lines into oppositely sensed toroidal field lines at low latitudes north and south of the equator.

The double peak in Cycle 23 is a consequence of the Northern Hemisphere peak leading the south by about a year. When north and south are *in phase,* a single peak occurs. When they are in phase and both north and south peaks are strong, one gets a powerful cycle, as in Cycle 19 in 1958 ($R_i = 201$)[3]; see Figure 6.

Declining Cycle

Once solar maximum is reached, the respective toroidal fields at the root of the sunspots begin to *weaken,* and the strength of the now-reversed polar field begins to *increase* in strength. The two magnetic toroids continue to move closer to the equator taking their families of sunspots with them, but in ever decreasing numbers.

Finally, as the current activity cycle nears an end and its two magnetic toroids are about to fade out, new toroids appear much farther north and south. The first few furtive spots of a new cycle flash briefly into existence, and nature's cycle begins to repeat. The National Solar Observatory (NSO) saw what was *thought* to be the first unequivocal Cycle 24 sunspot pair on July 23, 2006, but little else has been seen since.

Conveyor Belt

Still, key questions remain. Why does the polar field actually reverse sense and then build up? Why doesn't the activity just remain at maximum for all time after that?

Although the cause is not clear, observations show significant north-south plasma flows in the convection zone between the equator and the poles. There is a large-

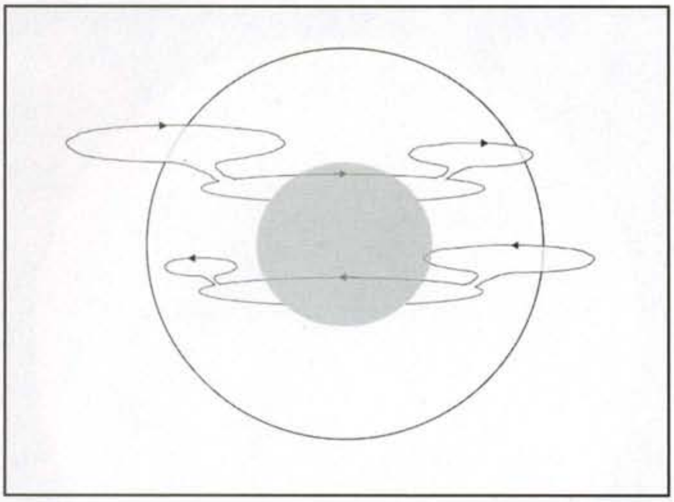


Figure 5. When bulges in the two toroidal field rings become large enough to break through the solar surface, they expand into large loops above the surface and leave a sunspot pair at the points where the field punches through the surface. For simplicity, only one toroidal field-line loop is shown in each hemisphere.

scale upwelling of plasma near the equator that then flows near the surface both north and south toward the poles. Near the poles the gas sinks, and then flows back toward the equator again, now deep in the convection zone. Since these circulation patterns flow along longitude meridians, they are referred to as *meridional flows,* shown schematically in Figure 7.

The meridional flows are the conveyor belts that drive the solar cycle. They drag leftover surface fields from old sunspots toward the poles and then suck them down deep in the convection zone and back toward the equator. These "old" fields will form the *nuclei* for the next generation of sunspots. Curiously, the Southern Hemisphere conveyer belt flow has been running much slower than the Northern Hemisphere flow for a number of years now. This is the apparent reason why the southern polar reversal has trailed the north for the last two or three cycles.

The Sun's Magnetic Memory: It takes 30 to 50 years for the conveyor belt to make one complete circuit. Since the new-cycle spots reappear at about 30 degrees latitude, they only ride the conveyor part way around. Even so, it takes something like twenty years before some of them reappear. Thus, the "remembered" field fragments from at least the last two cycles (and maybe more) "seed" the current cycle's sunspots and active regions.

Predicting Cycles

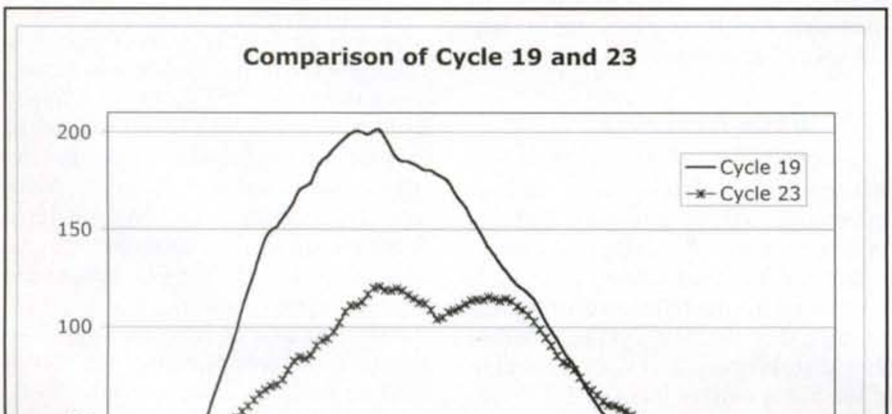
Since the past history of solar activity seems to play a role in the evolution of future activity, today it is reasonable to assume that one could find ways to make accurate long-range forecasts.

This has been an underlying assumption in past prediction efforts as well. However, without understanding how the past and future were *physically* connected, there has been much disagreement about which of the measurable characteristics are the most important.

In principle, there are two broad approaches to predicting future solar cycles, statistics and physics. The parameters one might predict would include: the maximum amplitude of the cycle (e.g., the smoothed sunspot number Ri), the date of the peak, and the length of the cycle. Table 1 shows some actual values from the last five peaks.

Until the last couple of cycles, very little was directly known about the details below the visible surface of the Sun, simply because those regions could not be seen or measured. For decades the only prediction approaches were based on statistical relationships seen in previous cycles. This still remains the most common approach today. However, today there is one novel method that applies actual solar interior data to a physical model of the Sun's interior structure.

Currently there are more than twelve different published professional predictions of the characteristics of Cycle 24; almost all are of the statistical variety. These various methods produce answers that range from a very strong maximum, perhaps a year earlier than expected, to one of the weakest on record—and everywhere in between.



Statistical Methods

One approach is to amass a database of the solar and terrestrial observables from as many past cycles as possible. These might include the length of the cycle, the rate of rise and fall of the cycle amplitude, peak amplitude of cycle maximum, amplitude and polarity of the global field, intensities of the local magnetic fields, and various geomagnetic indices.

Then, one could look for statistical correlations among these different factors in different cycles. If a dependable set of correlated factors were found, then

Figure 6. Cycles 19 and 23, respectively, are good examples of single- and double-peaked cycles. Notice the delay in even the first peak of Cycle 23 with ← respect to Cycle 19.

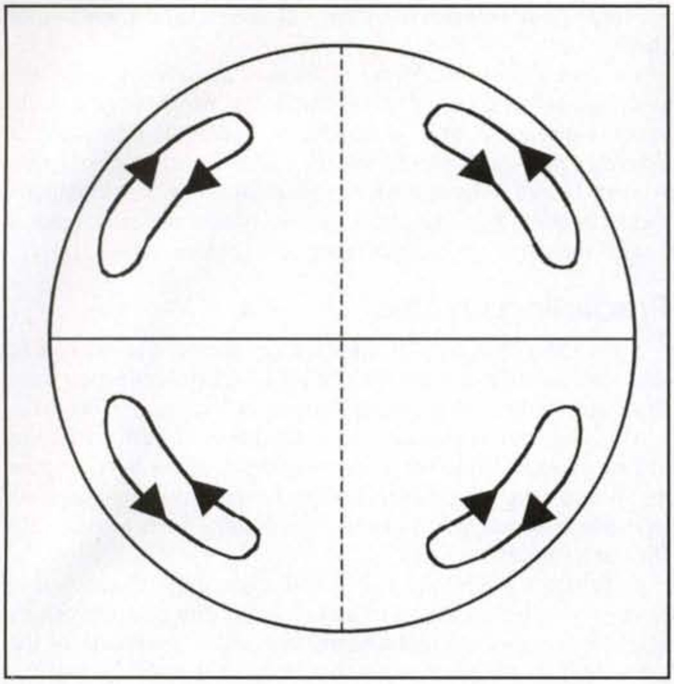


Figure 7. The meridional circulation currents of near-surface plasma from the equator to the poles trap residual magnetic fields from "dead" sunspots that are recycled into future solar cycles, perhaps one to three cycles later.

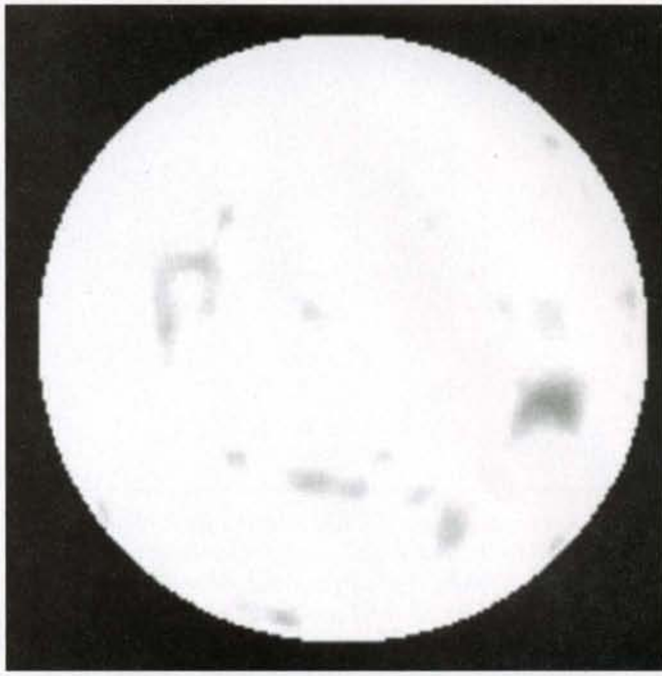


Figure 8. A GONG "image" of near-surface active regions on the Sun's far side. Clever data processing of seismic waves within the Sun permit this "x-ray" view through to its far side. The large feature on the right just below the equator emerged as a nearside sunspot group four days later. (Credit: GONG/NSO/AURA/NSF)

one could use those relationships to predict the values of a future cycle.

The 240-Year "Cycle." As an example of a *statistical* approach, there seems to be a pattern in the solar cycle *lengths* with a period of roughly 240 years. With some fluctuations, cycles tend to get shorter for about 120 years, then tend to get longer for about 120 years, and then the pattern appears to repeat. Since Cycle 14 (beginning in 1902) the trend generally has been toward shorter cycles.

Weighted Averages. Another straightforward example of the statistical approach is that of John Kennewell at Australia's IPS Radio and Space Services. He currently uses a system based on weighted averages of the characteristics of a few recent cycles.

Wilson's "Rule." Predicting the date of the next maximum could also depend on the date of the *preceding minimum.* Known as "Wilson's Rule," recent solar cycle minimums usually occurred about 34 months *after* the first full day with *no visible spots* on the Sun.

Dave Hathaway, at NASA's Marshall Space Flight Center, notes that the first spotless day of Cycle 23 occurred on January 28, 2004. Based on Wilson's Rule, the Cycle 23 minimum should have occurred in November or December 2006. This date is consistent with the recent trend toward short cycles, mentioned above. However, the minimum did *not* occur in 2006. If it had, it would have suggested that the Cycle 24 maximum would occur in late 2010.

Four Years After Minimum. The solar minimum date is also important because the next maximum usually occurs about four years after the minimum. In any case, almost all prediction methods get pretty good once the new cycle actually starts and some real data starts to accumulate.

Precursor Methods

Several seasoned researchers hold that the *precursor* prediction methods are among the best. These methods are based on the hypothesis that the configuration of the Sun during one cycle determines the major features of the Sun during either the next cycle or the one after that. Without access to the details of the Sun's current internal configuration, precursor methods look for gross measurable indices as "proxies" for the real physical details.

Geomagnetic Precursors. Some of these methods rely on variations of the geomagnetic aa[4] index at the preceding solar minimum as a predictor of the following maximum, such as one by Joan Feynman at NASA's Jet Propulsion Laboratory. Richard Thompson, recently retired from IPS Radio and Space Services in Australia, uses the number of days during the previous cycle that the geomagnetic field was disturbed. More recently, Hathaway and Wilson have developed a hybrid method that incorporates parts of both the Thompson and Feynman approaches.

Cycle	Date Max	R_i Max
19	Mar. 1958	201
20	Nov. 1968	111
21	Dec. 1979	166
22	July 1989	159
23	Apr. 2000	121
24	?	?

Table 1. Comparison of recent cycles.

Solar Precursors. Some time ago, Ken Schatten, at Ai-Solutions, Inc., constructed an index relating to the Sun's buried dynamo fields. He assumed that if geomagnetic effects have some prediction success, then actual solar magnetic fields measurements should work even better. He uses an index that tracks the total magnetic field, including both the polar and toroidal components. Leif

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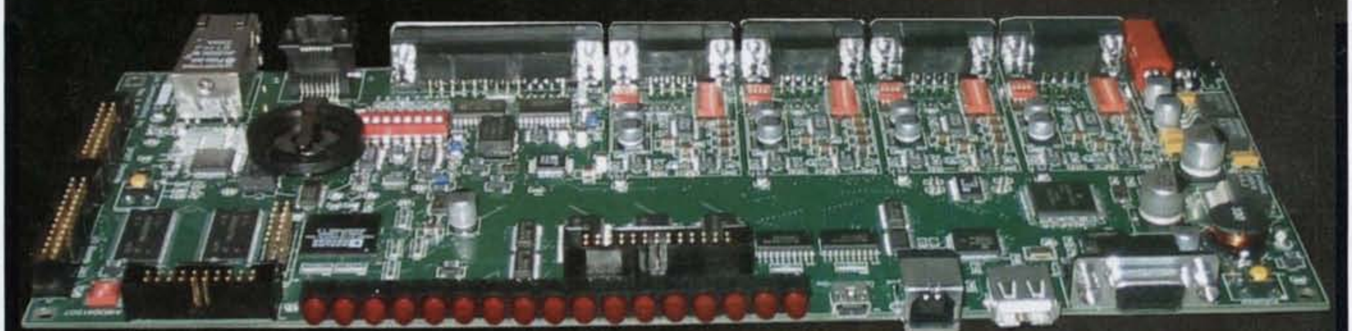

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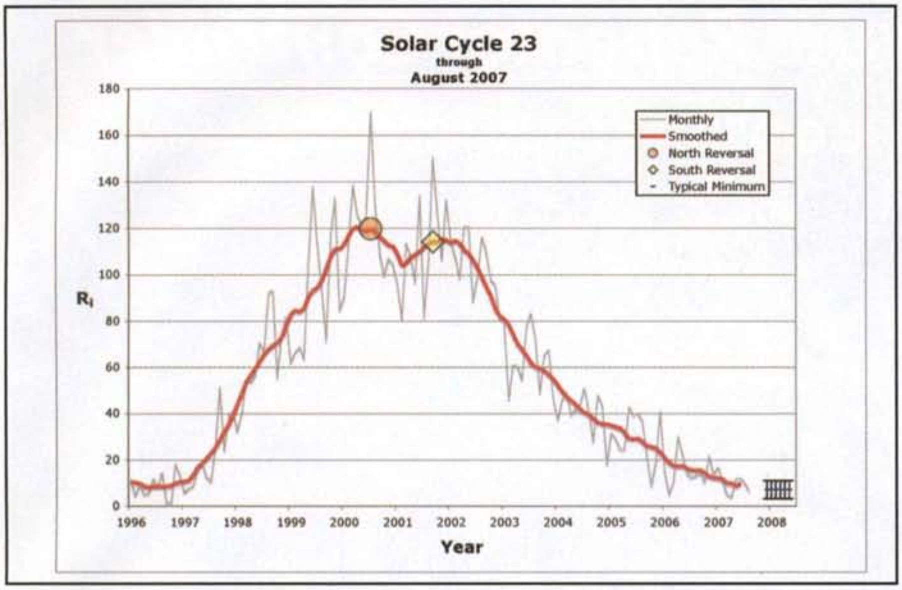

Figure 9. This plot of the Cycle 23 R_i overlays the monthly and 12-month running-average smoothed values. The shaded circle and diamond show the points of north and south polar-field reversal, respectively. The line with error bars in the lower right corner shows the mean and one sigma range of the smoothed R_i as seen at solar minimum for the last 100 years.

Svalgaard, at ETK, uses a somewhat similar method based only on the polar field strength at solar minimum.

Magnetohydrodynamic Models

Developments permitting actual observation of the *interior* of the Sun are beginning to offer intriguing new possibilities in solar cycle prediction. The study of helioseismology uses sound waves, traveling through the inside of the Sun, to visualize the structure and dynamics of the solar interior, something like a medical CT scan. Collaborative research projects at the National Solar Observatory[5] and Stanford's Wilcox Solar Observatory[6] have collected a full solar cycle of data on the evolution of the Sun's internal structure.

These techniques have yielded many key pieces of information in understanding the processes that take place inside our nearest star. They also have led to practical short-term predictive tools, including the visualization of active regions on the far side of the Sun, away from the Earth. This is enabling prediction of when new or returning activity will rotate back into view and become geoeffective (Figure 8).

Armed with these and other data, one could construct magnetohydrodynamic predictive models that start from first principles, the *physics* of the Sun itself. One such model has been developed by Mausumi Dikpati and her collaborators at NCAR's High Altitude Observatory. While still being fine-tuned, they insert structural data from previous cycles in a computer model of the flow interactions, and predict what a subsequent cycle should look like. It has been very successful in reproducing previous cycles, including the double maximum in Cycle 23.

This sort of approach might be quite accurate at predicting one or two cycles in the future. However, there is an important caution. There is good reason to believe that the fine details of the solar flows are basically chaotic processes.

Thus, like the weather on Earth, short-term predictions might be fairly accurate, but longer term predictions would be progressively less reliable.

Hindcasts and Forecasts

No matter what kind of method or model one uses, the fine tuning of the approach is based on applying the scheme to *past* cycles, where "what happened" is already known, and then adjusting the details for the best match. This is a process known as *hindcasting*. Most methods work pretty well when you already know the answer! In the past, the use of those methods to *forecast* has met with very mixed results.

Who to Believe?

Table 2 shows a comparison of the predictions by six respected forecasters and a consensus committee. These are samples of the available methods, chosen to reflect the diversity of predictions based on the various general approaches. The dates are approximate and the activity predictions range from awful to terrific. (The same has been true of past predictions for previous new cycles.)

In the current case, the two solar precursor methods are making very pessimistic predictions, while the two geomagnetic precursor methods are making optimistic predictions.

One would think that the solar precursor methods, based on parameters closer to the root source—the solar magnetic field—would be more reliable. However, the Dikpati model, *if correct,* should be the most accurate. Curiously, it disagrees with the solar precursors shown and produces the most optimistic prediction of

Lead Researcher	Method	Cycle 23 Min. Date	Cycle 23 Min. R_i	Cycle 24 Max. Date	Cycle 24 Max. R_i
Dikpati	Flux Transport Dynamo	Late 2007–Early 2008	—	Jan. 2012	169 ±12
NOAA Committee	High Consensus	Mar. 2008	—	Oct. 2011	140 ±20
Kennewell	Recent Cycle Statistics	Oct. 2007	8.5	Aug. 2011	134 ±50
Schatten	Solar Precursor SODA Index	—	—	Oct. 2011	100 ±30
NOAA Committee	Low Consensus	Mar. 2008	—	Aug. 2012	90 ±10
Hathaway	Super Geomag Precursor	Aug.–Sept. 2006	7.2	Jun. 2010	147 ±24
Wilson	Wilson's Rule	Nov.–Dec. 2006	—	Nov.–Dec. 2010	—
Svalgaard	Solar Precursor Polar Field	Oct. 2006	—	2011	75 ±10

Table 2. Comparison of several prediction methods.

all, even exceeding those of the geomagnetic methods. Whatever actually happens, we should learn something.

The NOAA Committee. The National Oceanic and Atmospheric Administration convened a committee of experts to try to reach a consensus prediction. In late April 2007, the committee issued a report saying that they were evenly split into two camps. One group steadfastly believes that the cycle will be good (but not great), and the other group feels that it will be a rather poor cycle. The only thing they agreed on is that the minimum was likely to be about March 2008.

It is also important to note that the last three predictions in Table 2 have already failed to predict the solar minimum date. At this writing (September 2007) it seems unlikely that solar minimum occurred *before* August 2007.

Beware the Error Bars

Another caution about predictions is their error estimates. They are often quite large. Each method is predicting not one value, but a *range* of values. For example, a value of $R_i = 150 \pm 50$ might appear to predict a fairly good cycle. However, it actually predicts Ri to be anywhere between 100 (a very poor cycle) and 200 (a rival of the amazing Cycle 19).

Predictions with large error bars reflect a lack of confidence in the precision of the method's predictive capability (usually based on previous experience). In any case, large error bars don't provide a very precise *quantitative* or *qualitative* picture of the predicted activity.

A Reality Check

As noted, there was a brief appearance of what appeared to be new Cycle 24 activity in mid and late 2006. However, this hopeful flurry of activity quickly dissipated. Figure 9 shows the progress of Cycle 23 from the previous minimum in 1996 through August 2007. The slope of the smoothed R_i was clearly still negative.[7]

The shape of the plot suggests that the curve may round out to reach minimum by late 2007. However, if R_i minimum is much lower than 10, it could even be Dikapti's prediction of early 2008.

When Will the DX Start?

From a DX perspective, the crucial question isn't "When is the solar maximum?" Rather, it is "When will solar activity be high enough for good propagation?"

R_i	NOAA Panel Low	Recent Statistics	NOAA Panel High	MHD Model
Minimum	Mar. 2008	Oct. 2007	Mar. 2008	Jan. 2008
60 – TEP	**Dec. 2010**	**Aug. 2009**	**Dec. 2009**	**Aug. 2009**
100 – E/W F_2	—	**Sept. 2010**	**Dec. 2010**	**Jun. 2010**
134	—	Oct. 2011	Oct. 2011	Mar. 2011
147	—	—	Mar. 2012	June 2011
169	—	—	—	Jan. 2012

Table 3. Possible Figure 10 dates.

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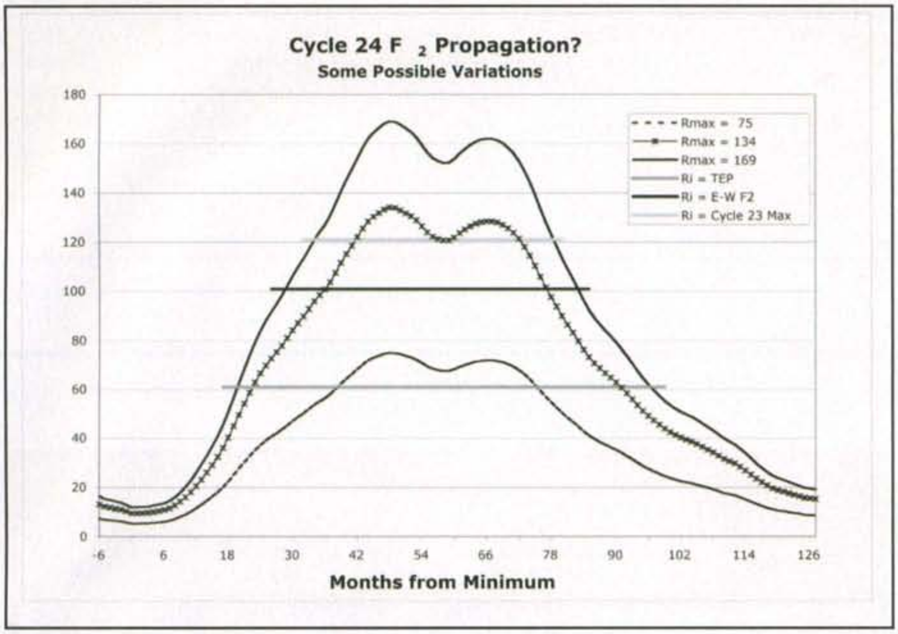
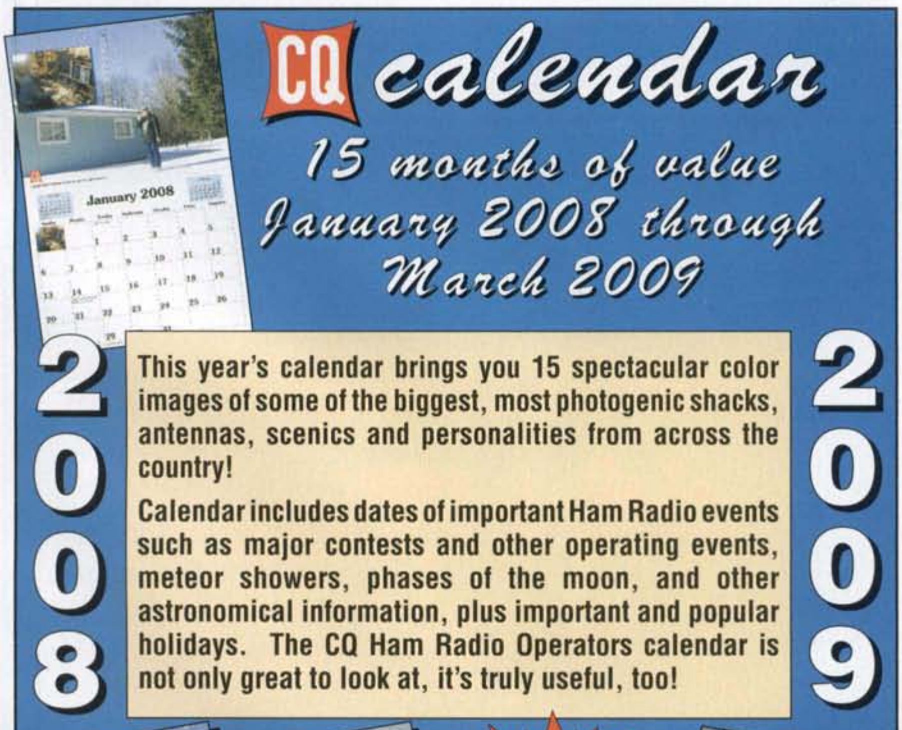


Figure 10. These are three realizations of an R_i model scaled to the maximums predicted by Svalgaard, Kennewell, and Dikpati, respectively. It assumes that the slowdown in the Southern Hemisphere meridional flow "conveyer" will lead to another doubled-peaked maximum, much like Cycle 23. It shows the time relationship between the preceding minimum and the onset and duration of Cycle 24 TEP at R_i about 60, east-west F_2 at about 100, and the period above Cycle 23 at R_i = 121.



My own experience shows that once the smoothed R_i rises above about 60, the MUF will regularly start peaking above 50 MHz—subject to the usual seasonal effects (i.e., *no* TEP [transequatorial propagation] in the summer and winter, and *no* F_2 during local summer). This generally will show up first as north-south TEP, taking advantage of the ionization boost of the equatorial anomaly. As R_i rises to about 100, east-west F_2 will also start to show up. Depending on the cycle strength, TEP and linked TEP can start as early as about 18 month after *solar minimum*, and east-west F_2 about a year after that.

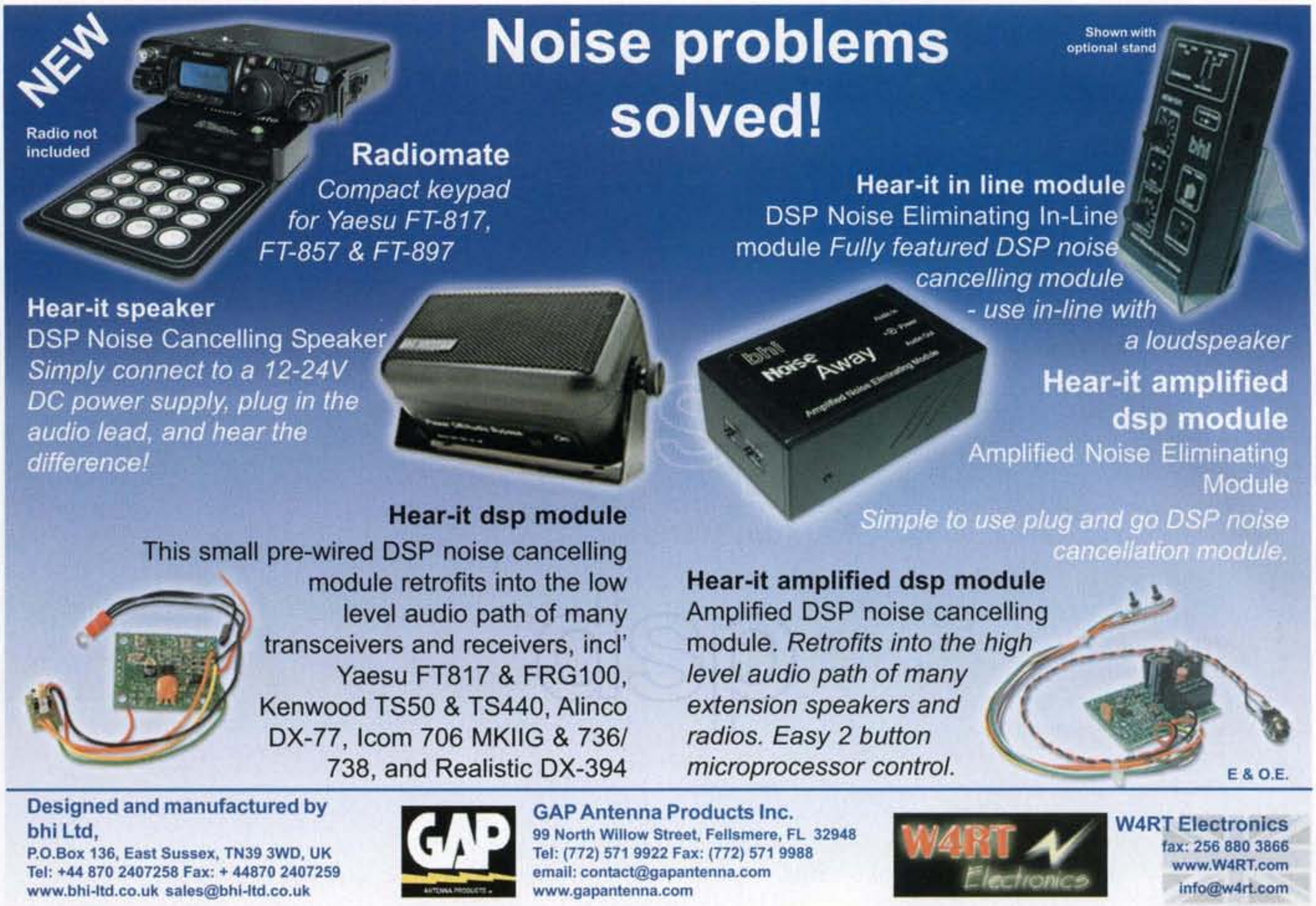
To illustrate this, Figure 10 shows an example of three different *possible* Cycle 24s. The current evidence is that the slowdown in the southern meridional flow, which probably led to the double peaks in Cycles 22 and 23, is continuing. Thus, the shape of the curves is based on a highly smoothed version of Cycle 23 and is identical in each case, except for the scale factor. The curves are then scaled to the maximum R_i predicted by Svalgaard, Kennewell, and Dikpati and shown in Table 2.[8] Notice that the higher the maximum value of R_i the more rapidly the propagation thresholds are reached.

These were chosen as representative examples of low, medium, and high cycles. Note that all the curves are *based on the date of solar minimum*, not a calendar date.

While no representation is made for the detailed accuracy of the figure 10 models, if one focuses narrowly on the date of the onset of propagation, once the actual date of solar minimum is established, the models should be useful in tracking toward the start of good propagation.

The time between the previous minimum and the new maximum is right about four years, based on many previous cycles. With the actual minimum date and an estimate of the R_i at maximum, even a straight line drawn from the minimum to the maximum R_i four years later will be a good estimate of the ramp up of activity in between those two dates, *if* the maximum R_i estimate is about right. Figure 10 gives three choices that bracket the range of R_i maximum predictions.

Now, to restore some possible *dates* to figure 10, one can take the solar minimum dates of the corresponding maximum R_i predictions in Table 2 and project the dates at which various values of R_i might occur (using figure 10). The results are shown in Table 3. The values in bold show the dates R_i would reach the TEP and E-W F_2 levels. Of course, to be more realistic, one



must take into account the seasonal patterns of these propagation modes. Applying these, the range of starting dates is:

• **TEP: Fall 2009 or Spring 2010** (except for the NOAA low, Spring 2011)

• **E-W F_2: Fall/Winter 2010**

It is interesting that even though they predict different minimum dates, the three more-optimistic models all seem to converge on about the same starting seasons for each of the TEP and F_2 propagation. This is a result of the interplay between the minimum dates and the different rates of R_i rising toward maximum.

These are just examples, not really predictions (and remember the error bars, too!). The real point here is that unless the cycle is very poor, the DX will start *before* the maximum.

So when will the DX really start? We'll have to wait and see. However, we don't have to wait passively.

Once the minimum is reached and the rising phase of the cycle gets under way, one can begin plotting the monthly R_i values over the figure 10 curves and get a sense of which of the rising curves they are actually on. After several months the pattern will probably emerge and one can then get a sense of *when* and *what* will happen.

Cycle 25 and Beyond

Some people are even beginning to think about Cycle 25. One interesting factor is the 240-year pattern of shorter and longer cycles. If this pattern in previous data is real, the exact length of the period still is not precisely known.

If it really is pretty close to 240 years, then Cycle 23 should be a *short* cycle. But, it *exceeded* 11 years in May 2007, and at this writing we don't know when it will end. We still don't have clear signs of the Northern Hemisphere new cycle kicking in, and it would be expected to start *before* the start in the Southern Hemisphere.

All this is consistent with several of the predictions in Table 2, and with the observation that the Southern Hemisphere meridional conveyor belt is slowing down. It is also consistent with the notion that the 240-year pattern is either shorter than 240, or it is starting a few years early. If so, then Cycle 24 and Cycle 25 will likely be long cycles.

Acknowledgements

The author appreciates comments and suggestions by Jack Harvey at NSO, and the graphics skills of Kirk Pu`uohau-Pummill at Gemini in producing the renderings for Figures 2 and 4. The sunspot data used here are from the compilations by the Solar Influences Data Analysis Center (SIDC) at the Royal Observatory of Belgium (www.sidc.be).

Notes

1. *50 MHz F_2 Propagation Mechanisms,* Kennedy, J. R., 2000, in *Proceedings* 34th Conference Central States VHF Society, (ARRL Pub. 257), 87–105.
2. The value of R_i is essentially the same as the historical R_z (Zurich) sunspot index, by deliberate design.
3. See: www.ips.gov.au/Educational/2/3/1.
4. This index is derived from the three-hour averages of the *K* index at two antipodal Earth-based observing stations.
5. The Global Oscillation Network Group (GONG).
6. The Michelson Doppler Imager (MDI) experiment on the SOHO spacecraft.
7. For the last few data points only, the smoothing span has been shortened from the traditional 12 months.
8. Note that these models are *not* the detailed models of Svalgaard, Kennewell, and Dikpati, but different models merely scaled to their nominal predictions for the maximum R_i.

Amateur Radio and the International Geophysical Year 1957–1958

Fifty years ago the International Council for Scientific Unions (now known as the International Council for Science, or ICSU) oversaw an 18-month period of worldwide scientific exploration and research known as the International Geophysical Year, or IGY. Amateur radio operators were invited to participate in the research as it related to propagation. Here WA2VVA documents some of the amateur-radio-related research that took place during the IGY.

By Mark Morrison,* WA2VVA

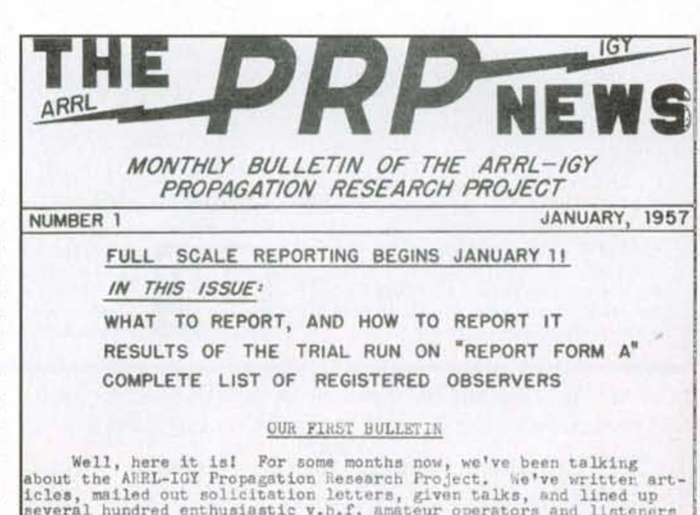
The International Geophysical Year (IGY) was an 18-month period starting in July 1957 and ending in December 1958. Timed to coincide with the peak of the 11-year sunspot cycle, it was a cooperative effort of scientists, amateur as well as professional, from around the world.

Unlike most scientific endeavors, unskilled observers were invited to take part, the idea being that if competent people could be organized to make coordinated observations around the world, the amount of data collected would be that much greater. "Project Moonwatch" was the name given a satellite-tracking program using amateur astronomers to visually track the artificial satellites launched during the IGY. A separate program named "Project Moonbeam" invited amateur radio operators to track these same satellites using radio equipment not uncommon in many radio shacks of the era. The November 1957 issue of *QST* published the official invitation made by Dr. Pickering of the Jet Propulsion Lab.

Over the past year and a half *QST* has carried a number of articles describing various sections of the Minitrack system of satellite tracking as developed at the Naval Research Laboratory. The NRL activity is part of the work of a special group in the U.S. National Committee for the IGY. Dr. Pickering, head of this Working Group on Tracking Computation, issues here an official invitation to qualified amateur groups to participate in the volunteer satellite-tracking program—now known as "Project Moonbeam."

Through the efforts of the ARRL, which coordinated amateur radio activities through its "Propagation Research Project," VHF enthusiasts also collected data on various modes of VHF propagation, including aurora, meteor scatter, transequatorial and sporadic-*E*. A special newsletter called the "PRP News" published reports of significance and useful information for "PRP Observers," including beacon frequencies, identification of special observing days called the "world days," and myriad other items of interest. Figure 1 is a reproduction of the first issue.

The propagation data collected through the "PRP News" was to be analyzed by PRP staffers and the U.S. Air Force through its Cambridge Research Center. Looking for patterns in monthly heard and worked reports, it was hoped that new discoveries might be made, particularly with regard to transequatorial propagation. This mode of propagation was discovered by radio amateurs in 1947 and was a major reason for recruiting them during the IGY.



THE ARRL PRP NEWS IGY

MONTHLY BULLETIN OF THE ARRL–IGY PROPAGATION RESEARCH PROJECT

NUMBER 1 — JANUARY, 1957

FULL SCALE REPORTING BEGINS JANUARY 1!

IN THIS ISSUE:

WHAT TO REPORT, AND HOW TO REPORT IT

RESULTS OF THE TRIAL RUN ON "REPORT FORM A"

COMPLETE LIST OF REGISTERED OBSERVERS

OUR FIRST BULLETIN

Well, here it is! For some months now, we've been talking about the ARRL-IGY Propagation Research Project. We've written articles, mailed out solicitation letters, given talks, and lined up several hundred enthusiastic v.h.f. amateur operators and listeners around the world. These fellows, including yourself, have filled out project registration forms. Many have tried out sample reporting forms for us. Now we are able to take another step forward, and send out issue number one of The PRP News. As you can see, its format is patterned after that of the popular ARRL CD Bulletin. We hope you're going to like it.

Figure 1. This is the first page of the first issue of the "PRP News," a special newsletter that published reports of significance and useful information for "PRP Observers."

The PRP expressed interest in all forms of propagation save one—tropospheric ducting. Yet it was via tropospheric ducting that arguably the greatest amateur accomplishment of the IGY took place.

From "PRP News" January 1957:

What We're Not Interested In

Reports of ground-wave work out to 75 or 100 miles will not be of use in PRP. Likewise, we are not concerned with contacts made by tropospheric propagation. This includes those due to air mass boundary bending and duct effects caused by the changing weather pattern, and those due to scattering from the troposphere. Either of these will provide contacts out to perhaps 500 miles, the former with irregular, strong signals, and the latter with consistent, weak ones. Since we are studying ionospheric propagation only, reports of such tropospheric work are not solicited.

**5 Mount Airy Road, Basking Ridge, NJ 07920*
e-mail: <mark1home@aol.com>

Amateur radio was well represented at the XII General Assembly of the International Scientific Radio Union (URSI) held at the University of Colorado Aug. 22 — Sept. 5. This group, in front of the University Memorial Center in Boulder, includes, left to right, Tilton, ARRL, W1HDQ; Dickson, USA Signal Propagation Agency, Ft. Monmouth, N. J., K2HJU; Booker, K2SKB, son of Dr. Booker of Cornell; Dieminger, Max-Planck Institut for Physik des Ionosphare, DL6DS; Burbank, USN Electronics Lab., San Diego, W6CDF; Moore, Univ. of N. Mex., W5WBZ; Dinger, NRL, W3KH; Peterson, Stanford, W6POH; Menzel, URSIGRAM Committee, Geneva, Switz., DL1UR; Seddon, National Academy of Science, Wash., D. C., W4SBQ; (kneeling) Silberstein, NBS, Boulder, WØYBF; Herbstreit, NBS, Boulder, WØIIN; Johnson, Dartmouth, W1FGO; deBettencourt, Pickard and Burns, Inc., W1CXJ.

Other amateur delegates to the Assembly, not present for the picture, included Dyce, Stanford, W2TTU/6; Carpenter, NBS, Wash., D. C., W3OTC; Cumming, Wilton, Conn., W1FB; Kirby, NBS, Boulder, WØLCT; Menzel, Harvard, W1JEX; Rohdin, Royal Board of Telecommunications, Stockholm, SM5FD; Swenson, Univ. of Illinois, K9ESK; Morgan, Dartmouth, W1HDA.

Seven of the above are QST authors.

Photo 1. From November 1957 QST, *this is a photo of amateur radio operators who attended the XII General Assembly of the International Scientific Radio Union (URSI) held at the University of Colorado from August 22 to September 5, 1957. (Photo courtesy of the ARRL and* QST *magazine)*

At a time when aurora and meteor scatter dominated the VHF DX scene, few considered tropospheric propagation of much value. Most considered meteor scatter or sporadic-*E* the best modes for long-haul operations. Either way, operators from around the world took advantage of the IGY to reach for new VHF distance records. Indeed, with the number of hams expected to participate during the forecasted favorable conditions of the forthcoming sunspot cycle, it was just a matter of time before someone hit it big. This entry in "PRP News" shows that Australian operators were looking to bridge the Pacific on 6 meters and possibly even 2 meters:

Here are two well-known v.h.f. ops -- Joe and Hal Taylor, K2ITP and K2ITQ, of Riverton, New Jersey. Hal is seated before the receiving gear (6AK5-404A converter into S-40B), while Joe stands alongside the closet wherein resides a 4-250A rig run at 700 watts c.w., 650 watts AM phone and 1 kw. SSB. The antenna is a 5-over-5 spaced 5/8 wavelength and 65 feet above ground. That array of certificates (including two PRP Consistent Reporting Awards) and 50-Mc. DX cards speaks for itself!

Photo 2. From August 1958 "PRP News," this is a photo of Hal (seated) and Joe Taylor at their ham station.

Transpacific Anyone?

Norman Burton of 143 The River Road, Revesby, NSW, Australia sent us a very interesting letter recently with an eye toward establishing schedules between Australia and the U.S. west coast on 5/6 and 2 meters. Norman passes along word of verified reception of the BBC-TV sound channel (41.5 Mc. In London) in Australia. This makes him feel that 5 meter work (the Australians use 56 to 60 Mc.) is a certainty over the path he suggests, and 2 meter work a distinct possibility.

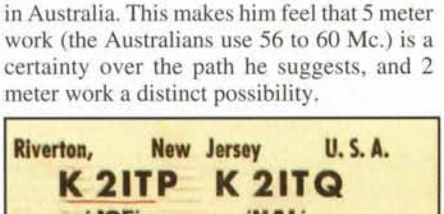


Photo 3. Hal and Joe Taylor's common QSL card.

What Norman would like to see is automatic or scheduled 50.5 Mc. transmissions beamed on Sidney from our west coast. He says that on or about February 1, there will be two beams on the San Francisco area every day from "down under." More observers may be added later on, as may 5 meter transmissions, and eventually, 2 meter attempts.

Anyone interested in getting in on this work is invited to get in touch with Norman at the above address. We will also pass along any information that comes this way.

Although many significant radio contacts were made during the IGY, including transequatorial contacts between the Northern and Southern Hemispheres, it was a lone tropospheric contact that broke all the records. After eight months of schedules with little to show for it, the persistence of Ralph "Tommy" Thomas, W2UK/KH6UK, and John Chambers, W6NLZ, finally paid off when their 2-meter signals spanned 2500 miles of the Pacific Ocean on July 8, 1957. This historic QSO, which practically doubled the 2-meter DX record of the time, is arguably the greatest amateur achievement of the IGY.

News of the big event spread quickly and was widely publicized not just in *QST*, but in the "PRP News" as well. From "PRP News":

Although you must have already either read or heard the following information, we thought we'd mention it here because it is so

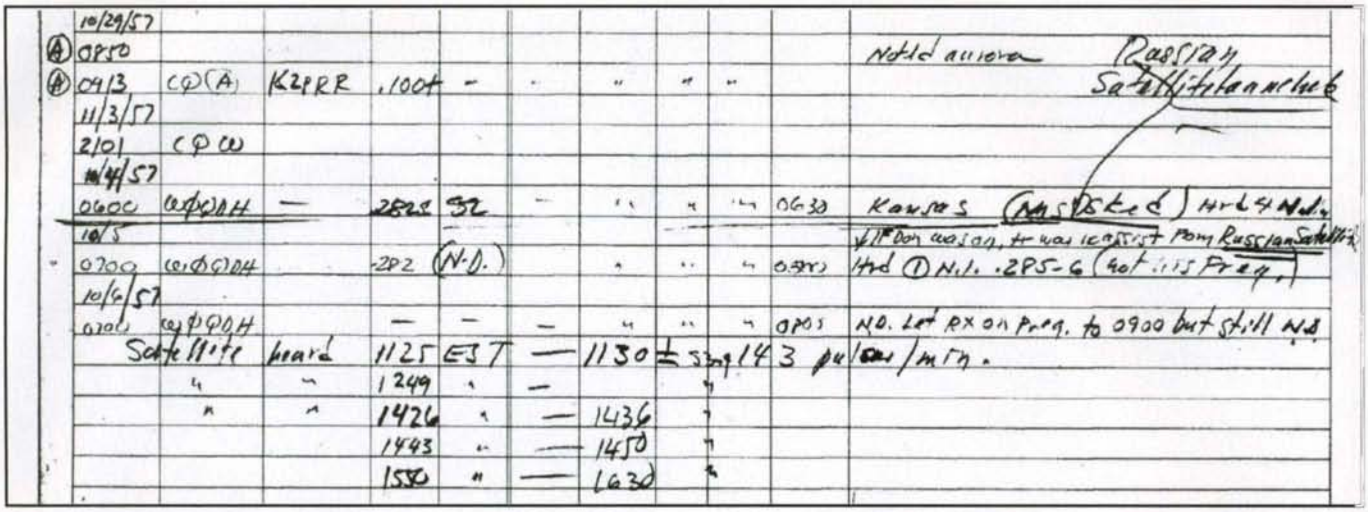


Figure 2. An excerpt from the logbook of W2CXY. Such excerpts were the basis of the reports published in the "PRP News."

very noteworthy. On July 8th, W6NLZ and KH6UK set a new DX record of about 2540 miles with their 2-meter contact. The QSO took place between 2211 and 2227 PST. Quite a haul! An interesting point is that a check of report forms show that sporadic-*E* skip was absent from the 6-meter band at this time, so some sort of tropospheric super inversion was probably the cause.

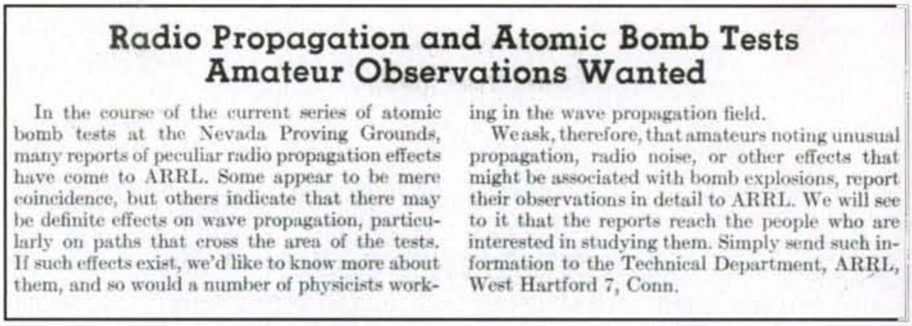
The fact that the ARRL used 6-meter reports, or the lack of them, to rule out the possibility of a sporadic-*E* contact is very interesting, because Tommy, KH6UK, once considered the same thing in reverse. In an audio letter to W2CXY Tommy put it this way:

> I had hoped to do some work on 6 in conjunction with 2 meter experiments as I thought maybe if I could pick out the periods when 6 was open from sporadic-*E* we might be able to do something on 2 at that time.

This plan was defeated, however, by local interference from the RCAC transmitters in Kahuku. Even so, Tommy and John continued their schedules and scored a second QSO a month later. From "PRP News" September 1957:

More California to Hawaii on 144

Remember that 2 meter contact between W6NLZ and KH6UK that took place on July 8th? A new DX record of about 2540 miles was set. Well, they did it again! On August 18th at 1800 HST, KH6UK's automatic transmission was heard by W6NLZ. Signals were weak and fading until 1850 and the contact lasted through until about 1915. Your report forms for the second half of August haven't started to arrive yet, so we are unable to get an idea of what was happening on the band at that particular time. This California-to-Hawaii haul is beginning to look promising!



Radio Propagation and Atomic Bomb Tests
Amateur Observations Wanted

In the course of the current series of atomic bomb tests at the Nevada Proving Grounds, many reports of peculiar radio propagation effects have come to ARRL. Some appear to be mere coincidence, but others indicate that there may be definite effects on wave propagation, particularly on paths that cross the area of the tests. If such effects exist, we'd like to know more about them, and so would a number of physicists working in the wave propagation field.

We ask, therefore, that amateurs noting unusual propagation, radio noise, or other effects that might be associated with bomb explosions, report their observations in detail to ARRL. We will see to it that the reports reach the people who are interested in studying them. Simply send such information to the Technical Department, ARRL, West Hartford 7, Conn.

Photo 4. From November 1957 QST, *this is a copy of the recruitment announcement for amateur radio operators to observe the potential effects of atomic-bomb blasts on radio propagation. (Photo courtesy of the ARRL and* QST *magazine)*

In August 1957 scientists of the International Scientific Radio Union (URSI) met in Boulder, Colorado to discuss radio matters related to the IGY. This excerpt from the October 1957 "PRP News" shows that the KH6UK/W6NLZ contact received more that just a passing interest.

The U.R.S.I. General Assembly
A Brief Report
By E. P. Tilton, W1HDQ
VHF Editor of QST

Late in August your VHF Editor had the pleasure of attending the XII General Assembly of the International Scientific Radio Union (URSI) at Boulder, Colorado. The first worldwide meeting of URSI to be held in this country since 1927, it was probably the most important and widely attended of any. Top-level scientists from at least 26 member countries took time out from their heavy IGY schedules to come to Boulder and discuss their mutual problems. To have been privileged to sit in on their informal discussion and technical sessions was an experience this reporter will not soon forget.

Hearing these world-renowned physicists talk shop presented a fine opportunity for sensing the great potential worth of our ARRL Propagation Research Project for the IGY. The world's wave propagation problems are far from solved, and again and again we ran across areas of conjecture where amateur operations may provide useful evidence that would be obtainable in no other way. There was great interest in the record 144 Mc. work of KH6UK and W6NLZ, for example. Dozens of delegates to the Assembly came to the writer to get more information on it. Without exception, these people voiced the strongest praise for amateur work of so high an order.

There was much talk of transequatorial scatter, the ham-discovered phenomenon that largely was responsible for our entry into the IGY picture originally. The worth of amateur observations in the study of this, and in learning more of auroral and sporadic-*E* phenomena, was reaffirmed by many.

One of the hams who attended the conference was a scientist with direct involvement in the IGY. This press release from Dartmouth College describes the contribution of Dr. Millet G. Morgan, W1HDA, during the IGY:

> During the International Geophysical Year (IGY, 1957–8) Prof. Morgan chaired the US National Committee's Panel on Ionospheric Research of the National Research Council, which oversaw radio studies conducted all around the earth. In early 1958 he joined the re-supply mission to the US Antarctic station on the Weddell Sea as the senior scientific representative. In his own IGY research he maintained an extensive series of stations throughout the Americas.

Photo 1 is from November 1957 *QST*. The picture shows some of the people who attended the conference. Note that Dr. Morgan is listed as one of the delegates.

Other hams were scientists who contributed to the IGY in different ways. Dr. John Kraus, W8JK, inventor of the helical antenna and well-known radio astronomer of Ohio State University (OSU), was mentioned regularly in the "PRP News." His circularly polarized antennas, now standard equipment on all major space missions, were of considerable interest to VHF enthusiasts pondering "moon reflection" work during the IGY. Many amateurs wrote to Dr. Kraus asking for advice and he kindly replied. Dr. Kraus played a significant role in tracking the first satellites using his radio astronomy telescope.

Still other hams were just teenagers during the IGY but went on to become respected scientists in their own right. Two regularly mentioned in the "PRP News" were brothers Joe and Hal Taylor from New Jersey. Both were serious operators on the VHF bands. Hal, K2ITQ, received a PhD under Dr. James Van Allen, the University of Iowa scientist who originally conceived of the IGY. Hal went on to became a professor of physics at The Richard Stockton College of New Jersey, where he taught for more than 30 years. Hal became a Silent Key in 2002, succumbing to cancer.

Joe, K2ITP, now K1JT, received the Nobel Prize for his work with binary pulsars and is more recently recognized as the Princeton physicist who revolutionized meteor-scatter and moonbounce operations with his WSJT signal-processing software. Using this software, it now is possible for radio amateurs to make meteor-scatter contacts practically any time of the day or night.

Photo 2 from the August 1958 "PRP News" shows Hal and Joe at their station. Photo 3 shows their joint QSL card.

October 1957 was an exciting month for the IGY, as the Soviet Union launched Sputnik, the world's first artificial Earth-orbiting satellite. Long before this launch amateur radio publications in the U.S. (*QST*) and Russia (*Radio*) prepared operators for what to expect. The Russians would use 20 and 40 MHz for Sputnik, while the U.S. would use 108 MHz. For some reason, the official U.S. ground stations were not prepared to monitor Sputnik when it was first launched, so amateur operators provided listening reports until they could be changed to the lower frequency. Many PRP observers recorded such reports in their logbooks and sent reports to the "PRP News." Figure 2 is an example from the logbook of W2CXY.

Using PRP reports such as this one, and knowing the location of each station reporting, it was possible to estimate the orbit of the satellite as it circled the Earth.

Dr. Kraus later reported that he could track Sputnik as it flew over his 96 helix

array in Ohio. At that time the WWV station was located near Washington, DC and transmitted time signals on 20 Mc. At night, when the signals generally faded, an occasional meteor would provide sufficient ionization to reflect the WWV signal for reception. Dr. Kraus theorized that Sputnik, in moving through the lower limits of the ionosphere, might cause ions to be bunched up in front of the satellite, thus providing sufficient reflectivity to bounce radio waves from WWV. When he checked his chart recorder, he found that the WWV signal had indeed appeared at the time Sputnik crossed the path of his OSU telescope.

While Sputnik allowed people around the world to witness the birth of the space age, many believed the ability to launch an Earth-orbiting satellite could lead to nuclear weapons dropped anywhere on Earth. Some people responded by building their own bomb shelters. Others, especially hams, responded by joining their local Civil Defense organization. In spite of these sobering effects, however, atomic testing proved something of an opportunity for wave theorists to learn more about radio propagation. It had been discovered that atmospheric tests created propagation effects similar to those experienced during solar flares, and since amateurs had long been bouncing signals off the aurora borealis, the ARRL requested radio amateurs to report any unusual radio communications that might be associated with nuclear testing. Photo 4 is the ARRL announcement that appeared in the November 1957 issue of *QST*.

While Sputnik was significant as the first satellite launched by man, it was Explorer I, launched by the U.S. in 1958, that provided what many consider the greatest scientific accomplishment of the IGY: the discovery of areas of high-energy particles trapped within the Earth's magnetic field and largely responsible for the aurora borealis. The Van Allen Radiation Belts, named in honor of the University of Iowa professor credited with their discovery, were of importance to the VHF operator because of their DX potential. In the years prior to meteor scatter, it was "aurora work" that opened the door to DX on 2 meters. The so-called "buzz sessions," a name that describes the effect of auroral activity on

Photo 5. Dr. William H. Pickering, Dr. James A. Van Allen, and Dr. Wernher von Braun (left to right) hoist a model of Explorer I and the final stage after the launching on January 31, 1958. Explorer I, the first U.S. earth satellite, was launched by a Jupiter-C with U.S. Earth–IGY scientific experiments of Dr. James A. Van Allen, which discovered the radiation belt around the Earth. (NASA photo)

Of more than a little interest to PRPers, if mail and report notations are any judge, has been the 49.99-Mc. IGY installation at Yellowknife, N.W.T. These stations (there is also one on 38.07 Mc.) are operated by Canada's Defence Research Telecommunications Establishment, and were described in the "PRP News" for June. In addition to reception reports, we have received several requests for information about the double-stacked square loop antennas used at Yellowknife. Through the kindness of Mr. J. H. Crysdale of the Defence Research Board, we have obtained the excellent photo reproduced at the right, and also considerable data which should be of great help to anyone contemplating the construction of such an array. The following is from Mr. Crysdale's letter:

"The vertical spacing between the individual bays of each antenna is ap-

Photo 6. From the "PRP News," this is a write-up of the Yellowknife transmitters.

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received signals, added many states to the VHF enthusiast's states worked list. Photo 5 shows Dr. Van Allen (center) along with Dr. Werner Von Braun (right) and the same Dr. Pickering (left) mentioned earlier in this article.

When Sputnik finally returned to Earth, Dr. Kraus reported that he could track its descent using radio waves reflected off its ionized debris trails. The source of the radio waves was once again the WWV station near Washington, DC. From "PRP News" February 1958:

Sputnik Scatter

MS-type propagation was recently put to work for a purpose far removed from point-to-point communication. Our source is a news clipping sent us by Ed Collins of the *QST* Advertising Department. The place was Ohio State University. There, Prof. John D. Kraus, W8JK, came up with a radio reflection system for tracking Sputnik I. With this method, "radio signals, at a frequency of 20 Mc., from radio station WWV near Washington, were detected at the university after being reflected from the ionization columns produced by the satellites in speeding through the upper atmosphere." Results? It was revealed that Sputnik I broke up into no less than eight separate pieces; these then disappeared one or two at a time until nothing was left on January 11.

Important resources of the IGY were the VHF beacons. Some amateurs made their own beacons using old phonographs and coded disks that keyed their transmitters with pre-programmed messages. Some beacons were nothing more than existing transmitters, such as the VOA transmitters in Japan. Others, such as the Yellowknife transmitters in the Northwest Territory in Canada, were erected specifically for the IGY. Photo 6, from the "PRP News," is a write-up of the Yellowknife transmitters.

The success of KH6UK and W6NLZ crossing the Pacific on 2 meters inspired others to follow. In the spirit of the IGY, Walt Morrison, W2CXY, coordinated a 2-meter transatlantic attempt with amateurs in Holland. Although success eluded them, this is perhaps the only coordinated attempt made during the IGY. Here's what PRP had to say (from "PRP News" April 1958):

144-Mc. Transatlantic Tests

The information for this item came to us the long way 'round; PPR observer Walt Morrison, W2CXY, came up with the idea, sent it off to the Radio Society of Great Britain, and we read about it in the March 1958 RSGB Bulletin. Walt feels that neither meteor nor auroral propagation looks too good for accomplishing that dream of 2-meter operators, a transatlantic contact. He believes that three possibilities remain—ionospheric scatter under conditions of intense F2-layer ionization, moon bounce, or tropospheric propagation. Whatever the mode of propagation, then the signals, if there are at all, will be extremely weak. Obviously, an emulation of the W6NLZ-KH6UK effort is called for, making use of the best possible equipment.

W2CXY will operate on 14.095 Mc. and 144.01 Mc. simultaneously transmitting "IGY TEST IGY TEST IGY TEST DUAL 14095/144010 DE W2CXY" at about 20 wpm for five minutes commencing at 1330, 1900 and 0300 GMT (0830, 1400 and 2200 EST) on Saturdays and Sundays and at 2330 GME (1830 EST) Mondays to Fridays. The five-minute transmission period will alternate with similar listening periods on both bands.

Equipment to be used by W2CXY includes a Collins KWS-1K running 1 kw to a ground plane on 14 Mc. For 144 Mc., the transmitter comprises a modified SCR522 driving push-pull 4.125As also running 1 kw input and feeding a 40-element array consisting of four 16 ft long Yagis spaced 12 ft by 12 ft on a 70-ft tower. A new coaxial final using an Eimac 4CX1000A tunable from 60 to 450 Mc. will be completed soon. The station is east of Chatham, New Jersey. Best of luck Walt!

It should be noted that a successful transatlantic QSO on 2 meters has yet to be accomplished and the coveted Brendan Trophy still awaits those who are the first to succeed.

In June 1958 the following special bulletin went out to PRP observers via "PRP News." This is a perfect example of how amateur radio was uniquely suited to make special IGY observations with little advance notice.

Important Bulletin to all Satellite Listeners!

As some of you may have heard, something very puzzling has been noted in connection with the 20 and 40 Mc. transmissions from USSR satellites. This is the "ghost satellite" or antipodal reception effect. It seems that on many occasions reception has been possible not only when the Sputnik was within line of sight but when it was on the opposite side of the world!

To pick this up is quite simple. One listens for the signal at plus or minus about 52 minutes from the time it makes a close pass. The satellite will then be about half way around the world with respect to the observer. The signal seems to reappear for a period of three or four minutes and then vanishes until the satellite is once more within line of sight. The antipodal effect is heard best in

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the evening hours, and is observable on about 50 percent of the days, on the average.

It is very difficult to explain this reception without more information on its characteristics and properties. Ham reports can be absolutely invaluable here. The data required are (1) whether the signal was heard or not, and if so, roughly how strong it was; (2) at what times the operator listened and (3) the direction from which the signal was coming, if this can be determined or estimated. Note that, as in PRP reporting, negative reports are fully as important as positive ones. Note also that correct signal identification is vital; here the "L" signal now being transmitted is very useful.

Please try your hand at making these observations and send your results to PRP Headquarters at 530 Silas Deane Highway, Wethersfield, Connecticut, USA. We'll see that they go to the people who can figure this thing out. Thank you.

P.S. *Please* keep all satellite reports *separate* from your regular VHF propagation reports!

2-METER STANDINGS

Figures are states, U. S. call areas, and mileage to most distant station worked.

W1REZ	29	8	1175
W1AZK	24	7	1205
W1RFU	22	7	1120
W1OAX	22	6	800
W1AJR	21	7	1130
W1HDQ	20	6	1020
W1MMN	20	6	900
W1IZY	19	6	875
W1AFO	17	6	920
W1ZJQ	17	6	860
W1CLH	17	5	450
K1ABR	16	6	810
W1BCN	16	5	650
W1KHL	16	5	570
W2CXY	37	8	1360
W2ORI	36	8	1250
W2NLY	35	8	1390
W2AZL	28	8	1050
K2GQI	27	8	1000
W2BLV	25	8	1020
K2IEJ	24	7	1060
W2DWJ	23	6	860
K2HOD	23	7	950
W2AMJ	22	6	960
W2SM	22	6	940
K2CEH	21	8	910
W2LWI	21	6	700
W2RXG	20	6	700
W2UTH	19	7	880
W2RGV	19	6	720
K2RLG	17	6	980
W3RUE	30	8	975
W3GKP	29	8	1020
W3KCA	28	8	1110
W3TDF	28	8	915
W3SGA	26	7	700
W3FPH	22	8	1000
W3NKM	20	7	730
W3LNA	20	7	720
W3LZD	20	7	650
W4HJQ	36	8	1150
W4HHK	35	9	1280
W4ZXI	34	8	950
W4AO	30	8	1120
W4MKJ	28	8	850
W4UMF	27	8	1110
W4VLA	26	8	1000
W4JCJ	23	6	725
W4EQM	22	8	900
W4WNH	22	8	800
W4OLK	20	6	720
K4EUS	19	6	710
W4CPZ	18	6	650
W4TLV	18	7	1000
W4RFR	18	7	820
W4MDA	17	6	650
K4YUX	16	8	830
W4CLY	15	5	720
W4RMU	10	5	860
W4LNG	10	5	800
W4KCQ	10	4	860
W4GIS	9	2	335
W5RCI	33	9	1215
W5DFU	25	9	1300
W5AJG	22	8	1280
W5JWL	21	7	1150
W5KTD	20	8	1250
W5LPG	19	6	1000
W5ML	15	5	700
W5PZ	14	6	1255
W5FSC	12	5	1390
W5HEZ	12	5	1250
W5CVW	11	5	1180
W5NDE	11	5	625
W5VY	10	3	1200
W5ONS	9	3	950
W5FEK	8	2	560
W6NLZ	12	4	2540
W6DNG	9	5	1040
W6AJF	6	3	800
W6ZL	5	3	1400
W6MMU	3	2	950
W7VMP	11	5	1280
W7JRG	6	3	1040
W7LHL	4	2	1050
W7JIP	4	2	900
W7JU	4	2	353
W8KAY	38	8	1020
W8WXV	35	8	1200
W8LOF	33	8	1060
W8PT	32	8	985
W8SVI	30	8	1080
W8SFG	30	8	1000
W8LPD	29	8	850
W8EHW	28	8	860
W8WRN	28	8	680
W8BAX	27	8	960
W8DX	26	8	720
W8ILC	25	8	800
W8JWV	25	8	940
W8NOH	21	8	975
W8LCY	21	7	610
W8BLN	21	7	610
W8BLN	18	7	780
W8GTK	18	7	550
W9KLR	39	9	1160
W9WOK	39	9	1150
W9GAB	32	9	1075
W9REM	31	8	850
W9AAG	30	8	1050
W9ZIH	30	8	830
W9EQC	26	8	820
W9ZHL	25	8	700
W9BPV	25	7	1030
W9PBP	23	8	820
K9AQP	23	7	780
W9LF	22	7	825
W9KPS	22	7	690
W9PMN	19	6	800
W9ALU	18	7	800
W9JIY	17	8	790
W9LEE	16	6	780
W9DDG	16	6	700
W9DSP	15	6	720
W0SMJ	27	8	1075
W0IHD	27	7	890
W0BFB	27	8	1060
W0GUD	25	7	1065
W0RUF	23	7	900
W0INI	21	6	830
W0UOP	21	7	900
W0TGC	21	7	875
W0ZJB	18	7	1180
W0RYG	17	6	925
W0IFS	16	6	1100
W0JHS	13	5	700
W0IC	12	5	1240
VE3DIR	28	8	1100
VE3AIB	26	8	910
VE3BQN	19	7	790
VE3AQG	17	7	800
VE3DER	16	7	820
VE2AOK	13	5	550
VE3BPB	14	6	715
VE7FJ	2	1	365
KH6UK	1	2	2540

Figure 3. An example of the QST *Standings box published periodically in "The World Above 50 Mc." column. Note the last entry of KH6UK.*

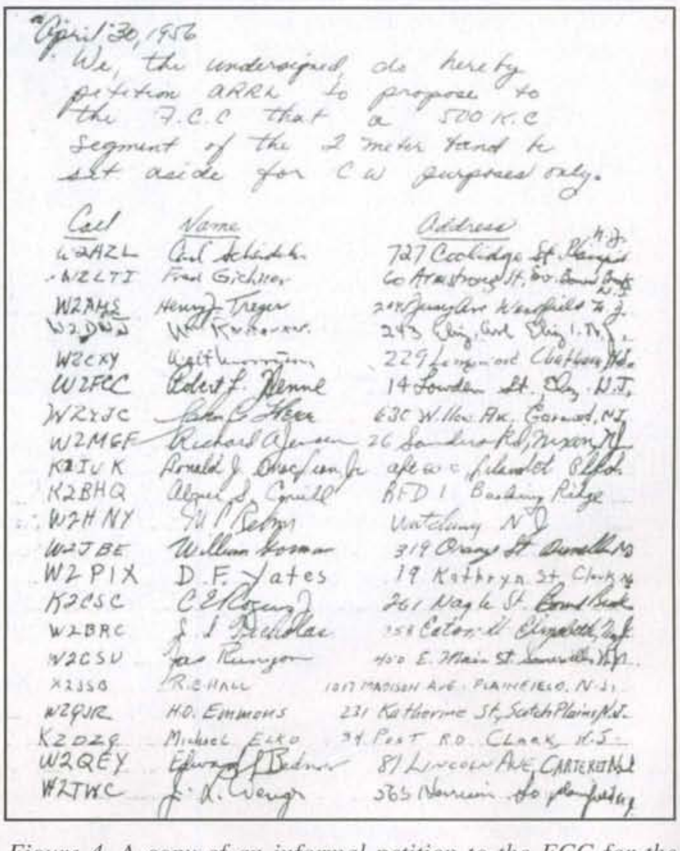
During the 1958 VHF contest Walt Morrison, W2CXY, took best DX working the *Perseids* meteor shower. Note that in spite of the impressive distances worked by many amateurs, including Walt, still nothing compared to that of Tommy and John's record-breaking QSO of 1957, as illustrated in the *QST* Standings box as shown in Figure 3.

With the popularity of wide-band crystal-controlled converters, and the ever-increasing number of high-powered VHF stations, crowding and cross modulation started to become problems. In 1956 W2CXY and others petitioned the FCC through the ARRL to reserve part of the 2-meter band for exclusive CW use for the purpose of "furthering the understanding of this medium about which so little is understood." The fact that the IGY was actually encouraging studies of the ionosphere at this time didn't hurt their cause. Figure 4 is a copy of an informal petition to the FCC for the CW subband.

This excerpt from "PRP News" of August 1958 shows that the FCC recognized the contribution of these hams:

FCC Proposes CW Segments for 50 and 144 Mc.

In response to a request from the ARRL, the FCC has issued a notice of proposed rule making seeking comments on the establishment of 100 kc. segments exclusively for CW at the low ends of the 50 and


April 30, 1956
We, the undersigned do hereby petition ARRL to propose to the F.C.C that a 500 K.C segment of the 2 meter band be set aside for CW purposes only.

Call	Name	Address
W2AZL	[illegible]	727 Coolidge St. [illegible] N.J.
W2LTI	Fred Gichner	60 Armstrong St. [illegible]
W2AHS	Henry Treger	[illegible] N.J.
W2DWJ	[illegible]	[illegible]
W2CXY	Walt Morrison	229 [illegible] Chatham N.J.
W2FCC	Robert F. [illegible]	14 [illegible] St. [illegible] N.J.
W2YJC	[illegible]	630 Willow Ave. [illegible] N.J.
W2MGF	Richard A. [illegible]	26 [illegible]
K2IUK	Ronald J. [illegible] Jr	[illegible]
K2BHQ	[illegible]	RFD 1 Basking Ridge
W2HNY	[illegible]	Watchung N.J.
W2JBE	William [illegible]	319 Orange St. [illegible]
W2PIX	D. F. Yates	19 Kathryn St. Clark N.J.
K2CSC	[illegible]	261 Nagle St. [illegible]
W2BRC	[illegible]	[illegible] Elizabeth N.J.
W2CSU	[illegible]	400 E. Main St. [illegible] N.J.
K2350	R.E. HALL	1017 MADISON AVE. PLAINFIELD, N.J.
W2QJR	H.O. Emmons	231 Katherine St, Scotch Plains N.J.
K2DZG	Michael Elko	34 Post Rd. Clark N.J.
W2QEY	Edward [illegible]	81 Lincoln Ave. Carteret N.J.
W2TWC	[illegible]	565 [illegible]

Figure 4. A copy of an informal petition to the FCC for the CW subband.

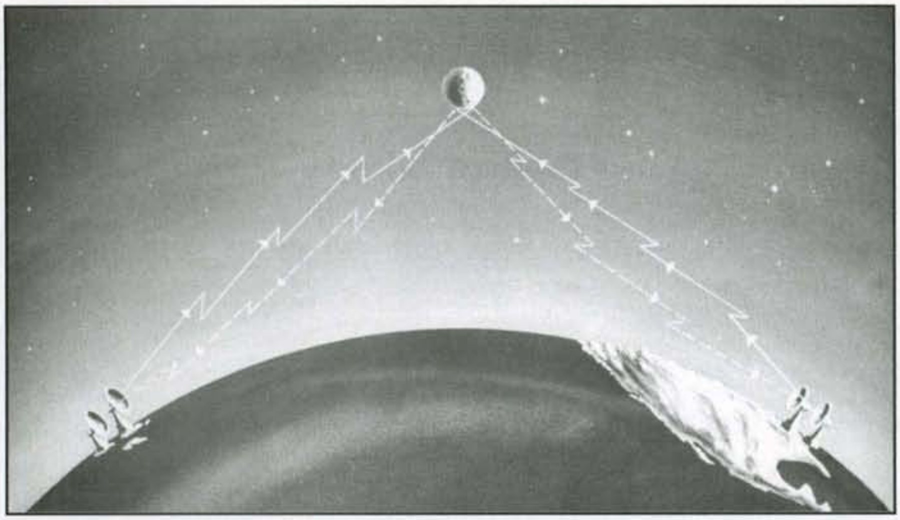


Photo 7. This is a graphic illustration of satellite communications from the book From Semaphore to Satellite, *by Anthony R. Michaelis, published by the International Telecommunication Union in 1965. (Photo courtesy of the ITU)*

144 Mc. bands. This is of special interest to PRPers because the League based much of its argument in favor of the proposal on contributions to the art made by amateur groups such as ours. The text of the League's proposal and the Commission's notice appear on pages 54–55 of August *QST*. Perhaps you will wish to express your own views on this matter directly to the FCC, Washington, DC by August 29th so that they may know the extent to which the League's proposal is supported by amateurs.

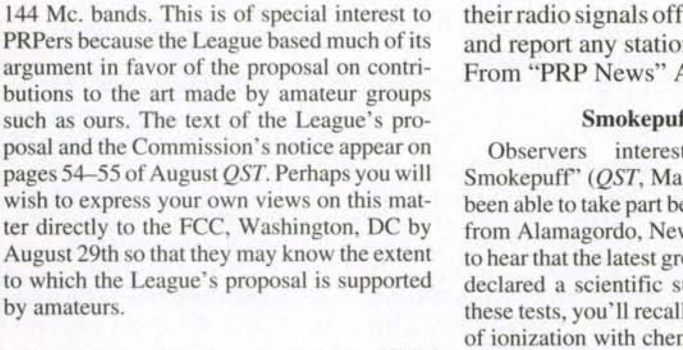
It is interesting to note that the FCC ultimately did reserve 100 kHz at the low end of 2 and 6 meters exclusively for CW, both of which exist today.

"Operation Smokepuff" was an IGY experiment using rockets launched from White Sands, New Mexico to release ionizing chemicals into the atmosphere. Radio amateurs were asked to bounce their radio signals off the ionization cloud and report any stations heard or worked. From "PRP News" August 1958:

Smokepuff Results

Observers interested in "Operation Smokepuff" (*QST*, May 1957) who have not been able to take part because of living too far from Alamagordo, New Mexico will be glad to hear that the latest group of firings has been declared a scientific success. The object of these tests, you'll recall, was to create a patch of ionization with chemicals released from a research rocket. A network of hams was organized to help prove the existence of this ionization by bouncing their HF and VHF signals from one side of the patch to the other.

On May 20, 21 and 22, Nike-Cajuns soared aloft with their ionizing cargoes. A "hardware" difficulty cause the middle missile to release its gas 30 km. higher than the intended 120 km. altitude but, other than this, things went well. On all three occasions, the released chemicals produced visible clouds larger in apparent diameter than the moon, making excellent photography possible. The first test produced a 15-minute echo on a 3-Mc. ionospheric recorder.



IGY

1957 1958

National Academy of Sciences
U. S. National Committee for IGY

Air Research and Development Command
United States Air Force
Air Force Cambridge Research Center
Geophysics Research Directorate

The American Radio Relay League, Incorporated
International Geophysical Year
Propagation Research Project

ARE PLEASED to acknowledge the outstanding services rendered by WALTER J. MORRISON operating amateur radio station W2CXY during the period of the United States program of the

International Geophysical Year

January 1957 — December 1958

Your unselfish cooperation with the ARRL-IGY Propagation Research Project has contributed significantly to the world's scientific knowledge in the field of v.h.f. ionospheric radio propagation.

Director, Geophysics Research Directorate — Executive Director, U.S.N.C.-I.G.Y. — President, A.R.R.L.

Photo 8. A copy of the certificate issued to Walt Morrison, W2CXY, for his participation in the ARRL's Propagation Research Project. (Author photo)

Throughout the IGY many amateurs experimented with moon-reflection work, or simply moonbounce. Although many hams reported hearing their own echoes, it wasn't until years later, 1960 in fact, that the first amateur QSO would take place. It was during the IGY, however, that the Navy began installation of a two-way moonbounce network that later became operational between Washington, DC and Hawaii, also in 1960. Photo 7 is from the book *From Semaphore to Satellite,* by Anthony R. Michaelis, published by the International Telecommunication Union (ITU) in 1965.

Although an amateur moonbounce QSO did not take place during the IGY, the seeds were planted for serious VHF amateurs to reach for this loftiest of goals—the ultimate DX record. The events leading up to the first successful amateur moonbounce will be covered in a future article.

As the IGY came to a close, special certificates were awarded to those who participated in the ARRL's Propagation

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Research Project. Photo 8 is a copy of the certificate issued to Walt Morrison, W2CXY.

There is no doubt that amateur radio made significant contributions to the scientific purpose of the International Geophysical Year of 1957–1958. Although much has been said about this, Ed Tilton, W1HDQ, may have said it best when he wrote the following words on the 20th anniversary of his *QST* column "The World Above 50 Mc." in December 1959.

Amateur radio stock rose markedly in the world of science with the announcement of the success of KH6UK and W6NLZ in working from California to Hawaii on 144 Mc. in 1957 and on 220 Mc. in 1959. Our contribution to the world-wide effort in the International Geophysical Year has brought and is bringing words of appreciation from people in many high places. . . . If, in 1979, we can say that the occupants of the world above 50 Mc. have done as well in the second 20 years as they have in the first 20 of this department's existence, the cause of amateur radio as a whole will have been well served."

What Did the IGY Mean to Me?

Compiled by Joe Lynch, N6CL

In commemoration of the 50th anniversary of the start of the International Geophysical Year (IGY), I asked for responses to the question: What did the IGY mean to me? Here are a few of the responses that I have received so far:

Joe Taylor, K1JT:

In 1957 I was 16 years old and a sophomore in high school. My two-years-older brother Hal and I had passed our Amateur Extra Class license examinations a year or so earlier—I was K2ITP, and he K2ITQ —and together we had built a very capable 6-meter station, mostly from free or almost-free military surplus equipment and junked TV sets. We were keenly interested in all things technical, and especially VHF radio communication. We subscribed to *CQ* and *QST* and avidly devoured all the technical articles that arrived each month.

When the ARRL IGY Propagation Research Project came along, we eagerly signed up as volunteer observers. As I remember it half a century later, our main task was to get on the air, listen, and file biweekly reports on any unusual propagation observed. This was easy to do, because (except for filing the reports) it was exactly what we had been doing anyway! Of course, we understood that we were entering the peak years of solar cycle 19, and our favorite band, 50 MHz, was already exhibiting some exciting propagation. We were "riding the MUF," looking for thrills. Many were the mornings that we pointed our beam northeast and listened to the video carrier of BBC channel 2 at 51.75 MHz, 30 dB over S9, and wished that European operators had privileges on our band. We did make many exciting DX QSOs, despite the licensing restrictions. One that I recall vividly was one of the first US-Argentina 50 MHz contacts ever, with LU9MA, I think in the fall of 1956.

We dutifully filed our reports on aurora, *F2*, *E*-skip, and the like, every few weeks for a year or more. We proudly displayed the "Consistent Reporting Award" sent to us by the ARRL, with its accumulating endorsement stickers. This was our first taste of doing systematic research in a scientific field, and although our parts in it were small, we liked it. Obviously the experience had positive effects on both Hal and me, and helped to shape our career interests. We both studied physics in college, went on to complete Ph.D. degrees, and both became professors of physics. Hal died of cancer in 2002, or he too would be writing here about what the IGY meant to him.

Bill Tynan, W3XO:

The IGY gave hams, particularly those interested in VHF ionospheric propagation, a chance to participate in an important scientific investigation. When I was in college back in the late 1940s, I considered solar physics as a career, but concluded that everything about the Sun was already known. Was I ever wrong!

Al Katz, K2UYH:

I was licensed in '56, in high school and just getting started on VHF. I remember being impressed with the articles on the upcoming IGY year in *QST* and *CQ* magazines. But when 1957 arrived, I do not remember it having a great impact on my involvement in ham radio. I was not much of a 6 meter operator; I did make my first 2 meter aurora QSOs about this time. And study of the aurora borealis was part of the IGY. Sam Harris, W1FZJ, then VHF editor of *CQ*, was stirring my interest in VHF and EME. Sam and the IGY year certainly were a factor in steering many young hams toward careers in science and engineering. In the US, we need something similar today.

Arnie Coro, CO2KK:

The International Geophysical Year, 1957, a very well-organized scientific effort that was aimed at studying, among other things, the activity of the Sun during the maximum of Cycle 19 (so far, as you know the most powerful cycle that we have registered), did have a tremendous and unexpected impact in my life. I was 15 years old and already had an "Amateur Radio Operators Certificate" but not an actual license with a callsign. So I used to visit the local radio amateurs and operate their stations as a "second operator," something that was allowed at that time.

Then on the 4th of October of 1957, something really fantastic happened. The Soviet Union announced the launching of Sputnik I, the first manmade object to orbit the Earth by reaching the 4 kilometers per second required speed to keep it circling the Earth.

The AP and UP news agencies announced two frequencies, one very near WWV's 20,000 kHz channel and the other one around 40,000 kHz. Using my Super Pro 400 receiver and a 40 meter band half-wave dipole, I was able to pick up the 20,000 kHz signal around 20,003 to 20,005, although the calibration of their radio did not allow me to know the exact frequency. But the BIP ... BIP ...BIP ... of Sputnik I was there, coming out of the loudspeaker. I then went to see Oscar Morales Tur, CO2OM (Oscar, CO2OJ's dad), and we talked about the Russian satellite. Oscar Sr. was also able to pick up the signals and we even taped them on a Webcor tape recorder using quarter-inch tape. I then contacted a friend of my grandfather who was a newspaper reporter, and told him we had picked up the signals, explaining that not one but three Cuban radio amateurs had heard several passes of the satellite, because later we learned that Miguel J. Enciso, CO2CT, had also heard Sputnik I. Both Oscar Sr. and Miguel are now SK, and I will always remember them for all what they taught me about amateur radio.

The next thing that happened was that my report was published in one of Havana's most important newspapers, *Informacion*, and later Alberto Giro, CO2GY, who was a columnist for the *Diario de la Marina*, another of the capital's newspaper, also published a report.

So, as you may realize, the IGY was very important for my amateur and also professional radio careers, as from then on it was simply impossible to stay away from the radios at any spare time I had from the senior high school that I was attending at that time!

P.S.: For the skeptics who questioned if we had heard or not heard Sputnik I, we kept the tape recording available, and Oscar Sr. made a copy and gave it to the CMQ Radio News Department which played it on the air on one of the newscasts. A year later, using a modified FM tuner, we also picked up Explorer I, which used a frequency slightly above the 108 MHz top end of the FM broadcast band, and as it happened with the first ever EME contact from Cuba between CO2KK, Arnie Coro, and KB8RQ, Gary Crabtree.

I was also involved in the first attempts to communicate via satellite with my amateur radio station. But that event passed by without me taking down notes, so now I don't remember which satellite was used or when it happened!

Quarterly Calendar

The following is a list of important dates for EME enthusiasts.

Nov. 1, 2007	Last Quarter Moon
Nov. 4, 2007	Good EME conditions
Nov. 9, 2007	New Moon and Moon Apogee
Nov. 11, 2007	Very poor EME conditions
Nov. 17, 2007	First Quarter Moon and *Leonids* Meteor Shower Peak
Nov. 18, 2007	Moderate EME conditions
Nov. 24, 2007	Full Moon and Moon Perigee
Nov. 25, 2007	Moderate EME conditions
Dec. 1, 2007	Last Quarter Moon
Dec. 2, 2007	Moderate EME conditions
Dec. 6, 2007	Moon Apogee
Dec. 9, 2007	New Moon. Very poor EME conditions
Dec. 13, 2007	*Geminids* Meteor Shower Peak
Dec. 16, 2007	Good EME conditions
Dec. 17, 2007	First Quarter Moon
Dec. 22, 2007	Moon Perigee and Winter Solstice
Dec. 23, 2007	Moderate EME conditions; *Ursids* meteor shower peak
Dec. 24, 2007	Full Moon
Dec. 30, 2007	Moderate EME conditions
Dec. 31, 2007	Last Quarter Moon
Jan. 3, 2008	Moon Apogee
Jan. 4, 2008	*Quadrantids* meteor shower peak
Jan. 6, 2008	Very poor EME conditions.
Jan. 8, 2008	New Moon.
Jan. 13, 2008	Good EME conditions.
Jan. 15, 2008	First Quarter Moon.
Jan. 19, 2008	Moon Perigee.
Jan. 20, 2008	Poor EME conditions.
Jan. 22, 2008	Full Moon
Jan. 27, 2008	Moderate EME conditions
Jan. 30, 2008	Last Quarter Moon
Jan. 31, 2008	Moon Apogee
Feb. 3, 2008	Very poor EME conditions
Feb. 7, 2008	New Moon and annular Solar Eclipse that will only be visible over some parts of Antarctica. A partial eclipse will be visible throughout New Zealand and some parts of eastern Australia.
Feb. 10, 2008	Good EME conditions
Feb. 14, 2008	First Quarter Moon and Moon Perigee
Feb. 17, 2008	Moderate EME conditions
Feb. 21, 2008	Full Moon and Total Lunar Eclipse visible throughout most of the Americas, Africa, and Europe
Feb. 24, 2008	Moderate EME conditions
Feb. 28, 2008	Moon Apogee
Feb. 29, 2008	Last Quarter Moon

—EME conditions courtesy W5LUU.

Current Contests

November: The second weekend of the **ARRL 50 MHz to 1296 MHz EME Contest** is November 24-25.

January: The ARRL VHF Sweepstakes is scheduled for the weekend of January 19-20.

For ARRL contest rules, see the issue of *QST* prior to the month of the contest or the URL: <http://www.arrl.org>.

Current Meteor Showers

November: The *Leonids* is predicted to peak at around 0250 UTC on November 18.

December: Two showers occur this month. The first, the *Geminids,* is predicted to peak at around 1645 UTC on December 14. 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 100–120 meteors per hour at its peak.

The second, the *Ursids,* is predicted to peak on December 23. It is an east-west shower, producing an average of no greater than 10 meteors per hour, with the rare possibility of upwards of 90 meteors at its peak.

January: The *Quandrantids,* or *Quads,* is a brief but very active meteor shower. The expected peak is around 0640 UTC on 4 January. 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 more information on the above meteor shower predictions see Tomas Hood, NW7US's "VHF Propagation" column starting on page 80. Also visit the International Meteor Organization's website: <http://www.imo.net>.

Pounding the Key on 6 Meters
A Summer of 6-meter CW Fun

Does operating CW give one an advantage? Features Editor WB2AMU decided to conduct his own informal test of that theory. Here are the results of his efforts.

By Ken Neubeck,* WB2AMU

In an article that I wrote for the Spring 2007 issue of *CQ VHF* ("CW—An Important Mode on VHF"), I discussed in detail the advantages of operating CW on the VHF bands and why it would continue to be an important mode in the future. I pointed out, among other things, the ability of CW to punch through marginal conditions and its usefulness in working DX on 6 meters. The article focused on the positive merits of CW and the fact that many operators would still use it on the VHF bands even though it was no longer an FCC requirement for an amateur radio license.

With this in mind, I thought that I would conduct my own informal survey by concentrating more on using CW rather than SSB on the VHF bands during the summer of 2007. All too often in the past, it seemed easy to run a string of SSB QSOs on 6 meters when the band was open. This past summer I decided I would specifically work on calling CQ more on CW during some of the better 6-meter sporadic-*E* openings and see which stations would respond. As a rule, in the past I usually did not call CQ often, except during intense openings. I did this primarily because I was still resolving both antenna and interference issues at my home QTH on Long Island, New York.

However, with recent improvements in my TV and other appliance setups, I am now able to run a moderate amount of power (150 watts) to a two-element Yagi on 6 meters without causing significant interference. Previously, I could only run 10 watts at home, as higher power levels would get me into the phone and the front end of the TV set. By now being able to put out a decent signal for the most part, I could actually call more CQs and expect to get answers to my calls.

Thus, during the summer I entered into a campaign of a significant amount of calling CQ during good 6-meter sporadic-*E* openings and found some interesting results that not only show the value of CW, but also the value of calling CQ at the right times.

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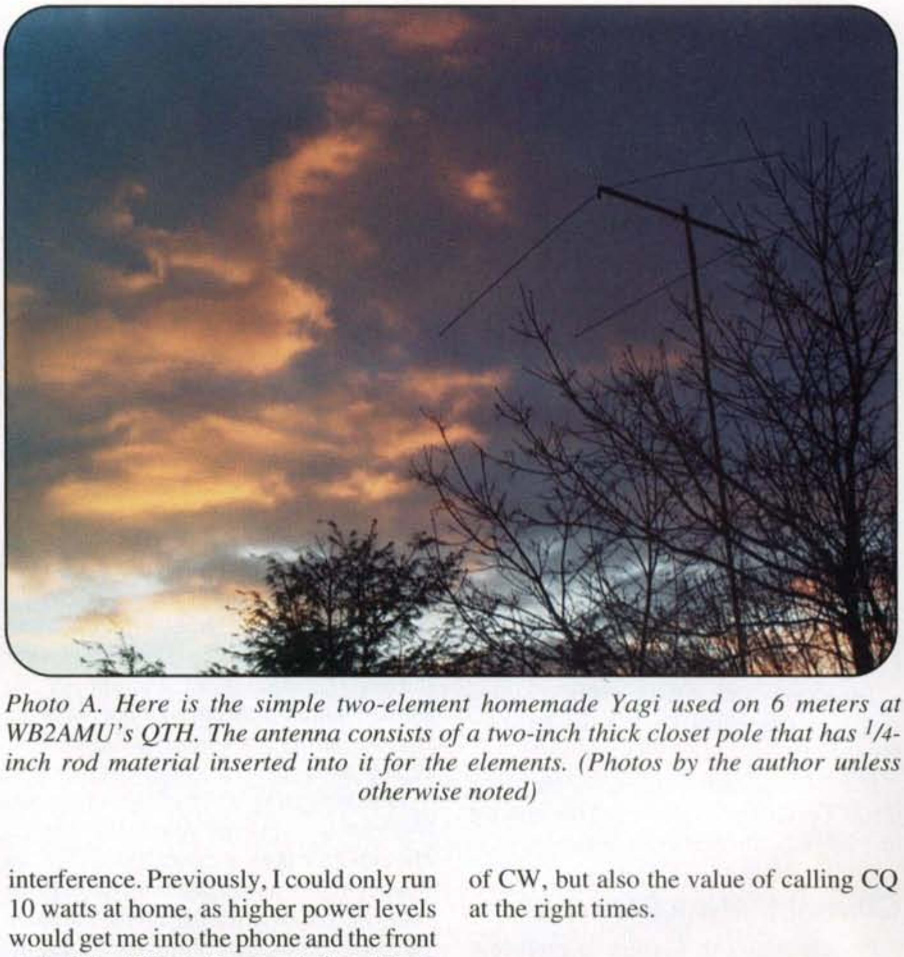

Photo A. Here is the simple two-element homemade Yagi used on 6 meters at WB2AMU's QTH. The antenna consists of a two-inch thick closet pole that has 1/4-inch rod material inserted into it for the elements. (Photos by the author unless otherwise noted)

The Setup at My QTH

My home setup includes a classic Kenwood TS-670 transceiver that puts out 10 watts on 6 meters. I hook this up to a Mirage A1015G amplifier that puts out roughly 150 watts, and this goes to a homemade two-element Yagi that is up about 25 feet (Photo A). This is a modest setup on 6 meters that is limited because of the size of my lot on Long Island. There are many strong signals on 6 meters that come from great stations that have bigger antenna arrays and higher power amplifiers. However, a large number of 6-meter operators have moderate setups, usually running a maximum of 100 watts from an HF-plus-VHF transceiver with a multitude of different antennas ranging from 40-meter dipoles to seven-element 6-meter Yagis. However, if we consider a moderate setup such as mine as an average station, the results that were obtained should be reasonably achievable by similar or better stations.

I use a straight key when I am on CW, as I have always preferred that for my ham radio operations. The key that I have been using with my base station at home for about the last ten years is a vintage brass key that is about 80 years old (Photo B); I found it in an antique store and bought it for $15. I have it mounted on a nice piece of wood and it has the best spring action out of all the straight keys I have used. After the article I wrote for the Spring issue of *CQ VHF*, I received an e-mail from another straight-key operator, Karl Zuk, N2ZK, who got on 6 meters for the first time this past summer. Photo C shows his collection of straight keys, so it looks like there are more straight-key operators out there than one would think.

As I live on a geographically challenged one-third acre lot, I had to find the right antenna setup for 6 meters that would fit in the backyard and not be too noticeable. I ended up with a very simple setup consisting of a homemade two-element Yagi that uses a closet pole for the mast of the beam and 1/4-inch rod material inserted into the mast. I have it mounted on 25 feet of aluminum mast material that I had bought over the years from RadioShack. At this point, I have not bothered to put a rotator on the setup, as I generally point it west or southwest (remember that I live on eastern Long Island and I do not have that many openings to the east of me!)

CQ Sporadic-*E*!

There were at least five or six good U.S. sporadic-*E* openings during which I was able to do well by using one beam heading, choosing one frequency, and holding it while calling CQ. As many VHF operators know, sporadic-*E* openings on 6 meters can range from weak affairs to very strong conditions.

Photo B. This is the straight key used by the author at his home station, along with some of the QSLs that came in the mail during the summer. The key is an old brass key that goes back about 80 years, and it is mounted on a varnished piece of wood.

One major advantage of being able to hold a frequency on 6 meters and call CQ is that eventually some of the weaker sounding stations that usually come in via double-hop sporadic-*E* will call. A case in point is a good sporadic-*E* opening that I experienced on the evening of June 30th. Beginning at 7:30 PM local time, I was working several stations in the Midwest in 9-land and 8-land in the CW portion of the band, when I worked KØCL in Colorado. I then found a clear spot a few minutes later on 50.095 MHz and started calling CQ. I was able to hold the

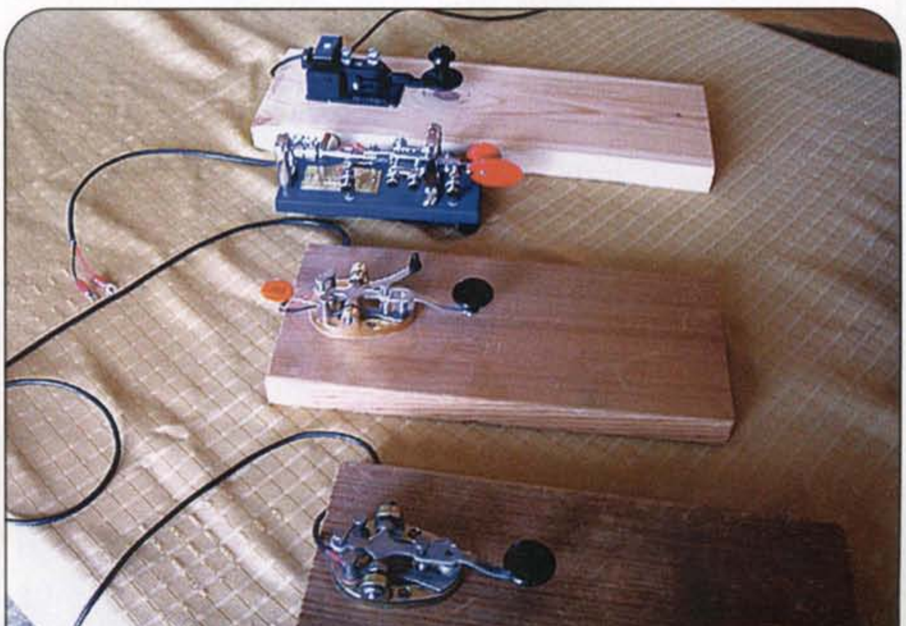

Photo C. Here is a selection of straight keys that Karl Zuk, N2KZ, uses at different times for his work on HF and 6 meters. (Photo by N2KZ)

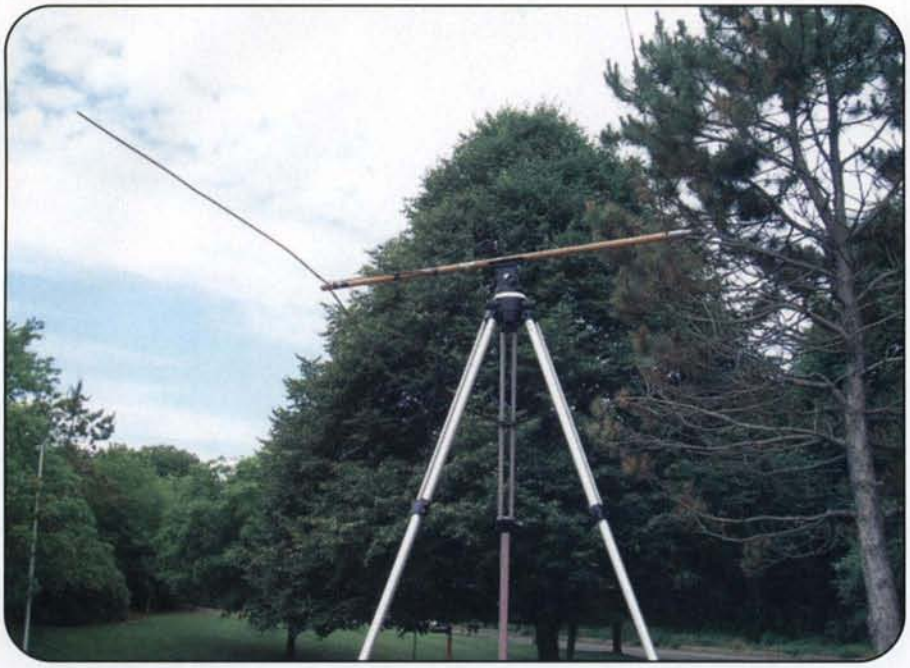

Photo D. A two-element Yagi that WB2AMU made for portable operation. It is designed to be mounted in a telescoping tripod, and because of its light weight, it can be positioned on the car roof while parked.

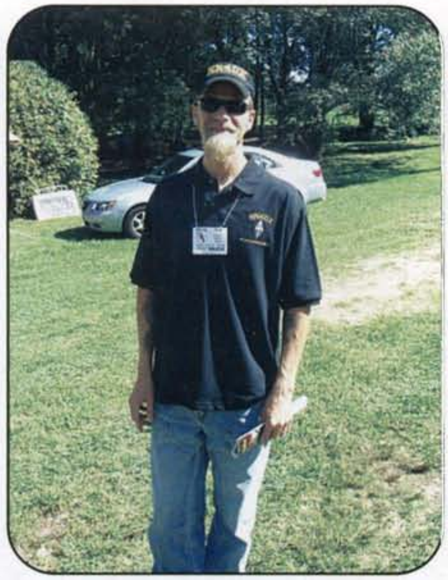

Photo E. Tim Havens, NN4DX, is the force behind one of the most active 6-meter spotting sites, dxers.info. This site proved to be a most valuable tool in spotting some of the rare grids and DX stations on 6 meters during the summer of 2007.

frequency and had stations in the Midwest coming back to my CQ, when I started hearing weaker signals come back to me, indicating double-hop activity! I proceeded to work W5ZF in New Mexico, WØETT in Colorado, N7KO in Arizona, N5KY in New Mexico, W6OUU in Idaho, and W6PJ in Arizona, all over a 12-minute period. These stations were interspersed with a few Midwest stations, too, so my CQing was bringing them out. I would venture to say that more stations are now listening on 6 meters, so it paid off to call CQ at the right time to draw them out. Some of the signals were marginal, so it is doubtful that I would have been able to work them on SSB instead of CW.

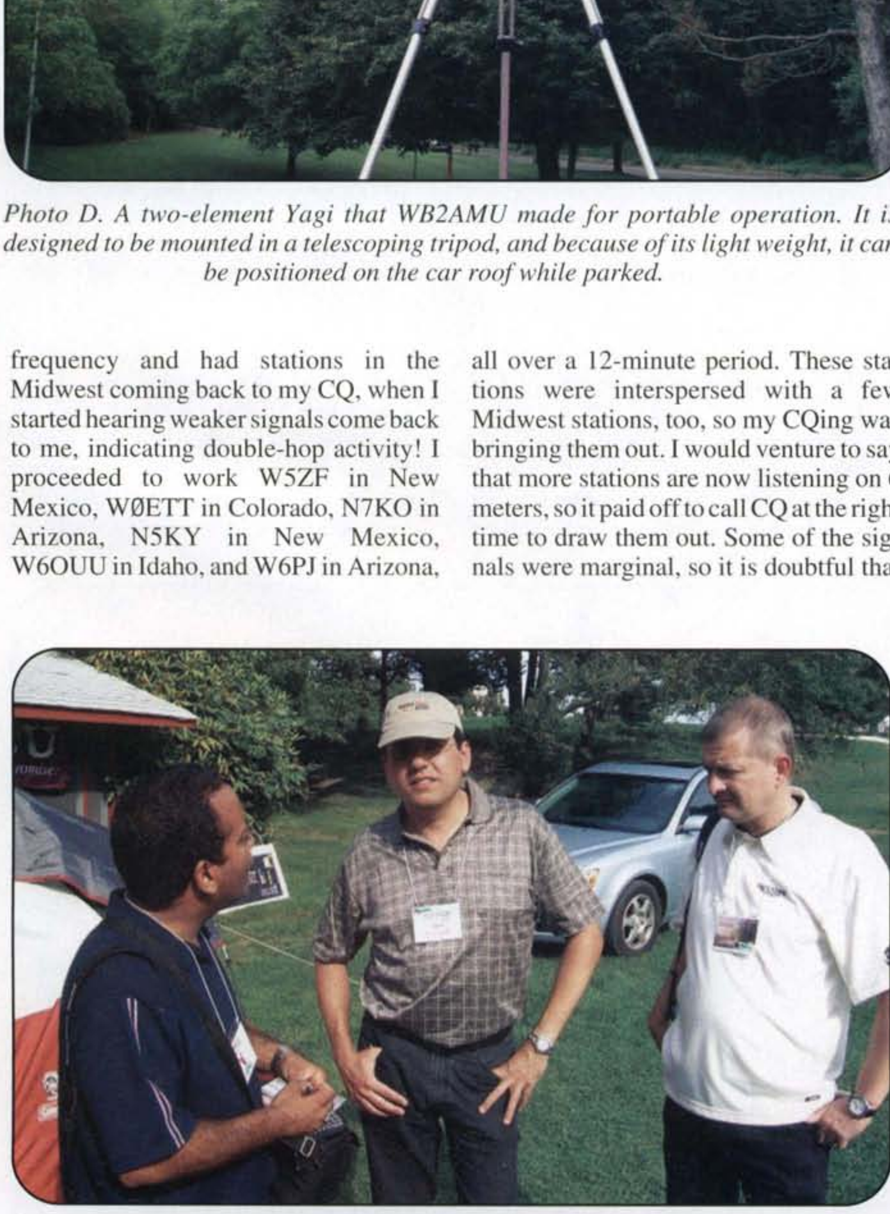

Photo F. These three DX stations, seen here at SMOGfest 2006, keep their countries active on the Magic Band every summer. They are Ted, HI3TEJ, Jose, EA7KW, and Johan, ON4IQ. All three are good CW operators who can pull in weak signals during marginal openings.

I had similar good fortune over the month of July on days when the sporadic-*E* skip was strong. Sometimes the skip was only an hour or so long, as was the case for the CQ WW VHF Contest on the weekend of July 21st and 22nd. At about 6:45 PM local time, sporadic-*E* started to come in full force after several hours of very weak band conditions. After working a few stations in 8-land and 4-land, I found an opening on 50.093 MHz in the CW band and started to call CQ. For about 25 minutes I was almost able to keep a rate of one contact a minute, and I worked into the Ohio, Michigan, and Illinois areas. At some point, there were no answers to my CQ, so I started to search around on SSB and pick up a few more contacts before the skip gave out.

During the summer of 2007, there was a fair amount of activity between the eastern U.S. and Europe, but it was not like it had been in 2006. I was able to cross the Atlantic two or three times, with one of my CW QSOs being with Gary, CU2JT, using a portable two-element beam setup mounted on my car at work at noontime on June 18th (Photo D). Some New England stations had posted the information on Tim Haven's site, dxers.info (Photo E). In addition to Gary, the regular European 6-meter group—

VHF Propagation Hunter Progress Report
The ARRL September VHF QSO Party

SEPTEMBER 2007 ARRL VHF CONTEST

Grids worked on 432 MHz

by WB2AMU in FN30, Long Island, NY

(Grids in green = typical line of sight, in yellow = tropo enhancement)

FN03	FN13	FN23	FN33	**FN43**	FN 53
FN02	FN12	FN22	**FN32**	FN42	FN 52
FN01	FN11	**FN21**	**FN31**	**FN41**	FN51
FN00	**FN10**	**FN20**	**FN30**	FN40	FN50
FM09	**FM19**	**FM29**			
FM08	FM18	FM28			
FM07	**FM17**	FM27			
FM06	FM16	FM26			

As mentioned in my article "VHF Propagation Hunter" in the Summer 2007 issue, I promised to try to provide periodic updates on some good tropo openings occurring on the VHF bands.

The ARRL September VHF QSO Party fell on a weekend when a tropical storm was moving towards the east coast of the United States. There was a predicted tropo opening based on the maps from the William Hepburn website for Sunday of the weekend (September 9th). At the hilltop location on Long Island (grid square FN30) where I operated QRP portable, I saw only modest tropo activity on the VHF bands on Saturday afternoon. However, when I arrived at the site early in the morning on Sunday, I saw some major tropo activity on all of the VHF bands.

When I first listened on 2 meters at 6:15 AM local time, I heard W4VHH in EM95 contacting N2RRA in FN31, and I knew that this was most likely a long tropo path. I was not able to get W4VHH, but then some signals started coming in very strong both on 2 meters and 432 MHz. Booming signals were coming from stations such as K3TUF (FN10), W4IY (FM19), KA3EJJ (FM19), KC3RE/rover (FM08), K8EP (FM09), K8GP (FM08), N3OC (FM19), and W3SO (FN00). After I worked KO4YC in FM17 on 2 meters at 8 AM, I asked him to move to 432 MHz and I was eventually able to work him there, too. I could not believe how loud some of the signals were on 432 MHz! The figure shows the grids that I worked on 432 MHz which appeared to be tropo-enhanced. Also look at the Hepburn tropo map and see how closely the two maps line up.

It was very fortunate that a significant tropo opening occurred during a high-activity event on the VHF bands such as the ARRL VHF QSO Party. I'll continue to update tropo-opening reports in the future as events occur.

This is the simple antenna setup that WB2AMU used during the September ARRL VHF QSO Party— a three-element 2-meter Yagi mounted on a telescoping tripod placed on the roof of his car. The 2-meter antenna was also able to load up on 432 MHz, where the pattern is similar to a dipole, and a couple of dozen stations were worked on this band as well.

This is the tropo map prediction for September 8th that appeared on William R. Hepburn's website, >http://www.dxinfocentre.com/tropo.html>. Note that the storm activity was in the North Carolina area and that fronts developed from the lower part of New York into western Pennsylvania, Maryland, and Virginia. (Map courtesy of the website of William R. Hepburn)

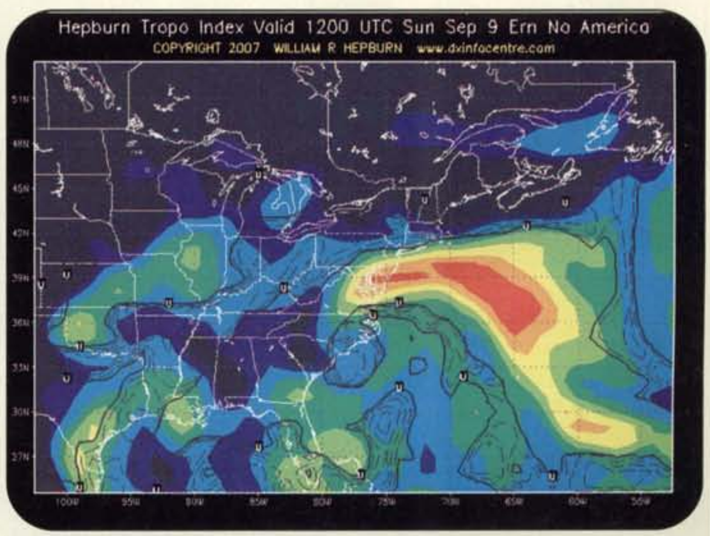

Photo G. Jose, EA7KW, is receiving a Haiti QSL for 6 meters from Chris, W3CMP, from his 2006 trip there. Chris repeated the same trip in June 2006 and worked many stations who needed this rare country on 6 meters.

Photo I. Lance, W7GJ, on the right, with Joe Taylor, K1JT, the inventor of WSJT software. Several times during the past three summers, Lance generated some major pile-ups on 6 meters via double-hop sporadic-E.

including Johan, ON4IQ, Jose, EA7KW, and Joe, CT1HZE (Photos F and G)—were worked by several U.S. stations during a few transatlantic openings.

There were a number of Caribbean DX stations, including expeditions that were planned by veteran 6-meter operators such as Chris, W3CMP, in Haiti; Dennis, K7BV, in Belize; Jimmy, W6JKV, in Grenada; and Howard, WB4WXE, operating from Antigua as V26HS for over two weeks (Photo H). A lot of credit has to be given to these operators, as they kept listening and calling for several hours at a time. Belize, for example, is a location where there is only an occasional two-hop sporadic-*E* path to the East Coast. On July 13th I was lucky to finally work this one as a new country, with both V36M and V31UM being worked in a matter of ten minutes!

Cross-mode contacts using CW were very important for me, not only during my QRP efforts during the June VHF Contest, but also during situations where there were large pile-ups on stations in rare grid squares or rare countries. As I did in 2006, I was able to work Lance,

Photo H. Here is the view of the ocean and the three-element 6-meter Yagi at V26HS. Howard, WB4WXE, repeated his trip to Antigua in 2007 (he was there in 2006 as well) and stayed for a two-week period in June. He worked over 1600 stations on 6 meters as V26HE. Of those 1600 QSOs, 450 of them were with Europe. Howard concentrated on SSB, but he copied a number of CW stations for cross-mode contacts when conditions were not optimal. (Photo by WB4WXE)

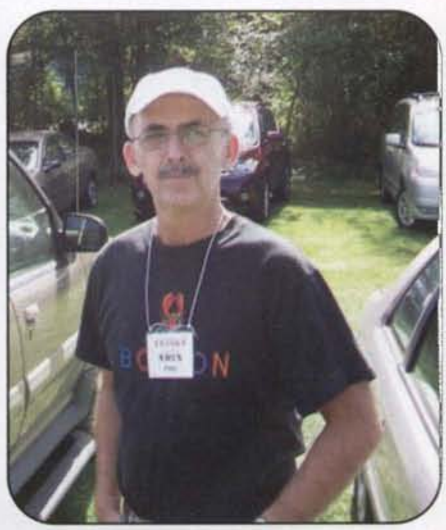

Photo J. Pete, VE3IKV, is an active mobile operator on 6 meters and also goes to rare grids in northern parts of Canada. In June 2007 he activated Nunavut as VFØX and made several CW QSOs in addition to SSB QSOs with the U.S. and Europe.

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W7GJ, in Montana by calling him on CW in order to break the pile-up (Photo I). Lance specializes in EME work, where CW is important, and he, along with the other operators who have been mentioned in this article, are very good CW ops who can pick out a CW signal in the throng of SSB signals.

It was a good summer for me in that I picked up two new countries on 6 meters (Antigua and Belize), along with about ten new grids in the U.S., mostly in the western states, such as New Mexico and Colorado. CW was a major plus for me in getting some of these stations on 6.

Summary

On 6 meters during the summer there will be a number of times when conditions are optimal and when sporadic-*E* enhanced signals are booming. Sometimes these openings may last for only an hour or sometimes they last for a few hours. While it has been said that it is important to make noise on 6 meters when the band is quiet, the same can be said when the band is very active. That is because there may be more than one sporadic-*E* cloud formation, which can often lead to marginal or moderate double-hop sporadic-*E* conditions. Thus, during the very quiet times and during the very active times, it make sense to find an open frequency and call CQ.

More important, it can be seen that CW still remains a very important mode of operation. The great majority of the callsigns that I worked during this past summer appeared to be callsigns of hams who have been around a while. They certainly were proficient on CW. I worked a few newcomers, too, basing that judgment on the code speed or the newer callsign.

Newcomers to CW will find it most beneficial to learn this mode at least on a rudimentary level so that they are able to identify beacon messages on 6 meters. A good way to start is to learn the dits and dahs sequence for the numbers, as all beacons make use of numerical characters in their messages. For example, the K2ZD beacon in New Jersey sends the callsign, along with the grid FN20. Therefore, learning to be able to identify the numbers, such as "20"in this case, is a start for identifying potential sporadic-*E* skip conditions when certain beacons start coming in. While you may never want to use CW as your main mode of operation, it would be a major advantage to be able to copy the beacons and know where to point your antennas.

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Moondata Update 2008 and Related Comments

One of the most important factors in EME communications is knowing when it is best to communicate via moonbounce. W5LUU presents a summary and table of the best and worst conditions for EME in 2008.

By Derwin King,* W5LUU

The Earth-Moon distance and the cosmic (sky) noise temperatures in the direction of the Moon are predictable, cyclical variables that set the basic quality of Earth-Moon-Earth (EME) communications for frequencies below 1.0 GHz. The best conditions occur when: (1) the Range Factor (Earth-Moon distance) is at the absolute minimum, and (2) the Sky Temperature toward the Moon, as seen from Earth, is the coldest along the moon path. While the Range Factor is independent of frequency, Sky Temperature decreases with frequency, up to ~1 GHz, and then levels out. The EME signal-to-noise ratio, in dB, is usually degraded from the ideal by a factor (DGRD, see below) which varies with time over hourly, daily, weekly, monthly, and yearly periods. The DGRD, in dB, for 144 and 432 MHz, and other pertinent EME data, are listed in the W5LUU Weekend Moon Data for each Sunday at 0000 UT and provide a guide for the basic EME weekend conditions (see the accompanying table). Random variables such as ionospheric disturbances, local noise, and polarization mismatch will increase the "apparent" DGRD.

EME conditions generally will improve in 2008, with all moon perigees at north declinations, but on many weekends the moon is at right ascension, where Sky Noise is 1 to 4 dB above minimum, and five good weekends are negated by New Moon. Many weekdays will be good or better. Over the next one to two years, as perigees occurs near the best cold sky region, conditions will improve. During the annual ARRL EME Contest period there are no ideal, high declination weekends for VHF due to the high sky temperatures. Dates will have to be a compromise. For 1296 MHz and up, several high declination dates are near perigee and near ideal.

Definitions

DEC (deg): Moon declination in degrees north and south (–) of the equator. This is cyclical with an average period of 27.212221 days. The maximum declination during a monthly cycle, plus and minus, ranges from 18.15 up to 28.72 degrees with a period (maximum to minimum and back to maximum) in about 19 years. *The last maximum was on 09/15/2006.*

RA (hrs): Right Ascension, in hours, gives the east-west position of the moon against the sky background. The average period of RA cycle is 27.321662 days, but it can vary by a day or so due to effects of the Sun on the Earth and Moon motion.

144 MHz Temp (K): The 144-MHz cosmic (sky) noise in direction of moon expressed as absolute temperature.

Range Factor (dBr): The additional EME path loss, in dB, due to Earth-Moon separation distance being greater than absolute minimum (348,030 km surface-to-surface). Varies from a low of 0 to 0.7 dB at perigee up to 2.33 $\pm$0.1 dB at apogee.

DGRD (dB): The degradation in EME signal-to-noise (in dB) due to: (1) the excess sky noise temperature (in dB) at the stated position of the Moon compared to the lowest cold sky temperature and the system noise temperature (all at the frequency of interest); plus (2) the Earth-Moon range factor (dBr) for the listed time and date. The tabulated DGRD is referenced to the lowest possible sky noise temperature along the Moon path, for a system noise temperature of 80 °K at 144 and 60 °K at 432, an antenna beam width of ~15°, and to the absolute minimum Earth-Moon (surface-to-surface) distance.

The dBr affects DGRD equally at all frequencies, but sky noise decreases rapidly as frequency increases. During a monthly lunar cycle DGRD can vary by 13 dB on 144 MHz and 8 dB on 432 MHz. DGRD varies less with small antennas than with large ones.

Moon Phase: Shows new moon (NM) and full moon (FM) along with the number of days (d) or hours (h) before (–) or after (+) these events. At NM sun noise is a problem, while at FM the EME conditions (at night) usually are more stable.

Conditions: Summary of EME conditions as controlled by DGRD at 144 MHz and NM. Conditions may be worse, due to ionospheric disturbance, local noise, and polarity, but not better than indicated. In general, 144 MHz DGRD <1.0 dB is considered Excellent, 1.0 to 1.5 is Very Good, 1.5 to 2.5 is Good, 2.5 to 4.0 is Moderate, 4.0 to 5.5 is Poor, and over 5.5 is Very Poor. Within a day of New Moon (NM), high sun noise can make conditions Very Poor regardless of the DGRD.

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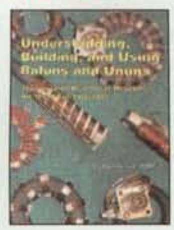

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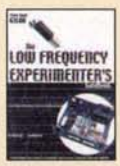

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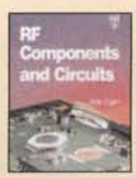

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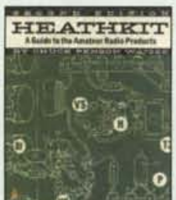

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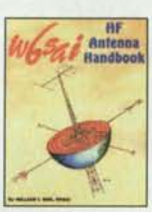

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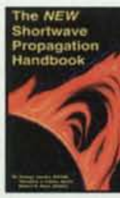

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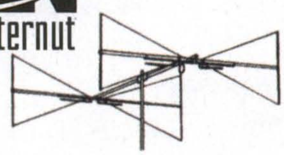

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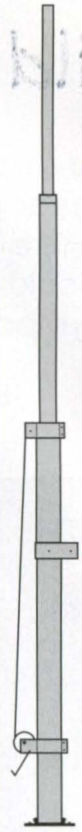

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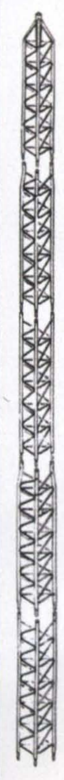

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Building a Beacon for 2401 MHz

Amateur radio operators who use weak-signal propagation on the microwave bands like having beacons available in order to determine whether or not a band opening is under way. Here W3HMS and K3VDB discuss theur 2401-MHz beacon project. Significant portions of this article also appeared in the *Proceedings* of the 2007 AMSAT-NA Space Symposium.

By John Jaminet,* W3HMS, and Charlie Heisler,† K3VDB

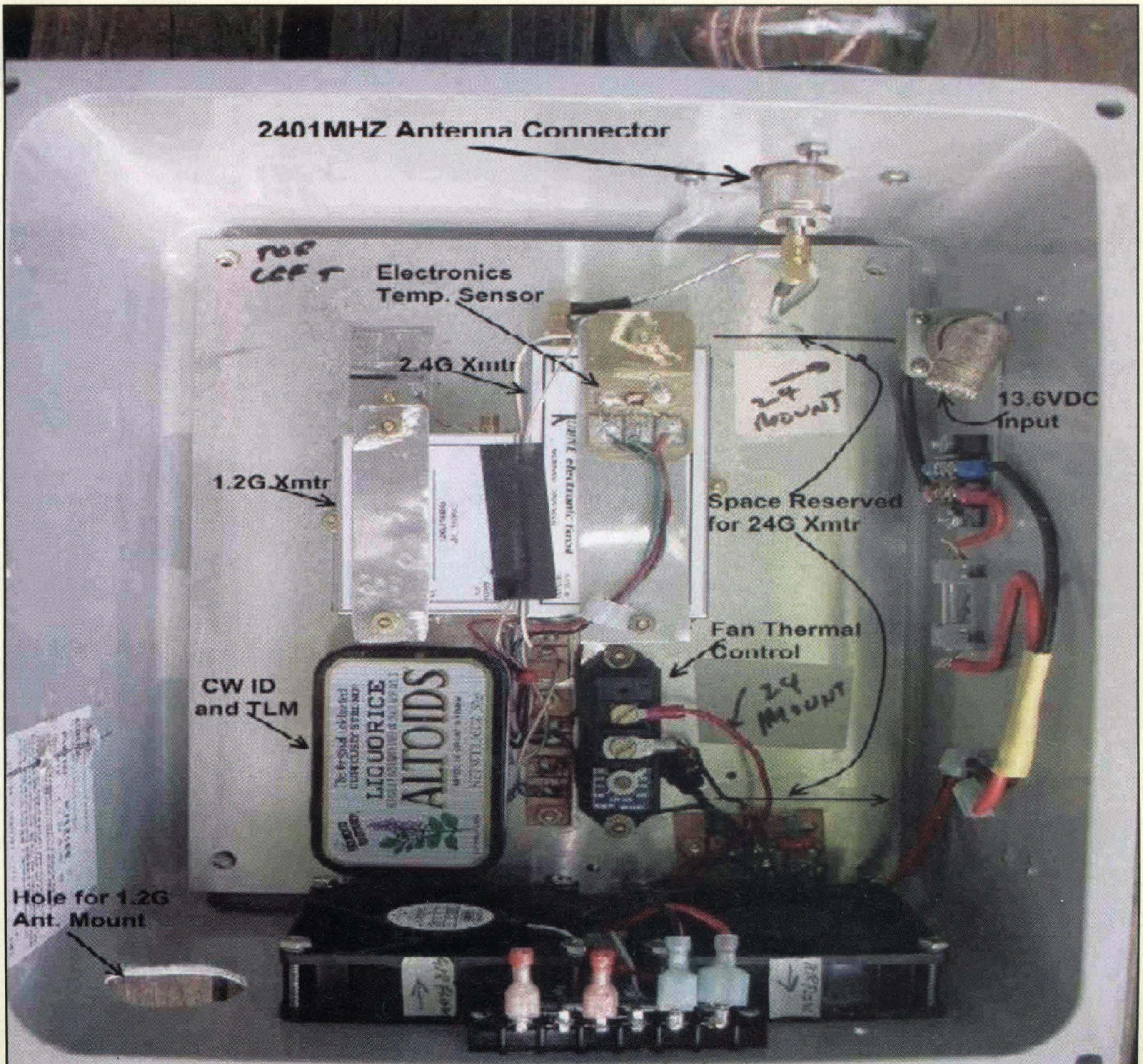

Photo A. Inside view of the beacon.

With no high-earth-orbit satellite to use as a signal source for quite some time, we thought a 24/7 beacon might be useful to folks around south-central Pennsylvania.

Overview

The microwave community makes extensive use of beacons for checking equipment equipment and propagation on all bands from 50 MHz to 24 GHz. Therefore, why not do the same for satellite users? Thus, we set about building a dual beacon for 1296.064 MHz horizontal polarization and 2401 MHz circular polarization, both in the same box.

The "we" in this case is Fred Lowe, W3MMV, Joe Lockbaum, WA3PTV, John Jaminet, W3HMS, and Charlie Heisler, K3VDB. We defined the tasks to be done and the purchases to be made and then shared the jobs among our group. I (W3HMS) have operated a Kuhne Electronics beacon on 10 GHz for about six years now and am so very pleased with the dependability of it, which is consistent with the company's other products that I use for contesting on VHF, UHF, and the microwave bands.

Technical Summary

The heart of the two beacons is the Kuhne Electronics of Germany "Bakensenders" for each band. Each was ordered with the frequency specified. Each uses F1 FSK keying in lieu of classic "make and brake" keying, as this promotes better short-term stability. The frequency will change a few kHz over time as the crystal ages.

W3MMV volunteered to fabricate "from scratch" the horizontally polarized Alfred Slot antenna for 23 cm. Likewise, K3VDB volunteered to fabricate the 13-cm circularly polarized Lindenblad antenna. The slot antenna gain is about 4 dB and the Lindenblad about 3 dB; both antennas are housed in radomes.

The 10-GHz experience told us that we wanted to use a WW2R keyer with telemetry so that we could remotely monitor the health of each beacon, keyed by the same keyer. We use two blowers both for air flow and dependability, and they are

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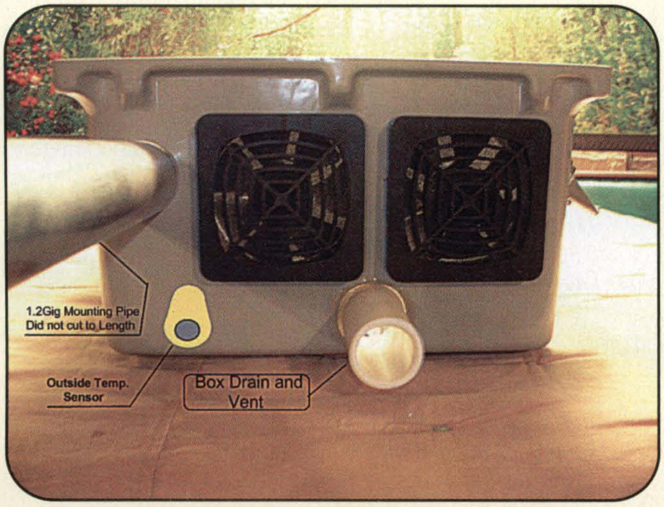

Photo B. Interior view of the beacon ready to install.

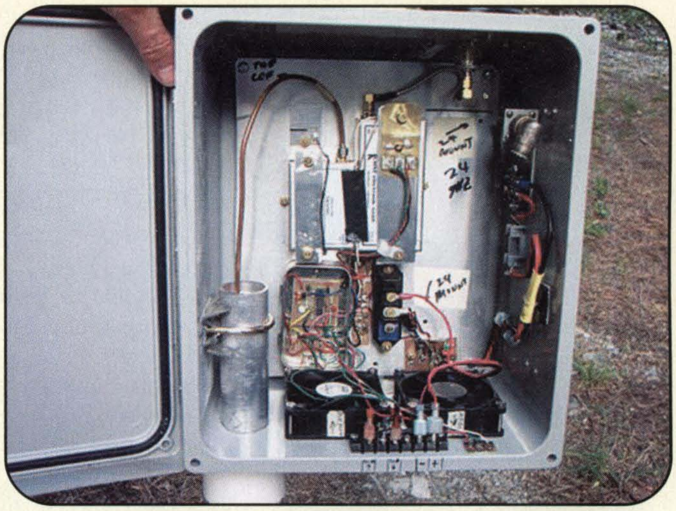

Photo C. Bottom view of the beacon showing the 23-cm antenna on the left.

turned on and off by a thermostat set to about 80 degrees. All is mounted in a waterproof box designed for the electrical trade to house both beacons. The 23-cm antenna is below in the box and the 13-cm antenna is on top. A single coax cable feeds 13 VDC to the beacons. The 23-cm beacon has an output power of 1.5 watts and the 13-cm MHz beacon 1 watt.

Telemetry (TLM)

The TLM has four positions of information. It was designed, built, and the PIC programmed by Doug Robinson, G4FRE/WW2R, in Texas. All the details are available on his website: <http://g4fre.com/radio.htm>. In the past, W3HMS and WA3PTV have used several of Doug's keyers for various functions, all with superb results. The keyer with telemetry is called an "Intelligent Keyer," and it is viewable on his site under this title with schematic. Doug programs your desired message at purchase time. It is possible to send any TLM sensor value that can be expressed in the range 0–5 VDC.

Beacon Message

We decided we wanted to send the following message: W3HZU/B W3HZU/B FN10PA FN10PA QSL TO W3HMS@AOL.COM, followed by the telemetry in four groups of three numbers, such as: 056 049 234 032. The message would then recycle. The telemetry consists of the DC bus voltage, the temperature from the thermometer mounted on the beacon transmit cover, the status of the vent fans, and the temperature outside the beacon.

DC Bus Voltage: The DC voltage on the beacon bus is calculated by a formula a bit too complex to do in your head, but easy to define in an EXCEL spreadsheet for common values. Let's say you copy the first group number 056. That number is equal to 12.60 VDC at the beacons.

Thermometer: The second set of three numbers is the thermometer mounted on the beacon transmitter cover. One half of the temperature in degrees Fahrenheit is sent in CW. As an example, 049 is sent, so 049 × 2 = 98 °F. The thermometer is the reasonably priced LM34DZ.

Vent Fans: If the two vent fans are on, the numbers are more like 231 than 000, as the latter indicates the fans are off. The

Photo D. The 1.2-GHz antenna.

fans cycle on and off about every six minutes at an outside temperature of 70 °F.

Outside Temperature: The temperature outside the beacon is sent as defined above for beacon temperature.

Performance

The beacon entered into service at a temporary site on June 6, 2007. Initial tests from the W3MMV QTH confirmed good operation, but the signal was weak at any real distance. K3VDB was able to obtain temporary permission to mount the beacons at a height of about 1130 FAS on a tower in Red Lion, Pennsylvania, grid square FM19qv.

The beacon signs W3HZU and FN10PA, as that is the ultimate destination on the 200-foot tower at about the 150-foot level. We have had excellent reports on the 23-cm beacon out to about 100 miles. The 2401-MHz beacon has been heard at about 75 miles. The Weak Signal Group has asked why not 2304 MHz, and we explained the needs of satellite operators at 2401 MHz. An Excel spreadsheet has been developed by K3VDB to record telemetry data in a scientific manner and is available on request.

Cost

These beacons are quality instruments and as such are not cheap! We will be happy to discuss this aspect with serious prospective builders.

The Particulars

The frequency of the 1.2-GHz beacon is 1296.079 MHz. The frequency of the 2.4-GHz beacon is 2401.00 MHz. The voltage at the power supply is 13.79 VDC. The voltage at the beacon is 13.67 VDC at 1.38 amps. The 1.2-GHz antenna is an Alford Slot, ~4 dB gain, horizontal in the PVC radome. The 2.4-GHz antenna is a Lindenblad, ~3 dB gain, right-hand circular polarization in the glass radome. The 1.2-GHz beacon's output is ~1.5 watts. The 2.4-GHz beacon's output is ~1.0 watts. *(Note: ~ indicates about, or to the best of our knowledge.)*

Some Temperature Observations

With an outside temperature of ~90 °F, the electronics temperature is ~108 °F with the fans on. At this temperature, the 2.4-GHz frequency is ~2401.00 MHz. At ~70 °F the fans cycle on and

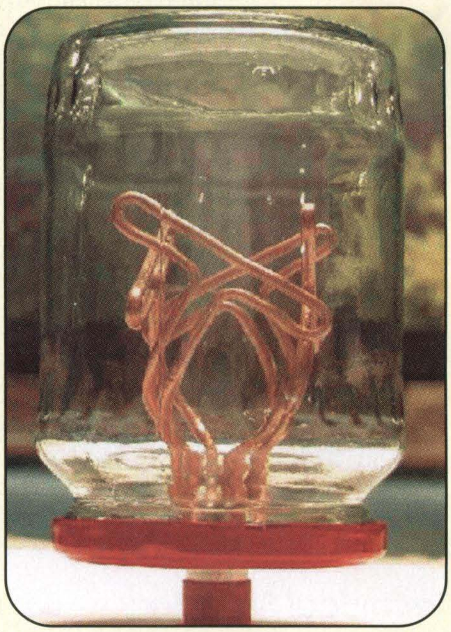

Photo E. The 2.4-GHz antenna.

off about every six minutes. The electronics temperature lowers about 4–5 degrees when the fans come on. At this temperature the 2.4-GHz frequency is ~2400.998 MHz.

The ID and Telemetry

The AFSK CW ID and Telemetry (TLM) message is: W3HZU/B (two times) FN10pa (two times) QSL to W3HMS @aol.com **XXXXXXXXXXXX**. Then there is ~14 seconds of key down; then it repeats. The "Xs" are beacon TLM numbers reporting beacon health. They are to be read in groups of three. The first group indicates power-supply volts, To decode the numbers, you would divide it by 51.2 then multiply by 11.283. The second group is the electronics temperature. Multiply this number by 2. The third group indicates whether the fans are on or off. Any number around 250 indicates that the fans are on; below 250 indicates that the fans are off. The fourth group is outside temperature. Multiply this number by 2 to get outside temperature. An MS Excel Spreadsheet is available for decoding the TLM.

Summary

We have included photos of the complete beacon package with the two antennas. Signal reports are welcomed. For further information and technical details, please e-mail Charlie Heisler, K3VDB, at <k3vdb@amsat.org>, or John Jaminet, W3HMS, at <w3hms@aol.com>.

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UG-21B/U	N Male RG-8 , 213, 214 Kings	5.00
9913/PIN	N Male Pin for 9913, 9086, 8214 Fits UG-21 D/U & UG-21 B/UN's	1.50
UG-21D/9913	N Male for RG-8 with 9913 Pin	4.00
UG-21B/9913	N Male for RG-8 with 9913 Pin	6.00
UG-146A/U	N Male to SO-239, Teflon USA	8.50
UG-83B/U	N Female to PL-259, Teflon USA	8.50

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The Lost Letters of KH6UK

Part 2 – The VHF Moonbounce Years (1958–1959)

In part 1 of this three-part series in the summer issue of *CQ VHF*, WA2VVA discussed how he came across the lost letters of Tommy Thomas, KH6UK, along with Tommy's QSO with W6NLZ. Tommy's story continues here in part 2 with a discussion of his efforts on EME.

By Mark Morrison,* WA2VVA

Tommy Thomas, KH6UK, once commented to Walt Morrison, W2CXY, that the inversion season in Hawaii was the same as on the east coast of the U.S., from July to September. Therefore, it was during the winter months that Tommy did the routine work of maintaining old antennas and making new ones.

Following the successful 144-MHz tropo season of 1957, John Chambers, W6NLZ, suggested to Tommy that he prepare for 220-MHz tests the following year. At the same time, other hams in W6-land—including W6PJA, W6AJF, K6QFI, W6DNG, and W6WSQ—were asking Tommy for schedules on 144 MHz. Tommy obliged both interests by building an array for 220 MHz and replacing his existing 144-MHz array with an even bigger one. This larger antenna would serve as Tommy's entry into serious moonbounce tests.

Tommy had been thinking about moonbounce ever since landing on Hawaii. The only thing holding him back was his not knowing exactly what to build. Tommy would write many letters to other hams working on the "moondoggle," as he called it, asking for test results of their various antenna designs. Jim Kmosko, W2NLY, and Herb Johnson, W6KQI, were testing Long John Yagis of unconventional element spacing. John, W5VWU, was pushing circularly polarized arrays. Walt, W2CXY, was testing Long John Yagis with more conventional parameters. Fran, W2OPQ, was evaluating UHF resonator colinears. And Ross Bateman, W4AO, one of the first amateurs to hear his own echoes off the moon in 1953, was using stacked rhombics. Whatever kind of antenna Tommy built would depend largely on the testing performed by these other amateurs. Not having time to experiment on his own, it was essential that Tommy listen to what they had to say.

From the very beginning, Tommy was concerned about having enough antenna gain for moon-reflection work. At first he considered 25 dB to be the minimum gain required. In a letter to W2CXY he put it this way:

> The gain of 25 dB in the antenna as a requirement for a Moon Bounce signal may or may not be correct. The Amateurs have always done better than it was supposed possible.

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e-mail: <mark1home@aol.com>

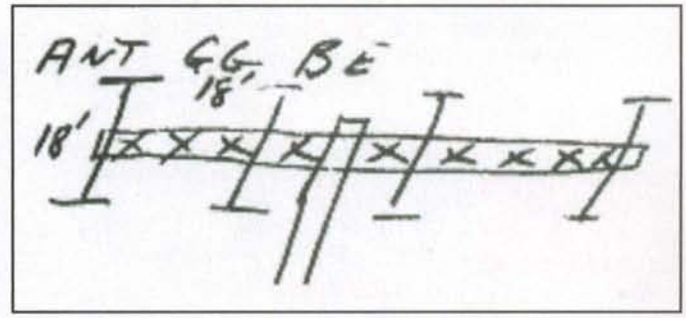


Figure 1. The sketch of what Tommy had in mind for a moonbounce array in October 1957.

Later, based upon what little information existed at the time, and the results of amateur testing where echoes had been heard, he conceded that 20 dB might be enough. Still, he used to wonder why some stations could hear their own echoes but not be heard by others, and why these same stations could only hear their echoes when the moon was low on the horizon. With the exception of Ross, W4AO, all such stations were using four Long Johns of one type or another, with gains on the order of 20 dB.

Tommy was also concerned about the high winds at his seaside location in Kahuku. When Tommy put up his first antenna for 144-MHz tropo testing, he placed it high up on a utility pole where it was subject to these high winds. Concerned that an even larger antenna might not survive the winds, Tommy took the advice of Walt, W2CXY, by placing his antenna close to the ground:

> I think I agree the thing to do is to put up something fairly big on the stick and to build a big array like you plan—near the ground where you can tilt it and where it isn't apt to blow down.

In the end, Tommy decided on a 2 × 4 array of eight Long John antennas with two-wavelength spacing between each antenna. Such a large array would certainly address Tommy's concerns about antenna gain, but brought new concerns about mechanical integrity. Tommy described his latest project in a letter from October 1957 (see Figure 1).

> I am on the verge of ordering 8 Big Berthas from Gonset but then there is the problem of the boom—probably need some alum. Tower

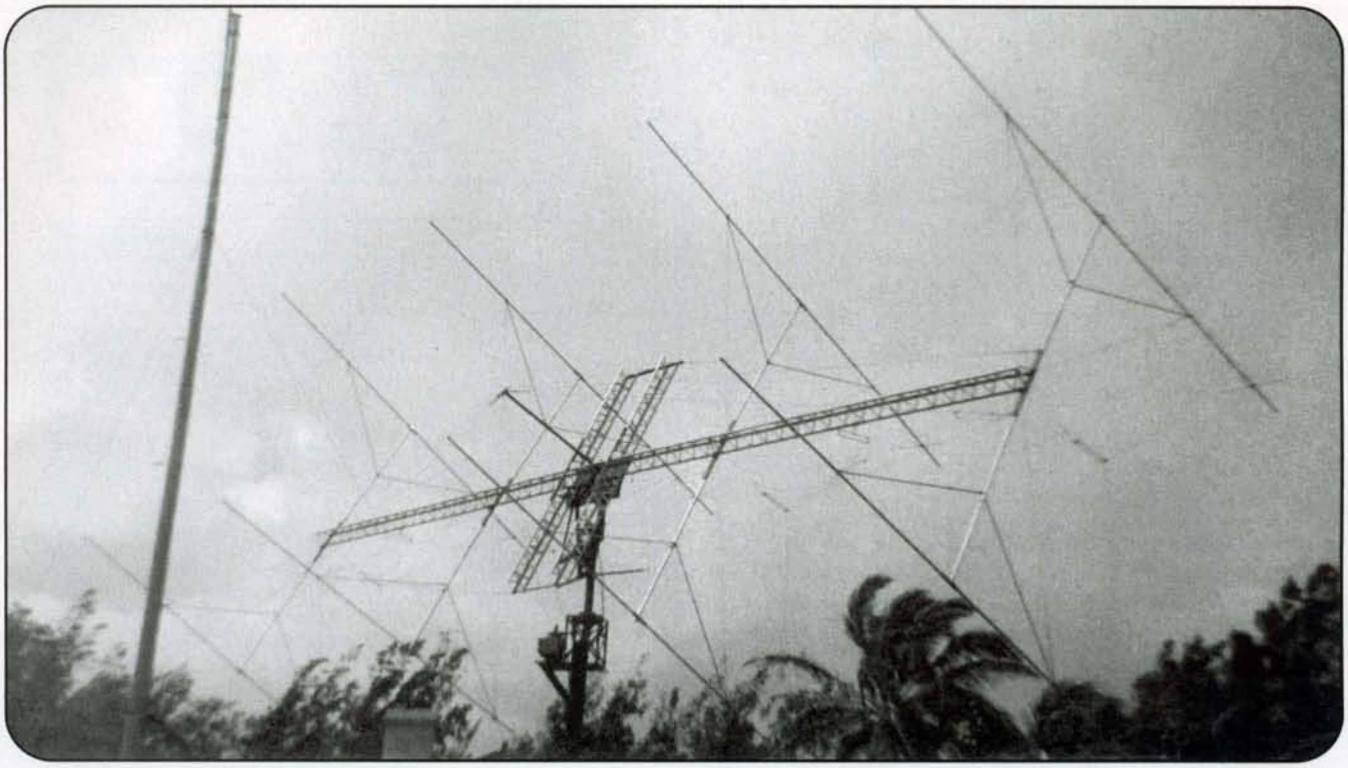


Photo A. KH6UK's moonbounce antenna array in August 1958.

sections for that—and would probably have to order those from the Mainland as doubt if they carry them out here. Maybe circular polarization would be the answer—someone should try it. Sort of hate to load myself up with a lot of stuff that I will have to jetison when I had back east next fall.

In December 1957 Tommy reported that one obstacle still remained, that of tilting his array:

Work is progressing slowly on my antenna due to holidays, etc. Still haven't figured a good simple way to tilt the thing. Could use some good suggestions from you guys of the Basement Lab group. I know you in particular are good at that stuff.

It appears that Tommy wasn't alone when it came to moonbounce activity on the island. In this letter he reveals that the military was working on a secret moonbounce project not far from his QTH:

That dope on Moon Bounce signal between here and the W.C. [West Coast] was supposed to have come from someone in the Navy, working on the stuff. It is supposed to be restricted—so could get no details—but understand high-power pulses were used. Maybe it was a case of transmission from KH6 land to the W.C., one say. I dunno Walt, more or less a rumor, with some basis in fact.

By the summer of 1958 Tommy had completed his moonbounce antenna and was ready for testing. Photo A is dated August 1958. Note the palm tree swaying in the wind in the lower right-hand corner of the array.

Upon close inspection of the photo, it appears that the antenna could be tilted but not rotated. The platform just beneath the antenna array appears to hold a motor with a cable that runs up to the hinged vertical masts. It does not appear that this design could be rotated, something Tommy mentioned later on. Tommy described his new antenna this way:

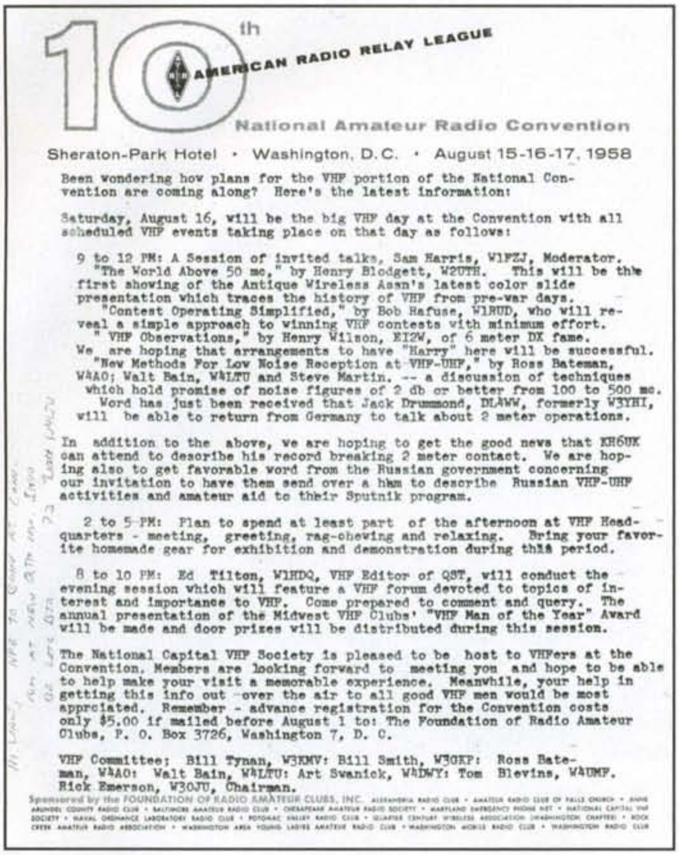
The "monster" seems OK, Walt, although I have made no attempt to check gain or pattern on it. I have no help out here as we are remotely located and no one else in this area is interested in or has had experience with 144 mcs so have to do every thing myself—except of course for the rigging, where I am extremely fortunate.

Initially, Tommy had two hams interested in serious moonbounce tests: John, W5VWU, and Walt Morrison, W2CXY. At the time it was generally believed that hearing your own echoes off the moon was a prerequisite to holding schedules with others. By the summer of 1958 neither Tommy, John, nor Walt had accomplished this task, so Tommy continued 220-MHz tropo testing with John, W6NLZ, and 144-MHz tropo testing with the other West Coast hams. These schedules kindled lasting friendships, especially with Frank Jones, W6AJF, a long-time contributor to *QST* magazine who wrote his first article in 1926 (as 6AJF!). Here is what Tommy had to say in a letter from the summer of 1958:

Moon-bounce and tropo tests with W6AJF have been non-productive to date. I have tried for my own echoes a few times but N.D. [no deal]. Hope to catch it on the horizon tonight or tomorrow and hope for better luck… Weather conditions over Pacific have not been as favorable as last year. We have lots of stormy weather this year while last year the trades were light and very little rain, etc… Frank has been a very reliable keeper of skeds and I hope for his sake we can break through for a contact one way or another. He certainly deserves it.

It was Frank who later assisted Tommy with several key components that led to UHF moonbounce success years later—something to look forward to in Part 3 of this series.

In order to keep tabs with his fellow "moonbouncers," Tommy held weekly skeds on 14.095 MHz. It was here where all the "red hot dope" could be heard and discussed, including the progress of stations hearing their own echoes and who was running schedules with whom. Tommy reported in one of his letters that W6NLZ heard a tape recording of W2NLY's 144-MHz echoes off the moon and said they were good enough for



10th AMERICAN RADIO RELAY LEAGUE

National Amateur Radio Convention

Sheraton-Park Hotel • Washington, D.C. • August 15-16-17, 1958

Been wondering how plans for the VHF portion of the National Convention are coming along? Here's the latest information:

Saturday, August 16, will be the big VHF day at the Convention with all scheduled VHF events taking place on that day as follows:

9 to 12 PM: A Session of invited talks, Sam Harris, W1FZJ, Moderator.
"The World Above 50 mc," by Henry Blodgett, W2UTH. This will be the first showing of the Antique Wireless Assn's latest color slide presentation which traces the history of VHF from pre-war days.
"Contest Operating Simplified," by Bob Hafuse, W1RUD, who will reveal a simple approach to winning VHF contests with minimum effort.
" VHF Observations," by Henry Wilson, EI2W, of 6 meter DX fame.
We are hoping that arrangements to have "Harry" here will be successful.
"New Methods For Low Noise Reception at VHF-UHF," by Ross Bateman, W4AO; Walt Bain, W4LTU and Steve Martin. -- a discussion of techniques which hold promise of noise figures of 2 db or better from 100 to 500 mc.
Word has just been received that Jack Drummond, DL4WW, formerly W3YHI, will be able to return from Germany to talk about 2 meter operations.

In addition to the above, we are hoping to get the good news that KH6UK can attend to describe his record breaking 2 meter contact. We are hoping also to get favorable word from the Russian government concerning our invitation to have them send over a ham to describe Russian VHF-UHF activities and amateur aid to their Sputnik program.

2 to 5 PM: Plan to spend at least part of the afternoon at VHF Headquarters - meeting, greeting, rag-chewing and relaxing. Bring your favorite homemade gear for exhibition and demonstration during this period.

8 to 10 PM: Ed Tilton, W1HDQ, VHF Editor of QST, will conduct the evening session which will feature a VHF forum devoted to topics of interest and importance to VHF. Come prepared to comment and query. The annual presentation of the Midwest VHF Clubs' "VHF Man of the Year" Award will be made and door prizes will be distributed during this session.

The National Capital VHF Society is pleased to be host to VHFers at the Convention. Members are looking forward to meeting you and hope to be able to help make your visit a memorable experience. Meanwhile, your help in getting this info out over the air to all good VHF men would be most appreciated. Remember - advance registration for the Convention costs only $5.00 if mailed before August 1 to: The Foundation of Radio Amateur Clubs, P. O. Box 3726, Washington 7, D. C.

VHF Committee; Bill Tynan, W3KMV: Bill Smith, W3GKP: Ross Bateman, W4AO: Walt Bain, W4LTU: Art Swanick, W4DWY: Tom Blevins, W4UMF. Rick Emerson, W3OJU, Chairman.

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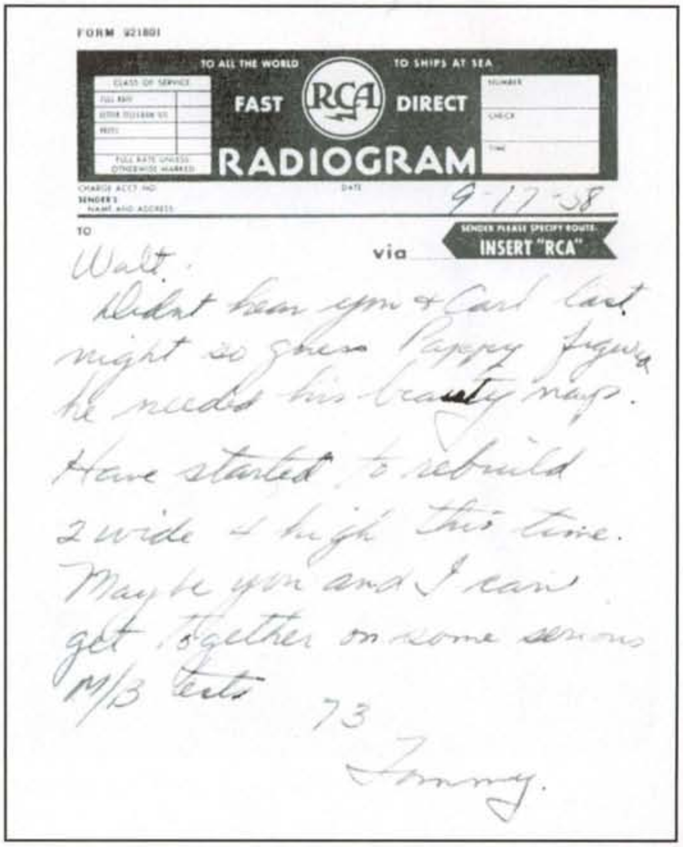
Figure 2. A copy of the 1958 ARRL National Convention leaflet anticipating Tommy's visit to Washington, DC.



FORM

TO ALL THE WORLD — TO SHIPS AT SEA

FAST RCA DIRECT

RADIOGRAM

9-17-58

TO Walt.

via — INSERT "RCA"

Didnt hear you & Carl last night so guess Pappy figures he needs his beauty naps.
Have started to rebuild 2 wide 4 high this time.
Maybe you and I can get together on some serious M/B tests
73
Tommy.

Figure 3. In this note Tommy suggested that Walt, W2CXY, should get ready for serious moonbounce tests.

a QSO. In another letter Tommy mentioned that Walt Bain, W4LTU, was in the Washington area at that time and maybe getting ready for skeds with Jim, W2NLY. Tommy also mentioned that the boys in W4 land, most likely W4AO and W4LTU, had been twisting his arm to attend the National Convention in Washington, DC. Figure 2 is a copy of the ARRL National Convention leaflet that shows that Tommy's visit was much anticipated. Note the handwritten note from Walt Bain, W4LTU, to Walt Morrison, W2CXY, on the left-hand side.

Later that summer Tommy updated Walt on the moonbounce progress of John, W5VWU:

> John, W5VWU, reports hearing his own echoes for about 4 mins at moon-set the other night. Only time he has heard anything and nil when the moon is high in the sky.

In September 1958 Tommy reported that he was rebuilding his 144-MHz array, this time 2 wide by 4 high. Such an unusual configuration would have made tilting the array much easier, possibly even by hand. Figure 3 is a note, written on RCA Company stationary, in which Tommy suggests once again that Walt, W2CXY, should get ready for serious moonbounce tests.

By December 1958 Tommy reported that his new antenna should be much stronger than the original, suggesting that the winds of Kahuku had plagued his original "2 over 4" design:

> I guess I will proceed with my plans to rebuild the array using eight 23 ft. Yagis—2 wide and 4 high. Have new heavier tower section for the upright sections and going to use the older/lighter sections for cross members. This will make a much stronger job and only hope it isn't too heavy.

Tommy also provided more information on that secret Navy MB circuit:

> The Navy is now installing two 85 ft. dishes out here for MB ckt [moonbounce circuit] with Wash DC so if we don't hurry up they will beat us to the punch. The one used for rcvg will be installed only a few miles from here … somehow or other Walt you have to get something [better] up than the four 24 footers, good as they are… I am going to try to get all set by 1st April so you can figger accordingly.

Figure 4, from "Satellite to Semaphore" published by the International Telecommunication Union in 1965, illustrates the Navy's Hawaii to Washington, DC EME (Earth-Moon-Earth) circuit.

Finally, Tommy reported that his receiving setup would benefit from some additional gain thanks to the efforts of W6AJF:

> Thanks for all the dope on converters, par [power?], amps, etc.—all sound very intriguing and hope they produce. We sure have to find some way to pick up some more decibels on the VHF bands. W6AJF is bldg a par amp job and maybe he will have some info on our sked tomorrow. I work him on Mondays on 21 Mc to keep in touch until we ready to get going again on 2 meters.

On June 22, 1959 Tommy made the first two-way contact with John, W6NLZ, on 220 MHz, establishing a world's DX record that stands to this very day. Following that success, Tommy and Helyne left Hawaii for their first vacation in four years. While vacationing in Miami in December 1959, Tommy wrote W2CXY a letter, parts of which are reproduced in the accompanying sidebar. What is significant about this letter is

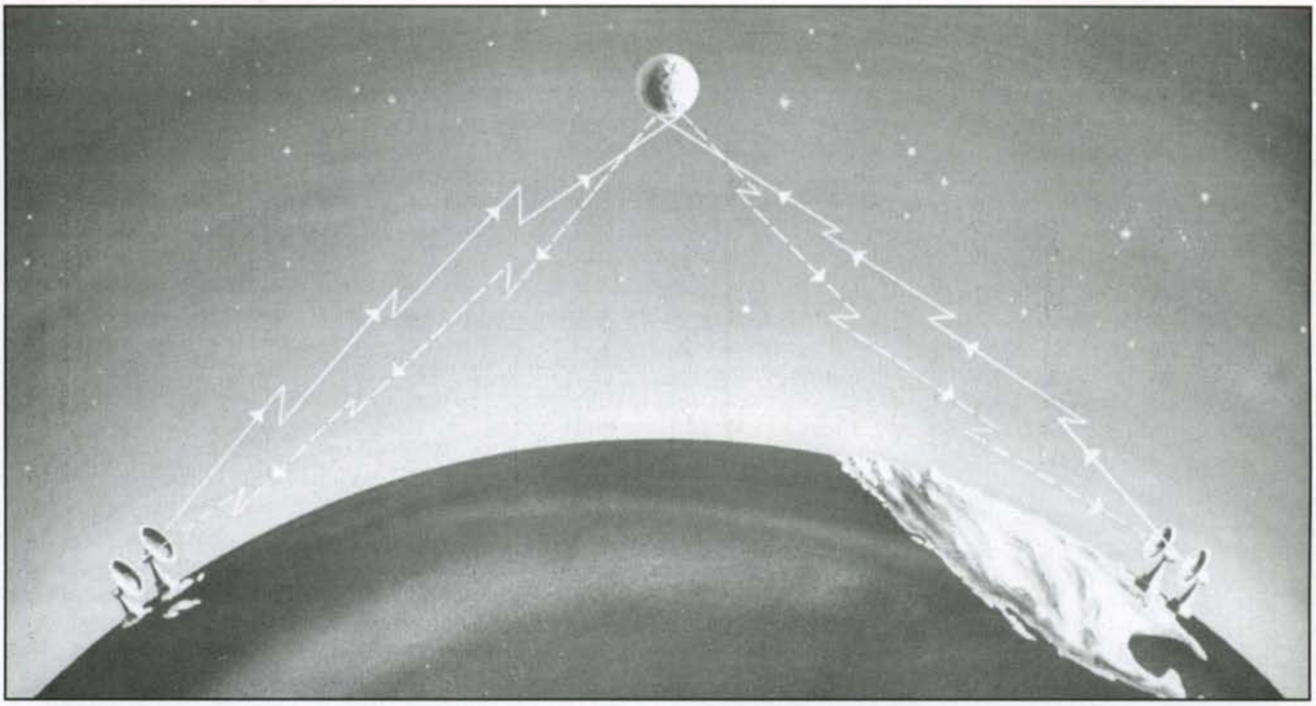


Figure 4. The Navy's Hawaii to Washington, DC EME circuit. (From "Satellite to Semaphore," published by the ITU in 1965)

that it may be the last one written by Tommy in the 1950s, an historic decade that witnessed many changes in amateur VHF communications, including the first meteor-scatter QSO, the first use of passive satellites for reflection work, record-breaking tropospheric work, advances in weak-signal work, amateur participation in the IGY (International Geophysical Year), and the very first amateur reflections off the moon, some of which were pioneered by Tommy and his friends, including Ross Bateman, W4AO, Paul Wilson, W4HHK, Carl Scheideler, W2AZL, and Walt Morrison, W2CXY. This letter hints at the influence that Tommy wielded, even outside amateur circles, something that would be needed in the years ahead. Part 3 of this article picks up in 1960 with the rest of Tommy's moonbounce story.

The Last Lost Letter of the '50s

This is probably the last lost letter from Tommy during the 1950s decade:

23 Dec 59
Miami, FL

Hi Walt,

Am sitting out on the lawn enjoying the balcony breezes while scribbling this letter to you. Sorry we couldn't get together for one more confab before we left as there are several things in connection with M/B we should have discussed. The meeting with the boys in Wn [Washington DC] was very enjoyable but produced nothing concrete. Ross was out of town—darn it. Anyway that info you already have from Ross should give us enough— with what we already know—to go ahead with. Carl [W2AZL] was going to give you my Miami address so you could mail me a copy of Ross's letter but I'll bet he forgot all about it as I have looked for it in vain. As we plan to leave here this weekend for the West Coast better mail it to me c/o W6AJF as I will visit him on way back.

Let me have the dope on the antenna as soon as possible so I can get started on it. I am going to forget the big dishes for a while as they are too much work, etc., and only worth while for 400 Mc or higher. About all the time I will have available will be taken up with trying to get across on 432 Mc and with our M/B project. Will have my hands full getting set up and running skeds on these bands in 1960—anything higher will have to wait til 1961—don't expect to do anything further on 220 Mc just now.

Sorry I couldn't accomplish more with MARS in Wn. for you—but just didn't have the time—and things didn't click like I had hoped. One of the men I counted on was on vacation & Chief [of] MARS is being re-assigned shortly. Did have a meeting with head of the Army Communications tho and he said they were much interested in our work and to let him know if they could be of any assistance. Top Brass—these boys! Nice to know our work is recognized and appreciated in the right quarters!

Well, Walt, let me hear from you—either via W6AJF or direct to Kahuku. Should be back there around Feb 1st at latest as want to [get] started as soon as possible. Best to Carl.

Aloha + 73
Tommy KH6UK

By Bob Witte,* KØNR

FM

FM/Repeaters—Inside Amateur Radio's "Utility" Mode

The 2007 Colorado 14er Event

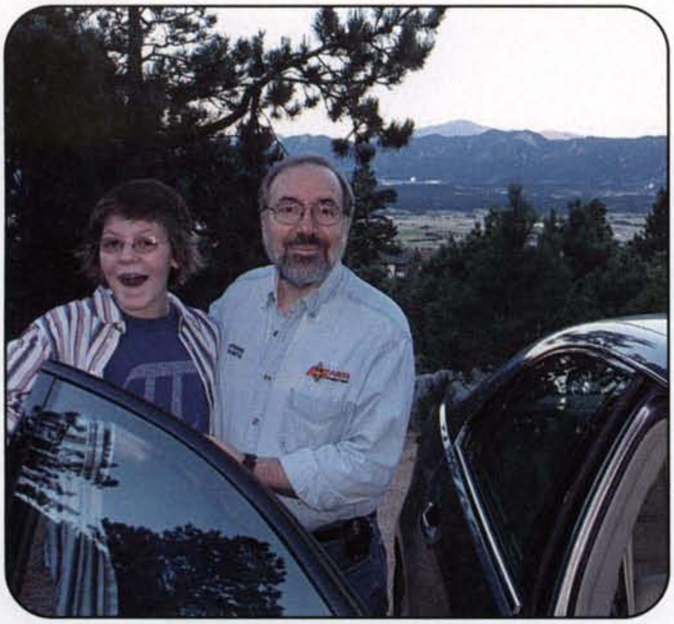


Photo A. Stephen, KCØFTQ, and Steve, KDØBIM, about to depart from home. (Photo via KCØFTQ)

The Colorado 14er Event originated from a simple concept: Let's all go out and operate from Colorado's highest mountains on the same day. Many amateur radio operators like to take along handheld or portable transceivers when they hike or climb, so a little bit of organization was all it took to create this annual event. There are 54 summits in Colorado recognized as distinct 14,000-foot (or higher) mountains, commonly referred to as "14ers." Most of the mountains require a strenuous climb, but a few can be driven up. This year I operated from Pikes Peak, a drive-up summit close to Colorado Springs.

The road to the summit of Pikes Peak was originally a carriage road, dating back to 1889. Later, an automobile road was constructed on the same route, which today is operated by the City of Colorado Springs as a toll road. The 19-mile Pikes Peak Highway is paved part of the way, with gravel on the remaining section of the road. It is not a terribly difficult drive, but your vehicle has to be in good running condition and you need to be tolerant of tight corners and *very* steep drop-offs.

In preparation for this year's event (August 12), I contacted my group of "usual suspects" to see who wanted to activate Pikes. The assembled crew turned out to be me, my wife Joyce, KØJJW, Stephen, KCØFTQ, and his son Steve (no radio license at the time). Actually, Steve had just passed his Technician class exam, but the FCC had not yet issued him a callsign. No problem, as we'd give Steve his chance to operate with one of us acting as control operator. Our usual practice is to operate under the club callsign KØYB, which is short and easy to understand on the air.

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As I rolled out of bed at 5 AM, I thought about the hams out climbing who were on the trail by then. Any thought of complaining about getting up early faded quickly as I thought about the *real mountaintop operators* out there. The typical 14er climb includes 4,000 feet in vertical change and 4 miles in distance. Some are easier, some are harder . . . none are trivial.

I had loaded the SUV with all of the radio gear the night before and the fuel tank was topped off. A short time later, Joyce and I were cruising west on Highway 24 towards the Pikes Peak Highway. We reached the toll gate at 7 AM, where there was a line of cars waiting for the road to open. We headed up the road and arrived at the summit around 8:30 AM. We contacted Stephen and Steve on 147.42 MHz on our way up and determined that they were just a few miles behind us (Photo A). The primary operating hours for the event are from 9 AM to noon, designed to allow time for the climbers to make it to the summit and then retreat before the afternoon thunderstorms roll in. We wanted to be set up and operating no later than 9 AM.

Mount Harvard

The day before, Chris KØCAO and his wife Kelli had left the North Cottonwood Creek Trailhead and backpacked about 5 miles, camping at an elevation of 12,000 feet (Photo B). This camping spot positioned them well to finish off the remaining 1.5 miles to the summit of Mount Harvard in the morning. This is a great strategy for a hike-in summit—break the hike into two parts by camping part way up the trail. At 7:00 AM they were on the trail and they made the summit at around 8:30 AM. This gave them plenty of operating time ahead of any potential afternoon thunderstorms.

Chris used his dualband FM handheld transceiver to make radio contact from the summit (Photo C). In all, Chris worked nine other radio operators on 14ers and made about 20 QSOs. Chris also had taken along a signaling mirror and used that to flash other nearby mountaintops. (This has become a secondary activity for some of the 14er operators where mountaintops are close together.) Kelli and Chris made a video of their climb, available on the YouTube.com website (see references and Photo D).

At 14,420 feet above sea level, Mount Harvard is the third highest peak in Colorado. This peak was named by Josiah Whitney, while leading a group of students from Harvard up the peak in 1869. Whitney was a professor at Harvard but he grad-

K4S from Mount Sunflower, Kansas

By Bruce Frahm, KØBJ*

The first K4S effort by the Sand Hills and Trojan ARCs was in 2006. The goal was to activate the highest point in Kansas, Mount Sunflower, especially for the Colorado 14er radio event and it was a limited-time operation. At only 4039 feet above sea level and a mere two-thirds of a mile from Colorado, this gentle knoll in a pasture presents a laughable scene when compared to the Colorado 14ers location on Pikes Peak. Thus, we laughed our way to success and fun! Whether describing our "struggles" with altitude sickness and arduous climbing, or speculating on the odds that a newly minted cow pie would ratchet our elevation up a foot, we had fun sharing our surroundings during our 20-meter and VHF/ UHF QSOs.

Both clubs draw members from a wide, sparsely populated area and Mt. Sunflower lies between the two. It's about an 80-mile drive for most members. We occasionally team up to activate Mt. Sunflower, and the cooperative effort affords great camaraderie. We had a nice complement of VHF/UHF equipment in 2006, but committed an error by staging the entire expedition on Sunday. By the time we were on the air, many of the 14ers were descending their locations, and we only contacted three groups. What we did experience was lots of interest and welcoming by the 14ers. Being 10,000 feet higher, actually in Colorado and (in most instances) having *climbed* to get to their operating positions, they could have "laughed us off the face of the Earth," but instead they were interested and appreciative. HF certificate chasers were also eager to work us.

This year we had limited crew and equipment available, but we did arrive on Saturday for setup. Bob, KCØWJT, and Bruce, KØBJ, overnighted at "summit camp" in Bob's pull trailer (his family performs Bluegrass music, so the trailer has been the scene of prior harmonics and modulation—of audio frequencies). HF QSOs mainly on 20 meters SSB attracted interest on Saturday evening. A great short-skip opening to Missouri and even southeast Kansas put some acquaintances in the log. We also worked into Kansas City on 2 meters SSB. The lack of any towns for a considerable distance brought an awesome Milky Way enriched sky after night fell and the *Perseids* meteors punctuated the scene.

Sunday morning just after sunrise Ray, KCØZSM, and Jim, KCØZSH, arrived. We switched our 11-element 2-meter Yagi from horizontal to vertical and got serious about looking for 14ers. Being ready early paid off, and we logged KØYB and KØNR from Pike's Peak; K5BIL and NØXGZ from Mt. Evans; KCØYIH on Mt. Sherman; NØXDW from Mt. Bross; and KØNA on Mt. Bierstadt. We also snagged WO9S mobile in Nebraska; KG6TDB at home in Ft. Collins; and eked out a marginal QSO with ABØTX in Newton, Kansas. We narrowly missed logging KØCAO on Mt. Harvard. We're fascinated with his video clip of receiving us and QSOing others, available at <http://video.google.com/videoplay?docid=-6446083004152361265>. On Sunday HF activity didn't ignite like it had on Saturday night, but all told 140 HF QSOs went in the log.

The heart of our equipment complement is a 50-foot tower trailer. This crankup/tiltover beast was given to the Wheat Belt Radio Club a half century ago by a TV dealer who had used it for demos of that new invention to rural folks in the 1950s. It's been a mainstay of western Kansas Field Days and VHF bivouac sites ever since. An old Cushcraft HF tribander, 11-element 2-meter Hy-Gain, and two homebrew tape-measure Yagis graced the tower and the camper's awning.

The K4S (Kansas 4er Sunflower) 2007 crew—neophytes Ray and Jim, budding op Bob, and 40-year ham Bruce—appreciate those who QSOed us. Special thanks to the ARRL VEC for arranging the Special Event call and Jodi, KA1JPA, for getting our info into the ARRL's online Special Events list on short notice. And thanks again to the Ed Herold family, who allow public access to Mt. Sunflower. QSL to WØWOB.

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uated from Yale, so he made it a point to name another nearby 14er Mount Yale.

Back on Pikes Peak, when we arrived at the summit, the first priority was to get the 2-meter FM station up and running. This band and mode are the most popular for this event, since most of the hikers carry FM handheld radios. Our 2-meter FM station consisted of a Kenwood TM-231A transceiver connected to a Diamond X-50 vertical antenna. Usually the action is fast enough on the band that an omnidirectional vertical (with a little gain) works better than having to deal with rotating a Yagi antenna. We inserted a DCI bandpass 2-meter filter in the transmission

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Photo C. Chris, KØCAO, making radio contact from the summit of Mount Harvard. (Photo via KØCAO)

Photo B. Chris, KØCAO, walking up the trail to Mount Harvard with backpack. (Photo via KØCAO)

Photo D. Chris, KØCAO, and wife Kelli standing on the summit of Mount Harvard. (Photo via KØCAO)

line to help suppress interference on the peak. Since for the annual event there are multiple transmitters up there, I've had problems in the past with my transceiver getting overloaded by all of the RF energy. The TM-231A didn't have a hint of a problem with the filter installed.

The X-50 antenna was placed on the top of three sections of RadioShack standard TV mast, held by a homemade drive-on mount (Photo E). The drive-on mount is a piece of 2×8 lumber with a short piece of pipe held by a floor flange. The pipe is just the right size to let the TV mast slip over it. This is a common portable operating technique, useful for special events, portable operation, and emergency communications.

We had Steve operating the 2-meter FM rig, with his dad supervising as control operator (Photo F). This was Steve's first real radio operation and he sounded like a pro. He called "CQ 14er Event, this is Kilo Zero Yankee Bravo on Pikes Peak" as if he had been doing it for years. He was able to click through contacts at a fast rate, using the right phonetics and operating procedures. I think his dad got to make a few contacts, but the majority of the contacts from Pikes Peak were made by young Steve.

Our SUV housed the other station, which covered 2-meter SSB using a Yaesu FT-100 driving an M^2 9M2 horizontally polarized Yagi. We used a special mount that fits into the 2-inch hitch receiver and is sized to hold a standard TV mast vertically (Photo G). This vehicle also housed the 222-MHz FM station and the 440-MHz FM station, both using mag-mount antennas on the vehicle's roof. The 222-MHz rig was an old ICOM IC-32A recently acquired via eBay. A Yaesu FT-50 covered the 440-MHz band for us.

For power, we used a Honda AC generator. This provided a steady power source and eliminated the hassle of relying on the vehicle battery. The generator ran very quietly and did not have a problem with running at that high altitude. (Driving to a mountain's summit does have its benefits.)

Mount Sunflower

Long before we arrived at the summit of Pikes Peak, another mountaintop radio operation was already in place from another high "peak." The Trojan Amateur Radio Club was operating a special event station using the callsign K4S from the highest point in Kansas: Mount Sunflower. At an elevation of 4,039 feet, Sunflower is lower than most of the state of Colorado. However, these brave souls fought the elements and risked exposure to oxygen deprivation to activate this Kansas peak (Photo H). They asked for our understanding, since they don't have 14ers (14,000 foot mountains) in Kansas. They refer to Mount Sunflower as a "4er," hence the callsign K4S (Photo I).

We knew about the planned Sunflower operation, so we wanted to be sure to work them during the event. This was one of the reasons for taking along the 2-meter SSB rig and a decent Yagi antenna. Mount Sunflower is about 160 miles east of Pikes Peak, so I expected to work them easily on 2-meter SSB. It turned out that the Yagi wasn't necessary. While we were setting up, I heard K4S calling on the 14er event calling frequency—147.42 MHz FM. I had the mobile rig monitoring this frequency using a not-so-optimal 1/4-wave antenna mounted on the hood of the vehicle. We easily worked them using the vehicle's FM rig and the

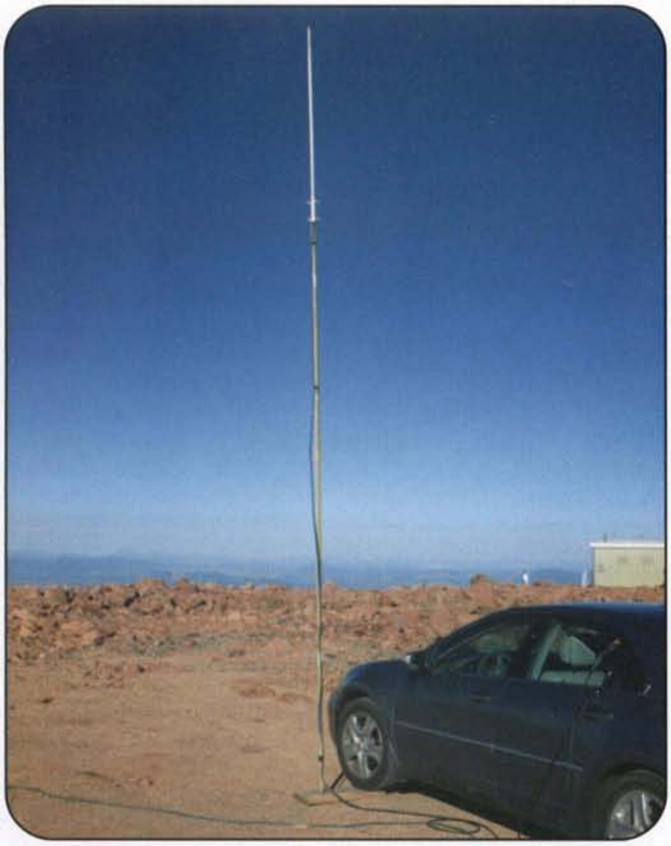

Photo E. The mast for the 2-meter FM antenna on Pikes Peak was held in place by a drive-on mount. (Photo via KØNR)

simple antenna. The K4S crew was running about 50 watts to an 11-element Yagi on 2 meters, so they were putting out a really nice signal. They were coming in quite strong on Pikes Peak all morning.

The Mount Sunflower crew had set up Field Day style, camping out for the weekend. They operated two stations, one on VHF and one on HF. The radio crew at Mount Sunflower included

Photo F. Steve on Pikes Peak operating the 2-meter FM rig like a pro! (Photo via KØNR)

Photo G. Joyce, KØJJW, setting up the 2-meter Yagi while Bob, KØNR, supervises. (Photo via KCØFTQ)

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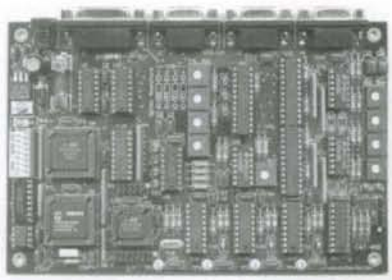

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Photo H. The Mount Sunflower operation in western Kansas. (Photo via KØBJ)

Bob, KCØWJT, and Jim, KCØZSH, on the VHF station (Photo J), while Bruce, KØBJ, and Ray, KCØZSM, handled the HF rig.

Making the Contacts

On Pikes Peak, Steve kept racking up the 2-meter FM contacts at a decent pace, while Joyce and I filled in on 440 MHz and 222 MHz. I fired up the 2-meter SSB station on 144.200 MHz a few times and worked a handful of stations on that mode. I didn't operate there all of the time, as I knew it would interfere with the 2-meter FM station. Any band and mode can be used during the event and some of the 14er operators set up HF stations. Still, most of the fun is on the VHF and UHF bands.

In the end we made a total of 77 QSOs:

Band	QSOs
2-meter FM	50
2-meter SSB	3
222 MHz FM	4
440 MHz FM	20
Total	77

Photo I. The K4S Special Event QSL card from 2006. (Courtesy of KØBJ)

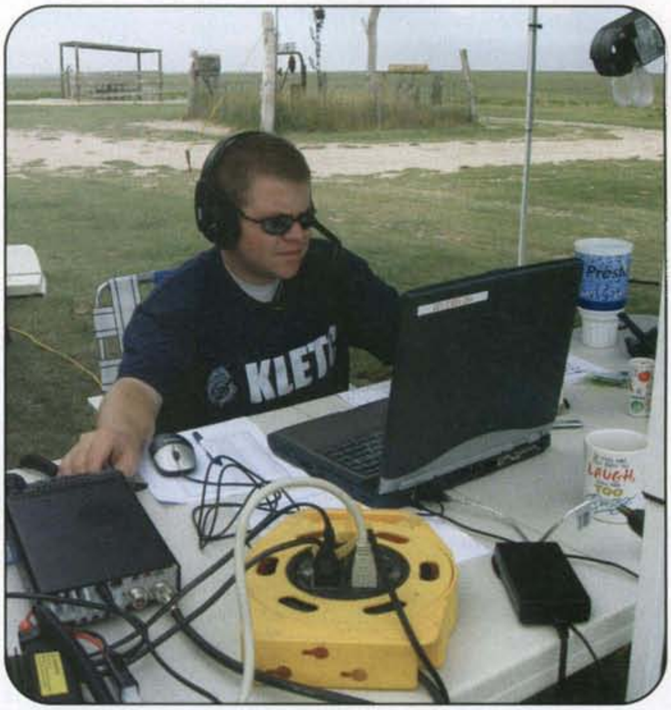

Photo J. Jim, KCØZSH, operating VHF from the K4S Special Event station. The official Mount Sunflower marker can be seen in the background (Photo via KØBJ)

We worked hams on the summits of the following 14ers: Sherman, Evans, Antero, Harvard, Torreys, Grays, Bierstadt, Quandary, and Bross. We also worked a number of operators who were out hilltopping on smaller peaks. Our best DX was the K4S station on Mount Sunflower.

Pikes Peak is an especially good location for this event. It towers over Colorado Springs and has a line-of-sight path up to Denver, Boulder, and Fort Collins. At the same time, it has a good shot to all of the 14ers around the state. This can cause an interesting pile-up effect, as the station on Pikes Peak can hear almost every station in the event but they can't hear each other. Sometimes the QRM gets a little intense with multiple stations transmitting on the same frequency. With the capture effect of FM, the strongest signal usually wins, wiping out the weaker and more distant ones. Just when you are trying to work that weak station on one of the distant mountains, someone nearby fires up their 50-watt mobile rig and covers them up.

Around 12:30 we tore down the stations and packed up our gear. We stopped for our traditional picnic lunch at the Halfway Picnic Area, relaxed, and discussed the results of the radio operation. We all agreed that this is a great event that allows hams to get on the air and have some fun.

A few days later, I received an e-mail telling us that Steve was officially licensed as KDØBIM. Congratulations, Steve!

The next Colorado 14er Event will be held August 10, 2008.

73, Bob, KØNR

References

The Colorado 14er Event website: <http:// www.14er.org>

Pikes Peak Highway website: <http://www.pikespeakcolorado.com/>

Video of the Mt. Harvard climb: <http://video.google.com/videoplay?docid=-6446083004152361265>

By Joe Moell,* KØOV

HOMING IN

Radio Direction Finding for Fun and Public Service

USA's 2007 ARDF Championships and Emergency Transmitter News

"World-class radio-orienteers shouldn't have to sleep in unheated garages!" That was the good-natured complaint of Jay Hennigan, WB6RDV, at breakfast on the first competition day of this year's national Amateur Radio Direction Finding Championships (ARDF). He was recovering from a night in a rustic cabin near the shore of Lake Tahoe in the Sierra Mountains of east central California. The temperature had dipped into the 30s overnight, but was heading for the 70s under clear skies.

Jay went on to win a gold medal in the category for men age 50 to 59. He had to navigate with map and compass through the forest from the start line to the finish while finding all required transmitters (four in his category) in the least elapsed time. A typical course is five to eight kilometers long, if you travel the shortest possible route. Vadim Afonkin of Boston, the day's fastest, did it in an hour and two minutes. Others took up to three hours, which was the time limit for this hunt.

This 2-meter competition took place on Saturday, September 15. The next day there was a similar competition on the 80-meter band in a different part of the forest. Both courses were set by Bob Cooley, KF6VSE, of Pleasanton, California. A long-time orienteer, Bob used the experience he gained in 2003 when he mapped the area and helped set courses for the national championships of the US Orienteering Federation.

General Chair of this year's championships was Marvin Johnston, KE6HTS, of the Santa Barbara Amateur Radio Club. SBARC teamed up with the Los Angeles Orienteering Club (LAOC) to organize the events and to set up electronic scoring. Maps were provided by the Bay Area Orienteering Club. International Amateur Radio Union (IARU) rules for ARDF were followed as closely as possible.[1]

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Bob Cooley, KF6VSE, set all courses for the 2007 USA/IARU-R2 Championships and for two days of intense training prior to the event. (All photos by the author)

These Seventh USA ARDF Championships were combined with the Fourth ARDF Championships for IARU Region 2 (North and South America).[2] Unfortunately, the USA was the only Region 2 country represented. The foreign visitors came from Germany in Region 1 and Australia in Region 3. For the second year, Nick Roethe, DF1FO, and his wife Brigitte included the USA Championships in their auto touring of the US.

SBARC looked forward to even more foreign visitor participation, including two hams from Mongolia and five from the Ukraine, but it was not to be. Their entry visas to the USA were denied. Although no reason for the refusal was given, it is believed to be related to the statistically higher percentage of "jumped" visas from some countries. The denials came two weeks before the championships, which was too late for the appeal process.

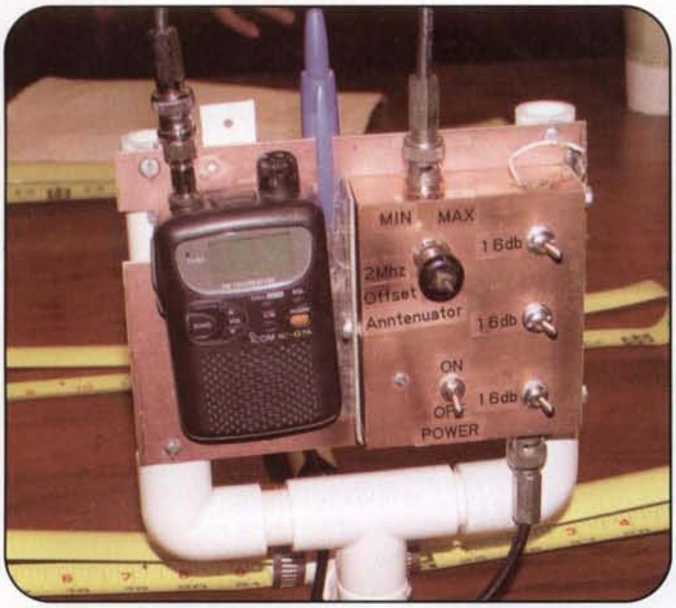
One competitor who had no trouble gaining entry to the US was Bryan Ackerly, VK3YNG. He has been coming to ARDF events on our continent since the first IARU Region 2 Championships in 1999 near Portland, Oregon. Over the years, he has shed pounds and gained speed to become a world-class performer. His time in the 80-meter event was the best overall at the championships. Afterwards, he had enough stamina to run back onto the course for another hour, just to take photos of the other competitors.

On arrival, two days before the 2-meter hunt, Bryan got over his jet lag by hiking 10 miles round trip from Camp Concord to the top of Mount Tallac, 9,735 feet above sea level. Since there was no food at the camp when he got back, he went for another 10-mile run into town and back again.

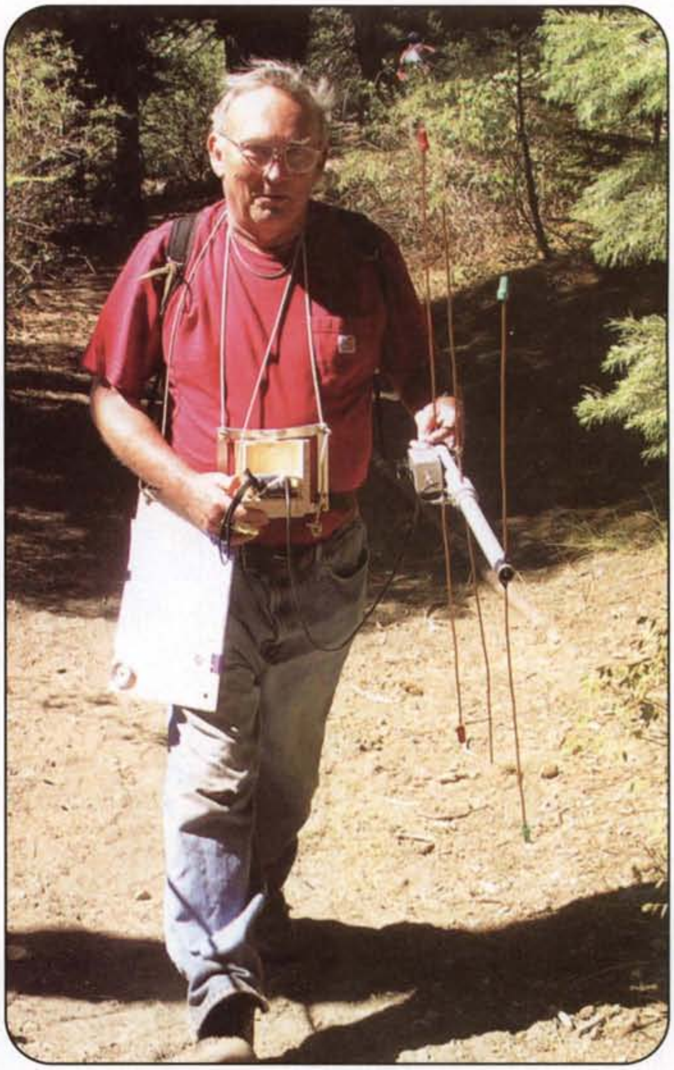
VK3YNG and other foxhunters in the Melbourne area enjoy on-foot ARDF and vehicular foxhunting almost equally. When Bryan is not out tracking radio foxes, he makes and sells a small VHF receiver designed especially for ARDF (more on that later).

This is the second time that SBARC and LAOC have organized the USA ARDF Championships under the direction of KE6HTS. In 2004, the event was headquartered in Gorman, California, at the top of Tejon Pass, halfway between Burbank and Bakersfield. The 2-meter competition was at Vasquez Rocks State Park and the 80-meter hunt was in the forest of Mt. Pinos, near Frazier Park.

To bring and keep radio-orienteers together as much as possible, KE6HTS and KF6VSE chose Camp Concord for the



This is how Paul Gruettner, WB9ODQ, mounted his small handie-talkie and active attenuator to his 2-meter RDF antenna.



Neil Robin, WA7NBF, in the 2-meter starting corridor. He carried his receiver in a neck harness. His home-built 2-meter Yagi has stiff wire elements instead of the more typical steel measuring tape. Note the wire nuts for eye protection at the element ends.

2007 event headquarters. This 29-acre facility is owned and operated by the Community and Recreation Services Department of Concord, California, 25 miles northeast of downtown San Francisco and a 170-mile drive from the camp.

Camp Concord, which is celebrating its 40th year, hosts over 600 children every summer in six one-week sessions that include swimming, archery, sailing, horseback riding, and leadership exercises. A separate foundation provides funding for families who otherwise could not afford to send their kids there. Even the counselors do not know which kids are on such scholarships and which are not. At the same time, in the other half of the facility, family camp is taking place.

As I talked with Camp Director Marylou Chopelas about her fine programs, I imagined how wonderful it would be if amateur radio operating and hidden-transmitter hunting were included in the regular summertime activities for youth and families. That would take lots of effort and ongoing support from hams in El Dorado County. How about it?

Radio Sporting Goods

Every competitor at the championships had his or her own vision of the optimum 2-meter RDF setup. It was hard to find two identical sets of equipment, unless they belonged to members of the same family. Those who first experienced ARDF in Europe tended to prefer one-piece receiver-antenna units from the Ukraine or Russia. They typically have a continuous tuning dial covering 144 to 146 MHz, sometimes modified to go up to 148 MHz for the Western Hemisphere.[3]

These European sets have AM detectors because that mode is standard for ARDF on that continent. They have relatively wide IF stages, so they often experience interference from other strong 2-meter signals in urban areas. This was not a problem in the forests of eastern California, however.

The most popular ready-to-use RDF set in Australia and the USA is Sniffer 4, designed and produced as a side business by VK3YNG. Bryan brought several with him on the trip and they were quickly snapped up. Sniffer 4 covers the full American 2-meter band and the VHF aircraft band. Frequencies are entered in the usual four-digit way, so punching in "F6565" sets it to the USA T-hunting frequency of 146.565 MHz and "F2150" brings up the 121.5 MHz aircraft ELT frequency. A touch of the mode button changes the output between AM and FM reception on either band.

Australian foxhunters like tone-pitch signal-strength indicators. They call it the *whoopee mode* because of the "wheeee-oop" sound as the beam is swept across an incoming signal. Sniffer 4 has a high-sensitivity whoopee response, making it easy to find the peak or null direction.

As you approach a radio fox and the signal gets stronger, Sniffer 4 automatically increases the input RF attenuation in range steps of about 15 dB each and beeps to tell you when a range change has taken place. The single-digit indicator displays the current attenuation range. When the signal goes off-air, attenuation drops to zero in two seconds (adjustable between one and five seconds)

The term "sniffer" implies a receiver with reduced sensitivity and selectivity, intended primarily for closing in on strong signals. However, in my tests the whoopie indicator would easily detect a 2-microvolt signal on 2 meters. That's not quite as sensitive as most handie-talkies, but it's more than adequate to hear all the foxes on an international course with a three-element beam. At the other end, a 100-millivolt signal (maximum output of my bench RF generator) only registered in the "5" range on the 9-step attenuator. Even next to fox transmitter antennas, the unit doesn't get swamped.

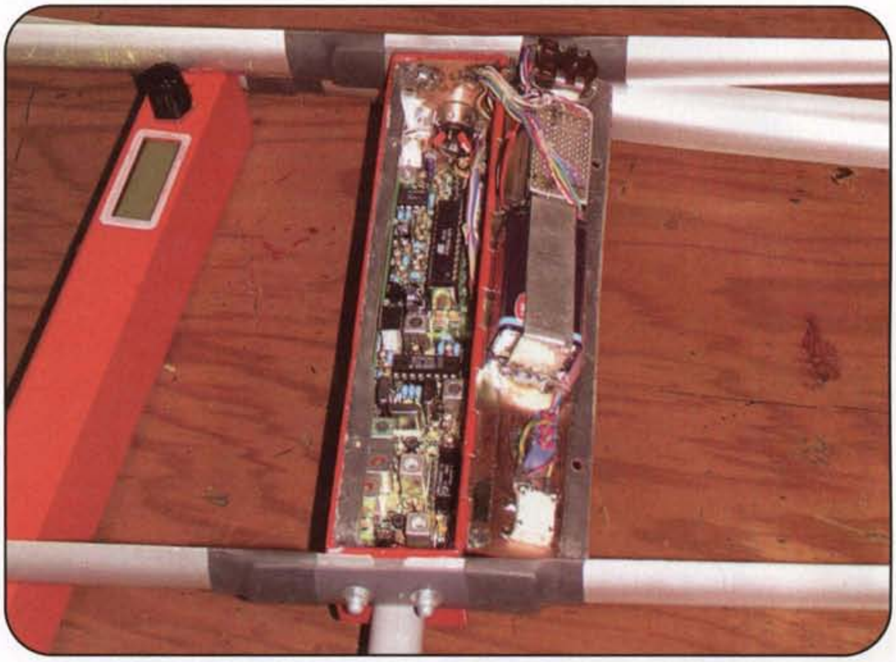
Changing batteries necessitates removing four screws to open the back of the unit—not something to do in the middle of a hunt. Two AA alkaline cells will power Sniffer 4 for about three hours, depending on audio volume, indicator brightness, and whether you wear headphones. Lithium AA batteries will keep it going for about 14 hours. Nickel-cadmium (Ni-Cd) or nickel metal hydride (Ni-MH) cells aren't an option, because their terminal voltages are too low.

Like most microprocessor-controlled radios, there are bells and whistles for advanced users, such as a memory to tell you the maximum attenuation value achieved since the last frequency change or power-up. There's also a 0–99% battery-remaining indicator, automatic volume reduction when the battery gets low, and a low-tone whoopee option for persons with poor high-frequency hearing.

A popular feature for five-fox international-rules competitions is the built-in timer. Synchronize it to the start of fox #1 and it will beep a warning ten seconds before the end of each fox's transmission, then beep out the number of the next fox to transmit. At switchover time, it immediately resets the attenuation to zero so you are ready if the next fox is weak.

Sniffer 4 supports stereo headphones. In one ear you get whoopee tone and in the other signal audio so you know which transmitter is on the air. For more information, download the complete manual on the web.[4]

In my experience, Sniffer 4 is ideal for teaching RDF to newcomers, youth, and Scouts. I tell them to simply turn the beam for the highest pitch at the highest number. However, for some serious hunters that's too much automation. They prefer to manually dial in the RF attenuation as they approach foxes. Sniffer 4 has a mode for this. Almost as effective, if you have a 2-meter handheld receiver with S-meter, is to use it with an external offset attenuator.[5] Make provisions to mount both the receiver and attenuator to the antenna for one-hand operation in the woods.



Nick Roethe, DF1FO, built this 2-meter ARDF receiver into the boom of his RDF Yagi.

Yagis of three or four elements give much better bearings in reflection-prone terrain, compared to two-element Yagis or HB9CV-type phased arrays. Foxhunters who build their own usually choose tape-measure designs for flexibility and safety in the brush.[6] WB6RDV is an exception, preferring his four-element log-periodic with braid-over-fiberglass elements.

Tracking 406-MHz Rescue Beacons

As I write this column, searchers continue to look for aviator Steve Fossett, who has been missing since September 3. It was reported that his aircraft had an Emergency Locator Transmitter (ELT) and that he wore a Breitling Emergency watch.[7] However, no emergency signals have been heard directly or via satellite.

Aircraft ELTs are designed to activate automatically on impact, but there are estimates that they fail to do so about a third of the time. What's worse, ELTs activate falsely during hard landings and at other inappropriate times. I don't know if it is true, but a story has been circulating on the Internet about employees of an aircraft manufacturer who are said to have "borrowed" a life raft from the production line to go on a river trip. Hours later, a Coast Guard helicopter appeared overhead to "rescue" them because the raft carried a beacon that had activated without their knowledge.

Even if that story is fiction, it's a fact that an overwhelming majority of the activations of ELTs and Emergency Position Indicating Radio Beacons (EPIRBs) are accidental or non-emergency related. When it happens, the continuous 121.5- and 243-MHz signal is picked up by SARSAT/COSPAS satellites and relayed to the Air Force Rescue Coordination Center (AFRCC), which determines the approximate location using Doppler shift of the signals as received at the satellites. AFRCC notifies the agency responsible for response in the area of the "hit." An effort must be made to track each activated beacon, not just because it's possible that lives are in danger, but to clear the frequency for other activations.

New 406-MHz EPIRBS transmit a burst of data that includes traceable unit identification and the option of GPS coordinates. Because of their widespread acceptance, and because of the high costs of investigating false hits, the International COSPAS/SARSAT Organization is scheduled to stop satellite processing of anonymous 121.5- and 243-MHz signals on February 1, 2009. The satellites will continue to relay the identification and GPS coordinates transmitted by the new 406-MHz beacons. Although the National Transportation Safety Board strongly recommends that all aircraft be retrofitted with new 406-MHz ELTs, and has asked the Federal Aviation Administration to make this mandatory, the FAA has not issued such a ruling so far. The Aircraft Owners and Pilots Association is on record as opposing it.

Despite the reluctance of agencies to mandate a switchover to 406-MHz beacons, they are rapidly gaining popularity. Beginning four years ago, FCC regulations permit the sale of Personal Locator Beacons (PLBs), which are identical in most respects to ELTs and EPIRBs, but are marketed to hikers and sportsmen for terrestrial use.

ARDF Championships 2007 – A Perspective

By Neil Robin, WA7NBF

Neil Robin, WA7NFB, participated in the M60 class in the 2-meter competition and won the bronze medal.

This is a brief report on the US National and Regional ARDF Championships held at Lake Tahoe during September 14–16, 2007. This event was sponsored by the Los Angeles Orienteering Club along with the Santa Barbara Amateur Radio Club.

Radio orienteering is a sport that is much more popular in Europe and other parts of the world but slowly gaining interest in the US. It combines orienteering with radio direction finding. You may ask, "What is orienteering?" In short, its the athletic ability to travel cross country to multiple control points in the minimum amount of time. At each control point there is a type of recording device to show that you reached that point and your elapsed time. Control points are only made known when you reach the "starting gate." Of course, you can travel through thickets, brush, swamps, or whatever to reach these points, but a smart contestant will read the special orienteering map handed him or her once in the "starting gate." Strategy is very important to work around obstacles. Most will make use of trails and roads to cover large distances quickly. A web source of more information on orienteering can be found at: <http://en. wikipedia.org/wiki/Orienteering>.

Radio orienteering changes "control points" to hidden radio transmitters (foxes). You have to use radio direction finding (RDF) skills to locate these new points, and then punch the clock as you reach them. When you're handed the map, only the terrain is shown, not the location of the transmitters. You must use your RDF skills to build your strategy and minimize the time needed to find all the required transmitters yet avoid obstacles along the way. Transmitters will almost always be hidden in the bush, not near trails or roads. Of course, VHF radio signals bounce a lot, so taking bearings is a developed skill. The winner is the one who finds the required number for his or her class in the least time. This arrangement is called ARDF, or Amateur Radio Direction Finding, and involves international rules. The US is part of IARU Region 2, but we use Region 1 rules.

Orienteering maps are built from topographical maps, but symbols and legends are added to show detail that potentially limits travel or helps identify positions. Once you start to travel cross country, you will almost always become lost in a matter of minutes. You no longer know exactly where you are. Using the features of the map in coordination with what you see will help you re-establish or at least estimate your location. For me, half the fun is figuring out where you are. Figure 1 is an example of a map.

The color coding is much different from topo maps. Dark green is very rough terrain with cross-country travel being discouraged. The "starting gate" is located in the lower left corner as a purple triangle. The circle surrounding the start is the "exclusion zone" with a radius of 750 meters. No transmitters will be found within this area. The "finish" is the two concentric circles. No transmitters will be found within 400 meters of each other or the "finish." That's what the smaller circle is all about. When you're handed the map, you could guess where up to five transmitters are located, but you will need RDF to pinpoint them over each 5-minute re-cycle period. The challenge is to reach each required and return to the finish in the least amount of time and before the course overall duration expires. Map legends can be found at this link: <http://www.williams.edu/Biology/Faculty_Staff/hwilliams/Orienteering/map.html>.

Orienteering map used in 2-meter hunt showing only the start and finish points.

In southern California, the Civil Air Patrol (CAP) is responsible for responding to all satellite-relayed emergency beacon activations. Two of the area's most active CAP members are Bob Miller, N6ZHZ, and Cathy Livoni, KD6CYG, who go on many ham radio transmitter hunts as practice for their search-and-rescue direction-finding. Bob reports that time to locate 406-MHz ELTs with GPS assistance is usually much faster that finding 121/243-MHz ELTs by RDF. However, there are instances when there is no GPS data on 406 MHz, or it's inaccurate, and the 121/243-MHz signals from the same ELT fail or can't be copied. Then the RDF has to be done on 406 MHz.

Transmissions from a 406-MHz ELT are 5 watts or more, giving greater range than typical 100-milliwatt VHF ELTs. The bursts can be as short as 440 milliseconds and occur at about 50-second intervals. If you have ever tried to track a low-rate pulse transmission with a directional antenna such as a Yagi, or with a dual-antenna RDF set, you know that it's very difficult. You can't sweep the beam through a full azimuth circle in less than a half-second. It can take many minutes to get enough transmissions for a reliable bearing.

What about using a Doppler-type RDF set to track these PLB bursts? Dopplers have the advantage of making hundreds of "virtual sweeps" every second. However, the minimum transmission time for accurate bearing determination is a function of the set's audio filtering and detection circuits. It is not instantaneous.

Most Dopplers have high-Q switched-capacitor filters. They are heavily damped to provide the narrowest possible audio passband.[8] Ideally, the filter would pass only the detected Doppler tone frequency, which is the same as the frequency of antenna pseudo-rotation. If it were wider, the data modulation on the signal would introduce errors in bearing readout. Unfortunately, these high-Q filters are slow to acquire and resolve the Doppler tone. N6ZHZ reports that his Doppler, a commercial unit from a well-known company, consistently gives bearing errors of 90 degrees on his practice 406-MHz EPIRB, even though bearings on continuous signals in the same frequency range are accurate.

Digital signal processing (DSP) may be the path to Doppler RDF accuracy on short-burst data-modulated signals such as UHF distress beacons. I have corresponded with two DSP design experts who are experimenting with it. Doppler filters contain "garbage" at signal acquisition, which must be quickly and com-

Bryan Ackerly, VK3YNG, had the best time for the five-fox course on Sunday. He is the designer and builder of the popular Sniffer 4 RDF receiver, which covers 2 meters and the aircraft band.

The international rules control many aspects of the hunt: Rules and information can be found at: <http://members.aol.com/homingin/intlfox.html#rules>. No use of GPS is allowed, and it's an individual sport relying only on map, compass, and RDF skills. You can't attempt it as a team, so you must travel alone, but all have enough skills that getting truly lost is rare indeed.

My Results

I only entered the 2-meter competition. Although Dale Hunt, WB6BYU, loaned me an 80-meter receiver, I didn't put the time into learning how to use it so I could compete effectively. Nearly all competitors were experienced enough that my practice was very important for any success that I could expect. Propagation on 80 meters works differently than on 2 meters in that you don't have the reflections, but you also don't have a good indication of signal strength. In a practice session I completely walked around a transmitter but couldn't tell how far away it was. It turned out that I was nearly on top of it but didn't know that at the time. Experience helps a lot!

I won the bronze medal for my M60 class in the 2-meter competition. It wasn't hard, because the M60 class had few competitors since this is a race that requires considerable physical endurance, which discourages older participants. Being an insulin-dependent diabetic, I didn't want to push myself at the 6,500-ft. altitude of Lake Tahoe, so I took a long two-hour time to get to the finish. I was very pleased that I received the bronze medal and have the utmost respect for the serious runners. Most have been at it for several years.

The best of the US team still rarely wins world-class metals. The Europeans, particularly the Ukrainians, are the ones to beat on the world stage. Orienteering and radio orienteering are sports in which their high school students participate, so it's a very common activity for them as they grow up.

Attendees included Brian Ackerly, VK3YNG, from Australia. Brian is most noted for his design and manufacture of the Sniffer 4 two-meter foxhunting receiver. Brian is so good that he competed in a lower age class just so he had to find all five transmitters. He won the "gold" in that class!

One member told of disturbing a bear that was sleeping on one hunt. I am sure glad that the bear didn't follow him to the finish line!

pletely pushed out and replaced by signal data to prevent erroneous bearings. DSP holds promise for accomplishing this at high speed. I welcome your ideas and will report on progress in future "Homing In" columns. It may even be possible to make Dopplers work well on the 20-millisecond pulses from wildlife research tags.

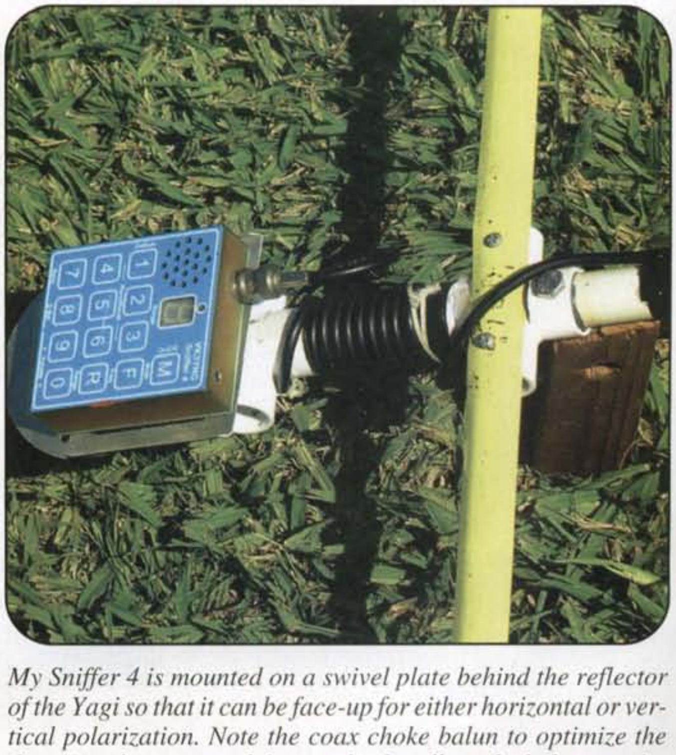
More TracMe® News

In the Spring 2007 issue of *CQ VHF*, I reported that TracMe® Beacons, an Australian company, is introducing a lower-cost alternative to satellite-tracked PLBs. A TracMe transmitter sends a recorded voice call for help at 10 milliwatts on Family Radio Service (FRS) Channel 1. TracMe is not offering FRS RDF equipment for sale to the public at this time, so my column delved into equipment and techniques that hams and other searchers can use to locate these devices when activated.

Not surprisingly, TracMe's product has stirred controversy. Its cost is attractive, but there is concern that buyers will confuse TracMe with satellite-tracked PLBs, thinking that activation will automatically trigger a rescue effort.

While a TracMe might guide rescuers to you, it is betting against the odds to expect it to be an effective alerting device. Aircraft pilots monitor 121.5 MHz, not FRS Channel 1. Someone must be in ground range of the 10-milliwatt UHF signal, this person must have a FRS radio tuned to Channel 1, the channel must be clear of QRM, and the radio's CTCSS function must be turned off so that your non-CTCSS signal isn't squelched. The listener must believe that the recorded call for

At age 12, Monique Beringer was the youngest competitor at the USA Championships. Here she is running through the starting corridor with my measuring-tape Yagi and Sniffer 4 receiver.



My Sniffer 4 is mounted on a swivel plate behind the reflector of the Yagi so that it can be face-up for either horizontal or vertical polarization. Note the coax choke balun to optimize the directional pattern and the wooden handle at the balance point to avoid wrist strain.

Good News for the
VHF/UHF Enthusiast

The all-time favorite magazine for the VHF/UHF enthusiast, CQ VHF is better than ever and now on sale for the holidays!

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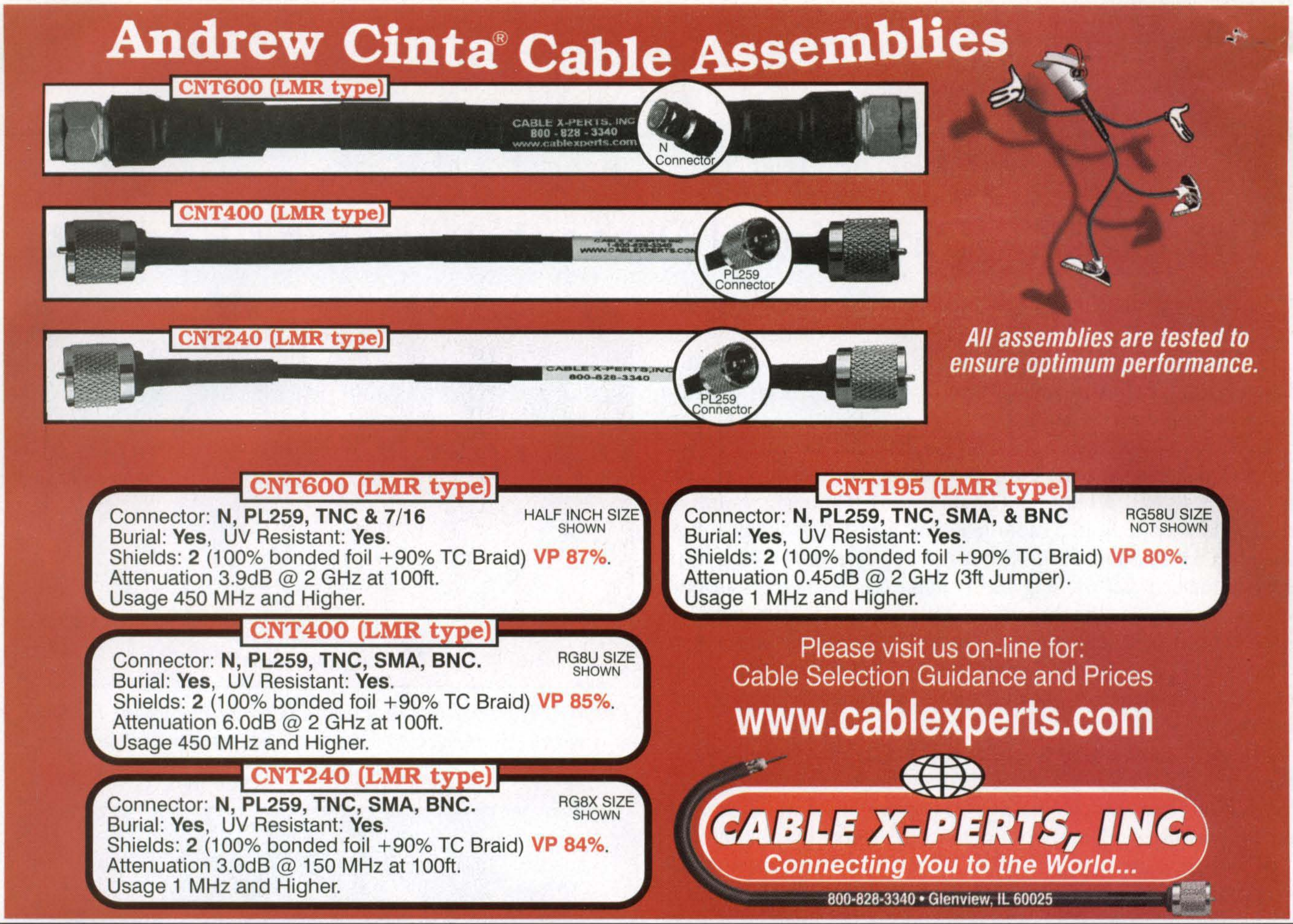

help is real (since no live voice transmit or receive capability exists in TracMe) and must summon authorities.

Within the fine print on the back of the TracMe package is this statement: "TracMe is not an EPIRB unit and does not communicate via satellite." In the Important User Practices section is this: "Leave written instructions about your location and itinerary with the phone number of the nearby County Sheriff." The package includes a card for users to place on the vehicle dashboard when parked at a trail head to advise potential rescuers that they are carrying a FRS rescue beacon.

On July 10, the FCC wrote to TracMe, requesting that the company cease using the term "Personal Locator Beacon" and choose a more representative name. The FCC pointed out that PLB is an equipment class for Part 95K devices, but TracMe is actually a Part 95B device. The letter went on to state that the FCC and the US Coast Guard believe that the term PLB is a misrepresentation of the device, as well as confusing because it implies an alerting function.

In response, TracMe contends that "PLB" is a generic description. According to the Frequently Asked Questions page on the company's website,[9] "It is a beacon which specifically emits a signal to assist in locating a lost or incapacitated person—hence the term Personal Locator Beacon. The term applies to TracMe and a variety of other beacons, including those which link to satellites and others which do not."

The FAQ concludes, "Since satellite PLB technology was one of the earliest and most widely known PLB technologies, some people mistakenly conclude that a device must use satellite technology to be a PLB. However, the term PLB does not necessitate that the device employ satellite technology."

TracMe FRS beacons are now available for sale. Will purchasers be confused? I am sure that this is not the end of the controversy.

Thanks to all of you who have sent information on transmitter hunts and other RDF-related activities in your area. I welcome your stories and photos for future "Homing In" columns.

73, Joe, KØOV

Notes

1. More on international rules for ARDF competitions can be found at <http://members.aol.com/homingin/intlfox.html>.
2. IARU Regional ARDF championships are held in odd-numbered years. World Championships take place in even-numbered years.
3. The main hunt frequency was 145.565 MHz to accommodate European and Asian competitors' equipment.
4. <http://www.users.bigpond.net.au/ vk3yng/foxhunt/foxhunt.html>
5. Offset attenuators are described in "Homing In" in the Winter 2006 issue of *CQ VHF*. Construction plans are at <http://members.aol.com/joek0ov/offatten.html>.
6. <http://home.att.net/~jleggio/projects/ rdf/rdf.htm>
7. <http://breitling.com/en/models/professional/emergency/>
8. For more on optimizing Doppler RDF sets, read "Homing In" in the Spring 2004 issue of *CQ VHF*.
9. <http://www.tracme.com>

By Kent Britain,* WA5VJB

ANTENNAS

Connecting the Radio to the Sky

The DDRR – Directional Discontinuity Ring Radiator

Yes, it kind of looks like a halo, but the DDRR is a vertically polarized antenna (Photo A). For decades this antenna has been known as the Directional Discontinuity Ring Radiator, but in recent years it has often been called a Directly Driven Ring Radiator.

In Photo B we have a 2-meter DDRR that is only 7 inches across, and this antenna does provide a low-profile vertically polarized signal. What looks like a threaded antenna mount on the top is used to hold a radome cover. Photo C is what is marketed as a 440-MHz DDRR, but it is really more of an inverted-F antenna, since the ring barely makes it 180 degrees around. Again you can see the threaded antenna mount on top, which is used to hold its radome cover. This time the antenna uses a standard NMO (new Motorola) mount, and the washer out on the end forms a capacitor back to the body of the car for fine tuning the SWR.

Figure 1 shows how to make a slot antenna. Normally, we think of a dipole as a 1/2-wave of conductor surrounded by insulator. However, now we have a 1/2 wave of insulator surrounded by conductor. The two antennas are opposite in construction and opposite in polarization. A horizontal slot antenna is a vertically polarized antenna. The metal slot antenna shown in Photo D is horizontally polarized, and the PC-board slot array in Photo E is vertically polarized as shown—opposite in where you put the conductors/insulators and opposite in the polarization that has come out.

There are many ways to excite a slot antenna. Those of you who have been through FCC Part 15 compliance testing with your computer products probably have found out the hard way that slots in a computer case, such as the one shown in Photo F, can be very, very efficiently driven by traces on a PC board.

The original DDRR antenna was developed as an HF antenna by Northrop Corporation in the 1960s, and there have been a few modest attempts to market smaller ones as ham antennas. You can also think of the DDRR as an inverted-F antenna bent into a circle.

There has been a big push to revisit DDRRs because of their low profile and small size for a vertically polarized antenna. In Photo G we have some 433-MHz, 915-MHz, and 2450-MHz DDRRs designed for utility-meter applications. These work great when you don't have a lot of room. One place to mount on would be on your water meter. Water-meter lids typically are mounted even with the ground, and a 1/4-wave whip sticking out the top of the water meter works great—until someone mows the grass. The PC board really capacitively loads the antenna. The 433-MHz version is only 1.4 inches across; the 2450-MHz model is about the size of a shirt button!

Photo H shows a very basic DDRR antenna. The bottom ring acts as the ground plane and the top ring excites the slot between the rings. Just start out with a length of stiff wire. Cut to length

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

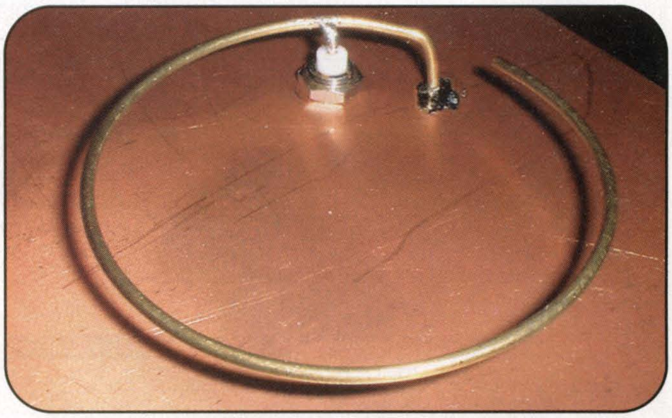

Photo A. The DDRR (Directional Discontinuity Ring Radiator) is a vertically polarized antenna. (All photos and artwork by the author)

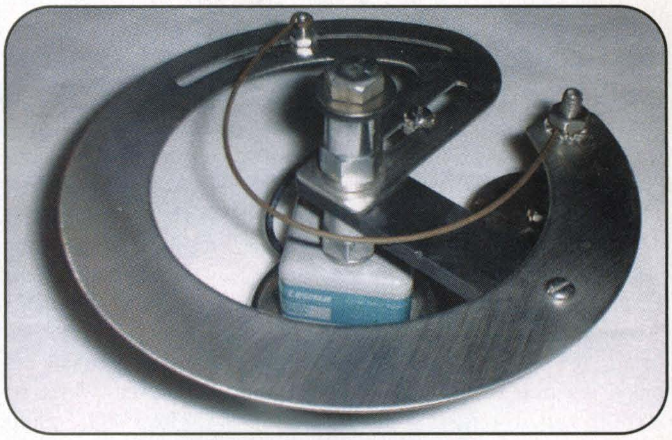

Photo B. A commercial 2-meter vertically polarized DDRR antenna.

Photo C. A commercial 440-MHz vertically polarized DDRR antenna.

and bend per the dimensions in Table 1. After cutting the wire to length, bend at 90 degrees right in the middle. Come up the spacing, or height, and then bend it back again. Now find a soup can or pipe and bend the U into a circle. Solder the bottom tip to the bottom of the U and you've got it.

While I haven't build a 146-MHz or a 222-MHz basic DDRR antenna, if you have any kind of antenna analyzer that tunes 2 meters, just scaling up the 440-MHz dimensions will get you very close to 146 MHz, and then you can tweak and snip to your heart's delight.

The tip of the radiator is a very high impedance point. Just by bending it up and down a small amount, you can shift the antenna frequency quite a bit.

Also, you don't have to build the DDRR of out of wire. I have also built them out of sheet metal. A piece of metal is cut to roughly the dimensions of the wire antenna, bent in a circle, and soldered.

The DDRR can be made even smaller. The HF versions use a capacitor at the tip of the top ring to lower the resonate frequency, such as the one shown in Photo I. This allows the antenna to have much smaller loops, and the smaller loop has an even more omnidirectional pattern. You may need to slightly move the coax tap point to tweak the SWR if you move the loop a lot of MHz.

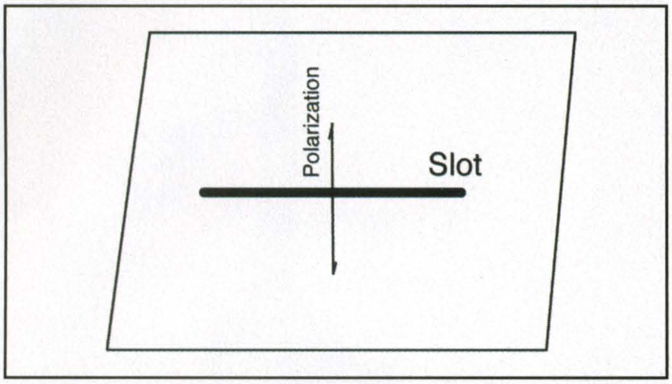

Figure 1. The basic slot antenna.

Unintentional Slot Antennas

Back in my EMI/EMC (electromagnetic interference/electromagnetic compatibility) days I had to explain to a lot of computer engineers that when they put the covers on their comput-

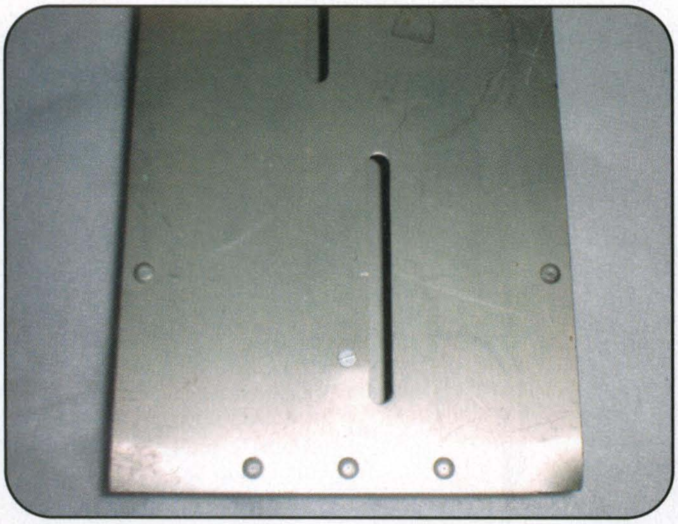

Photo D. A horizontally polarized 2.4-GHz slot antenna.

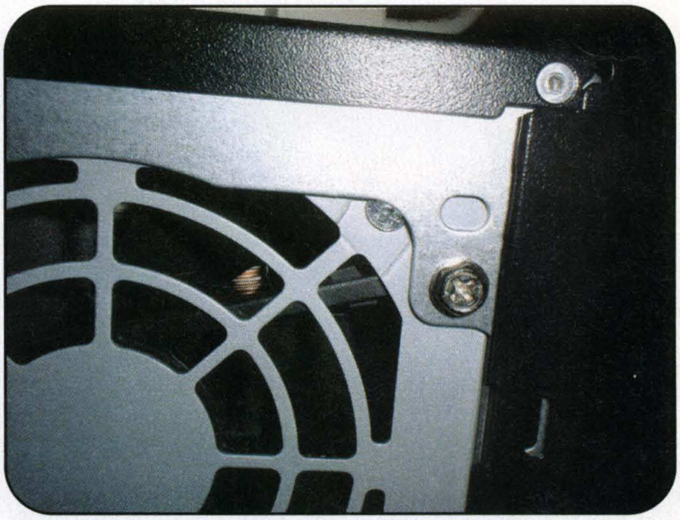

Photo F. An unintentional slot antenna—a computer case.

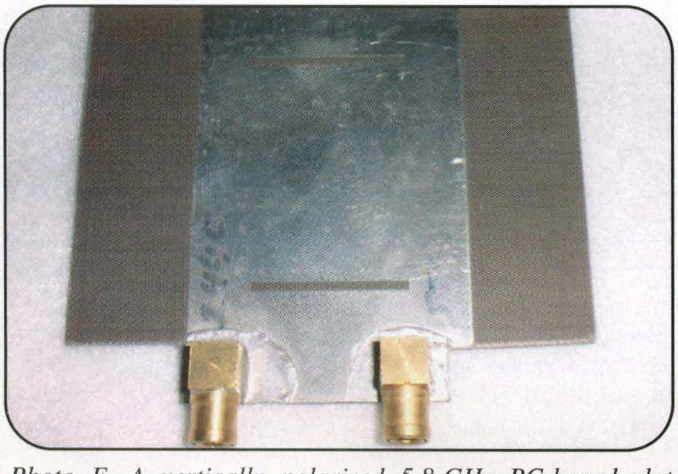

Photo E. A vertically polarized 5.8-GHz PC-board slot antenna.

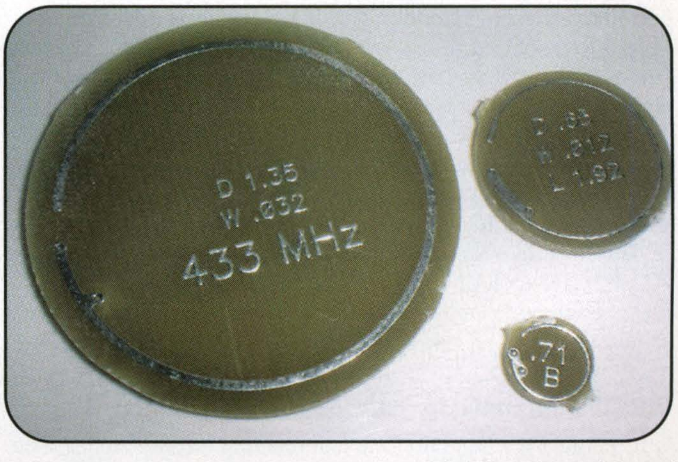

Photo G. 433 MHz, 915 MHz, and 2450-MHz PC-board DDRR antennas.

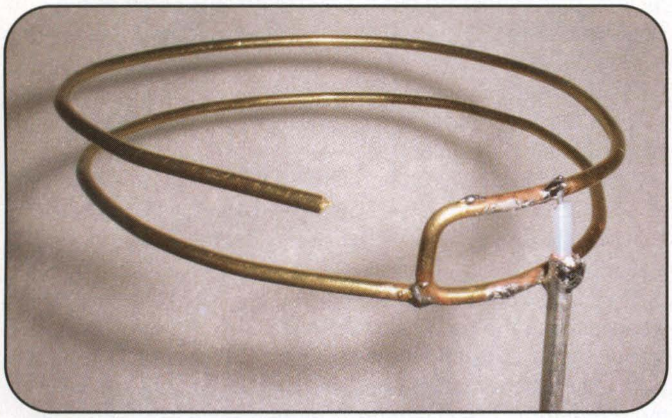

Photo H. Basic wire DDRR antenna.

	Wire Length	Height	Feed Point
440–450 MHz	15 inches	3/8 inch	1/2 inch
900–930 MHz	7 inches	1/4 inch	1/4 inch
1250–1300 MHz	4 1/2 inches	1/4 inch	3/16 inch

Table 1. Dimensions for the basic DDRR shown in Photo H.

Photo I. Using a capacitor to lower the DDRR's frequency.

ers, if the cover didn't have a good electrical connection at all points around the edge, they just made a very efficient slot antenna. I used to do a demonstration in which I had a loop antenna inside an old 486 computer case. The loop was connected to a sweep generator, and I passed another antenna connected to a spectrum analyzer around the outside of the case. On the frequencies where that slot was resonant, the signals levels were *strong*. The idea is to have enough screws in your case such that all the slots resonate above the highest frequency leaking off the computer board. Now you know why microwave assemblies have so many screws. You have to keep those slots smaller that the microwaves.

"But the slot is so narrow!" "Can you build a dipole antenna out of 1/100-inch thick wire? Of course. Also, a slot 1/100th of an inch wide and a half-wave long makes just as good an antenna.

Neat Antennas—Passive Repeaters

In Photo J we have not one antenna, but two antennas. You slip this assembly over the top of your driver's side window, with the top part outside the car and the base section inside the car. The horizontal dipole in the base picks up the signal from your cell phone (I'll bet this works much better when you have the cell phone in your left hand, but also be aware of restrictions about talking on a cell phone while driving as well as the safety factor!), and a short length of coax carries the signal to the whip and re-radiates the signal outside the car.

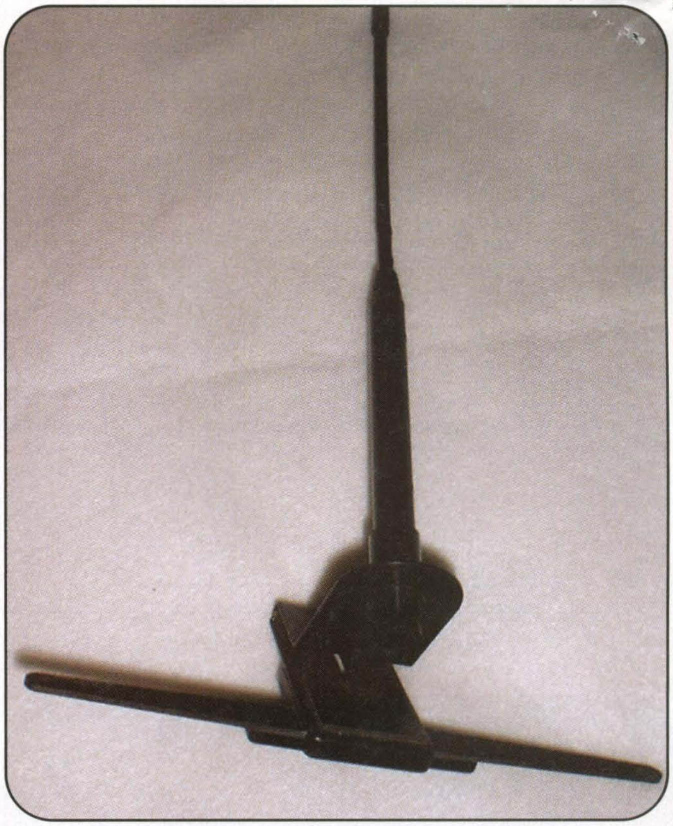

Photo J. A passive repeater for using a handheld cell phone in the car.

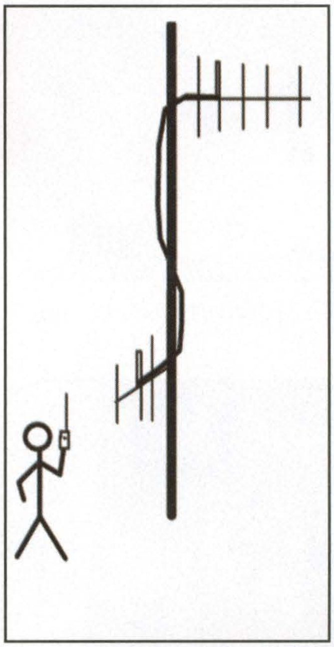

Figure 2. The basic passive repeater.

There are several ways a passive repeater can be used. In Figure 2 we have the most basic passive repeater. Let's say you can't quite hit your favorite repeater from your basement. Mount a small beam in the basement, some low-loss coax up the tower, and another beam pointed at the repeater. Don't expect this to take the signal from S0 to 40+, but it often gets you over the hump. Commercially, this technique is often used to get VHF/UHF signals into underground parking garages, RF-tight rooms, tunnels, and so on.

73, Kent, WA5VJB

CQ's 6 Meter and Satellite WAZ Awards

(As of October 1, 2007)

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	2,16,17,18,19,21,22,23,24,25,26,28,29,34,39
11	GØLCS	1,2,3,6,7,12,18,19,22,23,25,28,30,31,32
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	1,2,17,18,19,21,22,23,26,28,29,30,38,39,40
82	W4UM	18,19,21,22,23,24,26,27,28,29,34,37,39

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

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, 17 Green Hollow Rd., Wiggins, MS 39577. 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>.

**17 Green Hollow Rd., Wiggins, MS 39577; e-mail: <n5fg@cq-amateur-radio.com>*

By Bill Brown,* WB8ELK

UP IN THE AIR

New Heights for Amateur Radio

ARHAB 20th Anniversary Celebration

Amateur radio balloon groups converged on Findlay, Ohio this past August 11th to celebrate the 20th anniversary of the first Amateur Radio High Altitude Balloon (ARHAB) flight in the U.S. Five balloons were launched in the morning from the same location as my first flight at the farm of George Flinchbaugh, WA8HDX.

Ham radio payloads were flown by Nick Stich, KØNMS, Robert Rochte, KC8UCH, Taylor University (KB9ZNZ), and me (WB8ELK). In addition, the University of Akron and Taylor U flew experiments using a 900-MHz spread-spectrum downlink, and members of the University of Tennessee, Knoxville ARC balloon group (AA4UT) were in attendance for the launch and chase, but didn't fly their experiment. (See Photo A.)

Some very unique payloads were flown during the event. Nick, KØNMS, flew his license-free Garmin Rino unit, which performed extremely well (Photo B). These are handheld units with embedded GPS that transmit position on an FRS/GMRS channel to other handheld units. Even from 30 miles away, we had great reception using just an identical handheld Rino on the ground. Taylor U and University of Akron flew a 900-MHz SS (spread spectrum) system that provided high-speed data links that worked well. I flew one of my first ATV payloads (live TV camera with GPS overlay). After 20 flights up to the edge of space and back, the package consists mostly of duct tape . . . after all, real science is not possible without duct tape!

I also flew a simplex repeater on 2 meters using an Alinco DJ-S11T and a RadioShack simplex repeater module. Quite a few folks from several states were able to work through it. Taylor U flew a crossband FM repeater (2 meters and 70 cm). The Ft. Wayne ARC operated net control for the repeater, and it was in constant use from launch to landing with excellent signals across a large portion of the Midwest.

Four of the balloons were launched at the same time, and some of them made it to almost 100,000 feet. They all landed about 30 miles south of the launch site and were recovered a few miles apart from one another. Quite a few balloon trackers were on the chase, and after tromping through acres of soybeans and trying to pry payloads from balloon-eating trees, all of the payloads were recovered in good shape (Photo C).

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e-mail: <wb8elk@aol.com>

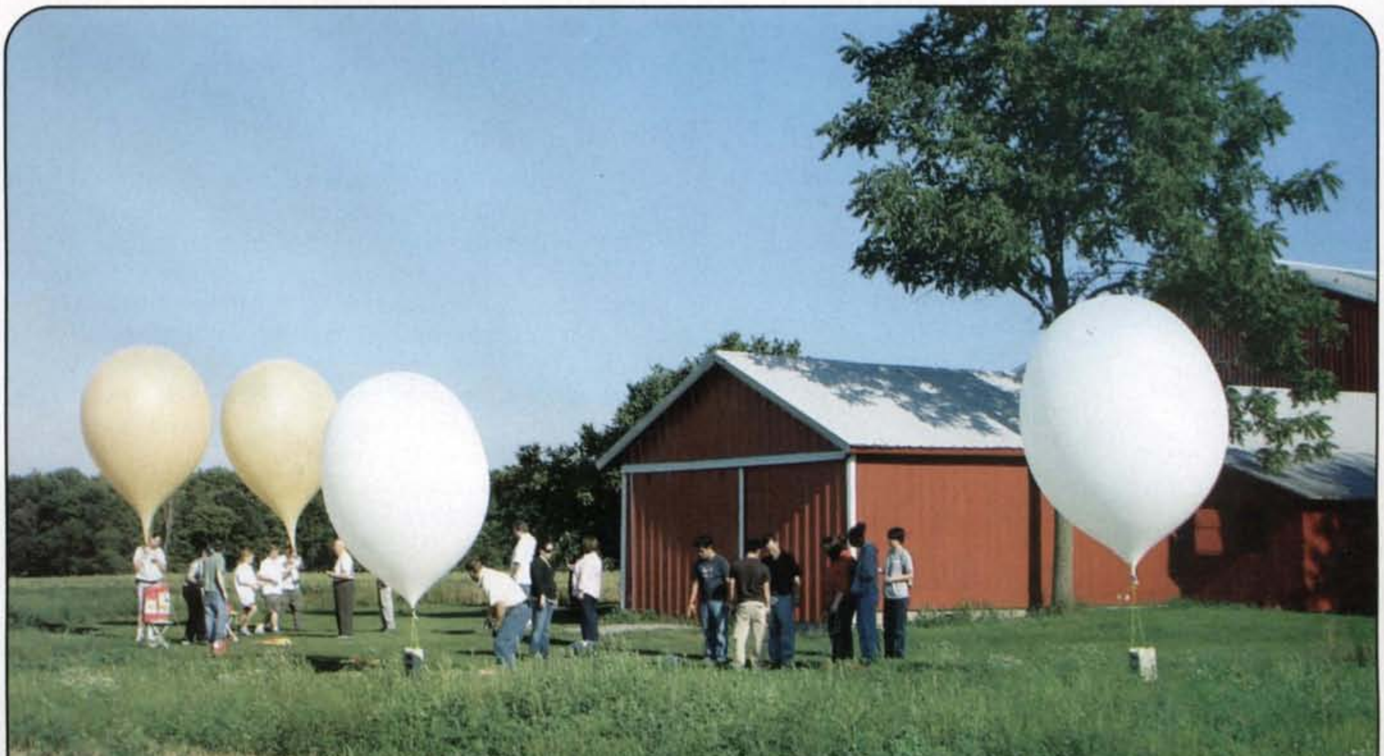

Photo A. Four balloons launch at once at the 20th Amateur Radio High Altitude Balloon (ARHAB) celebration.

Photo B. Nick Stich, KØNMS, demonstrates his Rino tracking payload.

Photo D. Robert Rochte, KC8UCH, launches his Superpressure balloon.

Photo C. The recovery team after a successful chase and recovery (l to r): Joe Demeyer, KD8EYH; Dave Snyder, KB8PVR; Mike Ricksecker, W8MDR; Greg Williams, K4HSM; David Hoffman, KE4FGW; Janice Hoffman; and Nick Stich, KØNMS.

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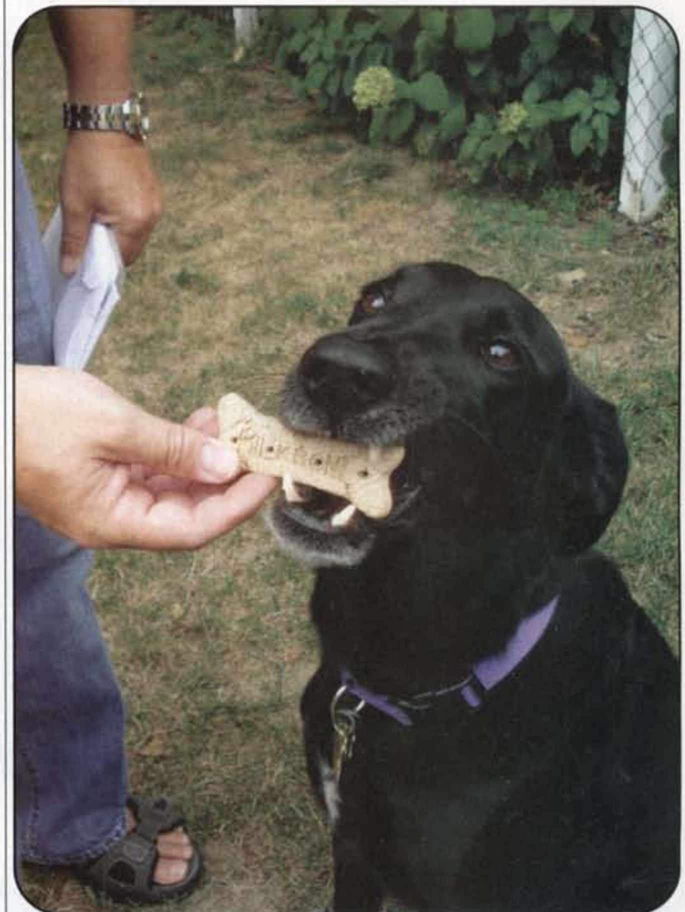

Photo E. Spencer devours the near space dog biscuit.

In addition to the four latex weather-balloon launches, Robert, KC8UCH, brought along a unique new Superpressure balloon that he designed and built (Photo D). Basically a Mylar™ cylinder that overpressures to float at a particular altitude for long durations, he attached a 5-ounce APRS system consisting of a Byonics Microtrak300, GPS receiver, and a pair of lithium 9-volt batteries. Keeping things as lightweight and simple as possible, his payload was packaged in a mailing envelope. Robert's balloon turned out to have quite a ride, as it floated for hours at 7,000 feet and came down in the wee hours of the night near Lexington, Kentucky. To everyone's surprise, it came back to life the next morning as the sun warmed it up and off it went for another day's flight, eventually coming down at sunset in a rugged area just east of Bowling Green, Kentucky. As luck would have it, his payload landed near a highway and someone driving by recovered the payload shortly after it landed. The balloon actually lifted off for a third flight after he cut free the APRS payload.

I've flown some intriguing experiments over the years, including a batch of "Peeps in Space," but this time Brian Tanner's dog Spencer wanted to fly an experiment of his own. Spencer wanted to see if a dog biscuit tasted better if it had been flown to the edge of space. The answer apparently is a resounding *yes* (Photo E).

Special thanks go out to Joe Brown, WB8MSJ, for transporting all the helium tanks and George Flinchbaugh, WA8HDX, for the use of his farm.

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By Keith Pugh,* W5IU

SATELLITES

Artificially Propagating Signals Through Space

Back to the Basics

Once in a while it is good to go back and review the multi-faceted topic of amateur radio satellites and answer some of the many questions that come up over and over on the AMSAT nets, at hamfests, and at club meetings. I will try out a Question and Answer format to accomplish this communication. I can't ask and answer all of the questions heard over the years, but I will try to hit the most prominent ones. The answers are covered in the literature and in some cases contain my opinions. Naturally, there are several correct answers to some of these questions.

Q: Are amateur radio satellites new? How long have they been around?

A: The first amateur radio satellite was Orbiting Satellite Carrying Amateur Radio 1, or OSCAR-1. It was launched on December 12, 1961 from Vandenberg Air Force Base in California and circled the Earth transmitting the Morse code letters "HI" on the 2-meter amateur band. It was battery powered and transmitted until the batteries ran down. The speed of the Morse characters was proportional to the temperature of the satellite.

Q: How many amateur radio satellites have been launched? How many are still active?

A: At the present time, the OSCAR designation has been awarded to 61 satellites and the RS (Radiosputnik) designation to 18 that I know of. There have been numerous CUBEsats launched that achieved orbit; I estimate 21. This brings the grand total to 100. A score card is maintained on the AMSAT web page. As satellites come and go, approximately 12 are operational at any given time. This activity level has been maintained for several years now. In the beginning, we were lucky to have one at a time.

Q: Who builds the amateur radio satellites and how are they financed?

A: Amateur radio satellites are built primarily by volunteers for AMSAT organizations worldwide and by students at schools and universities. Most of the AMSAT "Birds" are financed by donations from individuals around the world. In many cases the donations are for products such as software, books, clothing, etc. In some cases donations, "in kind," of equipment, services, launch opportunities, and so on, have come from corporations, foundations, government agencies, and other groups. Many of the satellites built by schools and universities have been at least partially financed by education grants. We have long since left the period of the "free launch," so we must now raise all or a significant part of the money for our launches.

Q: Who controls the satellites? Must I have a separate license to operate on them?

A: By regulation, satellites are licensed in the country of their manufacture. The group that builds them generally maintains a command station or a network of command stations. Hams throughout the world regularly are asked for help gathering telemetry to aid the command stations and using agencies (school projects). Your amateur radio license is all of the authority you will need to work or use the satellites. Membership in the organizations that build and maintain the satellites is desirable but is not usually necessary.

Q: What is the minimum amount of equipment necessary to operate on satellites?

A: The absolute minimum is a dual-band FM HT covering the 2-meter and 70-cm bands. In general, you will need a receiver for the satellite downlink and a transmitter for the uplink. These can be separate units or combined within the same unit. The minimum antenna would be a long "rubber duckie." For some satellites, equipment that is capable of SSB and/or CW is necessary. There are also other specialized modes available.

Q: What about antennas? Is a large dish necessary?

A: In general, not even a small dish is necessary. Most of the current satellites have uplinks and downlinks on the 2-meter and 70-cm bands where conventional antennas are usable. For the LEO (Low Earth Orbit) satellites, omni-directional antennas can be used with success, particularly if a pre-amp is used on the receive side. Small Yagis are very beneficial; however, with any directive antenna comes the necessity to steer it in, at least, the azimuth dimension. As we go up in frequency, small dishes, helicals, loop Yagis, corner reflectors, Lindenblads, and patches are popular. For HEO (High Earth Orbit) satellites, higher gain antennas are necessary, along with the requirement to steer them in both azimuth and elevation.

Q: Okay, I'm hooked. What equipment would be necessary to form the basis of a good all-mode satellite station capable of using all of the "Birds?"

A: First you will need a good multimode transceiver capable of simultaneous operation on (at least) 2 meters and 70 cm. Two separate multimode transceivers for these bands can be used instead. Transceivers such as the ICOM IC-910H, Yaesu FT-847, and Kenwood TS-2000 will fill this requirement. Some

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of the newer generation multimode transceivers, such as the FT-817, can be utilized if two of them are used. Older multimode separates such as the IC-275 and IC-475 will fill the bill. Many other older radios such as the FT-726, FT-736, IC-970, and TS-790 can still be used as well; however, the capability to computer-control these radios varies and may not be as good as the current generation models. Some of these radios can be purchased with additional bands—for example, 1200 MHz can be included or "plugged in." A more versatile way to add other bands is to add out-board transverters or converters.

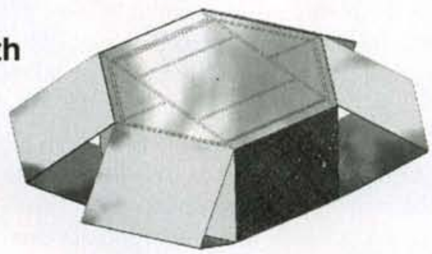
An antenna mount that is steer able in azimuth and elevation will be required. It should be of a size such that it can handle antennas for 2 meters, 70 cm, and various microwave bands, along with space for transverters, converters, mast-mounted pre-amps, power supplies, etc.

Also, don't forget quality transmission lines and connectors along with adequate weather proofing.

Q: Is a computer necessary to operate on the satellites? What software is required?

A: Years ago I always "hedged" on the first part of this question. Today I will say yes. The first thing you need a computer for is to predict when and where your satellite will be available to work. This can be done either with a good satellite tracking program in your computer or you can go to several online sites on the Internet. You can also get Keplerian data for your favorite satellites from the Internet.

Eagle is the next generation of High Earth Orbit satellites from AMSAT.



Join AMSAT and be a part of the team that is creating a new era in amateur satellite communications.

For information on becoming an AMSAT member and supporting ham radio in space, visit the AMSAT web site at www.amsat.org

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Second, a computer is very useful for automating a station. With proper interfacing, it can also control your antennas, compensate for Doppler shift, and do telemetry capture and decoding. Interface hardware and software is much more readily available than it was just a few years ago.

Q: What is the difference between LEO and HEO satellites and what are the characteristics of each?

A: Low Earth Orbit, or LEO, satellites are generally in circular orbits at altitudes ranging from 300 to 2000 km. Most often they are in polar, 90-degree inclination, or near polar orbit. Quite a few, including the ISS (International Space Station), are at inclination angles of 50 to 60 degrees. They make a large number of orbits (14 to 16) per day, of which you will see 4 to 10 in range of your QTH depending upon station latitude. Each pass will last for 7 to 20 minutes, depending upon satellite altitude and how close to an overhead pass you have.

High Earth Orbit, or HEO, satellites may be in circular orbits (GPS and geosynchronous satellites) or elliptical orbits, such as the Russian Molynia and variations of this one. The apogee (high altitude) part of the orbit may be 30,000 to 60,000 km) and the perigee (low altitude) part of the orbit is usually around 1000 to 1500 km. Amateur radio satellites such as AO-10, AO-13, and AO-40 were in this type of orbit and permitted operation for 8 to 10 hours a day and worldwide coverage. AMSAT's vision is to have continuous, worldwide coverage through satellites of this type by the year 2012. The Phase 3E satellite from Germany and the Eagle satellite from AMSAT-NA will fulfill this vision when they are launched in high enough numbers.

Q: Why can't I simply lock my antennas in place like my satellite TV dish and forget it? Will I ever be able to do this?

A: All of the current amateur radio satellites are in orbits such that they are constantly in motion relative to your QTH; therefore, your antennas must move. TV satellites are in a circular orbit over the equator at an altitude (32,000 km) such that they always maintain a fixed relationship to a point on the equator, and thus a constant pointing angle to your QTH. This special orbit is known as *geosynchronous.* Naturally, it is a popular orbit for commercial purposes. It is also relatively expensive to achieve and maintain. So far amateur radio has not been able to afford this orbit; however, there is hope that space in a geosynchronous satellite may be available at a reasonable cost in the near future as costs come down and excess space becomes available.

Summary

Operation on the amateur radio satellites has never been easier than or as affordable as it is now. Yes, it can be challenging, but it is well within the capabilities of most hams if they will just allow themselves to think about it. No, you don't have to be a rocket scientist to operate on amateur radio satellites. However, if you will simply allow yourself to keep an open mind and learn while using them, you may *become* a rocket scientist. If you think of additional questions you would like for me to answer, please contact me.

73, Keith, W5IU

By Dr. H. Paul Shuch,* N6TX

THE ORBITAL CLASSROOM

Furthering AMSAT's Mission Through Education

New AMSAT Lab Completes First "Satellite"

Where would you build a ham satellite? At the dawn of the Space Age, OSCARs 1 and 2, the very first amateur radio satellites, were lashed together in the garages of a handful of dedicated San Francisco Bay Area hams. The next few OSCARs went together in more professionally equipped commercial laboratories, thanks to the generosity (and, in some cases, the ignorance) of various amateurs' employers. Still later, universities and colleges became home to satellite construction efforts, a trend that continues to this day. Still, for its most ambitious projects, AMSAT has required a more formal Satellite Integration Facility to carry out the final phases of space hardware construction and testing. We've boasted two such facilities in our nearly three-decade history, the first in the famous fishbowl at the NASA Goddard Spaceflight Center in Maryland, and later, another in a hangar on the Orlando Executive Airport in Florida. Now, AMSAT satellite integration activities enjoy a new home.

As reported in a past column, AMSAT recently forged a productive partnership with the University of Maryland Eastern Shore (UMES), which resulted in our acquiring a spacious satellite lab. The arrangement is decidedly synergistic: AMSAT owns a clean-room large enough to house our biggest satellites, which had long been in storage in Florida, but with no place to set it up. UMES, on the other hand, occupies a large building a little south of Salisbury, Maryland, but with no clean-room to set up there. The agreement now in place allows UMES to house and use our clean-room for its satellite projects, on a non-interference basis with AMSAT activities. This clearly benefits us all.

But wait, there's more! If you order now, in addition to the full set of Ginsu knives, you also get this unprecedented educational partnership....

That's right. In the words of last winter's AMSAT press release: "The agreement with UMES calls for AMSAT-NA to work collaboratively with UMES to identify opportunities to work together on satellite and related technology projects as well as to work with their students and faculty to enhance hands-on studies and dissertation research. The possibility also exists for AMSAT-NA scientists and engineers to receive Adjunct status at the UMES." In other words, we now have not just a new landlord, but a new educational partner (hence, the inclusion of this item in the "Orbital Classroom" column).

Therefore, it happened that in January of 2007 three rented vans full of equipment were driven north from Orlando, to join up with half-a-dozen AMSAT volunteers at the new facility in Maryland. Our stated mission was to unload the trucks and start setting up our new lab. However, given a spacious new facility, who could resist the urge to throw a satellite together? Certainly not AMSAT!

*Director of Education, AMSAT
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<www.AMSAT.org>

Duct tape is like "The Force": It has a dark side and a light side, and it binds the universe together.

The inspiration for CoasterSat I came from the table amenities at the local restaurant where UMES and AMSAT volunteers gathered for dinner the evening before move-in day. Someone noticed that the square coasters upon which our (adult) beverages were place measured roughly ten centimeters on a side. "Hey, that's the size of a CubeSat," your author opined. Thus, the rather large die was cast.

Since no Jedi or AMSAT away-team ever goes anywhere without a roll of duct tape, it didn't take long for CoasterSat to take shape. Looking around the table for solar cells to line its exterior, our gaze fell upon a plethora of properly colored and appropriate-size artificial sweetener packets. A pair of 6-inch coffee stirrers resonated conveniently as a Vee antenna for 70 cm. Faster than you can say, "orbital insertion," a new AMSAT bird was born! The result can be seen in the accompanying photograph. Although CoasterSat may never pass its vibration and thermal-vacuum chamber tests, this project speaks to the innovative spirit fostered within AMSAT and embraced by our educational partners in Maryland.

Our next effort, integration of the most capable Eagle satellite, may take just a little longer. Nevertheless, with the support and assistance of our academic partners, we are well on our way into orbit. UMES's students gain hands-on experience. We gain new orbital assets, and maybe a few new hams along the way. Seems win-win to me. Clearly, "The Force" is with us. 73, Paul, N6TX

By Tomas Hood,* NW7US

PROPAGATION

The Science of Predicting VHF-and-Above Radio Conditions

It's Open Season for Meteors

This past August did you see the *Perseids* meteor shower? Did you work any of the meteor plasma trails on amateur radio VHF (6 or 2 meters)? I've seen many reports of moderate success for operators in various regions of the world during the 2007 *Perseids* season. Along with working meteors, a mix of tropospheric ducting often occurs in some regions, and I wonder if the two propagation modes ever combine. I'm interested in hearing from you if you've observed and worked such combinations of VHF propagation.

The 2007 autumn meteor season is open for DX hunters. While the *Perseids* meteor shower is one of the impressive yearly showers, partly due to the time of year in which it appears, the showers that will occur over the next few months are great rivals.

The Next Shower

One of the largest yearly meteor showers occurs during November. Appearing to radiate out of the constellation Leo from November 10 through November 23, the *Leonids* will peak on the night of November 17 and the early morning of November 18. This shower is known to create intense meteor bursts. Since the source of the *Leonids,* the Tempel-Tuttle comet, passed closest to the sun in February of 1998, the years following were expected to produce very strong displays. The greatest display since 1998 was the peak of 3,700 meteors per hour in 1999. Every year since then has been significantly less spectacular. However, a few (lonely) forecasters think that we still might have a meteor storm with an hourly rate of thousands of meteors sometime in the next several years. The more common forecast is that we'll only have a rate of about 15 meteors per hour.

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 down toward pre-dawn.

A Possible Meteor Storm in November?

Keep alert for the *a-Monocerotids* shower, which will occur from November 15 through November 25. The peak will occur on November 22 at 0310 UTC. Normally, this shower produces about five meteors per hour, but this year it may produce a burst as high as 400 per hour. The most recent big burst was in 1995 with a reported ZHR (zenith hourly rate) of about 420. It was expected that the ten-year cycle would result in a large storm in 2005, but that never occurred. That is why we should stand ready this year, as the cycle could be longer than anticipated.

Will this be the year of a return of the storm-level activity? If so, it will make the prospect for exciting meteor-shower radio propagation probable. We just cannot know for sure, since it takes a direct interaction with the comet dust trail by the Earth in order to see such a higher rate of meteors entering the atmosphere.

The chances of Earth hitting a dust trail that is so narrow and filamentary are slim. This has proven true for most meteor showers in recent years, when we have missed various meteor trails nearly completely. During these misses, Earth slips between the clouds, where there is only a sprinkling of meteoroids.

December and January Prospects

After November, the annual *Geminids* meteor shower from December 7 to December 17 will peak on December 14 at 1645 UTC. This is one of the better showers, since as many as 120 visual meteors per hour (ZHR) may occur. It is also one of the better showers for operators trying meteor-scatter propagation from positions in North America. The *Geminids* is a great shower for the meteor-scatter mode of propagation, since one doesn't have to wait until after midnight to catch this one. The radiant rises early, but the best operating time will be after midnight local time. 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, peaking on January 4. This meteor shower is above average, and this season peaks are expected at around 120 meteors per hour. The best day should be the morning of January 4, just after midnight, and working through predawn.

Check out the website <http://www. imo.net/calendar/ > for a complete calendar 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 some 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. The meteors 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

*P.O. Box 9, Stevensville, MT 59870
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been used to make successful radio contacts off these meteor trains.

Lower VHF frequencies are more stable, and contacts 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 time available—for example, 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 can be found at <http://www.amt.org/Meteor_Scatter/shelbys_welcome.htm>. Palle Preben-Hansen, OZ1RH, wrote "Working DX on a Dead 50 MHz Band Using Meteor Scatter," a great working guide at <http://www.uksmg.org/deadband.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>.

Autumn Outlook

Autumn (November through January) is a relatively quiet season, with very little if any TEP (transequatorial propagation). TEP, which tends to occur most often during the spring and fall, requires high solar activity that 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. 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, which is not everyone's cup of tea.

Since we're at the very end of solar Cycle 23, and possibly at the start of Cycle 24, aurora is very unlikely. 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.

The Solar Cycle Pulse

The observed sunspot numbers from July through September 2007 are 15.6, 9.9, and 4.8, respectively. The smoothed sunspot counts for January through March 2007 are 12.0, 11.6, and 10.8.

The monthly 10.7-cm (preliminary) numbers from July through September 2007 are 71.6, 69.2, and 67.1. The smoothed 10.7-cm radio flux numbers for January through March 2007 are 77.5, 76.9, and 76.0.

The smoothed planetary *A*-index (*Ap*) from January through March 2007 is all 8.4. The monthly readings from July through September 2007 are 8, 7, and 8.

The smoothed monthly sunspot numbers forecast for November 2007 through January 2008 are 20, 23, and 25, while the smoothed monthly 10.7-cm is predicted to be 77, 81, and 89 for the same period. Give or take about 12 points for all predictions. Notice that this indicates a rise that correlates with the start of solar Cycle 24. While predictions are for mid-2008 to be the official start of Cycle 24, the real figures and analysis indicates that Cycle 24 is under way.

(Note: 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. I look forward to hearing from you. You are also welcome to share your reports at my public forums at <http://hfradio.org/forums/>. Up-to-date propagation information is found at my propagation center at <http://prop.hfradio.org/> and via cell phone at <http://wap.hfradio.org/>. Until the next issue, happy weak-signal DXing.

73, de Tomas, NW7US

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By Dr. H. Paul Shuch,* N6TX

DR. SETI'S STARSHIP

Searching For The Ultimate DX

When Will We Reach India?

When, one well may ask, will SETI succeed? We've been at this business for about a half century now, searching for radio evidence of our cosmic companions, and so far without success. Is this an open-ended enterprise, or is success in our sights?

At the SETI Institute, our friend and colleague Seth Shostak (you may know him as radio amateur N6UDK) has been grappling with this question, and he proposed an answer. In 2004, he submitted an article to the prestigious scientific journal *Acta Astronautica* entitled "When Will We Detect the Extraterrestrials?" Not one to shrink from controversy, Seth hung it all out there by proposing a definitive answer: within 20 years.

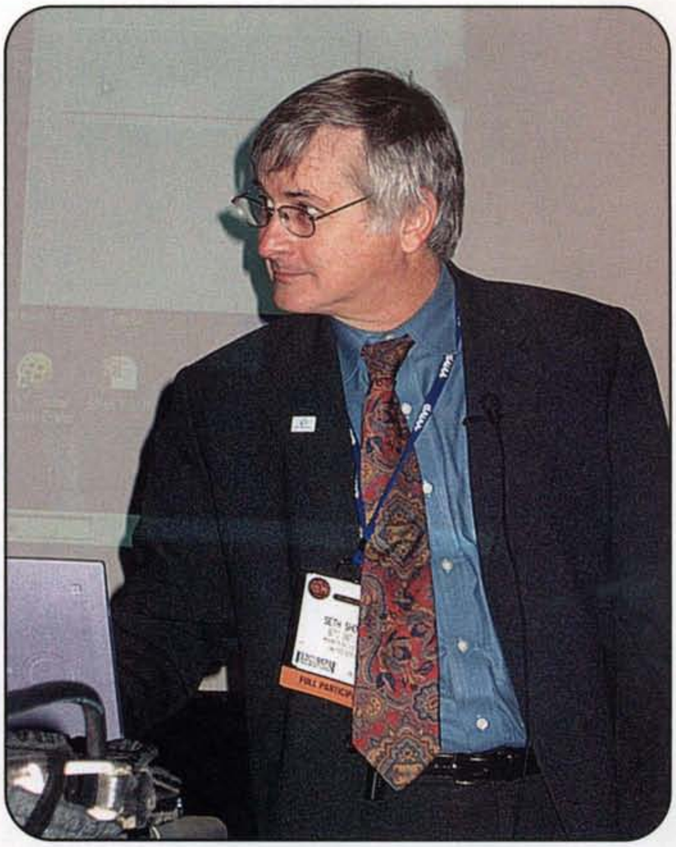
What led a respected scientist to take such a bold step, to go on record predicting SETI success within a single generation? Certainly, I'd never make such a prediction. (About a dozen years ago, I predicted 5,000 Project ARGUS stations would be online by the year 2000 ... and the actual number turned out to be just over a hundred.) No, I would have counseled caution, but Seth just had to go out there and make his numbers public. Did he pull his prediction out of a hat?

Hardly. What Dr. Shostak did, what we all do, is take the measure of the problem, state a set of assumptions, and attempt a plausible extrapolation from where we are now to where we need to arrive. Based upon his assumptions about the nature of ETI (which are just as valid as anyone else's), and his knowledge of technological trends (which is extensive, given his close involvement with the development of the Allen Telescope Array), he made a reasonable leap: At the rate our observational capacity is growing, if they're there and are like we think they are, we should have succeeded in detecting ETI by 2025.

You can quibble about the specific assumptions, but the methodology is sound. It reminds me of the prediction Christopher Columbus offered to Queen Isabella just as he was leaving port: "If our assumptions are correct, then I should reach India in sixty days."

Of course, Columbus never reached India. Instead, he bumped into a land mass the existence of which he had no reason to anticipate, no way to predict. Unwittingly, unknowingly, Columbus discovered the New World. Thus, I guess you'd have to call his quest a failure.

So too may the SETI enterprise end up a total failure. We may never pull that elusive radio beacon out of the aether. However, in trying, we are developing some incredible new technology, the very technology Seth considered in making his bold prediction. Also, no one can say what great new discoveries technology might enable, along the road to SETI success or failure.



At a recent International Astronautical Congress, Seth Shostak, N6UDK, sought to answer the question "When will we detect the extraterrestrials?" Seth chairs, and the author co-chairs, the SETI Permanent Study Group of the International Academy of Astronautics. (N6TX photo)

I find the title of Shostak's article especially interesting, because it underscores a paradigm shift that has occurred within his and my lifetime. In SETI science's formative days, the deeply held perception in scientific circles was that life on Earth is unique. Today, the overwhelming majority of experts envision a universe teeming with intelligent life, just waiting to be discovered. It is no wonder, then, that the article in question is entitled not "*Will* We Detect the Extraterrestrials?" but rather "*When?*" The existence of intelligent alien species is now accepted as a given. What remains to be determined is the *when* and the *where*. Seth Shostak has already made a guess as to the *when*, so I will now venture a prediction about *where*:

We won't find them in India, but rather in some previously unknown New World.

73, Paul, N6TX

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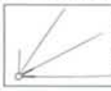

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