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Spring 2006

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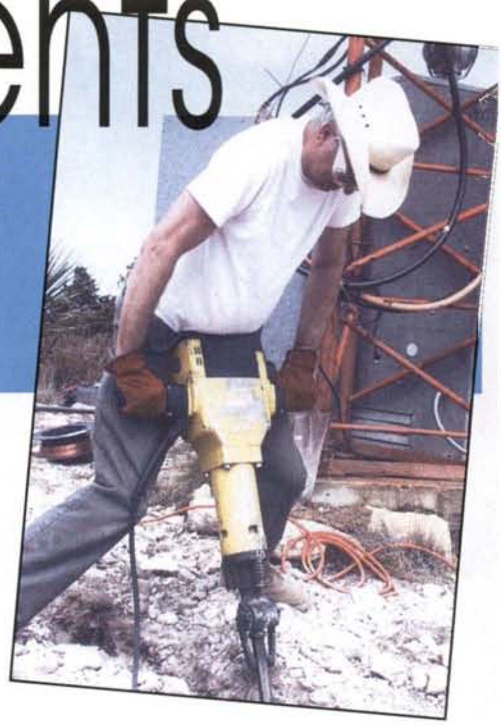

Spring 2006
Vol. 9 No. 1

FEATURES

COLUMNS

DEPARTMENTS

On The Cover: Rather than climb a mountain to get greater range on VHF, consider using a weather balloon to get the electronics aloft. In this photo WC5Z is shown with a "little" direction-finding antenna used to track the balloon. For details, see the story on page 8. (Photo by Bobette Doerrie, N5IS)

CQ VHF Ham Radio Above 50 MHz

LINE OF SIGHT

A Message from the Editor

Gordon West, WB6NOA, Ham of the Year

Gordon West, WB6NOA, *CQ VHF* magazine Features Editor, has been selected as the 2006 Dayton Hamvention® Ham of the Year. He will be honored later this month at the convention.

A licensed ham radio operator for more than 40 years, Gordo (as he prefers his friends call him) is best known for teaching ham radio classes and publishing study guides. An ARRL Certified Instructor and Instructor of the Year, Gordo has been responsible for thousands of amateur radio operators obtaining their licenses. He is also a Radio Club of America fellow.

Gordo has been teaching ham radio classes for nearly 40 years. In the 1980s, Gordo and his wife Suzy, N6GLF, began team teaching their classes under the name Gordon West Radio School. These classes include night and weekend sessions on college campuses, in county and city government buildings, and even at marinas. Wherever interested persons gather, be it 75 or 200, there is Gordo promoting the hobby. He also teaches classes for Commercial Radio operators, as well as providing free Technician Class amateur radio license training for youth and certified emergency responders for community emergency response teams (CERT).

Gordo also teaches ham radio classes annually for the Northern California Handiham Radio Camp. In addition, he volunteers with the American Red Cross communications team in Orange County, California. Commenting on these volunteer activities, Gordo says that it is his way of giving something back to a lifetime hobby that has meant so much to him.

Gordo has published hundreds of articles on amateur radio, commercial radio, and CB radio. At one time in the late 1970s, Gordo was the editor of *CB Magazine,* succeeding the late Leo Sands. A bit of trivia that Gordo doesn't remember is that once, while serving as editor of *CB Magazine,* he sent me a rejection letter.

The reverse has never been the case with me as the editor of *CQ VHF,* however. I am happy to have Gordo as one of the feature editors of this magazine. He has contributed at least 20 articles and shorts to *CQ VHF* since its rebirth four years ago at Dayton.

Gordo lives in Costa Mesa, California, where he has stations operational from 3.5 MHz to 10 GHz. A recent tornado, a rare occurrence in the area, damaged his towers and beams, but that hasn't deterred Gordo from spending at least a couple of hours a day encouraging new hams to get on the air via the many nets that he runs.

We at *CQ VHF* magazine join with scores of ham radio operators around the world in congratulating Gordo on this fine recognition of all that he has contributed to the survival and future of our hobby.

In This Issue

From bottoms to tops: From the bottom of the sunspot cycle to the top of the sky, this issue contains articles that appeal to both extremes of our niche in the hobby. Regarding the bottom of the sunspot cycle, Lance Collister, W7GJ, writes about the many considerations for a successful 6-meter EME station, concluding that it is not an impossibility for the average operator to be on the moon on this band. Also pertaining to the bottom of the sunspot cycle is the Propagation column by Tomas Hood, NW7US, who writes about the prediction that the next solar cycle will be a dandy.

Regarding the top of the sky, the husband-and-wife team of Jerome, K5IS, and Bobette, N5IS, Doerrie write about how to achieve a wider (albeit temporary) coverage of 2-meter communications from the relatively flat lands of the northern tip of the Texas panhandle by way of a surplus weather balloon. Also writing about the sky is Airborne Radio columnist Del Schier, K1UHF, who covers radio systems in model aircraft.

Going even higher in the sky, all the way up to the International Space Station, is Keith Pugh, W5IU, who writes about the first dual-orbit ARISS QSOs that took place in February and involved a school in Dale, Oklahoma on the first orbit and an elementary school in Dallas, Texas on the second orbit. Keith also covers the latest activities from space in his Satellites column.

Even higher up, Antennas columnist Kent Britain, WA5VJB, writes about constructing antennas for GPS receivers. Going into deep space is Paul Shuch, N6TX, who again covers the search for extraterrestrial intelligence. A bit closer to home is a new column that Paul is starting with this issue. Entitled The Orbital Classroom, in this column he explores ways in which amateur radio communications in space can be used educationally to encourage young people to become part of our hobby.

From the bottom to the top of the microwave bands is Steve Hicks, N5AC, who writes about bandswitching across the microwave spectrum while contesting as a rover. Also on top of the microwave bands is Gordon West, WB6NOA, who tells how to encourage the FM operator to consider operating on 10 GHz.

Speaking of contesting, Kevin Kaufhold, W9GKA, writes about the historical trends of *CQ* magazine sponsored VHF contests. The statistical model that he uses is detailed in a paper entitled "A Statistical Model of VHF Contest Activity," to be published in the 2006 Conference *Proceedings* of the Central States VHF Society.

Somewhere in the middle of the VHF spectrum is Joe Moell, KØOV, who writes in his Homing In column about pulsed emitters near 220 MHz. Speaking of homing in, Joe recently announced that the OH-KY-IN Amateur Radio Society is conducting a special hidden-transmitter hunt championship for blind and visually impaired persons during the Dayton Hamvention®. For more information on this unique T-hunt visit the website <http://www.ardfusa.com/>.

Speaking of the bottom, this time meaning the ground, Larry Higgins, W5EX, and Joe Jankowski, W5KTX, tell how to get a good ground in rocky soil by literally connecting wires to rocks. When it comes to getting a good earth ground in the boonies, there is no more pounding rocks for these two hams.

Regarding far-out digital communications, HSMM columnist John Champa, K8OCL, tells of the 6-meter experiment now under way that pertains to the long-range transmission of digital data on that band. Also pertaining to digital communications, ICOM's Amateur and Receiver Products Division Manager, Ray Novak, N9JA, reveals how D-STAR was used successfully by the US Army and FEMA in field tests earlier this year.

There you have it: From top to bottom and from cover to cover, in your hands is another great edition of the magazine with the best coverage of our niche in the wonderful hobby of amateur radio. Perhaps the next issue will contain a contribution from you. If so, I look forward to receiving your query about writing for *CQ VHF* magazine.

Until the next issue...

73 de Joe, N6CL

Considerations for Successful 6-Meter EME DXpeditions

As the bottom of the sunspot cycle nears, faithful 6-meter DXers seemingly are stalled in their quest to increase their countries worked totals. The only way around this dilemma is via EME. W7GJ tells how to make those EME QSOs happen on the Magic Band.

By Lance Collister,* W7GJ

Until only a few years ago, the prospects of using the moon to complete a 6-meter contact with a rare DXpedition or portable station were extremely remote. However, the increased sensitivity of the recently developed JT65 digital modes by K1JT greatly enhances the viability of such "Ultra Long Path" contacts. It is assumed that JT65A mode will be a key element to success in any 6-meter EME DXpedition, and also that interested 6-meter EME operators are already familiar with this mode. The standard mode for communications on 6-meter EME has become JT65A, which is the most sensitive of the JT65 modes. Detailed instructions of how to effectively use the WSJT software for JT65A EME contacts are available elsewhere and will not be covered here. New JT65 users are urged to review the following sites:

<http://www.bigskyspaces.com/w7gj/JT65checklist.htm>
<http://pulsar.princeton.edu/~joe/K1JT/Documentation.htm>

Our current time near the bottom of the solar cycle is the optimum time for 6-meter EME, and the amount of activity on it has been increasing dramatically. Remember that an EME station with a larger antenna essentially "makes up for" a smaller antenna on the DXpedition end of the circuit. Therefore, the increasing number of larger home stations (both with and without elevation) greatly increases the chances for success by a smaller DXpedition station, provided certain considerations are addressed well in advance. In fact, the portable 6-meter EME station now can probably fill up as much time as is desired on EME contacts, within the constraints of available moon time.

This is by no means to suggest that 6-meter EME is commonplace or trivial. In fact, nothing could be further from the truth! Six meters remains one of the most difficult bands on which to operate moonbounce, and the situation is exacerbated by the fact that 50 MHz signals are high enough in frequency to be affected by tropospheric ducting and low enough to be adversely affected by just about any kind of perturbation in the ionosphere. Of course, too, even when conditions are most favorable for EME, you always run the risk that Faraday rotation will change the polarity so that one (or both) stations will not be able to copy the other! This polarization shift is what makes it very rare for two stations to be copying each other at the same time, and is the reason why EME schedules are often so long—to permit each station to have a chance to exchange required contact information with the other.

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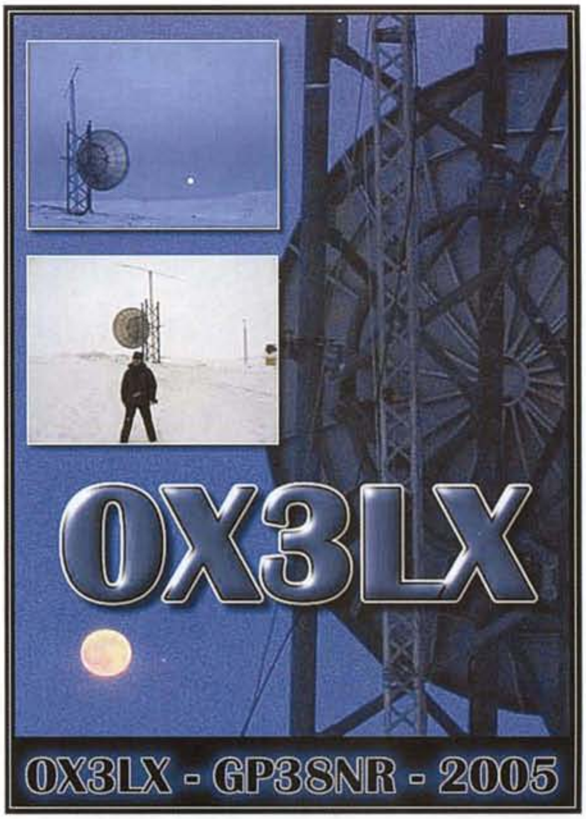


M^2 6M7 antenna at OX3LX, March 2005. (Photo courtesy of OZ1DJJ)

Certainly, if you are a DXpeditioner strictly interested in the number of contacts with the simplest equipment, HF is a much more attractive option. However, if you enjoy the challenge as well as the reward in overcoming the odds and completing contacts by sending signals 3/4 million kilometers, then you are just the type of DXer for 6-meter EME! I have always thought of EME DXing as having much in common with fly fishing. If your primary interest is to obtain a large number of fish, you could drive to the fish market. However, if you are more interested in relying on yourself, in a way that will require all your skill and cunning, then fly fishing will be more thrilling and rewarding—even if some get away! Like fly fishing, it is the challenge of the adventure and the process–plus the thrill of actually landing one—that makes it so rewarding!

Six-meter EME array at W7GJ (4 × M^2 6M9KHW fed with $1^5/_8$-inch heliax).

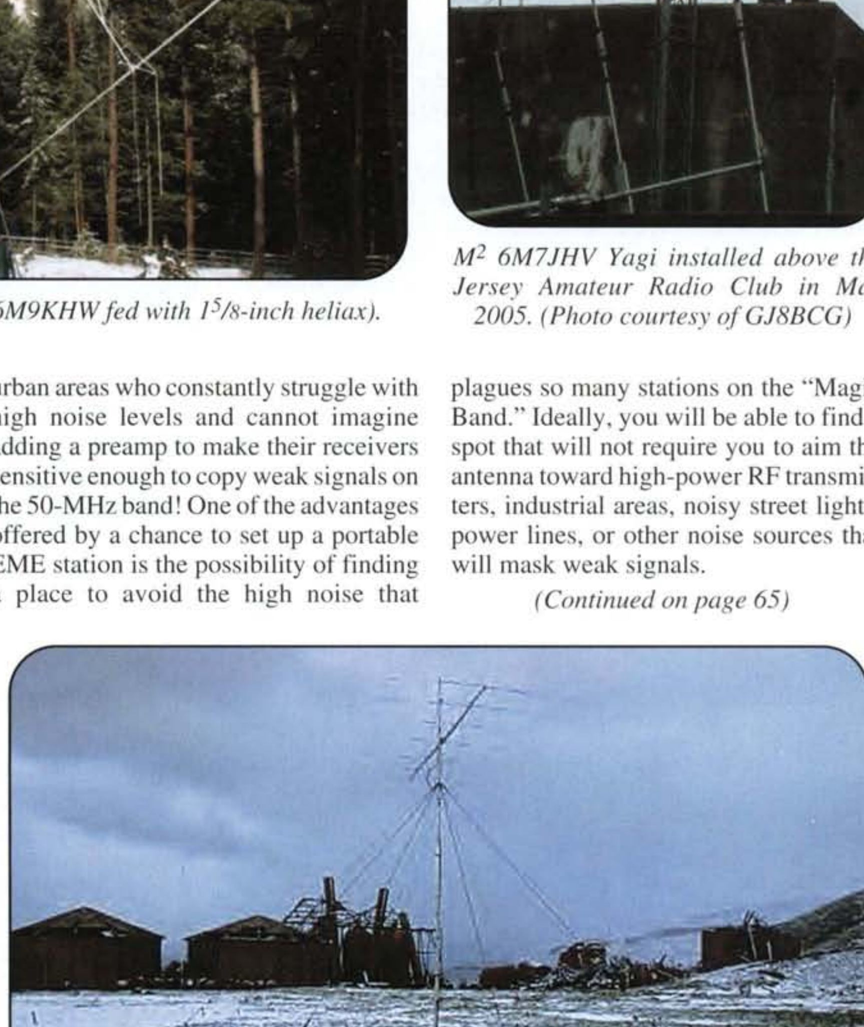
M^2 6M7JHV Yagi installed above the Jersey Amateur Radio Club in May 2005. (Photo courtesy of GJ8BCG)

There are a number of different approaches that can be used by a successful 6-meter DXpedition station, and it is not my intent here to attempt to prescribe any single protocol that has emerged as being most successful. Because this is such a new aspect of 6-meter DXing, we are all learning from the experience of each DX operation. However, there are definitely certain subject areas which will need to be considered prior to embarking on a successful DXpedition, and I hope to discuss a few of these elements that are particularly relevant to 6-meter moonbounce in order to assist stations thinking about preparing for 6-meter DXpeditions. I also will suggest some possible operating options that have come to light through recent 6-meter EME DXpeditions that might be used to increase effectiveness during future operations.

Planning

Certainly, the first thing to consider when you are selecting a location to set up for a 6-meter EME DXpedition is to find a good quiet location. For most of us, the local noise that surrounds us where we live is something beyond our control. There are many people who live in urban areas who constantly struggle with high noise levels and cannot imagine adding a preamp to make their receivers sensitive enough to copy weak signals on the 50-MHz band! One of the advantages offered by a chance to set up a portable EME station is the possibility of finding a place to avoid the high noise that plagues so many stations on the "Magic Band." Ideally, you will be able to find a spot that will not require you to aim the antenna toward high-power RF transmitters, industrial areas, noisy street lights, power lines, or other noise sources that will mask weak signals.

(Continued on page 65)



FT5XO 6-meter antenna (M^2 6M7NAN "Trip Yagi"), March 2005. (Photo courtesy of W7EW)

Greater Range at 100,000 Feet

"To get greater range on VHF, get your antennas higher. Go climb a mountain." —*The Old Timer*

By Jerome,* K5IS, and Bobette,† N5IS, Doerrie

There's not much in the way of mountains on the high plains of the Texas and Oklahoma panhandles. The local weak-signal operators joke about the interstate overpasses being 20-dB hills.

The ARRL Antenna Book lists the formula for line-of-sight radio horizon as D (miles) = 1.415 times the square root of the antenna height in feet. An altitude of 10,000 feet yields a range of 142 miles.

We considered erecting a 10,000 foot tower, but quickly discarded that idea. A small private airplane could easily reach this altitude and would be much cheaper than the tower. We have operated radios from the back seat of an airplane in spite of the engine noise. We knew there had to be a better way, though.

Operating on the summit of one of the 14,000 foot mountains in Colorado gives a similar communications range. However, weather factors cause operator discomfort.

If radios can be carried to 100,000 feet, the range becomes 447 miles, providing the possibility of stations 800 miles apart being able to communicate for a few minutes. Placing the antenna and radio equipment at 100,000 feet over Booker (northeast corner of the Texas panhandle), the communications range could reach hams near Dallas, Albuquerque, Denver, and Kansas City. The challenge becomes one of how to climb to 100,000 feet and still maintain operator comfort.

The solution: Use a weather balloon to carry the electronics aloft.

In the fall of 1992, Bobette, a high school physics teacher, started the Perryton High School Reach for Space program as an enrichment project for her science students. Our first balloon flight was in the spring of 1993. In this article we describe some of our experiences and tell what we have learned over the past 13 years from flying "weather" balloons up into the thin air of near space.

First We Thought We Needed Balloons

It began when Bobette attended a presentation on remote sensing at the state science teachers conference. A contest called SkyView, sponsored by the Texas Space Grant Consortium, involved taking pictures from a platform in the air—either a balloon or a kite. It had obvious amateur radio applications, because the camera probably would need radio signals to trigger it.

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Photo A. It takes a committee to prepare the payload, especially when there are problems. (All photos courtesy the authors)

In 1992 at a hamfest in Amarillo, Texas, we found a surplus dealer with a case of weather balloons. A deal was made and we had balloons. We knew nothing about lift capacity, ascent rates, burst altitude, tracking, recovery, amounts of helium needed, regulations, or the effect of age on latex balloons. We had balloons and we began our journey on the learning curve.

At that time, published information on the subject was very difficult to find. Bill Brown, WB8ELK, was encouraging ATV interest groups to use balloons as a platform for television repeaters. Details of various first flights were featured in his *73 Magazine* ATV column. We read several of the articles and decided we were ready to fly.

On a Saturday in March 1993, painter's drop cloths were spread on the floor of the auto shop at Perryton High School. Payload pieces were assembled in a Styrofoam™ picnic cooler. Balltrack (DOS version) was running on a computer. A Samsung 35-mm camera was taking pictures of shoe laces every three minutes. In addition, a label with our contact information and offer of a reward if the payload was found by someone else was taped to the cooler.

The balloon, a surplus 1400-gram Kaysam, was getting larger and larger as it filled with helium. We thus thought it would be a good idea to finish the filling process outside. There is something about helium filling a balloon that just seems to cause wind to appear. It's magic! In this case, as the balloon was inflating some wind started spinning our balloon around and around, twisting the neck tight. The helium had to be shut off and the balloon untwisted.

After a few minutes, which seemed like forever, the balloon was fully inflated. While we were attaching the payload to the balloon at the neck, the balloon envelope broke free, flying about as if it were an escaped bird. The payload stayed behind for us to stumble over.

From this initial experience we learned two lessons:

Lesson 1: *Don't start the camera until just before liftoff.*

Lesson 2: *Have extra helium on hand.* We had more balloons, but were out of helium.

With having learned these lessons, we were now initiated into the Fraternal Order of Ham Balloonists!

It was the same song, second verse when preparations were under way for launch in July. Again we used the school's auto shop, but this time because of strong surface wind gusts we finished filling the balloon inside. When we took the balloon outside, we had difficulty clearing the building and vehicles before releasing the balloon.

The sight of the ascending balloon and payload was beautiful and enhanced by the shouts of joy from the launch team. The Balltrack predictions indicated the flight would start out to the northeast and then loop back around and travel 100 miles west in six hours. We thought we had lots of time, so we let our attention wander from the balloon, and 93 minutes into the flight the beacon signals vanished.

Here is where we learned five more lessons:

Lesson 3: *The trackers' attention should be on the balloon position at all times.* We had to run a newspaper article entitled "Lost, One Really Ugly Balloon." Thirty days later we retrieved the balloon. We got lucky, and some boys riding dirt bikes in a pasture 17 miles northwest of Perryton found the remains and called us.

Lesson 4: *Use better packaging than Styrofoam™ picnic coolers.* On the way down, the payload hit a boulder and the contents inside shot upward, bursting through the lid. The crystal came out of the socket, causing the 2-watt 146.52-MHz transmitter to cease operation. Ironically, even after 30 days in the rain and sun the transmitter worked when another crystal was plugged in!

Incidentally, chase team members had driven within a mile and a half of the parachute and payload looking for it. The videotape of the launch shows someone grabbing the balloon with a pinch grip to prevent the balloon from hitting a vehicle.

Lesson 5: *Handle balloons gently.* The Kaysam balloon has an initial thickness of 0.0035 inch and at burst altitude it will be approximately 0.0001 inch. We wear soft brown cotton or surgical gloves while working with the balloon to protect the fragile surface.

Lesson 6: *Have plenty of line between sections of the payload.* We often use six feet or more to prevent tangling, as apparently happened in the second flight. A payload without an open parachute can hit the ground at over 100 mph! This leads us to the next lesson. . . .

Lesson 7: *Use a hoop on the parachute lines to help keep the lines from tangling and the chute open.*

At about this time all of the balloon enthusiasts were working on the same basic problems: payload components, selection of power sources, tracking, pay-

(Continued on page 72)

Photo B. Filling the balloon is a group effort—one person to control the helium, one to be sure the balloon doesn't twist, and at least two to keep the balloon upright.

Photo C. Tying off the balloon is an art, and it takes more than one person to do it.

Bandswitching for Multi-band Rover Contesting

Microwave contesting presents many unique challenges. In this article N5AC covers how he met his challenges.

By Steve Hicks,* N5AC

In a microwave contest, there are usually two key types of participants: the fixed stations and the rovers. The fixed stations operate from their homes, a club station, or perhaps even a portable location, while the rovers drive from grid square to grid square making contacts. Without a tower in the yard and with a love of driving, I decided early on that roving was for me. However, constructing a rover station presents a unique set of challenges.

Anyone who has been roving with a microwave station during a contest will tell you there are so many little things you have get right, that anything you can do to simplify your life is probably worth the effort. All of the difficulties are exacerbated by some contest rules that limit roving operations to two amateurs. Imagine getting a group of transverters, an IF rig, and all of the interconnect hardware to work, mounting antennas on a car (or having to assemble each time you stop on a hill), driving, logging, and navigating for 24–27 hours with only two people!

Since every rover configuration and situation is different (everyone has their own goals and a unique set of radios and configuration preferences), it doesn't make a lot of sense to "cookbook" explain how to construct a rover station. There are, however, some key components that every rover station needs, and the ability to control radios is a key one.

On my first roving trip before constructing any control hardware, I met up with Greg Jurrens, WDØACD, in south Texas. We had several beams and were operating on 6 meters, 2 meters, 440 MHz, and 1296 MHz, all with commercial amateur gear. Our beams were long and required assembly; some of the booms were in multiple sections. We had to setup on the side of the road when we were ready to operate. We quickly realized that manually switching the radio to different antennas was a lot of trouble and that there were probably a lot better ways to accomplish this (never mind actually assembling the antennas on the side of the road).

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Photo 1. Four surplus 6-pole SMA relays.

After building my first couple of transverters, I was looking for a way to control everything in my truck with only minimal effort required to switch bands. More important, I'm rather absent minded, and I knew that if I didn't make it fairly foolproof, it wouldn't be long before I was transmitting through a preamp or into piece of coax with no attached antenna. The control Holy Grail was a way to push-button switch between all bands. I decided I needed to build something that would control everything and be simple and foolproof. During a contest the obvious time advantage of being able to push-button switch bands made this project a top priority.

Craig, KA5BOU, an avid microwave and weak-signal enthusiast, had met up with me at Microwave Update 2004 and recommended that I buy a few of those 28-volt SMA coax relays that are so readily available and shown in photo 1. If I had a way to control them and switch my IF rig between each of my transverters while I drove down the road, roving would be much easier. I mounted a few beams on the truck (2 meters, 440, 902 and 1296 MHz to start) and mounted all of my transverters on a piece of polypropylene as shown in photo 2, along with a transverter interface box (TIB) from Down East Microwave (http://www.downeastmicrowave.com).

The TIB accomplishes a few key functions. The first is to switch the IF rig between a transverter and an antenna. This allows the IF rig to transmit 144 MHz directly to an antenna when switched off, and when switched on, it redirects the RF to the transverter. This is critical if you intend to also use your IF rig as a 2-meter radio during a contest. The TIB also keys the transverter when it sees PTT from the IF rig and the TIB is on (transverter in operation). The final function of the TIB is to provide a negative ALC voltage to the IF rig to turn down the power into the transverter when the transverter is in use. By doing this, a 50-watt IF rig can operate at full power when transmitting directly on 144 MHz, and at reduced power I use 2 watts when transmitting into the transverter without changing any settings on the front panel of the rig.

In my case, I had a number of transverters, so they all needed to be switched to the TIB IF output when they were in use. For this needed a single-pole, multi-throw RF switch.

While I was pondering how to make everything work, I came across an old Fluke 1780A info touch monitor I had bought at a surplus sale. This device is simply a VT100 emulator (a dumb terminal) that also has a capacitive touch screen (see photo 3). The touch screen sends ANSI escape sequences back to the device to which it is connected via RS-232. I decided I would try hooking this up to a BASIC stamp that I had bought to play with. After playing around a little, I quickly realized that I had a powerful combination for controlling my station! I could use the touch screen to select bands that should be connected to the IF rig, and my 28-volt relays would accomplish everything in the background.

I've been asked why I didn't use a computer for the display, and there are two key reasons: My main reason is that my initial thought was to have an "appliance" that is switched on and ready to go, as opposed to something that has to be booted up. The second is that I intended to use this rig primarily for contesting and during roving. With a computer for navigation and logging, I really didn't want to keep two computers running at the same time. Neither of these is a serious objection, and a computer is a very viable alternative to what I've done here.

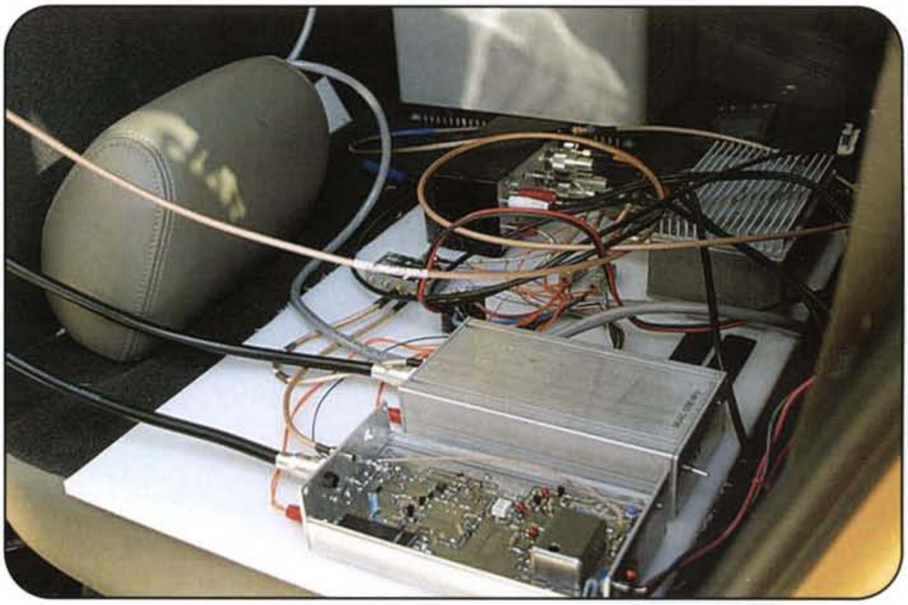

Photo 2. My initial manually switchable transverter arrangement.

Rudimentary Control

I started with a simple configuration and used a 2N2222 from the microcontroller to switch a relay between charging a capacitor with 12 volts and then placing it in line with the battery voltage (also 12 volts) to switch the relay. This is a common configuration I have seen used several times, and it uses an initial pulse of a higher voltage to switch a coax relay and then uses the sustained 12 volts to hold the relay in the correct position. This would eliminate the need for a 28-volt supply. I have also seen a number of 12-volt relays, so if you have one of these, the 28-volt circuit would not be necessary. All of this worked beautifully, and I was able to change the position of the coax relay programmatically.

I connected the center pole of the coax relay to the IF rig (actually the transverter output of the TIB), and then each of the positions on the relay were connected to each transverter. This took care of the RF switching, but generally PTT switching is also required, since the transverters also need PTT.

Initially, I was using the PTT output from the radio to directly control the transverters, and I was keying all of the transverters at the same time. This has advantages—namely that the receiver in the transverter is not exposed to the power coupled between the current transmitting antenna and the not-in-use receive antenna. However, it also has a disadvantage:

(Continued on page 78)

Photo 3. the Fluke 1780A touch-screen terminal under program control.

Connecting Wires to Rocks

One of the most important aspects of the fixed station is grounding. What happens when your station is surrounded by rocky soil or rocks? Here W5EX and W5KTX tell how they solved the problem.

By Larry Higgins,* W5EX, and Joe Jankowski, P.E.,* W5KTX

Have you ever tried to drive an 8-ft. ground into rocky soil—or into solid rock? Many of us have experienced the smarting pain as the hammer handle smacks the hands. Have you seen a ground rod go in for a while, only to make a 180-degree turn and reappear behind you? Maybe it was hilarious at the time, but it is hardly a useful electrical connection!

There is a solution to this problem, but one that is not well known. One of us (J.J.) recently received a short paper from Utah, wherein the authors used a *bentonite* slurry to encase a ground rod, thus expanding the electrical diameter of the rod.[1] References to this article brought us to others, one American,[2] the other Slavic.[3] From this review we learned of the superiority of this natural clay, which contains the mineral montmorillonite, as an adjunct to grounding at sites with poor soil conductivity.

Bentonite

A quick visit to the internet reveals hundreds of references to this widely used material of volcanic origin. It is used in the mining of oil, metal casting, pelletizing, grouting and sealing, and as a base for cosmetics. Aluminum and silicon form the metallic crystalline structure. With water added, ionization of the resident oxides of sodium, potassium, and calcium occurs, forming an alkaline electrolyte. Resistivity falls quite low—~250 ohm-cm at 300% moisture—at which point it swells up to 13 times its dry volume. This striking sponge-like "hygroscopic" property makes the material unique. Unlike ground-enhancing electrolyte solutions, there is no leaching out over time, and thus no replenishment with pricey patented chemicals is required. The material is non-corrosive. It is very sticky when wet and adheres tightly to any adjacent surface.

Let's Try Bentonite and See if it Works!

We examined two west Texas radio sites, the first located on a mesa near Ft. Stockton, the second on a low mountaintop near Sanderson. Both sites have a solid-limestone rocky base. Ft. Stockton has some sandy soil cover sufficient to support several species of cactus, some junipers, and a little grass; the Sanderson site is bare rock. The radio towers are sited on con-

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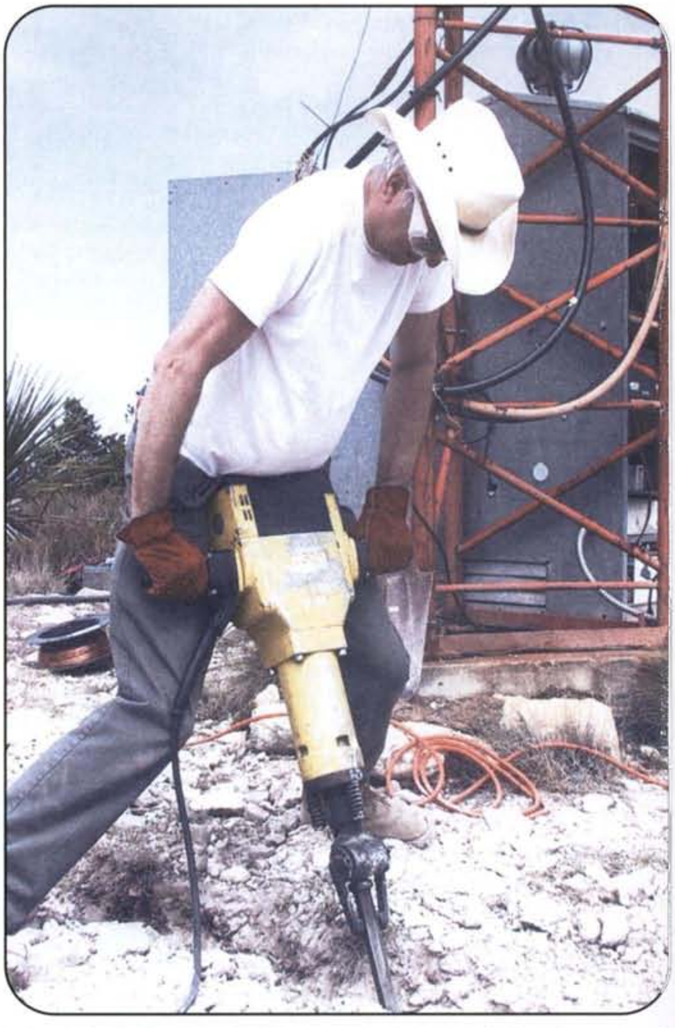


Photo 1. Mike, KD5FVZ, gouges the trench for the ground system. Note tower base and our tiny radio shack in the background.

crete bases; guy wires are attached to rods set in concrete shafts drilled at appropriate angles into solid rock. Average resistivity for gravel, sand stones with little clay or loam is about 10^5 ohm-cm; bedrock, 10^6 ohm-cm.[4]

The Ft. Stockton grounding system consists of a web of six 5/8-inch copper-clad grounding rods, driven to stop depth, on the average <3.5 ft., connected together with #6 solid-copper

Photo 2. Shallow trench with 8' × 5/8" copper-clad ground rod propped up 4 inches.

Photo 3. Greg, K5DRT, and Mike, KD5FVZ, mix bentonite with water. The hose is connected to a 55-gallon drum that we hauled to the mountaintop.

wire, then brought to a single grounding point within the radio shack. A 170-ft. guyed tower is connected to the loop via a bi-metallic clamp. Where possible, we drove the ground rods tangent to the roots of the juniper bushes in order to maximize rod depth. All rods were separated at a distance >2× their length and surround three sides of a small radio shack.

To create the Sanderson site grounding system we cut an 8" × 8" × 9' trench into the rock (photo 1). One 8' × 5/8" copper-clad steel ground rod was propped 4 inches above the base of the trench (photo 2). We mixed 100 lb. of bentonite powder with 50 gallons of water in a bin and then transferred the slurry into the trench (photo 3). Two 3-inch solar-panel mounts; a steel battery box mounted on a 4-inch pipe, cemented 2 ft. into the ground; and an 80-ft. guyed steel tower were connected to this rod and then to a common grounding point at a small sheet-metal shelter sited near the tower base. The shack is not otherwise grounded—as with attaching stakes, etc.

We borrowed the recently introduced AEMC Model 3731[5] ground-resistance tester for all measurements. These instruments inductively inject a 2.403-kHz signal into the grounding conductor under test and then measure the resulting current. Sixty Hz and extraneous noise are filtered out. The resistance of the ground reduces the resulting return signal current. Since the injected level is known, the resistance to ground follows from Ohm's Law.

Bentonite Really Works!

We measured resistances one month after completing the Sanderson grounding system, and four months after completion of the Ft. Stockton installation (photo 4). There had been a fairly heavy rain at both sites the night before. There were shallow puddles on the access roads to both sites. The exposed bentonite was very soft and mushy. Photos 5A and 5B compare the measured resistance of our grounding system (A) and the existing utility-pole ground wire (B). Table 1 summarizes our findings to date.

Discussion

From the data we achieved an excellent grounding system at both sites. Ground resistance should not exceed 25 ohms for residential or lower powered facilities (NEC Article 250, cited in ref. 4, pp. 2–5); for defense communications 10 ohms is the goal (op. cit.). Because of our extreme vulnerability to lightning, we strive for resistance <1 ohm. As can be seen from the preliminary results in Table 1, our grounds are 10× better than the DOD target values. Furthermore, at a site where driving rods, even for a few feet, is impossible, it would appear that the application of bentonite is very effective. At the more favorable desert environment at Ft. Stockton, multiple ground rods, separated at a distance >2× the length of the rod, seem to be equally usable. We feel that we have achieved an excellent grounding system at both sites.

Grounds at power poles may be less good, because they are often drilled into solid rock. Typically, the utility installs a "butt plate" before setting the pole. This butt plate is connected to the neutral/grounding conductor with AWG 6 solid-copper down lead. This is done at each pole in a distribution line. However, if the poles are set in high-resistivity and/or rocky soil, the effect depends on a large number of poles to achieve the 25 ohms or less acceptable to the utility.

To be fair, we must make further measurements late in the long hot summer, when the earth is drier. We would expect a greater increase in grounding system resistance at the Ft. Stockton site, where-

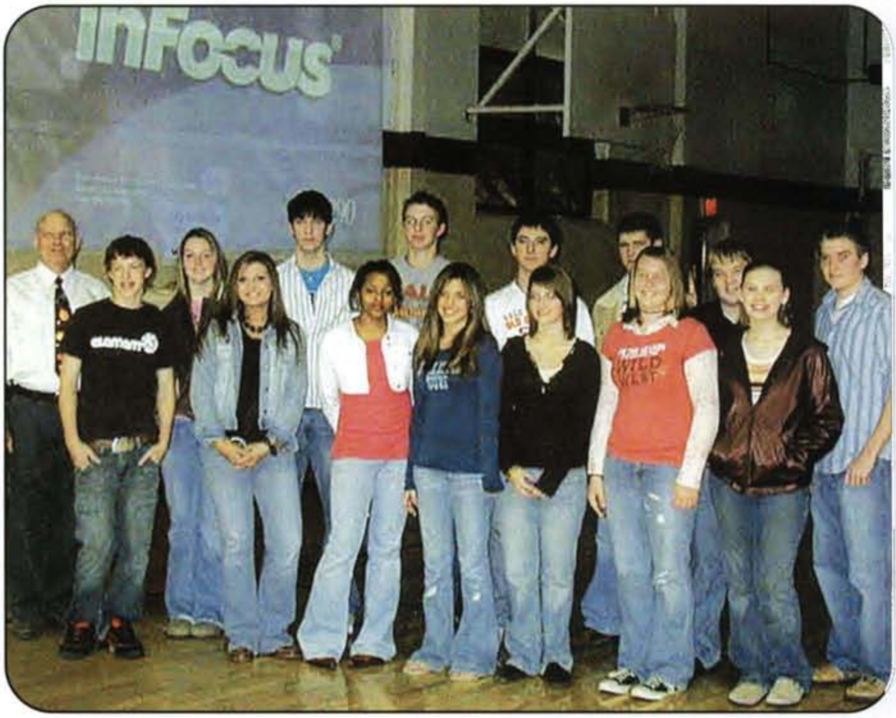
(Continued on page 76)

First "Back to Back" ARISS Contacts

Students at the Dale High School in Dale, OK, and at the DeGolyer Elementary School in Dallas, TX, made the first scheduled contacts on successive orbits with Bill McArthur, KC5ACR, during Expedition 12 to the International Space Station. Here is the story.

By Keith Pugh,* W5IU

On 7 February 2006 at 1456 UTC, students at Dale High School in Dale, OK, made a successful contact with Bill McArthur on board the ISS. One orbit later, at 1632 UTC, DeGolyer Elementary School in Dallas, TX, also made a successful contact with the ISS. These two schools are approximately 172 miles apart with Dale almost due north of Dallas. Thus, students in both schools were able to hear all of their own contact and most of the other school's contact as well. Much to the dismay of the "Texans," the "Oakies" are now claiming that "Oklahoma is Number One," since the Dale contact was first.



The first "back to back" ARISS QSOs took place on the morning of 7 February 2006. The first of the two QSOs was with the Dale, OK, public schools. Shown here are the Dale High School ninth grade scrince students with teacgher Gary Burkhart (left). (Photo courtesy of Coy Day, N5OK)

The Schools

Dale High School, Dale, OK. Several years ago, while driving home from a radio club meeting, Justin Cochrane asked his grandfather, Ron Cochrane, KD5GEZ, if students at his school could talk to the astronauts as had the students described in the evening's program. Ron replied that they could try. At the time, Justin was still in elementary school, so an application was made to ARISS for the J. D. Jackson Elementary School in Dale, OK, a small rural community about 30 miles east of Oklahoma City, OK.

Between the time of the application and the time of the scheduled contact, Justin moved on to Dale High School. All of the students who directly participated in the contact were Justin's classmates and had moved along with him. Since all of the Dale, OK, schools are located on a common campus, the contact actually became a project of the Dale Public Schools, and 500 of the 700-plus students were able to attend the contact conducted in the gymnasium. Gary Burkhart, a Dale science teacher, coordinated the students' questions and arrangements within the school. Ron Cochrane, a Dale High School graduate, was the radio contact coordinator, and he prepared the crowd by giving an excellent presentation on amateur radio and the space program. Justin and his father were members of the team, along with Ron and yours truly, that installed the antennas and the rest of the station equipment for the contact on the high school roof and in the gymnasium.

A high noise level (that hadn't been present during station check out) plagued the first 30 seconds of the contact. The rest of the 20-degree elevation pass went off without a hitch. All of the students were able to ask at least one of their questions. As usual, Bill McArthur on board the ISS did an excellent job of answering the questions.

Approximately 87 minutes after loss of signal for the Dale contact, the Dale students were able to hear Bill's answers to the DeGolyer students' questions. The original Dale crowd of 500 had to go back to class, but Justin's classmates who asked the Dale questions were able to come back and read the DeGolyer questions for the remaining Dale crowd during the DeGolyer contact. What a unique opportunity!

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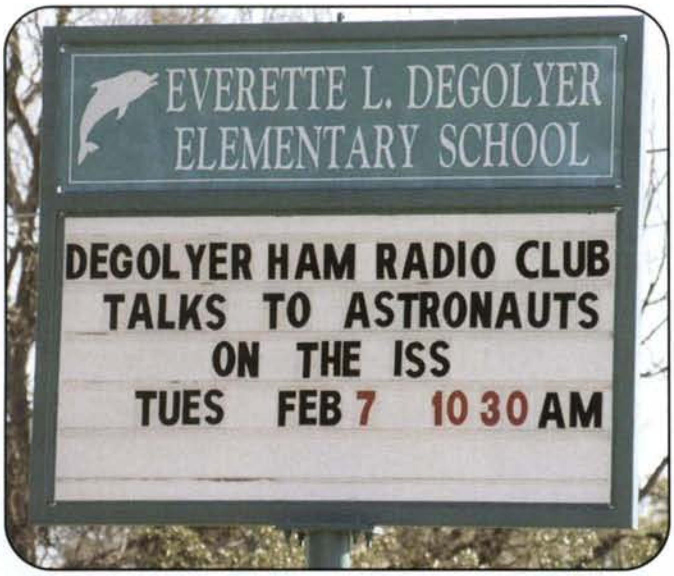
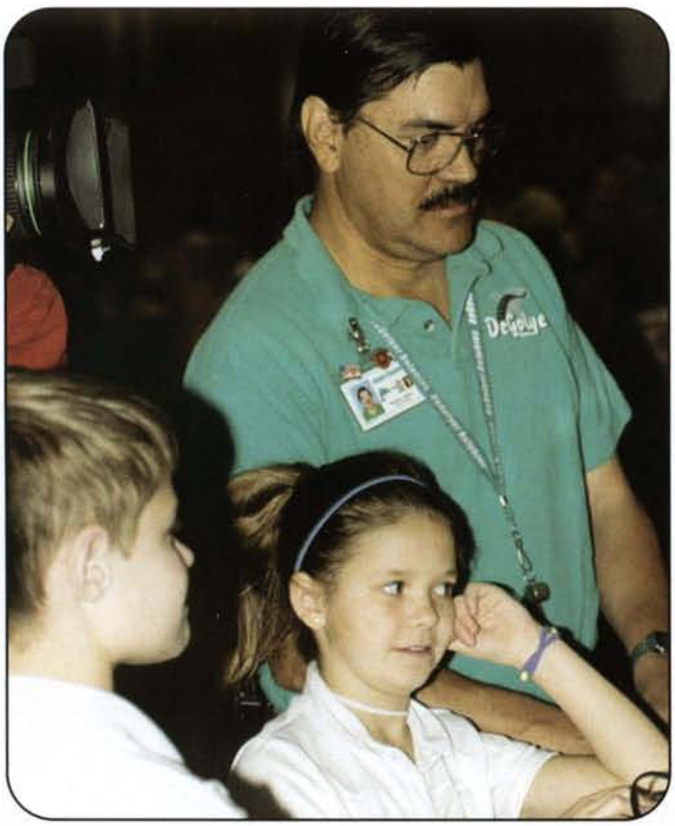


The billboard at DeGolyer Elementary School, in Dallas mades sure that the neighborhood knew what all the fuss (extra traffic, news media vehicles, Dallas Police Department vehicles) was all about. Hams at K5DES prepared to talk directly with Bill McArthur, KC5ACR, the commander of the International Space Station as he flew over the Dallas-Fort Worth metroplex. (Photo © 2006 and used with permission of R. Wayne Day, N5WD)



Richard Aguilar, K5LXM, one of the two sponsors of the DeGolyer Elementary School ham radio club, prepares to record the historic contact between the school and Bill, KC5ACR, operating on board the ISS on February 7, 2006. Aguilar is assisted here by two of the school's students. (Photo © 2006 and used with permission of R. Wayne Day, N5WD)

The event was covered by the local (Dale and Shawnee, OK) and Oklahoma City media. Dale school officials attended, and the ARRL was represented by Coy Day, N5OK, West Gulf Division Director, and John Thomason, WB5SYT, Oklahoma Section Manager. *CQ VHF* was represented by Joe Lynch, N6CL, Editor. ARISS was represented by Keith Pugh, W5IU, Mentor.

E. L. DeGolyer Elementary School, Dallas, TX. The start of the DeGolyer contact can be traced back several years to the formation of the ARRL's "Big Project." DeGolyer Elementary became one of the Big Project Pilot Schools under the guidance of Sanlyn Kent, art teacher, and local resident Jim Haynie, W5JBP, President of the ARRL at the time. DeGolyer Elementary became a very successful Big Project School, and a club station, K5DES, was formed under the guidance of Sanlyn Kent (now KD5LXO). Co-sponsor of the club is Richard Aguilar, K5LXM. One of the initial club projects was to apply for for a school contact with the ISS.

Between the initial application and the scheduled contact

Bob Landrum, W5FKN, operates the push-to-talk switch as students of DeGolyer Elementary School speak with Bill, KC5ACR, on board the ISS on Tuesday, February 7, 2006. Seventeen students were able to speak directly with the commander of the ISS before it moved out of range of the club station, K5DES. (Photo © 2006 and used with permission of R. Wayne Day, N5WD)

time, the DeGolyer Big Project team licensed a number (more than 30) of new amateur radio operators and continued their activity. They even built "throw away" cardboard and aluminum-foil satellite antennas and tested them at the 2002 AMSAT Space Symposium in Fort Worth, TX. Their club station, K5DES, is located in a neat corner of Sanlyn's art classroom and is used regularly.

For this ARISS contact, Sanlyn pulled together a number of current student members and graduates of the DeGolyer Big Project. Questions were submitted by all, and the final team was a mix of current and former members who shared one thing in common: *They all are licensed amateur radio operators.*

Equipment for the contact was drawn from the K5DES club station and supplemented as necessary with additional equipment. The station was set up in the school auditorium so that more people could attend. A team composed of Richard Aguilar, K5LXM; Harold Reasoner, K5SXK; Bob Landrum, W5FKN; and Bob Dickey, AK5V, assembled the required equipment and did the installation on the school roof and in the auditorium. The contact was also televised by closed-circuit television throughout the school.

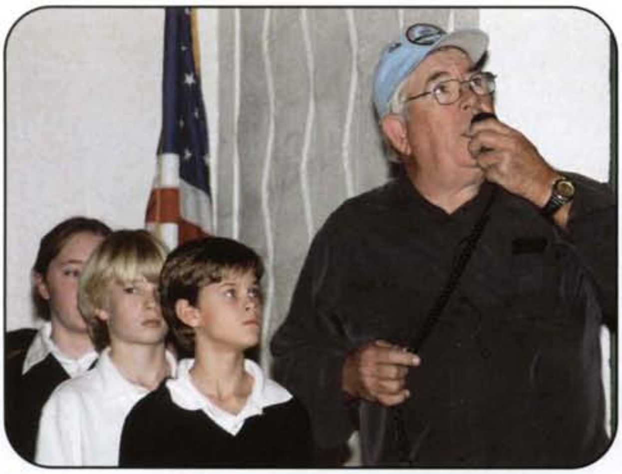
Not many of the DeGolyer group, other than the installation team, heard the Dale, OK, contact, but the Dale contact did serve as a good checkout of the DeGolyer equipment installation. This was a luxury the Dale group did not have.

The event was covered by the Dallas media and by a team from the Dallas Independent School District. The ARRL was represented by Jim Haynie, W5JBP, then President of the ARRL, and by Tom Blackwell, N5GAR, North Texas Section Manager. Keith Pugh, W5IU, was the ARISS Mentor for the contact, but was present in spirit only, since he was in Oklahoma for the Dale High School contact.

Summary

Without the willingness of Bill McArthur, these contacts would not have been possible on successive orbits. As a matter of fact, this same type of operation has now been done twice more during Expedition 12, and Bill now has over 35 school contacts to his credit. This record is amplified by his successful achievement of WAS, WAC, and DXCC during Expedition 12. Many other contacts were made during the hunt for these awards, and many other amateur radio operators were thrilled to make contact with an astronaut.

While the "back to back" contacts were neat, the real reward is the successful completion of two more school contacts, and the "sparks" that these contacts ignite in the minds of our youth. ■



Bob Landrum, W5FKN, and DeGolyer students eagerly await Acquisition of Signal (AOS) for the start of the contact while looking at the map. (Photo used with permission of Lisa Leon of Dallas ISD)

ISS track on a world map by Nova for Windows with an inset picture of Bill McArthur. (Photo used with permission of Lisa Leon of Dallas ISD)

Ionospheric Phenomena on Other Planets

Information obtained recently by various space probes points out ionospheric phenomena on other planets similar to those found in Earth's E-region. Further exploration in this area would help expand our knowledge of terrestrial modes of VHF propagation on Earth. WB2AMU explains . . .

By Ken Neubeck,* WB2AMU

The saying "we are not alone" has often been used in the past to describe the UFO phenomenon. In a way, this phrase is also appropriate to describe the various ionospheric phenomena that result in the different radio propagation modes that we experience on the planet Earth, in particular those which occur in the *E*-region of the ionosphere. Sporadic-*E* propagation is one such propagation mode, and it occurs in force during the respective summer months of the Northern and Southern Hemispheres on the 6-meter band, where signals are efficiently reflected off ion layers in the *E*-region. Another *E*-region phenomenon is the mysterious aurora mode, where radio signals are reflected off the active aurora in a backscatter mode and have tremendous distortion. Radio amateurs get to experience these really interesting modes by operating on the VHF bands at the right time.

It is so easy for hams to think that aurora conditions and sporadic-*E* propagation are unique only to Earth. However, as recent results obtained by various space probes have pointed out, it is apparent that many of the other planets in our solar system have similar physical phenomena. These include the aurora phenomenon as well as the existence of metallic-ion layers in the atmosphere.

Such an area of exploration would be extremely helpful in increasing our knowledge base of terrestrial modes of VHF propagation on Earth, such as aurora and sporadic-*E*. While other planets have noticeable differences in the reasons why these phenomena occur, the understanding of these differences and why they exist will ultimately lead to a clearer understanding of the behavior of aurora and sporadic-*E* propagation modes on Earth.

In this article we will concentrate on the above two *E*-region propagation modes on Earth and explore the form in which they exist on other planets in our solar system. The formal, structured ionosphere that exists on Earth—where there is a clear distinction between layers (known as the *D, E,* and *F* region)—may or may not exist in a similar manner on other planets. Although the presence of a metallic-ion layer (which is what sporadic-*E* is on Earth) and an aurora-type phenomenon has been noted in the ionosphere of other planets, at this time no determination of different layers has been made.

Discovery of Metallic-Ion Layers on Other Planets

In recent years a number of space probes have been launched that led to the discovery of similar phenomena on other planets. These have been documented in a number of recent papers. Table 1 summarizes these discoveries.

The planet Jupiter is a case in point, with data beginning collected as early as 1981 (reference 1). Over the years, observations of its ionosphere were made by the Voyager 2, Pioneer, and Galileo probes. The initial data suggested some very interesting phenomena in the area of metallic ions. It pointed to the existence of a low-altitude ionospheric layer with a peak electron density of 10^4 per cubic centimeter in the area of 350 to 450 km above Jupiter's surface. Data from a sub-

Planet	Presence of Aurora	Metallic-Ion Layers	Presence of Magnetic Field	Axis of Rotation
Mercury	No	No	No	0°
Venus	Yes	No	No	177°
Earth	Yes	Yes	Yes	23.45°
Mars	Yes	Yes	No	25°
Jupiter	Yes	Yes	Yes	3°
Saturn	Yes	Yes	Yes	26.5°
Uranus	Not known	Not known	Yes	97.5°
Neptune	Yes	Yes	Yes	28.5°
Pluto	Not known	Not known	Yes	120°

Table 1. In recent years a number of space probes have been launched that led to the discovery of ionospheric phenomena on other planets similar to those on Earth. These have been documented in a number of recent papers and are summarized here

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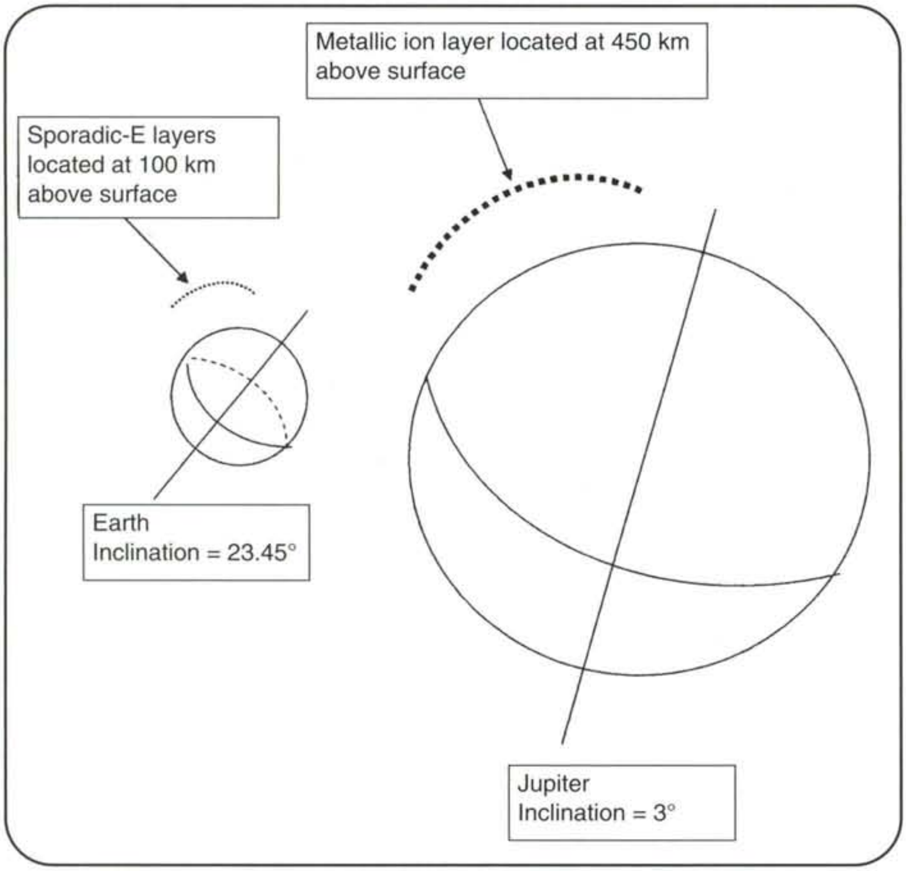

Figure 1. Comparison of Earth and Jupiter. (Note: Shapes are not to scale.)

sequent probe shows that this layer consists of long-lived metallic atomic ions that apparently originated from meteoric influx (reference 2).

For Jupiter, some rough calculations have been made which show that approximately 20,000 tons of meteoric material enter the planet's ionosphere per day, or on the order of 100 to 150 times greater than the influx of material entering Earth's ionosphere.

It is also noted that the diameter of Jupiter is 12 times greater than that of Earth, yet the average height above ground of the metallic layers (400 km for Jupiter vs. 100 km for Earth) is only four times greater. Thus, comparatively speaking, the metallic-ion layers are closer to the surface of Jupiter (see figure 1).

Voyager 2 data pointed out the existence of sharp layers of electrons, also on the order of 10^4 per cubic centimeter density (reference 3), in the ionosphere of the planet Neptune at around 700 km above its surface. The study notes the similarity of these layers to the *E* layer on Earth. The study also declares the importance of magnetic field in layer formation, as well as determining that magnesium metallic ions are the most likely metal to be found in the layers on Neptune.

Indeed, the discovery of metallic layers is not confined to just planets in the solar system. They also have been detected on some of the moons of these planets, such as Titan, the moon of Saturn. Ions of iron, magnesium, and silicon have been discovered on this moon at a 650-km height range above the surface, again in the neighborhood of 10^4 per cubic centimeter density range (reference 4).

It appears that the process for creating metallic ions is different on other planets than it is for Earth. It is well known that meteor ablation does not result in direct formation of metallic-ion (sporadic-*E* propagation) layers on Earth. VHF hams are well aware of meteor scatter, where localized ionization from meteor particles can occur. However, for sporadic-*E* layer formation there is a rather complex process in which metal atoms such as iron and magnesium fall to 90 km above the Earth, where many of the particles recombine with oxygen ions (in a charge exchange) and actually are transported to higher altitudes (reference 5).

For some of the planets, though, the process is different from that which occurs on Earth. For example, one paper (reference 6) notes, "For a heavy planet like Jupiter, far from the sun, impact ionization of ablated neutral atoms by impacts with molecules becomes a prominent source of ionization due to the gravitational acceleration to high incident speeds." Thus, this "instant ionization" is in contrast to the complicated process that takes place on Earth. The charge exchange in Jupiter's atmosphere takes place immediately between the ablated metal atoms with resident hydrogen ions. Figure 2 compares the processes on Earth and on Jupiter.

The paper also notes even more differences with regard to other planets: "Within the carbon dioxide atmosphere of Mars (and possibly Venus), photoionization is important in determining the ion density." Since the process of metallic-layer ionization is more direct and immediate on other planets, it can be speculated that there may be less of a possibility of a seasonal pattern as observed in the sporadic-*E* phenomenon on Earth.

Another paper (reference 7) speculates that a layer of magnesium ions should exist at around a height of 70 km for the planet Mars, with the same density level as listed before. The study also notes that the low ultraviolet absorption of the atmosphere on Mars makes it an excellent canvas for studying meteoric ablation and the formation of metallic-ion layers.

Discovery of Aurora on Other Planets

Aurora activity, prevalent in the higher latitudes of Earth, is the manifestation of the interaction between electrically charged particles from the sun and the neutral upper atmosphere as they precipitate along magnetic-field lines. There are not only visual displays associated with aurora; aurora also affects radio waves in the VHF region. Particularly during high periods of enhanced geomagnetic activity, the aurora region extends into the lower latitude, where backscatter aurora contacts are made on the 6-meter band and occasionally on 2 meters. However, from recent studies based on data collected from instrumentation on probes, it is apparent that the aurora phenomenon is not unique to Earth. Indeed, it is seen on several other planets in the solar system!

One recent paper (reference 8) states that auroral activity has been found on all four giant planets possessing a magnetic

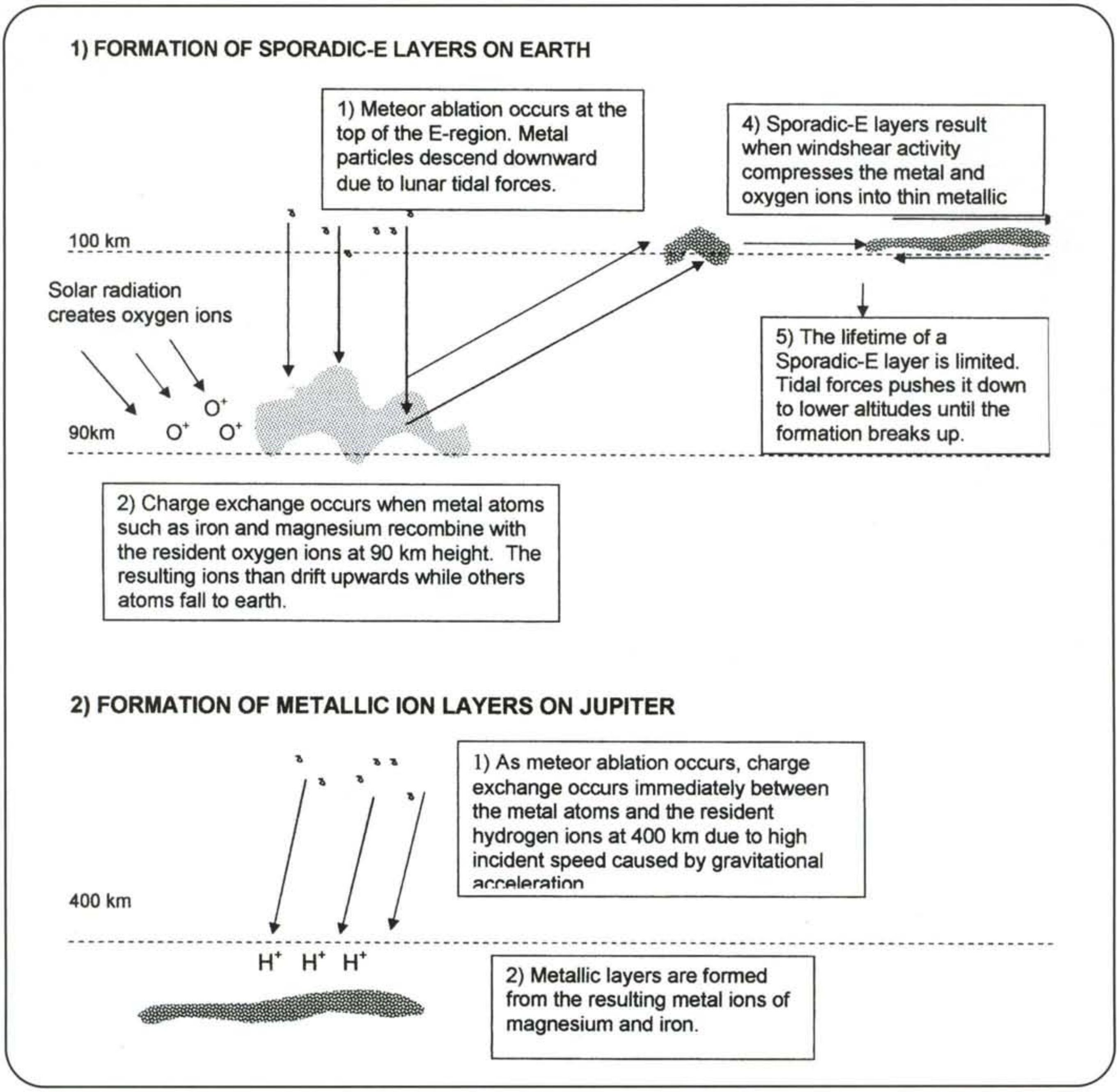

Figure 2. The differences in the process of how metallic-ion layers are formed on Earth and Jupiter. The process that occurs on Earth is an indirect, or two-step, process, whereas conditions on Jupiter allow for a more direct conversion, or "instant ionization, process when meteor ablation occurs.

field (Jupiter, Saturn, Uranus, and Neptune), and also on planets such as Venus and Mars, which do not have a planetary magnetic field that seems to be caused by high-energy electrons. The Mars Express probe, using an ultraviolet spectrometer, has determined that Mars' aurora is quite unique with regard to that of the other planets in that the aurora is highly concentrated and controlled by magnetic-field anomalies in the Martian crust. This is in contrast to the type of auroras that are centered around the geomagnetic poles on other planets.

Studies of the larger planets that have magnetic fields, Saturn and Jupiter, have shown some interesting differences between the two (reference 9). Saturn's aurora seems to respond to strong solar-wind conditions, in contrast to Jupiter. However, in contrast to Earth, where the solar-wind dynamic pressure and electric field are major factors, these two factors are of lesser impact on aurora formation on Saturn.

Relevance to Phenomena Experienced on Earth

It is truly amazing to think that there are phenomena similar to sporadic-*E* and aurora appearing on several other planets in the solar system! By studying the

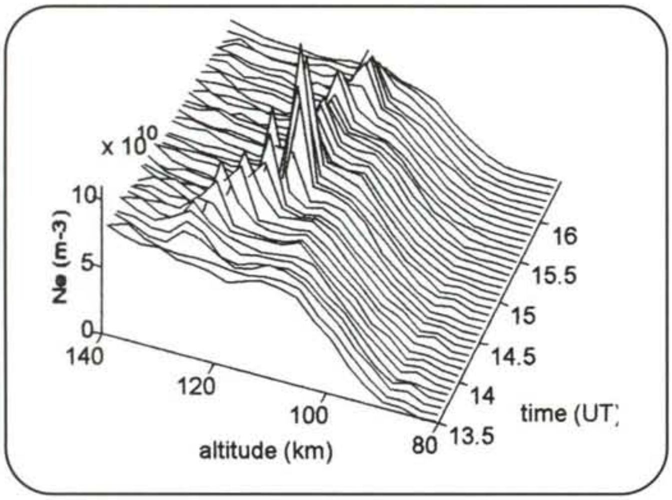

Figure 3. An EISCAT radar plot of a sporadic-E formation on Earth that is traveling downward in altitude due to the forces of the lunar tide. (Courtesy of S. Kirkwood)

behavior of similar phenomena on other planets, what can we learn about these phenomena on Earth? We will break this down into two areas: metallic-ion layers (*E* layer) and aurora.

I. Metallic-Ion Layers

1. Many aspects of the sporadic-*E* phenomenon on Earth are not unique! From the determination of specific ion types that are in the metallic-ion layers on Mars, Jupiter, and Neptune, and comparing these to Earth, it would seem that meteor debris is the primary source of neutral atomic metal material that eventually becomes metallic ions in the ionosphere of these planets. The most common metallic ions detected are iron and magnesium, with lesser amounts of sodium and silicon.

2. It would be of interest in the future to see if there are different chemical processes in the planet atmospheres that may produce more of one type of metallic ion than another. For example, could there be more iron ions than magnesium ions for one planet, with the situation reversed for another planet because of the different chemical and recombination processes in the ionosphere?

3. The effect of the geomagnetic field appears to a major factor of sporadic-*E* development on Earth as compared to other planets. Essentially, there are three zones on Earth—aurora, temperate, and equatorial—with the sporadic-*E* formation process being different in each due to the geomagnetic-field lines (see reference 5). The differences can be observed on the VHF bands as well.

4. The most unique aspect of sporadic-*E* on Earth is the existence of the strong summer sporadic-*E* season. This is directly related to the Earth's 23.45-degree tilt of the axis of rotation and effects of solar radiation on metallic-ion formation in the *E*-region. For a planet such as Jupiter, which only has a 3-degree tilt, the effects of seasons on the metallic-ion layer may not be present or as significant (see figure 1). By the way, when talking about a summer season on Jupiter as compared to Earth, the season is much longer in duration on Jupiter, as Jupiter's rotation around the sun takes over 11 Earth-years!

5. Tidal forces have a major effect on sporadic-*E* and are of major consequence in the lifetime of a sporadic-*E* formation. On Earth, the force of gravity drives the sporadic-*E* formation downward from the area of 120 km to 90 km, where it breaks up, with some ions fall to Earth and others traveling upward toward the *E* and *F* regions (see figure 3). The duration of a single sporadic-*E* formation on Earth rarely exceeds a continuous 10 hours and is almost never more than one day. On a planet such as Jupiter, which has a gravitational force that is much greater than that of Earth, it may be that a metallic layer would have an even shorter duration.

6. The larger amount of meteoric debris associated with Jupiter may result in denser metallic formations. Thus, if radio communications were feasible on this planet, the metallic-ion layers could probably consistently reflect radio waves at the extreme VHF frequencies (e.g.., 2 meters and 220 MHz)!

7. The existence of metallic-ion layers on several other planets besides Earth, as well as the direct conversion of meteor ablation into ion layers on the planet Jupiter, suggests that metallic ions are the primarily component of sporadic-*E* on Earth. This may rule out the idea that thunderstorms are the direct cause of sporadic-*E*. There is still the belief that thunderstorms may have an indirect effect on Earth's sporadic-*E* events by perhaps intensifying these layers (reference 10). Also, whereas the process of charge exchange is more direct with other planets, the process on Earth leading to the creation of sporadic-*E* formation is more complex, involving recombination processes with existing ions at certain heights in the ionosphere.

II. Aurora

1. As in the case of sporadic-*E* on Earth, the geomagnetic field plays a major part in aurora formation on Earth and several of the major planets. However, it is interesting to note that aurora exists on planets such as Venus, where there is no magnetic field.

2. Solar wind is the mechanism that drives the formation of aurora on all of the planets that experience this phenomenon. Just as in the case of Earth, solar activity (such as flares) that is geo-effective toward the poles of these planets would seem to cause increased aurora activity and extension into lower latitudes. In fact, some solar eruptions may affect some planets, depending on the geo-effective positioning and also the strength of the eruptions. It would be of interest to see the difference in the amount of aurora activity for Earth and for planets that are farther away from the sun.

3. It also would be interesting to see which planet experiences the most aurora activity and from that determine the ideal conditions (other than the impact of the solar wind) that would allow for more aurora on a planet.

4. Based on initial findings, it would be interesting to see if other planets besides Earth have the type of aurora that could reflect radio waves. A major component of the radio aurora (where signals can be reflected) on Earth is the aurora's interaction with the geomagnetic field. It is conceivable that while visual aurora is present on most of the planets, the radio aurora may only be present on Earth. Thus, the radio aurora, as opposed to sporadic-*E*, might truly be a unique phenomenon of Earth!

Summary

With respect to understanding sporadic-*E* and aurora phenomena on Earth, it will help to take a look at the "big picture," or the solar system itself. By looking at the various parameters of the planets of the solar system, information can be gleaned from each of the planets, while realizing the differences in several of the parameters (inclination of axis, rotation period, etc.). It is truly interesting to note that neither the existence of the aurora nor thin metallic layers are unique to Earth. They exist on several other planets as well in a somewhat similar fashion.

Indeed, many questions regarding the two phenomena on Earth appear to be answered by looking at the bigger picture. Perhaps the major question about sporadic-*E* that remains is in regard to its unique seasonal pattern—a major peak of activity during the summer, a minor peak during the winter, and significant voids during the equinox period. Yet from what has been observed for all planets, meteoric flux is fairly consistent.

Thus, part of the answer for Earth has to be connected to the ionization process that takes place at 90 km, which is more prevalent for those geographic areas that are experiencing summer. As metallic ions have been detected throughout the *E* region throughout the year by numerous rocket launches, it can be speculated that the reason for the voids is most likely not due to a lack of metallic-ion availability, but rather due to other factors that are unique to Earth (as compared with other planets). These factors may be associated with Earth's geomagnetic field and/or prevailing winds in the *E* region that cause significant changes in this region during the equinox period when significantly less sporadic-*E* formations occur.

Future space probes may provide more data to help in this area. The data may relate to the area of *F*-layer based phenomena such as TEP (transequatorial propagation) and *F2*-layer propagation. However, with Earth being the only planet in the solar system that has significant oxygen components in the atmosphere, the likelihood of a phenomenon identical to *F*-layer propagation is slim, since that involves solar energizing of the oxygen molecules.

I would like to thank Dr. Sheila Kirkwood, Dr. Joseph Grebowsky, and Dr. Jane Fox for providing me with background material that helped me in writing this article. I would also like to thank Dr. Jerry Hinshaw, KE7DJD, for reviewing my article prior to publication. ■

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Historical Trends of the CQ VHF Contest

The reasons for the ups and downs of VHF contesting are elusive and hard to determine. Here W9GKA analyzes the CQ VHF Contest to determine what role it plays in the overall picture of VHF contesting history.

By Kevin Kaufhold,* W9GKA

In an attempt to find out what has been causing the massive fluctuations in VHF contest activity, historical data on the ARRL VHF contests has been collected over the last several years. This article extends the effort to the CQ WW VHF Contest, and finds some interesting trends in the data and historical information.

History of the CQ VHF/WPX Contests

CQ magazine has sponsored VHF contests in two distinct eras: 1956 to 1966, and 1985 to the present. In the first era, the *CQ* contests were marked by an extraordinary amount of innovation. Counties and county equivalents were used as multipliers some 25 years before the League adopted the Maidenhead grid squares as sub-section multipliers. Operator effort was awarded through a multiplier for the number of hours of operation in which at least one contact was made. No corresponding item has ever been incorporated into the ARRL events. A power multiplier was established 30 years before the League moved to high- and low-power distinctions in the multi-op categories and 40 years before the appearance of the SOLP (Single Operator, Low Power) category. A one-day, 12-hour contest was experimented with 30 years before the four-hour long VHF Sprints were implemented in 1983. As early as 1960, a CQ Century Club award was given for anyone having a certain number of contacts on the VHF bands. This award predated the VHF UHF Century Club (VUCC) by some 23 years.

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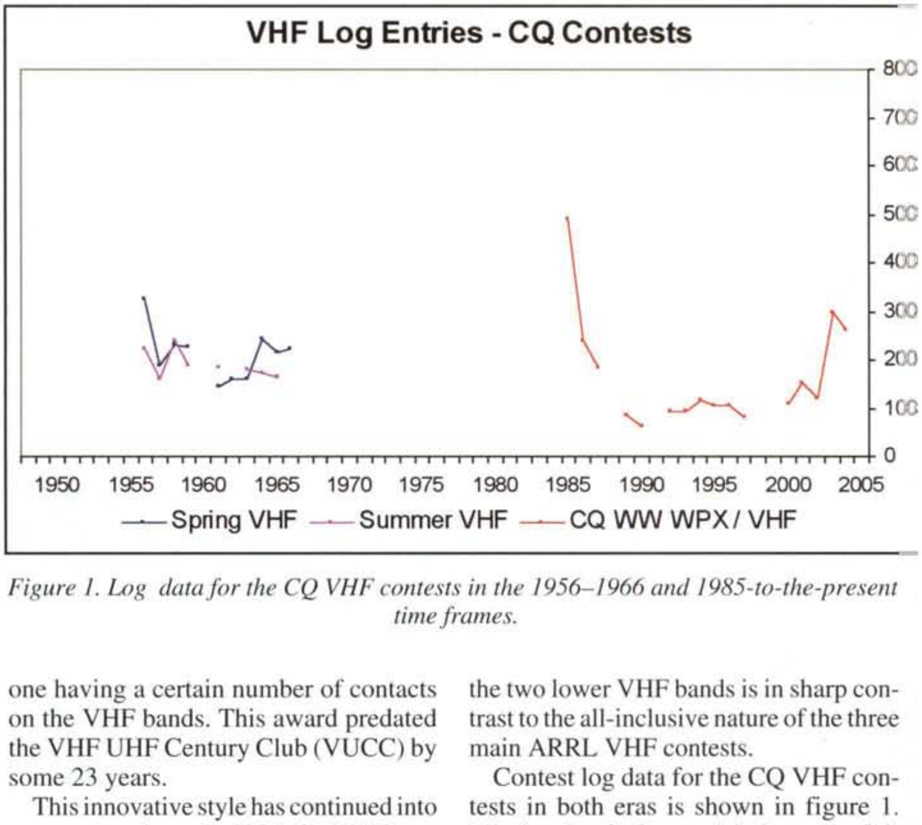

Figure 1. Log data for the CQ VHF contests in the 1956–1966 and 1985-to-the-present time frames.

This innovative style has continued into more recent times. In 1985, the WPX program was used as the basis for multipliers, and the contest was then styled as the CQ WW WPX VHF Contest. A CW incentive was awarded from 1992 through 1999, which is something that would still be of relevance today. In 2000, Gene Zimmerman, W3ZZ (then the newly installed CQ VHF contest coordinator), extensively revamped the contest to 6 and 2 meters only. This concentration on only the two lower VHF bands is in sharp contrast to the all-inclusive nature of the three main ARRL VHF contests.

Contest log data for the CQ VHF contests in both eras is shown in figure 1. Missing data in the graph is due to the following: no results are believed to have been published for spring 1960, 1998, and 1999; results were published but have not yet been located for summer 1966 and 1988; and no contests were conducted in summer 1960, 1962, and 1991. The author would be grateful to anyone who can supply information or published results for any of these.

Two annual events generally were conducted in the first era, while the focus has been on one July contest in the current period. In addition to these contests, *CQ* conducted a YL VHF contest between 1961 and 1964, as well being involved to a certain degree with the "VHF Amateur" contest in 1962 and 1963. In the late 1990s, *CQ* even attempted an "Internet" 6-meter contest that ran concurrently with the July VHF contest, experimented with VHF activity weekends, and also conducted VHF foxhunting activities.

Individual Rules Changes

When viewing only ARRL data, the current consensus among many observers is that individual rules changes have not greatly influenced the number of contest log entries. For instance, the adoption of grid squares and the development of the VUCC program by the League was warmly received and quickly accepted within the VHF community, but log entry data did not dramatically jump in response. In general, ARRL rules changes have had a far greater impact on contest point totals than on overall participation levels.

In looking at the CQ VHF, the same general pattern is evident. The *CQ* contests had significant rules changes in both eras, and yet contest participation and log activity did not dramatically and quickly change (with two possible exceptions, noted below). Some of these rules revisions included the addition of hours of operation and power as multipliers in 1958. Thereafter, changes included deleting power multipliers for multiband operations; dropping multi-ops altogether in the summer of 1963; starting the club competition in the spring of 1963; and moving to single-band-only competition in 1963.

The current era also has experienced major, if not radical, changes: modifications were made to the prefix and grid multipliers in both 1992 and 1995; the event was changed from a six-band run in 1985 to an all-band contest in 1995, and then to a two-band contest in 2000. Changes in both eras generated huge increases in point totals in all categories of operation, but in general did not measurably change log entry statistics.

Even when rules changes were made with the specific intent of boosting participation, things did not quite work out as planned. A separate 12-hour contest was attempted in March 1963 (styled as the VHF Amateur Contest), and this event enjoyed tremendous success. It was

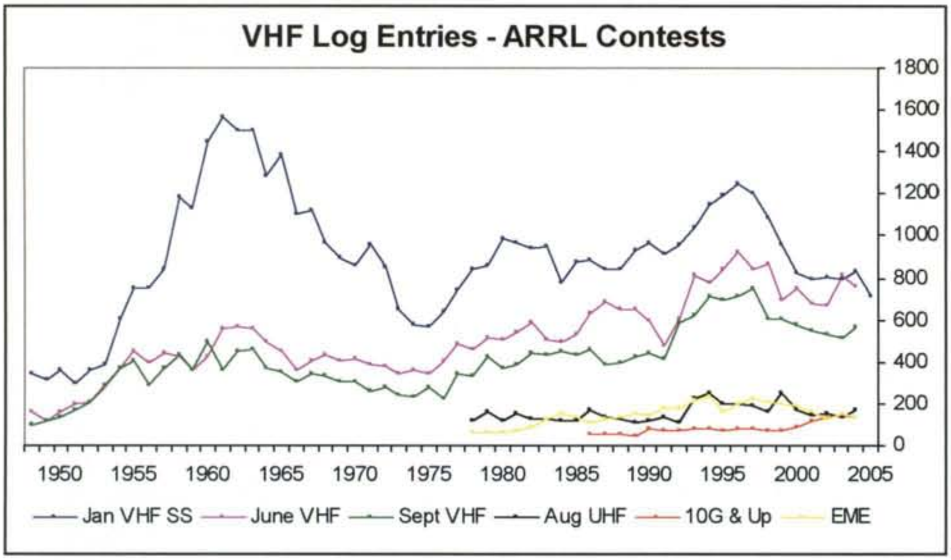

Figure 2. Log data for the ARRL VHF contests from 1950 through 2005.

hoped that a change to the 12-hour format in 1965 would produce a similar surge in operator interest. When the one-day, 12-hour affair was trotted out on short notice for summer 1965, however, the results were anything but exciting. Chaos and confusion existed among the contestants, and total log entries declined slightly from the year before. The 12-hour option was then abandoned for future summer events, but was next attempted in the spring of 1966. Log entries did not measurably increase then, either.

A one-time boost in contest activity did occur at the beginning of the second era of the CQ VHF contests, however. A certificate was issued to every single contestant in 1985, and the event was considered an initial success. The next year, the rules moved to a more traditional awards format, and this resulted in a massive reduction in log entries having smaller contact and point totals. For a further analysis of the impact of the special certificate upon the 1985 and 1986 contests, see *CQ*, July 1987, p. 11. This one-time effect on log submissions is similar to what the League experienced when it first issued participation pins in the 1993 August UHF. Log entries exploded from 108 submissions in 1992 to 223 logs in 1993. After peaking at 249 logs in 1994, log entries in the UHF contest thereafter resumed a downward course.

The most recent rules change, in 2000, to that of a two-band contest may also be impacting log entries. There has been a pronounced increase in participant levels since the new format was adopted. This is especially interesting when compared to the ARRL contests, which have gone through a down-trend and possible stabilization since 1996. Why has this one rules change evidently mattered when so many other changes have not mattered at all? Perhaps it is due to a basic redefinition of the nature of the contest, itself. The latest version of the CQ VHF contest is truly different from any of its predecessors and all of the ARRL VHF tests. The lower two-band concept draws on VHF contesting history in both *CQ* and ARRL events, being reminiscent of strong and wildly popular single-band runs that occurred on 6 and 2 meters in the 1960s. It is also comparable to many current HF domestic contests, with concentrations on only one or a few bands (10 meters, 160 meters, HF Sweeps at solar minima, etc.). To this extent, the current version of the CQ VHF may be filling a niche in the national VHF scene that has been missing up until this time.

Contesting Peaks

Two distinct and definite peaks in contest log activity have occurred in the ARRL VHF contests (see figure 2).

The explosion of contest activity in the 1960s centered on the January VHF Sweepstakes, while both the June and September VHF QSO Parties had a much smaller impact. The Sweepstakes was a club competition event, while during that time period the other two QSO Parties only included individual and multi-op entrants. This made the January VHF the one big contest of the year. The situation changed substantially beginning in the mid-1970s, with the June and September contests becoming comparatively more popular as interest from individual operators increased. The second contesting peak in 1996 shows more of a cyclical pattern in all three of the main ARRL contests.

The cyclical nature of the number of contest log entries has been traced to major regulatory changes occurring over the years. Several changes in regulations produced a tremendous influx of Novices and Technicians in the 1950s, as well as a flood of Technicians in the 1990s. VHF contest activity boomed in those time frames. VHF club activity, technological changes, demographic patterns, and even sociological and economic factors are also thought to have varying roles in the dramatic shifts in contest activity.

Amazingly, in both eras, the *CQ* contests do not appear to have peaked in conjuntion with spikes in the number of amateus joining the ranks, as the main ARRL VHF contests have done. Even with the great surge of amateurs coming onto the VHF bands in both the early 1960s as well as the early to mid 1990s, the CQ VHF did not increase its overall log entries in either era (although some of the log entry results on the CQ VHF were never published and the contest ran in only limited time frames, so it's difficult to make a definite conclusion in this regard). The apparent lack of peaks in the CQ VHF activity could be due to the radically changing nature of the contests during both critical time periods. The CQ VHF was going through self-described "transitional periods" in the early 1960s, while it came to a complete standstill in 1991, with a gradual revitalization occurring only thereafter.

The absence of a contesting peak could have another explanation, at least in the 1960s: Only the January VHF SS experienced a tremendous spike in operator interest. With no clubs being involved in the CQ WW VHF until 1963, the *CQ* contests more closely resembled the June and September VHF QSO Parties in style. In the late 1950s, new hams flocked to the clubs, as they were then at the very hub of amateur activity. With only individual participation in the *CQ* contests as well as in the VHF QSO Parties, non-club events had much lower support and activity levels than the VHF Sweeps. This does not explain the absence of a peak in the 1990 era CQ VHF data, however. With the major ARRL non-club contests showing definite upswings

Year	Call	2 m Qs	Asia Logs	EU Logs	% Logs
2002	E21DKD	587	19	—	3.2%
	F6IFR	420	—	7	1.7%
2003	HS4NLW	514	21	—	4.1%
	OK1KIM	451	—	28	6.2%
2004	E21DKD	592	41	—	6.9%
	OK1KIM	527	—	21	4.0%

Table 1. The top scorers in Asia and Europe in the last three CQ VHF contests.

in log submissions in the early 1990s, the lack of a similar pattern in the CQ WPX/VHF suggests that structural problems in the *CQ* contest itself may have overridden or effectively eliminated any increased activity stemming from new licensees.

Contest Administration

Many observers believe there is little or no relationship between ARRL administrative efforts and variations in contest log activity. Some of the more recent activities of the League (i.e., deletion of the line scores from *QST;* contest robot) have drawn jeers from contesters, while many of the League's innovations (the contest area of the ARRL website; LoTW [Logbook of the World]) have won applause from the proverbial peanut gallery. None of the League's efforts, however, have affected VHF contest activity to any great and measurable extent.

However, when the general styles of ARRL and *CQ* contest administrations are more closely examined and compared, some interesting trends emerge. *CQ's* handling of its VHF contests may involve unique and interesting experiments, but the execution of its events has been anything but routine in either contesting era. Much of the problem with *CQ* contest administrative efforts in the past simply may have been due to the *CQ* VHF columnist having a dual role which included directorship of the CQ VHF contests. Whenever the VHF column editor became busy on other matters, the contest suffered as a result. The contest structure at *CQ* just may have expected too much from one person, as writing a VHF column is time consuming in itself. Adding contest administrative duties to the "job" requirements of the column writer may have doomed the VHF contest to a chaotic existence for many years.

This is not to criticize past VHF column writers at *CQ*. Indeed, the column editors all have brought their own unique flare and style to a time-intensive, volunteer position: Sam Harris, W1FZJ, pioneered EME activities while writing the *CQ* column in the late 1950s; Bob Brown, K2ZSQ, merged an entirely separate VHF magazine into *CQ* in the early 1960s; Steve Katz, WB2WIK, reinvigorated the post in the 1980s, some 15 years after the column last appeared in the late 1960s. Furthermore, Joe Lynch, N6CL, not only edited the VHF column in *CQ* starting in August 1991, he went on to become the editor of *CQ VHF* magazine in 2002, when it was brought out again after it had ceased publication and been incorporated into *CQ* magazine for three years. In its initial four years of publication, *CQ VHF* magazine was edited by Rich Moseson, W2VU, the present editor of *CQ* magazine.

Contrast this situation at *CQ* with the ARRL. The League has consistently and methodically produced high-caliber VHF contests since the post-WW II period (and for many years before, when VHF Marathons and U.H.F. Relays were also included).

The VHF contests at the League and the "World Above 50 MHz" column in *QST* are handled by different people. This consistency of contest style and deep support from the contesting community comes at a large cost: the ARRL events are very slow to change, even in the face of stagnant to declining participation levels. The difficulty in quickly adapting the League's rules structure to changing circumstances may be a big reason why the ARRL contests are comprised of well-established participants. The preponderance of older, established contestants could be the distinct result of new contestants being unwilling or unable to compete against an entrenched group of operators who can repeatedly win with a fixed rules set.

Conversely, the *CQ* style of contest, with its unique rules, certainly attracts new participants. However, in the past, some burn-out has occurred in entrants who grew frustrated with the less-than-ideal execution of the formatand the continual changes in the rules structure.

Because the ARRL and *CQ* have such dramatically different contest management styles, reviewing both administrations side-by-side may be something of an "apples to oranges" comparison. Arguably, the ARRL may have a stifling amount of predictability, while historically *CQ* has suffered from a lack of predictability. To the credit of each of the contest administrations, the ARRL is attempting to bring more systematic change to its process, and *CQ*'s one annual VHF contest (as well as its current VHF column) has now run longer than all of its trailblazing VHF events and activities in the first era of VHF contesting. In addition, with the CQ VHF contest now having a separate contest coordinator (initially Gene Zimmerman, W3ZZ, and now John Lindholm, W1XX), the contest is running smoother than in prior years, while the "VHF Plus" column in *CQ* magazine has been a great addition to the VHF community over the 14 years that Joe Lynch, N6CL, has been its editor.

CQ VHF Contest Participation Levels

What accounts for the sizable difference in log entries between the CQ VHF Ccontest and the three big ARRL VHF contests? Certainly, many League members and affiliated clubs favor the ARRL events. The League's events also have something of a strategic advantage, in that they exclusively have occupied the same contest weekend for many years. This is in contrast to the CQ VHF contest, which is squeezed in between the ARRL VHF events and also has to contend with numerous VHF contests in Europe that occur around the same time.

A major reason for the log entry difference, however, could also be that a far lower percentage of stations that are generally active in contests are entering the CQ VHF contest than the ARRL events. This belief is tentative, as it is based on only two years of *CQ* log data and four years of ARRL data. The data collected so far, however, infers that the number of worldwide participants in the CQ VHF could be approaching the number of domestic contestants in the June VHF QSO Party, but that far fewer people have submitted log entries in the CQ VHF than in the ARRL VHF contests. This may be the result of the *CQ* contest appealing to many casual VHF operators, especially since 2000, when the format was changed to a two-band event. The ARRL contests have a more intensely competitive grade of operators who possess massive amounts of equipment and antennas all the way through the microwaves bands. These operators are much more likely to submit log entries.

Further, the CQ VHF contest attracts many international participants, whereas most of the ARRL events have specific rules banning DX-to-DX contacts (except for the EME, which is the only League event with an international following). In the last three CQ VHF contests, the top scorers in Asia and Europe made the number of contacts shown in Table 1 (thanks to John Lindholm, W1XX, for the statistics). These are amazing numbers. The top scorers in Europe and Asia had between 420 and 592 contacts on 2 meters. However, there were only 7 to 21 logs submitted from Europe and between 19 to 41 logs submitted from Asia. Thus, only 1.7% to 6.9% of the international stations who worked the world's leaders actually submitted a log entry to *CQ*. Even the 400 to 500 callsigns worked in Europe by the leaders may be small compared to the immense number of contacts made in other European VHF contests. The potential of the CQ VHF to reach an international audience is great and may already be under way.

In all, perhaps 8000 to 9000 stations worldwide have made at least one contact in recent CQ VHF contests (2003– 2004 statistics), and over 4000 callsigns were worked two or more times in a single CQ VHF contest (2003 data). This is comparable to published League information on the June VHF QSO Party, with 4600 to 6100 callsigns worked (2001– 2003 data). While the two sets of data may not be strictly comparable due to differences in master data-base collection and calculation methods, using callsigns worked rather than log entries submitted as the basic measure of "contest activity" changes the various trends of the CQ VHF in a rather dramatic fashion. Indeed, within an international context, the *CQ* event currently may be more popular than any of the domestic ARRL VHF events. While using log entries to gauge contest participation levels may be necessary when using historical data going back in time, relying on non-busted/non-unique callsigns as the basic indicator of contest participation may be more appropriate going forward in time. In this regard, the most recent post-2000 version of the CQ VHF contest stands up very well in a comparison with the ARRL VHF events.

Conclusion

The CQ VHF contests in both eras have

been innovative in style. Most of the major rules changes in the contest do not appear to have affected contest activity very much. The most recent rules change—that of moving to a two-band format in 2000—may have produced a dramatic increase in contest participation, however. The peaks of contesting participation noted in the ARRL VHF contests are not evident in the data that is available on the CQ VHF contest. This may be the result of interruptions in the sponsorship of the *CQ* event at the precise times when new amateurs were hitting the VHF airwaves. Recent CQ VHF contests may be enjoying heightened contest participation levels, especially when viewing information on callsigns and stations worked, instead of the more typical log-entry information.

In comparing the differences between the *CQ* and ARRL contest administrations, each administration generates its own set of strengths and weaknesses. The CQ VHF contest currently can be considered the "seventh" contest having substantial national support and participation from the VHF community. It may also be the only VHF contest of all US, EU, and Asia events to have a truly global following. The *CQ* administration is providing the innovation and flexibility necessary to sponsor a two-band specialty type of contest that the ARRL has so far been unable to develop. To this extent, the two contest administrations may even be complementary in nature. The *CQ* has been the informal testing ground for new and interesting ideas. The ARRL provides the depth of organization and membership support to ultimately incorporate many of *CQ*'s more successful experiments into its own contest structure.

I hope to hear you in the VHF contests.

Acknowledgements

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References

An explanation of the factors involved in VHF contest activity can be found in "A Descriptive Model of VHF Contest Activity," Kevin Kaufhold, W9GKA, *National Contest Journal*, May/June 2005, pp. 14–16.

Historical data on the VHF contests, including the CQ VHF contest, can be found at: <http://www.w9smc.com/SMC%20VHF/uvhfdata.pdf>.

The statistical model is detailed in "A Statistical Model of VHF Contest Activity," to be published in the 2006 conference *Proceedings* of the Central States VHF Society.

A discussion of the non-regulatory factors affecting VHF contest activity is in "Other Impacts on VHF Contests," Kevin Kaufhold, W9GKA, 9-2005 version, and can be found at: <http://www.w9smc.com/SMC%20VHF/OtherImpactsarticle.pdf>. This document also contains a statistical model that tests the various factors and data collected on the VHF contests.

Selling SSB to FMers

With the increased availability of multi-mode rigs on the VHF-plus ham bands comes the potential for introducing other modes, in particular SSB, to the casual FM operator. Here WB6NOA tells how to go about bringing these operators onto the SSB mode.

By Gordon West,* WB6NOA

The new entry-level Technician Class Element 2 question pool goes into effect on July 1st this year. Out go the old 511 questions, and in comes a fresh set of 396 questions specifically geared to more current ham radio technologies:

- VHF/UHF courteous operating technique
- Weak-signal SSB AND CW operation
- Satellite and space communications
- IRLP, Echolink, and data communications
- Interference mitigation
- Licensing and rules and regulations

"There are still 35 multiple-choice questions on the entry-level exam, but the smaller question pool will allow for more classroom demonstrations, such as switching off from FM repeaters and working direct via SSB," comments Bill Alber, WA6CAX, while setting up his VHF/UHF antenna system for an evening class demonstration of OSCAR operation.

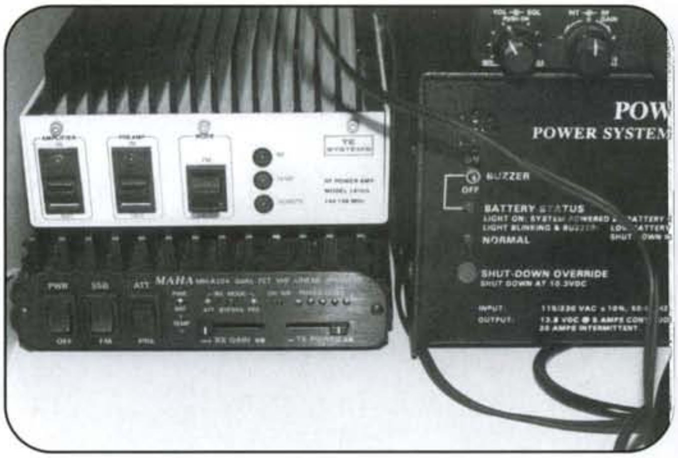
Brand-new hams are encouraged to consider VHF/UHF equipment with multimode capabilities. Kenwood, Yaesu, and ICOM all offer new VHF/UHF multimode rigs, but these are relatively expensive (in the $800 and up range). Students are encouraged to look for single-band 2-meter or 440-MHz used radios specifically with multimode capabilities.

"At a recent swap meet I counted ten used, working 2-meter multimode radios for sale, and most were selling for under $200," adds Alber.

Hundreds of hams have VHF/UHF multimode equipment, but only operate on FM. A good hunting ground for weak-signal operators is their local FM net. Have the net controller find out who has SSB capability on 2 meters and encourage them to hang around until the end of the net and meet on upper sideband, at 144.230 MHz.

Yet another hot selling technique for increasing our weak-signal ranks is to frequently announce SSB operation and a specific evening net on your local FM repeater. Before your weak-signal net starts up, switch over to the popular repeater pairs and make an announcement that anyone with 2-meter SSB capability should tune in to "USB," go to the specific frequency for the net, and give SSB a try!

One of the major problems for the FM operator going to SSB is cross-polarization. This is most evident in net operations. Typically, the FM operator uses vertical polarization. However, the SSB operator uses horizontal polarization. Even so, for net operations this need not be a problem if the net control opera-



Two-meter amplifiers with built-in preamps will help older "deaf" 2-meter multimode rigs.

The ICOM "fun-mobile" with a pair of 2-meter loops from KB6KQ.

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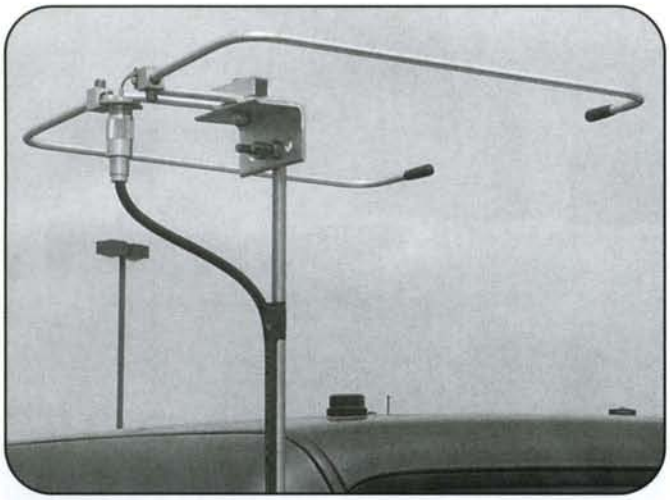
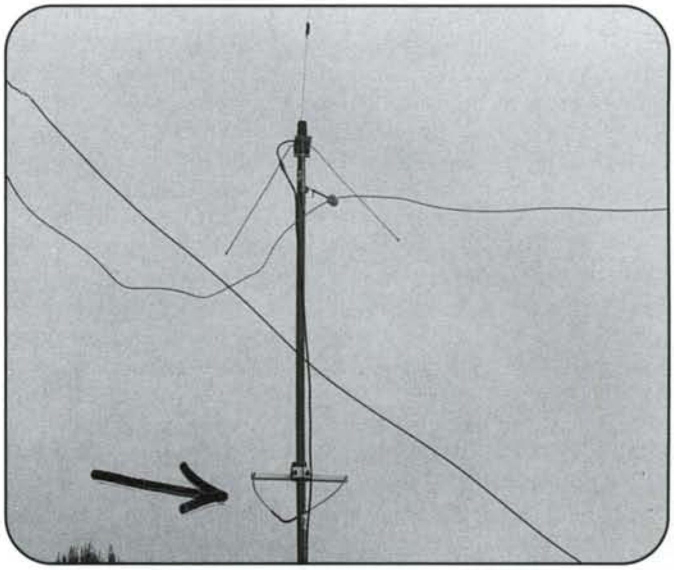


The KU4AB 2-meter SQ-144 in a mobile configuration.



The PAR Electronics horizontal loop is shown here in the middle of the mast.

tor has an antenna switch to connect a vertically polarized collinear antenna at his or her station, or simply work cross-polarized by pointing the beam in the general direction of any vertically polarized stations.

"We actually play up the fact that we are taking check-ins only from stations with vertically polarized antennas, and they really come out of the woodwork on SSB," comments Gabriel, KG6HMN, who is with the Western States Weak Signal Society southern California group. Both Gabriel and I conduct a warm-up net specifically to attract FM stations to SSB, regardless of polarization (see <www.WSWSS.org>).

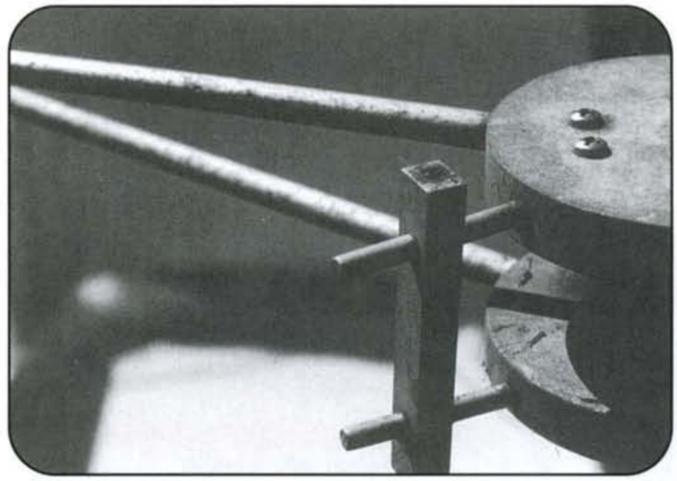
Once we "hook" an FMer into weak-signal work using single sideband, we next need to do another "sales job." They need to add the capability of using a horizontal antenna. No big beam yet—no big tower and a quagi, but rather a modest horizontal loop attached to a roof vent-pipe mast, or maybe hidden in the attic if they live in an area with antenna restrictions.

"There are at least 15 commercially available 2-meter horizontally polarized loop antennas available, all under $100, including some coax cable," comments Julian Frost, N3JF. Here are some of Julian's favorites:

M[2] antennas: on the web <http://www.m2inc.com>
KB6KQ loop: e-mail <kb6kqnorm@aol.com>
Olde Antenna Lab loop: phone 303-841-1354
PAR Electronics omniangle loop: on the web <http://www.parelectronics.com>
Tillo-Currie Big Wheel antenna: phone 734-668-8696
KU4AB loop: on the web <http://www.ku4ab.com>; phone 901-270-8049

How well do these commercially manufactured horizontal loop antennas work? Three years ago, Chip Margelli, K7JA, and I conducted multiple seaside loop tests. We concluded that commercial manufacturers of loops did their homework to achieve a 50-ohm match, minimum nulls, and good mechanical stability.

"While we did see a modest increase in signal strength by stacking a pair of loops, the single loop, horizontally polarized, was light years better than trying to operate cross-polarized with a whip to a distant station horizontal on SSB," comments Margelli, noting the biggest range expansion for SSB operation is similar horizontal polarization. Chip also points out the popularity of single loop antennas tied into mountaintop 2-meter and 70-cm propagation beacons throughout the United States. Under good conditions, a single horizontal loop to a 10-watt transmitter gets received hundreds of miles away!



Tillo-Currie's Big Wheel matching "hairpin" shunt.

Many commercially manufactured loops consist of a square, round, or triangular half-wavelength radiating element, matched either at the feedpoint as a closed loop, or matched opposite the feedpoint with open-air critical capacitive tuning, between 2 and 5 picoFarads.

"It's important to examine the feedpoint matching network to make sure there are no open elements that could be contaminated with dirt or snow," adds Frost, N3JF. "Consideration must also be given to any outside mounting in the wind where rod loop rigidity is important," pointing out the solid rod construction of Phil Brazzell's horizontal omnidirectional antennas, including the most unique dual-band horizontal loops with a single feed line (www.ku4ab.com).

When suggesting that newcomers go to SSB using a horizontal loop, it is important to tell them to first get the loop, and then purchase very large feed line—e.g., Belden 9913, or LMR 400 as a minimum.

"New hams may not realize the losses associated with RG-58 and RG-8X coax cables at frequencies above 50 MHz. Their SSB signals are just terrible, because they're running over 100 feet of the small stuff," comments Ken Neubeck, WB2AMU, author of several books on VHF and UHF operation.

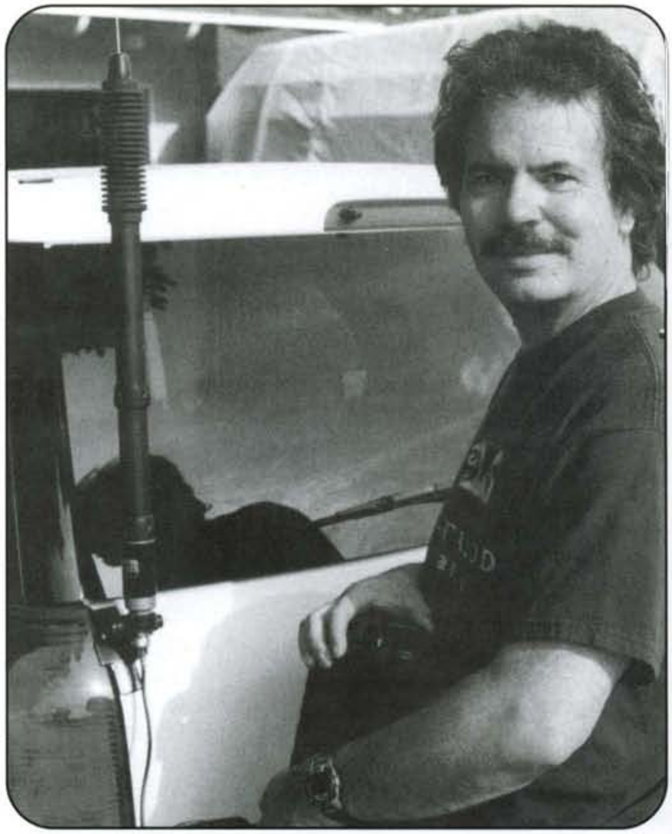
"It's not that they couldn't have run larger coax, it's just that the newer operator who has always been on FM with small coax doesn't realize the requirement for big coax," adds Neubeck, suggesting LMR-400 for runs as short as 25 feet away. Since the loop is essentially 0 dB in all directions, coax loss must be kept to an absolute minimum.

Also, older 2-meter SSB transceivers may lack a hot front end, so an added bonus would be an RF switching preamplifier, such as the SP-144 VDA from Advanced Receiver Research. This hot 15-dB receiver preamp goes down at the rig, not outside. Other ARR mast-mount preamps are available, but for the new ham, running the preamp down below with top-quality coax will certainly get them started big time on 2-meter SSB.

A slight amount of gain is achieved by stacking the loops, and a slight increase in gain is also achieved by going to a physically larger, one-wavelength loop, sometimes called "Big Wheel." Many times the "Big Wheel" is matched with a "hairpin match," and this matching system brings the feed point close to 50 ohms and provides a shunt to bleed off wind static when the loop is mounted outdoors.

Norm Pederson, KB6KQ, points out that since Hurricane Katrina he has had several EOC managers contact him and buy a stack of his loops in order to extend the coverage range of their stations when weather takes out local repeaters. He adds, "VHF SSB range is much better than repeaters, and the EOC guys are beginning to find that there are enough VHF SSB people around such that it pays to have SSB capability in an emergency."

Horizontal loop antennas are an ideal way to bring more FM operators over to the excitement of weak-signal SSB and CW. Many new hams are purchasing equipment that has General class HF features with plans to ultimately upgrade. These rigs normally incorporate 2 meters and 440 MHz multimode. What better time than now to get these hams involved in weak-signal work using SSB, tied into an inexpensive, elevated, well-fed loop antenna as high up in the air as possible. ■



Chip Margelli, K7JA, prepares for loop antenna tests at the beach.

Chip Margelli, K7JA, and WB6NOA conducted multiple loop tests at the beach several years ago. One of the antennas tested was on top of the communications van, shown here.

By Dr. H. Paul Shuch,* N6TX

THE ORBITAL CLASSROOM

Furthering AMSAT's Mission Through Education

Coordinating the Effort

Having recently retired for the second time (the first retirement, in 2004, was from academia; the second, just recently, from industry), I was very pleased to accept appointment to the post of Director of Education for AMSAT-NA. This new column, which will appear from time to time in *CQ VHF*, is derived from material prepared for the *AMSAT Journal*, and appears here by the kind permission of AMSAT. I hope it will serve as a constructive forum for sharing educational resources, and thus furthering AMSAT's educational mission.

Since its inception nearly four decades back, AMSAT has taken on an important role: bringing satellite technology into the classroom. Through our various OSCARs, SAREX, ARISS, and participation in the Cubesat program, many of us have exploited the mystique of space to captivate the interest and imagination of our students. However, we have not always done so in a coordinated manner. Coordination is a skill I most hope to bring to my new assignment.

My first priority as AMSAT Director of Education will be to promote integrated curriculum development at all levels (kindergarten through PhD), with emphasis on using satellites in the classroom to enhance the teaching of science, math, geography, social studies, technology, and the social sciences. To accomplish this, I have turned to the AMSAT membership to lend what significant resources and expertise already exist within our organization. I invite all teachers within AMSAT to share with me their current, past, or planned use of satellites in the classroom, their instructional materials, and their desires in terms of future curricular development. All current or former professional teachers, curriculum developers, and school administrators within AMSAT's ranks are invited to sign up as official AMSAT Educators (sign-up instructions will appear in the Orbital Classroom section of the AMSAT website). You will receive not only a nice certificate, but an opportunity to contribute materially to a coordinated and redoubled AMSAT educational effort.

I respectfully suggest that one key aspect of doing anything in the U.S. educational arena is a need for those efforts to be tied to the federal No Child Left Behind act, as well as the published educational competencies and graduation standards established by the various states. I hope to work together with our cadre of AMSAT Educators to evaluate the competencies and standards in force in the individual states so that our curriculum efforts can tie in to them to the greatest possible extent. Of course, we being AMSAT NA, I rely upon the expertise of our Canadian and Mexican AMSAT Educators to bring me up to date on the educational standards and curriculum requirements throughout the rest of North America.

One area in which AMSAT already has a rich history of educational activities is human spaceflight, most recently through the ARISS Program. I would not presume to modify these existing programs in any way. However, ARISS contacts should not be an end unto themselves. ARISS generates a great deal of enthusiasm, leading up to a contact with the astronauts on the International Space Station. Coordinating closely with Frank Bauer, KA3HDO, AMSAT VP for Human Spaceflight, I will be seeking ways we can encourage ARISS schools and teachers to take the next step, with programs to leverage that enthusiasm into an ongoing interest in math, science, and amateur radio.

Another key area of attention for me as the new Director of Education will be Cubesats. There is a definite educational mission in satellite construction, which goes far beyond the production and launch

(Continued on page 36)

The first-ever back-to-back ARISS QSOs took place on February 7, 2006. The first was with the Dale, Oklahoma public schools. The second was with the DeGolyer Elementary School, Dallas Texas. Students from the Dale school, plus others, are shown here gathered to listen to Expedition 12 Commander Bill McArthur, KC5ACR, respond to the DeGoyler school students' question. ARISS QSO mentor Keith Pugh, W5IU, is at the controls of the Dale ham radio station. (N6CL photo)

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By Kent Britain,* WA5VJB

ANTENNAS

Connecting the Radio to the Sky

GPS Antenna Project

There have been a couple of requests for a GPS (global positioning system) antenna construction project, but I am not sure how much it will help many of you. The problem is that those expensive little external antennas for your GPS receiver contain a high-gain, low-noise preamp. This preamp has been designed to work with the control voltage your GPS receiver sends back up the coax. I am unaware of any universal design for GPS antennas with integral preamps.

Shown in photo A is the ceramic element from an external GPS patch antenna. The dielectric constant of the ceramic material greatly reduces the size of the antenna. The trimmed corners create an imbalance in the patch, which gives you circular polarization. If you don't trim off enough from the corners, the polarization will be more vertical than horizontal. If you trim off too much, the polarization will be more horizontal.

For our prototype, the dimensions for the patch were tweaked on a network analyzer and the corners were trimmed for circular polarization on the antenna range (figure 1). Since I am using air dielectric, the antenna is much larger than the ceramic version.

Normally, we would have a much bigger ground plane under the patch. However, for GPS most of the birds are near the horizon, so we don't want the higher gain of a large ground plane. Again, the corners were trimmed to make the patch circularly polarized.

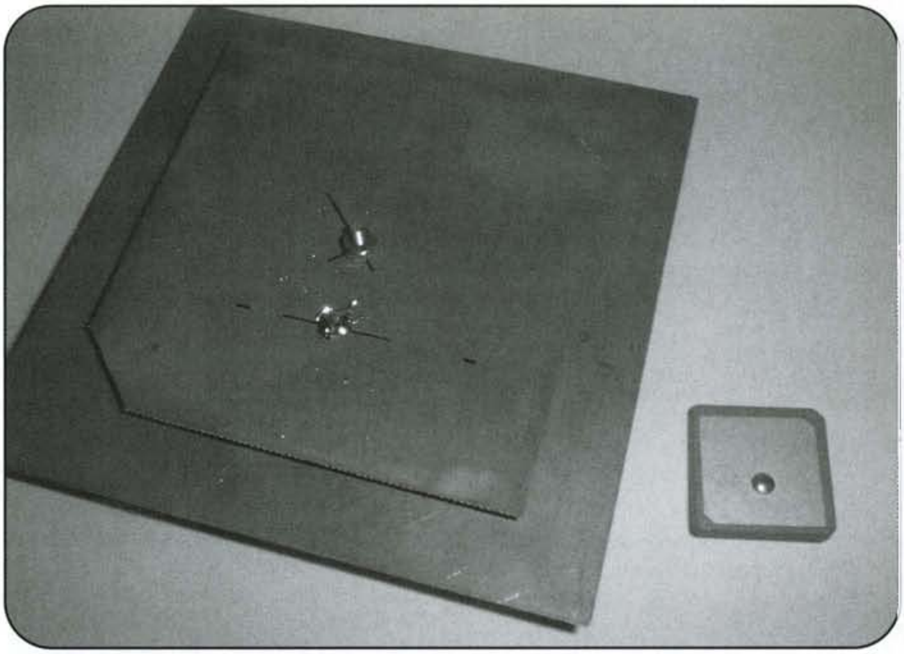

Photo A. Ceramic and homebrew GPS receivers.

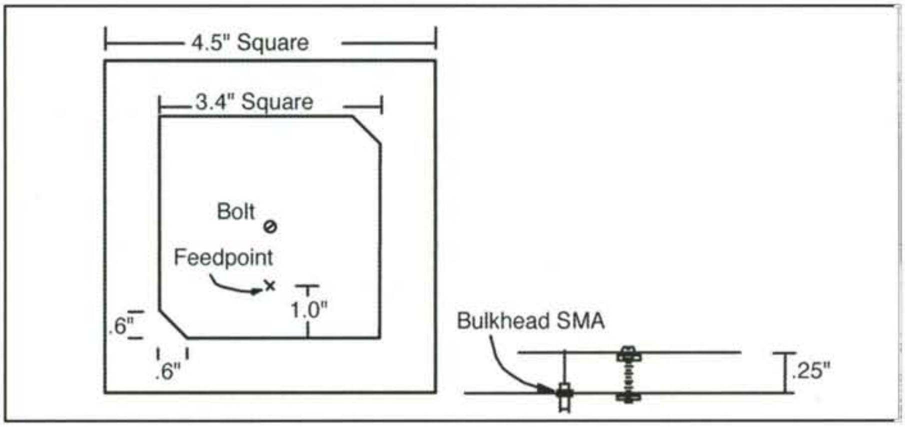

Figure 1. Dimensions for the patch antenna.

Construction

I used double-sided .031-inch PC board, but sheet brass or sheet tin would work just as well. You can use aluminum, or most any sheet metal for the base, but it's a lot easier if the patch is made out of something you can solder, too.

The very center of the patch is a null point. I used a 4-40 screw as the patch support, but if for some reason you need the patch to be electrically isolated, a plastic screw could be used, or the patch just could be supported on a small block of plastic. Again, the very center is a voltage null point, like the center of a Yagi antenna element.

The corners are cut for receiving GPS signals. If you are building a GPS simulator and want to transmit to a GPS receiver, you need to reverse the circular polarization. In this case, just trim back the opposite corners off the patch .6 inch.

Feedpoint

For this antenna the impedance at the edge of the patch was a bit over 150 ohms. By definition, the center of the patch is zero ohms. The impedance curve is not

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Photo B. A 5.8-GHz omni antenna, also known as a collinear-coaxial array.

exactly a straight line, but with a little experimentation, the 50-ohm point was right at 1 inch from the edge.

This should be an interesting project for those of you with specialized GPS antenna needs.

Neat Antennas

I was asked to make some measurements with a 5.8-GHz omni antenna (photos B and C). Known as a *collinear-coaxial array,* it starts out as a 1/4-wave section and ends with a 1/4-wave section, with alternating 1/2-wave sections in the middle. The RF energy goes through the inside of the coax, and then on the outside of the coax. When the RF energy is on the outside of the coax, it behaves like a 1/2-wave dipole. Stack up a bunch of them, and you have a collinear array made of out sections of coax. The one shown is a commercial version; it is neatly engineered, in that two pieces of brass and one piece of Teflon® are used to make virtually the entire antenna.

Some similar antenna construction projects with claims that defy physics are floating around on the internet. The first problem is power distribution. In theory, making a vertical collinear array twice as long gives you 3 dB more gain. However, if you are using a coax power divider, then you have at least twice as much coax. Loss in the coax means you are going to be lucky to get 2 dB gain. (Commercial guys who are using 6-inch EIA flanges are in a different league!)

With this kind of vertical collinear the first section gets all the power, the second section gets less power because some has already been radiated, and so on and so on. Thus, the top section does not get its share of RF power and gain is not as high as might be realized. Make the antenna with twice as many sections, and this problem becomes even worse. There is not much RF left at the end of two dozen sections. Therefore, doubling the number of sections does not give you 3 dB more gain, even with low-loss coax.

With really long versions you have another problem they like to leave out. . . .

Beam Tilt

On the design frequency the waves are in phase at each element and the maximum signal is 90 degrees to the antenna (figure 2). Change frequency, though, and the angle changes. Go up in frequency and the beam tilts downward. Go down in frequency and the beam tilts upward. While the antenna may have a good SWR at 5.8 GHz and 5.2 GHz, only one of these frequencies will be towards the horizon with a really long vertical collinear. Very, very few of the vertical collinears I have tested had the design frequency 90 degrees to the antenna. You have to measure distances very carefully and know the velocity factor of your coax when the antenna is made up of more than a few sections. Even then, it takes a couple of tries to get it right.

Letters

A comment to Terry: Sorry, but I have no plans to publish any J-pole antenna designs, as I feel that area has been thoroughly covered.

From Indiana there was a question of using other driven elements with Cheap Yagis. The short answer is "not with the published dimensions." The driven element impedance of the J element is near 150 ohms. By using the loading effect of the reflector and directors, the impedance is pulled down to 50 or 72 ohms. This makes it practical to just solder coax directly to the driven element. If the driven element is 72 ohms for a regular dipole—or, say, 300 ohms for a folded dipole—you will not get a good impedance match to the coax using Cheap Yagi dimensions. That is, the antenna will have a high SWR. The idea of employing the same technique of using the structure of the Yagi itself for impedance matching can be applied to other driven elements. You just have to re-calculate all the lengths and spacings of the other elements.

Cheap Yagis Website

My original 1994 paper on building Cheap Yagis has been updated a bit and is available as a download from my website, <www.wa5vjb.com>. Look in the reference section. Some other good papers are there as well, and I'm adding more all the time.

Please keep those e-mails coming! I'm always looking for project ideas.

73, Kent, WA5VJB

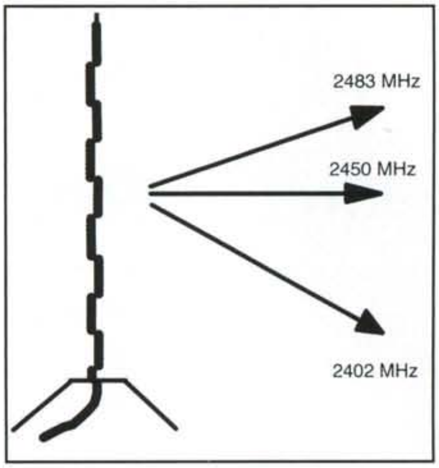

Figure 2. Side view of the antenna.

THE ORBITAL CLASSROOM

(from page 31)

of a payload. We should be seeking to find a way to get satellite builders talking to satellite users, in an educational setting. It is my hope that, by finding specific educational applications of existing and planned small satellites, and by providing proper training to satellite developers, we will get them fired up about supporting the classroom use of their creations.

AMSAT has a proud history of both technical and educational accomplishment. With the help of satellite enthusiasts everywhere, we can make great strides. I thank AMSAT president Rick Hambly, W2GPS, and his senior leadership team, for providing me with this opportunity to further serve an organization that has been near and dear to my heart for three and a half decades (which, incidentally, is about as long as I taught). I thank *CQ VHF* editor Joe Lynch, N6CL, for providing me with this bully pulpit from which to preach satellites in education. And finally, I thank *AMSAT Journal* editor Ed Long, WA4SWJ, for his kind permission for *CQ VHF* to reproduce some of my *AMSAT Journal* material. With their help, I'll certainly not be bored in my second retirement!

73, Paul, N6TX

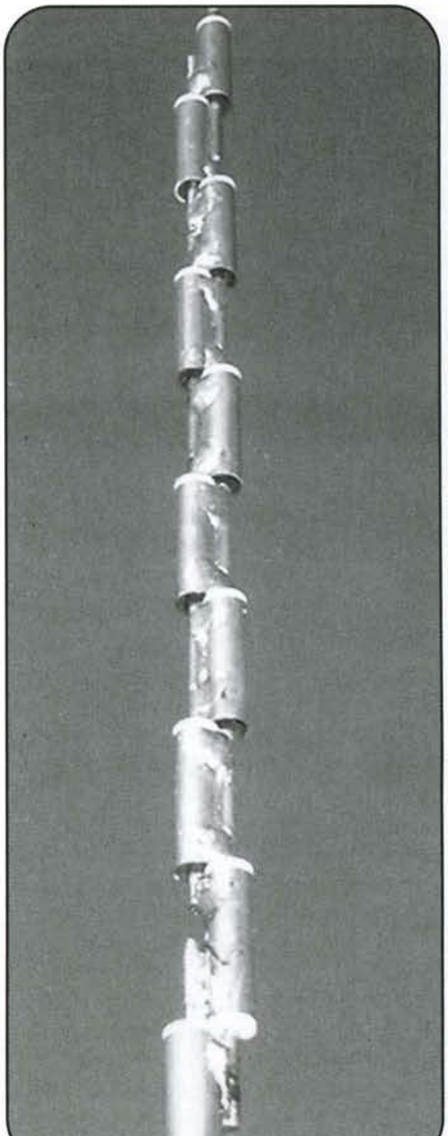

Photo C. Close up of the 1/2-wave elements.

D-STAR Test Results with FEMA and the US Army

Last year's devastating hurricanes revealed huge problems with communications integration. Here N9JA reveals how ICOM's D-STAR could be used as a possible solution.

By Ray Novak,* N9JA

I want to share with you information from our demonstration for FEMA and the US Army. I think it is about time to let the cat out of the bag.

Early in 2006, ICOM and several other vendors were asked to participate in a demonstration for FEMA and the US Army. The demonstration was designed to illustrate possible solutions to some of the communications issues experienced during the responses to Hurricanes Katrina and Rita last year.

In mid-February, the vendors and some volunteers gathered discretely to show the capabilities of an integrated communications design that included high-speed network connectivity via satellite, multiple mechanisms to transport network data, WiFi, and interconnected voice capabilities via VoIP, standard FM, and digital voice with D-STAR. The premise of the exercise was to illustrate a group of first responders actually being deployed, then having that team relay vital tactical and strategic information to other team members hundreds to thousands of miles away, and provide a seamless integration of this information into existing networks. The operation required full integration of voice and data networks, along with adding significant data capability to individuals in the response team.

While there were many items covered in our demonstration, I will focus just on the amateur radio portion of this demonstration.

Demonstration Overview: Both tactical and strategic communications relayed to the proper authorities through an integrated voice and data network.

Long-Haul Communications: For the long-haul communications, both FEMA and the US Army requested that our focus shift from HF to new and more robust communication methods. One comment that was made during the demonstration was "Why say it, when you can send it?" This underscored the importance of concise, accurate communications capabilities.

Thus, the primary focus was data, data, and more data. The government agencies obviously have satellite data solutions. The most recent solution to come on line is Hugh's R-BGAN Satellite solution. For those who are interested, there is a great resource of information on the R-BGAN technology at: <http://www. aosusa.com/bgan.html>.

With the bandwidth that was available with the R-BGAN technology, there was a lot of normal, everyday type communications being provided via network as well as VoIP communications. I realize that none of this really pertains to amateur radio, but this needs to be shared here so you see how D-STAR integrated seamlessly into the local communications network.

Now to the core of the D-STAR demonstration! There were some specific requests from FEMA and the US Army that needed to be addressed for the first responders. Here are some of them, and how we were able to immediately meet the requirements with D-STAR's simultaneous voice and data capabilities:

• First responder communications identification: D-STAR's Automatic Callsign TX with voice communications.

• First responder location (when landmarks are either below water level or no longer standing): D-STAR GPS/callsign along with voice communications.

• First responder assessment data: Transmission of data files using same-site repeater structure as voice communications.

• Last mile (really 30 mile) data coverage: Combination of 1-kbps and 128-kbps data.

1 kbps = small data files from "in-field" responders

128 kbps = mobile officials retain data connectivity for e-mail or WLAN network

128 kbps = level 2 communications networks outside WiFi range (connected to SATCOM data)

While some laughed at the 1-kbps data, it was really effective in moving FEMA incident-type reports. What we did was store the data locally, and then push a CSV file over the 1-kbps data stream. Once the file was received, the server expanded and populated a website with the details.

From the comments heard at the exercise, it was apparent that our traditional thoughts of providing "out of area" communications with HF should shift to providing "in-area" augmentation of data and voice capabilities. These functions won't replace our existing agreements and relationships with served agencies, but if we can add these new capabilities to our offerings, our services become much more attractive to some of the federal agencies.

We all agreed that the exercise was a huge success. While we can't share any of the specific details about the exercise and we don't know anything about future government directions, we do know that there is significant interest in expanding data communications capabilities for emergency communications. We were proud to be able to quickly respond and satisfy the requirements of the exercise organizers. We successfully demonstrated the capabilities of both the D-STAR technology and the spirit of the amateur radio community.

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By Tomas Hood,* NW7US/AAA0WA

PROPAGATION

The Science of Predicting VHF-and-Above Radio Conditions

The Cycle Minimum is Here
Cycle 24 Predicted to be the Best in 50 Years!

The start of the solar Cycle 23 minimum has officially been declared, signaling the fast approach of the end of the roughly 11-year sunspot cycle. Most likely, the end of the current cycle will be in December 2006, with the start of Cycle 24 occurring in January 2007.

The official declaration of the arrival of solar minimum was made by NASA, whose solar scientists believe that we're now witnessing the ending of the current sunspot cycle. This assessment is based on the frequent longer periods of solar calm, when for many days at a time the sun has no visible sunspots. The first of these significantly long periods of total solar quiet was the 10-day run starting on January 29, 2006, when there were no sunspots on the visible sun. Nearly the entire month of February passed without sunspots, too. There were sunspots on only nine days in February. During solar minimum whole months can go by without a single sunspot.

February 2006 was the first month in almost ten years with mostly no sunspots. We can now expect this situation to continue for the rest of 2006, until the next cycle, solar Cycle 24, fires up.

Without any significant sunspot activity, there's very few, if any, solar flaring or coronal mass ejections. When sunspots develop, they tend to be small and not very complex, triggering only minor flares which rarely exceed the C-class X-ray classification. This low solar activity means that VHF radio propagation via the *F*-layer is non-existent, because the ionosphere can only refract radio signals when it is energized by solar energy.

In May, and during the rest of the year, we still may have occasional sunspots and solar flares. During the first week in April 2006, for instance, we saw *K*-index readings of 6, indicating significant geomagnetic activity. This storm-level geomagnetic activity triggered a bit of aurora, which could have been enough to support aurora-mode propagation and sporadic-*E* propagation via the auroral ionization. During this same period in April, the 10.7-cm flux readings reached 100.

Historically, during each of the last three solar cycle minima in 1976, 1986, and 1996, the sun unleashed at least one X-class flare and produced at least one giant sunspot. However, the overall condition is a very quiet sun. Perhaps we're in store for a surprise event that could wake up VHF activity during this period (May, June, and July).

Solar Cycle 24—The Best in 50 Years

In March 2006, a team led by Mausumi Dikpati of the National Center for Atmospheric Research (NCAR) announced that the new solar Cycle, the 24th since sunspots were faithfully recorded, will be the most intense solar maximum in 50 years. Researcher Dikpati says, "The next sunspot cycle will be 30 percent to 50 percent stronger than the previous one." If this prediction is correct, the solar activity in just a few years will be second only to the historic solar cycle maximum of 1958.

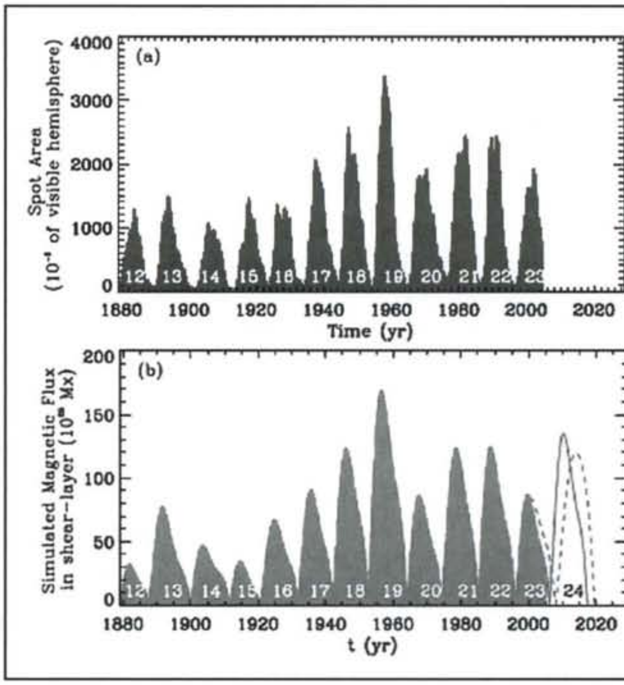

Figure 1. (a) Observed spot area (smoothed by Gaussian running average over 13 rotations) plotted as function of time. (b) Simulated toroidal magnetic flux in the overshoot tachocline within mid-latitudes for the case with a steady meridional flow (solid red area and curve) and with the time-varying flow incorporated since 1996 (dashed red curve). (Source: "Predicting the strength of solar cycle 24 using a flux-transport dynamo-based tool," by Mausumi Dikpati, Giuliana de Toma, and Peter A. Gilman, in Geophysical Research Letters, Vol. 33, L05102, doi: 10.1029/2005GL025221, 2006)

Veteran amateur radio operators remember that cycle. The solar activity was so strong that aurora was sighted three times in Mexico. Propagation on 6 meters and higher was open worldwide and for great lengths of time.

The NCAR team's prediction is unprecedented, and goes against the prevailing predictions, such as the popular forecast based on a precursor method. The precursor method predicts

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solar Cycle 24 will be considerably smaller than Cycle 23. In nearly two centuries since the 11-year sunspot cycle was discovered, scientists have struggled to predict the size of future maxima. Every time, they mostly failed. The new prediction is based on a flux transport dynamo model, which has the ability to correctly "forecast" the relative peaks of cycles 16 through 23, using sunspot area data from previous cycles.

Various methods of predicting the properties of an upcoming solar cycle that use old cycle data have been attempted since 1978. A particularly popular current method involves the use of polar fields from previous cycles as ''precursors'' of the next cycle.

The new method has been demonstrated to reproduce many solar cycle features, and is now considered the most reliable and accurate way of predicting the intensity and nature of the next sunspot cycle. The dynamo-based scheme of a group of researchers (K. H. Schatten, P. H. Scherrer, L. Svalgaard, and J. M. Wilcox, in their research paper entitled, "Using dynamo theory to predict the sunspot number during solar cycle 21," published in *Geophysical Research Letters,* Volume 5, pages 411–414) attempted to make a physical connection between the strength of an upcoming sunspot cycle and the previous cycle's polar fields, assuming that there is a ''magnetic persistence'' between these two. This ''magnetic persistence'' was based upon a relation between the surface polar fields and the spot-producing toroidal fields, generated by differential rotation shearing (the W-effect). Implicit in this ''dynamo based'' approach is that the polar fields of the previous cycle can be sheared by the solar differential rotation in time to produce toroidal fields of the new cycle.

Digging into the 1978 model, the NCAR team asked questions that finally led them to reveal that the sun has a memory about its past magnetic fields, a memory that spans at least 17 to 21 years.

The key to the mystery is a conveyor belt on the sun consisting of electrically conducting gas. We have something similar here on Earth, known as the Great Ocean Conveyor Belt. It is a network of currents that carry water and heat from ocean to ocean.

The sun's conveyor belt is a current that flows in a loop from the sun's equator to the poles and back again. Just as the Great Ocean Conveyor Belt controls weather on Earth, this solar conveyor belt controls weather on the sun. Specifically, it controls the sunspot cycle.

Solar physicist David Hathaway of the National Space Science & Technology Center (NSSTC) explains: "First, remember what sunspots are—tangled knots of magnetism generated by the sun's inner dynamo. A typical sunspot exists for just a few weeks. Then it decays, leaving behind a 'corpse' of weak magnetic fields."

Hathaway explained how "the top of sun's conveyor belt skims the surface of the sun, sweeping up the magnetic fields of old, dead sunspots. The 'corpses' are dragged down at the poles to a depth of 200,000 kilometers, where the sun's magnetic dynamo can amplify them. Once the corpses (magnetic knots) are reincarnated (amplified), they become buoyant and float back to the surface." And that's how we get new sunspots.

All this happens with massive slowness. "It takes about 40 years for the belt to complete one loop," says Hathaway. The speed varies "anywhere from a 50-year pace (slow) to a 30-year pace (fast)."

When the belt is turning "fast," it means that lots of magnetic fields are being swept up, and that a future sunspot cycle is going to be intense. This is a basis for forecasting: "The belt was turning fast in 1986–1996," says Hathaway. "Old magnetic fields swept up then should re-appear as big sunspots in 2010–2011."

Like most experts in the field, Hathaway has confidence in the conveyor-belt model and agrees with Dikpati that the next solar maximum should be quite active (see figure 1). However, he disagrees with one point: Dikpati's forecast puts the next solar maximum at 2012. Hathaway believes it will arrive sooner, in 2010 or 2011.

Either way, it is clear from current observations that solar Cycle 23 is at its end, and for the rest of 2006, we're in for mostly quiet solar activity. With that, we see very little higher frequency propagation except that occurring via sporadic-*E*, tropospheric ducting, and other non-*F*-layer propagation.

Aurora and Sporadic-Aurora-*E*

We are still seeing moments when coronal holes trigger geomagnetic disturbances, such as the one during the beginning of April 2006. The frequent occurrence of coronal holes may bring brief moments of life to 6 meters. Watch the spots on the OH2AQ DX Summit <http://oh2aq.kolumbus.com/dxs/> if the *K*-index rises above 5. If such a period of geomagnetic activity occurs, aurora-mode propagation (*Au*) as well as sporadic-Aurora-*E* (*Au-Es*) (like sporadic-*E*, except caused by highly ionized patches at the *E*-layer height caused by auroral activity) may provide the opportunity for North American VHF operators to engage in quick QSOs.

Sporadic-*E*

Sporadic-*E* propagation is an exciting but mostly unpredictable mode related to "clouds" of highly ionized, dense, small patches in the *E* region of the ionosphere. Ten-meter operators have known *Es* propagation as the summertime "short skip." These "clouds" appear unpredictably, but they are most common over North America during the daylight hours of late spring and summer. *Es* events may last for just a few minutes up to several hours, and usually provide an opening to a very small area of the country at any one time.

During periods of intense and widespread sporadic-*E* ionization, two-hop openings considerably beyond 1400 miles should be possible on 6 meters. Short-skip openings between about 1200 and 1400 miles may also be possible on 2 meters.

How can we know when a sporadic-*E* opening is occurring? Several e-mail reflectors have been created to provide an alerting service using e-mail. One is found at <http://www.gooddx.net/> and another at <http://www.vhfdx.net/sendspots/>. These sporadic-*E* alerting services rely on live reports of current activity on VHF. When you begin hearing an opening, you send out details so that everyone on the distribution list will be alerted that something is happening. They, in turn, join in on the opening, making for a high level of participation. Of course, the greater the number of operators on the air, the more we learn the extent and intensity of the opening. The bottom line is that you cannot work sporadic-*E* if you are not on the air when it occurs.

In addition to live reporting, there is a very powerful resource available on the Internet. Check out <http://superdarn.

jhuapl.edu/>. SuperDARN (Super Dual Auroral Radar Network) is an international radar network for studying the Earth's upper atmosphere and ionosphere. Using the SuperDARN real-time data 24-hour overview, you can view the day's ionization activity at the northern polar region. You can also view live radar displays of the same area. These graphs help identify *Es* clouds existing in the higher latitudes. One use for this would be the detection of a variation of *Es*, known as Auroral-*E*.

For a great introduction to mid-latitude sporadic-*E* propagation, visit the AM-FM DX Resource website <http://www.amfmdx.net/propagation/Es.html>.

Tropospheric Ducting

Scattered reports of some very strong tropospheric openings have been made during April (corresponding to severe spring weather), but we don't typically see widespread tropospheric ducting until summer. In tropospheric ducting, radio waves are trapped in a type of natural wave-guide between an inversion layer and the ground or between two inversion layers. Ducting causes very little signal loss and often signals are only heard at each end of the wave-guide. Ducting via the troposphere can propagate signals great distances, for instance from Hawaii to California. This ducting depends on large weather systems, however, that are more common during the late summer. With the early reports, though, it is worth watching for this mode of propagation. The summer weather season may well be violent and eventful.

Advanced visual and infrared weather maps can be a real aid in detecting the undisturbed low clouds between the West Coast and Hawaii or farther during periods of intense subsidence-inversion band openings. This condition also occurs over the Atlantic. There is a great resource on the Internet that provides a look into current conditions. Bill Hepburn has created forecast maps and presents them at <http://home.cogeco.ca/~dxinfo/tropo.html>, which includes maps for the Pacific, Atlantic, and other regions.

If you know that conditions are favorable for tropospheric ducting in your area, try tuning around the 162-MHz weather channels to see if you can hear stations way beyond your normal line-of-sight reception. It is possible to hear stations over 800 miles away. Amateur radio repeaters are another source of DX that you might hear from the other end of the duct.

These openings can last for several days, and signals will remain stable and strong for long periods during the opening. The duct may, however, move slowly, causing you to hear one signal well for a few hours, to then have it fade out and another station take its place from another area altogether.

Meteor Showers

The *Eta Aquarids* meteor shower will occur in May. The *Eta Aquarids* will peak on the morning of May 6, but start around April 21, 2006. This shower is expected to have a peak rate of up to 60 per hour this year. It is expected that this shower will have a broad period of maximum activity, starting as early as May 3 and extending out to May 10. Also, because of the low radiant, the meteors tend to have long ionized paths, making for strong signal reflections. Look for 6- and 2-meter openings off the ionized meteor trails.

June may have a strong shower, the *Boötids*. This shower is active from June 26 through July 2, with the peak occurring on June 27 at 1400 UT. The hourly visual rate can reach as high as 100 or more. Following its unexpected return in 1998, when the hourly visual rate was between 50 and over 100 for more than half a day, this shower is worth watching for. Another occurrence of significant activity with an hourly visual rate between 20 and 50 was observed in 2004. The shower was from Comet 7P/Pons-Winnecke, which has an orbit that now lies around 0.24 astronomical units outside the Earth's at its closest approach.

July has only minor showers. These showers have not typically yielded much radio activity. For more information on these, take a look at <http://www.imo.net/calendar/2006/>.

Trans-Equatorial Propagation

A seasonal decline in transequatorial (TE) propagation is expected during May. An occasional opening may still be possible on VHF. The best time to check for VHF TE openings is between 9 and 11 PM local daylight time. These TE openings will be north-south paths that cross the geomagnetic equator at an approximate right angle.

The Solar Cycle Pulse

The observed sunspot numbers from December 2005 through March 2006 are 41.2, 15.4, 4.7, and 10.8. The smoothed sunspot counts for June through August 2005 are 28.9, 25.9, and 27.5.

The monthly 10.7-cm (preliminary) numbers from December 2005 through March 2006 are 90.8, 83.8, 76.6, and 75.5. The smoothed 10.7-cm radio flux numbers for June through August 2005 are 91.9, 87.8, and 89.3.

The smoothed planetary *A*-index (*Ap*) numbers from June through August 2005 are 13.9, 11.8, and 12.2. The monthly readings from December 2005 through March 2006 are 7, 6, 6, and 8. These are significantly quieter than last year.

The smoothed monthly sunspot numbers forecast for May through July 2006 are 11.1, 9.1, and 7.2, while the smoothed monthly 10.7-cm is predicted to be 75.0, 73.4, and 71.9 for the same period. Give or take about 12 points for all predictions (yes, that means that the smoothed sunspot figures could be zero for any of these months, since we are now at solar cycle minimum). Note that these are preliminary figures. Solar scientists make minor adjustments after publishing, by careful review.

Feedback, Comments, Observations Solicited!

I am looking forward to hearing from you about your observations of VHF and UHF propagation. Please send your reports to me via e-mail, or drop me a letter about your VHF/UHF experiences (sporadic-*E*, meteor scatter . . .). I'll create summaries and share them with the readership. I look forward to hearing from you.

You are welcome to also share your reports at my public forums at <http://hfradio.org/forums/>. Up-to-date propagation information is found at my propagation center, <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

By Del Schier,* K1UHF

AIRBORNE RADIO

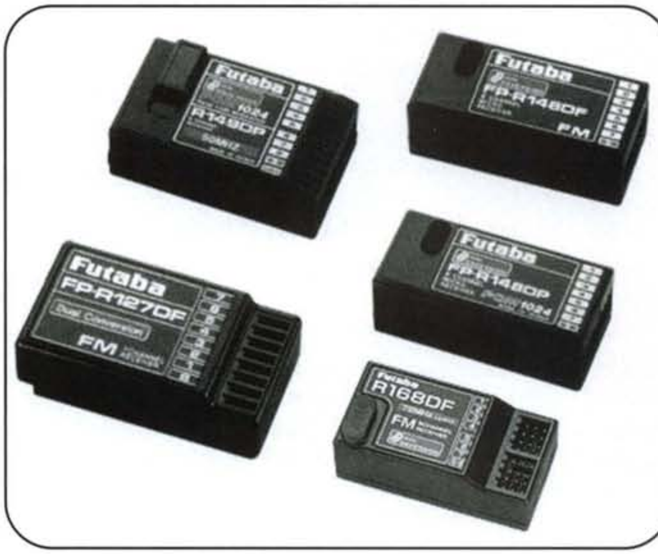
Using Amateur Radio to Control Model Aircraft

Radio Systems

This time I will cover RC (radio control) radios, the transmitters and receivers. There is no such thing as an RC transceiver . . . well, not quite. There are transceivers. More on their unique features will be found below. Normally, the transmitter, the part with the controls, is in your hands, while the receiver is in the airplane. The receiver controls the servos, which in turn control the airplane. The servos, in turn, are linked back to your fingertips with proportional control.

Many years ago I remember seeing old-time RC equipment at the ARRL museum. I don't think it is on exhibit any more. However, I couldn't get over how big and heavy everything was. The transmitter was a big wooden box, with a stick and a couple of switches, along with legs to support the transmitter on the ground. The airborne equipment, even with the relative lightness of subminiature tubes, was nevertheless weighted down by filament and plate batteries, requiring a big airplane to carry everything aloft. My first radios, made by Futaba™ and Kraft™, were in aluminum boxes that looked like standard Bud™ mini boxes. Now they look like something from *Star Wars.*

Today's RC radios are as modern as any other type of electronics, with digital technology adding endless features. Choosing your first RC radio equipment can be confusing, so here are the basics.



Futaba 6-meter receivers come in various sizes and levels of performance.

The Basics

RC transmitters and receivers are primarily classified by the number of channels they have, but there is much more. When I speak of channels, I refer to the number of control channels that the radio controls, rather than the frequency channel. To begin, you probably will need only three channels—one each for throttle, elevator, and rudder. It is hard to find a three-channel system. Even so, you should start out with more so that you can graduate to more sophisticated airplanes. To fly on the 6-meter ham band, you have no choice because the commercially available 6-meter radios all have seven or eight channels.

Manufactures that supply 6-meter transmitters and receivers include Futaba, JR, and Airtronics™. They only offer 6 meters

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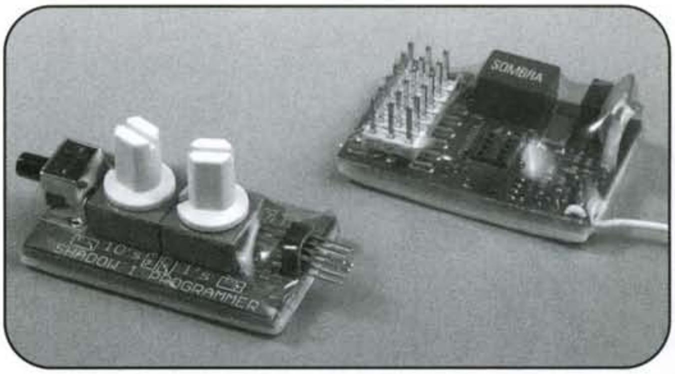
Airtronics 6-meter transmitter modules which plug into the back of the company's transmitters.

The RC equivalent of an IC-7800 or FT-dx9000.

A JR 9303 transmitter, near top of the line, but affordable.

A module-equipped Airtronics transmitter.



The micro Sombra with programming module.

in transmitters that have a plug-in transmitter module, a small RF deck that plugs into the back of the transmitter. These transmitters are their better versions, but they are relatively inexpensive. I purchased a used JR X347 module radio in perfect condition for $75 at the local hobby shop. My best new radio, a JR 8103, was $300. Both radios have about all the features an advanced modeler would need.

Anything but a very entry-level RC transmitter will be a "computer radio." Computer radios allow you to do things with RC airplanes that full-size airplane designers only wish they could do. A modern RC transmitter has functions similar to what a fly-by-wire Airbus or jet fighter might have.

Computer radios allow you to control everything any way you wish. In the U.S. (mode II system), the right stick usually controls elevator and ailerons, just like a real airplane stick. The left stick's up and down directions control the throttle. The left and right directions control the rudder. Note that simple airplanes without ailerons use the right stick, aileron channel, to control the rudder. Simple rudder-and elevator-only airplanes will roll right and left with rudder input due to dihedral in the wing.

Those are the basic controls. What about the other knobs and switches? Slider controls that are located alongside and below the sticks are "trim" adjustments. These trims function the same as trim controls in a full-size airplane—that is, they control how the airplane flies hands off.

The trim levers are especially important on a first flight with a newly built airplane. If the airplane was not built or designed correctly, the trims make it possible to quickly set the airplane to fly hands off. It is very difficult to hold the sticks to one direction to keep the airplane level. Therefore, the trims take care of that problem. Trims can also be set for landing, descent, or other modes of flight.

Most modern radios have something called "trim memory." Once you find the best trim settings for a plane, the radio will remember them. Then on the next flight the trim sliders can be centered. Most trims move a potentiometer, but some radios have digital trims that audibly beep their settings.

Depending on what you want your airplane to do, other switches can be used. The other controls may be customized to do different things, depending on how you program the radio. A switch can set the airplane for landing flaps down, and possibly gear down. Other switches can give you a choice of dual rate control throws (wild and tame, expert and easy, aerobatic and normal, for example). Switches can start or stop timers for fuel or duration. A momentary contact switch can perform an aerobatic snap roll. A typical use for a switch is to select a programmed mix.

A powerful feature of a computer radio is the ability to have programmable mixes. These mixes can remain on, or be selected by a switch. One example is a throttle-to-elevator mix that keeps the airplane from pitching up when power is applied. A mix might be turned on and off to couple the ailerons to the rudder to make the plane fly nice turns while only using one thumb on the right stick. However, this rudder mix should be turned off so as to properly fly aerobatics that require independent control of the rudder. As one can see, there are endless uses for the mixing capability of a modern computer radio.

A more exotic use of mixing is a camber mix, where the ailerons and/or flaps all can be raised or lowered together, allowing the airfoil shape to be changed and optimized for slow or fast flight. This could have the elevator channel mixed

A PCM (pulse-code modulation) FM transmitter module from Japan Remote Control Co., Ltd.

The Futaba FP-TP-FM RF transmitter module.

to the two flaps and the ailerons so whenever the plane is slowed with up elevator, the wing's trailing edge is lowered slightly, thereby generating more lift. The opposite is possible, too, thus creating less drag.

By the way, lift and drag are what wings are all about. This mix can be used in a sailplane to make it climb faster in a thermal updraft, or to glide farther when flying fast, or to cause a 3D aerobatic airplane to perform outrageously small loops and flips.

Before computerized radios, installing servos and control linkages had to be done precisely so the controls could move correctly. Now it is much easier; the servos only need to be set to center of travel. The radio is then programmed to set the correct direction and amount of travel. Computer radios can be set to have exponential rates that soften or increase the control resolution near the center of stick travel. To my knowledge, all RC radios have a basic digital resolution of 10 bits (1024 steps) for control.

A micro-size DSP receiver available soon on 50 MHz.

Receivers have 4.8-volt batteries and transmitters have 9.6-volt battery packs. These batteries usually are nickel rechargeable, and can be expected to operate more than one hour on a single charge. Generally, if these batteries are charged the night before flying, you will not have to worry about losing an airplane. Transmitters have low battery warning beepers and/or metering, just in case.

Now, about those transceivers: The reliable RF range for most radios is as far as you can see the airplane and still fly it. However, there are some circumstances when interference from an improper airborne electric motor, antenna installation, or external source will greatly reduce the range. If someone at your flying field turns on a transmitter on the same frequency as someone else who is already flying, that flyer can count on an airplane being lost. To deal with this problem, there are some transmitters that are transceivers that actually have a receiver listen and check for a clear frequency before transmitting. Normally, frequency control is done with a board with frequency pins, and that control is taken seriously. On 6 meters there is less chance of conflict, because there are fewer users due to the ham radio license requirement for operating on this band.

Radios usually come packaged with transmitter, receiver, servos, batteries, and a wall charger, but you may wish to buy these components separately. The servos and receiver may not fit in a particular airplane, but a good transmitter will work with anything. You also should consider that the better transmitters remember the settings for several models (model memory).

The choice of a receiver depends mostly on the physical size and weight and number of channels for a given airplane. Micro receivers are usually single conversion and are designed for use in small airplanes that are flown close in, as the range might be affected by the low image rejection. However, there are some very small receivers, such as the seven-channel 6-meter Sombra™, and the soon to be available Berg™, both of which have DSP filtering and synthesized frequency (RF channel) selection.

This issue's column was meant to be an introduction to RC radios. In the future, I will discuss installing and setting up servos and receivers and programming RC transmitters. However, in the next column I will cover electric power systems.

73 and happy flying! Del, K1UHF

Links

http://www.airtronics.net
http://www.bergent.net
http://www.futaba-rc.com
http://www.jrradios.com
http://www.sombralabs.com

By Joe Moell,* KØOV

HOMING IN

Radio Direction Finding for Fun and Public Service

RDF for the Masses
Pulsed Emitters Near 220 MHz

Visiting a high school last weekend reminded me how important the Internet has become in a relatively short time. On every bulletin board were flyers with URLs where students could find information, resources, and fun. Most of them probably can't remember a time when there was no Internet.

This month marks ten years since I put my "Homing In" website online.[1] I hoped that a site with basic information on hidden transmitter hunting would encourage more hams to try it. It would also answer the basic questions about radio direction finding (RDF) that I often received in letters and e-mails.

What I didn't expect was the number of non-hams who stumble onto the site and want to learn about RDF devices that they can use. From stolen cars to model rockets and missing children, there's a lot that people want to find and keep track of. From the beginning, I have tried to respond to every inquiry, no matter how vague or outlandish. In the process, I have learned a lot myself.

One of the first inquiries came from Tracy in Kansas, who wrote: "I have a friend who needs help with tracking his coonhounds. He says when they get out of hearing distance, it sometimes takes all night to find them. Yeah, I used to laugh too, until I heard how much money, prizes, and stud fees a good coonhound can bring in." I suspected that my leg was being pulled when I saw this postscript: "Dorothy and Toto send their love." Nevertheless, I answered as best as I could at the time.

As it turns out, Tracy was completely serious, and I discovered that a multi-million dollar market for RDF equipment has emerged among owners of hounds for sport hunting. When their dogs are following the scent of an animal such as a fox or raccoon, they may run several miles away from their owners. Radio tracking allows the humans to catch up and to round up any hounds that stray from the pack.

PL Boards and RDF Gear

Near the top of the list of companies riding this wave of demand for consumer RDF hardware is Communications Specialists of Orange, California.[2] This is the same ComSpec that has made subaudible tone (CTCSS) encoders and decoders for well over 20 years. However, according to owner Spence Porter, WA6TPR, "Our main business has not been building PL stuff. It's been building homing stuff."

ComSpec professional tracking receivers have been popular with wildlife researchers for decades. A photo in my "Homing In" column for Summer 2005 shows bat researcher Carl Herzog, AB2SI, programming a ComSpec Model R1000. Biologists have figured out ways to place radio tags on mammals, birds, reptiles, fish, and even insects, but growth of that market pales in comparison to the increase in individuals who want to keep track of their pets. Police and investigative agencies have an escalating need for trackers. Fliers of model aircraft and rockets are discovering RDF, too. ComSpec serves them all.

By regulation, wildlife tags must be very small and light, just a small fraction of the weight of the critters to which they are

This LoCATor pet tag weighs one-half ounce and has a breakaway link to prevent accidental choking of the animal. (All photos by Joe Moell, KØOV)

Communications Specialists PR-50 receiver and FA-1 Moxon rectangle antenna for RDF in the 218-MHz range.

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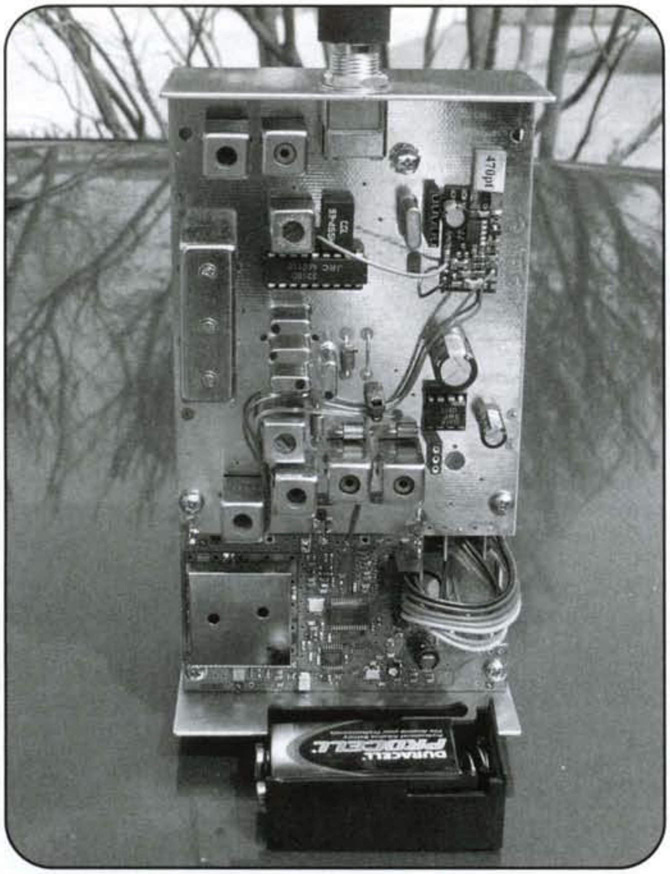
e-mail: <k0ov@homingin.com>



Inside view of the well-shielded PR-50 receiver. The 9-volt battery tray slides out of the bottom for rapid replacement in the field.

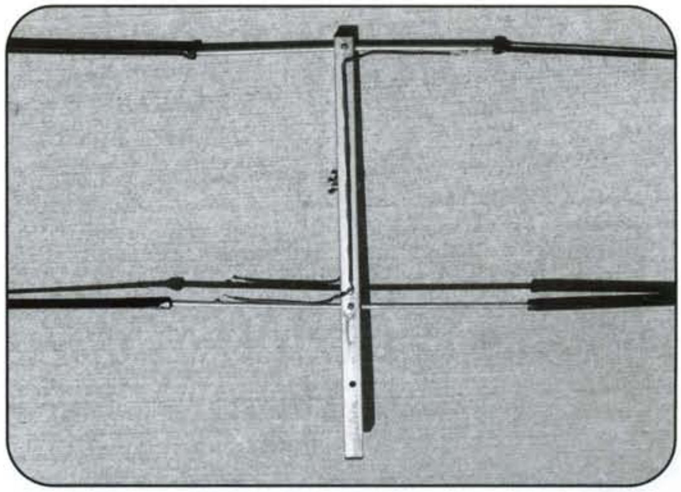
attached. They must operate for weeks or months with no opportunity for periodic maintenance. Life of their tiny batteries would be unacceptably short if radio tags transmitted continuously. Instead, they pulse on for a few milliseconds every second or so.

Until recently, almost all VHF radio tags were simple crystal-controlled "squegging" oscillators[3] that drifted in frequency as temperatures cycled and batteries aged. ComSpec met the demand for improved range and frequency stability by developing new designs with phase-locked loops and microprocessor controls. With about a half-milliwatt RF output and a 3-inch antenna, ComSpec's LoCATor feline tag can be supplied on any of 30 frequencies between 218.025 and 218.750 MHz. It is fully certified for unlicensed use under FCC Part 15. One CR2032 lithium coin-cell battery powers it for about six weeks in continuous service.

"We originally made the transmitters user-programmable with a magnet," says WA6TPR. "But that was a really bad idea. In stepping through all the channels, consumers would lose track. We had to take that feature out and simplify the manual."

The 216–220 MHz range is excellent for RDF of low-power pulse tags. There's not much interference from other services there. A quarter-wavelength transmitting antenna is only 12 3/4 inches. For the same gain and directivity, directional antennas are significantly smaller and lighter than at 150 MHz.

The peak field strength of a half-milliwatt 218-MHz LoCATor transmitter and its 3-inch antenna exceeds the 200-



The ANT1/144 two-meter RDF antenna by Ron Graham Electronics in Australia uses the classic HB9CV/PAØTBE design. Ends of the elements are sleeved flexible-tape sections that screw on and off for easy transport and safety in the brush.

microvolts/meter limits of FCC 15.209 for intentional radiators. However, it's the average that counts, and since the tags are on for just 16 milliseconds and then off for over a second, the average field strength meets FCC requirements.

In my first experience in wildlife tracking back in 1995, I found that I could detect and get bearings on desert tortoises up to about 3/4 mile away with a hand-held two-element antenna. That's about the same maximum range as one will get with the LoCATor tags out in the open. In cities or the suburbs, the intervening buildings and electrical noise will reduce range to a few blocks.

Teaching RDF to Pet Owners and Scouts

Radio tracking is easily understood by most hams, but not necessarily by the general public. According to WA6TPR, "I ran full-page ads for eight months in *Cat Fancy* magazine, and I can tell you that some people just don't get the concept. When I say the range is several blocks, they think it means just that distance from their home. I have to tell them that as their cat moves away, they can follow behind and still hear at the same relative distance. It's very simple to us, but not to every consumer."

ComSpec also sells higher power tags, including a 95-milliwatt peak model that is licensed under FCC Part 95G for law enforcement use only. It includes a strong magnet suitable for attachment to the underside of a vehicle. All transmitters are made in Spence's shop.

WA6TPR thinks that his LoCATor Part 15 transmitters would be perfect for getting Scouts and other young people to try hidden transmitter hunting. "Unlike typical ammunition-can foxes, these are really tiny and the batteries last for weeks," he says. "You could scatter a handful throughout a park and turn the kids loose."

I countered that with over a second between pulses, it might be difficult for youngsters to get bearings as they twirled an antenna around in a circle. "No problem," he replied. "I could easily change the pulse rate. The cat tags are about 50 pulses per minute to get 6 weeks of battery life. If we double or triple

At his 2005 Utah Hamfest forum, Mike Collett, K7DOU, of Layton, Utah, showed some of his RDF antenna projects, including this 2-meter Moxon rectangle that he was in the process of building.

For tracking 216-MHz pulsed radio tags in Project Lifesaver, Sam Vigil. WA6NGH, uses a three-element stiff-wire quad scaled from a 2-meter design.

that, it's almost the same as a constant carrier with a peak-reading S-meter, and their minds will easily remember which direction for best signal."

Could the cat tags be made to operate on the 125-cm ham band? "There would be no problem factory-programming to 223–225 MHz," says Spence. "All I have to do is shuffle the counters in the PLL. They're even capable of sending a periodic ID in CW. But they are already certified under Part 15 from 216 to 235 MHz, so they are legal for any use just as they are in that range, with no ID necessary."

Can't Hunt What You Can't Hear

Typical amateur radio on-foot hidden transmitter hunts have medium-power foxes with continuous transmissions of seconds or minutes. For that, an ordinary handie-talkie and an offset-type RF attenuator work very well to get bearings.[4] However, with flea-power short-pulse signals, it's another matter. It's necessary to open the HT's squelch and listen for the FM noise to be interrupted by the pulses.

Mfr.	Model	Mode	dBv	Nanovolts
CommSpec	PR-50	CW	–152	25.1
Kenwood	TH-F6A	CW	–149	35.5
ICOM	IC-R10	CW	–145	56.2
ICOM	IC-03A	FM	–144	63.1
Kenwood	TH-F6A	FM	–139	112.2
ICOM	IC-R10	FM	–138	125.9

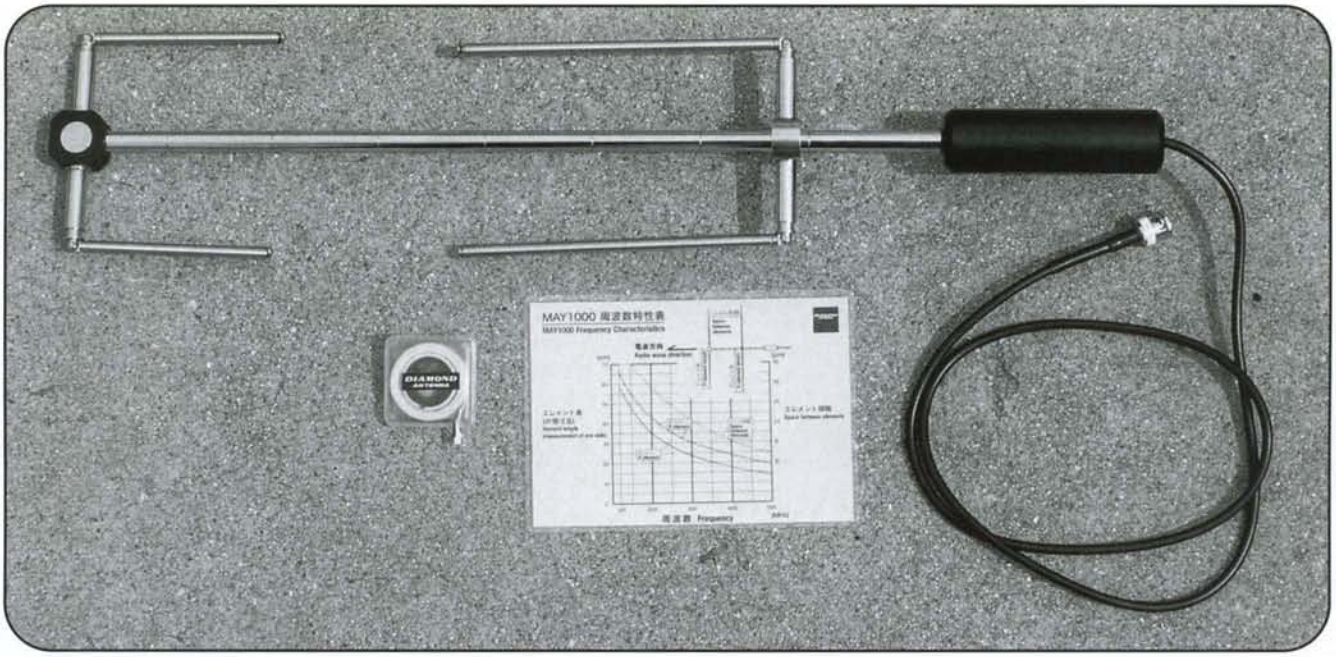
Figure 1. Threshold sensitivity comparison of receivers for pulsed-signal RDF near 220 MHz.

The pulsed output of a wildlife tag is just like a CW dit. It's much easier to discern the dit tone of a weak tag signal on a CW/SSB mode receiver than on an FM-only receiver, where the pulse produces only momentary quieting of the noise. When combined with the narrower bandwidth of receivers designed for CW reception, the effective advantage in threshold sensitivity can be 10 dB or more.

ComSpec builds the PR series of receivers, which are optimized for getting bearings on pulsed radio tags. Their sensitive front ends have helical resonator bandpass filters to eliminate images and out-of-band interference. The IF bandwidth is much narrower than the typical 12 kHz of FM receivers, giving the PR receivers better signal-to-noise ratio on unmodulated pulses.

Figure 1 lists my threshold sensitivity measurements of some typical scanners, ham receivers, and the ComSpec PR-50 receiver. Values in the table are RF input in nanovolts and in dB with respect to one volt for the weakest signal that could be detected and tracked. All measurements were on tag channel 10 (218.025 MHz), except for the IC-03A, which was measured on 224 MHz.

My data show that the PR-50 has a 3-dB advantage over the second-place receiver and 14 dB over a typical NBFM scanner. Each 6-dB increase in sensitivity translates into about twice the tracking range in open country, all other factors being equal.



The MAY1000 handheld two-element Yagi by Diamond Antenna telescopes and folds for storage. It comes with a frequency chart and measuring tape.

For closing in, RF attenuation is built into PR-series receivers, with a three-step range switch and gain control. A $1\frac{3}{4}$-inch speaker puts out lots of sound. The peak-reading meter makes it easy to distinguish signal-level changes of pulsed emitters while turning the antenna. Frequency control is channelized and the range of frequencies depends on the model.

The only disadvantage I noted is that at 1.3 pounds, a PR-series receiver is bigger and heavier than most imported handheld receivers. That might be problematic for use by a pack of Cub Scouts. A pistol-grip handle underneath at the balance point would make it much easier for pre-teens to carry.

The H, the Rectangle, and the Quad

Wildlife researchers have found that two-element beams are just right for on-foot field tracking, a good compromise between size and gain. Most popular among them is the compact HB9CV type, which they call the "H Antenna" because it's shaped like that letter. The HB9CV beam is an adaptation of the classic "ZL Special." The VHF version is attributed to Jan Jager, PAØTBE. Its two elements are fed out of phase with gamma matches on each to achieve excellent directivity with short spacing (0.12 wavelength).

Telonics, Incorporated is one of the most popular suppliers of H Antennas to the research market.[5] Telonics HB9CV beams feature wooden handles so that users can hold them high overhead with horizontal polarization while getting bearings. A HB9CV RDF antenna for 2 meters is sold by Ron Graham Electronics in Australia.[6]

An even more compact RDF antenna is the Moxon rectangle, originally developed by Les Moxon, G6XN. It is basically an enhanced two-element Yagi. Ends of the driven element are folded toward the reflector at about 0.18 wavelength from the feedpoint. Ends of the reflector are folded toward the driven element at the same distance from center. The gap between the driven element and reflector tips is critical. When it's optimized, the Moxon has a broad forward lobe, a deep rear lobe, and nearly perfect feedpoint match to 50-ohm coax.

Typical VHF Moxon rectangle dimensions are 0.36 by 0.15 wavelength. ComSpec's Model FA-1 RDF antenna, supplied with PR-series receivers, is a 8" × 20" Moxon made from strips of printed-circuit-board material. A wealth of information on Moxon antenna design and construction is available on the web.[7]

CQ National Foxhunting Weekend is Almost Here

Whether you prefer to fly the freeways or beat the bushes in search of hidden transmitters, be sure to get together with other hams in your locality for foxhunting fun during the 9th annual CQ National Foxhunting Weekend (NFW). On May 13–14 ham clubs and non-club groups across the country (and elsewhere in the world) will hold mobile and on-foot RDF contests.

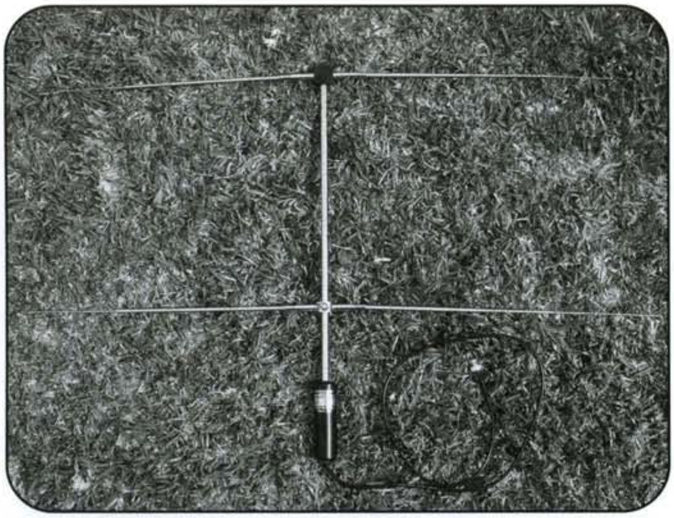
If there has never been a hunt in your area, or if it has been a while, have a simple one to get maximum interest and participation. If RDF is already a regular activity, try something new and be sure to encourage members who have not participated before.

If an all-on-foot hunt is your club's choice, make sure that the kids, grandkids, nieces, and nephews of all members are invited. They don't need driver's licenses or ham licenses to receive and hunt. It's a great way to show them that ham radio is more than HTs, computers, and QSL cards.

There are no formal rules for the NFW. You can be as creative (and sneaky) as you like, as long as your hunt is fair and safe for everyone. You don't even have to schedule it on May 13–14. Any weekend in the spring will be fine! For some ideas, read the results of last year's NFW in the May 2006 issue of *CQ* magazine. You can also read more about the NFW and this year's major ARDF events in my article "It's Radio Foxhunting Season" in the April 2006 issue of *CQ*.

After your hunt, be sure to write up the results and send to me, along with some candid photos of the hiders and hunters. Maybe your story will be included in my follow-up article.

Joe, KØOV
CQ NFW Moderator



The MAY1000 handheld two-element Yagi adjusted for RDF at 218 MHz. It can be set to any frequency from 120 to over 500 MHz.

For more gain, the popular "measuring tape" three-element Yagi design of Joe Leggio, WB2HOL,[8] could be readily scaled to 218 MHz. Cubical quads are small enough for hand-held use at 218 MHz, too. Back when there were monthly southern California T-hunts on the 222-MHz ham band, I found many of them with a stiff-wire quad scaled from a popular 2-meter design.[9]

An advantage of the stiff-wire quad over quads with thin wire strung between spreaders is that the stiff-wire quad better survives rough use in the field. If it gets a little bent up, it's easy to bend it back into shape. Sam and Eve Vigil (WA6NGH and KF6NEV) are using such a quad for tracking 216-MHz radio tags as part of Project Lifesaver.[10] They even have used this quad to get bearings from the San Luis Obispo County Sheriff's helicopter.

Whether you're seeking radio foxes, Alzheimer's patients, your pet, or your model airplane, I want to hear and share your experiences with tracking miniature pulsed transmitters. What are you doing to optimize your range and bearing accuracy? Drop me an e-mail or postcard at the addresses on the first page of this column.

New Frequency-Agile RDF Antenna

About five years ago, I was talking to an FCC engineer who wanted to know where to buy a hand-held RDF beam that was usable over a very wide frequency range, to complement his existing wide-range mobile-mounted RDF equipment. He didn't need wideband or spread spectrum signal-tracking capability; he just wanted to be able to adjust the beam to any UHF or VHF spot frequency where spurious signals or other problems might be occurring. I agreed that it would be very useful to have such a beam, and I would buy one myself.

In years past, FCC had obtained some three-element Yagis with large, square, slotted booms and telescoping elements that would slide in the slots along the boom. Director and reflector could be locked in place at just the right location to provide maximum gain and front/back ratio at the frequency of interest. Those clunky antennas had fallen into disrepair and were no longer procurable.

Each of us inquired at some machine shops, but none of them were interested in tooling up to make clones of those antennas in the small quantities that would be procured. However, the engineers at Diamond Antenna must have read our minds. Diamond's new MAY1000 Handheld Beam[11] does everything that we were seeking, and it's better designed than the FCC's old beams. It features two folding and telescoping elements. The driven element is fixed at the front end of the boom, while the reflector position is adjustable on the boom to optimize gain and front/back ratio at the receive frequency.

It only takes a minute or two to set up the MAY1000 before use. Fold out the elements, which automatically lock into place with spring collars. Slide and secure the reflector onto the boom at about 0.2 wavelength from the driven element. Pull out the telescoping driven element halves to 0.25 wavelength on each side. Pull out the reflector halves to 0.28 wavelength on each side.

You don't need a calculator, because Diamond supplies a card with curves showing the optimum element lengths and spacing in centimeters versus frequency. A metric tape measure is also included. It's best to use the values from the card, because they are optimized for gain, front/back ratio, and feedpoint impedance at each frequency, taking element diameters into account. For instance, best spacing is 0.233 wavelength at the high end of range and 0.175 wavelength at the low end. Using the graph values, SWR is specified to be 1.5:1 or better at any frequency from 120 to 500 MHz.

Besides being another way to track those pulsed radio tags from 216 to 225 MHz, the MAY1000 can be used in the aircraft band, three VHF/UHF ham bands, and everything in between. The elements telescope down to $4\frac{1}{2}$ inches on each side, so operation up to 600 MHz ought to be possible with somewhat degraded SWR.

Is this the only hand-held RDF antenna you'll ever need for VHF/UHF? Maybe not, because it isn't suitable for crashing through the brush. It's made from stainless steel and won't break easily, but for the woods, I prefer elements that give way for safety and speed. A tape-measure beam or stiff-wire quad would be better for that.

The MAY1000 has only the gain and directivity of a two-element Yagi, so you'll need a longer-boom antenna for maximum range. For rapid setup to hunt a signal anywhere it its wide frequency coverage, though, this Diamond antenna is hard to beat. I wonder how many the FCC has ordered.

73 and happy hunting, Joe, KØOV

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2. <http://www.com-spec.com>
3. <http://members.aol.com/joemoell/squegg.html>
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11. <http://www.rfparts.com/diamond/MAY1000.html>

By Bob Witte,* KØNR

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

Rack Mount Your Portable Station

A portable ham station comes in handy for many VHF radio activities: public-service events, emergency communications, vacations, VHF contests, and more. Here are some ideas on how to construct a portable ham station using rack-mount equipment.

Photo 1. The KØNR portable station with the Yaesu FT-90 and FT-100 transceivers.

The summer of 2002 brought a series of wildfires to the western U.S., including the Hayman Fire, the largest fire in the recorded history of Colorado. As part of the ARES support, I found myself operating my FM VHF station portable from a county fire station. My setup was typical of many such situations: an FM VHF rig fed by an AC power supply, connected to an antenna that was previously installed at the fire station. The rig was just lying on a table with the power supply next to it. There was no specific place for the microphone, so it also ended up lying on the table, too. I tried to prop up the radio so that it was easier to read the display, but it was not that great—functional, but not great. When the radio traffic slowed, I found myself looking at the pile-o-stuff and thinking that there had to be a better way.

Ultimately, this resulted in the creation of a portable ham station that has many uses (photo 1). My basic requirement was to have two transceivers, both covering 146 MHz and 440 MHz FM, as both bands get used during ARES deployments. Also, it is very handy to be able to monitor more than one frequency at a time, even on the same band.

I had a spare Yaesu FT-90 dualband (single receiver) transceiver and I acquired a Yaesu FT-100 HF/VHF/UHF rig. The FT-100 might be a little bit of overkill, but I liked the idea of having the CW/SSB modes on 6 meters, 2 meters, and 70 cm for VHF contesting. Including the FT-100 as the second radio gave me those modes, while tossing in the HF bands for free.

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I've used this portable station for public-service events, emergency communications, Field Day, and VHF contests. It also makes a decent home station, one that can be moved from room to room as required. My purpose in writing about this is not to have you replicate the same thing, but to provide some ideas on how you might create a portable station tailored to your needs.

The 19-inch Rack Box

I had been looking for a good way to mount equipment in a box so that it would be protected and portable. I discovered some equipment boxes that are designed around a standard 19-inch rack. These boxes are used in applications such as sound recording and live music. Your local disc jockey who provides music for parties is likely to have a rack like this. A protective cover latches onto the front of the box, and a carrying handle is molded into the enclosure (photo 2). I have encountered two manufacturers of these rackmount boxes, SKB and Gator (see references for web addresses). These should be available at your local music store, or on the web at Musicians Friend and Sweetwater Sound.

The 19-inch rack concept is based on an Electronics Industry Association (EIA) standard, so there is a quite an array of equipment and accessories available in this format. As the name implies, the hor-

Photo 2. The rack-mount box comes with a protective cover and carrying handle, making it easy to carry and transport.

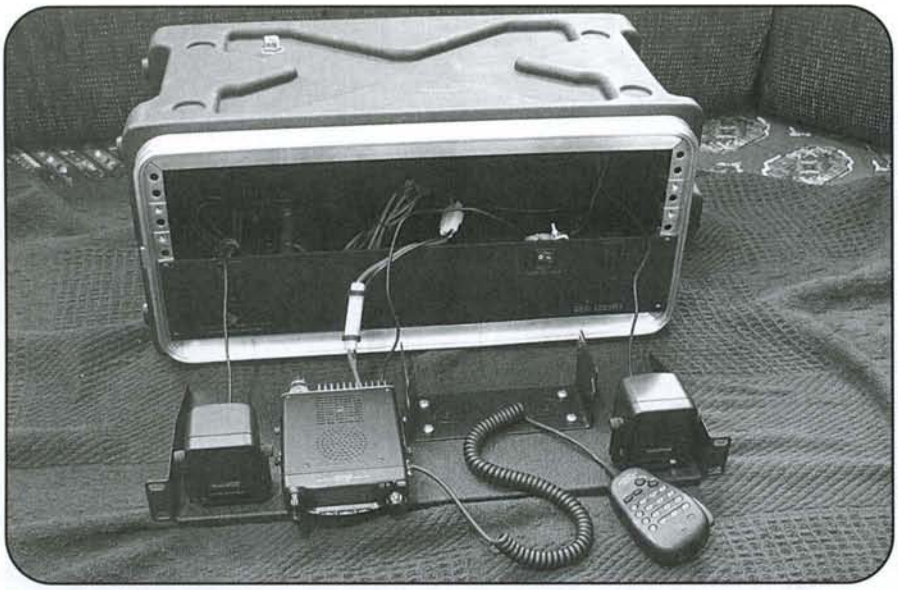

Photo 3. The two ham transceivers are mounted using a standard rack shelf.

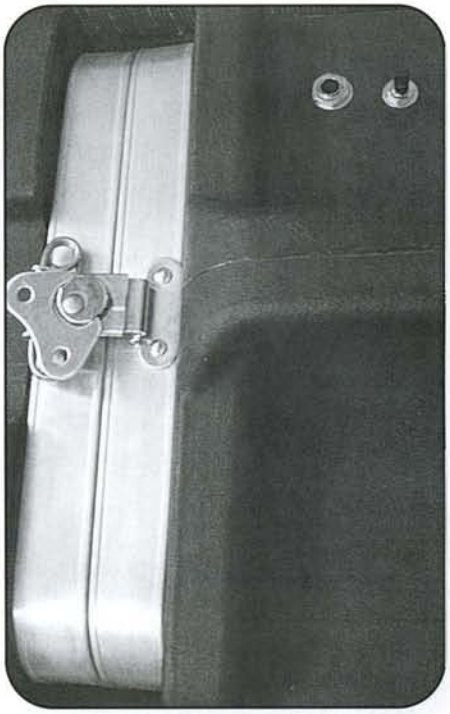

Photo 4. The KØNR station has a headphone jack and a switch that controls whether the external speakers are on or off.

izontal spacing of the rack is 19 inches. The vertical spacing is normally specified in multiples of 1.75 inches, which is referred to as a standard unit, or "U." Therefore, a 1-U high component occupies 1.75 inches of rack space, while a 2-U high component occupies $2 \times 1.75 = 3.5$ inches. The box I used is 4-U (7 inches) high, also referred to as a "4 space" rack.

The KØNR Station

My approach was to use as many standard rack-mount parts and as much standard equipment as possible. There are a number of power supplies available in a 19-inch rack format, from suppliers such as Astron and Samlex. I chose to use a Samlex SEC 1223R1 power supply. Ham radio equipment usually does not come configured for rack-mount installation, so I used a rack shelf to mount the transceivers (photo 3). The standard mobile mounts for the radios were easy to attach to the shelf using a few machine screws and nuts.

I was concerned about having sufficient audio coming out of the station. I installed two forward-facing RadioShack communications speakers (RS# 19-318), one for each radio. The idea is to direct the audio right to the operator and not rely on the internal speaker of the transceiver, which is facing upward inside the rack. The speakers are separated right and left so the operator can easily associate the audio with the appropriate radio.

I've also found that headphones are a very useful feature when doing emergency communications, so I included a stereo headphone jack (photo 4). I considered a number of different ways of wiring the headphones, but ended up with a relatively simple approach. The headphone jack is wired with the left radio in the left ear (only) and the right radio in the right ear (only). This maintains the natural separation of the radios so that when both of them are receiving a signal, the operator can keep them straight. The headphone jack is fed from the transceiver external speaker jacks and is live all of the time. A speaker on/off switch controls whether the audio also gets routed to the external speakers. This allows the speakers to be turned off in situations in which the sound is distracting to other people in the area. I mounted the headphone jack and switch by drilling holes in the plastic case. The rack box is made of relatively soft plastic, so this is easy to do.

Power

Any time the subject turns to portable operation, the power source is a major consideration. Should the power system be set up for 12 volts DC, 120 volts AC, or both? For emergency use, it makes sense to have a battery as a power source so that the station can operate independent of commercial power. This leads to the question of how much battery capacity is required. Ideally, it would be great to be able to operate for several days without AC power, but this requires a large battery, which would make the box larger and heavier. Another approach is to design the station around 12 volts DC and provide an external battery for power.

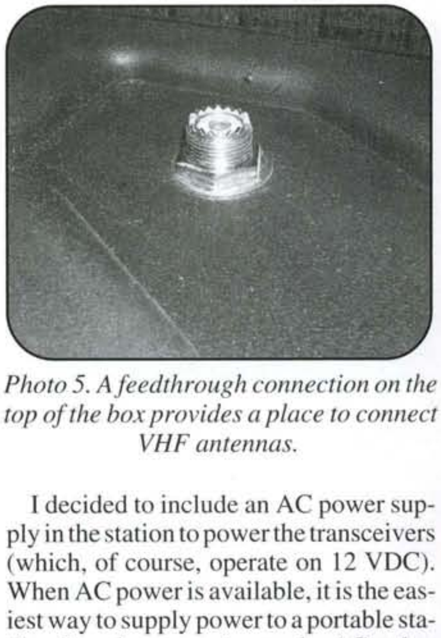

Photo 5. A feedthrough connection on the top of the box provides a place to connect VHF antennas.

I decided to include an AC power supply in the station to power the transceivers (which, of course, operate on 12 VDC). When AC power is available, it is the easiest way to supply power to a portable station. It makes sense to use the AC rather than deal with the battery charging and maintenance issues. (My experience is that the battery will go dead just when I need it most.) For extended operation, I own a gasoline electric generator, an efficient way to provide AC power for extended periods of time.

Switching power supplies are much lighter in weight and more compact than the traditional linear supplies,

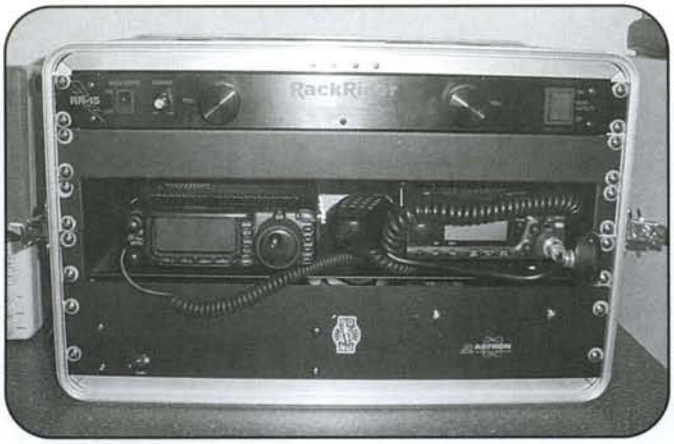

Photo 6. The two-transceiver KA5CVH portable station uses an Astron power supply and an AC power distribution strip. (Photo courtesy of KA5CVH)

Photo 7. Rear view of the KA5CVH station. (Photo courtesy of KA5CVH)

making them the obvious choice for a portable station.

I also made provision for disconnecting the AC power supply and running off an external battery or 12-VDC source. The DC power is distributed via an MFJ-1117, which is basically a box with four pairs of heavy-duty binding posts. This is not the most elegant solution for routing DC, but it can easily be reconfigured to meet almost any need.

Antenna Connections

The back of the rack box has a removable plastic panel that allows access to the back of the transceivers. My antenna connection scheme is simply to open the back panel and connect to the antenna ports on the radios. I also installed a PL-259 style feedthrough connection on the top of the box (photo 5). I connect a PL-259-to-BNC adapter and a VHF/UHF whip antenna (BNC connection) to this feedthrough. This is a simple, compact method of getting the station on the air.

Photo 8. The NC6T portable station includes four transceivers and an SWR meter. (Photo courtesy of NC6T)

KA5VCH Station

Recently, I discovered two other hams who have used the same basic approach for creating a portable station. Both Christopher Taylor, NC6T, and Mike Urich, KA5CVH, have portable stations based on the same type of rack-mount box. The KA5CVH station is very similar to mine, employing two transceivers but in a slightly larger rack (photo 6).

Mike chose a rack made by Gator that has rack-mount rails on the front and back of the rack (photo 7). This provides a larger rear-panel opening than the box I used, providing easier access. It also makes the rear of the box more useful in terms of mounting equipment. For example, Mike has experimented with mounting the power supply on the rear rails to balance the weight more effectively.

Mike used a rack-mount power conditioning strip (a RackRider RR-15), which provides a front-panel power switch, circuit breaker, and MOV transient/surge protection. The RR-15 also provides lighting for the front of the rack, complete with dimmer control, which is a handy operating aid for dimly lit environments. A careful look at photo 6 reveals that Mike added a toggle switch to the front panel of the power supply that switches between using the AC supply and an external DC power source. The chassis of the Astron power supply occupies a little less than half the rack width, so the rest of the space behind the rack panel is open, which makes it a convenient place to mount switches or other devices. Mike has a number of photos of his station on his website, so be sure to check that out.

NC6T Station

NC6T's station has four transceivers, including a 222-MHz FM rig and a 2-meter rig for packet (photo 8). Two of the rigs are FT-7800 VHF/UHF transceivers,

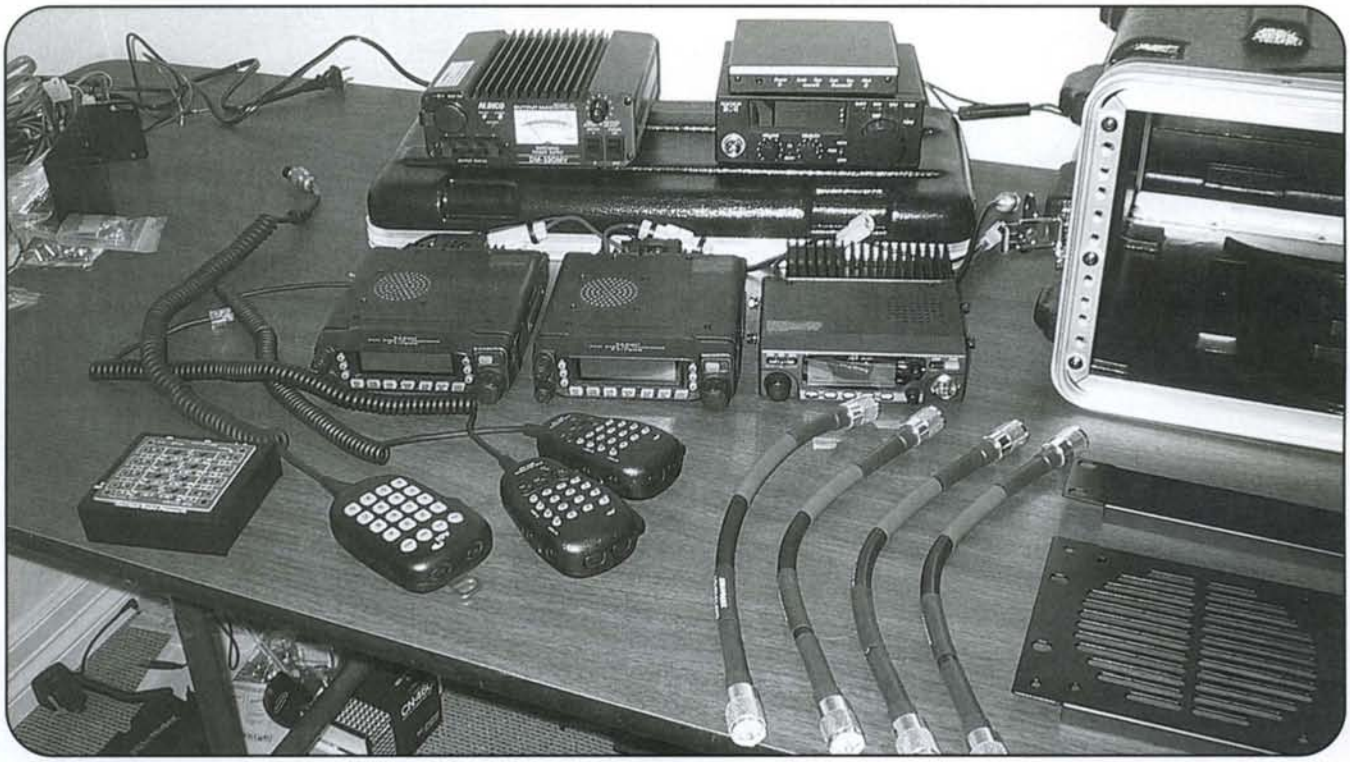

Photo 9. The NC6T portable station equipment, disassembled and displayed on a table. (Photo via NC6T)

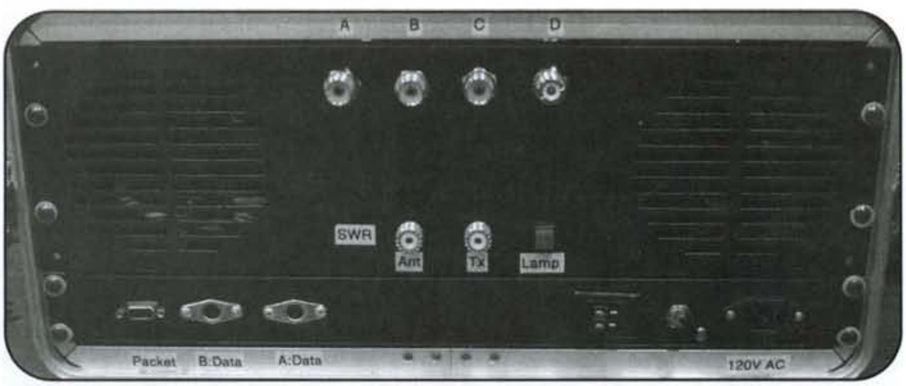

Photo 10. The NC6T rear panel has feedthrough connections for antennas (labeled A, B, C, D), data, and power connections. (Photo via NC6T)

which have their microphone connectors on the side of the radio, so Christopher extended the microphone cable out to the front for easy access. This allows all three voice rigs to have their microphones removed for transportation. Christopher chose to use a compact Alinco power supply, rather than a rack-mount supply. This makes the mounting slightly more difficult, but it takes up less space, especially the front-panel area.

With four rigs to contend with, NC6T did a nice job of labeling the radios. He also included an SWR meter for making antenna measurements. The "exploded view" of the NC6T station is shown in photo 9.

Christopher also used a rack that has rails on the rear panel, which he used to mount two panels for connector mounting (photo 10). The four antenna connections are labeled A, B, C, D across the top of the panel. The connections to the SWR meter are brought out to the rear panel so that any of the four antennas can be checked using a short jumper coax. Data connections to the two Yaesu rigs and the serial port for the packet station are shown in the lower left. At the lower right is a standard AC power-cord receptacle, which is connected to the Alinco power supply. Christopher also has Anderson power-pole connectors for supplying 12 volts DC to the station. A large toggle switch selects either AC or 12-VDC power for the station.

Acknowledgments

Special thanks go to Mike, KA5CVH, and Christopher, NC6T, for sharing their ideas and photographs of their portable stations. If you have additional ideas, drop me an e-mail telling me what you have tried. I know this is not the first (or last) portable VHF station to be constructed.

Thanks for reading the column, and check out my webblog at <k0nr.blogspot. com>. 73, Bob, KØNR

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Gator Cases: <http://www.gatorcases. com>
SKB Cases: <http://www.skbcases. com>
Musicians Friend: <http://www.musiciansfriend.com>
Sweetwater Sound: <http://www.sweetwater.com>

CQ's 6 Meter and Satellite WAZ Awards

(As of April 1, 2006)

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	1,10,18,19,23,31,32
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

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

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 Keith Pugh,* W5IU

SATELLITES

Artificially Propagating Signals Through Space

SuitSat, Expedition 12 Activity on the ISS, CubeSats, and more

Since the last column, SuitSat was deployed on February 3, 2006; Expedition 12 continues to be *very active* on the ISS (International Space Station); more CubeSats have been launched; the site that had been chosen (but was changed) for the the 2005 AMSAT Space Symposium was visited during the annual Acadiana Amateur Radio Club Hamfest in Rayne, Lousiana; and working AO-51 mode V/S in the rain at the Green Country Hamfest became a "team effort."

SuitSat

SuitSat was deployed on February 3, 2006 via an EVA (extra vehicular acivity) from the ISS. The successful deployment received unprecedented coverage in all branches of the media. Unfortunately, a problem developed with the signal strength from SuitSat and only large EME class stations were successful in copying much data. Everything in SuitSat worked, but the signal was approximately 30 dB weaker than planned. After an initial "scramble" to hear anything, telemetry was captured from about February 8–17. Nothing has been heard since February 18, and the batteries are presumed dead. The voltage dropped rapidly from about 26 volts to 18 volts before it went off of the air. As far as we know (as of March 27), SuitSat is still in orbit, but it has to re-enter soon.

Even with the low signal level, SuitSat is considered to be a success. It has shown what can be accomplished in a fairly short time with some imagination and a lot of hard work.

Expedition 12 Activity on the ISS

The Expedition 12 crew—made up of Bill McArthur, KC5ACR, Commander, and Flight Engineer Valery Tokarev—has been very active on the ISS. School contacts have been scheduled at two a week, and general operations have been greatly increased. More than 35 school contacts have been made. SuitSat has been assembled and deployed. Bill has now worked WAC on both VHF and UHF, WAS, and DXCC while on this mission. Many amateur radio operators can now say they have worked the ISS and done so with very modest stations.

CubeSats

Cute 1.7 was launched by the Japanese during this period and is doing well. Several earlier CubeSats, plus SuitSat, have now been given OSCAR numbers, and the latest is CUBESAT-OSCAR-58, or CO-58. Many more are in the works. We were treated to a display of hardware and a talk about the CubeSat project by student builders from the University of Louisiana at Lafayette during the annual Acadiana Hamfest in Rayne, LA. They are looking forward to a launch from Russia in May 2006.

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SuitSat-1 ready for deployment. (Photo courtesy of NASA/ARISS)

Visit to Lafayette, LA

During March, Roger Ley, WA9PZL, and I made our annual trek to the Acadiana Hamfest. Rayne is a small town just west of Lafayette, LA, which was to be the location of the 2005 AMSAT Space Symposium until the effects of Hurricane Katrina forced its cancellation. I'm happy to report that the area has now recovered and is largely back to normal. The crawfish crop was affected somewhat, and there was a temporary shortage of it for the annual Crawfish Boil. Roger and I waited too long to get in line and missed ours. We thus were forced to exist on the excellent shrimp etouffee, jambalaya, and gumbo made by the Rayne High School Scholarship Fund group. Tough duty indeed!

This has always been one of my favorite hamfests, and this year was no exception. Hopefully, we will be able to re-schedule the AMSAT Space Symposium back into this area in the future—possibly 2007.

Working AO-51 Mode V/S by Team Effort

March is a busy month for hamfests. My second one for the month was the Green Country Hamfest in Claremore, Oklahoma. This is an excellent hamfest that has grown every year since it moved out of downtown Tulsa and into the Claremore Expo Center. The only problem this year was rain. It looked like the rain was going to prevent my usual satellite demonstrations, but it "slacked off" a little bit and I decided to go ahead with an attempt for AO-51 Mode V/S. Partial cover was provided by the rear door of my mini van. The van also provided power for the S-Band to 2-meter down converter.

Two more brave souls decided to observe the attempt, and I put them to work. I held the S-Band antenna and down converter, along with the Yaesu FT-817 that was pressed into service as the 2-meter IF. I also assumed the duty of keeping the 817 tuned for the ±50 kHz of Doppler. One of the other fellows held the Arrow Antenna and kept it pointed in the general direction of the S-Band antenna. The third team member operated the Kenwood TS-D7 HT and did the talking. All of this effort was expended while trying to keep the radios as dry as possible in the light drizzle.

We did succeed in being recognized by the gang on the bird and made at least a half-dozen contacts during the 70-degree elevation pass. Not bad for a team effort in the rain! We did cancel the VO-52 listen-only demo to allow time to dry out the equipment and get ready for the AMSAT forum. As this is being written, it is next on to Weatherford, Texas to round out my attendance at March hamfests for another year.

Summary

As usual, there are satellite activities to keep you busy at any time of the year if you look for them. Bill McArthur, KC5ACR, and his efforts on board the ISS certainly will never be forgotten. However, Expedition 13 is waiting in the wings and will start with a trip to the ISS for the new crew this week (on March 30). Please support your area hamfests, and by all means, support the efforts of AMSAT to build our new projects—Phase 3E and Eagle. 73, Keith, W5IU

By John Champa,* K8OCL

HSMM

Communicating Voice, Video, and Data with Amateur Radio

The Hinternet and openHSMM Plus Experiments on 6 Meters

This month's column is guest authored by Paul Pescitelli, K4UJ, Assistant Emergency Coordinator, Gwinnett County, Georgia ARES. Paul is also the ARRL HSMM Working Group Project Leader for the openHSMM Project. He may be reached at: <dx.k4uj@gmail.com>.

The term "openHSMM" is derived from the combination of Open Source software and High Speed MultiMedia. Open Source software was designed to meet some of the goals of the ARRL's High Speed MultiMedia (HSMM) Working Group, chaired by John Champa, K8OCL. The intent of the working group is to research and implement new technologies in high-speed digital signaling networks.

*Chairman of the ARRL Technology Task Force on High Speed Multimedia (HSMM) Radio Networking; Moon Wolf Spring, 2491 Itsell Road, Howell, MI 48843-6458
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Design Criterion

The openHSMM-ap design criterion is to create a wireless-access-point appliance that contains features found in wireless access points that are commonplace today. Why re-invent the wheel? Today's consumer-grade access points lack two very important features that are necessary to create flexible wireless networks.

First, the deficiency lies in the radios. Consumer-grade access points traditionally have relied on a single radio to provide connectivity. While efficient in their design, they cannot provide the diverse connectivity options that may be required, especially in an unplanned environment such as those found during emergency communication deployments. Sometimes 802.11b works well, but it would be good to provide alternatives, such as 802.11a or 900-MHz WiFi for creation of backbones. This is one area that openHSMM hopes to address in the coming months.

The second deficiency is the lack of true networking protocols. In order to create a scalable network (wired or wireless), it would be beneficial to provide configuration options such as OSPF (Open Shortest Path First). OSPF is a tried-and-true routing protocol that broadcasts its routes to

League Requests Rule Change to Ease Spread Spectrum Operation

The following is from the *ARRL Letter*:

The ARRL has asked the FCC to modify one of its rules governing spread spectrum (SS) operation on amateur radio frequencies. The League has petitioned the Commission to drop all but the first sentence of §97.311(d), which now requires the use of automatic power control (APC) for SS stations running more than 1 W. The ARRL request would retain the 100 W overall power limitation for SS.

"The effect of the rule change would be to eliminate an automatic power control provision that has proven over time to be impractical" in terms of compliance, the League said in its Petition for Rule Making filed March 13. It also conceded that the provision—one the League had proposed and supported more than 10 years ago—was unnecessary to protect the operations of other licensees and had "unfortunately served as an unintended but effective deterrent to spread spectrum experimentation" on ham radio.

Since the FCC first approved the use of spread spectrum techniques for amateur radio in 1985 on bands above 225 MHz and at power levels up to 100 W, there's been limited—but never widespread—experimental amateur operation. More recently, the FCC has made the SS rules less restrictive in response to League showings that the rules were hampering SS experimentation and that interference has not proven to be an issue.

The ARRL says it now agrees with those who opposed the automatic power control provision in WT Docket 97-12, concluded in 1999. Those changes not only relaxed rules governing the use of spread spectrum techniques by radio amateurs, but opened the door to the possibility of international spread spectrum communication.

"Now seven years later, it is apparent to ARRL that the rules requiring APC indeed have proven to be difficult to implement, unnecessary, and something of a barrier to SS experimentation," the ARRL said in its latest rule making petition. "Section 97.311(d) can be greatly simplified without increasing the risk of intra-service or inter-service harmful interference."

The ARRL said keeping the maximum power at 100 W limits the power spectral density of an SS emission, contributing to compatibility between amateur radio SS and narrowband modes in the same allocations. The rules already in place make spread spectrum "essentially secondary to any amateur narrowband emission modes," the League pointed out, and make the APC requirement unnecessary to avoid interference to other users of the same spectrum.

In any event, the League concluded, radio amateurs employing SS modes would remain obliged to comply with the rule requiring use of "the minimum transmitter power necessary to carry out the desired communication." That was a primary reason the ARRL asked for the APC provision in the first place.

The FCC has not yet assigned a rule making (RM) petition number to the ARRL's petition nor invited comments.

In its Notice of Proposed Rule Making (NPRM) WT Docket 04-140, the FCC, in response to another ARRL petition, proposed extending the bands available for spread spectrum to include 222–225 MHz. On its own initiative, the Commission also recommended permitting SS operation on 6 and 2 meters, a move the ARRL opposes. In its comments, the League cited concerns about raising the noise floor on 6 meters and the fact that both bands already support substantial narrowband and weak-signal work, meaning "fewer opportunities for frequency reuse in those allocations."

The Commission is expected to conclude WT Docket 04-140 this year. The FCC suggested that restrictions on spread spectrum already in place should be sufficient to prevent any adverse impact of SS operation to other users of 6 and 2 meters.

Experiments on 6 meters

By John Champa, K8OCL

It's official! The FCC has issued an Experimental Special Temporary Authorization for the ARRL HSMM Working Group to conduct experiments on the 6-meter band. Thanks to help from the League's CTO, Paul Rinaldo, W4RI, callsign WC9XLP has been issued to John Stephensen, KD6OZH, in the San Joaquin Valley, Fresno, California. John is the Working Group's HSMM-VHF Project Leader.

The experiments will be conducted appropriately in the 50.3–50.8 MHz range with a maximum authorized power of 1.5 KW (ERP) using Orthogonal Frequency Division Multiplex (OFDM) modulation. This is modulation similar to that used with 802.11g, but employing much narrower bandwidth. It is hoped that the Working Group will be able to achieve a data rate as high as 240 kbps while occupying a bandwidth of no more than 200 kHz.

These digital test signals essentially will be on a non-interfering (no QRM) basis. First, they are spread out over as much as 200 kHz of bandwidth. With such low power density, it is *not* likely that they would be detectable on an FM receiver. If they can be detected at all, it might be with an SSB receiver, and then only as very faint background noise.

According to John, KD6OZH, "The 6-meter antenna is up *(it's a monster; see photos—ed.),* so I'll be able to try low-frequency HSMM soon. I've also attached a graph of troposcatter loss. The 50-MHz band is our best bet for long paths, as losses increase by the cube of the frequency. However, losses are high, so 50–100 km is probably the limit with the equipment that I have. The use of 1500 watts PEP and four long Yagis should allow 20 dB more path loss for a 200–250 km range, but it wouldn't be very portable (see picture from M^2). This is all speculation, as I don't know what fading and Doppler are going to look like over a 100–200 kHz bandwidth NLOS (non-line of sight)."

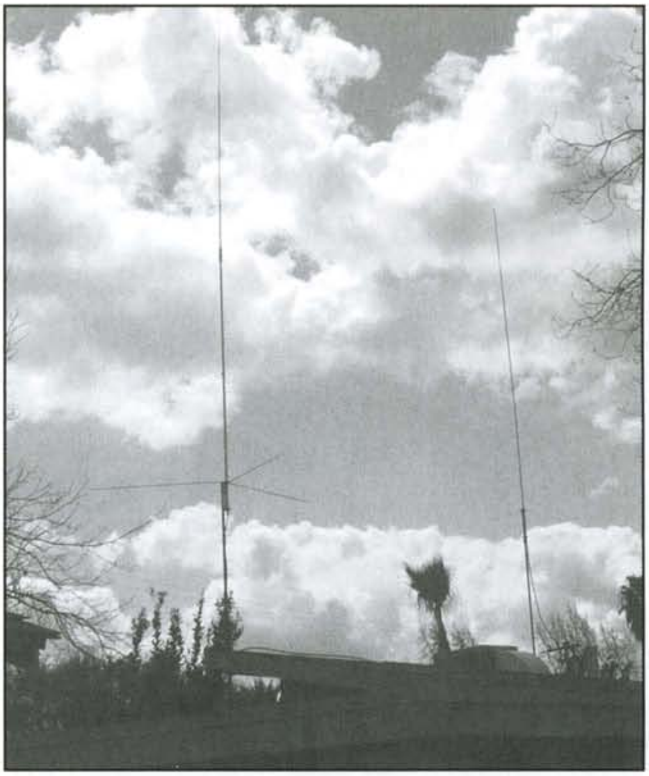


Photo A. The 6-meter antenna (left) is a monster!

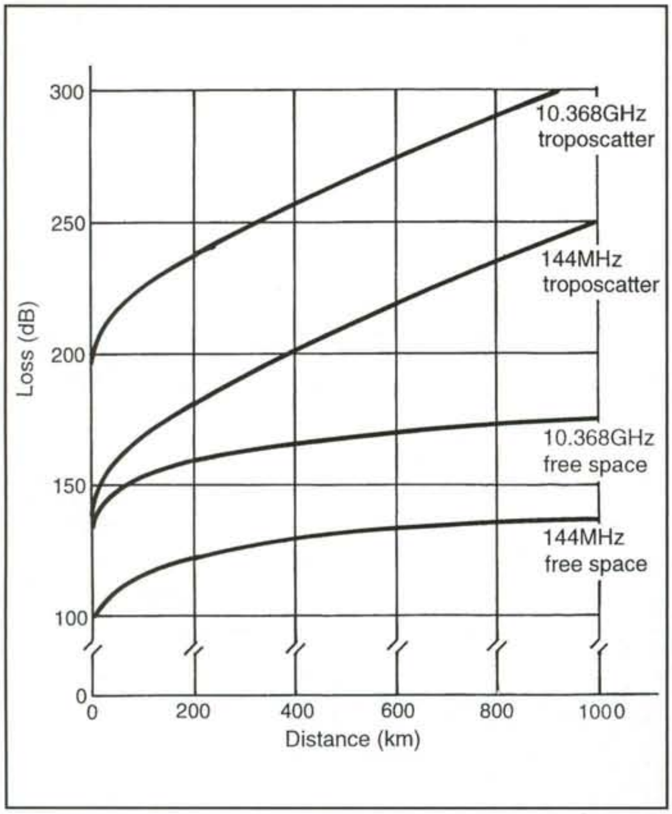


Figure 1. Troposcatter loss.

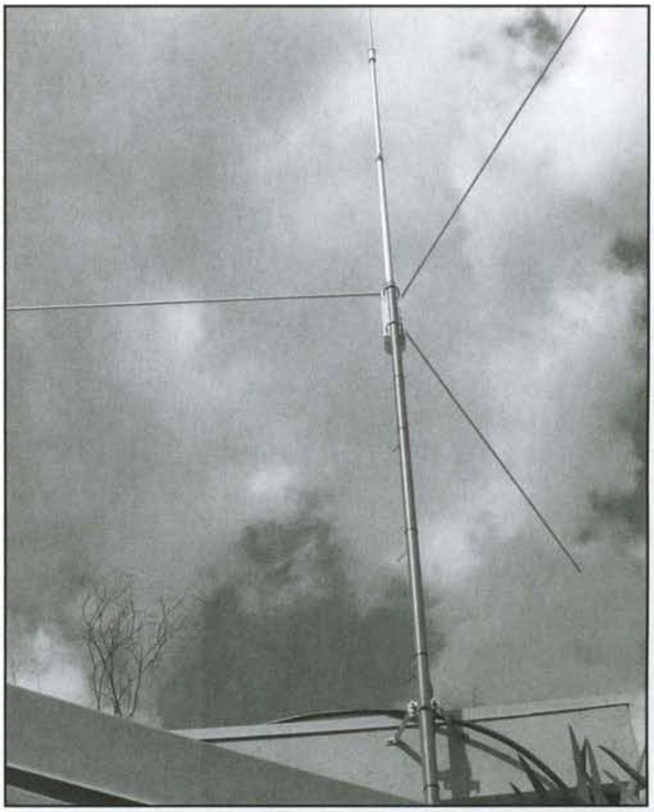


Photo B. Close-up of the 6-meter antenna.

its neighbors. This is a good fit for HSMM EmComm networks, which are created on an ad-hoc basis, and would allow for dynamic routing configuration as new nodes are brought online, or as some become unavailable.

Opportunities and Challenges

As an amateur radio operator operating under FCC Part 97, we have the benefit of experimenting with different RF technologies and being able to utilize higher power devices than folks deploying devices that adhere to FCC Part 15 regulations. What this means to us is that we can choose from a wide variety of radio spectrum (50 MHz, 900 MHz, 1.2 GHz, 2.4 GHz, and 5.8 GHz, etc.) and deploy those devices with amplifiers or high-gain antennas and create long-distance network links that cannot be achieved under Part 15.

Conversely, operating under Part 97 does offer some challenges, such as the use of encryption technologies. Currently, there is an approved process to utilize the basic encryption found in most WiFi access points; it is called WEP (Wired Equivalent Privacy). The downside to WEP is that with very little processing power the encryption can be decrypted. The HSMM Working Group is continuously working with the ARRL Chief Technology Officer (CTO), Paul Renaldo, W4RI, to find solutions to the encryption problem.

The Current State of openHSMM-ap

By the time you read this article, openHSMM-ap wireless access point should be available for download as an Alpha release. Running openHSMM-ap will require the use of a Soekris 4521 single-board computer and a WiFi card. The Soekris is a 486-equivalent computer with no moving parts. The lack of moving parts makes it an ideal candidate for enclosure in a weatherproof box to mount on the side of a tower.

The Future State of openHSMM-ap

There will be new versions of openHSMM-ap released throughout the year. They will include other features that will be helpful in creating true wireless networks. Some of these are a packet filtered firewall and a mechanism to limit bandwidth based on the type of service, which is commonly referred to as Quality of Service (QoS).

If you are interested in wireless networking, especially in the WiFi-type devices, you are encouraged to review the project web page (http://www. openhsmm.org) for up-to-date information. This may be just the type of device you want to include in your ARES/ RACES trailer or personal go-kit.

Deployment

In our local county, we have already identified and received permission to deploy these devices at four locations within the county. Neighboring counties have heard about our wireless networking project and are ready to become part of the local Hinternet. As it stands now, by the end of the year we expect to be connected to three surrounding counties and have a network that is capable of moving information out of an affected area in a timely fashion.

References

ARRL HSMM information: <http:// www.arrl.org/hsmm>
openHSMM: <http://www.openhsmm. org>
Soekris: <http://www.soekris.com>
Gwinnett ARES: <http://www.gwinnettares.org>

By Chuck Houghton,* WB6IGP

MICROWAVE

Above and Beyond, 1296 MHz and Up

Test Equipment for Power Measurements

Testing power at microwave frequencies can be somewhat perplexing if you don't have some basic tools. Some of the tools we will describe here might seem somewhat strange to those who are on the microwave frequencies. An example is the Bird Corporation Thruline wattmeters, and particularly the Bird 43 series of wattmeters.

Most amateurs who use Bird wattmeters assume they are good in frequency and power to about 450 MHz. Well, that's not true. They are capable of higher frequency operation and top out at 2304 MHz. I happen to have a selection of slugs that are rated at 5 watts for the Bird 43 meter. The slug for 400 to 1000 MHz performs fairly well at 1296 MHz and can be used at 1296 MHz with good results. You can obtain slugs that cover 1296 and 2304 MHz with better results.

A better method, however, can be brought into play. That is an AC-powered meter. The answer here is to use a low-cost microwave power meter from Hewlett Packard, such as the HP-432 power meter. To measure power above the +10 dB maximum all you need is an external attenuator to limit expected power to no more than +10 dBm. The HP 432A microwave power meter requires a connection cable between the thermistor power detection head and the meter itself. The power head is capable of a maximum power input to the meter of +10 dBm. If you exceed this limit, expect it to blow the thermistor internal to the power-meter head. Once gone or over-stressed with excess power, repair is possible if the thermistor is way out of balance. However, if it is open on one thermistor, it's gone forever and it's toast.

I like the 432 power meter because it's inexpensive, and the 478A power head does have a few chances of repair if it is over-stressed. Open heads still have a good temperature thermistor and can be used in combination with a single older thermistor head to achieve an operational condition. It's tricky but it can be done.

I over-stressed a good 478A power-meter head measuring power with what I thought was a 30-dB pad that should have protected the thermistor. When I applied RF in the range of 5 watts, it pegged the power meter. I shut down the RF source of power as soon as possible and checked things out. I found out that the Bird 30-dB pad I was using was actually model xxx3C. I got bitten by the 3C part number; it was not "30" as I had thought. You have to check things out to be sure it is a 3-dB pad, not a 30-dB attenuator!

The power meter would no longer balance and was given the repair technique. I rebalanced the power head so it was again operational. Check your attenuators with an ohmmeter to see what is going on. Table 1 lists a few examples of resistance values measured on a few pads in my high-wattage-pad tool box. You can use it as a guide.

See what you have in your collection of attenuators. Many of them function over the frequency of DC to 12.4 GHz using "N" connectors, some very small ones operate from DC to 18 GHz with SMA connectors, and some function on spot frequency. Both the "N" and the "SMA" connector types can function with 2 watts of power for a short duration. The "N" types function for a longer duration. The frequency of operation is a few MHz to 12 GHz on many attenuators. Some are frequency specific. The higher wattage types with heat sinks might be limited to 4 to 5 GHz. Exact values of dB loss and frequency of operation are usually printed on the device. If you need a 10-GHz attenuator, check what you have with a signal generator, if you have one. If the price is good enough, regardless of frequency of operation, pick up the attenuator as an item to use for trade or for your work-bench parts-box collection.

Take a look at the accompanying photo of my work-bench junk box. There are diode detectors, both positive and negative devices for sweep generator use, and general test devices. At the bottom left are miniature directional couplers that

*Member San Diego Microwave Group, 6345 Badger Lake Avenue, San Diego, CA 92119
e-mail: <clhough@pacbell.net>

Manufacturer	Model	Frequency	Loss	A into Ground	B into Ground	C into Out
Narda	765–20	4 GHz	20 dB	52 ohms	52 ohms	50 ohms
Bird	XXX-3C	—	3 dB	152 ohms	152 ohms	18 ohms
Narda	3NM	DC–12.4 GHz	—	50W term	NC	50 ohms
Weinsch	—	DC–8 GHz	30 dB	50 ohms	50 ohms	91 ohms
Narda	768-30	DC–11 GHz	30dB	50 ohms	51 ohms	93 ohms
Narda	768-20	DC–11 GHz	20 dB	62 ohms	62 ohms	52 ohms
Narda	766-3C ?	—	30 dB	144 ohms	162 ohms	108 ohms
Narda	766-6	DC–4 GHz	6 dB	87 ohms	90 ohms	35 ohms
Micro Lab	AB20N	—	20 dB	52 ohms	52 ohms	83 ohms
Micro Lab	AD-10	—	10 dB	64 ohms	64 ohms	51 ohms
HP	—	DC–12.4 GHz	30 dB	50 ohms	51 ohms	51 ohms
HP	—	DC–12.4 GHz	20 dB	56 ohms	56 ohms	89 ohms
HP	—	DC–12.4 GHz	10 dB	63 ohms	63 ohms	42 ohms

Table 1. Examples of various value attenuators in my junk box

also can be tested with a VOM to see if they are alive. Check the through path and the 50-ohm termination, for example. Believe it or not, I have found terminations that were blown, probably from excess power application. The simple VOM can give you great confidence when you attempt to pick up equipment such as attenuators, diode detectors, and directional couplers at swap meets. Of course, further testing on your work bench is needed before you actually use the device so that you will not replicate my mistake regarding the "3C" pad.

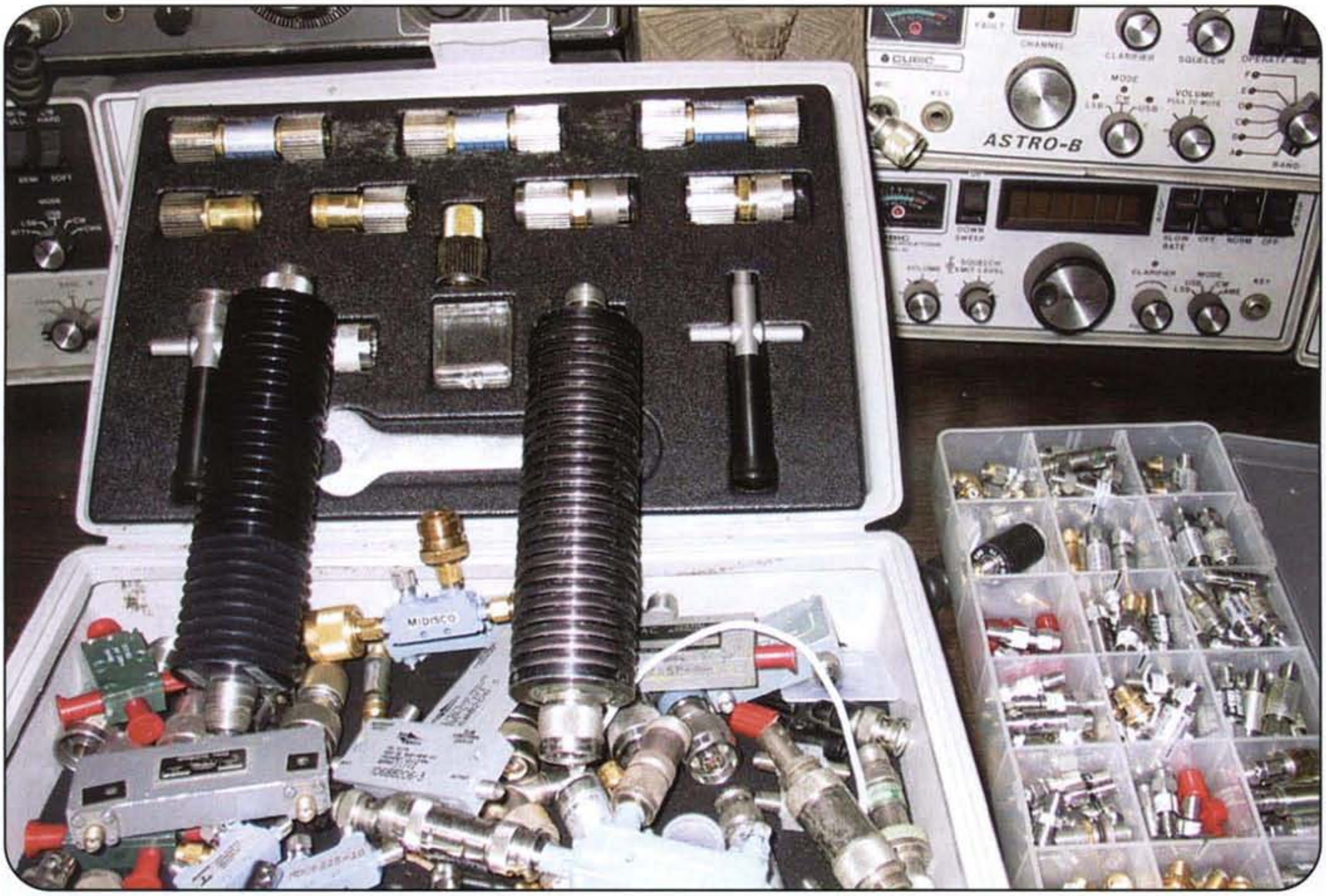
Check out all power meters that you find a swapmeets, because some may be a good deal, if only for parts. Who knows? You might get lucky and find a working 436A digital power meter for an unbelievable low price of $25! Checking out the HP 432 and 431 power meters, you will find that the 432 is an updated version of the 431 model, and usually one can be picked up for $25 or less. The cables to connect the meter to the thermistor detector head can be obtained for $20 to $35, and the 478A power head can be obtained for about the same price at swap meets or on eBay. All cables and power heads are interchangeable with the 431 and the 432 meters. I have a pair of 432 meters on the bench and love them. If you can, hold out for a 432 meter, as it's a great update over the 431 and is better in operation, drifts less, and is still low in cost.

To do a quick manual test of the 478A power-meter heads use a VOM. This will allow you to sort out defective power-meter heads on the spot at swap meets. Measure pins #1 and #3 to ground. They should be nearly the same resistance value, say 3K ohms. If the values are out of balance, the power meter (432A) will not balance its internal meter circuitry. Power heads way out of balance can be brought back to life by adding a very-small-value internal resistor to bring the meter back into balance. Send me an e-mail or drop your phone number in the mail to me and I will help you with repair techniques should you need it. Let's hope you don't need repairs, though!

Another great find is power attenuators, be they SMA miniatures or attenuators with heat sinks attached. These are usually fitted with type "N" connectors for the heat-sinked variety (see photo). The two big black attenuators in the photo are rated at 40 watts to 11 GHz.

If there are any specifications marked on the attenuator, pay attention to frequency of operation or possible power rating—e.g., 20 watts or loss value in dB. Here is where the VOM again comes into play. Test the attenuators with your ohmmeter to see what is alive. Most attenuators on the market are constructed with the "T" design; that's two resistors in series (in and out) and one from the center tap of the two series resistors internal to ground. Coax connectors get dirty, and don't let that taint your determination of the connector as good or bad. Give questionable center-connector pins a cleaning and then try the VOM test again. On "N" connectors they tend to become slightly dirty from general use. If the connector is gold plated, chances are it will be clean.

A set of pads and a good 432 power meter will allow you to make very accurate power-meter tests from a MHz to



Pads, including high-wattage versions (the large black pads). At the far right is a box of 1-dB step value SMA connectors.

12.4 GHz with confidence. To measure power at all microwave frequencies up to and including 12.4 GHz, again the best low-cost power meter is the HP 432. The frequency range can be stretched a bit with good calibration. Power-wise, in operation maximum input power is limited to +10 dB.

Now to measure a 10-watt TWT amplifier operating at 10 GHz. How do you do it? What you need is a 30-dB attenuator to reduce the 10 watts of expected power (40 dB). Connecting the attenuator output to the 432 power meter, you will read +10. This is true as long as the power amp or TWT for 10 GHz is putting out 40 dB of power. The power meter by itself is limited to +10 dB and extended to +40 dB with the 30-dB pad attenuator. To work in this manner is quite normal, as long as the attenuator used is rated to handle the 10 watts of power driving the 30-dB attenuator being tested. A 40-dB attenuator is a better choice to protect the thermistor head from excess power.

Another power meter is the Wavetek 1018B. It has an attached power-meter cable and head together with the instrument. On the expensive side, start off with the HP Digital 436 meter, which costs \$100 to \$150 for the meter, \$75 to \$50 for the meter cable, and \$100 to \$200 each for the power meter detector heads.

Also be on the lookout is attenuators, especially ones in the 10, 20, and 30-dB range, as this will give you a remarkable range of combinations of loss use, for example, use the 30-dB pad and the 10-dB pads together. Screw the pads together and you have a 40-dB attenuator. Using this combination with the power meter, you now have 10 watts indicating at 0 dB on the power meter a safety margin of 10 dB. I have measured a bunch of old attenuators in my junk box. Doing this gives you an idea of what to expect from your measurements of swap meet pads. There are a few bad pads in the examples in figure 1. I pick up even unknown ones without testing them *if the price is right.*

The pads in figure 1 are not actually bad, but some are over 10% of actual limits/pad value. For instance, I was checking my 10-watt TWT amplifier and only got +37 dB (5 watts of power). After further checking things out, I found a bad coaxial adapter from SMA to the type "N" connector. It looked good and was short free, but it was becoming hot with short applications of power. I replaced it with a name-brand adapter and got a full 40.4 dB of output power.

You never know when the snake will bite in this microwave world. Shown in the photo on top of the big white box is my collection of APC-7 pads. They act as my standards. The box in the bottom center contains the collection of everything else, with the high-wattage pads being the big black pads with heat-sink disks. The smaller box to the right is a collection of SMA pads in 1-dB increments.

This is material collected over many years. My latest find is a Narda 368BNM high-power termination good from 7 to 18 GHz at 175 watts. It is 12 inches long and $1^1/2$ inches square and looks more like an old-time rectifier. Now all I need is a higher power 10-GHz transmitter to put the pad to use.

73, Chuck, WB6IGP

A quiet location with excellent ground gain, as proven by 7P8NK in August 2004. (Photo courtesy of VA7DX)

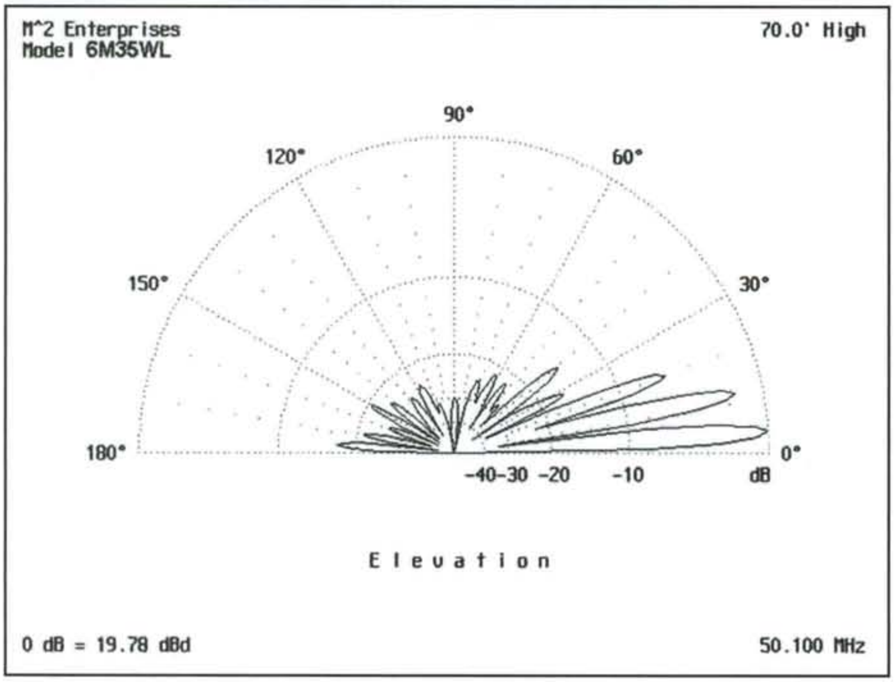


Figure 1. Vertical (H plane) plot of a single Yagi at W7GJ. (Courtesy of KØGU)

If you are planning to limit your EME operation only to the horizon, you also will want to make every effort to locate the station in as favorable a location as possible for the best possible ground gain. Usually, this means finding a clear, flat area, free of "ground clutter" (hills, boulders, or man-made objects such as houses, cars, etc., that can deflect ground-reflected signals away from your antenna). The best terrain for ground gain is salt water, although fresh water (such as a large lake or marsh area) or flat open ground also has been shown to work incredibly well.

When aimed on the horizon, the vertical pattern of a single Yagi antenna becomes a series of sharp, high-gain lobes and deep nulls due to ground reflections. For most small stations, one of the most critical elements in the equation for making an EME contact on 6 meters involves taking advantage of this extra "ground gain." Indeed, with a good, flat clear area in front of an antenna (unobstructed by a roof, HF antenna below the 6-meter beam, etc.), the ground gain of an antenna leveled on the horizon often makes a well located single Yagi perform like an array of two or four Yagis—at least when the moon happens to move in front of one of these lobes. The shape and elevation of these ground-gain lobes depends on the gain of the antenna and its height above ground. Generally speaking, ground-gain lobes are broader with lower gain antennas and lower height, although the lobes from such antennas also are higher in elevation and comparatively weaker.

For a single Yagi antenna at a typical "DXpedition height" (around 20 feet above ground), there is usually a good second ground-gain lobe up around 15-degrees elevation. The quality of the higher ground-gain lobes will depend more on the condition of the terrain in the near vicinity of the antenna in the direction toward the moon, and that is one reason this lobe often seems to be more effective than the "main ground gain lobe." It is much easier to have some control over the terrain a few hundred feet in front of the antenna compared to the landscape many thousands of feet away! Therefore, if you have the chance to set up by a lake or sea, it is definitely advantageous to be as close as possible to the water.

Of course, if you have the good fortune to be able to overlook a large lake or sea so that your most distant horizon is water, you will certainly also have a negative horizon, just from the curvature of the Earth. In such a case, you will find there is a "bonus ground-gain lobe" located around zero degrees elevation. Be sure to use this extra ground-gain lobe to advantage, and by all means plan to operate when the moon is down as far as negative 2 degrees! Just as important as locating your own station to maximize your own ground gain, it is important to look at the times when other stations will have ground gain to coincide with yours. This is especially important for smaller stations and/or stations limited to the horizon (either because they have no elevation, or because they have only very limited common moon window with you). The first assumption often is that there must be very little chance of being able to work another small horizon-only station. However, upon closer examination, one often can find a number of potential common moon windows when both single Yagi stations will have ground gain! Remember that you probably will have first and second lobes on both moonrise and moonset (perhaps plus an additional "zero degree" lobe due to a negative horizon), each of which provides an opportunity to match up with one or more similar lobes at the other station.

As you explore possible contacts, remember that the moon changes in declination every day, so new common moon windows are opened up with different horizon-only stations each day. As you plan your trip, you may also want to look at the times of day for your moonrises and moonsets. For example, if you are going out during a time of year prone to Es, F2 or TEP, you will want to pick dates affording windows in directions and at times of

6M7JHV Yagi during the J68AS DXpedition, June 2005. (Photo courtesy of W8QID/J68ID)

day least likely to be interfered with by these ionospheric propagation modes.

Generally speaking, any disruption of the geomagnetic field/ionosphere will have an impact on 6-meter signals. Even if the MUF is not high enough to produce effective ionospheric propagation at 50 MHz, the chances are quite good that signals can be deflected off their direct course toward the moon and back to you on Earth. Thus, ideally, one would avoid periods of expected cyclical disturbances (such as recurring 28-day coronal holes). However, the exact timing of these types of solar events often are not known with the same accuracy months in advance, the same way reliable Es, F2, and TEP seasons can be predicted.

In addition to the above-mentioned ionospheric considerations, there are two additional factors which can play a large role in the success of a 6-meter EME operation. Luckily, these are related to the moon's orbit and are very predictable. The first is distance to the moon, and the second is the sky temperature (noise) of space behind the moon.

The moon orbits the Earth once every month, and as it does so, it appears to move up and down in the sky. The moon therefore appears to pass through various spots on the celestial sphere, some of which are quiet and others that are extremely noisy down at 50 MHz. Of course, you generally also want to avoid days of the month for "new moon," since the noisy sun will be very close to the moon then. When the moon moves in front of a noisy place in the sky, trying to copy a weak EME signal is just as difficult as trying to hear someone whispering to you from across the room during a noisy party.

In addition, the moon moves closer and farther away from Earth over the course of its orbit each month. This change in distance alone causes a change in signal strength of about 2 dB. The combination of these two factors is commonly referred to as signal "degradation." Degradation is typically expressed as an index in dB, as compared to the ideal situation in which the moon would be at perigee (closest to the Earth) at the same time as the sky behind it is quietest. One would definitely want to plan a 6-meter EME operation during a time of month which affords the least amount of this degradation. These degradation figures (shown in real time on the JT65 operating screen) are also available in several of the popular moon-tracking computer programs available for use in planning purposes. One such free program that is still used by many EME operators is available at: <http://www.bigskyspaces.com/w7gj/tracker.htm>.

Unfortunately, the minimum degradation down at 50 MHz may not be much lower than a couple of dB, because perigee may not happen at the same time as the moon is in a quiet part of the sky. These two conditions move slowly in and out of sync over a period of years. Typically, the 6-meter degradation fluctuates between one or two dB and over 10 dB over the course of a month. If you have been keeping tally, you will notice that there are many factors that can reduce the already very marginal signal strengths on 6-meter EME! Obviously, when signals are just at the threshold of being detectable under the best of conditions, even just a dB or two makes a very significant difference! This may all begin to sound like an impossible game to win. However, with careful planning, the chances for success can be greatly enhanced.

Equipment

Perhaps one of the most fundamentiel elements of a 6-meter EME station is a computer with an interface to connect it to the radio, thereby providing digital capability. An equally important requirement to operate in JT65A mode is to ensure some way to maintain accurate timing of the internal computer clock. The reliability of internal clocks in most computers—especially laptops—is usually quite poor. Ideally, one would like to be able to maintain half-second accuracy at least over the course of an hour-long schedule. If internet access is available, there are very popular programs (such as Dimension 4, Tardis, DXTIME, or Atomic Clock Sync) that can be used to automatically reset the computer clock at a selectable interval (such as every 5 minutes).

If there is no internet available, the most common way to keep the computer clock accurate is to use a GPS unit plugged into the computer running a program such as NMEATime. In the event that neither a GPS unit nor internet is available, the computer clock can always be set fairly closely by ear using WWV, and fine-tuned by adjusting the DSEC control on the JT65A screen until the displayed time closely matches that transmitted by WWV. (Such manual timing would have to be checked regularly, though!) This last method was the resourceful technique utilized by operator N9AB to complete the successful contact from J68AS for W7GJ's 100th country on 6 meters!

Another important piece of equipment is an amplifier. Outstanding results have been achieved by stations using the ACOM 1000 amplifier (kw on HF plus 6 meters) on 6-meter EME DXpeditions, but other types of amplifiers with at least 400 watts output can also be quite suc-

Addition of fans to reduce blower back pressure on W7GJ's amplifiers.

Seven-element Yagi at LA8AV/OHØJFB June 2004. (Photo courtesy of OHØJFB)

cessful. Note that even a 400-watt amplifier has 6 dB gain compared to a 100-watt transceiver. That 6 dB makes a huge difference when signals are just barely discernable, as they usually are on 6-meter EME!

It also is very important to make sure your amplifier can withstand the roughly 48-second full-duty transmit periods of JT65 mode. Usually, the addition of an extra blower or fan to increase the air flow will permit full power operation for this amount of time. Here at my station, I use a pair of high-volume fans to suck the air out of the plate compartment on my amplifiers. This reduces the back pressure on the blower and greatly increases air flow through the tube. With this simple addition, the exhaust only becomes warm—not hot—by the end of the full-duty JT65 transmit sequence.

Another very helpful accessory is a preamplifier for the receiver, although many people have completed 6-meter EME contacts without an external preamp. With most commercial transceivers one will definitely notice the improved noise figure of an external low-noise preamplifier—especially if operating during an optimum time of month (low degradation factor) from a quiet location. As long as there is low feedline loss (less than 1 dB), the benefit from such a preamp will be just as effective if it is installed right in front of the receiver, and that is they way they are used at most 6-meter EME home stations.

A very popular preamp among 6-meter EME stations worldwide is the CA50T, which features a PHEMT device for high dynamic range as well as very low noise figure. It is available through the manufacturer, LNA Technologies: <http://www.lnatechnology.com/lnatech_015.htm>. LNA also has a new RFCA50T model that is RF switched and can be installed directly between the amplifier and a transceiver.

Regardless of the type of antenna used for a DXpedition, it is very important to use good-quality feedline. The loss in the feedline will be very critical on both receive and transmit, and one of the advantages offered by a DXpedition operation often is the ability to set close to the antenna, so only a very short piece of coaxial feedline is required. The availability of low-loss coax such as LMR600 has been a tremendous asset in optimizing 6-meter EME stations: <http://www.timesmicrowave.com/content/pdf/lmr/28-31.pdf>.

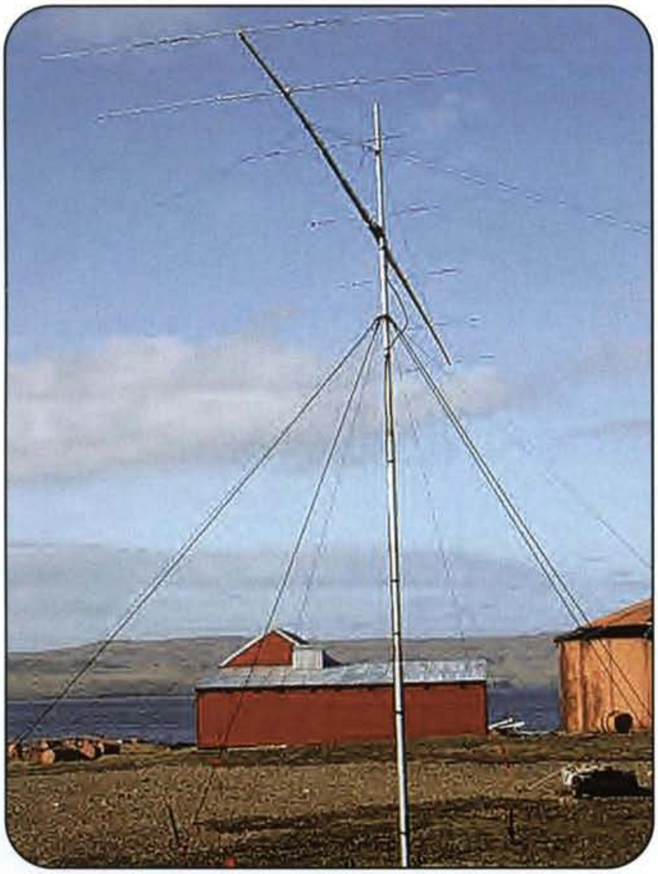
Various types of antennas have been used successfully on 6-meter EME operations. As already discussed, the performance of a small antenna can be greatly enhanced through the use of ground gain. Most successful DXpeditions have used a single, good computer-optimized 6- or 7-element beam. You can view some such antennas in the article, with more examples at the following site: <http://www.bigskyspaces.com/w7gj/6mEMEstns.htm>.

There are several good reasons for using the largest possible single Yagi. If the antenna is going to be aimed on the horizon, a single Yagi will generate multiple good ground-gain lobes, providing more opportunities to complete contacts. In addition, the second ground-gain lobe generated by a single Yagi is often more effective than the lower "main" lobe, simply because it is aiming higher,

Mast bracing and antenna rotating is most easily accomplished with a single yagi. If the azimuth and readout are manual, you can bury the mast in the ground (resting upon a solid object such as a board or concrete block), with a protractor around the mast. An indicator such as a bent paper clip taped to the mast is a very accurate and simple indication of direction.

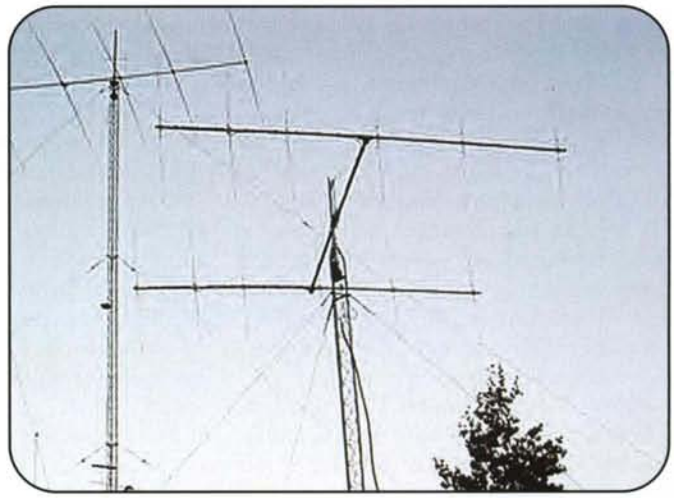
through less atmosphere/ionosphere, and is less subject to tropo ducting and/or interference from ionospheric factors. Another feature in favor of a larger single Yagi mounted as high as possible is that it will be higher and have a lower main-lobe angle of radiation, compared, for example, to a pair of smaller Yagis stacked vertically. In some cases where moon windows are very limited, it may be desirable to try to maximize the signal as low to the horizon as possible.

Of course, it also is mechanically much more secure for a portable operation to erect and guy a single Yagi as opposed to a vertical stack. If the object is to generate the most gain, a large single Yagi aimed at the horizon is the easiest way to do it!



Close-up view of the FT5XO 6-meter antenna (M² 6M7NAN "Trip Yagi"), March 2005. (Photo courtesy of W7EW)

FP/N6RA 6-meter antenna (M² 6M7NAN "Trip Yagi"), June 2005. (Photo courtesy of N6RA)



Six-meter EME array of two vertically polarized side-by-side Yagis. (Photo courtesy of NL7Z)

Mast bracing and antenna rotating is also most easily accomplished with a single Yagi. If the azimuth and readout are manual, a very effective method I have used on DXpeditions is to bury the mast in the ground (resting upon a solid object such as a board or concrete block), with a protractor around the mast. An indicator such as a bent paper clip taped to the mast is a very accurate and simple indication of direction.

The accompanying photos of M² 6M7NAN "trip Yagi" installations show how the mast can be guyed effectively to withstand even high winds. Notice how the antenna at FT5XO is held at the desired azimuth by the two lines that are connected to the rear of the antenna. These lines can be either tied to fixed objects or heavy moveable objects such as concrete blocks (which can be easily moved around to change the aiming of the antenna).

The advantages of a single Yagi having been said, there also are some very good reasons to consider a pair of smaller Yagis mounted side by side. Even though vertically polarized Yagis will sacrifice a few dB ground gain when aimed on the horizon, they can be mounted and elevated quite simply to track the moon. Also, because of the mechanical arrangement, it is easy to aim the array as high as desired—even directly overhead if necessary!

If a pair of good Yagis is used, the free-space gain (when the antenna is aimed up off the horizon) can almost be as much as the very brief peak in ground gain generated by a horizon-only antenna. In addition, as more and larger 6-meter EME stations come on the air, portable operations utilizing antennas with elevation will make the best use of the available moon time.

An example of how a single long-boom 7-element Yagi with elevation could be used to expand available moon windows was illustrated by JA1RJU during his very successful May 2005 operation from KHØ. Although the elevation was limited to about 45-degrees elevation, the moon time was substantially increased. The elevation was manual, with very simple, easily transportable indicators, as shown in the photographs by JA1RJU.

One final note about DXpedition equipment concerns filters. To ensure that the portable operation does not interfere with local TV or other communication services, it is advisable to include a good low-pass filter on the transmitter. In addition, if HF amateur transmitters are being operated nearby at the same time as 6-meter EME activities are planned, it will be very important to make sure they also are equipped with low-pass filters and good grounds. In addition, it can be very helpful to have a supply of ferrite beads to clip over audio leads going into and

Seven-element long-boom Yagi at KHØ/KH2K. (Photo courtesy of JA1RJU)

Elevation indicator at KHØ/KH2K. (Photo courtesy of JA1RJU)

Elevation mount at KHØ/KH2K. (Photo courtesy of JA1RJU)

out of the 6-meter radio and computer, to make sure that HF RFI does not corrupt the audio lines of the EME receiver.

Operating Options

There are various strategies that can be employed by an EME DXpedition station. Some of the same considerations that have been used in CW operations also apply to JT65 mode operation. As with CW operation, it is sometimes helpful to consider split-frequency operation (if QRM is anticipated), and it also helps to have the callers on JT65A spread out a little bit in frequency. Schedules can be set up on one frequency, with random calls always welcomed on another frequency (or, preferably, a small range of frequencies). As long all the frequencies are not too far apart (no more than 1 kHz), they can be viewed simultaneously on Spectran, and the DX station can determine whether to continue to call the scheduled station or to reply to a random caller.

Since the familiar CW pile-up type of operation does not work very effectively with JT65 mode (which does not tolerate QRM well), setting up separate schedules is often preferred. The biggest problem with this approach is that it ties up large quantities of valuable moon time (which is especially limited if the DXpedition has a horizon-only antenna). On the other hand, random CQs will very likely create callers, but often not at the same time that the DXpedition can copy them.

The most productive technique demonstrated so far is this: Home stations who hear a CQ let the DXpedition station know they are being copied, so they can run a quick schedule. In this way, the DX station can sequentially run skeds with stations copying him. This is quite easy if both stations have access to the internet, but internet access is frequently not available in remote locations.

For remote DX stations with which there is no internet contact, it would seem that the only options are pre-arranged schedules or random contacts from CQs. Based on results from this year's 6-meter EME DXpeditions, and previous experience with 2-meter EME DXpeditions, it generally seems that calling CQ is usually more fruitful in creating successful contacts—at least as far as the DXpedition station is concerned.

However, because both stations may not be able to have extended common moon windows to wait for a suitable situation when a CQ can successfully be answered in real-time two-way contact (if such a situation ever indeed arises), there is still a need to accommodate some aspect of scheduling with an individual station.

Although basic JT65 contact exchanges and procedures are based on traditional CW protocols, there are some very attractive new features possible with JT65 that can be utilized to make random DX operation more successful. These new methods have been tried to a limited extent so far, but with good success. Obviously, what would be very helpful is some indication from random callers that they are copying the DX station; otherwise, the DX station can waste much valuable time calling stations that cannot copy him. One way this currently could be done would be for the caller to send callsigns plus received dB signal-strength level. This could indicate that reception was taking place, and there would be a good chance for a quick contact. Table 1 is a possible scenario, shown in alternating transmit sequences.

There are a few comments warranted regarding this random contact. The first is that K6MYC accepted a couple of dB handicap by sending the signal-strength report when he called J68AS to show that he was copying. However, this may well prove to

DX Station Xmit Sequence	Home Station Xmit Sequence	Comments
CQ J68AS FK94	—	Calls CQ and sequentially decodes callers using the JT65A FREEZE filter with DECODE button.
—	J68AS K6MYC -27	Answers CQ with current signal strength, indicating how well he is copying.
K6MYC J68AS FK94 OOO	—	Sees that K6MYC copies so replies to him with standard reports.
—	RO	K6MYC replies with standard *shorthand* confirmation and reports, which are easily recognizable visually to DX on Spectran.
K6MYC J68AS RRR	—	DX acknowledges with final RRR, while still sending both calls so others will know whom he is working.
—	73	K6MYC lets DX know the contact is complete, with *shorthand* message also visible to DX on Spectran.
CQ J68AS FK94		DX goes back to sending CQ.

Table 1. The sequencing of a random J65 QSO.

be an effective trade-off if the DX station is copying well enough. After all, a contact only requires 3 minutes, if both stations are fortunate enough to have mutual propagation, so it is important for the DX station to identify stations who are copying him at the same time he is copying them.

The DX station also accepted a couple of dB handicap by sending RRR along with calls. This is very helpful, though, in the event the DX station had previously replied to another station with a signal report (such as may be the case if he is interrupting a schedule to make the random contact). Similarly, the DX station could continue to send RRR to K6MYC for an extended period of time (even if K6MYC faded away for awhile), and not worry that the message would be misinterpreted by any other stations. This ability for the DXpedition station to answer a random caller (or even call CQ), and then continue to pick up again in the middle of a contact with a scheduled station, provides great flexibility for the DXpedition station, and greatly enhances the chance of successful contacts for all the stations.

In the above example, K6MYC is able to reply using the standard contact information without callsigns because the DX station will know they are being sent to him. Furthermore, the DX station will know that they are being sent from K6MYC, because the FREEZE filter already has been set on him, and his signal (and its exact frequency) can be seen on Spectran. Visually decoding the RO and 73 messages on Spectran allows the DX station to focus on decoding other stations and preparing to reply to other callers and/or returning to his schedule.

The rule that seems to be suggested by this scenario is that (at least when there are multiple callers detected) the CQing station working random should probably always send complete calls along with OOO, RO, and RRR, while the callers can continue to use the standard shorthand messages by themselves. However, please note that this is possible only if neither station has a portable callsign. For example, if the DX station had been FP/N6RA (or the home station had been G8BCG/P), it would not have been possible in JT65 to send calls at the same time as RO and RRR. An example of a JT65A screen showing a contact where W1JJ answered a CQ by W7GJ using such a protocol is shown in figure 2.

In the example, you will note that the RO sequence received at 1237Z had a "?" after it. A FREEZE filter with a narrow TOL then was set up centered on the signal's SYNC frequency, and the sequence was decoded again. The fact that the "?" disappeared indicated it was a good transmission. The screen shot was taken as W7GJ was repying with final RRR to W1JJ, using callsigns in addition to the final RRR (so other callers would know to whom the RRR was being sent).

The other required element here is that stations calling on random in JT65A mode ideally would spread out with 200 Hz between them. This spacing ensures that

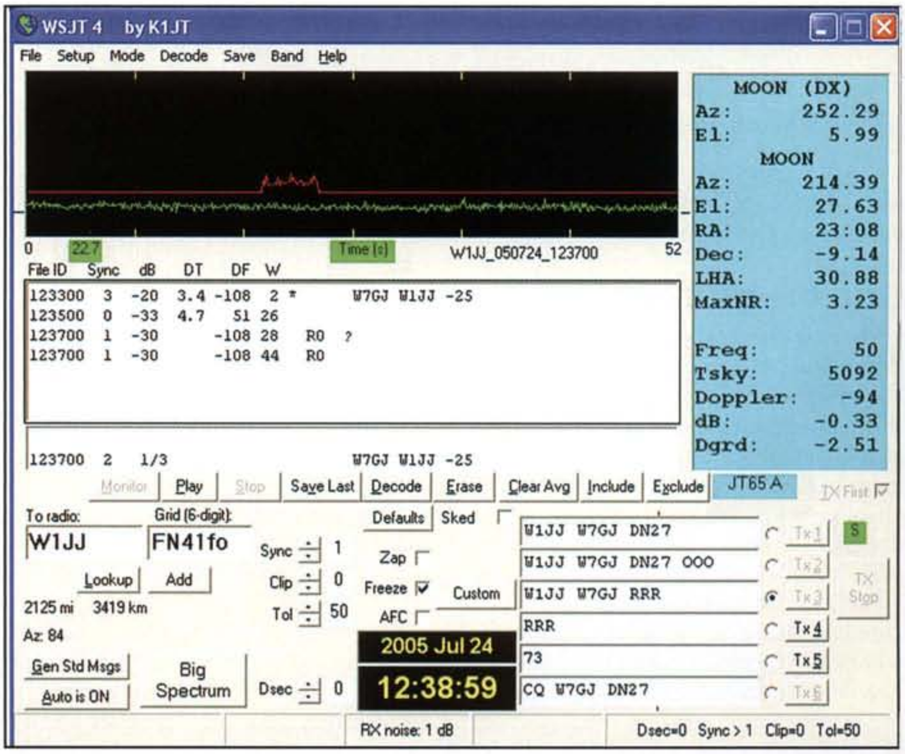


Figure 2. An example of a JT65A screen showing a contact where W1JJ answered a CQ by W7GJ.

they will not interfere with each other, and the DX station can easily separate them using 50 or even 100 Hz TOL settings with their FREEZE filter. An arrangement that would appear to work here is for the sked stations to call 200 Hz *down* in frequency, while all random callers reply *higher* in frequency, trying to space out at 200-Hz intervals. The DX station could then clearly identify the sked station (as the only trace with negative DF) and still be able to see the random callers. To provide an opportunity to practice selecting and alternately decoding stations answering a CQ by using the FREEZE filter, six files are provided while W7GJ was completing first with K7BV (who indicated he was copying, by sending a dB signal level when he called), and then with K1SG. These can be downloaded from: <http://bigskyspaces.com/w7gj/JT65Apracticefiles.zip>.

The problem remains, of course, that with horizon-only capability, the DX station has little time available to wait for the polarity to rotate in order to complete a contact where propagation is not mutual. He probably needs to give it a good 20-minute try before going off to call CQ or answer other random callers. He can always return to the sked station later if he sees him again. If the DX station has elevation, he is not nearly as limited by a few narrow ground-gain lobes, and has the luxury of more time to operate random. In such a case, it makes sense for the DX station to set up schedules with horizon-only stations and/or stations with limited common moon windows, but also to always watch for off-frequency random callers and to call CQ during any non-sked times.

As experienced JT65 users are well aware, the visual aspect of receiving EME signals is an equally critical element in efficiently operating the station. Often, it is seeing the presence of calling stations during a receive period that provides the operator the extra time to decide where to set his FREEZE filter to be ready for the decode at the end of the receive period, so he can set his next transmit period accordingly. Obviously, if he simply visually decodes the final RRR shorthand message from one station, he can quickly set up to decode another caller instead, thereby being able to decode and reply to the new station before the next transmit period begins. Similarly, if he sees absolutely no visual trace from the schedule station, but observes another strong station calling slightly higher in frequency, he safely focus on the random caller. Or, if he sees a trace on the schedule frequency, he can set up to first decode that caller, and try to complete with the sked station. Callsigns and messages are quickly selected automatically by simply double clicking on the caller's callsign. It is the combined use of the visual waterfall display, along with skilled selective sequential decoding of various signals, that will enable the DX station to send the most judicious information, and thereby maximize EME contacts. You will be able to practice recognizing the appearance of the shorthand messages, as well seeing the different callers, if you download the above practice files.

Conclusion

In conclusion, I can't over-stress the importance of effective planning and some actual pre-trip practice with the JT65A software and the particular equipment assembled for the DXpedition. With good planning and preparation, you can enjoy the results of "Ultra Long Path" contacts, even if the 6-meter band would otherwise appear "dead."

Whether you are planning a DXpedition for meteor scatter, VHF contesting, or HF, I hope you will think about adding 6-meter EME capability as something special to fill the time when the moon is beckoning. Here's wishing you a healthy amount of good luck in making some very special "Celestial Magic" on the 6-meter band! ■

load packaging, telecommand, recovery, flight prediction, balloon selection, and how to improve our techniques. In true ham fashion, there was much being done by trial and error. Murphy's Law was a frequent visitor to each launch.

One group near the Gulf of Mexico had put color TV and other nice electronics into a payload package that was not waterproof and could not float. The winds aloft carried this flight out over the Gulf, never to be seen again. They now launch much farther inland and pay much closer attention to the winds aloft! There are lots of stories about the bumps in the learning curve.

In order for us to share our stories and experiences, a conference dedicated to ham ballooning, the first National Balloon Symposium, was hosted in Denver by Edge of Space Sciences (EOSS) in August 1993, just two days after the recovery of our flight number two. Groups represented at this first conference included the host EOSS, Pacific Northwest Balloon Launch Team, Bill Brown (WB8ELK), Perryton High School "Reach for Space," Wichita Area Balloon Chasers, Space Science Over Kansas (SSOK), North Texas Balloon Project, Utah State University, and HABET (Iowa). The *EOSS Handbook* and *Symposium Proceedings* helped fill the information void and allowed many more individuals and groups to get into ballooning.

My guess is that probably over 600 ham missions have flown. For instance, Reach for Space number 20 was one of the six that flew on Saturday, April 16, 2005. Interest in flying balloons is on the rise. Ralph Wallio, WØRPK, is collecting records of the various balloon flights and posting them to a web page at <http://users.crosspaths.net/~wallio/>.

There is Always a Parachute

The parachute is made from rip-stop nylon, which costs about $5.00 a yard. The most visible colors are fluorescent pink, yellow, or orange, and a yard and a half makes two parachutes. Of course, you need two only if you lose the payload, since the parachutes are reusable! Cut six panels, using the pattern, and sew them together. Press each seam to the side and sew again, 1/4 inch from the seam, and trim off the excess.

The top of the parachute is open and hemmed, with crossed straps made of 1-inch strips of the nylon folded in half, then the sides folded into the middle and sewn. These are pinned in an X across the opening and securely sewn to opposite sides of the hole. Hem the bottom of the parachute, and attach grommets (metal eyes) through the hem at each seam (and halfway between, if you prefer). These are applied with a special pair of pliers (about $12.00) or a hammer and the little shaped rod that comes with the grommets.

Four feet of nylon string is tied through the grommets, double knotted, and then hot glue is put on the knots. One of the tips we got from other groups is to add a hoop at the bottom of the parachute strings to prevent tangling and loss of the payload if the parachute doesn't open. The end of each string is then tied to the hoop, double knotted, and hot glued. A swivel is attached to the center of the crossed strips at the top to separate the rotation of the balloon from the payload. Four lines go from the hoop through the eye of another swivel for the payload string below. A drawing of the finished product can be seen in figure 1.

Keep It Legal

We may not think about it, but there are regulations concerning what can be located in the air above us. For instance, did you realize there are regulations for the little rubber balloons that you see at car dealerships? I suspect the owners of the car lots are not aware of those regulations either.

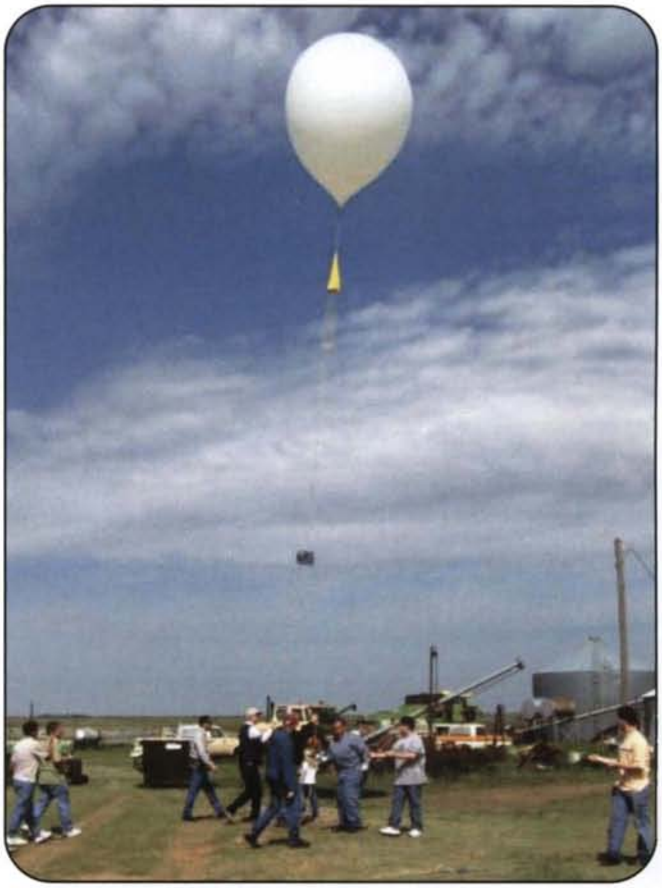


Photo D. Each part of the payload is controlled by one person, with the lines lying flat in each person's hands.

Rules for blimps, kites, unmanned rockets, moored balloons, and unmanned free balloons are found in Part 101, subchapter F, Air Traffic and General Operating Rules, of Title 14 of the Code of Federal Regulations (this string of words is the official name for the regulations). There is some room for interpretation as to what is meant by "use a rope or other device for suspension of the payload that requires an impact force of more than 50 pounds to separate the suspended payload from the balloon." We had some students run a series of drop-weight tests on #18 stranded nylon string. They found the breaking point to be 11 pounds. We use up to four strings in parallel for the load-bearing lines that hold the payload to the parachute and the parachute to the balloon.

Some other groups interpret this to mean a cutting force and use a stronger string than we do. We know to melt the ends of the nylon string after we cut it, but learned the hard way that knots in the string can untie themselves. Here was another opportunity to learn a lesson.

Lesson 8: *Hot glue all knots.* Needless to say, knot failures are not any fun, especially when they untie themselves at some altitude!

In the regulations there is a blanket exemption for payloads under four pounds. If you meet certain size requirements, then the payload can be up to six pounds, and it is possible to string on several payload packages if everything is 12 pounds or under.

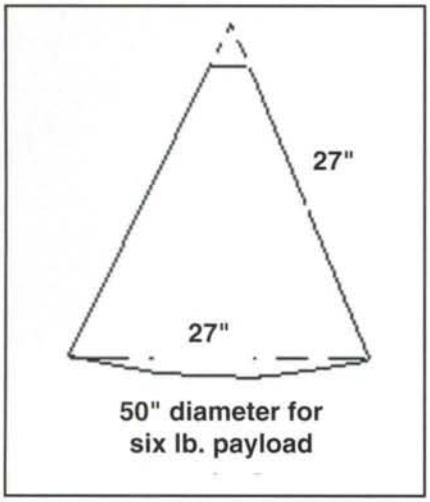


Figure 1. The finished product.

More regulations: "No person may operate an unmanned free balloon in such a manner that impact of the balloon, or part thereof including its payload, with the surface creates a hazard to persons or property not associated with the operation. . . . Nor may you operate during the first 1,000 feet of ascent over a congested area of a city, town, or settlement or an open-air assembly of persons not associated with the operation." These regulations led us to yet another lesson. . . .

Lesson 9: *Move launches away from the school and town setting.*

Also, as the regulations say: "At least two methods, systems, devices, or combinations thereof that function independently of each other are employed to terminate the flight of the balloon envelope; and the balloon envelope is equipped with a radar reflective device." If you fly latex balloons, the natural bursting characteristic of the balloon counts as one of the cut-down devices. Rubber balloons are required to have two devices. Cut-down methods will be discussed in another section of this article.

A radar reflector is a simple addition. A friend connected with an oil field told me about a field experience in the late 1960s near Midland, Texas. Work was slow, so to entertain themselves, someone brought out a big party balloon. They filled it with some helium, tied a roll of aluminum foil to it, and let the foil unroll as the balloon took off. They were having a lot of fun until a couple of interceptor jets appeared overhead. They ended up agreeing with the Air Force officials that chasing jack rabbits would be a much better cure for their boredom, and they said they certainly would never do that again.

Photo E. Mike Helm, WC5Z, with his "little" direction-finding antenna.

I assume this story confirms the usefulness of aluminum foil as a lightweight radar reflector. For several flights we laminated 12 to 15 feet of aluminum foil. Now we use the "space blankets" to make mechanically stronger reflectors. These rules can be found on the EOSS web page at <http://www.eoss.org>.

Payload Containers

Each group seems to have its own favorite payload container. On our flight number 20, we experimented with duct taping things to the outside of a payload container. As long as the batteries don't freeze (at –60° Celsius), it appears the electronics will function fine. We have many great photos from a Vivitar 35-mm digital camera that was included in the duct-tape experiment. The 2-meter beacon transmitter belonging to Michael Helm, WC5Z, provided a good signal until the center conductor of the antenna broke off at the circuit board. Michael describes his beacon and camera circuit in his article entitled "A Telemetry Beacon and Digital Camera Controller System for Experimental High-Altitude Balloon Flights," which appeared in the Fall 2005 issue of *CQ VHF*.

The taping of additions to the outside of the packages is not a recommend practice. We have used Styrofoam™ picnic coolers, Styrofoam™ minnow buckets, insulation board (for houses), foam core, aluminum boxes, cardboard boxes, and plastic food containers. A plastic food container is our favorite. Inside the container, a Styrofoam™ block is cut out so each item has its own space and is surrounded on all sides when the lid is put on.

Because switches can accidentally be turned on or off at the wrong time, we bring the power lines outside the box and use a polarized quick-disconnect power cable (#270-026). It is very easy to visually inspect for plugged or unplugged connection status.

In receiving signals from the balloon, we have experienced deep fading when using horizontal polarization, so now we use vertical dipoles made from hook-up wire. Ice picks are used to make the necessary holes, and after the wire is passed through, hot glue is used to seal the wire in place.

If we will need some warmth inside the container, we use chemical foot or hand warmers we obtain from a sporting-goods store. Right before lift off, someone crumples the warmer, puts it inside the container, closes the lid, and tapes it shut.

For power we use a surplus lithium battery rated 3 volts at 7.5 amp-hour. These batteries are available from S & G Electronics, Philadelphia, PA.

Each group has its own favorite container. In order to increase the ground range of the 2-meter signals, some are experimenting with designs for the payload always landing top up, placing the 2-meter antenna up off the ground. Some are using nylon jackets to protect the outer surface of their packages. The packages range from the simple to complex, depending on the goals and talents of each team.

Cutdown Devices

There are times when a group may want to bring down its payload before the balloon bursts. This is typically done if the balloon is traveling to an undesired area, such as over a large body of water, into restricted airspace, or over a city. There are three kinds of devices: incendiary, heated nichrome wire, and a guillotine, using a razor blade. The most common is the nichrome wire used to melt nylon cord. Each is activated by a radio signal, sometimes independently of the rest of the payload, and sometimes as part of a set of commands. The device usually has its own power supply. Craig Brunson, N7TSZ, of the Reno (Kansas) County Amateur Radio Association, RCKARA, describes the group's device in these terms:

> We use ~3.5 inches of 30 AWG nichrome wire and heat it with either two each 2/3 A (6V) or three each 2/3 A (9V) lithium batteries. This is used to cut 215 lb., 550 lb., and 1000 lb. nylon cord. It will cut the cord in 3 to 5 seconds. The nichrome is wound around the cord with seven loops. This is the standard cutter that we use for NASA and NOAA. It is not affected by the cold and has been tested dozens of times to well over 100K ft.

The group's website has pictures from the Great Plains Super Launch 2004, as well as other information, and it is well organized. Go to: <http://www.rckara.org>. A very clear photo of the device used by Michael Gram, KD7LMO, of Arizona Near Space Research, is on the group's website at <http://www.kd7lmo.net/cutdown.html>, along with a short description. Wire may become brittle at the extremely low temperatures of near space, and the group recommends Teflon®-coated wire instead of common CAT-5 ethernet cable or telephone hookup wire. Recommendations and devices are the result of flights with failures. It is valuable to learn from other groups, rather than repeating the experience!

HOBO Data Logger

The HOBO data logger is a tiny, lightweight logger that receives input from sensors and stores it until it is downloaded upon recovery. Onset, the manufacturer, produces a line of sensors for recording temperature data, as well as a variety of other sensors. Paul Verhage, KD4STH, has published instructions for building your own light and temperature sensors in *Nuts and Volts,* a publication we highly recommend if you enjoy hands-on electronics. Paul gives lucid, detailed instructions for building components, and high school students can follow his directions independently. One of the benefits of our balloon flights is the enthusiasm for science and interest in the environment that students experience, especially when they themselves build some of the payload. The HOBO data logger is an excellent addition to a flight.

Photo F. It's out in this field somewhere...

Student Experiments

One of the goals of near-space research is to give students the opportunity to try some of their own experiments in conditions they would not have had otherwise. Our students at Perryton (Texas) High School have flown experiments investigating cosmic rays and devices to sample air pollution at different heights in the atmosphere. Ordinarily, the students involved are university students who may design their own circuits and test data collection devices, radio propagation, or control commands in writing their own programs.

Simple experiments that fit in a ping-pong ball are an exciting idea for younger students, and they have tested ideas such as the effect of conditions of near space on seed germination or bacteria viability. The research and design of simple experiments is a valuable exercise in problem solving. Publication of university experiments, especially with stamp controllers, may be found at <http://www.parallax.com/html_pages/downloads/apps/third_party_articles.asp>.

Paul Verhage, KD4STH, is compiling his articles in *Nuts & Volts* into an e-book published on the Parallax website at <http://www.parallax.com/html_pages/resources/custapps/app_nearspace.asp>, and he includes suggestions for student experiments.

While telemetry data can be sent down via radio frequencies, with our simple circuits only a very limited amount of data can come down. In his articles Paul brought to our attention data loggers. These tiny modules record lots of data. We chose a four-channel HOBO from Onset. The unit is very small, about the size of a matchbox, and weighs less than 1 ounce. Recording data every second, it will collect for 2 hours and 15 minutes, while recording in 60-second intervals it will collect for 5 days and 15 hours. With these devices it is easy to become buried in data!

APRS

One of our trackers, Joel Bennett, KK5XS, says, "The use of APRS (Automatic Position Reporting System) is somehow like cheating." Joel prefers the manual triangulation methods of tracking. Receiving the position reports from the balloon is fantastic until something causes the loss of data. We find it is a good idea to have our chasers equipped for both the APRS and manual techniques. A program called Balloon Track is available from EOSS, and it provides a prediction of the eventual touchdown spot, if the information entered into the program is accurate. Necessary information includes winds aloft, lift, ascent rate, payload weights, and balloon size and type. The winds aloft are available from the National Weather Service from its twice-daily releases; we download them from the University of Wyoming website at <http://weather.uwyo.edu/upperair/sounding.html>.

Photo G. The payload was recovered in less than half an hour from "splashdown"!

GPS units are available as engines, built into the antenna, or as complete hand-held units. Check on the Ralph Wallio, WØRPT, web pages for the units that will work above 60,000 feet. Many units are altitude limited. The hand-held Garmin Etrex and model GPS-35 (engine built into antenna module) have been flown successfully by many groups (see <http://users.crosspaths.net/~wallio/>). Also, Ralph's balloon links list 59 groups, so there may be a group near you. The records lists are very interesting reading as well.

Popular TNC units are the Tiny Track and Pocket Tracker from Byonics (http://www.byonics.com) and Scott Miller's Opentracker (http://n1vg.net/opentracker/). Scott offers group and education discounts. Balloonists use the 144.390-MHz national APRS frequency, and more are going to 144.340 to get away from the congestion of the national frequency.

Many groups I-gate their balloon's APRS information onto the internet. Many use a –11 on their call-signs. On <http://www.findu.com> watch for WBØDRL, KD4STH, K5IS, KE5BFH, WB8ELK, KD7LMO, W5ACM, KC7NAX, KEØVH, N4TXI, N9XTN, and W5SJZ. This is a partial listing. On any Saturday and Sunday you will find balloon tracks being displayed.

Into the Future

More groups will be flying. It would be interesting for weak-signal operators to have the use of linear translators as cross-band repeaters for SSB and CW signals. More experiments need to be done on the microwave frequencies. Much more work needs to be done to eliminate the electromagnetic interference (EMI) between the components within a payload package. In our own projects we would like to add an interface to translate sensor data into Morse Code.

We hope to see many more partnerships between balloon groups and students of all ages. The age of near-space exploration by private citizens has arrived!

Summary

We have had a steep learning curve, and it has been an exciting adventure. We began with the idea of designing balloon flights that were inexpensive, with a basic package of two beacons, transmitters, a camera, and simple packaging. We have come to appreciate the addition of more complex components such as digital cameras and BASIC stamps. No one warned us that balloon flights can be addictive, even if they are frustrating.

One of the most enjoyable aspects of the experience has been the cooperation between groups and individuals. Few people can master all the skills needed for a complex flight, and the contributions of fellow hams have been welcomed and appreciated. We have learned from each launch we have attended or done ourselves. And when you get down to it, it is just a lot of fun! ■

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Photo 4. Joe, W5KTX, measures the resistance of the #6 ground wires attached to the copper-clad steel rod encased in the center of the 8" × 8" × 9' trench.

as at Sanderson, the continued absorption of ambient atmospheric condensate may be an adequate source of ionic activation of the bentonite.[6] Published measurements of resistivity of a typical soil vary from >10^6 ohm-cm for 0% moisture to ~10^3 for 30% moisture. We also must measure resistance in midwinter, when the earth's surface has cooled. Marked variation in resistivity occurs with temperature changes:

At 20°C resistivity is >10^6 ohm-cm; at 40°C (not uncommon in west Texas) soil resistivity *decreases* to ~$10^{1.5}$ ohm-cm. In our Texas desert, rain, excluding thundershowers, is often rare for months at a time Heat is predictable and it surprised one of us that the sun is on our side!

Geometry of the bentonite ground is relevant. The resistance to earth of a rod driven into homogeneous soil is characterized as a series of concentric buried spherical elements. A solution for resistance of a single rod is (after ref. 4):

$$R_0 = \frac{\rho}{2\pi\ell} \ln \frac{4\ell}{d}$$

where d = rod diameter in cm, ρ = earth resistivity in ohm-cm; ℓ = rod length in cm; and ln is the base of natural logarithms.

Note that length, as well as the logarithm of length, affect the resistance, with length predominating over diameter in its effect. However, it can be shown (ref. 4) that 92% of the resistance of a 10' × 1" rod is obtained within a 20-ft. radius cylinder.

Kostic, *et al* [3] compared periodic measurements of resistance for 1000 days. Their test setup consisted of zinc-coated steel strips laid in trenches 0.6m deep × 0.3m wide at the base, formed in a loop 5m × 5m. They show rather wild variations of resistance over time in the conventional buried-loop ground, whereas both bentonite suspension and powdered bentonite poured in the ground strap trench maintained a low nearly constant resistance through the observation period, which included Yugoslav winters. Of interest in west Texas was their comparison of the resistance of ground loops backfilled with waste drilling mud. Although resistances started out fairly identical for the first 200 days, there is divergence toward higher resistance in the mud, as compared with fresh bentonite.

Site	Location of Conductor	Resistance (ohms)
Fort Stockton	Radio shack	0.27
	Tower Base	0.25
	Guy Anchor	45.0
	Meter loop butt plate	4.3
Sanderson	Radio Shack	0.17
	Rod in trench 8" deep	0.1 (0.04)*
	Tower Base	0.17
	Guy Anchor	743.†
	Solar-panel support rod	4.3
	Meter loop butt plate	590.

**The AEMC instrument accuracy is not defined for reading below 0.1 ohms.*
*†Average of 3.**

Table 1. Findings to date.

Kostic, *et al* also evaluated the corrosiveness of bentonite. Based on measurement of corrosion velocity of the zinc-coated steel strips, they characterize bentonite as a *very inactive* corrosive material (0.005 mm/yr.). Drilling mud measured 0.05 mm/yr., and is characterized as an *inactive* corrosive material. They also conclude that bentonite powder can be "successfully used instead of bentonite suspension." This finding markedly decreases the expense and labor required to install a grounding system.

Jones[2] reports similar experiments conducted in upstate New York. They investigated the effects of bentonite used as backfill in hardpan silt, clay-cobbles-gravel, and mixed soil with a sandstone layer beneath. Driving rods into hardpan and the sandstone was nearly impossible. They broke drill bits in achieving usable holes to insert rods and backfill. No comparison measurements were possible with the hard pan, because driven rods bent over after going 1 foot into the soil. Hardpan resistivity was nearly constant over one year at 3,700 ohm-cm. For clay-cobbles, a 23% reduction in resistivity (2,060 to1,590 ohm-cm average over one year; for sand and silt over sandstone, 36% reduction of resistivity (4,260 to 2,710 ohm-m). The advantage was constant over the year of observation.

Jones shows that the advantage is a "direct result of increasing the effective surface area of the ground rod." Using the equation above, he showed that (for very non-conductive surrounding soil) increasing the effective diameter of the rod from 5/8 inch to 6 inches produces a 34% improvement, regardless of resistivity. These figures compare favorably with their experimental results, reported above. If, in solving the rod resistance equation, an assumption of negligible resistivity in surrounding soil is untrue, "bentonite's benefit will diminish…The greatest % reduction in rod resistance will be realized with resistivities over 10,000 ohm-cm."

Photo 5A. Direct clamp-on measurement of the ground conductor resistance near the radio shack. Unit reads less than 0.1 ohm, its limit of resolution.

Because we lacked the drill rigs available to Jones, we opted for the approach reported by Watts.[1] We were able to borrow a heavy-duty electrically powered rock hammer to make the shallow trench required. Watts's trenches were sometimes 24 inches deep—beyond our aerobic capacity! (Watts had a narrow bucket backhoe and often dug three trenches.) This was, by far, the most difficult part of the installation, with slurry mixing an equally muscular task. Both Kostic and Watts showed that one could just pour the powder in the trench. We expect to do this for the next project, but we will require some heavier backfill to keep the bentonite in place. They made a point of brazing their copper connections for a better bond. This, too, is an excellent suggestion!

Photo 5B. Direct clamp-on measurement of the utility pole ground-wire resistance—590 ohms.

For amateur radio operator purposes, there are several ways of making underground connections that provide molecular bonding. Exothermic techniques such as "Cadweld" [7] are well known. The Burndy HyTap[8] compression techniques do not require heating or exothermic processes, but use mechanical compression of up to 12 tons to provide near molecular bonding and are UL-listed for direct burial.

Conclusion

We tried a recently reported technique for acquiring adequate earth connections at rocky desert radio sites. By pouring bentonite slurry around our 5/8-inch rod, we constructed an 8-inch thick cylinder whose exterior tightly adheres to the surrounding rock. If repeated resistance measurements demonstrate values one ohm or below, we shall use this inexpensive adjunct more widely.

Added Note . . .

Last spring lightning struck nearby. All of our AC circuit breakers were destroyed and all power-supply fuses blew out. However, none of the equipment, including two C-MOS UHF repeater controllers, suffered any detectable damage. We had the site back on the air within minutes of our arrival! ■

Notes

1. Watts, LB, 1980, Improved grounding system for mountain top radio sites. Personal communication.

2. Jones, WR, 1980, Bentonite rods assure ground rod installation in problem soils. IEEE Trans Pwr Apparatus and Systems. Vol. PAS-9(4) July/Aug 1343–6.

3. Kostic, MB; Radakovic, ZR; Radvanovic, NS; Tomasevic-Canovic; 1999, MR Improvement of electrical properties of grounding loops by bentonite and waste drilling mud IEE Proc.-Gener. Transm. Distrib. Vol. 146 (1) Jan 1-6.

4. Anon., Military Handbook: Grounding, bonding and shielding for electronic equipment and facilities. 1982 US Dept of Defense MIL-HDBK-419A. Available from DOD Stock Point; Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120. Also available at: <http://tscm.com/MIL-HDBK-419A.PDF>.

5. Chauvin-Arnoux, Inc. d.b.a. AEMC® Instruments; <www.aemc.com>.

6. Rudenberg, R.. cited in ref. iv above.

7. Erico International: <www.erico.com>.

8. Framatone Connectors, Burndy Electrical: <www.portal.fciconnect.com>.

The transverters with an integrated class-A brick would be drawing power when not transmitting. For now, this seemed to be an acceptable tradeoff.

Bells and Whistles

Having accomplished basic control, I decided to try out reading the frequency of my IF rig, a Yaesu FT-857D, adding the offset for the actual microwave band I was on and displaying this on the screen at the same time. I created a polling loop that reads the radio using standard CAT commands and displays the current frequency ($f = f_{IF} + f_{LO}$) on the display. This worked great, and it was reactive enough to be able to watch the display change rapidly as I tuned around on the band with the knob on the 857. Whenever the software is not processing any other commands, it is in a loop reading the radio and updating the frequency display.

It's really not a big problem to know what frequency you are on, since most of the time 144.100 coincides with 2304.100, 3456.100, etc., so no real mental gymnastics have to take place. There are times, however, when a transverter oscillator will not reliably start on the desired frequency, which necessitates setting the LO up off-channel. Since the control system is able to add any arbitrary LO offset, you can now look at the display and dial seeing the actual frequency you are on (let's forget drift for a moment!).

I also added a few features that seemed as if they might be of use during a contest. First, I added memory to remember the current frequency on the band in use. Whenever I switch off one band and went to another, I save the frequency in memory. When I switch back to the original band, the frequency is reset on the IF rig. This is great for situations where I work someone on a higher band and return to a liaison frequency, and then someone says, "Hey, I heard you up there. Can you go back and I can work you there, too?" It's just a button push away. This also eliminates some of the mental gymnastics associated with remembering on which bands the transverters are slightly off frequency. The Fluke 1780 and my Yaesu 857D are shown in photo 3.

Display Troubles

While the 1780A was a good solution on the bench, keeping a 110-volt display running mobile has its challenges.

First was the mounting challenge. The 1780A weighs 18 pounds and is 14" × 11" × 6". Mounting this in the truck where it is accessible has proven troublesome. At present, the only good solution seemed to be to place it on the dash in front of the passenger. This allows the logger to control the transmit band and the display is still readable by the driver. I used long strips of hook-and-loop fasteners to mount the display and have successfully driven the display over a number of rough Colorado mountain passes. The fasteners work well once the adhesive has had time to cure.

My second problem was keeping the display properly powered. Initially, I figured I would just use any 110-volt inverter I had on hand. I had a 700-watt Xantrex inverter handy, and I did some testing in the truck with this unit. All seemed fine until my first contest. The display went blank about 20 minutes into the contest. Upon examination, I found that the fuse had blown. Fortunately, I had brought a backup 1780A, and I quickly swapped out for this one (figuring that a real internal problem had blown the fuse). When the fuse on the second 1780A blew another 10 minutes into the contest, I began to suspect the inverter. I ended up switching to a backup inverter rated at only 250 watts that I had brought with me. This inverter has been in continuous use since that contest and has created no additional problems. Apparently, there is something about the Xantrex that was blowing fuses in the display.

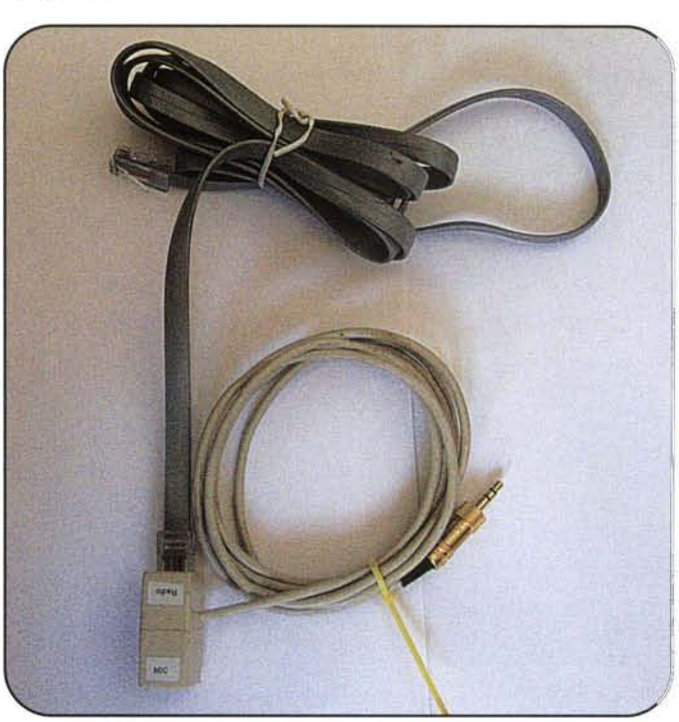


Photo 4. Microphone sense and PTT control cable.

Later I added a TE Systems 350-watt 2-meter amplifier to my mobile configuration and found that I had RF entering the display, causing it to lock-up. The logic in the display, although somewhat shielded by the case of the unit, is still susceptible to a high RF environment. With my initial homebrew 4-element 2-meter antenna on the roof of the truck and the control electronics in the cab, the display relaibly would lose its mind when I keyed and talked on 2 meters with the amp on. I tried placing toroids on the AC line and the RS-232 line to the display with no improvement. For a recent trip, I swapped the antenna for a 2M7 from M^2 and moved the control electronics to the bed of the truck. The problem subsided. Nevertheless, as I add amplifiers on other bands, this problem is likely to reappear.

My long-term solution to these problems is to replace this with a custom control head or perhaps even a laptop. Having said that, I believe the 1780A makes a very good display for home station control. It's just not ideal for mobile use.

Expansion

Having been bitten by the microwave bug, and considering the success of my control system, I expanded to include all bands from 6 meters through 3456 MHz and 10 GHz. My IF radio handled three bands directly—6 meters, 2 meters, and 440 MHz—since they all were in the radio. My switching for these bands just controlled the antenna the radio was on. For bands with a transverter—namely 220, 902, 1.2, 2304, 3456, 5760 MHz, and 10 GHz—I used a six-position coax switch. This is actually seven transverters, but 220 is connected to the TIB directly, since my IF for 220 is 28 MHz. The relay position is directly controlled by I/O lines.

Photo 5. Steve, N5AC, operating the touch-screen control system.

With the number of transverters I had now, it seemed prudent to control the PTT directly. I had some concerns about using the PTT out of the transmitter, since it only goes active once the transmitter is already transmitting. If it took too long to key the transmit on the transverter, it might be damaged by keying into the IF output of the receiver. Instead of risking this, I built the small connector shown in photo 4 to take the key output to the transceiver and use this as an input to the BASIC stamp. I used one of the RJ-45 female-to-female connectors, split it open, and then split the PTT line and the ground out using a 3-pin stereo jack. By

Photo 6. Greg, WDØACD (left), and Steve, N5AC, at the 2005 NTMS/RMG 902 and Above contest.

Photo 7. LCD control head.

doing this, I could watch the microphone being keyed, I could key the transverter, and then I could key the transmitter. This is a very rudimentary form of sequencing and is very easy to implement. When I'm not using the radio as an IF rig, I just unplug the microphone from the RJ-45 connector and plug back into the rig.

I then used a separate I/O line on the BASIC stamp for each transverter as a PTT line. With the system running, you can tell the radio doesn't key instantly, but the lag is very minimal and not something that alters operations.

Contest Performance

With the noted exception of having display problems with the 2-meter amplifier on, the systems works very well. The final setup as run in the NTMS/RMG 902 and Above contest in 2005 is shown in photos 5 and 6. I find that when I go to run the bands with a fixed station, I can switch bands and be on frequency ready to go much faster than any fixed station I have worked to date. In all fairness, many fixed stations have TWT and tube amplifiers on some of the bands. These take time to warm up, and you would not want to leave them on due to the heat generation. All of the amplifiers I have are solid state and require no warm-up.

More Enhancements

Although I'm very pleased with what I have now and it is a very capable contest station, there are always things that can be improved. For the January 2006 VHF Sweepstakes contest, I built the LCD display shown in photo 7 with a few control buttons in lieu of the touch-screen display. I had a band-up and band-down button that allowed me to quickly shift between bands, and my control head was significantly smaller than the Fluke 1780A. My Dad, W5TX, and I used this with great success, until it failed part way through the contest in our rent-a-rig shown in photo 8! Against some advice I was given, I opted not to worry too much about RF getting into the control head. While operating, the display blanked from high RF and I was unable to resurrect it. For the remainder of the contest I controlled the system through the serial port via a laptop, which worked fine.

I am currently debating what I want to do next with the display. I have a touch-screen laptop in the truck, and it would be easy to write a front-end to by BASIC stamp controller that would work on the display. However, this often would require switching applications between logging and transverter control on the laptop, and I have concerns that this would be burdensome. Another option to all of the fancy display and buttons would be a radio-only control system. By this, I mean that just the IF rig would be used for control. For example, if the IF rig were on 440 and you hit the band-up button, the radio would roll around to 1.8 MHz (on my Yaesu it works this way). If I saw this happen, I could put the radio on 144 MHz and switch on the 902 transverter. At this point, the next band-up would go to 440, and again I would put it back on 144 MHz and switch to the 1296 transverter. I've tried to find a way to display 902 MHz directly on the radio, but I've had no success. The 857D has a transverter function and will display up to 10 GHz in the display, but I've had no luck in locating any CAT commands to control this functionality remotely. Therefore, the challenge in doing this is how to indicate the band you're on. I'm working on this problem, although my next project will likely be to run all of my hardware from the MW-520 touch-screen computer in the truck.

My current system also doesn't save the mode. The mode is controlled separately on the radio itself, and if I switch to CW, as I run up the bands, the radio stays in CW. This has not proven to be a major problem, but there may be some utility in saving the mode per band and switching the mode along with the band. This is easy to accomplish, as all of the functionality is available on CAT; it's a simple matter of programming.

One of the final enhancements I'm considering is implementing a few memories per band. On the higher bands I don't think there's a lot of use for this in Texas. There is just not a pile-up on 3456 in Texas. On 2 meters, though, it would be nice to be able to save the calling frequency, a liaison frequency, etc., and be able to quickly switch between all of these.

Photo 8. WDØACD/K5FOG (left) and N5AC/W5TX roving during the January 2006 VHF Sweepstakes.

QUARTERLY CALENDAR OF EVENTS

Current Contests

ARRL June VHF QSO Party: The dates for this contest are June 10–12. Complete rules are in the May issue of *QST*. Rules can also be found on the ARRL website (http://www.arrl.org). Many are making plans to activate rare grids. For the latest information on grid expeditions, check the VHF reflector (vhf@w6yx.stanford.edu) on the internet. This is a very popular VHF contest. For weeks in the run up to the contest postings are made on the VHF reflector announcing Rover operations and grid expeditions. It is a contest that will create for you plenty of opportunities to introduce the hobby to friends who are not presently working the VHF-plus bands or are not hams.

SMIRK Contest: The SMIRK 2006 QSO Party, sponsored by the Six Meter International Radio Klub, will be held from 0000 UTC June 17 until 2400 UTC June 18. This is a 6-meter-only contest. Exchange SMIRK number and grid square. Score 2 points per QSO with SMIRK members and 1 point per QSO with nonmembers. Multiply points times grid squares for final score. Awards are given for the top scorer in each ARRL section and country. Please note that the rules have changed for this year's contest. In particular, the .150 rule has been eliminated. Also, the person to whom you send your logs has changed. Please send a legal-sized SASE for a copy of the log forms. Logs and log requests should be sent to: Dale Richardson, AA5XE, 214 Palo Verde Dr., Kerrville, TX 78028. Entries must be received by August 1. For more information go to <http://www.smirk.org> and click on the SMIRK Contest link at the top of the page.

Field Day: The ARRL's classic, Field Day, will be held on June 24–25. Complete rules for this contest can be found in *QST* and at <http://www.arrl.org>. In years past, tremendous European openings have occurred on 6 meters. Also, as happened in 1998, tremendous sporadic-*E* openings can occur. Certainly, this is one of the best club-related events to involve new people in the hobby.

Six Club Contest: The Six Club Contest runs from 1800 UTC July 8 to 2100 UTC July 9. All logs are due 30 days from end date of the contest and they go either by e-mail, fax, or snail mail to: Mike Urich, KA5CVH, Six Club Contest Director, 9807 Oakmont Dr., LaPorte, TX 77571; fax: (281) 867-9416; e-mail: <contests@6mt.com>. For further information go to <http://6mt.com/contest.htm>.

CQWW VHF Contest: This year's CQ WW VHF Contest will be held from 1800 UTC July 15 to 2100 UTC July 16. The rules can be found at <http://www.cqww-vhf.com>, <www.cq-amateur-radio.com>, and in the June issue of *CQ* magazine.

There are two important contests in August. The **ARRL UHF and Above Contest** is scheduled for August 5–6. Complete rules can be found in the July issue of *QST*. The first weekend of the **ARRL 10 GHz** and above cumulative contest is scheduled for August 19–20. The second weekend is September 16–17. Complete rules for this contest also can be found in the July issue of *QST*.

Quarterly Calendar

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

May 5	First Quarter Moon.
May 7	Moon Apogee. Moderate EME conditions.
May 13	Full Moon.
May 14	Poor EME conditions.
May 20	Last Quarter Moon.
May 21	Good EME conditions.
May 22	Moon Perigee.
May 27	New Moon.
May 28	Poor EME conditions.
June 3	First Quarter Moon.
June 4	Moon Apogee. Moderate EME conditions.
June 11	Full Moon. Very poor EME conditions.
June 16	Moon Perigee.
June 18	Last Quarter Moon. Good EME conditions.
June 21	Summer Solstice.
June 25	New Moon. Poor EME conditions.
July 1	Moon Apogee.
July 2	Moderate EME conditions.
July 3	First Quarter Moon.
July 9	Very poor EME conditions.
July 11	Full Moon.
July 13	Moon Perigee.
July 16	Good EME conditions.
July 17	Last Quarter Moon.
July 23	Poor EME conditions.
July 25	New Moon.
July 29	Moon Apogee.
July 30	Moderate EME conditions.
Aug. 2	First Quarter Moon.
Aug. 6	Very poor EME conditions.
Aug. 9	Full Moon.
Aug. 10	Moon Perigee.
Aug. 13	Good EME conditions.
Aug. 16	Last Quarter Moon.
Aug. 20	Poor EME conditions.
Aug. 23	New Moon.
Aug. 26	Moon Apogee.
Aug. 27	Poor EME conditions.
Aug. 31	First Quarter Moon.

—EME conditions courtesy W5LUU.

Current Conferences and Conventions

Dayton Hamvention®: The Dayton Hamvention® will be held as usual at the Hara Arena in Dayton, Ohio, May 19–21. For more information, go to <http://www.hamvention.org>. N6CL is scheduled to be one of the speakers for the VHF forums, and CQ Communications will have its booth in the main arena.

The annual **Ham-Com Hamfest** will be held June 9–10 in their new location in Plano, TX. As always, the North Texas Microwave Society will present a microwave forum. For details, see the Ham-Com website at <http://www.hamcom.org/>.

This year's **Central States VHF Society Conference** will be held in Bloomington, Minnesota, July 28-29, at the Ramada Mall of America. For more information, go to <http://www.csvhfs.org/CSVHFS2006.html>.

EME Conference 2006: This conference will be held in Wuerzburg, Germany on August 25–27. For more information, go to <http://www.eme2006.com>.

Calls for Papers

Calls for papers are issued in advance of forthcoming conferences either for presenters to be speakers, or for papers to be published in the conferences' *Proceedings*, or both. For more information, questions about format, media, hardcopy, email, etc., please contact the person listed with the announcement. The following organizations or conference organizers hve announced a call for papers:

The **Central States VHF Society Conference**: The Central States VHF Society is soliciting papers, presentations, and posters/tabletop displays for the 40th Annual CSVHFS Conference to be held in Bloomington, Minnesota (across from the Mall of America) on July 28–29. Papers, presentations, and posters on all aspects of weak-signal VHF and above amateur radio are requested. Deadline for submissions: for the *Proceedings*, May 1; for presentations at the conference and for notifying them that you will have a poster to be displayed at the conference, July 3 (bring your poster with you on the 27th of July). Further information is available at the CSVHFS website (http://www.csvhfs.org). Also available are the following: "The 2006 Conference," and "Guidance for *Proceedings* Authors," "Guidance for Presenters," and "Guidance for Tabletop/Poster Displays." Contacts: Technical Program Chairman, Jon Platt, WØZQ, at <W0ZQ@aol.com; *Proceedings* Chairman, Donn Baker, WA2VOI/Ø at <Proceedings.WA2VOI@OurTownUSA.net>.

EME Conference 2006: To be held in Wuerzburg, Germany on August 25–27, interested authors are invited to present a paper(s) for the conference. Electronic submissions in Word®97, Word®2000, Acrobat®5 (PDF), or text format will be accepted by e-mail or CD. Please ask if you are using another format. If you are interested in writing and/or presenting a paper, send an e-mail to Rainer Allraun, DF6NA, at <df6na@df6na.de>. Please contact him as soon as possible with an abstract or even a general idea. This will help the conference team with its planning activities. For more information about the conference go to <http://www.eme2006.com>.

ARRL and TAPR Digital Communications Conference: Technical papers are solicited for presentation at the 25th Annual ARRL and TAPR Digital Communications Conference to be held September 15–17 in Tucson, Arizona. These papers will also be published in the conference *Proceedings* (you do *not* need to attend the conference to have your paper included in the *Proceedings*). The submission deadline is

(Continued on page 83)

By Dr. H. Paul Shuch,* N6TX

DR. SETI'S STARSHIP

Searching For The Ultimate DX

"The Listeners" (2004 edition), by James Gunn

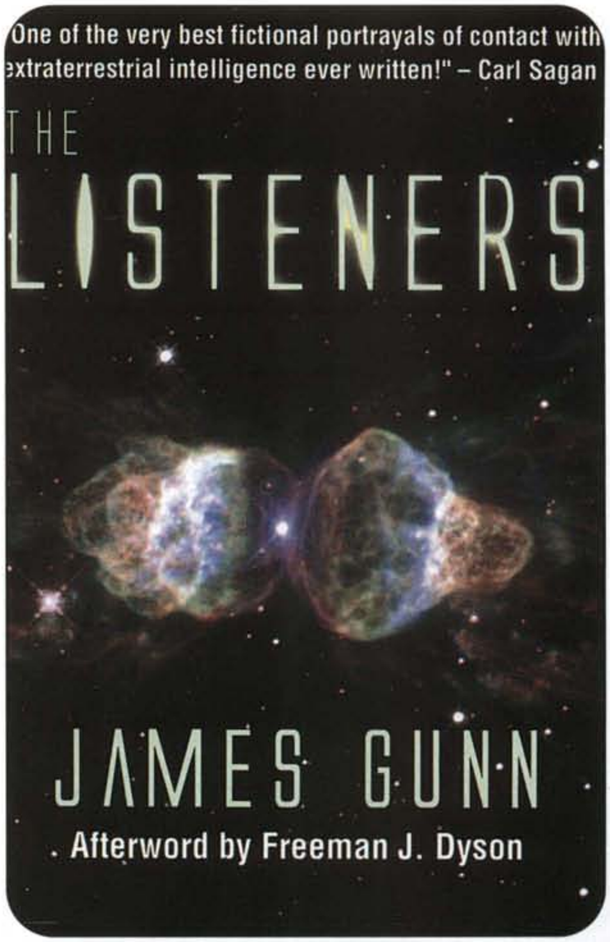
The search for intelligent signals from space was the lonely life's work of Robert MacDonald. Today, he would not be quite so alone, as many of us have been privileged to follow in his fictional footsteps. Indeed, in the three decades since *The Listeners* was first published, SETI has grown from an obsession of a handful of scientists working on the fringe into a household word pursued by literally millions of amateur and professional enthusiasts. However, we have yet to uncover the Call from Capella, which was central to the plot of this science-fiction classic. Perhaps we never will.

The widespread public interest and support which SETI now enjoys is indeed a tribute to human optimism. It also speaks volumes about Gunn's novel, recently reissued by BenBella Books, of Dallas, Texas (2004 ISBN 1-932100-12-1, $14.95 [trade paperback], available through The SETI League, Inc. Order online at <http://www.setileague.org/ photos/premiums.htm>). This is the book that inspired a generation of SETI scientists to pursue the seemingly impossible. Many of us decided early on that we wanted to be Robert MacDonald when we grew up, and if we ever do grow up, one or more of us may someday achieve that goal.

The SETI Institute's Tom Pierson notes in an insightful introduction to this new edition that the growth in our technological prowess since Jim Gunn first penned this book has been astronomical. Our searches today are just beginning to approach the sensitivity of Big Ear (Gunn's fictional space-based one, not the recently demolished radio telescope of the same name at Ohio State University). Our computerized signal-analysis hardware and software are expanding the search space to include most of the microwave spectrum, as well as significant segments in the infrared and optical regions. Soon the entire electromagnetic realm will reveal its secrets to us. All we need to do is wait . . . perhaps, as MacDonald did, for most of our lives.

More important, maybe, than our technological prowess is our societal progress, for the notion of humankind's uniqueness in the universe is falling into disfavor (due, in large part, to this very novel!). The idea that we are but one civilization among the many is fast becoming the accepted paradigm. For my children's generation, the burning question is no longer *whether* we will achieve contact with our cosmic companions, but rather *when*.

A major shift in funding has occurred in the years since *The Listeners* first saw print. What Jim Gunn envisioned as a massive government-sponsored project has gone grass-roots. Indeed, since the lamented day a dozen years ago when Congress cancelled the NASA SETI program, thousands of radio amateurs and signal-processing experimenters have turned their own modest back-yard dishes toward the stars.



The Listeners *(2004 edition) by James E. Gunn and published by BenBella Books, Dallas, Texas. Jim Gunn's inscription inside my personal copy reads: "To Paul, for helping to realize what I only imagined." Although not himself a radio amateur, Gunn clearly understands the importance and significance of amateur SETI.*

Millions of ordinary citizens have lent their spare computer cycles to the process of analyzing data from the world's greatest radio telescope (the very one Robert MacDonald used in Gunn's story). Also, a handful of dedicated industrialists have financed the design and construction of arrays grander and more sensitive than those contemplated in fiction. SETI is truly the science that refuses to die.

We who dedicate our lives to "The Search" well realize that ours may be, like MacDonald's, a multi-generational effort. We can only dream large, as Jim Gunn has taught us to do, and count the days (or centuries) until our dreams are realized.

73, Paul, N6TX

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

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CALENDAR *(from page 81)*

July 31. Papers should be sent to: Maty Weinberg, ARRL, 225 Main St., Newington, CT 06111, or you can make your submission via e-mail to: <maty@arrl.org>. Papers will be published exactly as submitted and authors will retain all rights.

Current Meteor Showers

May: May minor showers include the following along with their possible radio peaks: *ε-Arietids,* May 9, 1300 UTC; May *Arietids,* May 16, 1400 UTC; and *o-Cetids*, May 20, 1300 UTC.

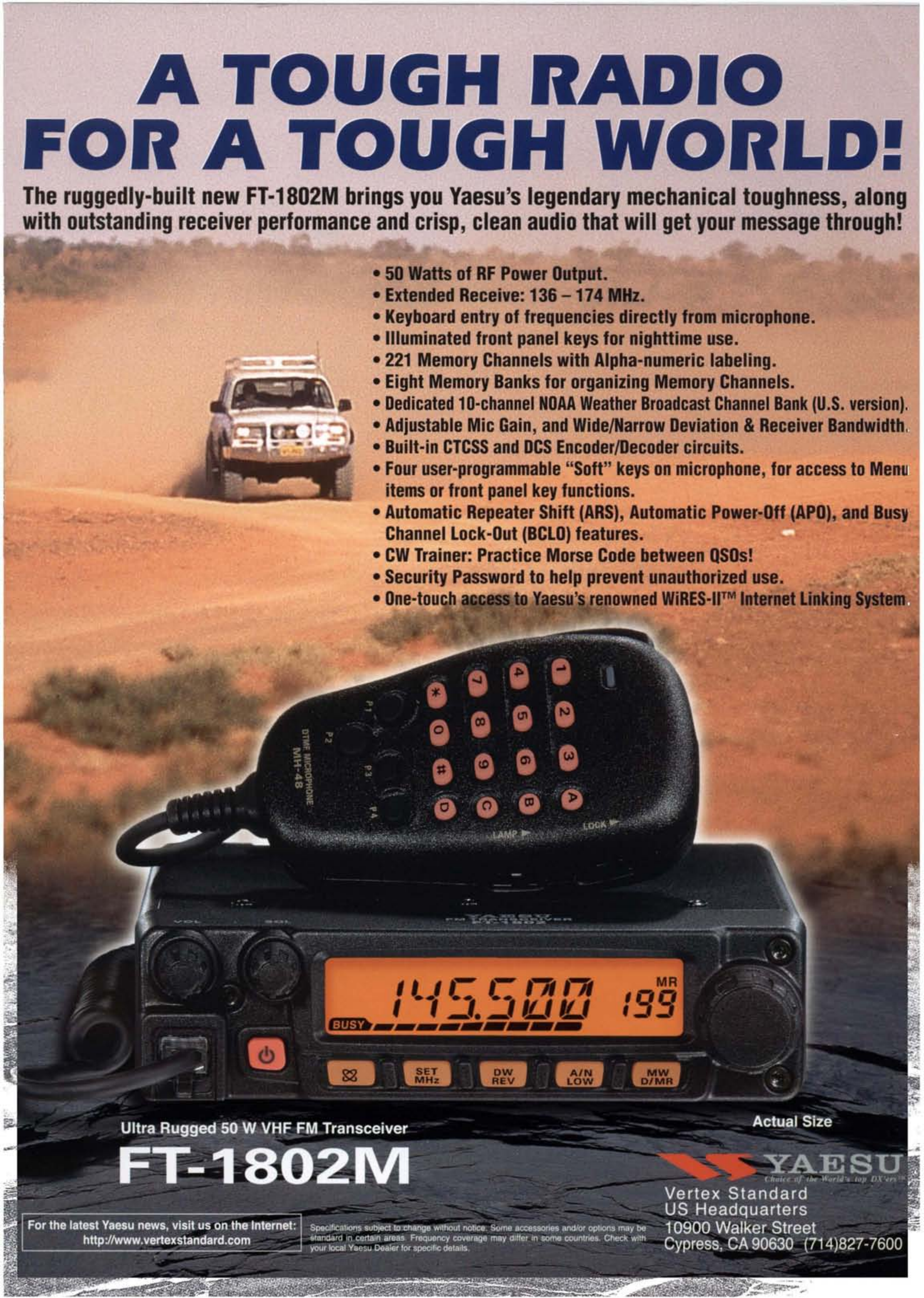
June: Between June 3 and 11, the *Arietids* meteor shower will once again be evident. This is a daytime shower with the peak predicted to occur on June 7 at around 1600 UTC. Activity from this shower will be evident for approximately eight days, centered on the peak. At its peak, you can expect around 60 meteors per hour traveling at a velocity of around 37 km/sec (23 miles per second).

On June 9 the *Zeta Perseids* is expected to peak at around 1600 UTC. At its maximum, it produces about 40 meteors per hour. The *Boötids* are expected to make a showing between June 26 and July 2, with a predicted peak on June 27 at around 1400 UTC. On June 29 the *Beta Taurids* is expected to peak. Because it is a daytime shower, not much is known about the stream of activity. However, according to the book *Meteors* by Neil Bone, this and the *Arietids* are two of the more active *radio* showers of the year. Peak activity for this shower seems to favor a north-south path.

July: This month there are a number of minor showers. The most intense, the *delta-Aquarids,* is a southern latitude shower. It has produced in excess of 20 meteors per hour in the past. Its predicted peak is around July 28.

August: Beginning around July 17 and lasting until approximately August 14, you will see activity tied to the *Perseids* meteor shower. Its predicted peak is around 2300–0130 UTC between August 12–13. According to the International Meteor Organization: "Simulations by Peter Brown made some years ago suggest enhanced *Perseid* activity is possible this year, though perhaps not as strongly as in 2004. The timing of any enhancement, though probably not far from the expected spread of possible maxima noted here, is not known."

For more information on the above meteor shower predictions see Tomas Hood, NW7US's propagation column. Also visit the International Meteor Organization's website: <http://www. imo.net/calendar/2006/>.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