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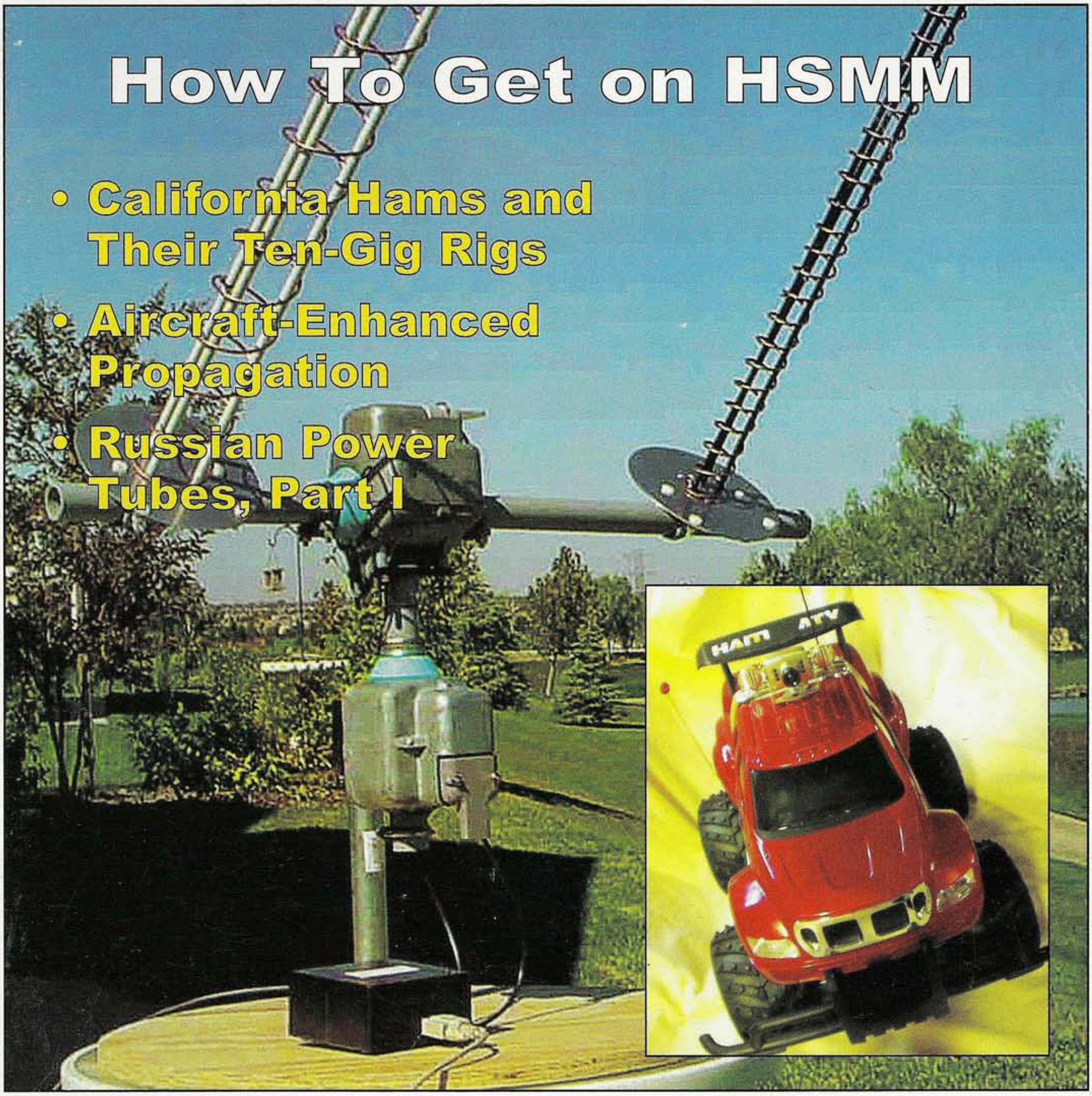

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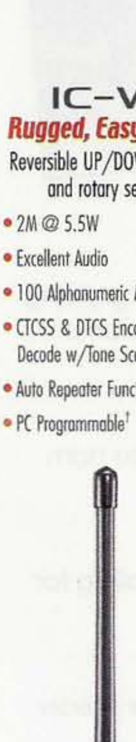

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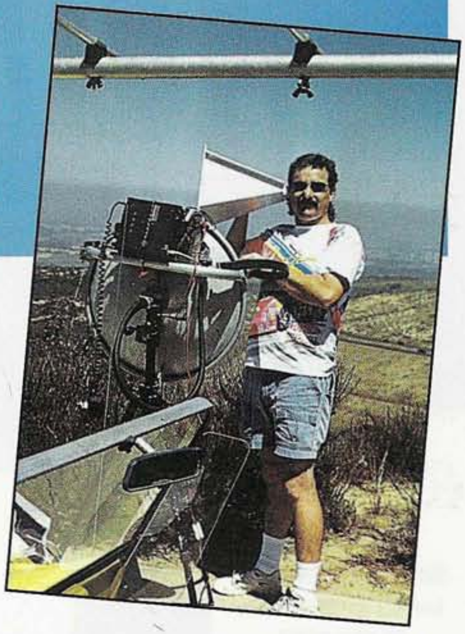

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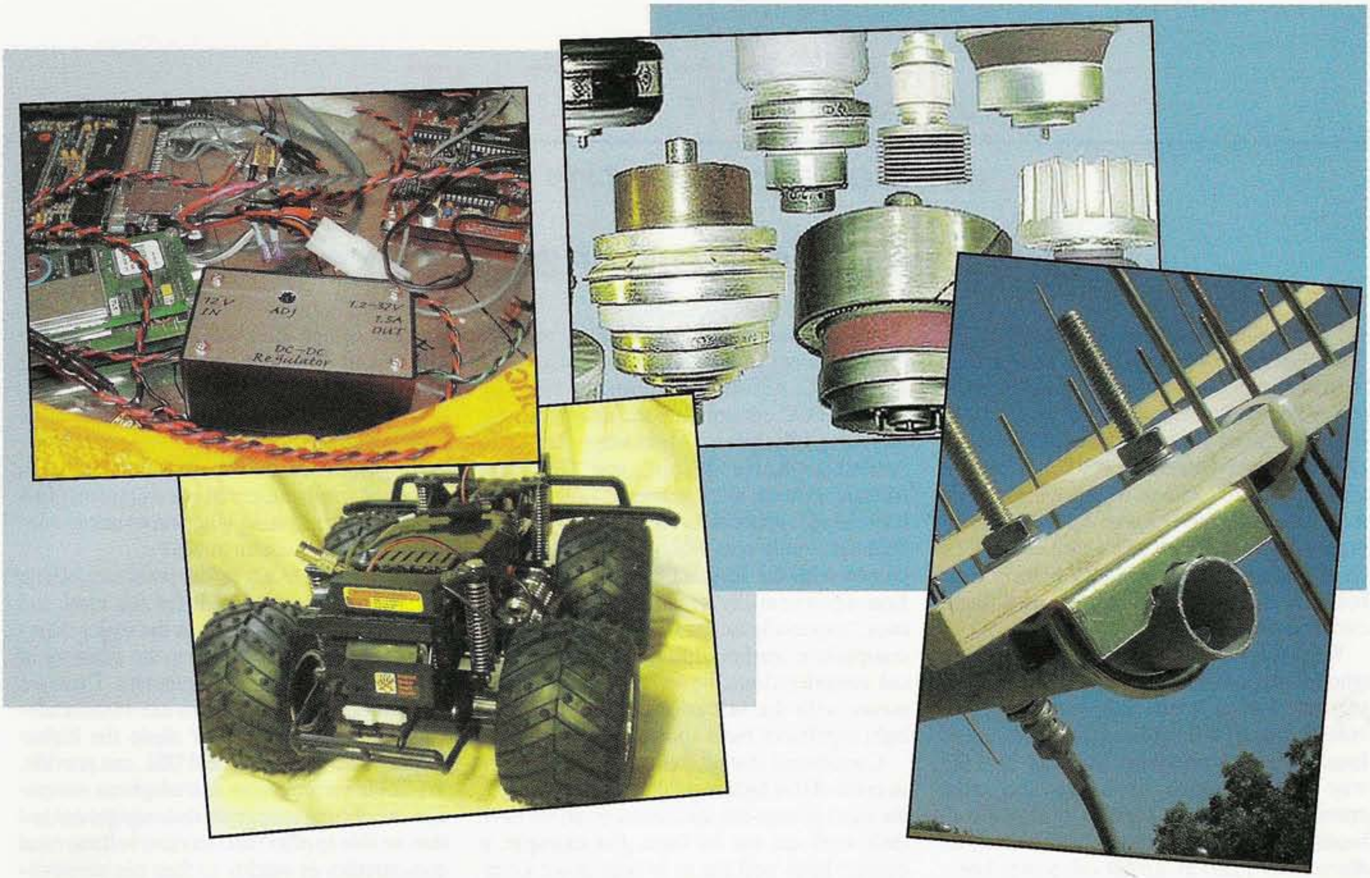
Vol. 6 No. 3

FEATURES



COLUMNS

DEPARTMENTS

ON THE COVER: It's one thing to have antennas with which to work stations via the amateur satellites. It's another to be able to point those antennas at the satellites. From the old Alliance U100/U110 rotors to sophisticated software techniques, "Satellite" columnist Tom Webb, WA9AFM, discusses several different approaches (see p. 54). In the inset, just in time for the holidays is the idea of modifying a remotely controlled truck for ATV (that's amateur television, not all-terrain vehicle) operation. Read Jason Baack, N1RWY's real reason for doing so on p. 12.

CQ VHF Ham Radio Above 50 MHz

LINE OF SIGHT

A Message from the Editor

BPL: What's Really at Stake?

If you believe the American Radio Relay League, the Broadband over Power Line (BPL) service is perhaps the greatest threat to our hobby to date. Is this the case, or is it really, as Glenn Hauser[1] of the *DX Listening Digest* reports United Power Line Council spokesman Brett Kilbourne as saying, " 'This is an enormous money maker for them [meaning the ARRL],' because many hams will be more willing to donate if they believe their hobby is in peril. 'There is certainly a financial incentive.'"

What are the issues? For utility companies who are responsible for the delivery of electricity to all of our homes, BPL technology provides the point for them to enter the high- speed Internet service providing business in a big way—actually much bigger than any other provider presently is capable of doing—all because of the built-in delivery vehicle, the medium-level, 1,000 to 40,000 volt power lines.

To understand something about BPL, let's delve a bit deeper into this business of BPL.

Basically, there are two proposals on the table. One is for In House BPL service and the other is for Access BPL service. The proponents of In House service want BPL service to be available within buildings, and the proponents of Access service want BPL service available over those outside medium-level power lines. While somewhat problematic, In House BPL is not nearly the problem that Access BPL is, for two reasons: technical and economic.

The sympathetic argument for Access BPL is that folks in rural areas and remote-access areas cannot presently obtain high-speed Internet service such as is delivered via cable or a digital subscriber line (DSL) to those of us who live in metropolitan areas serviced by either one or both types of services. They have a point. Even though I live in the metropolitan area of Tulsa, Oklahoma, I do remember that it wasn't that long ago when we didn't have either cable or DSL service available to us here in the city.

Now enters BPL with the offer to serve the rural and remote-access potential customer with their existing powerlines. However, in order to do so, they need some major concessions from the FCC in the form of huge relaxations of regulations.

At the moment, things look pretty rosy for these proponents—particularly when it comes to the FCC. According to positions taken by the five FCC commissioners, most of them, including Kathleen Abernathy, Jonathan Adelstein, Kevin Martin, and Chairman Michael Powell, want to take a "light regulatory hand" approach. According to Piper Rudnick,[2] only one, Michael Copps, is concerned with the issue of cross-subsidization from a power utility's regulated energy activities, "especially as this issue pertains to noncompetitive markets." Regarding the technical considerations, however, Copps has no issues with the rest of the commissioners' light regulatory hand approach.

Considering that all five commissioners are in favor of this light regulatory hand approach, the users of over-the-air communications have their work cut out for them. For example, it doesn't bode well for us to read about Commissioner Abernathy's speech to the United Powerline Council's annual meeting in which she exuded praise for BPL while ignoring the problems associated with the service.

Speaking of problems, here is where I see an issue that is getting little attention: In my reading the text of Abernathy's speech,[3] I have a problem with her justification of the FCC's light regulatory hand approach. In particular, she states:

> As a regulator, I am keenly interested in BPL technology for a number of reasons. One of my central objectives as an FCC commissioner is to facilitate the deployment of broadband services to all Americans. I also fundamentally believe that the FCC can best promote consumer welfare by relying on market forces, rather than heavy-handed regulation. The development of BPL networks will serve both of these key goals. It will not only bring broadband to previously unserved communities, but the introduction of a new broadband pipeline into the home will foster the kind of competitive marketplace that will eventually enable the Commission to let go of the regulatory reins. I want consumers to have a choice of multiple, facilities-based providers, including not only cable and DSL, but also powerline, wireless, and satellite services. Such a robustly competitive and diversified marketplace is something I would call broadband Nirvana.

She goes on to state, "There is little question that BPL services will compete with more-established cable modem and DSL services—and in some markets, satellite and fixed wireless services."

In particular, I am concerned that she is attempting to say that on the one hand, the marketplace will be the judge of who is the best provider of high-speed Internet service. On the other hand, by saying that BPL will "bring broadband to previously unserved communities," she admits that BPL will be the initial monopoly service provider in these communities. Where is the marketplace competition in these previously unserved communities? How can BPL be competing with non-existing competitors in these communities?

Getting back to my earlier point concerning the sympathetic argument for the rural and remotely served areas, we in the major metro areas here in Oklahoma are in the minority of geographic coverage at the moment. There are many rural communities that are without adequate Internet service, let alone the higher speed service that cable and DSL can provide. While the various cable and telephone companies are rushing to upgrade their equipment and thus be able to offer such services to these rural communities as quickly as they can economically do so, in some cases these communities are at least a few years away from gaining access to higher speed Internet service.

Enter BPL. Using those existing medium-level power lines, with the go ahead from the FCC, electrical powerline companies could be up and running in a matter of months, well ahead of their potential cable and DSL competitors—thus, no competition, and no reliance on market forces to determine who will be the best provider of higher speed Internet services.

While it is commendable that the ARRL stay on point in commenting on the technical problems associated with BPL, I think that in addition the League needs to address the economic problem by also taking the approach that should the FCC give the electrical powerline industry carte blanche to enter these rural and remote areas with BPL service, it would immediately create a business monopoly that will be extremely difficult, if not impossible, for potential competitors to overcome. As such, these potential competitors would in all likelihood abandon these areas, thereby leaving BPL as the only service available. Furthermore, in being the only service available, where would there be the incentive to do its best to provide the best possible service? The answer is that there wouldn't be any incentive.

It seems to me that as the only player in the rural location, "This is an enormous money maker for them [meaning the electrical powerline industry]. There is certainly a financial incentive."

Do these words seem familiar to you, Mr. Kilbourne? I thought that they might be.

73 de Joe, N6CL

[1] *See: http://www.worldofradio.com/dxld3172.txt*

[2] *See: http://www.piperrudnick.com/db30/cgi-bin/pubs/CommAlertMay03.pdf, page 6*

[3] *See: http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-239079A1.doc*

Join The Gang on 10,000 MHz

It's as Easy as "Plumb and Play"!

Among microwave enthusiasts there is a growing interest in operating on 10 GHz. WB6NOA describes recent activity in the runup to, and then during, the ARRL 10 GHz contest.

By Gordon West,* WB6NOA

Imagine a ham radio band 500 MHz wide! That is what you get at X-band with a Technician class or higher license. Your antenna requirements won't bug your neighbors. They would probably mistake your dish for something that might pull in satellite television signals. Little do they know that your effective radiated power is around 2000 watts! (That's 20 watts into a 20-dB gain parabolic reflector.)

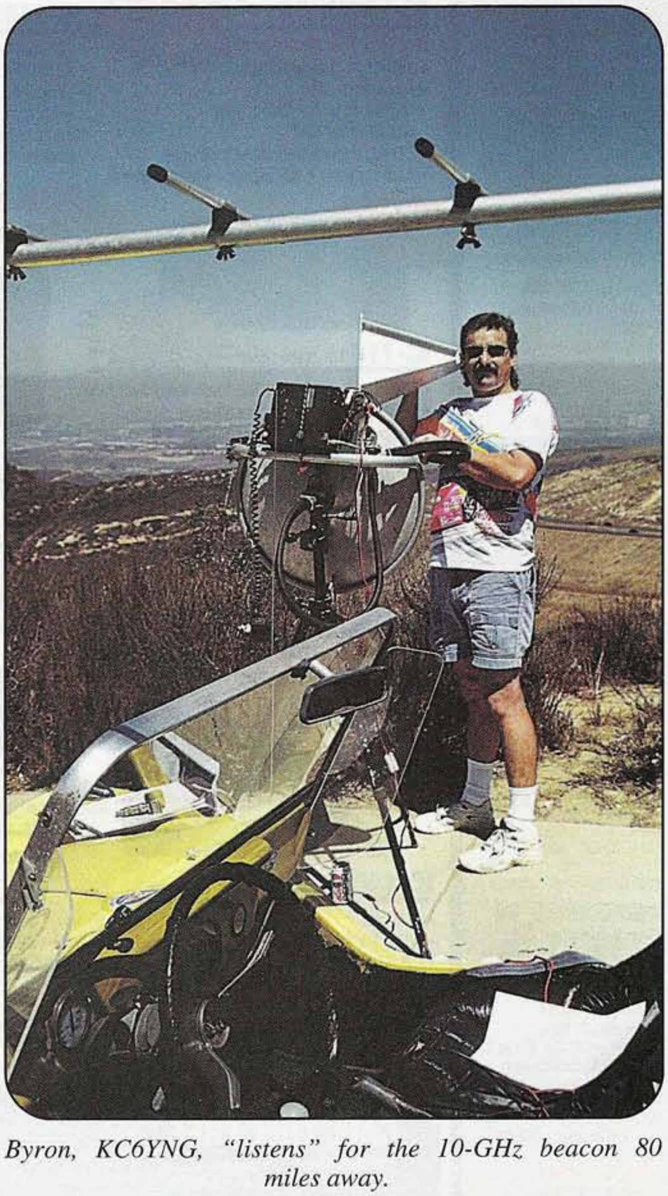
Your neighbors will rarely find you playing X-band around the house. More than likely, you'll be out on a hill or along an oceanfront, beaming your microwaves hundreds of miles away with ease. The latest equipment is literally "plumb and play," so coming up to 10,000 MHz is as easy as adding a transverter to your existing 10-meter or 2-meter multimode rig.

The 10-GHz X-band extends from 10,000 MHz up to 10,500 MHz. At the top of the band, near 10,451 MHz, are satellite allocations. Below that are point-to-point amateur fast-scan television links. At the bottom of the band and in the middle of the band, several hundred megahertz exist for microwave point-to-point FM links. With 50- to 75-mile direct-path shots, 10,000 MHz is an ideal band for using our spectrum to the fullest (use it or lose it) and reusing exact frequency pairs, because multiple microwave links rely on *precise* dish-pointing techniques, which all but eliminate any same-frequency interference to other links crisscrossing a specific geographic area!

For X-band microwave enthusiasts looking for a big "turn on" when operating on frequencies higher than that of their home microwave oven, nothing beats the excitement down at 10.368.1 MHz, which falls within the weak-signal portion of the band.

"One hundred *milliwatts* beyond a 600-mile path was not too bad, huh?" comments Wayne Yoshida, KH6WZ, with the San Bernardino Microwave Society, Inc., a non-profit amateur technical organization dedicated to the advancement of communications above 1,000 MHz (see <http://www.ham-radio.com/sbms/>).

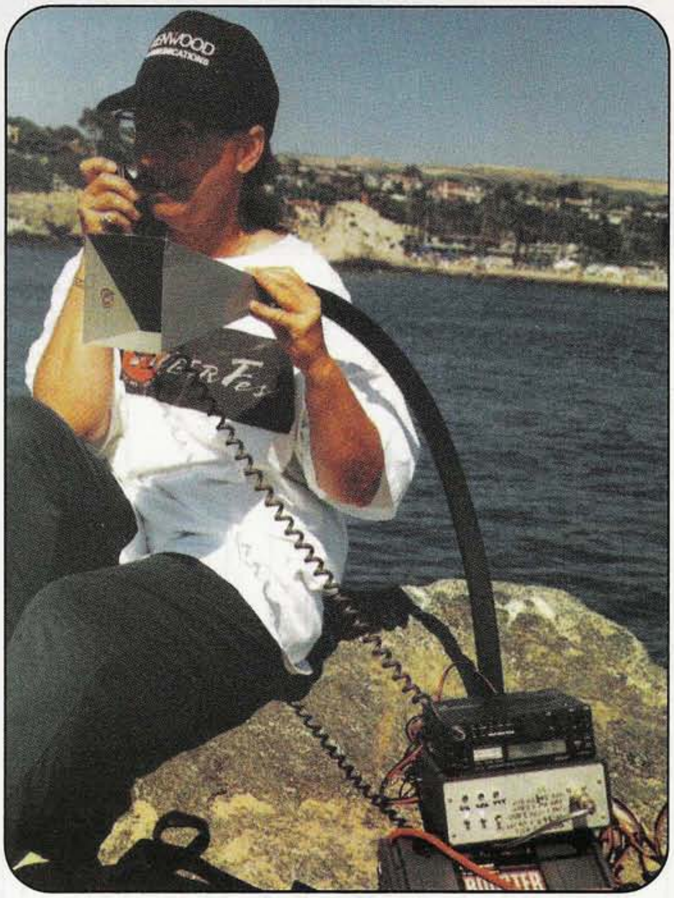
"I had my 5-watt, 10,000-MHz microwave system alongside my 160-watt, 2-meter SSB mobile, and 10,000 MHz was easily out-talking 2 meters!" comments Kent Britain, WA5VJB,



Byron, KC6YNG, "listens" for the 10-GHz beacon 80 miles away.

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

Assembling a 10-GHz system is much like plumbing!



Flexible waveguide allows for easy horn pointing for over-water "easy shots," as Suzy, N6GLF, demonstrates.

editor of the North Texas Microwave Society's newsletter, "Feedpoint" (see <http://www.ntms.org>).

Contesting on 10 GHz

Ten-gigahertz microwave activity peaks every September over the two-weekend ARRL 10 GHz contest. An August tune-up party gets all the local 10-GHz operators on, shall we say, the same frequency. Ten-gigahertz enthusiasts bring their equipment down to a central open-field test site, and a 10,000-MHz signal source goes on the air with a cesium standard to show a correct frequency, then step attenuation down to a microwatt power level that only the most sensitive of receivers and big antennas can pick up. If you are hearing the signal down range just above the noise level, and three other operators with the same diameter 2-foot dishes are hearing the test signal in the noise, you can be reasonably well assured that all your systems are working properly on receive.

After the reception test, each operator is asked to send his best and most powerful 10-GHz signal to a calibrated field-strength system down range. This procedure gives everyone a chance to double check that each 50 milliwatts up to 15 watts output to his individual dish antenna is performing as expected. Results are computerized and posted on the microwave group's web page.

The Contest Weekend

This same meeting of the "microwave minds" also lists the various VHF/UHF coordination frequencies for the weekend enthusiasts to get pointed in the right direction. In southern California, liaison was courtesy of the Cactus Intertie 440-MHz system, dynamically managed to link up microwave operators *simultaneously* throughout California, Arizona, and Nevada.

"I am sending a solid carrier now," comments Miguel, W6YLZ, hundreds of miles south of the Mexican border, providing the ultimate DX to southern and central California X-banders.

"You are just about knocking me off the hill. Drop your carrier and let's work!" comments Dennis Kidder, WA6NIA, part of a roving team working well over 600 miles from atop Frazier Mountain.

The Mexico group operated at 10,368.450 MHz. The rovers set up on 10,368.360 MHz, with Jack Henry, N6XQ, and the gang down in Mexico holding the frequency 10,368.440 MHz. Yes, with over 100 stations active on the air in central and southern California plus adjoining southwestern states, individual frequencies on 10,000 MHz were necessary to prevent QRM.

"I knew the 10-GHz frequencies ahead of time, so when my 440 FM rig died while I was at the top of the hill, I simply waited on specific X-band frequencies for a distant station who would ultimately point his dish down my way," comments Julian Frost, N3JF.

The 10-GHz contest rovers would always move at least 10 miles to re-establish a new area to begin operating, which allowed them to rework distant fixed stations so that both operators could receive

(Continued on page 66)

The Flight of El Fenix
North Texas Balloon Project Number 10

This past summer members of the Lockheed Martin ARC decided it was time to launch a high-altitude ham radio balloon. Here is how they dealt with the changes that had occurred since their last flight, five years ago.

By Doug Howard,* KG5OA, and Tommy Davis,† W5TCD

During the summer of 2002, the members of the Lockheed Martin Amateur Radio Club (LM ARC) in Fort Worth, Texas were busy preparing to host the 20th AMSAT-NA Space Symposium and Annual Meeting held November 7–11, 2002 at the Lockheed Martin Recreation Area. This was the third AMSAT Symposium held in the Fort Worth-Dallas area, but it was still an event that required a lot of coordination.

As happens at many planning meetings, sometimes there is a lull in the activities. During these lulls sometimes ideas that are completely unrelated to the agenda at hand seem to come out of the synergism taking place.

Such was the case at one of the coordination meetings for the AMSAT-NA Symposium. Tommy Davis, W5TCD, asked Doug Howard, KG5OA, if he would be interested in doing a high-altitude amateur radio balloon launch after the symposium was over. It had been almost five years since the North Texas Balloon Project had launched its ninth mission under the direction of Bill Davis, KG5IE. Tommy and Doug agreed that it was a project that needed to be revived. Thus, the planning of what would ultimately become the flight of El Fenix began.

Organization

A balloon project is a very large undertaking. To be successful, team effort is required. It is a great project for an amateur radio club, because there is something that interests almost everyone. Tommy is very good at organization, and he arranged for us to have our first coordination meeting in February 2003. In an effort to increase involvement, we wanted folks to be in charge of different parts of the project. Tommy and Doug agreed to be project coordinators. Bill Penny, WM5U, decided to help Doug with payload development and integration. Mark Felton, N5UWM, headed the direction-finding (DFing) operation with John Newman, KA5WAL. Billy Mason, KD5KNR, would fly in the recovery aircraft. Tommy was in charge of FAA FAR Part 101 rules oversight. Bill, WM5U, volunteered to order balloons. David Forbes, KC5UYR, would get the helium for us. Bill, KG5IE, would arrange for a launch site.

Filling the balloon with helium.

Tommy volunteered to be launch team coordinator. Charles Gunter, KD5MHC, and Harold Reasoner, K5SXK, were in charge of getting the ATV ground receiving equipment together. Jory McIntosh, KJ5RM, agreed to conduct the HF launch net, and Mike Heskett, WB5QLD, volunteered to set up an APRS tracking station at the launch site. Larry Westmoreland, K5PHD, was in charge of the video crew for recording different aspects of the operation on launch day. Larry, KM5R, and Melissa Rasmussen handled public relations, including launch announcements, websites, post-flight announcements, and so forth. Randy McLean, WO5M, was to be our BALLTRAK expert and predict where

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†e-mail: <tommyd@iols.com>

View inside the radio package.

the landing site would be. Now you can see how much had to be done and how many of the Lockheed Martin ARC members stepped up to help.

Project Development

There were many things that we could still use from the projects undertaken during the 1990s, but there were many things that needed to be updated or developed from scratch. As we went through all the equipment we had previously used for the project, it occurred to us that the launch of our balloon would be like the phoenix, a bird rising from the ashes to fly once again.

There is a restaurant in the Fort Worth-Dallas area called El Fenix, which serves fantastic Mexican food. We decided to ask them for some sponsorship and to use their logo on the side of our flight payload. Donald Jones, W5DWJ, contacted them, and they agreed to sponsor us. Donald also had T-shirts made up as a bit of a fundraiser.

One of the first things we had to choose was what to fly. We decided to put items in two packages, because the FAA rules dictate a maximum package weight of six pounds. The first package would be built by Doug and be a capsule shape made from styrofoam. Bill, KG5IE, had already put together some APRS equipment that had yet to be flown: a Motorola Oncore VP GPS receiver, a Kantronics KPC-3 TNC, and a Kantronics 2-meter, 1-watt beacon transmitter. He also donated his ICOM IC-24AT handie-talkie to be used as a cross-band repeater. Bill, WM5U, still had a simplex parrot repeater consisting of a Jay Crasswell, WBØVNE, PortaPeater[1] board and a Kenwood TH-21 handie-talkie.

Bill, WM5U, would put together the second package: a HATS (Houston Amateur Television Society) TR-1 1255-MHz FM ATV transmitter, two color video cameras with a video switch timer, and a 35 mm Ricoh still camera with a timer circuit. Both payloads were powered by 12-volt, 7 amp-hour lithium battery packs. There were two such battery packs in the capsule package and one in the ATV package.

During the first coordination meeting we selected a launch date of August 30. At the second meeting two weeks later we developed a schedule for construction and integration testing of the payloads and another schedule for development of DFing skills. These two items were critical to our selected launch date. The DFing operation was to be a team effort, with each mobile unit making reports to the others using the little-known DF function of APRS. The recovery aircraft would carry a digipeater and a cross-band voice repeater to facilitate communications between the mobile DFing units and the airplane. The DFing practice schedule emphasized team coordination and developed increasing skills in radio-DFing and DFing by GPS position reporting.

We had several more coordination meetings, one about every three weeks throughout the time leading up to the launch. This was important, because several activities were potentially distracting to the balloon project. The Lockheed Martin ARC supported the Ham-Com Convention in early June and Field Day in late June. These activities, combined with various members going on vacation throughout the summer months, could have taken away from the focus on the balloon project. However, it was through the coordination meetings that the continuity of the project was maintained. In a

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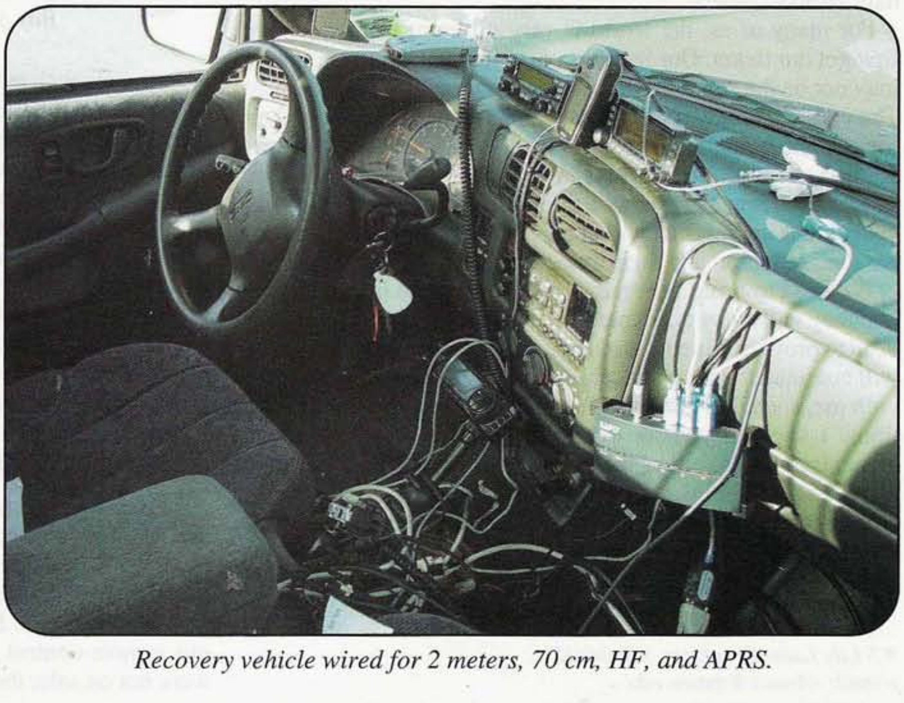

Recovery vehicle wired for 2 meters, 70 cm, HF, and APRS.

Amateur Television on the Move

Keeping Ham Radio Rolling for Future Generations

Have you run out of ideas for attracting people to our hobby? N1RWY presents a unique attention-getter—the ATV toy truck.

By Jason Baack,* N1RWY

What first excited you about ham radio? Take a minute and think back to when amateur radio was something new to you. What aspect drew you into the hobby? Was it the ability to talk to someone in a far-off country? Was it the computer-to-radio interface of digital communications? How about the melodic sounds of Morse code coming over the speaker? I am willing to bet that the memories of your first moments of being involved in ham radio are combined with thoughts of the first person who introduced you to it.

How did that introduction take place? Was it a book that someone loaned you or was it a hands-on demonstration? Was it voice or data? At what point during the introduction did you realize that this was going to be something you wanted to do?

The reason I ask these questions is to put you into the frame of mind of the days when you were first introduced to the whole notion of amateur radio. Reliving what it felt like when you became interested in the hobby can bring back the excitement you felt with your first radio purchase or the pride you experienced the first time you overcame microphone shyness. This excitement is what we have to focus on when we introduce ham radio to others.

For many of us, the world is very different from when we first got our ticket. Our feelings of excitement about ham radio may not be the same for this new generation of possible hams. The youth of today have so many other interests to occupy their time. Computers, the internet, video games, and many sports are just a few of the activities in which the youth of today are interested. How can we, as a community, offer ham radio as yet another interest that will compete with all the other options for their attention and their time? In a word, *activity*.

We need to bring ham radio to young people in such a way that they will *enjoy* the experience and want to know more. We need to provide this education as a way to ensure that our hobby will continue for future generations. I know many of you agree with me, spending countless hours on projects and demonstrations. I applaud you for your participation and dedication. Presentations and education sessions in which there is something that participants can hold, manipulate, or examine (whether it be a 6-meter Squalo antenna or some time spent on the keyboard with the latest WSJT software) often generate the greatest interest from the audience. Participants seem energized when they can take an active role in the presentation.

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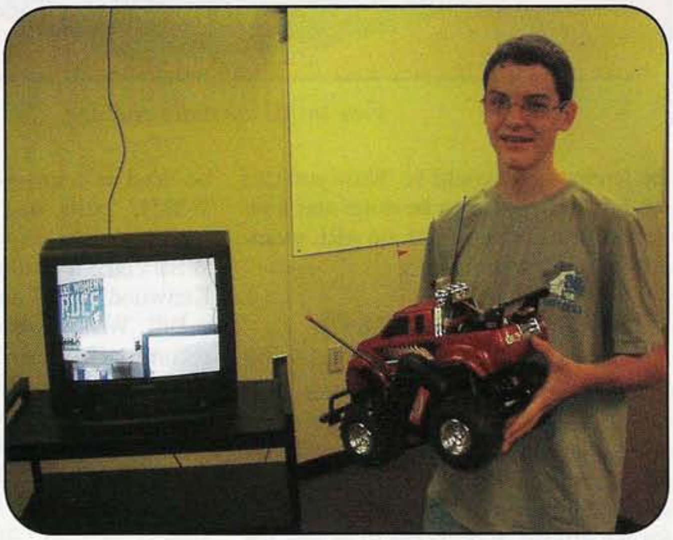
e-mail: <baack@maine.edu



Richard Young, KB1JHM's son Josh, who should be licensed by the time this article is printed, has recently completed his Boy Scout radio merit badge.

Activities such as the Boy/Girl Scouts Jamboree as well as the school ARISS (Amateur Radio on the International Space Station) projects are great ways to involve kids in ham radio. While they do a great job of introducing ham radio, these activities do tend to involve a lot of people, time, and planning. I wanted to develop something that I could put together fairly quickly while being interactive enough to hold interest, and at the very least, generate a few smiles during a hamfest or a club meeting. We know that a hands-on presentation provides more than information about a subject; it also provides lasting memories of the personal experience associated with the event. In other words, a good hands-on presentation can put the *fun* back into learning!

Enter the ATV Truck

Most of us can't pass up the latest sale at an electronics store, and when I happened to pass by my local RadioShack, I couldn't pass up the deal I saw. Sitting there in the window of the store was the leftover stock of all the remote-control (R/C) vehicles from the holidays. Boxed up about three-feet high were various remote-control cars, trucks, and even boats. These items were not on sale; they had closeout prices! Well, I do not have

Who says radio-control toys can't be used for learning?

to tell you the excitement the word *close-out* brings to the enterprising ham. Most of the time, closeout (a.k.a. "really cheap price") means that you can pick up something for less than half of the original cost. In my case, the closeout sale was 75 percent off, which sealed the deal.

My choice was one of the larger trucks, which was good for my project. I wanted something that I could use indoors as well as outdoors (such as in a hamfest parking lot), and I also wanted something that could manage extra weight without much effort. The truck model I chose is called the Ramrod, which is a 4×4 truck with oversize tires, two speeds, and plenty of room for modifications! Its total cost was less than $35. When I got it home, all my wife did was shake her head and walk into the next room. This thing is *large*.

Exposing the bare "frame" of the truck, you can see the Videolynx transmitter attached to the rear of the truck above the motor using Velcro®.

The Modifications

While the stock truck is impressive in its own right, I wanted something I could use for presentations and at hamfests to really pull the kids into the action. I needed something that would "sell" ham radio—something they would remember. What aspect of ham radio could do that? Hmm…A small receiver so folks could hear what was on the local repeater? Nah. As the truck moved around, folks would not be able to hear the receiver very well, and with the noise of the engine, the radio would have to be quite loud, which might be more annoying than educational. How about a CW key on the bed of the truck? It would be a good visual item. I wanted something more interactive, however. I needed something else.

ATV to the Rescue!

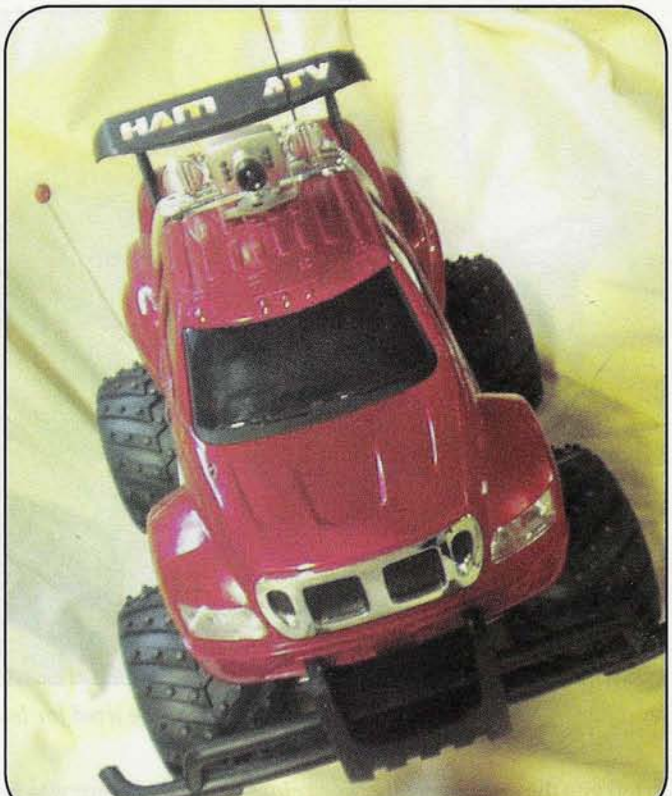
This spring during a lull in some 6-meter activity, I found myself sitting in the shack browsing the web. I happened to stumble upon the website of the DATS amateur radio club, <http://www.detroitatvrepeater.com/>. The folks of this Detroit club are extremely active in the ATV aspect of ham radio. One project, the remote-control car made by Jeff Basting, N8QPJ, really piqued my interest. His project is an incredible marvel of technical expertise and amateur radio exploration. I highly recommend that you take a peek at his web pages. After visiting Jeff's site, I knew I wanted to do something similar, yet on a much simpler scale.

Simplicity was important for me for several reasons. I wanted to show new hams that ham radio does not have to complicated and that it can be some project that can be assembled in a few short hours. Second, I wanted to introduce ATV to the local ham community.

ATV gives hams the ability to create and transmit their own video signals. Just think—your own personal television station! I knew ATV would provide the excitement I was looking for.

ATV is one of those VHF modes that is included in most VHF books, although

Adding custom logos really brings attention to your project!



ATV ready to roll!

it is never highlighted. It rarely gets the attention that VHF FM, SSTV, or even weak-signal SSB and CW receive. Surprisingly, it is quite easy to get started with ATV. It is available on the 70-, 33-, 23-, and 13-cm bands (427 MHz to 2.4 GHz), perfect for the newly introduced Technician class ham! Getting started with ATV, depending upon the band you start with, can consist of nothing more than an ATV transmitter, an antenna, and a camera. Just like all other aspects of amateur radio, you can start small and grow with ATV to the degree that your tower, space, and budget will allow!

Last, I wanted to build something I could replace easily if anything happened to break. Remember, this was supposed to be an interactive, hands-on project. There are no exotic parts used in this design, as I wanted all items to be able to be found either at the local RadioShack or online. The transmitter I used for the project was the Videolynx 434, a 433.92-MHz, 100-mw transmitter. Because no tuning or other modifications are needed, the equipment is very easy to operate. A 9-volt battery, a small antenna, and a camera are all you need to start transmitting! A cable-ready television tuned to cable channel 59 was to be my receiver. The camera I used was purchased via eBay. It is a small color CCD cam with 350 lines of resolution that can operate off 9 volts. For the antenna I could have made a small $^{1}/_{4}$-wave antenna. However, I happened to need a new HT antenna, so I found one that could do dual duty with the R/C ATV project, and then on my HT when the truck was not in use.

When I completed the project and brought it to my first hamfest, I moved the truck around the floor, snaking around trash cans, pointing at the various boxes of random stuff found at all hamfests. Most people just glanced over and then looked away. However, as soon as one of them noticed the bright, bold HAM ATV logos on the rear spoiler, he/she would start to pay attention. Soon inquisitive stares were replaced with smiles, as well as the viewers' eyes darting around the room looking for the fellow next to the television that had pictures of them on it!

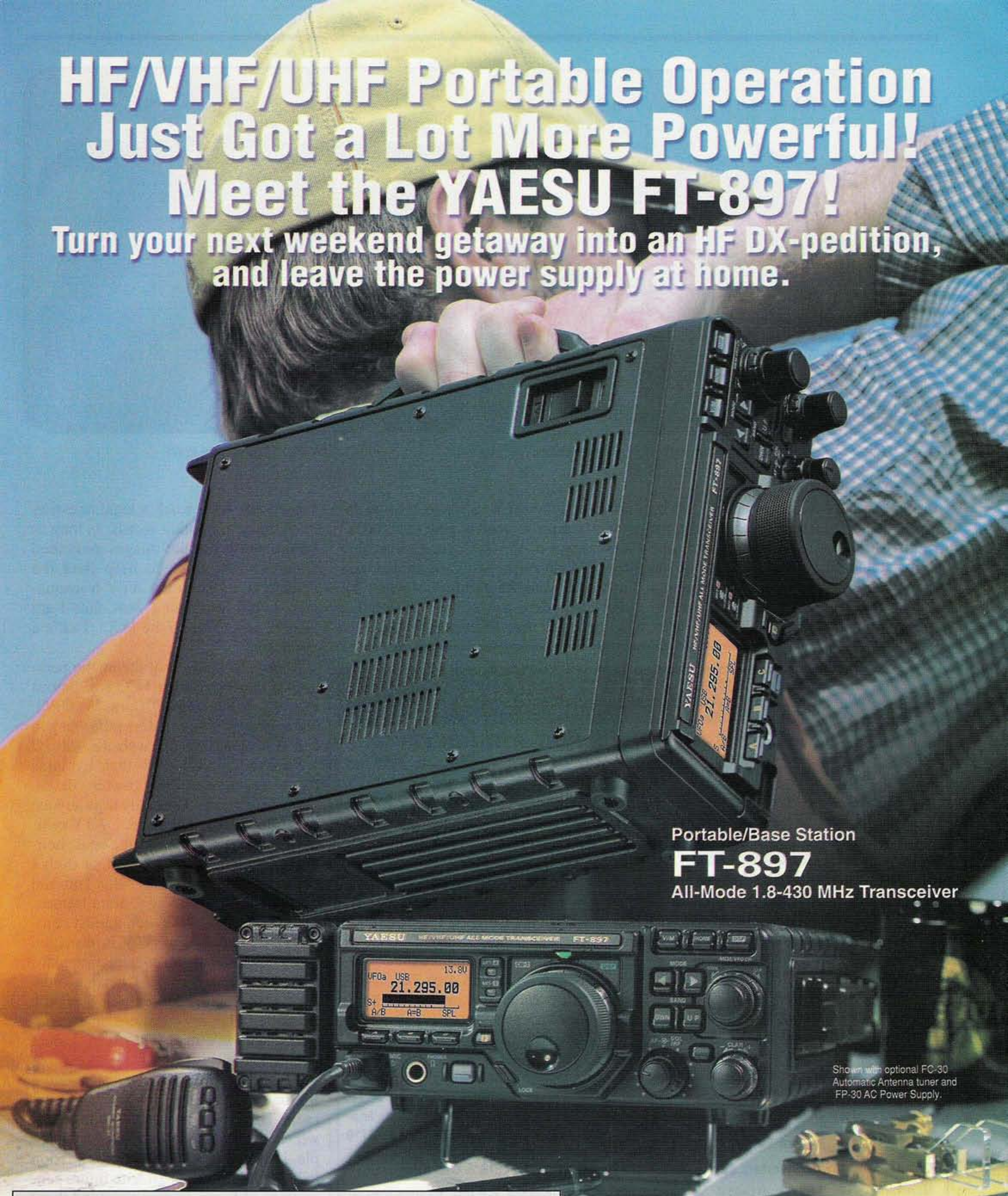
The television that I usually put in a common area is always a popular focal point. Motion always draws people to glance at the TV as they pass by. Then when they are told that it is a live image (or when they happen to see their own shoes on the television), the questions begin: What frequency is this on? How is it being transmitted? Is it wireless? How much power is being run? How do you power it? Then as I pull the truck up to the group of people (young and old alike, I should add) most of them usually bend down and start to look over the whole thing.

Generation Digital

I am a product of the computer generation. I grew up with a TI99-4A, the Commodore PET, and other associated historical computers. Many nights during my youth when everyone else in the house was asleep, I was typing away in BASIC or playing first-generation video games. This relationship with computers is probably what drew me to the digital modes of amateur radio. For me, ATV was something to which I was instantly attracted. I believe the computer-oriented youth of today would find ATV as fascinating as I do. Just think—in charge of your own mini television station! Who (young or old) wouldn't love that!

R/C ATV: Is it legal? Identifying your call every ten minutes during continuous transmission and at the end of a transmission is required with ATV, as it is with all other amateur modes.

Several aspects of the FCC regulations Part 97 prohibit Amateur Radio Service bands to be used to further any business purpose or for broadcasting, news gathering, and retransmitting any other service or music, except as allowed for occasional emergency preparedness drills. However, there has been some confusion about when and how an ATV vehicle, such as the one described here, is legal to operate. The old transmitter control laws (specific to remote-control vehicles) stated that any transmitter that was under 1 watt was not required to identify. However, there has been some question as to how this applies to modern ATV and R/C vehicles. In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IDing the cheap and simple way every 10 minutes!

N1RWY/M ready to roll!

my case, the R/C car is on 49 MHz, which is not an issue with any amateur radio restrictions. On the other hand, the ATV transmitter does operate on an amateur-radio-approved frequency (433.92 MHz), so several aspects of Part 97 apply to it. In my case of the R/C truck and the ATV video, as long as the video source is used as part of the control aspect of the R/C truck (watching the TV monitor to avoid tables and parked cars in the parking lot when the truck wanders out of sight), coupled with the fact that the transmitter is under 1 watt, my ATV truck a legal one-way transmission. In other words, as long as I continue to use the images generated from the R/C truck to help steer the vehicle and I keep the ATV transmission output less than 1 watt, then I am "legal" according to the FCC. That's a good deal!

It must be stated that the above paragraphs concerning the FCC regulations are very brief. Tom O'Hara, W6ORG, has a great PDF file (R-C-1.pdf) that you can download off his website, (http://www.hamtv.com/) and that explains these regulations in greater detail. Speaking of Tom, I strongly urge anyone who is looking to make an R/C ATV vehicle of any type (car, truck, boat, helicopter, model rocket, balloon, or even a plane!) to check out his website. Tom and his wife Mary, WB6YSS, are a tremendous help to the ATV community, providing a great deal of ATV information on their website, from construction plans to recommended parts. I need to give them a big "thank you" for taking the time to answer all of my questions on the telephone and via e-mail. They were a great help to me in this project.

I firmly believe that one can spend a lifetime exploring all the facets of ham radio. This hobby is very vast and diverse, which makes it appealing to so many people. I urge all of you to find your passion in ham radio and share it with future generations of hams. I know you (and they) will not forget the experience.

I hope to see you on ATV very soon—perhaps on my TV monitor at a hamfest near you! ■

Aircraft Enhancement

Some Insights from Bistatic Radar Theory

This article is an abridged version of a paper originally presented at GippsTech 2000, the annual Australian Conference designed to encourage participation in VHF, UHF, and Microwave amateur operations.

By Rex Moncur,* VK7MO

Aircraft enhancement is widely used on the east coast of Australia for VHF and UHF contacts in the 240 to 480 mile (400 to 800 km) range. Typically, for a few minutes it produces enhanced signals that are 20 to 30 dB stronger than would be expected, based on radar reflection or tropo scatter. The key difference between aircraft enhancement and normal radar reflections is that the aircraft must be closely in line between the two stations to achieve the enhancement.

Interestingly, the phenomenon that is called *aircraft enhancement* by Australian amateurs is a manifestation of theories put forward by the French physicist Augustin Fresnel back in 1819, and the enhancement at light wavelengths is known as the Fresnel Bright Spot.

This paper draws on the literature on bistatic radar (transmitter and receiver located a large distance apart) to give some insights into aircraft enhancement. Skolnik[1] gives this example: For a sphere of radius ten times the wavelength, forward scatter is enhanced by 36 dB compared to back scatter as it applies to the more normal monostatic radar (transmitter and receiver co-located). A sphere of this size—40 meters in diameter at a wavelength of 2 meters—would present a much larger area than the largest aircraft. The example does show that large enhancements can be produced.

In terms of a large aircraft, such as a 747 front on, bistatic radar theory shows that while the normal radar back-scatter area is only a little more than 100 square meters, the effective forward-scatter area at 2 meters is in the order of 30,000 square meters. At 70 cm the forward-scatter area can reach 240,000 square meters.

I have applied the theory to simple shapes (sphere and sections, which approximate the wings, cabin, and tail of the example aircraft) rather than the complex shape of an aircraft. Nevertheless, I believe it does give some useful insights that help explain some of the observations of amateurs who have experimented with aircraft enhancement. For example, it explains significant signal enhancements, why larger enhancements might be obtained at higher frequencies, and why large enhancements only occur when the aircraft is close to the triangular alignment of the aircraft with the opposing two stations.

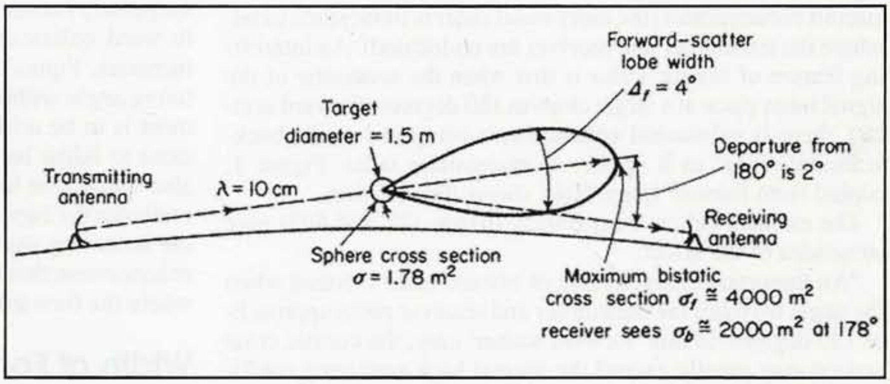

Figure 1. An example of bistatic radar where the transmitter and receiver are close to alignment. (Copied from Barton[9])

Information is given on the construction of a simple model based on a map, tracing paper, and a drawing pin that allows the prediction of aircraft enhancement from known flight paths.

Background

In 1985 McArthur, VK3UM,[2] reported peaks of 30 dB or more enhancement of 144-MHz signals between Melbourne and Sydney related to aircraft which lasted from a few minutes to tens of minutes. He stated that the enhancement was significantly greater than what was determined by the radar equation.

However, before we look too hard to explain aircraft enhancement, we need to understand what we mean by it. For example, do we mean enhancement over what is calculated by the normal radar theory, or over the average tropospheric scatter conditions, or above the noise in our receiver, etc.? Not only because it is easier, but also because it focuses on the reason for enhancement, I have chosen to try to answer the question as to *why and by how much the enhanced signal is greater than calculated by normal (monostatic) radar theory.*

Looking at McArthur's article, he reported increases of 30 dB or more related to aircraft and stated that he could observe signals he could relate to the radar equation which were 3–6 dB above forward scatter (tropo scatter) which was itself 3 dB above the noise. This equates to enhancements above the normal radar equation of 21 to 24 dB or more.

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McDonald, VK2ZAB,[3,4,5] Harrison, VK2ZRH (then VK2ZTB),[6] and Cowan, VK1BG,[7,8] have vigorously debated the mechanisms for aircraft enhancement, with proposals ranging from reflection from the undersurface of the aircraft to refraction in the hot air produced by jet engines. McDonald's thinking has progressed since he proposed reflection from the undersurface of the aircraft in his October 1985 article. In his May 1989 article McDonald highlighted the link to bistatic radar theory. McDonald has also advised me that Kent Britain, WA5VJB, discussed this link as early as 1986.

I will quote from the literature on bistatic radar later on in this article. First, however, some explanation of bistatic radar is in order.

Bistatic Radar

A bistatic radar is one in which the transmitting and receiving sites are at different locations, which is the situation with aircraft enhancement (the more usual radar is monostatic radar, where the transmitter and receiver are co-located). An interesting feature of bistatic radar is that when the scattering of the signal takes place at a target close to 180 degrees (forward scatter), there is substantial enhancement compared to the back-scattered signal as it applies to monostatic radar. Figure 1, copied from Barton[9] (page 504), shows the situation.

The extracts below from Barton (pages 121 and 503) give some idea of the effect:

"An important characteristic of bistatic radar is found when the angle between the transmitter and receiver paths approaches 180 degrees. In this 'forward scatter' case, the bistatic cross section may greatly exceed the normal back-scattering coefficient. This is because of the fact that the total power in the forward-scatter lobe is equal to that scattered over the remainder of the 4π steradians around the target."

In addition, "the bistatic cross section may be increased by a large factor, as compared with the normal, monostatic radar cross section of the target." This increase is because of the relatively larger 'forward scatter' of the target, shown by Siegel[10] to be equal to:

$$\sigma_f = 4\pi A^2/(\lambda^2) \qquad \text{Equation 1}$$

where A is the projected area of the target and λ is the radar wavelength.

Note: Equation 1 applies where the dimensions are much larger than a wavelength.

One way to visualize the enhanced signal is to think of an ocean wave coming to a small island. The wavefront diffracts around both sides of the island, and at a point some distance beyond the island you see the two wavefronts adding together to give an enhanced wave. In the case of aircraft enhancement, we are doing the same thing in three dimensions, so the energy is adding from waves from both sides—the top and the bottom, and in fact all around the object, to produce a significantly enhanced wave.

Forward-Scatter Enhancement

In the case of a sphere (radius r), the ratio of the forward-scatter target cross section to the back-scattered target cross section—which I will call forward-scatter enhancement, f_e—is given by Skolnik as:

$$f_e = (2\pi\, r/\lambda)^2 \qquad \text{Equation 2}$$

Equation 2 is applied in Table 1 to give examples of the enhancement of forward scatter over back scatter for spheres of various diameters at wavelengths of 2 meters, 70 cm, and 23 cm.

Radius of Sphere (meters)	Projected Area of Sphere (square meters)	Wavelength (dB) 2 m	70 cm	23 cm
1	3	10	19	29
5	79	24	33	43
10	314	30	39	49

Table 1. Enhancement in dB of forward-scatter radar cross sections compared to back-scattered cross sections for spheres at different wavelengths.

However, before we get too excited about near 50-dB enhancements at 23 cm, we must take into account that general principle that you don't get anything for nothing. In this case, the penalty for more enhancement is that the solid angle in which forward enhancement occurs reduces as the enhancement increases. Figure 1 shows the importance of keeping the scattering angle within the forward-scatter lobe if useful enhancement is to be achieved. This means that the aircraft must fly close to inline between the receiver and transmitter. Figure 1 also shows that for practical radio paths, the height of the aircraft plus the curvature of the Earth will limit the ability to keep the scattering angle small. This, in turn, limits the amount of enhancement that is possible, particularly at higher frequencies, where the forward-scatter lobe becomes much narrower.

Width of Forward-Scatter Lobe

Barton (page 504) gives the width of the forward-scatter lobe at the 3 dB points, Δf, as:

$$\Delta f = \lambda/L \text{ radians} \qquad \text{Equation 3}$$

where L is the length or diameter of the target in the plane in which Δf is defined.

While the 3-dB point is a useful measure of the width of the forward lobe, it should be noted that forward-scatter signals can still be received at larger angles, but they will be weaker. That said, we will use the 3-dB point from 180 degrees, or angle of departure, Δd, which is half Δf as a useful indicator. Substituting for Δd and converting Equation 3 to degrees gives:

$$\Delta d = \lambda * 45/(r * \pi) \text{ degrees} \qquad \text{Equation 4}$$

Table 2 applies Equation 4 to give examples of the angles of departure that result from using spheres of different sizes.

Radius of Sphere (meters)	Wavelength (degrees) 2 m	70 cm	23 cm
1	28.6	10.0	3.3
5	5.7	2.0	0.7
10	2.9	1.0	0.3

Table 2. Angle of departure from 180 degrees at the 3-dB point for spheres at different wavelengths.

Essentially, Table 3 shows us that the very high level of enhancements in Table 1 for large spheres and at very short wavelengths is only possible if the angle of departure is very small. In practice, very small angles of departure cannot be achieved at distances of a few hundred kilometers because of Earth curvature and aircraft height, and thus this limits the enhancement that is possible.

Now we can use Equation 4 to define the radius of a sphere in terms of Δd and substitute in Equation 2 to derive the maximum forward enhancement in terms of the angle of departure:

$$F_e = (90/\Delta d)^2 \qquad \text{Equation 5}$$

Putting the maximum forward enhancement into dB and subtracting 3 dB to find the forward enhancement at the departure angle or the receiver gives:

$$F_{er} = -3 + 10*\text{Log}((90/\Delta d)^2)\ \text{dB} \qquad \text{Equation 6}$$

Using geometry, and assuming a target altitude of 10 km, enhancement at the mid-point of the path, and taking account of radio refraction with the 4/3rds Earth radius rule, we can calculate the angle of departure as shown in Table 3. Substituting the angles of departure thus determined in Equation 6 gives the maximum forward-scatter enhancement at the receiver for a sphere as also shown in Table 3.

Distance Between Transmitter and Receiver (km)	Angle of Departure Δd (degrees)	Maximum Forward-Scatter Enhancement at Receiver (dB)
100	22.9	8.8
200	12.1	14.4
300	8.6	17.3
400	7.1	19.1
500	6.3	20.1
600	5.8	20.7
700	5.6	21.1
800	5.6	21.2
900	5.6	21.2
1000	5.7	21.0

Table 3. Angle of departure resulting from a target height of 10 km and Earth curvature based on 4/3rds rule and resulting maximum forward-scatter enhancement from spheres for different distances. Target is at mid-point.

Table 3 shows us that for the typical aircraft enhancement paths of several hundred kilometers the angle of departure will be around 5 to 7 degrees and the maximum forward enhancement for a sphere compared to the back scatter is around 19 to 21 dB. This is encouraging, as it on the order of that observed by McArthur.

Now we can use Equation 4 to determine the maximum radius of a sphere in terms of angles of departure:

$$r = \lambda*45/(\Delta d*\pi) \qquad \text{Equation 7}$$

Table 4 applies Equation 6 to give the maximum radius spheres to be within the 3-dB beamwidth at an angle of departure of 7 degrees.

Wavelength	2 m	70 cm	23 cm
Radius of Sphere (meters)	4.09	1.43	0.47

Table 4. Maximum radius sphere to allow 3-dB points of forward-scatter lobe within 7 degrees.

An Aircraft Compared to a Sphere

In most cases where aircraft enhancement has been observed, the aircraft presents a front or rear aspect as a scattering target. The nose is likely to be equivalent to a sphere and exhibit similar characteristics to those examined above. Equation 1 shows that it is the projected area that determines the level of forward scattering. Thus, an aircraft will have the same characteristics coming or going, and its cabin, if it were circular, would be equivalent to a sphere of the same radius.

Using Table 4 we can see that in order to use the main forward-scatter lobe we need to have aircraft with cabins less than 4 meters in radius at 2 meters and substantially less at 70 cm and 23 cm. While the cabins of aircraft will be useful at 2 meters (even a 747 is just less than 4 meters radius in the vertical), most will be too large for the higher frequencies.

The wings, however, are a different proposition, as they present an aspect that is many times wider than their height. Returning to Equation 2, which determines the beamwidth, this means that instead of a cone-shaped forward lobe, the wings will generate a fan-shaped forward lobe with the fan in the vertical plane. This has the advantage that we can cope with larger angles of departure in the vertical where we have the problems of aircraft height and Earth curvature. However, the downside is that the horizontal beamwidth of the forward-scatter lobe is substantially reduced, so the aircraft must be much closer to in-line in the horizontal plane.

If we assume that the back-scattered area is close to the projected area, then the forward-scatter enhancement can be derived from Equation 1 as follows:

$$F_e = 4\pi A/\lambda^2 \qquad \text{Equation 8}$$

The projected areas in square meters for various sections of 747 and 737 aircraft, scaled from diagrams in *Jane's Aircraft*[11] (page 322 for 747 and page 319 for 737) are set out in Table 5 together with the heights of the sections in meters in brackets.

Aircraft	Cabin	Engines	Front Wings	Rear Wings	Tail	Total
747	38 [8]	18 [3]	54 [2]	10 [1]	7 [10]	127
737	14 [5]	7.5 [2]	12 [1]	3.6 [0.5]	2.4 [5]	39

Table 5. Projected areas (square meters) and heights in brackets (meters) of various sections of 747 and 737 aircraft.

Table 6 applies the total areas with Equation 8, converted to dB, to give the potential enhancement of these aircraft if there were no angle of departure.

Aircraft and Projected Area (square meters)	Potential Enhancement (dB) 2 m	70 cm	23 cm
747 [127]	26	35	45
737 [39]	21	30	40

Table 6. Potential enhancement for a 747 and 737 aircraft with no angle of departure.

In practice, it will not be possible to achieve the full enhancement listed in Table 6. This is because the beamwidth of the larger vertical sections of the aircraft (i.e., tail) will be too narrow in the vertical plane to be used with an angle of departure of 5 to 7 degrees as required from typical aircraft enhancement contacts. We can modify Equation 3 for the length, L, of the scattering target, and in terms of the departure angle (degrees) it will be:

$$L = \lambda*90/(\Delta d*\pi) \text{ degrees} \qquad \text{Equation 9}$$

Table 7 applies Equation 9 to find the maximum height of aircraft sections that will allow a beamwidth of 7 degrees and thus be useful on a typical aircraft enhancement contact.

Wavelength	2 m	70 cm	23 cm
Section Height (meters)	8.2	2.9	0.9

Table 7. Maximum height of aircraft sections to be useful (at the 3-dB point) with a 7-degree angle of departure.

Table 7 tells us the size of sections that are useful for typical aircraft enhancement contacts at the 3-dB points. Thus, if the section is of the size shown, only half of it is effective, but if it is 50% or less, it will almost fully contribute to the projected area.

From the combination of Tables 5 and 6, we can see that for a 747 at 2 meters the tail is too long to be useful and the cabin is on the margin (i.e., the 3-dB point), so we should allow only half. That is, the effective projected area at a 7-degree departure angle should be reduced to 106 square meters. At 70 cm only the wings are useful, giving an effective projected area of 64 square meters. At 23 cm much of the front wing is too large, and much of the rear wing on the 3-dB point, and the effective projected area drops to around 20 square meters.

For a 737 at 2 meters the tail must be deleted, as it adds to the cabin, like stacking two vertical antennas; thus, the effective projected area is 37 square meters. At 70 cm the tail and the cabin are too large, so the projected area drops to 24 square meters. At 23 cm only the wings can be used and parts exceed the 3-dB points, so the effective projected area drops to around 6 square meters.

The data for a 747 and a 737 are summarized in Table 8.

	Effective Projected Area (square meters)		
Aircraft	2 m	70 cm	23 cm
747	106	64	20
737	37	24	6

Table 8. Effective projected areas for a 747 and a 737 at a 7-degree angle of departure.

Now enhancement, as I have defined it, is the ratio of the forward-scattered signal to the back-scattered signal (i.e., that for a normal monostatic radar), noting that the effective forward-scatter area is somewhat less than the projected area as shown in Table 8.

$$\text{Enhancement} = 4*\pi*(A_f)^2/((A_b)*(\lambda)^2) \qquad \text{Equation 10}$$

where A_f is the effective projected area in the direction of forward scatter; A_b is the back-scatter area, approximated by the projected area.

Table 9 applies Equation 10 to the data in Table 8 for A_f and Table 5 total areas for A_b to give the enhancement in dB of forward scatter over back scatter for a 747 and a 737 at 2 meters, 70 cm, and 23 cm.

	Enhancement (dB)		
Aircraft	2 m	70 cm	23 cm
747	24.4	29.2	28.7
737	20.4	25.8	23.4

Table 9. Enhancement of forward scatter over back scatter for 747 and 737 aircraft at 7-degree departure angle.

A value of 24.4-dB enhancement for a 747 and 20.4 dB for a 737 is in line with that which derives from the observations by McArthur[2] (21 to 24 dB or more). The results as presented in Table 9 show increases of around 5 dB from 144 to 432 MHz, consistent with a statement by McArthur in relation to 432 MHz: "the peak signals may be greater than 144 MHz." Note that at 23 cm the enhancement is lower, as much of the projected area of the aircraft cannot be used at a 7-degree angle of departure.

It is interesting to now look at the beamwidth in the horizontal plane, as this, combined with the speed with which the aircraft passes through alignment, controls the duration of enhancement. The horizontal beamwidth Δf is controlled by the length of the section in the horizontal plane and can be derived from Equation 3 as follows:

$$\Delta f = \lambda*180/(L*\pi) \qquad \text{Equation 11}$$

In Table 10, Equation 10 is applied to look at the beamwidth in the horizontal plane based on a wingspan for a 747 of 64 meters and for a 737 of 28 meters. We also look at the cabin sections 747 (6.8 meters) and 737 (4 meters), as these can contribute a wider beamwidth, although lower enhancement lobe at 2 meters.

	Wavelength (degrees)		
Aircraft Section	2 m	70 cm	23 cm
747 wing 64 meters	1.8	0.6	0.2
737 wing 28 meters	4.1	1.4	0.5
747 cabin 6.8 meters	17	—	—
737 cabin 4 meters	29	—	—

Table 10. Beamwidth of forward-scatter lobe at the 3-dB point for aircraft sections in the horizontal plane.

Table 10 shows us that when using scatter from the wing, the aircraft needs to be aligned to within less than two degrees for a large aircraft at 2 meters, which on a 500-km path means it must be within 8 km of alignment in the horizontal plane. The alignment needs to be much closer at higher frequencies, and at 23 cm is less than 1 km. This indicates that at higher frequencies the period of enhancement as the aircraft passes through alignment will be reduced. Providing the same section of the aircraft is usable at the higher frequency, then the reduction should be in proportion to the wavelength. This conclusion is at least partly supported by McArthur, who stated in comparison with 144 MHz, "It appears that only one half to two thirds of the enhancement period exits at 432 MHz."

At 2 meters the cabin can contribute to the enhancement, and it will provide a wider horizontal beamwidth, but at a lower level. For example, with a 747 aircraft the effective projected area for radar forward scatter of the cabin at 7-degrees departure angle is around half of the actual (i.e., about 20 square meters). Applying Equation 8 gives a wider enhancement of about 10 dB, compared to the peak enhancement of 24.4 dB. For a 737 most of the cabin will be effective at 2 meters, giving a wider enhancement of around 12 dB compared to a peak of 20.4 dB. In practice, such results will be complicated by the contribution of the engines and the fact that minor lobes from the wing will add and subtract from the cabin lobe at different angles. However, they do give an idea of what one might expect.

Limitations of the Approach

It is noted that the above analysis is based on some major approximations. First, the application of Siegel's formula, Equation 1, is based on the target being much larger than a wavelength, and in many cases the parts of an aircraft that are used for scattering will be on the order of a wavelength or less. Second, the method of approximating the complex shape of an aircraft has its limitations. Given these approximations, we should see bistatic radar theory as applied in this paper as guiding us to what might be expected, rather than providing exact answers.

Total System Calculations and Some Measured Results

Skolnik (page 590) gives the equation for the received power for a bistatic radar system. After deleting terms for propagation losses which are negligible at VHF and UHF and converting to dB, this is as follows:

$$P_r = P_t + G_t + G_r + 2*\lambda + \sigma - K - 2*R_t - 2*R_r - L_t - L_r \qquad \text{Equation 12}$$

where:

P_r = Received signal in dBw
P_t = TX power in dBw
G_t = TX antenna gain in dB
G_r= RX antenna gain in dB
λ = Wavelength in dB in meters
σ = Scattering cross section, in dB in square meters
  Back scatter = Projected Area
  Forward scatter =
    $4*\pi$*(Projected Area Squared)/(Wavelength Squared) †
K= Constant $(4*\pi)^3$ in dB
R_t =Range from TX to target in km in dB
R_r =Range from RX to target in km in dB
L_t = TX feedline loss in dB
L_r = RX feedline loss in dB

(†From Siegel, at scattering angle of 180 degrees. Where the scattering angle is less than 180 degrees, the effective projected area may need to be reduced; see text.)

In Table 11 Equation 12 has been applied to some practical situations and compared with measured results.

When investigated, the around 30-dB differences in measurements by VK7MO and VK3KME proved to be due to the aircraft being out of line of site, so these can be ignored. Nearly all other results are within the expected range, considering possible larger aircraft (which for a 747 can result in 9- to 10-dB increases), measurement accuracy, and the limitations in the methodology used to calculate the effective areas for forward scattering. McArthur's 432-MHz result is much greater than can be explained by these variations. While one might be prepared to ignore this as a one-off result, both McArthur and Cowan advise that there were numerous examples of such significant enhancements on 432 MHz. I accept that I cannot adequately explain McArthur's 432-MHz results.

Side Projected Areas of Aircraft

It is interesting to think about aircrafts side-on, as they have a much larger projected area. The projected area for a 747 comes out to about 600 square meters, and much of it is less than the critical 8 meters high, so it will contribute to practical forward scattering on 2 meters—let's say 500 square meters. Compared to our 106 square meters for effective front-on forward scattering, such an aircraft would have about 22 times, or 13 dB, improvement in signal level. However, the fact that an aircraft is flying across the path means that the improvement would be for a much shorter period, perhaps just a few seconds. However, it would be interesting if someone could test the theory.

Predicting Enhancement

Based on the bistatic radar theory, a simple physical model has been developed to predict the possibility and time of enhancement for particular situations. It is based on the use of

RX Station	Dist. (km)	Freq. (MHz)	Power Output PEP (watts)	TX Feedline Loss (dB)	TX Antenna Gain (dBi)	RX Antenna Gain (dBi)	RX Feedline Loss (dB)	Measured Signal Level (dBm)	Aircraft (if known)	Estimated Signal Level 747 (dBm)	Estimated Signal Level 737 (dBm)	Difference cf 737 (dB)
VK7MO	530	144	15	2	2	10.4	1	–147	737	–140.9	–150	3
VK7MO	540	144	25	3	12	10.4	1	–163	737	–125.3	–135	–29
VK3KME	540	144	100	1	10	12	3	–160	737	–119.3	–128	–32
VK3UM	720	144	400	0.5	19	19.5	0	–116	—	–109.7	–119	3
VK3UM	720	432	400	1	24	29	0.5	–91 to –85	—	–99.1	–108	17 to 23
VK2ZAB	700	144	200	2.5	20	20	1	–117	—	–113.7	–123	6
VK2ZAB	700	432	—	3.5	23	24	1	–117	—	–111.6	–120	3
VK2ZAB	550	1296	—	1	22	27	1.5	–123	—	–115.3	–126	3
VK3AJN	550	1296	—	1.5	27	22	0	–123	—	–114.3	–125	2
VK2BE	525	1296	—	1	22	30	0	–111	—	–110	–120	9
VK2ZAB	780	144	400	0.5	15	20	0.5	–117	—	–115.1	–124	7
VK2ZAB	780	432	400	0.5	21	22	1	–123	—	–112	–121	–3
VK2ZAB	780	1296	200	1	27	27	1.5	–129		—115.1	–126	–3
VK2ZAB	713	432	—	2	19	22	1	–132	—	–121.9	–131	–2
VK2ZAB	713	1296	—	4	22	27	1	–136	—	–125	–136	–1

Table 11. Observations compared to the theory. The receiving stations made the original observations. VK3KME kindly provided observation 3; VK3UM observations 4 and 5; and VK2ZAB collected the remainder.

a map on which the aircraft flight path and the locations of the stations are plotted. A drawing pin is placed through the map from the back at the point of the transmitter location to act as a pivot. Next a piece of tracing paper is marked with a straight line. At the center of the line is a point that represents the position of the aircraft. Two lines are drawn from this point to represent the beamwidth of the forward-scatter lobe (refer to Table 10). In the opposite direction to the beamwidth lines a slot is cut along the first line. This slot is placed over the drawing pin. The point that represents the aircraft now can be moved so it follows the flight path. As the slot maintains alignment to the transmitter, the area between the beamwidth lines now shows the region in which enhancement is possible.

Conclusions

The following conclusions are made from the information presented in this paper:

1. Bistatic radar theory can explain significant signal enhancements because of aircraft, compared to those which are calculated on the basis of normal radar reflection. On 2 meters, 70 cm, and 23 cm enhancements of 20 to 30 dB can be expected.

2. Based on bistatic radar theory, one can build a simple model to predict aircraft enhancement.

3. Large enhancements will only occur when the aircraft is very closely aligned between the transmitter and receiver. This means the aircraft needs to being flying along the path if it is to keep within the forward-scattering lobe for a useful period. Under these conditions, typical enhancements are of a few to several minutes in duration and more than sufficient to complete a QSO.

4. At shorter wavelengths there is a significant increase in the potential enhancement, but the alignment must be improved to gain the benefit. Given that Earth curvature prevents close alignment, it is likely to be much more difficult to use aircraft enhancement at microwave frequencies.

Acknowledgements

I would like to thank the following:

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Doug McArthur, VK3UM; Gordon McDonald, VK2ZAB; Ian Cowen, VK1BG; and John Patterson, VK3ATQ, who reviewed the original paper and made a number of suggestions to improve it and/or provided data.

Chris Morely, VK3KME, and numerous VK stations who assisted with experiments and provided data.

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A Summertime 6-Meter Grid-Square Expedition

Although you may not be able to operate from some far-off, exotic land on the HF bands, traveling to a rare grid square and operating on 6 meters can be a fun and rewarding experience. WB2AMU did just that this past summer.

By Ken Neubeck,* WB2AMU

A trip to a rare grid to operate on 6 meters is a poor man's version of a DXpedition on the HF bands. One of the exercises I often conduct during the slow months of the winter is to scout potential sites for trips to rare grids for the upcoming summer season. This exercise involves the use of the Internet to look for various state parks, along with calculating the mileage and time needed to reach these spots. I am sure that a lot of 6-meter operators do the same thing from time to time.

One of the areas of interest to me during this past winter was Pennsylvania, which has a number of moderately rare grids. Two of the grids that jumped out at me were FN01 and EN92. FN01 is a moderately rare grid for many on 6 meters, because it is a low-population area with no major cities. EN92 has only a small sliver of land on the U.S. side, Lake Erie, and a moderate amount of land on the Canadian side. There are some resident operators in these two grids, but the demand seems to overwhelm the supply.

For most of my portable operations I use a homemade two-element Yagi, which has been described in previous issues of *CQ VHF* magazine. Basically, it is built using a broomstick handle and removable telescoping elements. This is lightweight, compared to a commercially made three-element Yagi that is made of metal, and it is easy enough to suspended from a tree (using Teflon® wire line); hence the nickname "tree beam."

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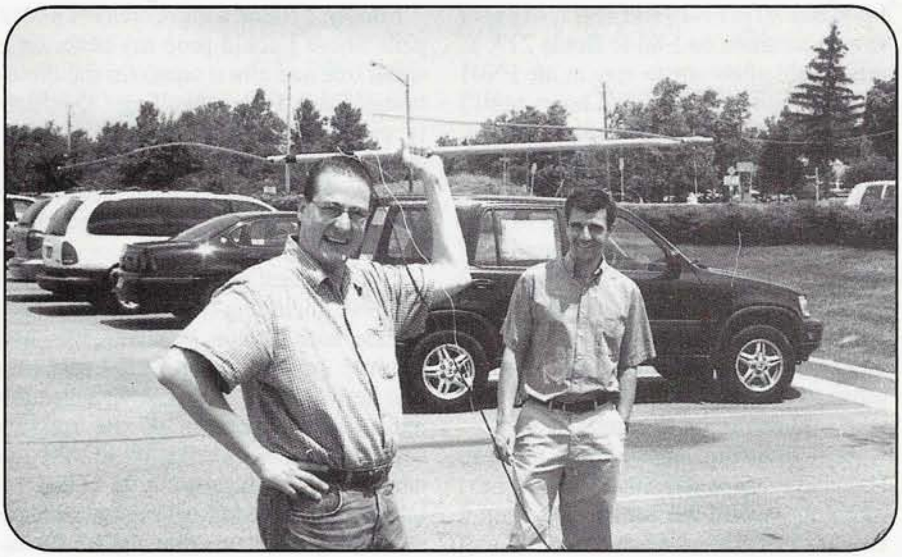


This photo was taken in Rochester, New York after a meeting of hams who operate on 6 meters. In this photo Mark Hoffman, K2AXX, is holding the portable two-element Yagi (nicknamed the "tree beam") that Ken used for much of his trip. Jeff Luce, K2EHF, is in the background. (Photos by Ken, WB2AMU)

Another antenna that was to be used while driving is my quarter-vertical magmount antenna. This antenna is suitable for many of my sporadic-*E* contacts. There is little cross-polarization effects loss because the signals are rotated during reflection. The main loss is due to the lack of gain of the vertical in comparison to a directional antenna. However, I was able to make several QSOs with local stations using the vertical even with the cross-polarization loss (they were using horizontal antennas) by using moderate amounts of power, in the area of 65 watts, from my FT-100 radio.

An opportunity at work came up for me to travel to the Buffalo and Rochester, New York area during early July 2003. This was a good chance for me to pass through these rare grids before, during, and after the business assignment. I planned to leave on Sunday, July 6, with a route plan in mind over the next few days until my return on July 9. I knew from experience over the years that the odds favored the likelihood of sporadic-*E* openings appearing on 6 meters.

An Excellent Grid-Square Adventure

My trip started out well, as I made mobile QSOs while traveling on the Long Island Expressway in FN30, going onto

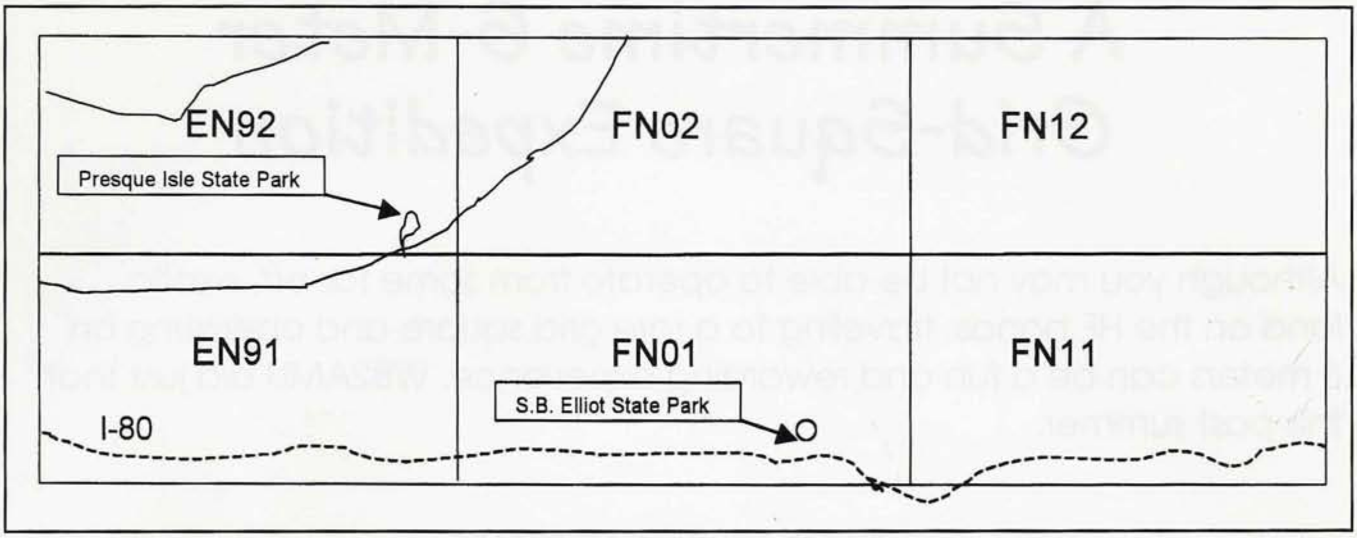


Figure 1. WB2AMU's July 2003 grid-square operation locations.

Interstate 80 in FN20 and FN11. My goal was to continue on I-80 to Route 219, as this would allow me to stay in the FN01 grid for approximately two hours until I left the grid to go northward to Buffalo, where I would be staying for the night. Unfortunately, the band was dead from the time I entered the grid at 2:30 PM until 5 PM. I had entertained the thought of traveling west to grid EN92 when I reached Route 17 in the lower part of New York. I was tired at this point, however, and with the band dead, it made more sense to go directly to Buffalo and then take a quick run up to Niagara Falls.

As it turns out, my decision to go to Erie and Presque Isle State Park the next morning worked out for the better for a number of different reasons. First, I was rested, and the ride from Buffalo to Erie was a quick hour and a half via the New York State Thruway. Second, the park was not an overnight one, and it closed at dusk. Finally, the 6-meter band would actually open by the time I reached Erie at around 9 AM.

Approximately 10 minutes after I entered the area of Erie and I was inside grid EN92, I started to hear some activity on my mobile setup. I worked Gary Vest, NW5E, in Orlando, Florida on CW, so it appeared that my timing might be perfect in catching some sporadic-*E* while I was in the grid square. I found the entrance to park in short order and stopped at a number of parking areas once I was inside the park. I was looking for a spot near a tree where I could hang my two-element beam and aim south toward the Florida area, where the sporadic-*E* opening was developing.

Finally, I found a quiet area off a bike path where I could prop my beam on a small tree and aim it south (in the direction of Erie). I started calling CQ initially on 50.125, and moved up the frequency when I could. There were a fair amount of signals coming from the Mississippi/Texas area and some of them were quite strong.

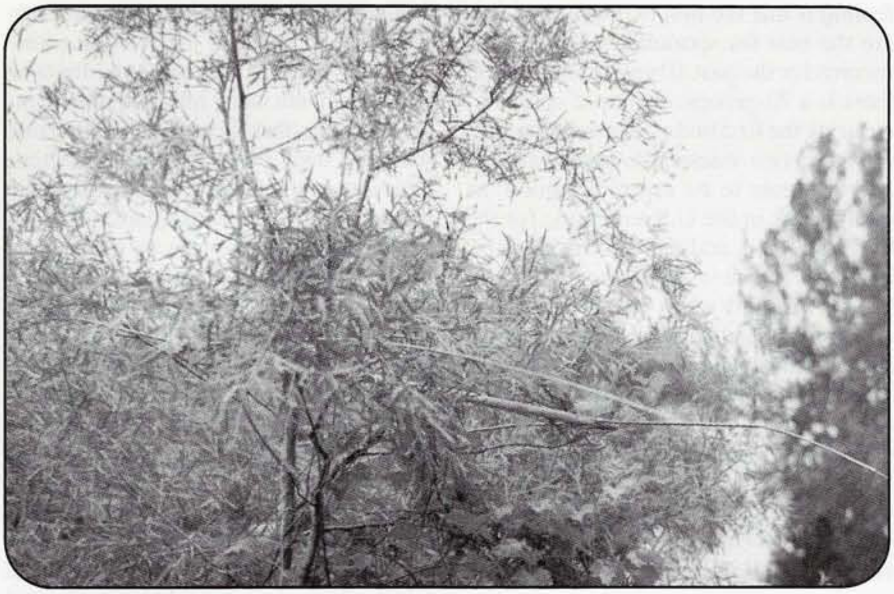
I made a total of 16 QSOs while I was in EN92, including one with a local ham in Erie, Jack Colson, W3TMZ, who had recently gotten on 6 meters. I told him that he would be very popular when the band opened because of the relative scarcity of the grid. By 10:30 AM the band pretty much gave out, and I had the long ride to make to Rochester, where my work assignment was that night. I did listen on the mobile setup while making this three-hour trip, but I did not hear very much, so it seemed as if I had left at an opportune time. After doing my work assignment that night, I was fortunate to catch a good band opening for the one-hour-plus ride from Rochester back into Buffalo. The highlight was working Mark Hoffman, K2AXX, to set up our lunch date for the next day, as well as finally working my Canadian callsign counterpart, Rick Behma, VE4AMU, on 6 meters!

The next day, July 8, was going to be an hour-plus drive back to Rochester, where I would meet Mark for lunch. The band was open again, and I worked stalwart Gervas Davis, KØAWU, while on the Thruway again. When I pulled into the parking lot of the restaurant in FN13 at 11 AM, double-hop sporadic-*E* conditions started appearing, and I worked Steve McDonald, VE7SL, in CN78 using the whip! I had worked Steve a number of times during the great *F2* season of 2001, and I was happy to catch his attention in the pileup for a short QSO. Shortly afterward, Mark and his friend Jeff Luce, K2EHF, arrived. They were surprised to hear double-hop conditions on my mobile setup.

Mark is an active 6-meter DXer, and he has worked over 120 countries on the Magic Band since he started in the late 1980s. Jeff is active as a rover station during the VHF contests. After lunch, I showed Mark and Jeff my portable, lightweight two-element tree beam. The trip had already been successful, with some QSOs made from different grids as well as having eyeball QSOs with some of the VHFers I had worked on the air!

Leaving Rochester, it was a long haul heading down toward Pennsylvania, where once again I was going to try to make some contacts from FN01, this time from S. B. Elliot State Park, off I-80, near the town of Clearfield. I made a few stops along the way, including Letchworth State Park in FN12, a place I had visited as a child with my family. There were no signals during the afternoon on 6 meters during my travels. Finally, I pulled into S. B. Elliot State Park shortly after 6 PM and found a campsite that actually had a tree with a branch suitable for hanging my portable beam.

Setup did not take more than 10 minutes, and I got my beam facing in a generally west direction. My GPS could not get a good reading with all the trees around, so I followed the track of the sun for determining direction. By 7:45 PM I



*Here is the two-element tree beam resting on a small tree in Presque Isle State Park near Erie, Pennsylvania in the moderately rare grid EN92. During his two-hour stay in the park Ken made a small run of sporadic-*E *QSOs on 6 meters with stations in the south.*

started hearing a few loud bursts on 50.060 MHz, the home of the W5VAS beacon. Ah, good . . . the band was showing some signs of life! At 8 PM I called CQ and worked Dalton Bergeron, N5HYV, in Louisiana, and then started hunting around for many different callsigns to work. The opening shifted from the southeast U.S. area to the Midwest by 9 PM, and I started working a number of stations in Minnesota, including Steve, KØAWU, again! The band was opening to the northeast. Also, I worked George McLellan, VE9DX, and Bill Elliott, VE1MR, in the maritime provinces of Canada, and even George Szymanski, VP9/GM4COK, in Bermuda.

Things really started getting interesting when double-hop sporadic-*E* made an appearance at 10:30 PM. I worked Keith Hoyt, K6GXO, in DM04, then Dave Feljar, NJ7A (DN30), in Utah, Carl Young, K5HK (DM09), in Nevada, and finally Paul Kiesel, K7CW (CN87), in Washington. The beam made a big difference compared to the mag-mount vertical. By the way, whenever I worked a CW station, I had to start the car to complete the QSO, as the current draw on the battery for the CW mode made the signal sound chirpy. I made over 25 QSOs from my campsite that night.

In the morning the band was open again at 8:30 AM toward the south, and I made almost 20 more QSOs before the band faded by 10:30 AM. I could hear some of the southern stations working into Europe, but I did not have any paths toward

there. I was happy with the amount of activity and would like to have made more QSOs from this grid, but then again, the band could have been dead during my overnight stay.

The band opened a few hours later during my return trip to FN30. I worked a few stations while I was in different grids on I-80, again including Steve, KØAWU, who worked me during my short trip while I was in five different grid squares: FN12, FN02, FN03, FN01, and FN11. It is always good to have some who monitor the band on a regular basis during the summer! I made a quick stop to visit fellow 6-meter operator Dave Ripton, K2SIX, in FN20, and within two hours I was home.

July 2003 turned out to be one of the better times for sporadic-*E* activity. I observed sporadic-*E* on 26 of the 31 days, for an 80-percent rate. It was one of the best Julys for 6 meters that I have observed over the 14 years that I have been keeping records on that band. In addition to my trip, there were several other grid trips, such as those of Lawrence Reiser, N9LR, in EN53; John Stegert, WB9MVQ, in DN87; John Walker, WZ8D, in various Canadian grids; and George, GM4COK, in many water grids in the Atlantic Ocean. Also during July there were several Caribbean DXpeditions that operated on 6 meters, including VP2MX, FS/N3OC, and HI3/ON4IQ.

Indeed, this brings up a very interesting question: Statistically, what is the best day or week for sporadic-*E* activity during the month of July? The general feeling is that the first two weeks of July are the best for sporadic-*E*. In fact, my records for the past 10 years indicate that there is a 70-percent chance of sporadic-*E* during the first two weeks of the month. Of those two weeks, the period around July 4 seems to be especially good, as many hams in the U.S. are home for the holiday period, adding to potential activity. Therefore, it is good to keep this time period in mind when planning a summertime grid-square or DX trip for 6 meters. Luck played an important part for me, as the work opportunity came up at the same time, which allowed me to travel through rare grids. I also was lucky to have sporadic-*E* activity when I was in those rare grids, both in the morning and during the evening hours. All the pieces seemed to fall into place.

The FN01 Question

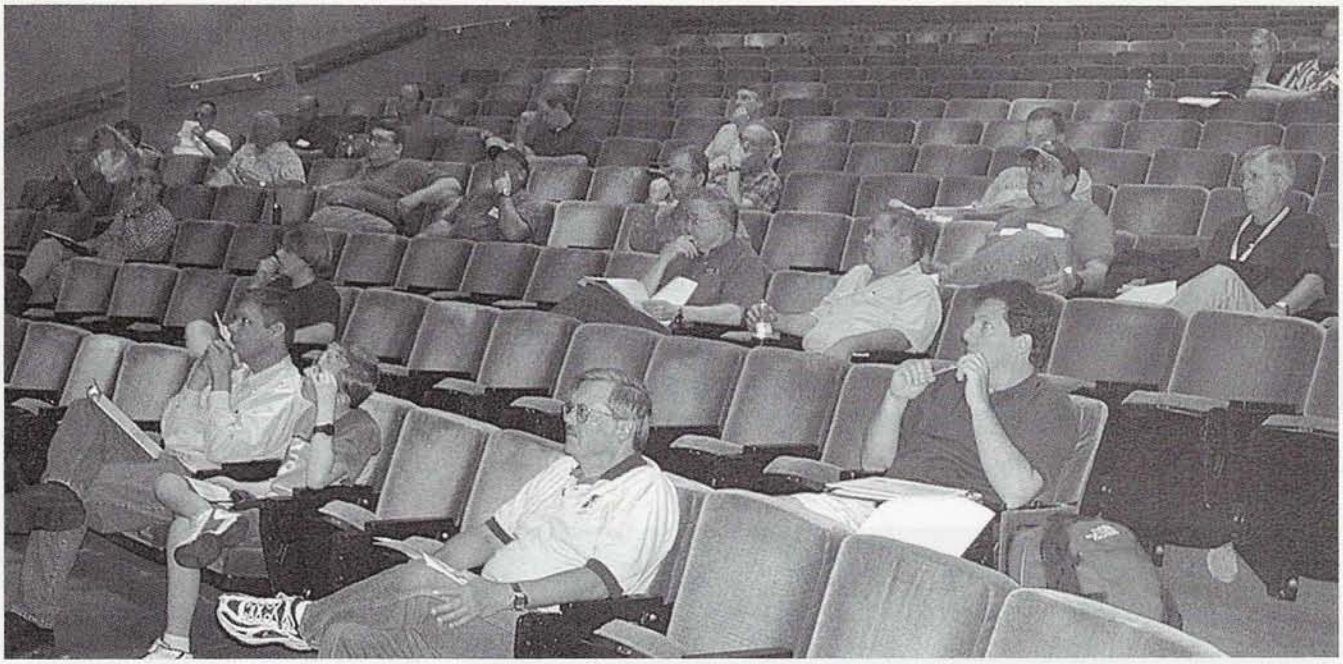
My visit to FN01 brought up a number of issues for me regarding both daily VHF operating and VHF contest operating. FN01 is a good example of a "quiet" grid in the northeast. There are no major cities located in this grid square, and consequently, there are no major population centers in which VHF activity can flourish (both in the area of FM repeaters and weak-signal work). The irony of this is that this grid contains many high spots in the form of mountains where heights can exceed 2000 feet, which is ideal for hill-topping efforts or for placing a repeater installation.

The "quiet" grid syndrome is quite commonplace in many of the western states, such as Wyoming, Nevada, and Montana. While there are many hills and mountains in these areas that are good for VHF work, there are only a few population centers. Unless there is sporadic-*E* propagation, 6 meters is very quiet with regard to line-of-sight activity in the remote areas. Two meters may be quiet as well, except if there is a local repeater setup. The weak-signal portion of the 2-meter band may be quiet in these areas even during a VHF contest, which is why I concentrated only on 6 meters for this trip. In order to achieve some success, I knew that I would have to rely on sporadic-*E* propagation appearing, and I was fortunate in this regard. Also, I could use a modest setup on 6 meters with a portable two-element beam for good results. Two meters would have required a multi-element beam, high power, and some sort of tower installation in order to make contacts.

This situation is what makes it very difficult to promote VHF contest activity throughout the U.S. Basically, it becomes a regional contest—the northeast, the southeast, and the population centers of California. A ham in Wyoming might not bother to participate in the September event because 6 meters probably will not see any sporadic-*E* propagation. The options are limited on 2 meters and 70 cm. If propagation appears in January or June, enough contacts can be made on 6 meters for a log to be submitted. Meanwhile, the east coast and west coast stations know the benefit of being able to make sufficient amounts of line-of-sight contacts even if no propagation appears. There is a big difference between a busy grid such as FN31 in Connecticut and the quiet grid of FN01 in western Pennsylvania.

Summary

The summertime sporadic-*E* season can make the sport of conducting rare grid expeditions a lot of fun. There are state parks in every state, and there are quite a few in rare grids as well. In my opinion, the state parks are actually decent areas in which to do portable 6-meter operations. You have some wide-open space, some hills, and most important of all, a minimal amount of RFI concerns. One thing to keep in mind is that many campsites are on a first-come, first-serve basis and tend to fill up very quickly during the weekends. Weekdays are generally an easier time to obtain a site. Start planning a rare grid trip for next summer! ■



The audience listens to APRS advice.

North Texas Hams Study APRS

In September hams gathered to discuss the Automated Position Reporting System and its use in various types of amateur radio activities. Here is a report on the activities and seminars that took place.

By Doug MacDonald,* W4FH

A total of 123 amateur radio operators from 46 cities throughout Texas and from as far away as Witchita, Kansas gathered Saturday, September 6, 2003 at the Conference Center at the University of Texas, Dallas Richardson Campus for an all-day workshop on the use of the Automatic Position Reporting System (APRS) in ham radio. The Plano Amateur Radio Klub (PARK) and the Comet Radio Club of UTD jointly sponsored this activity. The overall coordinator for the event was John Beadles, N5OOM, who worked closely with Barry A. Goldblatt, WA5KXX, President of PARK, and Justin McAllister, K5AEA, President of the Comet Amateur Radio Club. The seminar also received wide publicity and support from Roy Raby, AD5KZ, North Texas Section Manager for the American Radio Relay League. The workshop included 18 presentations, one panel discussion, and one "show and tell" session.

Attendees at the conference included 41 Technician, 4 Tech Plus, 23 General, 6 Advanced, and 47 Extra Class licensees, and 2 non-hams. The average attendee had been an amateur radio operator for 15.9 years. Of those responding to the check-in questionnaire, 56 of the attendees already use APRS in some form, while 67 do not and were interested in learning about the mode.

APRS Background

The APRS system was developed by Bob Bruninga, WB4APR, and permits automated position reporting using systems suitable for use on the amateur radio bands. The system enjoys wide popularity in the north Texas area, and the region is particularly well supported with wide-

Andy Vrabel, K5TOE, presents his THD-7.

area digipeaters and stations providing "gating" services to and from the internet.

The Seminar

The seminar focused on three basic areas: the hardware and radio systems necessary for effective APRS use; the software programs available to hams for employment on APRS; and operating practices appropriate for this useful communications system. Seminar attendees were encouraged to bring their own APRS systems to demonstrate to other

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Byon Garrabrant, N6BG, chats with Scott Garrabrant, KD7GMT, and Justin McAlister, K5AEA, about the TinyTrak3.

John Galvin, N5TIM, Jim Schultz, W5OMG, and John Beadles, N5OOM, lead a discussion of APRS for Special Events.

John Beadles, N5OOM, Tony Campbell, W5ADC, Barry A. Goldblatt, WA5KXX, Glen Frasier, KD5DMG, and Pete Loveall, AE5PL, in the Q&A session.

attendees. Help was available from hardware and software experts to configure systems and to repair ailing systems.

One of the high points of the event was the presence of Byon Garrabrant, N6BG, of Las Vegas, Nevada. Byon is the designer of the popular TinyTrak and TinyTrak3 APRS GPS position encoders, and he provided substantial assistance to amateurs needing help with their units. He also discussed the theory and practice of designing small APRS systems with many different participants throughout the event. Byon's company, Bionics.com, provided two TinyTrak3 units as door prizes. A third door prize was a free copy of UIView32, provided by its author, Roger Barker, G4IDE. UIView32 is one of the most popular APRS presentation and control programs.

Pete Loveall, AE5PL, who currently develops the JAVAAPRS Server software for the worldwide amateur internet community, made the following presentations: "APRS Point, " "APRS in North Texas," "APRS & the Internet," "An Introduction to APRS + SA," and "Introduction to PocketAPRS."

John Beadles, N5OOM, in addition to serving as overall coordinator for the event, provided presentations on "APRS Functions for Public Service Events" and "APRS & Digital Map Data." He also hosted the "Tiny Tracker Show and Tell" presentation and chaired a panel discussion on "APRS for Special Events" that included John Galvin, N5TIM, and Jim Schultz, W5OMG. Gerry Creager, N5GXS, from College Station, Texas, presented "An Introduction to GPS Receivers" and "HSMM (802.11b) In Amateur Radio." Tony Campbell, W5ADC, headed the discussion "APRS Tracker Examples," and teamed up with Andy Vrabel, K5TOE, to present "Configuring TMD-700 and TH-D7 APRS Transceivers." Glenn Frasier, KD5DMG, made presentations on "Configuring AGWPE," "An Introduction to UI-View," and "Weather Tracking with APRS."

Justin McAllister, K5AEA, and Jerry Karlovich, KD5OM, teamed up to lead a discussion on "Building and Configuring the TinyTrak3," with able assistance from the unit's designer, N6BG. Mark Davis, KD5WIN, presented "An Introduction to WinAPRS/MacAPRS."

Ed Lawrence, WA5SWD, gave useful information on "Antennas and Transmission Lines in APRS." Barry, WA5KXX, who is not only the President of P.A.R.K. but also of Resource800, Inc., made a presentation on "Battery Usage." Complete copies of all presentations made at the 2003 North Texas APRS Symposium are available at: <http://www.n5oom.org/2003_nt_APRS_workshop>.

Summary

A number of issues came out clearly during the day's discussions. These are items that should be considered by all amateurs who make use of the APRS system. Although the recommendations were developed specifically for the North Texas area, they are capable of improving the efficiency of APRS frequencies in any location.

APRS via amateur radio on RF is a tactical communications system; it is intended for short-range use and to provide relevant information within a limited area.

How To Get Into HSMM

What is this HSMM stuff? What kind of radio is that? Is this something cool and fun that I might enjoy? Is it expensive? Can I afford it? Will I understand how it works? What can it do? K8OCL and KA3JIJ provide answers to these questions.

By John Champa,* K8OCL, and Ron Olexa,† KA3JIJ

First, HSMM stands for High Speed Multimedia radio. It is not a specific operating mode, but rather more of a direction or driving force within amateur radio.

Second, HSMM, although digital radio, it is *not* primarily keyboard radio communication, as in packet radio. Among the capabilities of HSMM are digital voice (DV) and digital video (ATV). Yes, you can type keyboard messages back and forth (chat mode) as in PSK. Also, you can do file transfers as in RTTY, but at significantly higher speeds! In additional, if there is a server on the radio network, you can do e-mailing and maybe even surf the internet. That is why it is called *multimedia* radio.

If an operator is using HSMM radio to access the internet, don't forget amateur radio content restrictions, which means no porn, no commercial business e-mails, etc. Don't worry about pop-up ads. Although a nuisance, these are no more illegal than an ATV station that is transmitting an outdoor scene inadvertently, picking up a billboard in the station camera.

How about a little history first?

Background

A survey conducted by the ARRL Technology Task Force, consisting of League members and other amateurs, revealed that the number one amateur radio interest in new technologies is high-speed digital radio networks. Some suggestions included:

- High-speed radio data links up to 20 mega bits per second (M bit/s)
- Ethernet at 2 mbps on 10 GHz
- Encourage development of a high-speed amateur digital radio network
- High-speed digital audio/video radio

In January 2001 the ARRL Board of Directors voted unanimously that the League should develop high-speed radio digital networks for the Amateur Radio Service. ARRL President Jim Haynie, W5JBP, appointed a group of individuals from the international amateur community and industry who were knowledgeable in the field. The group would report to the Technology Task Force. These were the humble beginnings of the High Speed Multimedia (HSMM) Working Group.

The HSMM Working Group

The working group's first focus is on creating skills within the amateur radio community to build portable and fixed high-speed radio local networking. At the present time that's where amateurs interested in HSMM radio can offer the most value to local RACES and ARES organizations, plus other homeland security and emergency communications efforts.

During Field Day and simulated emergency tests we encourage amateurs to hone their skills in doing rapid site-surveys and deploying broadband HSMM radio networks in the field. In the process, we are trying to understand how to enhance the reliability of our mainstream radio network connections. Through various emergency communications training programs, we will be trying to incorporate information to help local hams be the people who deploy these high-speed microwave radio networks on demand.

One way that amateurs can do this today is by adapting off-the-shelf IEEE 802.11 gear to operate within amateur radio regulations. This is also known as WiFi equipment, and it is commonly available at computer equipment retailers. As sold, the equipment operates in the 2.4-GHz ISM bands under Part 15 rules. The 802.11b standard was developed about six years ago for the purpose of providing a wireless alternative for office LAN installations. This wireless capability was to allow office LANs to be deployed without the expense and nuisance of running CAT5 cable to each computer. Because of the increase in the number of homes with multiple computers, as well as the rapidly falling price points for WiFi equipment, WiFi hardware has had a significant penetration into the home marketplace. In a recent *CQ* magazine survey ("What You Have Told Us," September 2003 issue, p. 40) eight percent of the respondents reported already using some kind of wireless networking, so there is a growing understanding of the technology within the amateur ranks.

The equipment as purchased has significant operating limits. Power is severely curtailed because of the Part 15 operating rules. Remember that just like cordless phones, this hardware has to allow uncoordinated operation of many unlicensed devices with minimal interference. In addition, many users of this technology adopted it because it allows unencumbered connectivity for a laptop computer. By nature of the fact that a lap-

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top is battery powered, most client cards offer only a small fraction of the power authorized under Part 15 rules in order to maximize battery life.

Depending on your needs as an amateur radio operator, neither of these considerations is a limit on your use of the WiFi technology. While a system as sold may have a range of only 50 to 100 feet, proper set up of a system under amateur regulations can provide coverage far in excess of that. In fact, one of our HSMM WG test networks, called the Hinternet, in Livingston County Michigan can easily do 5–15 mile ranges at speeds of up to 54 M bit/s (half-duplex) using small mast-mounted dish antennas in conjunction with off-the-shelf, consumer-grade hardware.

Buying a New HSMM Rig

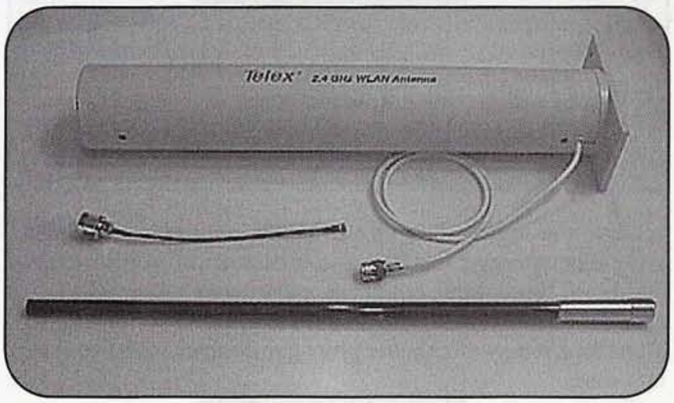
Getting operational with this equipment is a bit more complex than going to a full-line amateur radio dealer and buying an HF, VHF, or UHF rig, then going home and connecting a key, a microphone, and an antenna. Because this is data local area network (LAN) equipment, it expects to be communicating with a computer, or more precisely, with software running on a computer. First, you must decide what interfaces you are going to need to connect to your computer. Luckily, equipment is available for all the standard computer interfaces: Ethernet, USB, and PCMCIA.

If you use a laptop in your station, get the PCMCIA card. We recommend the type with an external antenna connection. If you have a PC, get the WLAN adapter type that either plugs into the USB port or plugs into the RJ45 Ethernet port. Select the one that is best suited to your computer and to your experimentation.

This is the heart of your new station. It is a computer-operated HSMM 2.4-GHz radio transceiver, and it probably will set you back about $60 to $80. It is usually easier if you start off by teaming up with another ham radio operator who lives nearby and do your initial testing together in the same room. Then as you increase distance, going toward your separate station locations, you can coordinate by using a suitable local FM simplex frequency. On our radio test networks we most often use 446.00 MHz, the National Simplex Calling Frequency for the 70-cm band.

Go to your local OfficeMax®, RadioShack®, Best Buy®, ABC Warehouse®, or other consumer electronics outlet to purchase some economical and readily available wireless local area network devices. We recommend that you select devices that state whether they comply with IEEE 802.11b and whether they are WiFi compatible. Because numerous manufacturers make these devices, each using different techniques to achieve the same thing, initially there were complaints about interoperability between devices of different manufacturers. An industry group known as the WiFi consortium was formed to provide testing and certification of 802.11b devices. If the equipment is WiFi certified, it will interoperate with any other WiFi-certified equipment, which will ease your initial installation and troubleshooting by assuring that device compatibility is not the root cause of a start-up problem. These devices operate on the 2.4-GHz band using direct-sequence spread-spectrum (DSSS) modulation at speeds up to 2 mbps and complementary code keying (CCK) modulation for speeds of 5.5 and 11 M bit/s. Operating speed is selected automatically by the equipment, based upon signal-to-noise and signal strength of the operating channel. These 802.11b devices are usually the least expensive, they are the easiest to work with, and they offer the good propagation.

HSMM HT: In the center is the well-recognized PDA (Personal Data Assistant), or hand-held PC. This one, however, is equipped to work on 2.4 GHz using IEEE 802.11 PCMCIA cards. One of these cards (essentially, the cards are the transceiver RF section in a module) and some software turns this PDA into a potential amateur radio HSMM HT.



Top: The 15-dBi 2.4-GHz Yagi antenna mounted in a protective PVC tube. Horizontal polarization is the most often preferred orientation for amateur radio use of IEEE 802.11 technology. Middle: A good strain relief cable, or pigtail, is the secret to success with HSMM using 802.11. It allows you to adapt the specialized PCMCIA card connector to a normal N-series connector. Bottom: Although most amateur radio HSMM stations use horizontal polarization to help avoid (in some instances) Part 15 traffic sharing the band, depending on your location and use, vertical polarization may be suitable. Pay attention to whether or not the vertical antenna provides down-tilt of the main radiation lobe. The design you select will depend on your particular situation.

If you can afford a few extra bucks, move up to the newer IEEE 802.11g devices. 802.11g is a relatively new standard that increases the speed of the channel from 11 M bit/s maximum to 54 M bit/s maximum. They also operate on the same 2.4-GHz frequencies, but they use a form of modulation called orthogonal frequency division multiplexing (OFDM) to

HSMM in a Briefcase

By Michael W. Burger, AH7R, and John J. Champa,† K8OCL*

Among ham radio uses for 802.11b, we should remember the potential for portable short-range nets. These could include races, parades, flower shows, homeland security exercises, and other general emergency preparedness over short ranges. HSMM allows use of video transmissions as well as typing and voice to coordinate such activities.

A briefcase containing a laptop equipped with an 802.11b card in its PCMCIA slot and a reasonable, portable antenna structure will do the job. When one is operating during a parade, for instance, the individual stationed at a critical point can see the traffic flow, the specific unit that is passing, and the overall progress of activities occurring up to at least one mile down the route.

For emergency communications (EmComm—for more information on emergency communications, see <http://www.emcomm.org>) HSMM can show what is going on at a coordination center a mile or so away, which could be a critical point. Impromptu networks of several portable units can be set up on demand to provide tight communications over a limited area such as a workstation intranet.

These are examples of activities using a laptop computer that have immediate applications and should fit well within the HSMM goals of using inexpensive, off-the-shelf components. This type of activity is one with which many hams are regularly involved.

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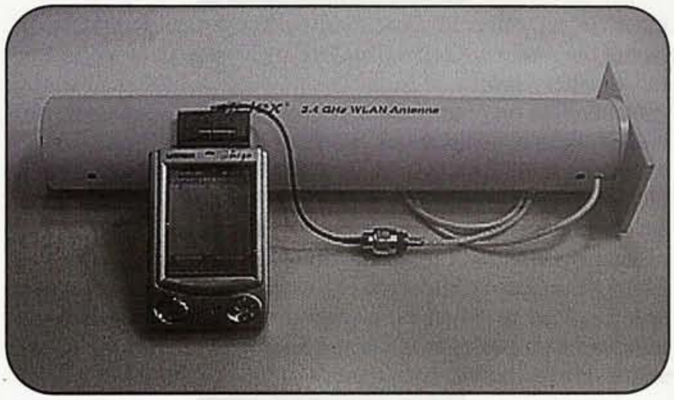
achieve the higher data rates. OFDM requires significantly more signal strength and signal-to-noise ratio in order to achieve 54 M bit/s throughput, but appears to tolerate multipath effects caused by radio signal reflections better than CCK modulation. Therefore, it may offer better propagation characteristics in certain cases.

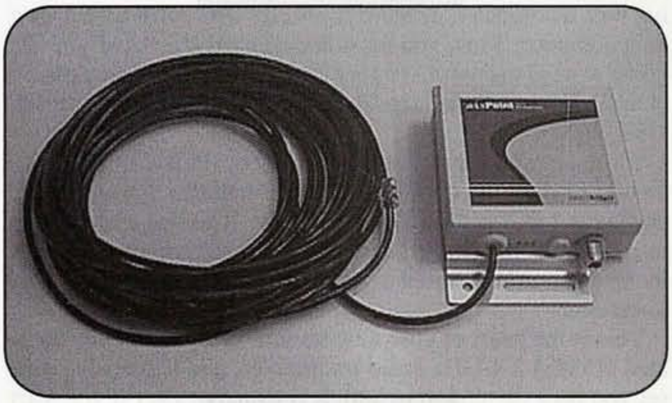
There are a few things to be aware of when purchasing your equipment. First, make certain that the supplied rubber- duck antenna(s) are removable and/or there is an external antenna port. If the device does not have an external antenna connection, check the "Digital Connection" column by Don Rotolo, N2IRZ, in the February 2003 issue of *CQ* for details on how to modify the device. Second, look at the radio specifications for the device. The transmit power and receive sensitivity vary widely among devices. Try to buy a device with the best (highest power and lowest receive sensitivity) specifications. The best generally available equipment has 100 mW (20 dBm) transmit power and –93 dBm receive sensitivity at 11 M bit/s, while the poorest specs are 25 mW (13 dBm) transmit power and –87 dBm receive sensitivity at 11 M bit/s.

At these frequencies radio behaves the same as radio at any other frequency: a 6 dB power increase will double effective range. Here we are dealing with a 12-dB advantage of the higher performance equipment versus the lower. In a small Part 15 home LAN the difference is probably not noticeable. For our purposes, operating longer distances under Part 97, a 12-dB difference is critical and can make the difference between successful experimentation and frustration and failure.

If the device does have an external antenna connection, then go to any issue of *CQ* magazine and look up Nemal Electronics®, CableXperts®, or another cable supply source and order an 18–24 inch strain relief cable, which is also called a "pigtail," of



HSMM HT + pigtail + Yagi can provide several miles of range back to the Access Point (AP) at the Emergency Operations Center, etc., depending on terrain and other obstacles. Using free software such as Mini Stumbler (www.netstumbler.com), you can also use the HSMM HT to locate other APs.



Access Point designed for outside mounting at the antenna to avoid feed-line losses.

the type needed for your device. It will probably cost less than $20. If you purchased a PCMCIA card, the pigtail will have a strange-looking miniature antenna connector at one end, and it should have a normal N-series connector at the other.

The first thing you will need to do is install the device in your computer. If you are using a PCMCIA or USB device, you will need to install drivers. If you are using a device with an RJ-45 Ethernet interface, no drivers are needed for the device, but there are drivers needed for the Ethernet port in the computer. In addition, there will be a method to communicate with this device for configuration. The included directions will explain how to accomplish this.

After you load up the software drivers on your PC, you will have two choices for configuring the equipment: *ad-hoc* and *infrastructure* mode. For now, set the device for ad hoc mode, and set it to any channel between 2 and 5 (they're in the amateur band). If all is operating correctly, the two cards (yours and your buddy's) should see each other and set up a communication session. Once the cards are talking, you can share files between the two computers in the same manner as if the computers were hardwired together on a LAN.

Once you have the cards tested and you know you have a connection between them, it's time to add the antennas and see what distances you can achieve between the two devices. Hook up any external commercial (e.g., Comet®) or home-brew 2.4-GHz antenna. For some good designs, shop around where the AMSAT-OSCAR 40 guys buy their Mode-S antennas. Keep in mind that the higher the gain of the directional antenna, the smaller the main lobe will be, so aiming a high-gain antenna will be more critical than aiming a low-gain one. Most 802.11 equipment has a utility included which shows signal strength and signal-to-noise ratio. Using this utility to monitor signal strength as you aim your antenna will be of great assistance in finding the optimal aiming direction. Remember that these antennas are directional in both the horizontal and vertical planes, so you have to aim carefully in both azimuth and elevation to get optimum signal at the receiver.

Another thing to keep in mind is coax. Coax losses at these frequencies are enormous. Don't even try to use RG-8 cable to connect between the device and the antenna. You will need to purchase the best coax you can afford in order to keep line losses minimized. In fact, the antenna coaxial cable will likely be the most expensive part of the entire station, as you will want to use the lowest loss type you can handle—e.g., LMR-400, etc.

That's all there is to it. Best of all, you may not have spent more than $100 so far, depending upon what antenna hardware you have around.

Testing . . .

Now point your antennas at one another and fire away. At these power levels there is not much concern for RF safety, but if you are using a high-gain antenna, it is recommended that you avoid standing directly in front of the business end while you are on the air.

Do remember that it's your responsibility to identify your station properly during use. In the mode you are presently using, the ad hoc or direct station-to-station mode, the most common technique is simply to ID in-mode—i.e., if you are transmitting voice, simply speak your callsign into the microphone; if you are transmitting video, just hold a QSL card up to the camera, or you can send a ping containing your callsign. Remember that as long as the RIC (radio interface card, short for a WLAN PCMCIA card used for HSMM radio) is operating, even with no traffic the system is transmitting!

Depending upon how close your ham buddy is to your location, how high and clear your antennas are, the quality of the coaxial cable you are using, and many other factors, you should be able to get a range of several miles. Remember, these HSMM radio devices are truly QRP and run only about 30–100 mw of RF output. Be resourceful and experiment often with different antennas, etc.

If your signals are not covering the path between you and the nearest HSMM radio station, then open a copy of any edition of the *ARRL Handbook* and read the sections on antennas, transmission lines, and UHF propagation. Consider putting the antennas higher, getting or building higher gain antennas, using lower-loss coaxial cable, and so on, until the link is achieved. You may also find a way to mount your gear at the antenna, avoiding the expense and loss of coaxial cable. This is another reason to consider devices that have Ethernet output. Standard CAT5 Ethernet cable can be run up to 300 feet with no loss. In comparison, USB can only be run 9 feet without a signal booster being installed. By using an Ethernet-based device, it is easy to remotely mount the unit close to the antenna and run cheap CAT5 cable back to your computer.

Running higher power is an expensive last resort, not only because running low power is sound operating practice—i.e., running the minimum power needed to maintain the communications—but also because it is good old-fashioned common sense. Be considerate of others who may be using the band, both amateur and non-amateur. Use only the power needed for the link.

HSMM Radio Repeaters

The next step up the functionality ladder is to add a "repeater" to your system. More properly called a *wireless hub* or an *access point* (*AP*), this device will allow several amateur radio stations to share the network (and all the devices and circuits connected to it). An 802.11b AP sells for about $100, and an 802.11g AP sells for about $140. The AP acts as a central collection point for traffic and can be connected to a single computer or to a network. The AP is provided with an ESSID, which is the name it broadcasts. For our purposes, the ESSID can be set as your callsign, thus providing automatic, constant identification. To use an AP in your network, the computer users have to exit ad-hoc mode and enter infrastructure mode. Infrastructure mode requires you to specify the network to which the device belongs. This is what the ESSID does: identify the AP to its users, so the users can find the home system to which they belong. Set your computer device to recognize the ESSID you assigned to your AP.

The AP can also be used as one end of a point-to-point network. For example, if you wanted to extend a network connection from one location to another, you could use an AP at the network end and use it to communicate to a computer at a remote location.

Using an AP allows more features and security than provided by ad-hoc mode. For example, most APs provide DHCP service, so they will automatically assign an IP address to the computers connected to the network. In addition, they provide filtering that allows only known users to access the network.

HSMM Software

For operating software, most amateurs are using Microsoft® NetMeeting collaborative software, which comes free with the Microsoft Windows® operating system. Also, other forms of open-source groupware using Linux are popular. Try using OpenH323 or Speak Freely. By connecting a microphone to the audio input of your soundcard, you can have digital voice QSOs. By connecting an inexpensive digital camera ($20), you can do digital video QSOs. These are not the same quality as the usual ATV contacts, but the equipment is much less expensive!

HSMM Traffic

How do you keep Part 15 unlicensed traffic from accidentally using your Part 97 licensed HSMM network? A traffic separation technique that is considered acceptable involves the use of WEP (wired equivalent protection)—*not* for encryption, but for authentication. If you use this approach under Part 97, you must publish the WEP key. We recommend that you request your HSMM repeater's WEP key be published on the HSMM URL (www.arrl.org/hsmm/), or simply use the amateur common WEP key already designated on that URL. Again, the WEP is used to avoid the accidental mixing of Part 15 and Part 97 traffic—i.e., authentication, *not* encryption. Another approach gaining in popularity with many HSMM stations is the use of 44 domain IP (Internet Protocol) addresses, which are only available to the Amateur Radio Service.

The HSMM Radio Future

The HSMM Working Group is cooperating with AMSAT-NA and their proposal to experiment with ground-based 5-GHz inband transponders. Future plans may call for what Dr. Tom Clark, W3IWI, has called a C2C transponder onboard an amateur high-altitude OSCAR. This would be a high-speed digital radio transponder, with both uplinks and downlinks in the amateur 5-GHz band.

There are other avenues of radio networking investigation which may also yield positive results in terms of the eventual development of an HSMM Radio Backbone Network or "Hinternet" for the Amateur Service.

The HSMM-HF Radio Project is to use Gerry Youngblood's, AC5OG, software defined radios, the Model SDR-1000, as the test platform. See http://www.flex-radio.com for additional details.

The HSMM-VHF Radio Project is examining numerous alternatives, from FSK to Q15X25 to MT63. The use of VHF (50.6–50.8 MHz) frequencies for 256-kbps links appears most promising at this time. The goal is to choose that mode which is some appropriate combination of optimum and useful.

Recommendations

Amateurs of all license classes are encouraged to get on the air with HSMM radio using 802.11 off-the-shelf gear under amateur regulations. It is easy, low-cost spread-spectrum microwave radio experimentation.

As you can see, however, there are a lot of initiatives in many bands. Experimenting with localized connectivity at 2.4 GHz is only one of them. For more details and for the latest developments on all these initiatives, check out the link to HSMM WG open reflector at Texas A&M University on our URL: <http://www.arrl.org/hsmm>. ■

Suggested Reading

Ford, Steve, WB8IMY, "VoIP and Amateur Radio," *QST*, February 2003, pp.44–47.

Mraz, Kris I., N5KM, "High Speed Multimedia Radio," *QST*, April 2003, pp. 28–34.

Olexa, Ron, KA3JIJ, "Wi-Fi for Hams, Part 1: Part 97 or Part 15," *CQ*, June 2003, pp. 32–36.

Olexa, Ron, KA3JIJ, "Wi-Fi for Hams, Part 2: Building a Wi-Fi Network," *CQ*, July 2003, pp. 34–38.

Reinhardt, Jeff, AA6JR, "Digital Hamming: A Need for Standards," *CQ* magazine, January 2003, pp. 50–51.

Rinaldo, Paul L., W4RI, and Champa, John J., K8OCL, "On The Amateur Radio Use of IEEE 802.11b Radio Local Area Networks," *CQ VHF*, Spring 2003, pp. 40–42.

Rotolo, Don, N2IRZ, "A Cheap and Easy High-Speed Data Connection," *CQ*, February 2003, pp. 61–64.

Quarterly Calendar

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

Nov. 2	Moderate EME conditions.
Nov. 9	Full Moon. Poor EME conditions.
Nov. 10	Moon apogee.
Nov. 13	Highest Moon declination.
Nov. 16	Last quarter Moon. Good EME conditions.
Nov. 23	Moon perigee. Moderate EME conditions.
Nov. 24	New Moon.
Nov. 26	Lowest Moon declination.
Nov. 30	First quarter Moon. Moderate EME conditions.
Dec. 7	Moon apogee. Poor EME conditions.
Dec. 8	Full Moon.
Dec. 10	Highest Moon declination.
Dec. 14	Good EME conditions.
Dec. 16	Last quarter Moon.
Dec. 21	Moderate EME conditions.
Dec. 22	Moon perigee.
Dec. 23	New Moon and lowest Moon declination.
Dec. 28	Good EME conditions.
Dec. 30	First quarter Moon.
Jan. 3	Moon apogee.
Jan. 4	Poor EME conditions.
Jan. 5	Full Moon.
Jan. 6	Highest Moon declination.
Jan. 11	Good EME conditions.
Jan. 15	Last quarter Moon.
Jan. 18	Poor EME conditions.
Jan. 19	Moon perigee.
Jan. 20	Lowest Moon declination.
Jan. 21	New Moon.
Jan. 25	Good EME conditions.
Jan. 29	First quarter Moon.
Jan. 31	Moon apogee.
Feb. 1	Poor EME conditions.
Feb. 3	Highest Moon declination.
Feb. 6	Full Moon.
Feb. 8	Good EME conditions.
Feb. 13	Last quarter Moon.
Feb. 15	Very Poor EME conditions.
Feb. 16	Moon perigee and lowest Moon declination.
Feb. 20	New Moon.
Feb. 22	Good EME conditions but near NewMoon.
Feb. 28	Moon apogee and first quarter Moon.
Feb. 29	Very Poor EME conditions.

—EME conditions courtesy W5LUU.

Contests

November: The second weekend of the ARRL International EME Competition is November 15–16.

January: The ARRL VHF Sweepstakes will be the weekend of January 24–26, 2004.

Complete rules for the ARRL contests can be found in the *QST* issue the month prior to the contest or the month prior to the first weekend of contests extending over two months. Complete rules can also be found on the League's website, <http://www.arrl.org>.

Meteor Showers

November: While another peak in *Leonids* activity is two or three years away, it is still important to pay attention to this shower, as it may produce a surprise ZHR in excess of 250, five days ahead of its predicted peak. It is predicted to peak at 0150 UTC on November 18.

December: Two showers occur this month. The first, the *Geminids,* is predicted to peak around 1510 UTC on 14 December. The actual peak can occur 2.5 hours before or after the predicted peak. It has a broad peak and is a good north-south shower, producing an average of 100–110 meteors per hour at its peak.

The second, the *Ursids,* is predicted to peak around 0100 UTC on 23 December. It is an east-west shower, producing an average of greater than 12 meteors per hour, with the possibility of upwards of 90 at its peak.

January: The *Quandrantids,* or *Quads,* is a brief, but very active meteor shower. The expected peak is around 0450 UTC on 4 January. The actual peak can occur three hours before or after the predicted peak. The best paths are north-south. Long-duration meteors can be expected about one hour after the predicted peak.

For more information on the above meteor shower predictions see Tomas Hood, NW7US's "Propagation" in this issue. Also visit the International Meteor Organization's website, <http://www.imo.net>.

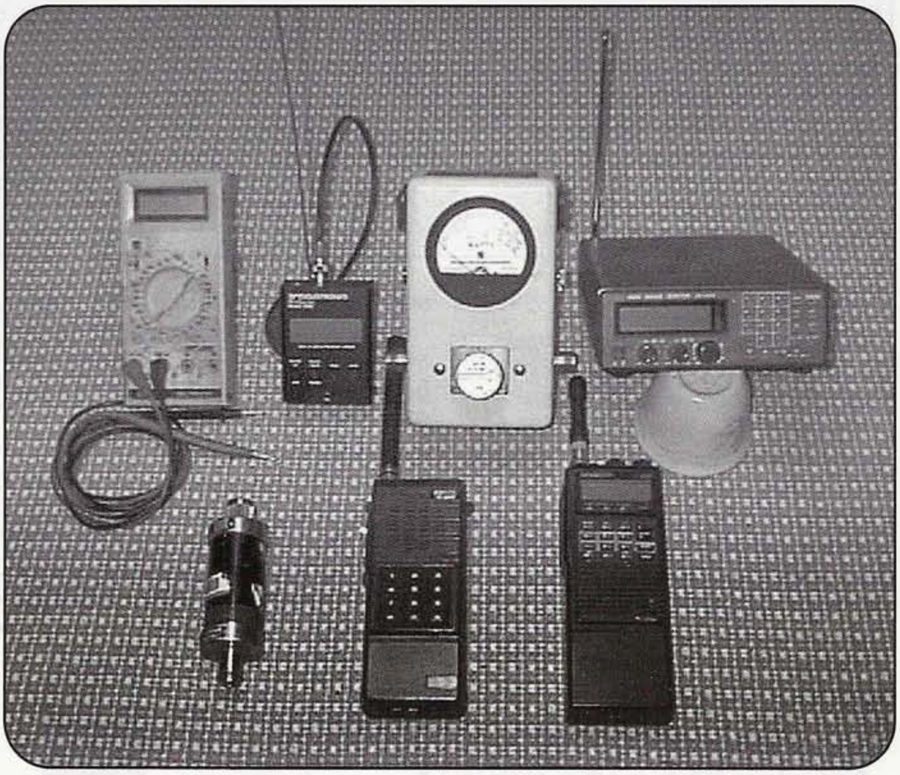
Simple Test Gear and Techniques for Measurements above 50 MHz

Troubleshooting our ham radio equipment is often a challenge, at best. Here K3YWY suggests several off-the-shelf items that greatly simplify the task for our VHF-and-above radios.

By Charles W. Pearce, Ph.D.,* K3YWY

The prospect of building, modifying, or troubleshooting today's ham gear is a daunting proposition for many. For average hams who lack what they perceive as the necessary test equipment, this challenge may be perceived as insurmountable in the realm above 50 MHz. Sophisticated equipment such as micro-wattmeters, noise-figure meters, and spectrum or network analyzers, even when obtained used, may cost many thousands of dollars, a price tag which many but the most dedicated are unwilling to pay.

It is possible, however, to use relatively simple equipment and techniques to achieve success above 50 MHz as outlined in this article. Figure 1 depicts my collection of "test equipment" which has been used to build and repair our rover station.[1] The current rover station is QRV on 50 to 2304 MHz. The equipment shown in the photo includes a multimeter; counter; Bird equivalent wattmeter; scanner; a 10-dB, 10-watt attenuator; 144-MHz HT; and 220-MHz HT.



The author's test equipment. Top, left to right: multimeter, counter, bird equivalent wattmeter, scanner. Bottom, left to right: 10-dB, 10-watt attenuator; 144-MHz HT; and 220-MHz HT.

Signal Sources

Harmonics are a ham's best friend. For example, the 7th harmonic of 40 meters can easily be heard on 50 MHz. A 2-meter HT will provide a usable 3rd harmonic on 432 MHz. I was able to copy the 17th harmonic of my low-band rig, a Yaesu FT-920, on 6 meters on 903 MHz and its 25th harmonic on 1296 MHz. These harmonics tend to be weak, so if you do hear them, it's a good sign your receiver is working well. Remember, though, any error at 50 MHz is multiplied by a large factor, so tune slowly and use CW to locate the harmonic.

Power Measurement

The Bird model 43 wattmeter is the de facto choice of many hams for the HF bands, and it functions well into the microwave realm with proper elements to cover a wide range of frequencies and power levels. The problem is that the elements are fairly expensive, costing about $70 new and $40 used. However, by a judicious choice of elements, it is possible to cover a wide range of frequencies and power levels with just a few elements. The trick is that the elements will

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work over a wider frequency range than listed on the element, often with very little degradation in accuracy.

We use a 25E (a 10E would also be a good choice) element that is a 25-watt, 400- to 1000-MHz element to cover 432, 903, and 1296 MHz. At 1296 the error is only about 10%. This element also works on 220 and 144 MHz, albeit with an error of about 100%, but remember that in many cases, a relative reading of power is all that is needed. A good choice here, however, if more accuracy is desired, would be either the 10D, 25D, or 50D, which cover 100 to 400 MHz (and beyond).

For higher power levels, the range can be extended by the use of an attenuator between the source and the meter. We use a 10-dB, 10-watt attenuator obtained at a hamfest. Its thermal mass is sufficient to withstand power levels of 40 or 50 watts for a few seconds without overheating.

Lower power levels are more of a challenge, but think of your scanner as a microwatt meter. Remember 50 mV developed across 50 ohms is 50 microwatts. Therefore, a scanner can be used to detect very small power levels. After all, that is what receivers do for a living! I've been using the AOR-2500, which covers up to 1.5 GHz.

Frequency Measurement

Frequency measurement is not the problem it used to be, with the availability of inexpensive counters for about $100 offering good performance. I've used the Optotronics mini-counter model 3300 for several years. It works up to 2.8 GHz and covers all the bands we currently operate. Also, it is great for checking out crystal oscillators in local-oscillator (LO) chains. This type of counter can be fed directly with a signal source up to the milliwatt range, and it works well with a small whip antenna. When roving, we also have hooked it up to a 2-meter whip on the cab of our truck. As we transmit, it gives us an indication that we really are on the air. If you're ever in doubt about its calibration, try this approach: Drive to a local FM station and measure its frequency directly off the air.

A scanner can also function as a frequency-measuring device, with somewhat less accuracy. Furthermore, it can function nicely as a spectrum analyzer of sorts. You can locate and hear all the harmonics of an LO chain using a scanner. Weak or missing harmonics indicate a problem in the LO.

Multimeter

Even though the equipment might be working at microwave frequencies, circuits still need voltage and current to work. Checking for biases and current draw works just as well above 50 MHz as it does below 50 MHz. Consider measuring voltages and current of equipment when it is working. These values can be used for troubleshooting, should problems arise.

Summary

Don't let a lack of test gear be an excuse for not exploring higher frequencies. In your shack you probably already have some of the equipment I use. Even starting from scratch, a few hundred dollars will outfit you nicely.

Note

1. I Rove; Therefore, I Am, C. W. Pearce, K3YWY, and W. L. Ziegenfus, N3LJK, *CQ VHF*, Spring 2003, pg. 24. ■

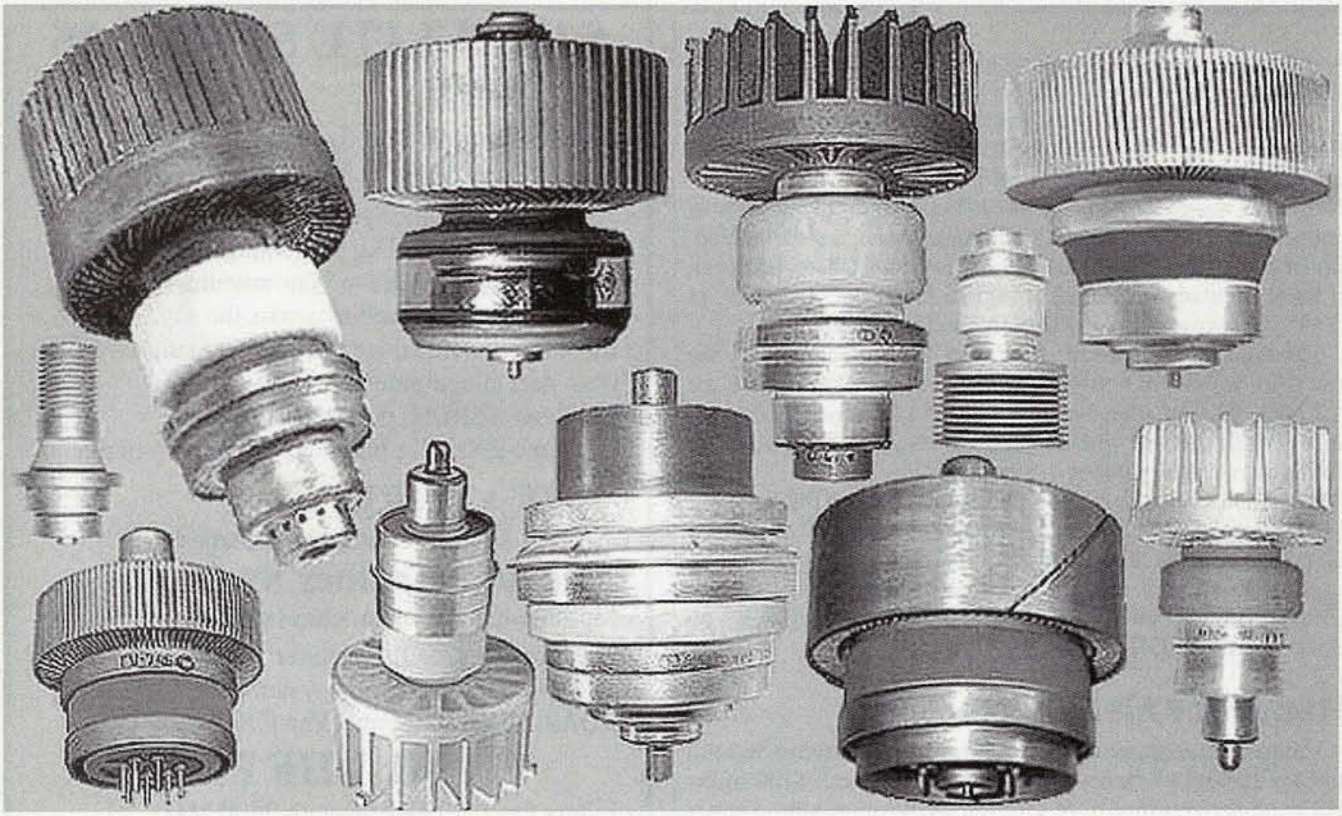

Photo 1. In today's amateur radio market Russian power tubes abound. Here is a sample of the many tubes covered in this two-part article.

Russian Power Tubes in Amateur Radio, Part I

In the aftermath of the fall of communism in the late 20th century, Russian tubes, in particular power transmitting tubes, literally flooded the amateur radio market. ND2X has spent considerable time researching many of these tubes and reports his findings.

By Paul Goble,* ND2X

A while back I had to replace the 8874 (3CX400A7) required for an ancient Alpha 76 HF linear. After a short time of checking prices, I quickly discovered the gap between the price tag and my budget. Still reeling from "sticker shock," I attended a Roadrunners Microwave Group (http://www.k5rmg.org/) meeting.

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At that meeting one of the guys did a "show and tell" on the Russian GI-7B "microwave triode" he had recently purchased for possible use in a PA on 23 cm. The performance claims were pretty impressive, and the cost in comparison to anything Eimac® was minimal. The trap was sprung, and I was irrevocably drawn into the world of Russian power tubes. Performance claims and reasonable cost notwithstanding, it became painfully obvious rather quickly that pitfalls and used-car salesmanship exist in the world of Russian tubes, the same as in all other aspects of life.

Having experienced some success, sort of, in falling (kicking and screaming) into the computer age, it seemed to me that searching the internet for information about Russian tubes—their application to amateur radio, and their availability—might be fruitful. The process was tortuous. Although a lot of information was available, it was scattered all over the internet, and figuring out what search criteria to use to find it was often a challenge.

In addition, websites, especially those originating from some of the former Soviet Union "bloc" countries, were prone to disappear. To prevent losing data, I began copying applicable web pages off the web onto the my PC hard drive.

In talking with others, it occurred to me that it would be neat if there could be a reliable site on which this information could be stored and available for posterity. It should be a site to which one could go to see as much information or internet links as avâilable on the subject. The site would also act as a library of information which might otherwise be volatile and disappear. Thus, the idea of a "clearing house and repository" for information regarding Russian tubes as they apply to amateur radio was born.

An early recommendation by Dr. Alex Gavva, MD, UR4LL, turned out to be solid gold. He is not only a very reliable source for reasonably priced tubes, but also a source of numerous other Russian electronic components. Most applicable to this subject, he provided pages from Russian tube manuals listing the specifications for the tubes that he had for sale.

Queries were sent to many hams around the world regarding information they had "published" on websites of their own. Also, they were asked about their involvement with PAs using Russian tubes, which had been mentioned in various e-mails, (e.g., on the AMPS reflector, etc.). Information began trickling in, including permission to replicate data that folks already had on their websites.

The result of all this effort is compiled in a "QRO Index" at <http://www.nd2x.net/base-1.html> in a series of tables. The index cross-references PAs, according to the Russian tube type used, with the callsign of the individual from whom the information originated. A URL to a site presenting one or more Russian-tube PAs not currently in the index is also included.

This venue of information has become so popular that it has come to the point where folks send me e-mails regarding data that also might be appropriate for listing in the QRO Index. These e-mails say things such as, "You've got to see *this*!" Other e-mails have comments concerning a PA they have that uses Russian tubes, asking if it would be desirable to list and present *their* Russian-tube PA information.

From the beginning I have been the beneficiary of information from some extraordinarily talented and knowledgeable hams from QTHs ranging from my home state of Texas, across the U.S., west to Japan, and east to eastern Europe. Even so, I continue to request information on Russian power tubes. If you have appropriate information, you may e-mail me via the e-mail address on the first page of this article.

The Nature of The Information Presented

All data in this article originated from the information gleaned from the internet and hams around the world. The information on the previously mentioned website is presented as received. I act as a reporter and facilitator of this information. Some of the PA descriptions are not complete, but the purpose of the website is to present what folks (worldwide) are doing with these tubes and to illustrate the possibilities. Even incomplete information can give examples of what can be done, pique curiosity, and provide direction for those interested.

I am not a vacuum-tube expert. Even so, one cannot spend several years gathering data on a given subject—even if much of it is anecdotal—and not learn a thing or two. Unfortunately, "a thing or two" is not all-inclusive. Therefore, the information does not cover all aspects of all tubes, not even for the relatively small subset of Russian tubes, which are tabulated on the "Russian Tube Data" page at <http://www.nd2x.net/tube-1.html>. It has, however, become semi-evident that even a little knowledge can often save a lot of "reinventing the wheel" and wasting of time!

General Information

The Russian tubes with which even I have had even the slightest contact (and some of the contact has been *very* slight) are listed at the "Russian Tube Data" page referenced above. They are (in order presented):

Triodes: GI-6B, GI-7B/7BT, GI-39B, GS-1B/2B, GS-9B, GS-31B, GS-35B, and GS-34.

Tetrodes: GS-3A, GS-15B, GS-23B, GS-36B, GU-43B, GU-74B, GU-78B, and GU-84B.

There are some generalities which, according to all available rumors, war stories, user anecdotes, and experience, apply to all the tubes listed above, starting with the simplistic statement that "GI" in the tube designator means the tube was designed for pulsed RF applications. Also, somewhat less simplistically:

1. Tube Ruggedness: The published specifications are quite conservative. There are all sorts of "war stories" about these tubes being run very successfully, over many months or years, at anode voltages well in excess of published maximums. The same applies for tetrode screen grid voltages. Heater voltages can often be run below stated values with no loss of emission. Amounts of "over/under" vary from tube to tube, but rumors of outstanding tube ruggedness abound across the board, and what one can "get away with" is empirical information.

2. Tube Specifications: Published specifications can vary from source to source. When asked about this inconsistency, more than one former Soviet bloc ham has stated that the specifications manuals were published under the Soviet system by folks without technical expertise of any kind, concerned only with number of pages created or printed. The manuals, therefore, contain many errors. This is the reason why some hams have empirically tested tubes they buy, including breaking them apart and studying tube interiors. The one specification that does *not* seem to track is the maximum frequency for a given tube. This specification, especially for triodes, appears very optimistic. For tetrodes, just the opposite, with operation above maximum specified frequency, was found to be possible in at least two cases.

3. Purchasing Tubes: Hams in Europe and former Soviet bloc countries generally are reliable sources for these tubes. Horror stories about U.S. hams losing money trying to purchase them from these sources are 99.9% bogus, although at least one source has promulgated such stories to convince people to pay high prices to buy from him here in the U.S. With as much communication as I have had with folks who have bought these tubes, not one verifiable story about ripoffs has surfaced. In fact, if problems are encountered, the stories are usually about a tube being damaged in shipment and how the supplier replaced the damaged item in short order based on just the word of the U.S. ham. It was not generally necessary to return the damaged item. Occasionally a tube will arrive DOA or gassy; replacement has never appeared to be an issue in this case either.

Most U.S. hams with questions about the purchase process have been concerned about how to make payment. While I would never use a credit card because of personal paranoia, proven

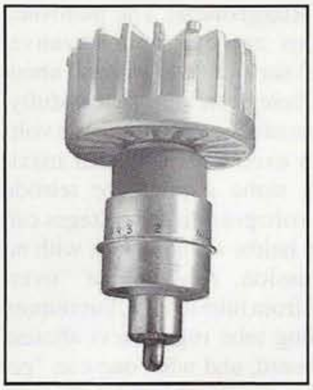


Photo 2. The GI6-B triode.

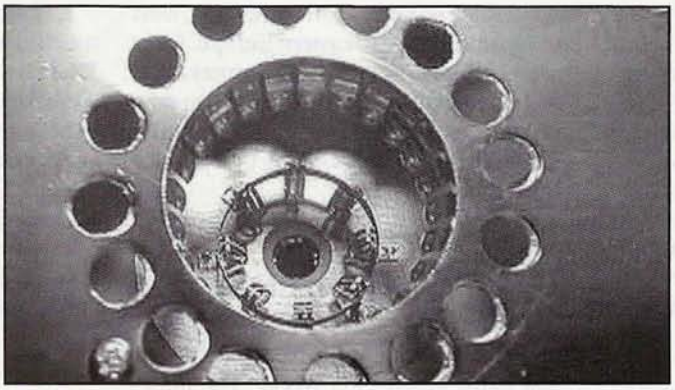


Photo 3. The GI6-B socket.

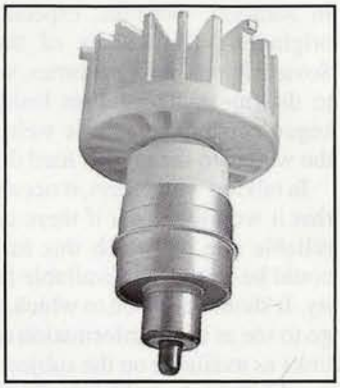


Photo 4. The GI7-B triode.

methods for paying for tubes bought from an overseas supplier include sending cash in U.S. dollars via registered mail, sending bank drafts in the selling ham's currency of choice, Western Union money transfer, paying for an item via eBay's methods, and using Pay Pal.

4. Triodes versus Tetrodes: Not one Russian triode from the list above has proven totally successful at frequencies above the 70-cm band because of thermal drift. Those tetrodes so rated, subject to a selection process for the GS-23B, have proven to be very solid performers at 33 cm and 23 cm. In addition, the triodes are subject to thermal drift at high duty cycles at 70 cm as well, especially if hi-Q tuned circuitry is used. I have been told that this is true for all triodes, independent of source or manufacture, "because triodes draw grid current," which in turn heats the grid and causes mechanical distortion, altering inter-electrode capacitances.

Whether true or not for all triodes ever manufactured, the fact is that for the Russian triodes tried at 33 cm and above (GI-7B, GS-9B, GS-34, GS-31B, and GS-35B), thermal drift makes it impossible to use them anywhere near their full power rating. It may be of interest to note that all these triodes are "in-line," with a screen structure forming the grid between the emitter at the bottom and the anode at the top. Only the GS-34 from this list has a planar grid; the remainder of these tubes have a dome-shaped screen structure forming the control grid.

The physically larger tetrodes on the list are of true coaxial construction, with concentric elements, while the small GS-15B has planar grid structures. Also, the anode air coolers for all triodes listed are removable, while none of the tetrodes has this feature.

5. NOS, Old Stock: It is not uncommon to encounter tubes manufactured as long ago as the early 1970s via the Russian surplus market. They have not been used, and they are termed "New Off the Shelf, from Old Stock," hence the opening words of this paragraph. Because of the nature of the physical materials, a certain amount of gas is always trapped inside the metals and ceramics, and so forth, that are used to construct each tube. While the tube is in storage, a certain amount of the gas trapped in its materials is "leached" into the vacuum of the tube. If one were to plug such a tube into a PA and apply all voltages plus drive, the small amount of gas within the tube would ionize and arc over, likely in a destructive manner. To prevent such destruction, it is necessary to put these tubes through the "gettering" process. A procedure is described at <http://www.nd2x.net/tube-prep.html>, which also links to the associated SM5BSZ page on the subject.

Tube Specifics

Having stated the above, there is tube-specific information gleaned by this author, either as empirical measurements or from specific experiences of hams around the world, regarding many of the tubes listed. This knowledge could impact one's plans to use or not use one of these tubes in a proposed PA project, and that information is given below. The tubes are presented in the order listed previously under the heading "General Information."

Triodes

GI-6B: The GI-6B triode (photo 2) is designed for use in microwave oscillator circuits with no external feedback, providing continuous-wave or pulsed operation with anode modulation in the decimetric wavelength range. The Germans originally developed this tube during WW II for self-oscillating radars. After the war the Russians copied it and the radar for which it was used. It was employed even as recently as the beginning of the 1970s. Reportedly, the original German tube designation for the LD6 or GI-6B was either LD11/GI11B or LD12/GI12B.

This particular tube is useless as an amplifier in the decimetric wavelength range because it has physical internal capacitive coupling—that is, there are three wires welded to the cathode going through holes in the grid and forming a capacitor to the anode. This feature was noted by someone who had broken one apart and actually seen the interior tube construction. As with most Russian power triodes, the heat sink on the GI-6B is removable. At $15 to $25 for NOS, old stock, it is easy to justify experimenting with this tube.

This triode is physically identical to and electrically *very* similar to the GI-7B triode. Internally, the grid is a dome-shaped screen located between the cathode in the bottom of the tube and the anode. The tube specifications listed at <http://www.tubes.ru/techinfo/TransmittingPulseTubes/gi-6b.html> are similar to those for the GI-7B listed at <http://www.tubes.ru/techinfo/TransmittingPulseTubes/gi-7b.html>, except the transfer and output capacitances are reversed. There are additional differences between the "tubes.ru" specs and those published in the Russian tube manual supplied to me (see <http://www.nd2x.net/gi6b.html>), and which one is correct is a matter for conjecture.

Application: The GI-6B is rated at 350 watts plate dissipation. It is being used quite successfully as an amplifier at HF and 6 meters. Some say it is useful at even as high as 70 cm. Three of them in par-

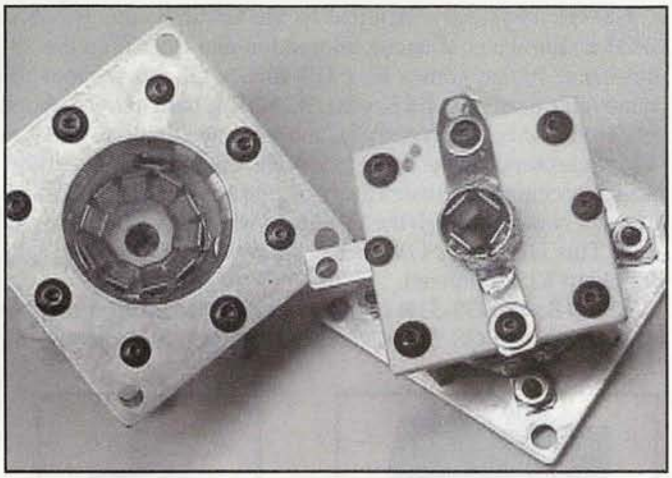


Photo 5. The W4EMF GI-7 socket.

allel at 6 meters (and below) should do full legal limit with 2500 VDC on the plates and on the order of 50 watts of drive. Like the GI-7B, one can expect about 400 watts output from one of these tubes at these frequencies with 15 to 20 watts of drive.

Very detailed instructions regarding construction of sockets for the GI-6B (photo 3) can be seen at <http://www.nd2x.net/jh0-1.html> as part of the instructions detailing construction of a 6-meter PA using three of these tubes in parallel. It is also a simple matter to make clamp connections to the contact surfaces, as shown for the GI-7B.

GI-7B and GI-7BT: Another copy of a WW II German tube design, the GI-7B triode (photo 4) is physically identical to the GI-6B above as noted, along with the GS-9B, which is documented later in this article. The GI-7B is electrically similar to the GI-6B, with specification anomalies as noted, without the internal feedback structures from the cathode to the anode through the same domed grid structure. It is historically one of the most commonly available and reasonably priced tubes on the surplus Russian tube market.

The two versions listed differ only slightly electrically, but the physical difference is evident. The GI-7BT (photo 4), which is designed to function and survive in the severe physical environment of a tank, is physically more rugged than the GI-7B and is rated 300 MHz higher, at 3300 MHz. It is apparently a slightly better performer than the "B." The air cooler is easily removed. This tube, NOS, old stock, is available for $20 to $30, delivered.

Although tube sockets exist for GI-7B series tubes, it is relatively simple to homebrew one, and even simpler to make clamp or fingerstock connections to the contact surfaces. In cavity-based PAs, of course, sockets are not applicable, but if one is required, any socket good for the GI-7B is good for the GI-6B and GS-9B as well.

Lawson Summerrow, W4EMF, has designed a nice homebrew version (photo 5), and occasionally Russian sockets can be found on the surplus market (photo 6). For 2 meters and above, it's probably best to mount the tube directly on the chassis (photo 7). W4EMF's socket details are available at <http://www.nd2x.net/gi7-socket.html>. The Russian sockets generally are used (removed from Russian military radio equipment), and doing a "GI-7B socket" search using your favorite internet search engine can identify sources. The direct-mount method shows a spring clip on the bottom, filament connection, although this could be a small screw clamp like the larger one shown on the filament-cathode connection just above.

Photo 6. The Russian GI-7 socket.

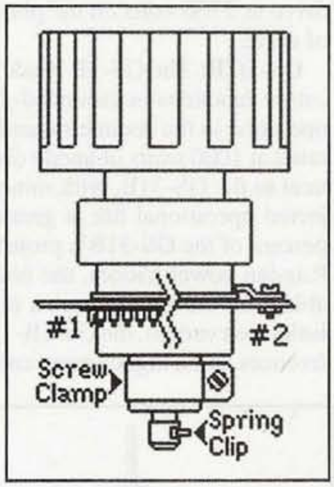


Photo 7. Drawing depicting how the GI-7 can be mounted directly to the chassis.

Two methods of direct chassis mount are depicted, with the first using fingerstock (the method shown at <http://www.nd2x.net/jh0-1.html>) and the second using a small clamp, four to six of which would be arranged around the tube, clamping it to the chassis using the ridge around the grid contact ring.

Application: The GI-7B series tubes are rated at 350 watts of anode dissipation. They are in use from HF through 23-cm amateur bands. Full, 400-watts-per-tube output can be expected through 2 meters and probably 125 cm as well without thermal-drift detuning problems. There have been a few reports of thermal drift at 70 cm when running at full ratings. However, cutting per-tube output power (decreasing drive) to 300-plus watts and using low-duty-cycle modulation (SSB is around 12 percent, unprocessed) ameliorates the problem.

At 23 cm one should not expect more than 250 watts out, under best conditions, without severe thermal detuning. Even with outstanding cooling, higher powers result in severe thermal-drift problems. The most forgiving (air) cooled design is from OK1KIR, since it uses a 1/4-wavelength anode cavity, which is quite broadbanded compared to the 3/4-wavelength cavities normally used. Even so, the extensive additional grid-cooling measures used in the OK1KIR design do not solve the thermal-drift problems. As Andreas Broeker, DL6YEH, points out, the grid was designed for radar pulse applications and "*not for linear modes!*" This is because of internal construction, which limits the ability of the grid to transfer heat to the large grid contact ring on the outside of the tube. In addition, the OK1KIR design will not accept the GI-7BT due to physical limitations imposed by internal cavity dimensions.

Water-cooling does not improve thermal performance of this tube!! I have seen drawings and heard rumors of multi-tube GI-7B 23-cm PAs, but no documentation showing them has surfaced. The only documented, successful multi-tube 23-cm PA is one by Marcelo Franco, N2UO, which is actually two single-tube PAs with outputs added through a hybrid combiner (see <http://www.nd2x.net/N2UO.html>).

GI-39B: This tube was recommended to me recently by OK1VPZ. It is rated to 1200 MHz at 440 watts plate dissipation. It is a direct replacement for the older (discontinued) GI-14b. Also, it can be used to replace the GS-1B and GS-31B for amateur applications. OK1VPZ reports his 2 x GI-14B 70-cm PA delivers 900 watts output with 40 watts of drive at 2700 volts on the plate, and 1200 watts with 60 watts of drive.

GS-1/2B: The GS-1B triode fulfills generation and amplification functions in grounded-grid circuits in continuous-wave operation in the decimetric and metric wavelength ranges. It is rated at 1000 watts of anode dissipation and is physically identical to the GS-31B, with minor electrical differences. Its projected operational life is greater than 250 hours, which is 25 percent of the GS-31B's projected 1000+ hours. As with most Russian power triodes, the heat sink on the GS-1B is removable. The GS-1B, without a radiator, is designated GS-2B. A little-seen variant, the GS-1B-1, exists, with minor physical differences and a higher input capacitance than the GS-1B.

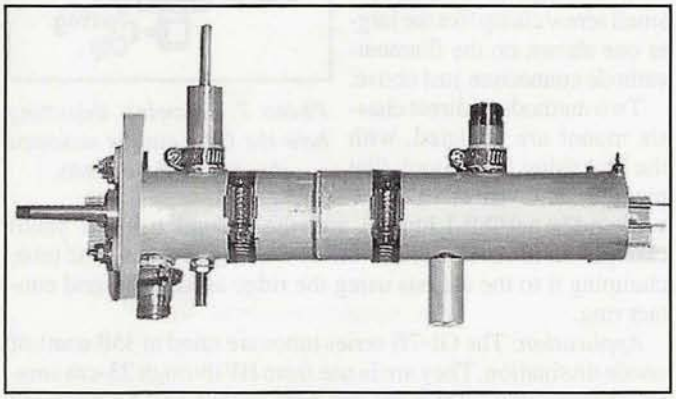


Photo 8. A K9EK-designed cavity for the GS-9B.

GS-9B: Physically identical to the GI-6/7B, this triode is rated at 300 watts of anode dissipation and is used on the 13-cm band. It also comes as a GS-90B, a GS-9B without the removable air cooler. Ed Krome, Jr., K9EK, built a cavity-tuned PA around this tube (photo 8), and it is capable of as much as 140 watts output at low duty cycles. The GS-90B grid-ring ridge is visibly centered between the two large hose clamps; the anode is water cooled through the fittings shown at the left of the picture. This is the only GS-9B PA known to me. The tube sells for about $25, delivered.

GS-31B: The GS-31B triode (photo 9) is a "little brother" to the powerhouse GS-35B (described later on). Its projected life

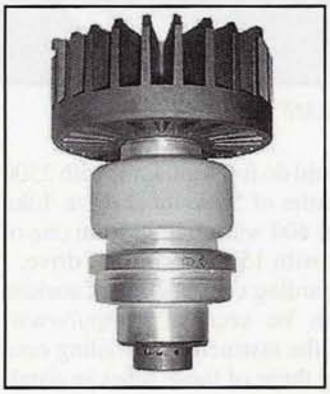


Photo 9. The GS-31B tube.

Photo 10. The GS-31 tube with the anode cooler removed.

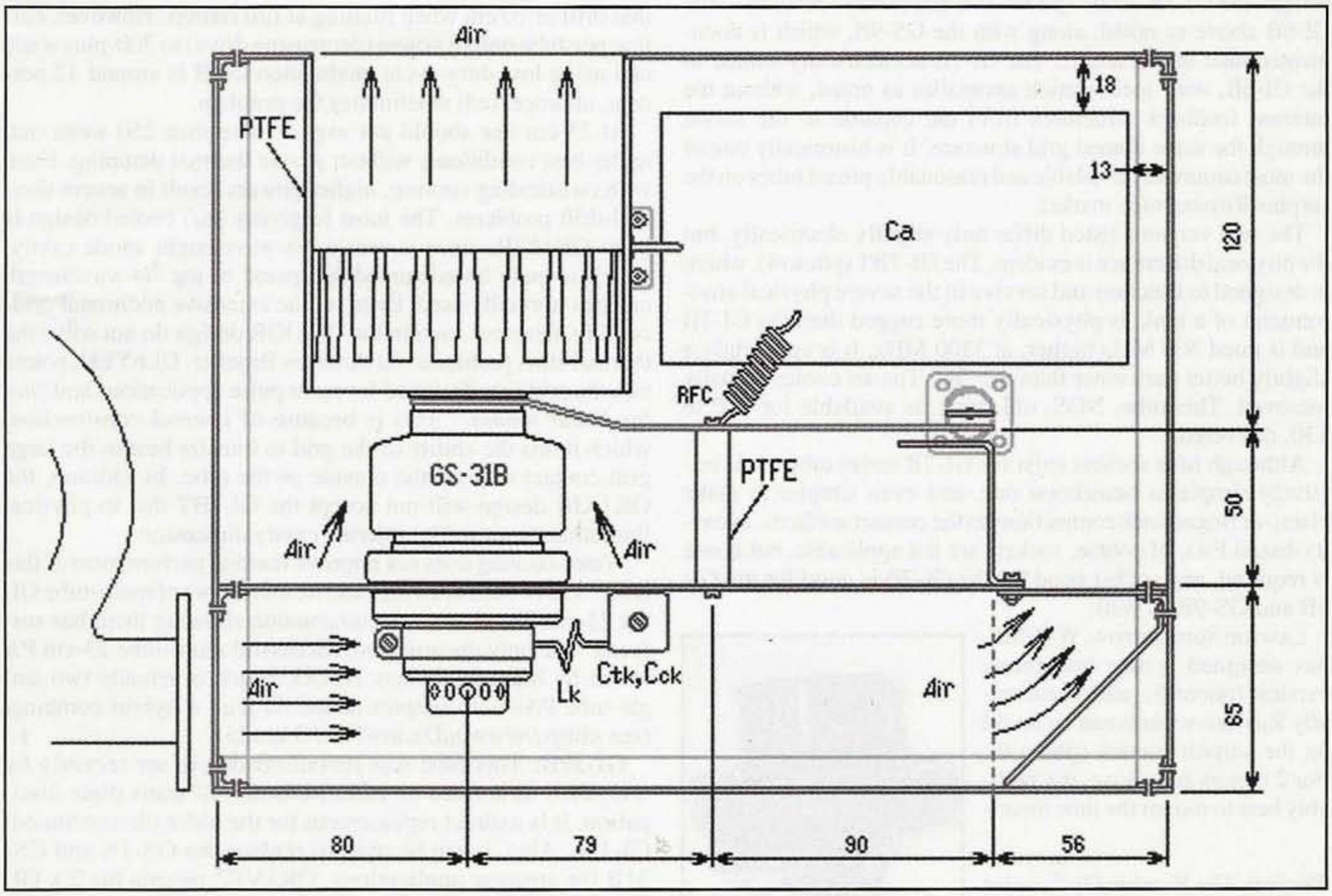


Photo 11. The cooling scheme used by YU1AW.

is greater than 1000 hours. The anode cooler, which sits atop the external anode structure, is removable (photo 10). This tube is available for $60 to $70, delivered, NOS, old stock.

Application: The GS-31B triode is rated at 1000 watts of anode dissipation through 1000 MHz and will deliver 1200 watts easily at HF and through 70 cm with 2500 volts on the plate and 40 to 50 watts of drive. It will likely do 1500 watts through 2 meters with the full 3000 volts maximum rated anode voltage, or slightly more (with proper attention to cooling). The cooling scheme used by YU1AW (photo 11) shows air first passing over the filament-cathode connections before passing into the anode compartment and out through the anode cooler. This meets cooling requirements of approximately 2 CFM for the cathode and approximately 11 CFM for the grid. The YU1AW scheme cools the area below the tube mounting deck in which the tube is directly mounted (see PA side-view drawing; the complete PA design is at <http://www.nd2x.net/yu1aw-432. html>). At least one design for a 23-cm GS-31B PA exists, but thermal-drift problems identical to those experienced with the GI-7B make the effort to build this PA of questionable value.

As stated, no Russian triode that has been tried has performed to specification at wavelengths shorter than 70 cm. Internal capacitance changes, caused by mechanical distortion of grids because of thermal effects, detune these PAs well beyond outside acceptable limits.

GS-35B: The GS-35B triode powerhouse (photo 12) is very commonly available on the Russian tube market. It's just shy of 7 inches tall, and the removable, 10-cm diameter (3.9-inch), all-copper anode cooler alone weighs on the order of 4 pounds. The external anode structure fits up into the center cooler cylinder and provides more contact area for cooling than the GS-31B. In the past it could be found for as little as $50 plus shipping, but the most common price is $100, delivered, NOS, old stock.

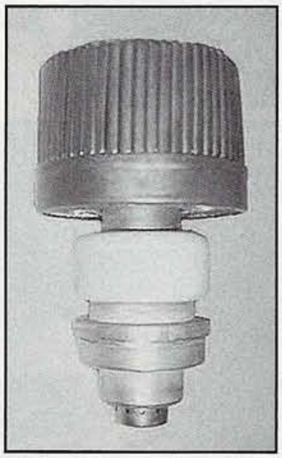


Photo 12. The GS-35B tube.

Application: The GS-35B triode is rated at 1500 watts of anode dissipation, 2000 watts if water-cooled (see the article by DJ5RE in *DUBUS* 2/1999 for an effective water cooler), through 1000 MHz. GS-35B PAs have been designed and built for amateur bands from 160 meters through 23 cm (with the exception of the 33-cm band). Results have been outstanding for all HF and VHF bands. At HF, a grounded-grid GS-35B PA cathode, with properly tuned and loaded anode, presents a good approximation of 50 ohms without tuning circuitry at the input. The 3000 volts maximum specified plate voltage is often exceeded in practice.

While obviously illegal according to U.S. FCC regulations for the Amateur Radio Service, one documented 2-meter PA measures 4000 watts output with 4500 volts at 1.25 amps on the anode and 200 watts of drive; this same PA does 3000 watts out with 150 watts of drive. At 70 cm, with 4500 volts at 1 amp on the anode and 150 watts of drive, a similar PA measures 2500 watts output. Tables of empirically gathered operational parameters for the two 4500 volts of plate voltage PAs mentioned above, and other GS-35B amplifiers used on 6 meters, 2 meters, and 70 cm, can be seen at <http://www.nd2x.net/tube-ops.html>. Air-cooling requirements are specified for the GS-35B at 150 M^3/hr (88.3 CFM) for the anode, 3 M^3/hr (1.8 CFM) for the cathode, and 18 M^3/hr (10.6 CFM) for the grid. If operating the GS-35B above specification—e.g., such as above, with 4500 volts on the plate—cooling requirements increase. At full legal limit on the 70-cm band, thermal detuning of the PA can occur in hi-Q circuits, even with *good* cooling, if duty cycles significantly exceed that of SSB.

Many GS-35B users have reported that this tube "likes grid current." Internal inter-element capacitance changes under operating conditions would seem to belie this assertion. The large, dome-shaped screen forming the grid structure distorts when it gets hot! To illustrate, a 23-cm PA design exists for this tube, but four separate attempts to replicate it, two in Europe and two here in the U.S., have failed to achieve designers' claims of 1000 watts plus, with no thermal drift. Output appears to be limited to 600 watts with thermal detuning effects, even with the anode water-cooled and plenty of air on the cathode and grid.

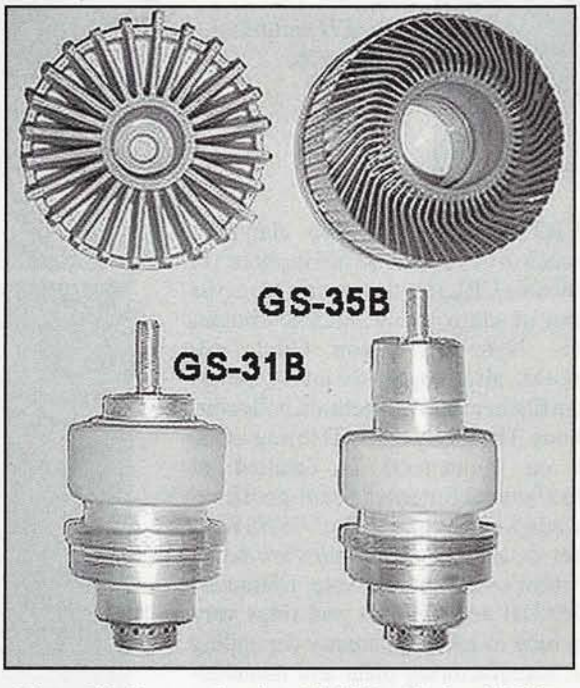


Photo 13. Comparing the GS-31B with the GS-35B.

GS-31B/35B Comparison: The difference between the GS-31B and GS-35B triodes is primarily in the cooling (photo 13). The anode structure is different for each, and the coolers reflect these differences.

GS-31B/35B "Sockets": Since the GS-35B is physically identical to the GS-31B from the ceramic structure down to the filament connection, all mounting considerations good for one will work for the other. Sockets useful for HF PAs are made for this tube by at least one ham, Tom Adams, WB8WJU. However, direct chassis mount is the method normally employed. One may purchase or machine a mounting block. As an alternative, one may clamp the grid ring directly to the chassis, as has been done by Geoff Brown, GJ4ICD.

The WB8WJU socket, suitable for use at HF, is shown in photo 14 with a GS-35 installed. Mounting-block examples are shown as follows: DL6YEH (photo 15), G4HBA (photo 16),

Photo 14. The GS-35B tube in its socket.

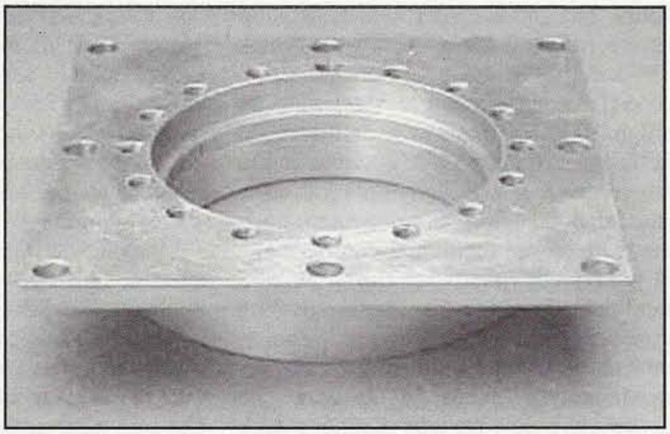


Photo 16. The G4HBA mounting block for the GS-35B.

Photo 15. The DL6YEH mounting block for the GS-35B.

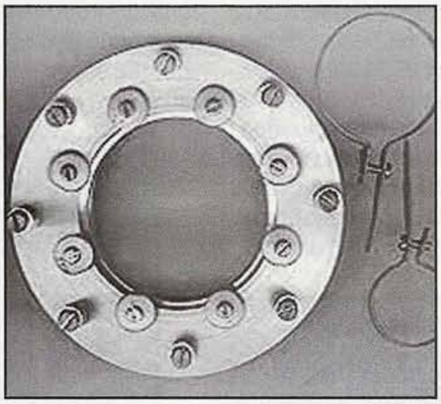
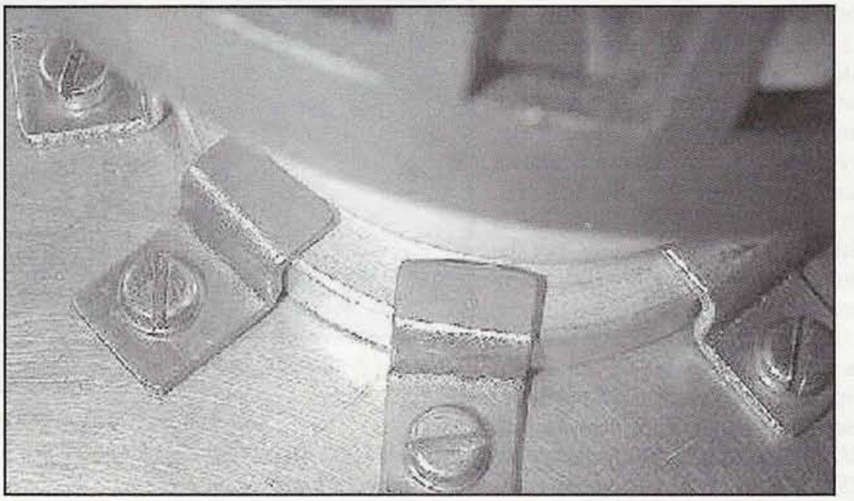


Photo 17. The OZ1GOK mounting block for the GS-35B.

Photo 18. The clamping approach of GJ4ICD for the GS-35B. ↓



OZ1GOK (photo 17). The clamping approach of GJ4ICD is shown in photo 18. Applicable URLs for the mounts are at the bottom of <http://www.nd2x.net/mount.html>. Note that Egon Gjerlufsen, OZ1GOK, also supplies the screw clamps for the filament and filament-cathode connections. The PA by GJ4ICD (using a GS-31B on 6 meters) is detailed at <http://www.btinternet.com/~geoffrey.brown3/gs31b.html>. The WB8WJU socket details are at <http://www.nd2x.net/wb8wju-soc.html>. Note: Diameters of GS-31B and GS-35B grid rings vary from tube to tube, apparently depending upon manufacturing plant and manufacturing run. Care must be taken to ensure proper fit when using or manufacturing mounting blocks for these triodes.

GS-34: The GS-34 planar triode is a newer Russian design, significantly smaller at 67 mm (2.6 inches) tall, compared to 110.5 mm (4.4 inches), than the older GI-6/7B copies of German technology, even though it is rated at the same 350 watts of anode dissipation. Photo 19 shows the GS-34 without the cooler. Photo 20 shows the GS-34-1 with a 50-mm diameter transverse air cooler. There is also a GS-34-2 (not pictured), which sports a cooler only 25 mm in diameter. Tube life is designed to be more than 1500 hours.

While no known socket exists, contact surfaces are the same as those on the GS-15B tetrode, which is documented below (minus the extra grid contact), and dimensions for connectors can be found in the construction details for a 23-cm GS-15B PA design at <http://www.nd2x.net/kd5fzx-gs15-1.html>. It has been available for as little as $20 and as much as $35.

Like most Russian triodes, the anode cooler is easily removed. The air cooler attachment hardware on top of the GS-34 disassembles completely; even the cooler mounting stud comes off. Loosening the round "nut" allows removal of the pin inserted through the hole in the anode cylinder and the head of the mounting stud, after which the entire hardware structure simply falls out of the anode cylinder!

Application: The GS-34 is rated at 350 watts of anode dissipation and demonstrates 16 dB gain at 33 cm, but like all of its triode cousins, it is still prone to internal capacitance changes because of thermal effects. John Berker, N8OU, and Mats Bengtsson, KD5FZX, tested this tube in 23-cm and 33-cm PAs, respectively, with virtually identical results. Thermal drift proved to be unacceptable and incurable in both, and water cooling

Photo 19. The GS-34 tube.

Photo 20. The GS-34-1 tube with a 50-mm transverse air cooler.

the anode did not diminish the problem. Capable of 500 watts output at these frequencies (measured), the GS-34 cannot maintain it without detuning, except perhaps at very low duty cycles, even if care is taken to stay well below specified dissipation levels. By reducing plate voltage, decreasing drive, and limiting output to about 200 watts, it can be used above 70 cm. The 33-cm test PA and characterization of the detuning problem are chronicled at <http://www.nd2x.net/kd5fzx-gs34.html>. The GS-34 has not been tried at lower frequencies, but all indications are that it should outperform the GI-7B in every application for which the GI-7B has proven successful. Electrically, it can be substituted for the GI-6/7B and result in a PA of 4+ dB higher gain and approximately 20 percent higher output power!

In the next issue of *CQ VHF* we will cover tetrodes. ■

By Neil Sablatzky,* K8IT

HSMM

Communicating Voice, Video, and Data with Amateur Radio

Is All Data Acceptable Data?

If I sent a data packet from my computer to yours via a legally identified transmission according to the Amateur Radio FCC Part 97 rules and regulations, would the data packet be legal? This column will explore this question and many related issues. First let's start by reading a letter.

Correspondence

The following was sent to me by Ken Patterson, N5EQT:

While on the way home from Ham-Com 2003, my sons (Aaron, KC5TEF, age 19; Joshua, KC5TEG, age 18; and Michael, KC5TEH, age 20) and I discussed Gerry Creager, N5JXS's HSMM presentation and came up with an interesting idea. During the presentation, Gerry mentioned that interactive games could be one use of HSMM. My sons and I think this application could give HSMM and amateur radio in general a real boost in interest and activity. Let me explain.

Players of multiplayer and First Person Shooter (FPS) games such as CounterStrike <http://www.counter-strike.net> and EverQuest <http://everquest.station.sony. com> desire the lowest transmission latency (pings) possible. Currently, cable-modem and DSL users have a 25- to 30-millisecond ping. If the same multiplayer games were played via HSMM, the pings would drop to about 6 milliseconds. This reduction in latency is very significant. It could easily make the difference in a player's ability to win.

A ping is a command that initiates an Internet Control Message Protocol (ICMP) Echo Request and Echo Reply message. These messages must travel to their destination and return to their sender, where the time required for the round-trip is measured by the originating sender. Think of an Internet ping much like the sonar pings used for decades by submarine crews to measure objects within their path.

Low pings are good. High pings are bad.

When a person is playing over the Internet using a client/server-based system, data flows from the server to the individual client (user). Anything the client does has to register with the server before it can happen in-game. For instance, if player A and player B in a First Person Shooter game were to fire at each other at the same time, the player with the lowest ping would hit the target first simply because that player's data registered with the server first. As you can tell, this is an obvious advantage in a game. The difference between winning and losing a game can come down to which player fired—or whose data actually reached the server—first.

Multiplayer games such as CounterStrike utilize User Datagram Protocol (UDP) transmissions. This protocol is a connectionless IP datagram service that guarantees neither delivery nor correct sequencing of delivered packets. The use of UDP by games such as CounterStrike is verified every time the user joins a CounterStrike server to play a game. UDP transmissions are most commonly used by streaming multi-media services, such as Microsoft's NetMeeting.

It would seem to me that the ARRL would be interested in pursuing an alliance with one of the top multiplayer manufacturers. This alliance would have the goal of incorporating HSMM into an existing game or a new game. The ARRL's role would be to promote the education of this new breed of amateur radio operators.

I have not quite worked out the logistics nor the pros and cons of such an alliance. Perhaps there is a list of problems larger than even I realize. However, I believe such a proposal is deserving of a public discussion by the amateur community. *—N5EQT*

First I would like to thank Ken for submitting this letter with such an interesting concept. Ken has a key point in that many gamers go to great expense simply to win. It's "speed." The fastest response to a command in an interactive game typically will prevail. However, is sending such data packets over an amateur link legal?

§97.309 RTTY and Data Emission Codes

(a) Where authorized by §97.305(c) and 97.307(f) of this Part of the FCC Rules, an amateur station may transmit an RTTY or data emission using the following specified digital codes:

(1) The 5-unit, start-stop, International Telegraph Alphabet No. 2, code defined in International Telegraph and Telephone Consultative Committee Recommendation F.1, Division C (commonly known as Baudot).

(2) The 7-unit code, specified in International Radio Consultative Committee Recommendation CCIR 476-2 (1978), 476-3 (1982), 476-4 (1986), or 625 (1986) (commonly known as AMTOR).

(3) The 7-unit code defined in American National Standards Institute X3.4-1977 or International Alphabet No. 5 defined in International Telegraph and Telephone Consultative Committee Recommendation T.50 or in International Organization for Standardization, International Standard ISO 646 (1983), and extensions as provided for in CCITT Recommendation T.61 (Malaga-Torremolinos, 1984) (commonly known as ASCII).

(4) An amateur station transmitting an RTTY or data emission using a digital code specified in this paragraph may use any technique whose technical characteristics have been documented publicly, such as CLOVER, G-TOR, or PacTOR, for the purpose of facilitating communications.

(b) Where authorized by §§97.305(c) and 97.307(f) of this Part, a station may transmit an RTTY or data emission using an unspecified digital code, except to a station in a country with which the United States does not have an agreement permitting the code to be used. RTTY and data emissions using unspecified digital codes must not be transmitted for the purpose of obscuring the meaning of any communication. When deemed necessary by an EIC to assure compliance with the FCC Rules, a station must:

(1) Cease the transmission using the unspecified digital code;

(2) Restrict transmissions of any digital code to the extent instructed;

(3) Maintain a record, convertible to the original information, of all digital communications transmitted.

*e-mail: <k8it@arrl.net>

HSMM Trivia Q&A

The following question, submitted by Darryl Smith, VK2TDS, was posed in the Summer 2003 issue of *CQ VHF:*

There is an antenna that performed the worst in our tests. What is the name of that antenna, and which company made the chips container for it?

Answer: The Pringles® Can Antenna, Pringles Potato Chips.

Shown here is a picture from the WI-Sys Communications Inc. website, <http:// www. wi-sys.com>, showing a correctly engineered 2.4-GHz RF antenna which resembles a Pringle® Can Antenna. However, this antenna works!

Features

- VSWR 1.5 max.
- 8 dBi gain
- Linear polarization
- SMA female connector
- 9 inch length
- Standard 1/4-20 thread insert
- Optional tripod and clamp available

I suppose the question here is whether we have obscured the meaning of any communication and if the data code has been specified publicly. Well, it is true that all the data bytes transmitted are represented in binary format. The meaning of each binary byte can be found on multiple "gamer" Internet web pages. Therefore, we can say that the format of the data can be decoded based on available public information. However, have we obscured the meaning of the data? I think the intent of "obscure" comes to play here. Instead of transmitting a long ASCII command such as "FIRE PLAYER #1 GUN," we have transmitted, say, a single byte of binary data that carries the same meaning. The definition can be found on a website, and we did not purposely try to mislead or hide the intent of the data. In fact, we used a form of compression which facilitates data exchange. This maximizes the use of the frequency by sending the smallest amount of data possible and is legal under the rules.

In summary, keep a log of your activity, making sure you maintain in your log book a printout of the data bytes and their meaning, the websites where such data was obtained, the time, the frequency, the mode, and the station playing such games, etc. It's always safer to be documented.

I do have one caution: If you cannot find a respectable public website that states the game format data stream to be transmitted and each data byte's meaning, do not play this game over the amateur link. Why? Because the meaning of the data cannot be defined per the rules.

This brings up another question. If the data stream represented financial data and the binary bytes could be documented, would the data be legal on a Part 97 link? Each data byte would meet the test by itself. However, the intent is what matters. Amateur radio regulations specifically exclude any communication in any form for the purpose of making money.

Network Architecture

It has come to my attention that we need to invent a way to route data packets in a worldwide network. Some proposals have suggested using the 44.XXX.XXX.XXX block of IP addresses. This has a number of issues, the biggest being the FCC does not issue an IP address with an associated callsign. In fact, the FCC requires the callsign to be used. How do we route traffic from K8IT to W1ABC? Another issue we have is configurable routing, based on changes of nodes and band conditions. We need some kind of smart configurable routing that does not broadcast to every possible node to locate a blind station. If any reader has a suggestion or a desire to submit a paper to address this need, please e-mail your thoughts to me.

Please keep in mind that as our amateur ranks tighten our associations with emergency management agencies, the need for this network routing will increase dramatically.

In other considerations, the ARRL TTF HSMM Working Group is investigating the type of medium that such a network will use. Current proposals being evaluated include a satellite link and high-speed, low-frequency networks. Other possibilities include a series of linked 6-meter nodes.

73, de Neil, K8IT

Moondata Update 2004 and Related Comments

One of the most important factors in EME communications is knowing when it is best to communicate via moonbounce. W5LUU presents a summary and table of the best and worst conditions for EME in 2004.

By Derwin King,* W5LUU

While a number of factors affect EME communications, the distance from the Earth to the Moon and the cosmic noise temperature in the direction of the Moon are predictable, cyclical variables that set the basic day-to-day quality of the Earth-Moon path. Other things being equal, best EME conditions occur when the Moon is: (1) at the best possible perigee and (2) near the RA and DEC (see definitions below) of the coldest sky along its path. Signal-to-noise degradation (DGRD) from these two variables, in dB referenced to the best possible conditions, are tabulated in the accompanying table, along with other pertinent data. These are for each Sunday at 0000 UTC to provide a guide to the 144-MHz and 432-MHz weekend conditions in 2004.

In 2004 the average DGRD continues to increase as Moon perigee occurs at increasing RA and at southern declinations where the sky noise (temperature) is generally higher. Moon apogee occurs at northern declinations. This trend will continue for the next two to three years as the average position of perigee moves ~2.7 hours RA per year along its nine-year cycle. DGRD will again be very low for several days each month in 2007–2010 as perigee occurs within a few hours RA of cold sky.

Meanwhile, don't give up. While there are *no* **Excellent** or **Very Good** days in 2004, many days are rated **Good** with DGRD of 1.8 to 2.5 dB. Early in the year the **Good** days occur at moderate, north declinations, but in the last few months several are at southern declinations with RA of 21–24 hours. Two or three weekends with north declinations are potentially usable for the ARRL contest, but for all, EME will be mostly a daylight operation. These dates are: September 11–12, October 9–10, and November 6–7. Also, September 25–26, October 23–24, and November 20–21 have **Good** conditions and the Moon at night. September 25–26 allows EME from most of Europe to VK and ZL (for a short period), but not for as many hours as for any of the three north declination dates. Good luck and enjoy!

The following are definitions of terms used in the accompanying table:

DEC (deg): This is the Moon declination in degrees north and south (–) of the equator. This is cyclical with an average period of 27.212221 days. The maximum declination during a monthly cycle is also cyclic, with a range of 18.15 to 28.72 degrees and a period of about 19 years. The next maximum is in September 2006.

RA (hrs): Right ascension in hours. This is the east-west position of the Moon against the sky background. The average period of RA cycle is 27.321662 days, but it can vary by a day or so.

144 MHz Temp (K): This is the 144- MHz cosmic noise in the direction of Moon, expressed as absolute temperature.

Range Factor (dBr): This is the additional EME path loss, in dB, due to the Earth-Moon separation distance being greater than absolute minimum (348,030 km surface-to-surface). It varies from 0 to 0 .7 dB at perigee to 2.33 dB ±0.1 dB at apogee.

DGRD (dB): This is the degradation in EME signal-to-noise, in dB, due to: (1) the excess sky-noise temperature, in dB, at the listed position of the Moon compared to the lowest cold sky temperature and the system-noise temperature (all at the frequency of interest); plus (2) the Earth–Moon range factor, dBr, for the listed time and date. The tabulated DGRD is referenced to the lowest possible sky-noise temperature along the Moon path, to a system-noise temperature of 80°K at 144 MHz and 60°K at 432 MHz, an antenna beam width of ~15 degrees, and to the absolute minimum Earth-Moon (surface-to-surface) distance. The dBr affects DGRD equally at 144 MHz and 432 MHz. but at 432 MHz the sky-noise effects are lower. During a monthly lunar cycle DGRD can vary up to13 dB on 144 MHz and 8 dB on 432 MHz. DGRD varies less with small antennas than with large ones.

Moon Phase: This shows New Moon (NM) and Full Moon (FM) along with the number of days (d) or hours (h) before (–) or after (+) these events. At NM the Sun noise is a problem, while at FM the nighttime conditions are usually more stable.

Conditions: This is the summary of EME conditions as controlled by DGRD at 144 MHz and NM. Conditions may be worse, due to ionospheric disturbances, but not better than indicated. In general, 144-MHz DGRD under 1.0 dB is considered **Excellent**, 1.0 to 1.5 is **Very Good**, 1.5 to 2.5 is **Good**, 2.5 to 4.0 is **Moderate**, 4.0 to 5.5 is **Poor**, and over 5.5 is **Very Poor**. High Sun noise at NM can make conditions very poor, irrespective of the DGRD.

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The information and accompanying table are printed here in CQ VHF *on a non-exclusive basis courtesy of Derwin King, W5LUU.*

W5LUU Weekend Moondata for 2004
For Sundays at 0000 UTC

2004	DEC (deg)	RA (hrs.)	144 MHz Temp (°K)	Range Factor (dBr)	DGRD (dB) 144 MHz	DGRD (dB) 432 MHz	Moon Phase	Conditions
Jan. 04	22.0	4.0	369	2.31	4.9	3.0	FM –3.6 d	Poor
11	16.7	10.2	191	1.64	2.1	1.7		**GOOD**
18	–22.4	16.2	561	0.44	4.6	1.5		Poor
25	–9.9	23.2	244	1.18	2.4	1.5	NM + 3 d	**GOOD**
Feb. 01	24.2	4.6	436	2.21	5.5	3.2		Poor
08	12.8	10.8	205	1.40	2.0	1.5	FM + 1.6 d	**GOOD**
15	–25.0	16.9	819	0.63	6.3	2.2		Very Poor
22	–6.4	23.7	247	1.29	2.5	1.7	NM +1.3 d	GOOD (but NM)
29	25.9	5.2	487	2.24	5.9	3.3		Very Poor
Mar. 07	8.3	11.3	226	1.13	2.1	1.3	FM + 1 h	**GOOD**
14	–26.9	17.7	2319	0.70	10.6	4.4		Very Poor
21	–2.5	0.2	258	1.51	2.9	1.9	NM + 1 h	Moderate (but NM)
28	27.1	5.8	507	2.25	6.0	3.5		Very Poor
Apr. 04	5.2	11.8	252	0.93	2.2	1.2	FM – 1.5 d	**GOOD**
11	–27.6	18.5	2091	0.63	10.1	4.9		Very Poor
18	1.6	0.7	275	1.74	3.3	2.2	NM – 1.5 d	Moderate (but NM)
25	27.6	6.4	435	2.28	5.5	3.3		Poor
May 02	1.5	12.3	292	0.84	2.6	1.3	FM – 2.8 d	Moderate
09	–27.2	19.2	749	0.47	5.8	2.5		Very Poor
16	5.9	1.3	290	1.92	3.7	2.4		Moderate
23	27.4	7.0	363	2.30	4.9	3.0	NM + 3.4 d	Poor
30	–2.3	12.8	313	0.87	2.9	1.4		Moderate
Jun. 06	–25.9	19.9	425	0.32	3.4	1.2	FM + 2.8 d	Moderate
13	10.2	1.8	313	2.01	4.1	2.6		Poor
20	26.4	7.7	272	2.28	3.8	2.7	NM + 2.2 d	Moderate
27	–6.5	13.3	319	0.95	3.1	1.4		Moderate
July 04	–24.1	20.5	339	0.29	2.6	0.8	FM + 1.5 d	Moderate
11	14.2	2.4	349	2.03	4.4	2.6		Poor
18	24.7	8.6	200	2.18	2.8	2.3	NM + 3.5 h	Moderate (but NM)
25	–11.1	13.4	343	1.04	3.4	1.5		Moderate
Aug. 01	–21.8	21.1	334	0.33	2.6	0.9	FM + 6 h	Moderate
08	17.8	2.9	364	2.00	4.6	2.6		Poor
15	22.4	9.0	167	2.04	2.0	2.0	NM – 1 d	GOOD (but NM)
22	–15.7	14.7	387	0.99	3.8	1.7		Moderate
29	–19.1	21.7	324	0.54	2.7	1.1	FM – 1 d	Moderate
Sept. 05	20.8	3.5	358	1.98	4.6	2.6		Poor
12	19.9	9.5	183	1.89	2.2	1.9	NM – 2.6 d	**GOOD**
19	–19.8	15.2	435	0.85	4.1	1.7		Poor
26	–15.6	22.3	258	0.82	2.2	1.2	FM – 2.5 d	**GOOD**
Oct. 03	23.3	4.0	366	2.02	4.6	2.7		Poor
10	17.1	10.1	188	1.80	2.2	1.8		**GOOD**
17	–23.1	15.9	510	0.60	4.4	1.6	NM + 2.9 d	Poor
24	–11.4	22.9	244	1.08	2.3	1.4		**GOOD**
31	25.3	4.6	417	2.10	5.2	2.9	FM + 2.9 d	Poor
Nov. 07	13.9	10.5	201	1.78	2.4	1.9		**GOOD**
14	–25.4	16.6	728	0.32	5.5	1.7	NM + 1.4 d	Poor & NM
21	–6.6	23.6	245	1.23	2.4	1.6		**GOOD**
28	26.8	5.2	481	2.21	5.8	3.3	FM + 1.2 d	Very Poor
Dec. 05	10.4	11.0	211	1.84	2.6	2.0		Moderate
12	–26.8	17.2	1311	0.13	7.7	2.5	NM – 0.5 h	Very Poor & NM
19	–1.8	0.1	257	1.25	2.6	1.7		Moderate
26	27.7	5.8	504	2.30	6.1	3.6	FM – 15 h	Very Poor

By Tom Webb,* WA9AFM

SATELLITES

Artificially Propagating Signals Through Space

Moving Your Antennas

Once the satellite rig is in place, the antennas are in the air, the tracking software is installed, and the current Keps loaded, you are now ready to work satellite—well, almost. Remember that those satellites are moving targets, and we have to follow their paths across the sky with our antenna array mounted on our azimuth/elevation rotors, a.k.a. az/el rotors. A variety of ways exist to control rotor systems, ranging from the good old "Armstrong" method to highly sophisticated computer-controlled interfaces, which also adjust your satellite rig to compensate for Doppler shift. Let's examine our options.

Armstrong

You may know this type of rotator as the "Field Day rotor," i.e., turning the antenna literally by hand (or tag line). For aiming satellite antennas, hand support and aiming are feasible because of the small size of the antennas. With the AO-40 satellite appearing in the sky at the same point every 48 hours, a fixed directional antenna is a valid option. However, if you plan to track a "fast mover," you are going to need help. For several Field Days I've enlisted the aid of "biped, carbon-based antenna supports" (two people who were willing to hold antennas), and another person with an accurate watch and listing of the azimuth, elevation, and timing of the satellite pass.

The human "controller" gave azimuth and elevation instructions to the human "rotors," who in turn pointed the antennas. This is a crude methodology, but it gets the job done.

Manual Rotor Operation

"BRC" (before rotor controllers), moving your satellite array was literally a hands-on proposition. Manual rotor control was the only way to keep the antennas on target. For High Earth Orbit (HEO) birds, such as AO-10, movement during usable portions of the orbit with such antennas only required adjustment every few minutes, or even less frequently. However, with Low Earth Orbit (LEO) birds, it was a different story. With passes lasting just a few minutes, you had to be able to operate rotor controls, compensate for Doppler shift on your rig, make notes on your scratch pad, and talk, all at the same time—which requires using both your hands and your feet (for the PTT foot switch, that is)! It could be done, which was part of the challenge—and the fun—of early satellite operation.

Early az/el rotor systems usually were a lash-up of a standard rotor for azimuth and a heavily modified rotor for elevation. The ancient and honorable Alliance U-100/110 (photo 1) was a favorite for elevation, as its mounting hardware was easily modified for elevation duties, not to mention it was fairly inexpensive. One of the first rotors produced as a dedicated elevation rotor was the KenPro KR-500. KenPro was bought out by Yaesu, who went on to produce the G-5400/5500 rotors, arguably the most popular az/el rotor systems today.

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Photo 1. The author's two helical antennas rotated by U-100 rotors.

As more birds went into orbit, hardware and software developers began to design and create the capability to control rotors automatically in the "hands-off" mode. Several units have been built. Unfortunately some are no longer available for one reason or another, but a generous selection of highly capable controllers is available, and several are in development.

Kansas City Tracker

The Kansas City Tracker (KCT) is the most popular rotor control interface. It was the first to be internally mounted in a computer. It comes with software, but most satellite tracking programs support KCT.

KCT comes with an interface cable for "plug & play" with the Yaeşu 5400/5500 az/el rotor systems. However, a cable to drive external relays can easily be fabricated for other rotor systems. KCT also comes with detailed instructions on how to interface KCT to non-Yaesu systems.

At my QTH, I used enclosed relays from RadioShack—two in each rotor control box, a Yaesu G-400 and G-500 (a.k.a. Kenpro KR-500). I had given thought to using solid-state relays, but I stuck with mechanical relays, as they provide a reassuring noise when operating. By happy circumstance, each relay makes its own distinctive sound, which lets you know that things are going well, or not so well, as the case may be. KCT initially came in two versions, one with a tuner function to change the frequency of your satellite rig automatically in order to compensate for Doppler shift, and a version only for control of rotors. Later versions have the tuning control as standard issue.

The KCT uses an ISA slot, and therein lies the problem. Motherboards with even one ISA slot are difficult to find these days. Word has it that L.L. Grace, the manufacturer of the KCT, doesn't plan to develop a PCI version because (1) too few KCTs are sold now to justify the research and development, and (2) computers are so cheap that many "bird chasers" dedicate an older (and inexpensive) computer containing plenty of ISA slots with satellite tracking. Unfortunately, the point may be moot, as L.L. Grace has ceased production of the KCT. It was available directly from AMSAT for $270. KCT units are no longer in stock, but check eBay, and keep a sharp eye out at your local hamfest. You just might find one.

SASI

SASI Tracker was designed with the laptop computer in mind, although it will work fine with any computer that contains a parallel port. SASI is designed to interface directly with the Yaesu 5400/ 5500 series rotors. However, it can be configured to interface with other rotor systems. Its primary advantage is size. The whole controller fits inside a parallel- port connector! A bonus feature is that it is self-powered. SASI is supported by NOVA For Windows, but it will also run with DOS-based software, including InstantTrack, QuickTrak, and RealTrak. Unfortunately, SASI, like KCT, is no longer available. Northern Lights Software Associates (http://www.nlsa. com) sold them for $229 at one time, but keep an eye out at hamfests and on eBay.

LabJack

With the Universal Serial Bus (USB) now becoming standard issue on computers, a USB rotor controller was bound to hit the market sooner or later. No USB/serial adapter here. LabJack is powered by the USB port. LabJack, Inc., of Lakewood, Colorado, (http://www. labjack.com), produces the LabJack U-12 (see photo 2), which is a "USB-base multi-functional data acquisition and control device," i.e., a USB-to-analog interface. Terrig Evans of E.T. Electronics in Napier, New Zealand worked in collaboration with the folks at Northern Lights Software Associates to produce the LabJack PiggyBack USB/ rotor interface (see photo 3). The unit will interface directly with the Yaesu 5400/ 5500. With extra modifications, the PiggyBack will also drive other rotor systems. The LabJack U12 runs about $119 directly from the manufacturer, and the PiggyBack is $30 plus shipping from Northern Lights Software Associates.

Photo 2. The LabJack U-12 USB-base multi-functional data acquisition and control device.

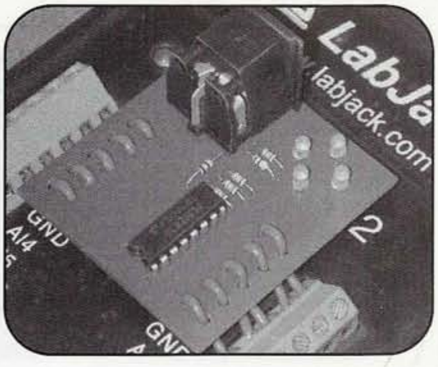

Photo 3. The LabJack PiggyBack USB/rotor interface mounted on the LabJack U-12.

Uni_Trac 2003

Designed and built in New Zealand by David Lamont, ZL2AMD, Uni_Trac is gaining popularity in the satellite community (see photo 4). New hardware and software versions of Uni_Trac are just being released. Designated the Uni_Trac 2003, the new unit will utilize a serial port rather than a parallel port, as in previous models. The 2003 will also be compatible with a USB/serial converter, making it usable with "legacy" or the latest, greatest notebook computers. The Uni_Trac

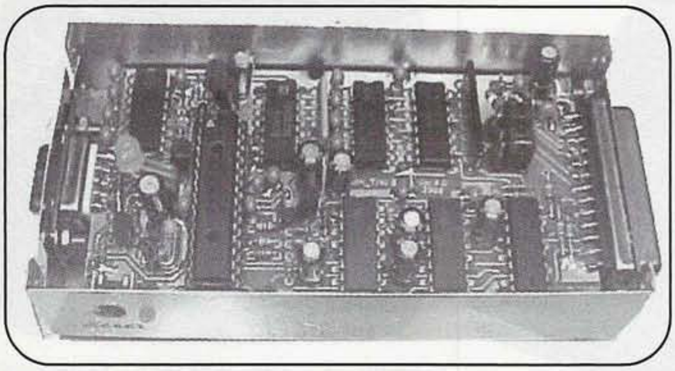

Photo 4. Uni_Trac 2000 is gaining popularity in the satellite community.

2003 will also have new software, which is "backward" compatible with the previous "metal case" Uni_Tracs, but not the earlier "plastic case" versions.

The Uni_Trac 2003 retains the standalone unit design—i.e., no slots taken up in the computer and no desk space lost. It will hold up to ten satellites in memory. Just select the bird you want, and at the appropriate time Uni_Trac will steer your satellite array. The Uni_Trac 2003 will interface directly with the Yaesu G5500 az/el rotor. With a bit of creative engineering, other rotor units can also be interfaced to the Uni_Trac.

Uni_Trac is supported by a number of tracking software packages, including Nova, SatPC32, Wisp, WinOrbit, and Wxtrack. For additional details and pricing on Uni_Trac, go to <http://www.etelectronics.com/uni_trac_2003.htm> or e-mail Spectrum International at <spectrum@spectrum-intl.com>.

RC-2800PRK

Manufactured by M^2 Antenna Systems, Inc. (http://www. m2inc.com), the RC-2800PRK is the heavy artillery of rotor controllers. It is designed to interface with M^2's heavy-duty az/el rotors (OR-2800 azimuth and MT-3000 positioners), and for the EME folks we're talking about a very serious antenna "positioning" system for the serious EME operator. The RC-2800PRK runs $435; packaged with the OR-2800, the price is $1,572. The MT-3000 elevation positioner goes for $1,330.

ARS/RCI

The Antenna Rotor System/Rotor Control Interface (ARS/RCI) is manufactured in Spain by Pablo Garcia, EA4TX (see photo 5). The original version was strictly an azimuth rotor controller, but a "daughter board" was developed to add elevation capability. The ARS/RCI-SE (second edition) provides az/el control all on one board, although an azimuth-only version is also available. The unit is quite popular in Europe, and it is gaining favor around the world. The ARS/RCI can be interfaced to any rotor system. The manual contains detailed instructions for this process. ARS/RCI-SE has its own software, but it is supported by virtually all the popular DOS and Windows® satellite tracking software. The current price is just over $100 for the azimuth-only unit and around $160 for the az/el version. The ARS/RCI may be ordered directly from ARS at: <http://www.ea4tx.com/support/FAQ7.htm>.

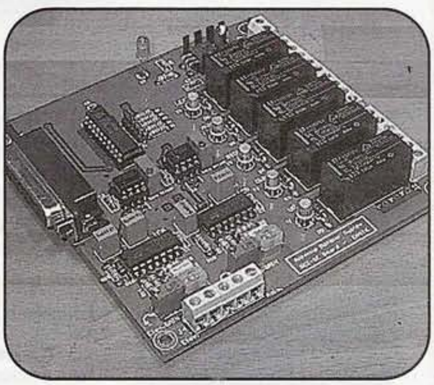

Photo 5. EA4TX's RCI-SE rotor-control interface.

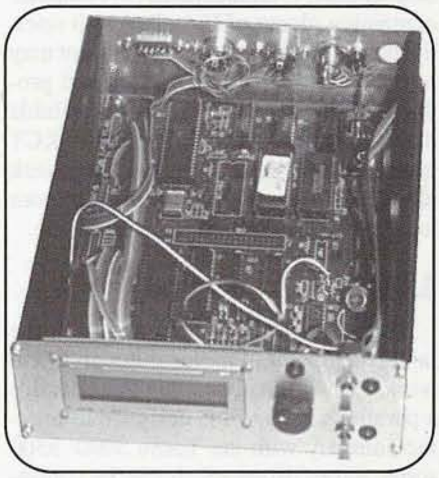

Photo 6. TrakBox was one of the first self-contained rotor controllers. It is no longer available, but the EPROM may be obtained from TAPR, Inc.

TrakBox

The TrakBox was one of the first self-contained rotor controllers (see photo 6). Designed and marketed by the Tucson Amateur Packet Radio, Inc. (TAPR), it arrived in kit form. The kit is no longer available, but for those brave souls who love to experiment, the EPROM is available through TAPR (http://www.tapr.org). TrakBox was a standalone unit and controlled the rotors directly. The operator selected the satellite of interest, and at the beginning of the satellite's pass, TrakBox moved the rotors all on its own.

SatEL

One unique system which came on the market recently is the SatEL Az/El system. It includes not only the controller, but also the rotors (see photo 7). Originally design by Jim Koehler, VE5FP, SatEL consists of two venerable Alliance U-100 rotors; one is mounted as it was designed for, azimuth, and the other is modified to mount as the elevation rotor. The controller is a classic in simplicity of design, four wires for one rotor and four wires for the other. The control board is rather small, only 3" × 3.75", and mounts in a small plastic case. The rotor assembly is compact and seems ideal for a portable satellite array. It even comes with a test stand! Although SatEL comes with its own software, it is supported by NOVA For Windows® and InstantTrack.

Photo 7. The SatEL Az/El system includes not only the controller, but also the rotors.

When Alliance went out of business, Norm's Rotor Service bought the rights to the U-100, and it is the primary source of rotors for SatEL. There is a certain irony to this system. In the satellite community the Alliance U-100 was a favorite as an elevation rotor. "Dead" U-100's also made dandy counterweights to balance satellite arrays. The SatEL system runs around $418 plus shipping. For additional information, go to <http://www. satelectronics.com>.

WinRotor

Manufactured in Germany by FunkBox, this unit provides rotor control from either the serial port or the parallel port, depending on the model you select (see photo 8). A USB unit, which is directly driven by your USB port, is also available, but it is only compatible with Windows® XP. Another unit is serial driven, and it comes with a USB/serial converter. Although support software comes with WinRotor, most of satellite tracking programs support it directly. The units run about 90–100 Euros (you'll have to do your own currency conversion) and may be purchased directly from WinRotor (http://www. winrotor.com).

ST-1

Originally manufactured by AEA, the ST-1 was another outboard controller housed in a case similar to, but slightly smaller than, the famous AEA PK-232. With the demise of AEA, the ST-1 is no longer available. However, the units do pop up on tables at flea markets, at hamfests, and from time to time on eBay. Depending upon the equipment's condition, ST-1's go for between $50 and $250.

Reports from "bird chasers" who use the ST-1 are quite positive. The ST-1 interfaces directly with the Yaesu az/el system, but it can be configured for other rotors. The main drawback is support, or lack thereof. As mentioned, AEA is no longer in business, and no one picked up the rights to the ST-1. Your main source of support would have to be from other ST-1 owner/operators.

Photo 8. WinRotor provides rotor control from either the serial port or the parallel port, depending on the model you select.

GS-232A/CT-17 Level Converters

If you wish to "roll you own" controller, either the Yaesu GS-232A or the ICOM CT-17 will provide you with a computer interface to drive control relays for rotors. Both devices give you RS-232 level signals to drive relays for control boxes, which have no provision for an outboard controller. Also, these devices allow a variety of logging programs to interface with your transceiver. Again, most current tracking software supports both units. Both the GS-232 and the CT-17 are housed in a small case. The GS-232 sells for approximately $500, and the CT-17 sells for about $130. Homebrew units have also been developed at a substantially lower cost.

A Tip of the Hat

I'd like to take this opportunity to thank the following folks for their assistance in putting this column together: Martha Saragotvitz, Headquarters AMSAT; Pablo Garcia, EA4TX, Antenna Rotor System; David Lamont, ZL2AMD, Uni_Trac; Terrig Evans, ZL2TJX, ETElectronics; Reinhard Mayer, DHØGMR, Funkbox Hard & Software; Eric Rawson, KN5KC, SatEL; Don Woodard, KD4APP, Uni_Trac 2003 "Beta Tester"; Laura and John, W9DDD, Koster, TAPR, Inc; Dr. Michael Owen, W9IP, Northern Lights Software Associates; and the folks at LabJack, Inc.

By Kent Britain,* WA5VJB

ANTENNAS

Connecting the Radio to the Sky

AMSAT "Mode L" Antennas

This month we are going to cover AMSAT "Mode L" antennas. These antennas are like 435-MHz AMSAT antennas, but they are centered on 1270 MHz (photo 1).

Normally when a Yagi gets this long, its bandwidth becomes very small, which makes construction very, very critical. I've backed off about 1 dB from maximum gain to come up with an antenna that works across the entire 1240-MHz to 1300-MHz band. If you miss it by 30 MHz, it still works at 1269 MHz. (See figure 1.)

Measured gain at just over 16 dBiC is what you can expect from the typical 3–3.5-foot dish system on L-Band. Mathematically, the formulas say that you can get 20 dBiC from a 3.5-foot dish, but you are not going to get that 60% theoretical efficiency with the feed blocking much of a small dish.

Wood

When you mount a Yagi element to a metal boom, you have to adjust its length slightly to allow for the effects of the metal boom. Normally we just consider wood to have no effect and go on. As Ed Manuel, N5EM, unintentionally showed me several years ago, the effect is *not zero!* In this case, an L-Band ATV antenna was built using a 1" × 1" wood boom, which makes nearly one third of the element inside wood! This detuned the antenna nearly 50 MHz. Even the 1/2-inch width boom used in this month's design lowers the center frequency of the elements about 10 MHz. Therefore, don't substitute a stronger/wider wooden boom. One ham built this antenna using plastic "hot water" pipe, but I haven't had that antenna on the antenna range to measure how much the frequency was pulled.

Construction

The boom is made from 1/2" × 3/4" wood. You might try 1/2" × 1", but I think 1/2" × 1/2" would be too weak. Do not substitute a thicker wood where the elements pass through!

The elements were made from 1/8-inch diameter silicon bronze welding rod, which is relatively cheap from your local welding supply. However, 1/8-inch hobby tubing or 1/8-inch aluminum ground wire can also be used for the elements. Make sure the ends are flat and square. Now is a good time to buy that pair of calipers you've been meaning to get for some time. You're going to have to be very careful with the measurements for the elements. You need to be within .05 inch (approximately 1/16 inch). It's better to be a few thousandths short than a few thousandths long for the elements. I used a bench grinder to bring mine into tolerance.

For the boom, start your measurements at the reflector and work your way forward. Use a good tape measure and mark each element. Do not start at the reflector and measure off 1 inch for the driven element, then measure 1.1 inch from the driven element to the first director. After doing that 16 times, any cumulative error will be much worse than if you had just used a good tape measure.

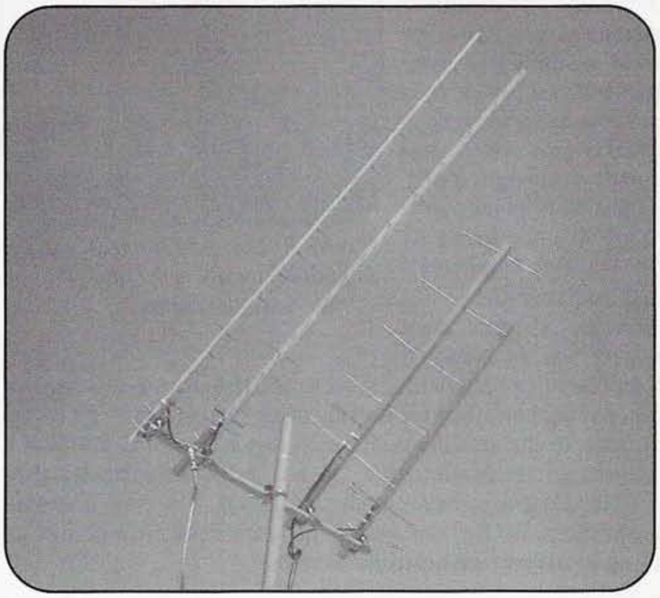
Photo 1. AMSAT Mode L antennas mounted for circular polarization.

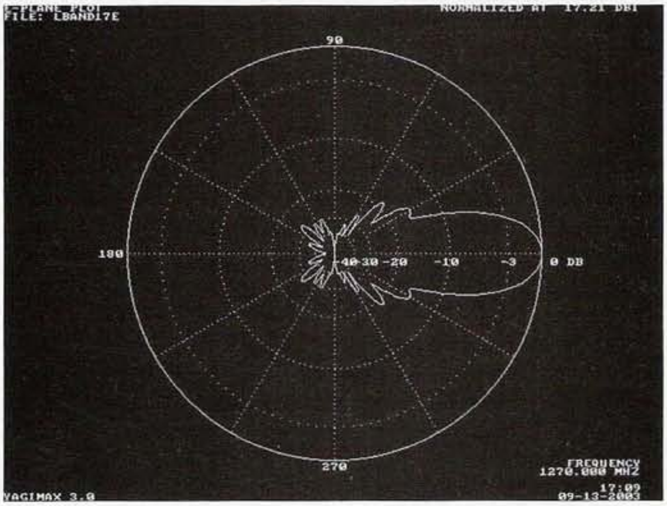

Figure 1. Computer plot of the 17-element Yagi.

I just drilled 1/8-inch holes in the booms and the 1/8-inch elements were nice, snug fits. The elements are secured with Super Glue®, epoxy, or a construction adhesive, such as Liquid Nails®.

The U-bolt works just fine, going through the wide part of the boom (photo 2 and figure 2). We can rotate polarization,

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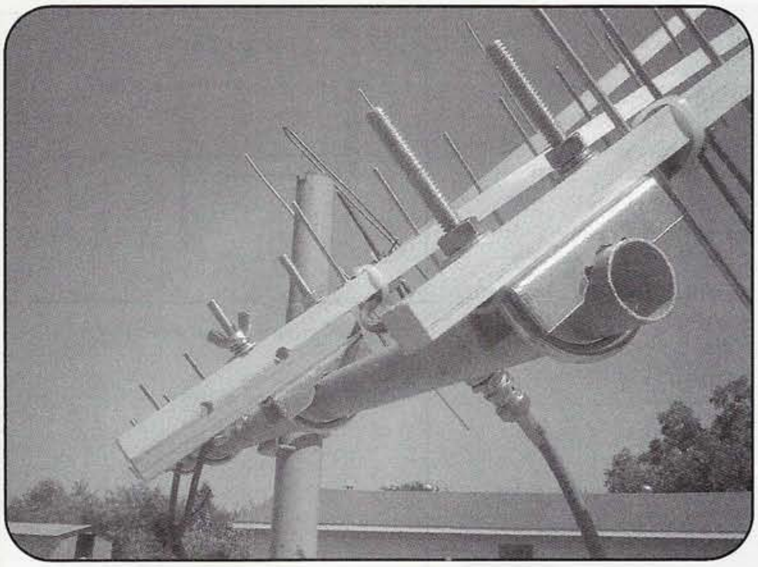
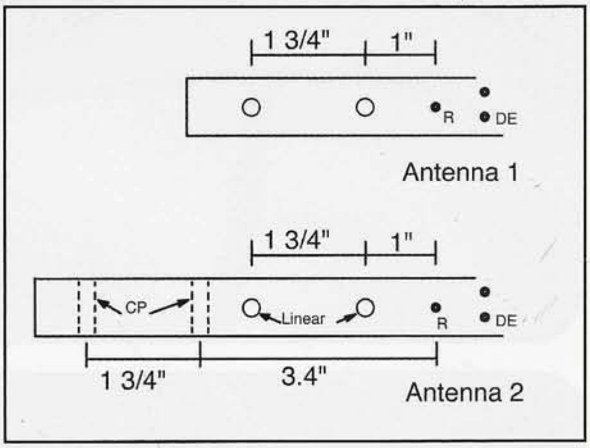


Photo 2. *U-bolt mounting holes.*

Figure 2. Mounting holes.



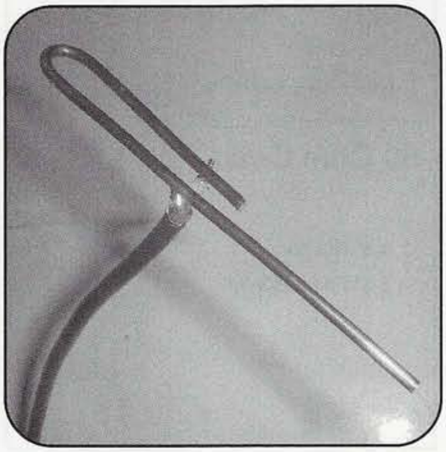


Photo 3. The driven element.

and drilling out the 1/2-inch side would make the boom just too weak. I glued on another section. A good glob of glue and a few finishing nails worked fine. Now you have enough thickness for the U-bolt holes.

Driven Element

The driven element is a "hair pin" or J of #10 bare copper wire (photo 3 and figure 3). Silicon bronze welding rod, 1/8-inch diameter, can be used, but it is a real problem to bend into shape. I tried bending 1/8-inch hobby tubing as the driven element once, but I didn't have much luck. Maybe if you have a hobby tubing bender, you might have fare better than I did.

With this antenna, I found it easier to solder the coax to the driven element and then mount it on the boom. Just watch your dimensions. Yes, the coax is slightly off center, and the ends overlap inside the wood. The capacitance of the ends inside the wood is actually helping the impedance matching. Simply built to the dimensions, your SWR should be less than 1.5:1 from 1250–1290 MHz. If you have access to an L-Band SWR meter, a network analyzer, or a spectrum analyzer with a tracking generator and a direction coupler, the return loss can be tweaked down to –30 dB. In SWR terms, that's about a 1.05 to 1 SWR. If you really want to tweak the antenna, I recommend putting 50-ohm coax on each antenna, and tune them one at a time. Then install the power divider.

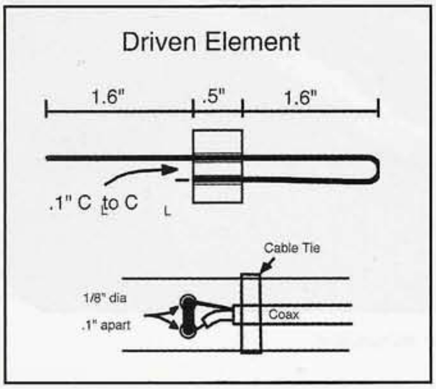


Figure 3. The driven element.

Elements

For many of the elements, you need to make up six or eight elements of the same length. If you're like me, some are going to end up a tad short and some will be a smidgen long. This length difference is easy enough to see when you have the elements all lined up. You want the longer ones closest to the driven element and the shorter ones closest to the end of the antenna. In figure 4 you can see how this helps maintain the taper of the elements.

Painting

If you plan to have the antenna outdoors for extended periods of time, I recommend painting the booms with Spar Varnish or clear spray paint. Wet wood will detune the antenna.

Power Divider

We need to split the signal equally to both antennas, yet maintain the 50-ohm impedance, which is often done with a 1/4-wave power divider (photo 4 and figure 5). In this case, 1/4 wave is just long enough, so I'm using a 3/4-wave power divider made of 72-ohm coax. RG-59 and RG-59 foam have different velocity factors and need to be different lengths. The foam is electrically a better coax, but it's very easy to damage/melt it while soldering to the driven element. I built one out of 72-ohm RG-59 with 72-ohm BNC connectors. The second one is just soldered with short leads. My network analyzer couldn't see much of a difference between these two power dividers. If you care to make your own power-divider design, be my guest. Just make sure the runs of 50-ohm coax between the power divider and the antennas are of equal length.

Mounting

There are three ways this antenna system can be mounted, and we will cover the advantages of each.

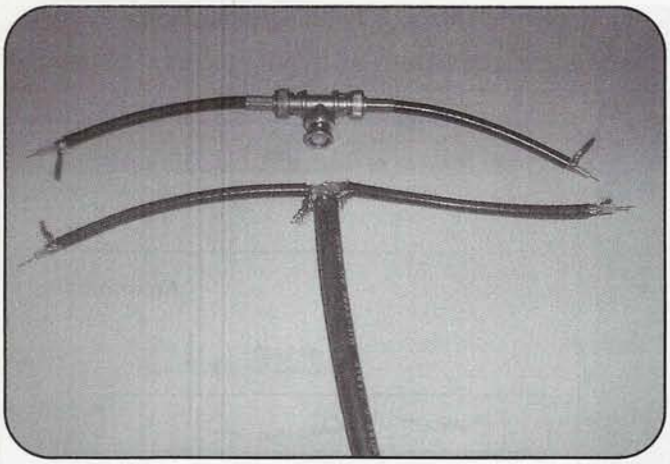


Photo 4. L-Band power dividers with splices and connections installed.

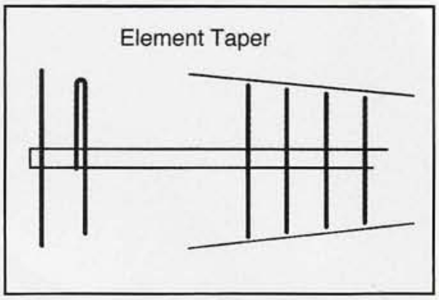


Figure 4. Element taper.

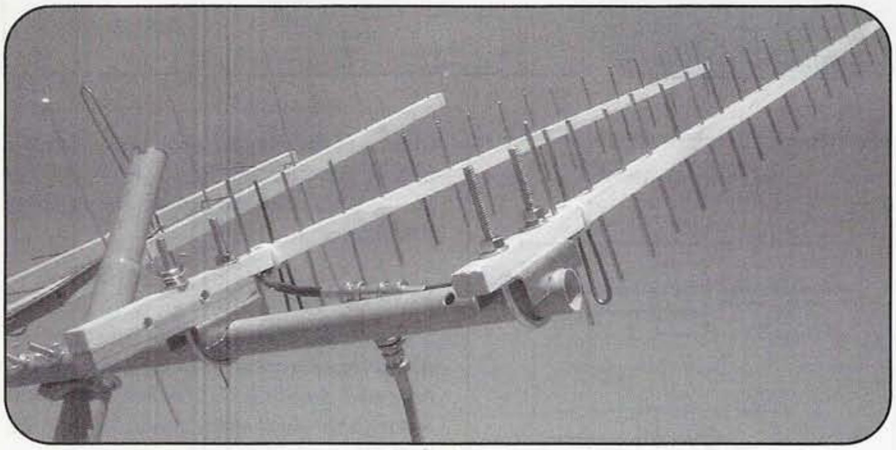


Photo 5. Linear mounting.

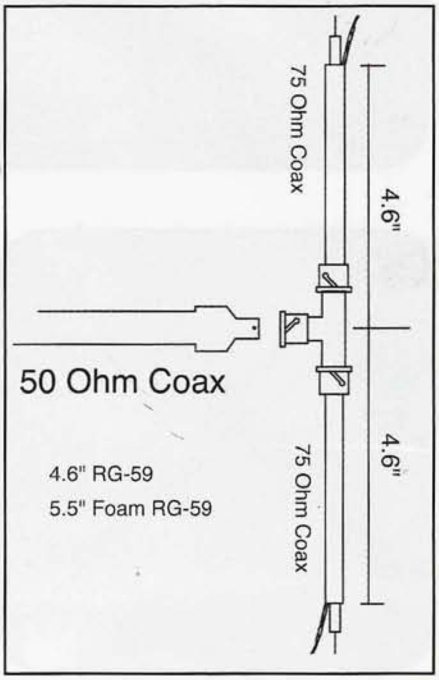
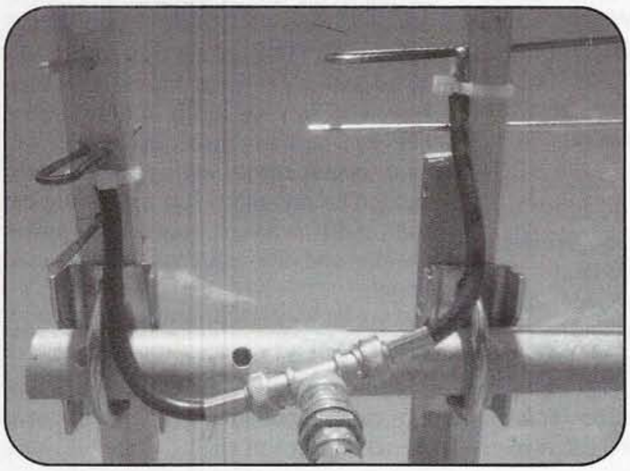


Figure 5. Power-divider dimensions.

Linear: Mount the antennas with the elements of both antennas oriented so that they are either vertical or horizontal (photo 5). Also, mount them so the elements are the same distance from the cross boom. We want the antennas to be in phase. Also make sure the loop side of the driven elements is on the same side of the booms. This configuration gives you $2\frac{1}{2}$ dB more signal on AMSAT, but there may be some rotation fading. In addition, it works great like this for 1250–1280 MHz.

ATV/Repeaters/Packet: This is also the way you would want to mount the antennas for a 1296-MHz SSB QSO, but these antennas are more centered for AMSAT. Gain will be down about 3 dB. Separation distance is how far you can space them without pulling out the power divider connections—about 7 inches.

Left Hand Circular Polarization (LHCP): Mount the antennas with one antenna $\frac{1}{4}$ wave ahead of the other (photo 6 and figure 6). In this case, it will be the one with the extra block on the back. At 1269 MHz this will be 2.3 inches, or 6 cm. Mount the antennas 5 or 6 inches apart. This distance is not critical.



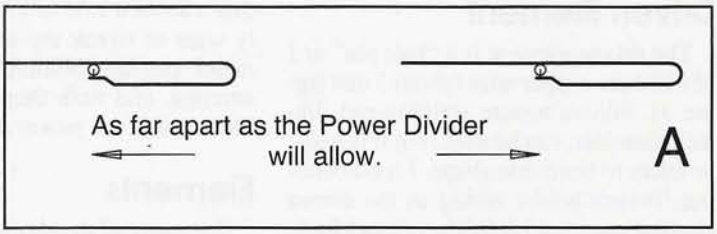


Figure 6. Looking back down the booms, driven-element positions for linear, LHCP, and RHCP.

← *Photo 6. Circular polarization mounting.*

Right Hand Circular Polarization (RHCP): Just flip one of the antennas 180 degrees. That is, flip it so the driven-element loop is coming out the other side of the boom. It really doesn't make a difference which antenna you flip. Mount the antennas 5 or 6 inches apart. This distance is not critical.

For you technical guys who could have written this article, yeah, the few inches of horizontal separation between the two antennas does mean that when looking 20–30 degrees off axis from the antenna, the antenna is elliptically polarized (sort of an egg-shaped circular polarization). The whole idea, though, is to point the antennas where they work best!

There are several fancy ways of generating switchable polarization. However, you can build several of these L-Band Cheap Yagis for the cost of just one coax relay.

Building it X Fashion

There are always several of you who want to build both antennas on the same boom. I'm not a fan of building them that way. The two antennas can easily be stored flat. The single X is going to get bent. With the two antennas, you can easily switch between three polarizations; the single X is going to be only one polarization, and in the case of the L-Band version, 48-inch long, 1/2-inch square wood is not going to be strong enough to support itself.

Dimensions for the 17-Element L-Band Yagis

Element	Position (in.)	Length (in.)
Reflector	0	4.6
Driven Element	1.0	see drawing
Dir 1	2.1	4.0
Dir 2	4.1	3.9
Dir 3	5.9	3.9
Dir 4	8.1	3.8
Dir 5	10.1	3.8
Dir 6	12.0	3.8
Dir 7	14.5	3.75
Dir 8	16.75	3.75
Dir 9	19.2	3.75
Dir 10	22.6	3.7
Dir 11	25.9	3.7
Dir 12	29.5	3.7
Dir 13	33.0	3.7
Dir 14	36.4	3.6
Dir 15	39.75	3.4

Finally

No matter how big I make an antenna, someone wants to make one bigger. Okay, here are the dimensions for a 20-element version, but I haven't had a chance to test it on the antenna range. It should have about 1 dB more gain. Good luck; you're on your own. (Let me know how it worked out.) Directors 14 and 15 are changed, and three new directors added. They are all still 1/8-inch in diameter. All other dimensions are the same.

	Length (in.)	Position (in.)
D14	3.7	36.4
D15	3.7	39.8
D16	3.7	43.2
D17	3.5	46.5
D18	3.4	49.9

You don't have to build two. Even a single antenna fed directly with 50-ohm coax can be used with good results on AMSAT Mode L, ATV, repeater, or any other 1240–1300 MHz service.

In the next issue we will cover horn antennas and other interesting topics. As always, I am interested in your comments and suggestions. ■

Letters, Letters . . . We Get Letters

From Jim: "Can you build dual polarization 'Cheap Yagis' on the same boom?"

It is possible to build two Cheap Yagis on the same wood boom and run two coaxes. I would suggest drilling the holes so that one is a few inches ahead of the other. At least that way you don't have two elements hitting each other as they pass through the center of the boom. There is another way, however!

For years I used the same 220-MHz Yagi on both SSB and FM. I mounted it at a 45-degree angle. Mathematically this means that gain is down 3 dB on both horizontal and vertical from a normally mounted Yagi, but just one feedline and half the wind load. I did need a coax switch in the shack to switch between my 220-MHz transverter and the 220-MHz FM rig. I said 220 MHz versus 222 MHz, which should give you an idea of how long ago this was.

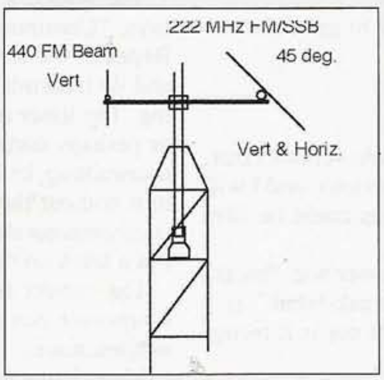


Figure 7. Using the same Yagi for both vertical and horizontal QSOs.

By Gary Pearce,* KN4AQ

FM

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

Questioning the Pool

Besides being the "all-knowing FM guru," I teach ham classes in my spare time. Twice a year I "bone up" on the question pool so I can prepare to guide eager students through the arcane matters that we hams cherish, or at least believe others must suffer through as we did, to obtain the rite of passage leading to the coveted FCC license. Each time I come across a few questions or answers that I don't like. Some are debatable, some cling to outdated dogma, while some, I think, are just plain wrong. After the class I get busy, however, and I don't think about the questions or the answers until they pop up again at the next class. This year, though, they became column fodder.

I'll restrict my question-pool comments to FM/repeaters, my supposed area of expertise. Eleven repeater-related questions set off my alarm as I was preparing to teach the new pool to the Technician license class. I'll put them in three categories:

- Serious Errors
- Dogma
- Difference of Opinion

This isn't target practice. I ran this column by Scott Neustadter, W4WW, the chairman of the Question Pool Committee, part of the National Conference of Volunteer Examiner Coordinators—the guys who write the questions. Scotty returned comments on most of them, and for the most part, he sticks to his guns. Now and then he allowed that I just might have an idea worthy of follow-up. I'll give Scotty the last word on each question. Then I'll include his review of how the committee comes up with the pool, and how you can participate. The questionable questions below come from the new Tech pool released last spring.

Dive in; the water's fine!

Serious Errors (2 Questions)

T4C06 (A): What is the proper way to interrupt a repeater conversation to signal a distress call?

A. Say "BREAK" once, then your call sign

B. Say "HELP" as many times as it takes to get someone to answer

C. Say "SOS," then your call sign

D. Say "EMERGENCY" three times.

This question could be in all three categories: serious error, dogma, and difference of opinion. I'll call it *serious,* and I will deal with it first because the "correct" answer could be life-threateningly wrong.

In the previous question pool the correct answer was "break-break." That answer was wrong because "break-break" is a regional expression at best, and it is not taught nor is it recognized nationally. In fact, hams in some areas (the ones I grew up in, of course) said that any use of "break" was a lid-like CB term. Some hams refused to recognize it on the air.

The new answer of a single "break" is even worse. Many (most?) hams interpret that as a desire to join the conversation or use the frequency, but attach no urgency to it ("Breaker acknowledged; we'll get back to you in a minute."). In other areas, "break" is the preferred term for interrupting a conversation. It is still a regional expression.

In my not-so-humble opinion, all three incorrect answers are better than the correct one. I prefer D, "emergency" (just once will do). That violates all kinds of radio tradition, where inventing a new "special" word to substitute for a common English one is an art. As I ask my class, though, "What is the one word that is best understood by all listeners, indicating that someone has an emergency?" They think for a minute, and eventually someone raises a hand and says, "Uh . . . 'emergency'? "Break" is at the bottom of everyone's list of words that would get one's attention. Even the dogma-thumpers in the ham community would recognize the "incorrect" use of the phrase "Emergency, KN4AQ." They might want to string me up later, but they'd handle the emergency first.

Before someone argues that "emergency" is English and might not be understood internationally, I'll point out that we're talking about repeaters here, not international HF. Even so, "break" is hardly an international term.

This is one of the most critical questions in the pool. Teaching someone to say "break" in an emergency could cost time, and ultimately a life.

Scotty says: "This one has bounced around for years. There is no Part 97 citation I can give you, but the ARRL Operating Manual has espoused this approach for years."

T9A17 (D): What is the purpose of a repeater time-out timer?

D. It limits the amount of time a repeater can transmit continuously.

The ARRL's new edition of *Now You're Talking* actually says, "Continuous operation can also damage the repeater." Repeater owners would scoff. Timer-equipped repeaters can and do transmit continuously for hours if the users keep talking. The timer resets as the repeater receiver's squelch closes, or perhaps during the courtesy tone while the repeater keeps transmitting its hang-time, and the next user takes his or her turn without the repeater transmitter ever dropping. The term is *continuous duty,* and repeater transmitters are built for that. Put a brick on the key and walk away.

The correct answer would be: *It limits the amount of time a repeater can transmit if the repeater's remote-control link malfunctions.*

Many hams think that three-minute timers are there to limit how long a windy ham can talk on a repeater without taking a deep breath. They may have that effect, but that's not why they

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are there. The use of timers is based on this rule for repeater (and auxiliary) stations:

97.213 Telecommand of an amateur station.

An amateur station . . . may be under telecommand where:

(a) There is a radio or wireline control link between the control point and the station . . .

(b) Provisions are incorporated to limit transmission by the station to a period of no more than 3 minutes in the event of malfunction in the control link.

Scotty says: "The timer does prevent continuous transmissions. You are absolutely correct that the timer resets as the repeater squelch closes, which means that the input signal to the repeater is no longer continuous. It stopped for a very brief time—so brief that it may appear to be continuous. At some repeaters, a courtesy "beep" is sent to indicate that the time-out timer has been reset. This reset is caused by a brief halt in the input signal, but the transmit receive relays, etc., have now cycled the repeater system to the receive mode. The purpose of this system is to save wear and tear on the repeater system. It is fully compliant with the rules, as the time-out timer would not have been reset if the input signal hadn't stopped."

Dogma (2 questions)

T9A01 (B): What is the purpose of repeater operation?

B. To help mobile and low-power stations extend their usable range

T9A14 (B): When should you use simplex operation instead of a repeater?

B. When a contact is possible without using a repeater.

These two questions go to the same issue, long taught as a sober truth of repeaters and reflected in the "correct" answers above: Repeaters are limited resources that must be protected from "improper" use by base stations and anyone in simplex range.

If this were ever true, it is not true anymore. Repeaters are social vehicles as much as they are technical ones. They are gathering places, the conduit for clubs or groups. Repeaters are the glue that holds together a local ham community.

In the old days (about a week ago), we might have made fun of two hams talking through the local repeater as they drove six car-lengths apart around the town beltline. They were "tying up a valuable resource" when they could have been talking simplex, leaving the repeater for stations that needed it. I participated in the finger pointing as much as anyone. Heck, I was the lead finger-pointer.

Then, I saw the light—or "heard the light" might be a more apt, if strained, metaphor. Sometimes this dogma might still be true on a few busy repeaters. Today, however, with the frequent cry, "nobody's using the repeater," it's not such a big deal. Lots of people are lurking, listening from the weeds. The conversation of those two mobiles is their entertainment. It's as much about the listeners as it is about the guys transmitting. Those low-power stations can break in any time they want and join in. If the mobiles go to a simplex channel, the guy on the other side of town with just an HT and rubber duck is deprived of the benefit of listening to their conversation.

The door now swings both ways. I encourage simplex, and more hams should use it. The old dogma is too rigid. The repeater is our "continuous club meeting on the air," and these days there's room for everyone. Nobody, mobiles included, should hog the machine during the busy times.

Scotty says: "T9A01 is correct. There are other reasons for repeaters, including the social ones you discuss. Your comments, 'Repeaters are social vehicles as much as they are technical ones. They are gathering places, the conduit for clubs or groups, the glue that holds a local ham community together' are true in some locations, but not in all. The extension of usable range, etc., is a correct answer. We did not ask what all the reasons are for repeater operation.

"For T9A14, the answer is correct. Good operating practice would be to minimize use of a repeater when simplex will do. Others may want to use the repeater. Spectrum is a valuable resource, and if you can communicate without using a repeater, you should. In this case, the use of a repeater is using more than the absolute minimum transmitter power. Obviously, certain communities use a given repeater as a social machine, as you describe. The question points to the correct 'per the rules' operating technique: If a given community has sufficient repeater assets that protracted use of one of the repeaters for 'local' communication is normal and accepted practice, nothing in T9A01 or T9A14 precludes such a use. They do *discourage* this use, as it is not consistent with the rules.

"Our questions do not state a dogma. They do state the normally accepted practice that, if followed, will prevent the newly licensed ham from making a mistake. If local practice is different, fine. The only rule I can find is the minimum-power concept. Remember that the question pool must cover operations in areas such as yours with active, highly social hams and areas where the attitude of the ham community is entirely different. As you are teaching a class, you can explain that locally, your group has a different approach, but by following the concepts delineated in these questions, you won't be wrong."

Difference of Opinion

T9A03 (D): During commuting rush hours, which type of repeater operation should be discouraged?

D. Third-party communications nets

Oh, why did I decide to break this up into three categories? This question is part of the same "repeaters are for mobiles" dogma, but with less importance and with a greater chance of argument (as if nobody will dare to argue with my "dogma" assertions). Most towns have more than enough repeaters going begging, even during rush hour. A "traffic net" might be just the thing to spur involvement and interest in this smokey ember of a one-time hot amateur activity. Writing third-party messages while driving might be dangerous, but I don't think that's what the Question Pool Committee had in mind with regard to discouraging the nets. Just pull over and copy the traffic on your Palm Pilot.

Scotty says: "The concept here is simple: Don't use a community asset (repeater) during known peak time for an activity that is not time sensitive. Again, the questions are used nationwide. We aren't discouraging nets, but the repeaters are l imited assets."

T9A04 (D): Which of the following is a proper way to break into a conversation on a repeater?

A. Wait for the end of a transmission and start calling the desired party

B. Shout, "break, break!" to show that you're eager to join the conversation

C. Turn on an amplifier and override whoever is talking

D. Say your call sign during a break between transmissions

This one doesn't belong on my list. It's really a fine tradition that works well. I'd just like to add the following to it . . . "and say what you want," such as "KN4AQ, may I join in?" or "KN4AQ, may I borrow the repeater to make a call?" Okay, this is personal and something nice to teach at a class, but it doesn't belong in the question pool. Your Honor, I withdraw my objection. (Nice job on answer C, guys.)

T9A08 (A): How could you determine if a repeater is already being used by other stations?

A. Ask if the frequency is in use, then give your call sign

B. If you don't hear anyone, assume that the frequency is clear to use

C. Check for the presence of the CTCSS tone

D. If the repeater identifies when you key your transmitter, it probably was already in use.

Most of the time I'm complaining about the old, stodgy fogies in ham radio, trying to hold back the urgency of youth. This procedure is pure MTV. "B" might be a perfectly good answer if we add "listen for a minute." It's not like on HF, where you might be in the skip zone of one of those old-time monologgers who can talk for 15 minutes straight (a technique I've never mastered, but I've timed out a repeater more than once). If the repeater is busy, you'll know in a few seconds. Okay, if you "gotta go *now*," it's better to ask if the repeater is in use. Just be prepared for the joker who will always answer, "No, it's in [put your city's name here]."

Scotty says: "Again, you're struggling in an area where Part 97 doesn't provide any guidance. We have tried to follow what the *ARRL Operating Manual* says, as it is recognized as a leading authority. You could have your own radio set up for decode on the tone squelch and not realize that the repeater is in use. If you're like me at this point, you haven't been looking at the S meter!"

T9B19 (B): What is a continuous tone-coded squelch system (CTCSS) tone (sometimes called PL, a Motorola trademark)?

B. A sub-audible tone, added to a carrier, which may cause a receiver to accept the signal

Defining CTCSS is tough. I promised in my last column that I would give it a rest. Besides, my shortest answer took two paragraphs and came in three parts. This is a pretty nice try and way better than "a thin slice of each channel that helps prevent crosstalk." I'll withdraw this objection, too.

Scotty says: "Great! We've struggled with this beast, too."

T9B20 (D): What does it mean if you are told that a tone is required to access a repeater?

D. You must use a subaudible tone-coded squelch with your signal to operate it

My problem is the improper use of the word *squelch.* You don't send a squelch. The simple answer would be: "You must send a subaudible tone to operate it." The knowledge tested here is that the

Oh, Canada!

The IRLP was born in Canada (Vancouver, if I'm not mistaken), and internet linking is quite popular there. One common phenomenon is internet-linked simplex base stations. Evidently, it has grown to the point where it's a bit of a problem—enough that the British Columbia Amateur Radio Coordination Council (BCARCC) decided to recommend some coordination and band planning.

Ian Soutar, VE7DJI, was on the committee that prepared a proposal adopted by BCRACC, and passed along the following information:

Coordination Councils in North America have not historically coordinated simplex stations. In the last three years, however, new internet-linked stations (IRLP, Echolink, and others) have been appearing in the VHF and UHF amateur radio bands, some on regular repeater duplex channels and others on simplex channels. The simplex internet-linked stations are appearing without coordination, and BCARCC believes it is important to establish guidelines for frequency use.

Current RAC Bandplans

The current RAC (Radio Amateurs of Canada, the Canadian national amateur radio society) band plans have no specific allocation for internet-linked base stations. Consequently, such stations have been popping up on random VHF simplex voice channels, causing complaints from other simplex users, and particularly from Emergency Program (EP) groups in Southwest B.C. Such EP groups, during their weekly emergency nets, are using most, if not all, of the available VHF simplex voice channels. They are upset when an IRLP station competes with their net. VECTOR's Emergency Frequency List (http://www.qsl.net/ve7vct/tox.htm), prepared in April 2000 by Tom Cox, VE7VCT, reveals this extensive use of the 2-meter simplex bands.

To lessen this conflict, the council is proposing that EP groups reduce the number of simplex channels used for their emergency nets, and that internet-linked stations be restricted to certain portions of the band.

We propose that:

(A) Internet-linked simplex stations be confined to the 147 simplex bands, as internet-PRIMARY;

(B) Permanent stations, requiring coordination, start at the top of the band and work down—i.e., 147.585, 147.570 MHz, etc.;

(C) Spectrum for Experimental stations be allocated as the first two channels in each of the present 147-MHz blocks—i.e., 147.420, 147.435, 147.450, and 147.465 MHz. These channels are to be Shared-Non Protected (SNP), not requiring coordination, but low power and CTCSS mandatory.

Promotion of Other Bands

It would be in the ham community's interest also to promote the establishment of internet-linked facilities in the 220- and 440-MHz bands. These bands are under-utilized, the channels are quiet and in relative plentiful supply, and the RF equipment for these bands is now similarly priced to [those on] 2 meters.

Ian's right. In the U.S., coordinators typically don't touch simplex. There are some general band plans in place, but down here it's pretty quiet. The complaints I hear are that nobody's using simplex!

Is there a groundswell of internet-linked simplex stations out there? Not within my 30-mile radius. Let me know what it's like in your area. I do think that this has the potential for filling simplex channels and maybe causing some conflict. A group of us use a simplex channel around town, and most of the time it's our private preserve. I suppose I wouldn't be too happy to hear a busy IRLP reflector dumped out on it one day. However, we do share these resources (didn't I read something about that in the Question Pool earlier in this column?). Do we need to be heads-up on this as the guys in B.C. are?

tone is subaudible, which, of course, it really isn't.

Scotty says: "Good catch; will put it in the hopper for potential revision on the next Tech Pool revision."

T9A15 (A): If you are talking to a station using a repeater, how would you find out if you could communicate using simplex instead?

A. See if you can clearly receive the station on the repeater's input frequency

Very good advice. There is no problem here, really, except when you teach this one, you might explain that hams using repeaters should run low power if they can (hey, dogma guys, this bone's for you!). When you listen on the input, you might hear a very weak signal that would be fine for simplex on high power. Ah, complexity.

Scotty says: "That was the idea of the word *clearly.*"

T9A13 (A): What is the common amateur meaning of the term "simplex operation"?

A. Transmitting and receiving on the same frequency

My answer would be: "Stations communicating directly with each other, without the assistance of a repeater or other relay device."

Back before repeaters, almost all ham activity was "simplex," but they didn't call it that because they didn't have to call it anything. There was nothing to differentiate it. Repeaters added the counterpoint. You could add "on the same frequency" to my answer if you insist. In the commercial two-way business, a very few operations put mobiles on one frequency and base stations on another, without a repeater, and they call it "half duplex" (it was so taxis couldn't compete with each other for fares, and maybe it kept the rag-chewing down among the mobiles). I suppose someone would complain if I said you could be on two separate frequencies and still be "simplex." The important thing, however, is that there's no repeater.

Scotty says: "Good point. The question could be improved, but is correct as written; the saving grace is 'the common amateur meaning.' Another one for the potential revision hopper."

Don't Stop There

Well, there they are, my problem questions. I'm sure you have your opinion about these questions and maybe others in the pool. This isn't a good place to stop, just complaining. Inquiring minds want to know: How did these questions get in the pool? How are questions selected for the question pool?

In the olden days, the FCC created the questions for the ham exams. They didn't do it any too publicly, and I don't recall much complaining about the content—just learn it and shut up. Now the pool is made up by hams, volunteers in the Question Pool Committee (QPC), part of something called the NCVEC, and the National Conference of Volunteer Examiner Coordinators. That is the group of hams who help coordinate the VECs, and the VECs are the level immediately above your local VE team (there are 14 VECs, with the ARRL and W5YI-VEC being the best known). You can't tell the players without a score card, can you?

Scotty Neustadter, W4WW, explains just how a question achieves the exalted position of being "in the pool":

"The question pools are on a four-year cycle. We just released the new Tech Pool in December '02 for use starting July 2003. With the release of the Tech Pool, we asked for comments/recommended changes for the General Syllabus which was available on the ARRL website. Later we released a 'working syllabus' that the QPC would be using for pool development; at the same time we asked for suggested new questions and suggested revisions. We asked that these be submitted by July 15, 2003. The QPC is presently sorting the new input (never enough) into the existing pool and getting our notes out on questions that have been challenged.

"The QPC started its formal review in September. As each sub element G1, G2, G3, ... GØ is worked by the QPC, a draft sub element develops, which is larger than necessary. Then each member recommends deletions, revisions, etc. We then take this draft pool and circulate it to our 'proofers,' whose job is to be a new set of eyes to look for confusing questions, ambiguities, etc.

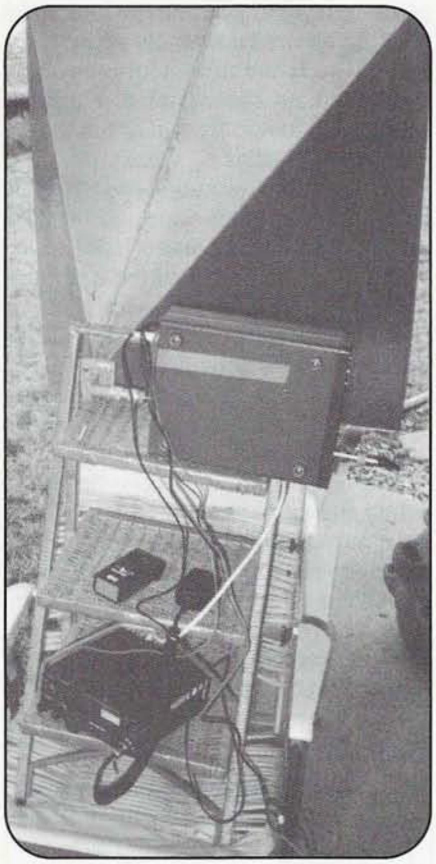
"The chair funnels the proofers' comments back to the QPC if they are not obvious fixes. The proofers are not voting members of the committee, and they don't comment on the content of the questions or syllabus. Their input is vital.

"At this point, the pool sub-element has good questions, but it is probably too large. The same process is followed for all sub elements. At the conclusion of this process, the QPC gets one last look at the pool. To ensure fairness, the chair of the QPC, who is not affiliated in any way with any ham radio publisher and receives no income from any ham radio source and business, makes the final down-select and releases the pool into the public domain. At the same time the QPC usually asks for suggested input to the syllabus for the next pool to be revised. This year, when the General Pool is released (December 1, 2003 for use starting July 1, 2004 through June 30, 2007), we will not ask for input to the Extra Syllabus, as the Extra Pool doesn't expire until July 1, 2006."

There you have it! A tip-o-the-hat to Scotty and the guys in the QPC. All of us have our opinions, and we spout them routinely. How many of us are willing to roll up our sleeves and get the real work done?

Until next time, enjoy the holiday season, and kerchunk a repeater for me.

 (from page 7)



Testing a homebrew 10-GHz horn. The green box at the horn feed on the top shelf is the transverter.

WB6NOA operating the microwave radio system at 100 miles out. The best DX was 450 miles with 100 milliwatts.

added points. On the second day of the Part 1 weekend, most of the fixed base stations down in Mexico and up on big mountains would also move 10 miles away, providing additional rework opportunities for any station unable to be moved easily.

"These are the two weekends that you get your gear out and up at a high site," adds Dave Glawson, WA6CGR. He is a microwave forum presenter at the American Radio Relay League Southwestern Division Convention and the resident microwave technical expert, who invites everyone with microwave gear to come to his lab and put together an improved microwave transverter system.

Along the West Coast, members of the San Bernardino Microwave Society were pleased with their results on the first weekend of the September contest. "I made 47 10-GHz contacts, 36 unique callsigns, and best DX was 741 kilometers," comments Tony, KC6QHP, who went roving from the flat lands to mountaintops.

"No problem here; I'll work Mexico from a bounce," comments Chuck, N6EQ, running a couple of watts on 10 GHz, aiming his signal at a hill about 50 miles away in the opposite direction of the group in Mexico. He completed the contact with ease, but when he pointed his dish directly at the stations in Mexico, nothing was heard! Case in point: When working over water, you literally might be too high above the duct to complete a direct contact on 10 GHz, but looking around for a bounce from a lower source might easily do the trick.

Well-known microwave DXer Chip Angle, N6CA, found the perfect answer to minimize his having to readjust dish pointing to stations regularly throughout the Southland. He drove to the vicinity of a big metal water tower, aimed his dish at the water tower, and *easily* worked stations hundreds of miles away, running just milliwatts off the two-way bounce. "I just sit here and work them in all directions in just *one* direction!" adds Angle with a smile.

To point out further that height over a water path is not important, I took our 500-mW, 10-GHz system down to the seashore and *easily* worked over the 500-mile path. The only problem encountered during my operating on the beach was the many onlookers who crowded around the dish and asked questions about my obvious whale migration tracking. At first I tried to explain ham radio microwave DXing, but I found it was much simpler to just say I was beaming in on the humpbacks.

The rovers, the Mexico operators, and the many 10-GHz fixed-site teams all included a cluster of stations to work the path consecutively. The strongest station usually went first so everyone could line up for the best signal strength. Then the progressively smaller stations within the group came up individually to make contact again, resulting in signal reports over 500 miles from stations running as much as 15 watts to a station with just under 50 milliwatts! Certainly, higher power makes a difference, but when the path is open, even the milliwatts can make the grade over hundreds of miles!

A further check of 10-GHz reception and propagation are the many 10-GHz propagation beacons. These beacons usually employ omnidirectional antennas, and a quick point toward the beacon will reconfirm frequency stability and spot-on operation, plus an open path to the distant continuously transmitting station.

How to Easily Operate 10-GHz Microwave

If you want *absolute* plug and play, and if you plan to work a pal with the same type of equipment, the wideband, full-duplex equipment from Advanced Receiver Research (ARR) is a fun way to get started. Just add a crystal microphone, plug into 12 volts, and start tuning around for your pal's signal. My best range on ARR equipment at 10,000 MHz was over 300 miles away!

For serious 10-GHz microwave work, however, you will want to use a multimode radio which you may already have as your operating equipment, either on 10 meters SSB or on 144 MHz SSB (always upper), which is then fed into a *transvert-*

er. The transverter takes your HF or VHF rig and works it up to the 10-GHz band (and even higher frequencies with different types of transverters). The best selection of fully assembled transverters comes from Down East Microwave <http://www.downeastmicrowave.com> and SSB Electronics <http://www.ssbusa.com>.

One of the best sources to help you choose the right type of transverter is found on the Down East Microwave website, and it is called "Interfacing Transverters." There are four great pages of explanations and drawings. You can also call Jerry at SSB Electronics, and he, too, will instantly become an expert on the most popular transverter for your particular IF radio.

"A transverter is a receive converter and a transmit converter joined by a common local oscillator. All filtering, signal processing, memory storage, scanning, frequency splitting, and all of the other bells and whistles that your transceiver can do may also be done on another band with a transverter," comments Down East Microwave on their website tutorial page. Look up 3-cm products and note that some of their transverters are completely assembled, while others are less expensive kits. Model numbers begin with the common 10-GHz frequency of 10,368 MHz. The complete transverter for 10 milliwatts output is priced at $395.

Jerry at SSB Electronics assembled my equipment. They import the DB6NT transverter system, which is a complete 3-cm transverter housed in one module. It puts out 200 milliwatts, and with a power amplifier, its output can be increased to a whopping 10 watts. For SSB Electronics pricing, call 570-868-5643, and tell Jerry that Gordo sent you!

Also, ask each of these component sellers about specific transverter tie-ins with

Putting Together The SSB Electronic USA 10-GHz System

By Gordon West, WB6NOA

Microwave enthusiasts wishing to get up and running on 10 GHz single sideband in multiple boxes may now do so with pre-assembled modules for a fun weekend project. Until recently the only way to get up on 10 GHz in a completely assembled package was via the transceivers available from Advanced Receiver Research. The ARR system is still a popular way to explore 10 GHz, but it offers only FM capabilities. Everyone is now switching over to SSB.

The SSB Electronic 10-GHz individual packages consist of the following modules:

- XLO-1 local oscillator module
- XRM-1 10.368-GHz receive down converter
- XTM-1 10.368-GHz transmit up converter
- HP8761 single-pole, double-throw RF switch
- SMA to 10-GHz wave-guide adapter
- Control relay
- Output TR relay

The modules come from Gerry Rodski, K3MKZ, at SSB Electronic USA (124 Cherrywood Drive, Mountaintop, PA 18707; 570-868-5643, <http://www.ssbusa.com/index.html>) . Gerry is quite knowledgeable about what it takes to put the system together and on the air. SSB Electronic equipment was used for the first 10-GHz EME QSO.

The XLO-1 local oscillator module puts out about 5 milliwatts on 2556 MHz. A fifth overtone crystal at 106.5 MHz is used in the temperature-compensated oscillator, and all multiplier stages are filter coupled in order to achieve a clean output.

The XRM-1 receive mixer requires an injection signal of approximately 5 milliwatts at 2556 MHz. A separate SMA connector is provided for LO output at 10.224 GHz for transmit mixer operation, and received signals are amplified by a two-stage, low-noise GaAsFET pre-amp. A cavity filter follows the pre-amp to provide filtering. A mixer is used to provide IF output at 144 MHz, using almost any popular 2-meter, multi-mode transceiver. In my case, I used a Kenwood TR-751 with the final PA amplifier bypassed in order to keep my exciter well below the 100-milliwatt drive. Thanks to Craig Clark at Kenwood for his instructions on power down for the 751.

The XTM-1 transmit mixer requires an LO injection signal of approximately 5 milliwatts at 10.224 GHz. We set the on-board attenuator to 100 milliwatts of IF drive. An active GaAsFET mixer is utilized to provide a sum and difference output of 10.224 GHz plus the 144-MHz IF input. The summed output of the mixer is selected by an on-board cavity filter tuned to 10.368 GHz, and the resulting signal is amplified to the 200-milliwatt level by three cavity-coupled GaAsFET amplifier stages.

The RF switching relay was a tough one to find. It's listed in the Hewlett-Packard catalog for just under $400, and you don't usually find these items at local swap meets. I lucked out and found an SMA to 10-GHz feed from Jim Ford, N6JF, who lives just across the street!

The modules are completely pre-tested and pre-assembled inside their rectangular silver cans. Gerry relies on hams to do their own assembly of the component parts he supplies. He indicates that if there is enough interest from those going to microwave on 10 GHz for a completely preassembled station, minus the IF, he might consider putting together the entire system—similar to what ARR does for its FM 10-GHz equipment.

Assembling these little boxes on your own and coming up with the HP relay, plus adding the cost of the multi-mode 2-meter transceiver, will probably cost you close to $850. While Gerry is not quite convinced that a microwaver would want it all put together and ready to roll for twice that amount of money, he nonetheless is open to suggestions. I agree that a couple of thousand dollars seems a bit much for the entire 10-GHz station, fully assembled for PTT operation, including a multi-mode 2-meter transceiver properly modified to put out absolutely no more than 100 milliwatts peak envelope power (PEP).

Once I got everything up and running, I quickly swept the dial and lo and behold, the N6CA 10-GHz beacon 40 miles away came pounding in loud and clear using a relatively small aluminum horn antenna. The beacon was so strong that I could pick it up in all directions, and even cross-polarized! I could hear it quite nicely off a passing airplane, and the flutter was unbelievable to listen to at 10 GHz. The next day I tried for additional beacons down the coast, and sure enough, they popped in loud and clear from over 80 miles away.

Frequency stability was excellent after a 20-minute warm-up time. Although squeezing the box didn't seem to make any difference, wiggling the power cables did! It doesn't take much to create warbles on the band, but with the SSB Electronic components, things are rock solid if you just quit messing with the loose wiring on the outside!

It's important to know that Gerry at SSB Electronic USA is an avid microwaver, and he's happy to talk with you to help you plan your system. While he doesn't have the time or personnel to put the system together for you, he can tell you exactly what you need to get it going using the components he has, plus fill you in on other sources for items such as the HP RF relay.

If you're looking for a new challenge, consider the SSB Electronic USA individual modules for 10 GHz on the full 10,000 MHz setup. On a hot summer afternoon when the tropospheric duct is in, it's quite possible to exceed several hundred miles with a transceiver that is pulling less than 600 milliamps at 12 volts DC.

If you've thought about getting on 10-GHz SSB, give Gerry Rodski, K3MKZ, at SSB Electronic USA a call!

your individual radio. You may need to run your local radio on minimum power output, and make absolutely sure it could never go to a higher power output that might damage the transverter input. You will also need to wire in hard keying to complete the TX/RX function on the transverter. Both Down East and SSB Electronics offer 10-GHz horns and dishes that can provide over 25 dB gain to your little microwave signal. You will also need waveguide or 10-GHz microwave tubing to get the signal in and out of the dish or horn. My own station uses marine 10-GHz radar flexible waveguide with minimal loss.

You may also wish to consider an additional preamp for your microwave system. They make a difference! Most recently, Dennis Kidder, WA6NIA, and I were demonstrating 10-GHz beacon reception off a bounce to a nearby tall building, when all of a sudden his receiver began crackling with an unknown noise source. At that very moment, the sun came up over the top of the building and gave us an additional 3 dB of receiver sun noise as it began to appear over the metal building's sharp rooftop structure.

A hot receiver to a minimum 2-foot diameter dish should exhibit a slight increase in background noise when the dish is aimed squarely at the sun, putting the front-mounted feed-horn shadow directly into the center of the dish. Most amazing, however, was the dramatic increase of background noise as the sun peaked over the top of the building, with our receiver aimed squarely at the top.

Did the central and east microwave operators beat the California 800-kilometer DX? If there had been another mountain a couple of hundred miles up the coast, we probably could have made 1000 kilometers on 10,000 MHz.

Are you tired of working the same old DX on the lower bands? Then come on up to what is rapidly becoming one of the most popular, top microwave bands and join in the fun. ■

Errata: "How to Transform a Transformer"

In the Summer 2003 issue of *CQ VHF,* on page 24, we ran the article "How to Transform a Transformer," by George Murphy, VE3ERP. Here is an additional table to go with that article.—*N6CL*

Round Enameled, Copper Power-Transformer Wire

Ref. *Reference Data for Radio Engineers,* 2nd edition 1949, p.126, & "Round Heavy Film Insulated Solid Copper" chart © Belden Corp.

AWG #	Wire Size	Enamel O.D.	Turns per in.	Max. I @ 1000 A/in.^{2}	Q/M ft. @ 20°C	Q/M ft. @ 50°C	Coil Margin	Layer Insulation
10	.1019	.1089	8.3	8.155	1.00	1.12	.250	.0100
11	.0907	.0976	9.3	6.467	1.26	1.41	.250	.0100
12	.0808	.0875	10.4	5.129	1.59	1.78	.250	.0100
13	.0720	.0784	11.6	4.067	2.00	2.24	.250	.0100
14	.0641	.0703	12.9	3.225	2.53	2.83	.250	.0100
15	.0571	.0630	14.4	2.558	3.18	3.57	.188	.0100
16	.0508	.0564	16.1	2.028	4.02	4.50	.188	.0100
17	.0453	.0506	18.0	1.609	5.06	5.67	.188	.0100
18	.0403	.0453	20.1	1.276	6.39	7.15	.125	.0050
19	.0359	.0406	22.4	1.012	8.05	9.02	.125	.0050
20	.0320	.0364	25.0	0.802	10.15	11.37	.125	.0050
21	.0285	.0326	27.9	0.636	12.80	14.34	.125	.0050
22	.0253	.0292	31.1	0.505	16.14	18.08	.125	.0030
23	.0226	.0262	34.7	0.400	20.36	22.80	.125	.0030
24	.0201	.0235	38.7	0.317	25.67	28.75	.125	.0030
25	.0179	.0211	43.2	0.252	32.37	36.25	.125	.0020
26	.0159	.0189	48.2	0.200	40.81	45.71	.125	.0020
27	.0142	.0169	53.8	0.158	51.47	57.64	.125	.0020
28	.0126	.0152	60.0	0.126	64.90	72.69	.125	.0020
29	.0113	.0136	66.9	0.100	81.84	91.66	.125	.0020
30	.0100	.0122	74.7	0.079	103.19	115.58	.125	.0015
31	.0089	.0109	83.3	0.063	130.12	145.74	.125	.0015
32	.0080	.0098	93.0	0.050	164.08	183.77	.094	.0015
33	.0071	.0088	103.7	0.039	206.90	231.73	.094	.0015
34	.0063	.0079	115.8	0.031	260.90	292.21	.094	.0010
35	.0056	.0070	129.2	0.025	328.99	368.47	.094	.0010
36	.0050	.0063	144.1	0.020	414.85	464.63	.094	.0010
37	.0045	.0057	160.8	0.016	523.11	585.89	.094	.0010
38	.0040	.0051	179.4	0.012	659.63	738.79	.063	.0010
39	.0035	.0045	200.2	0.010	831.78	931.60	.063	.0008
40	.0031	.0041	223.4	0.008	1048.86	1174.72	.063	.0008

All dimensions are in inches.
"Enamel" refers also to any plastic film coating.
Thickness of enamel varies among manufacturers. Values shown are maximum.
Turns-Per-Inch based on turns spaced at 110% of enamel O.D. center-to-center.
Current capacity based on 1000 amperes per square inch.

Billy, KD5KDR, radio operator for the airplane.

Billy, WM5U, displays the ATV package ready to fly.

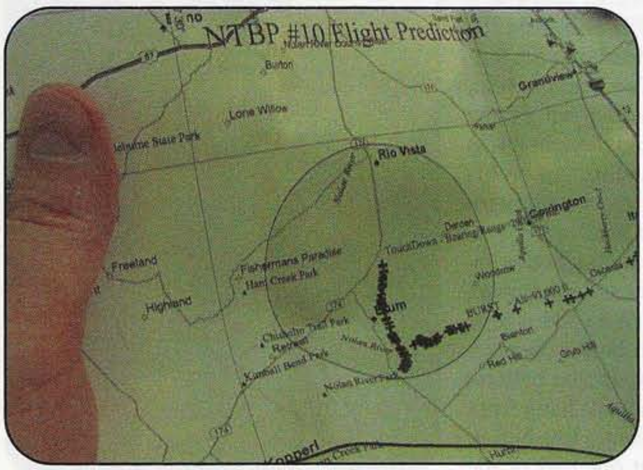
further effort to maintain the momentum we published minutes of the meetings on the club's e-mail reflector.[2]

Selecting a launch site was critical for us as well. The DFW International Airport is one of the largest and busiest airports in the U.S., and the airspace around DFW is Class B. There is a Terminal Control Area (TCA) for a radius of 30 nautical miles (nm) from the airport extending up to 11,000 feet above ground level. The FAA rules for balloons indicate that unmanned free balloons are not allowed to fly in this volume of airspace. With all of these considerations in mind, we decided to launch to the south. We selected the Hillsboro Municipal Airport (FAA identifier 5T5) and made contact with Dave Heald, the airport manager, who also happens to be an amateur radio operator (KA5ZAM). Dave was a great help, and he even allowed us to use his hangar to fill the balloon.

In the weeks leading up to the launch, several Boy Scout troops were contacted both in Fort Worth and Hillsboro. Members of the balloon project went to several troop meetings and helped some of the Boy Scouts with their requirements for the Radio merit badge. The boys were invited to watch the launch. As a result of this preliminary work, several Scouts showed up for the launch and said they thought it was cool to see a weather balloon going up. They watched the live ATV video and thought that was pretty neat, as well. In an effort to maintain this relationship with the Boy Scouts, the Lockheed Martin ARC plans to work with them to finish the Radio merit badge by participating in Jamboree-On-The-Air (JOTA) on October 18–19, 2003.

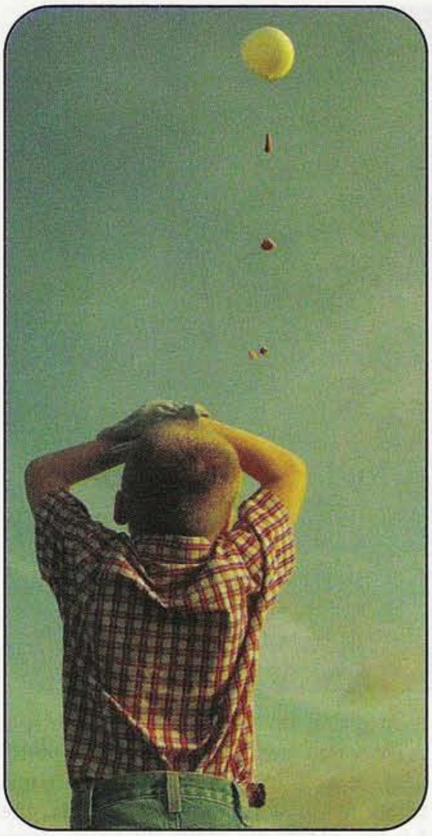
Houston, We Have A Problem…

Despite the best planning, you just can't have a project this big without "Murphy" making his presence felt. At the beginning of August, we heard that President Bush was going to spend the



Recovery team's flight-prediction map.

Several Boy Scouts attended the launch.



Carter Reid, grandson of Dave, KA5ZAM, the Hillsboro, Texas airport manager.

entire month at his ranch in Crawford, Texas, and he did not plan to return to Washington until a few days after our launch. This was important, because wherever the President goes, there are areas of Temporary Flight Restriction (TFR). There is a TFR area around Crawford, designated P-49 all the time, and it grows larger in radius to 30 nm. The TFR extends from the ground to 18,000 feet above ground level. As it turns out, Hillsboro Municipal Airport is located just over 36 nm from Crawford. There were several people very concerned about the potential of our balloon flight path violating the TFR.

Another complicating factor was the approach of a cool front from the north in the days prior to launch. Our experience had shown that launching close to a frontal passage tends to make the predictions from BALLTRAK inaccurate. A lot depended on the timing of the approaching front.

Countdown!

Launch day arrived, and it looked as though we would be able to beat the cool front. The BALLTRAK predictions in the days leading up to the launch showed a landing site to the northwest and substantially clear of TFR P-49. We met for breakfast at 5:30 AM and got to Hillsboro Municipal Airport by 7:30 AM. Randy, WO5M, performed the BALLTRAK prediction for the last time and declared that we were "go" for a launch.

At the same time, Jory, KJ5RM, set up the HF net station and Mike, WB5QLD, set up the APRS station. Several ATV ground reception stations were set up. In addition, the DF teams prepared their mobile DFing units. Meanwhile, John, KA5WAL, and Billy, KD5KNR, landed at the airport, and we had a laugh when we saw Billy get out and kiss the ground. He's not used to flying in small aircraft.

Tommy, W5TCD, got an area in Dave's hangar ready while David, KC5UYR, backed up the truck with the helium tanks. Final payload weights were taken and lift was calculated for a specific lift-to-weight ratio. Ken Knudsen, N5TY, the balloon-filling master, began his task while Doug, KG5OA, and Bill, WM5U, energized the payloads and verified that they were working.

It may have looked like a disorganized bunch, but everyone was taking care of his assignments. Everything was going along smoothly. In fact, we had everything ready to go some 30 minutes before the anticipated launch time. We'd never been ready to launch early! With the front approaching, the decision was made to go ahead and launch. The balloon was about 8 feet in diameter and the hangar door opened about 10 feet in height, which didn't give us much clearance.

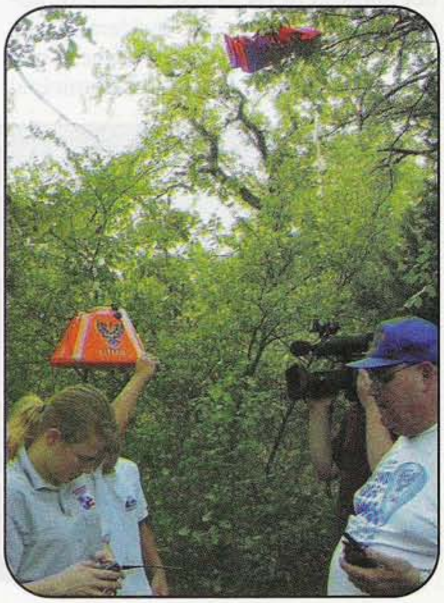
Ken, N5TY, saw a creeper and asked Dave if he could use it. With Bill, WM5U, and David, KC5UYR, steadying the balloon in the light wind, Ken held the neck of the balloon as he rolled out of the hangar on the creeper. Ken thought it was more dignified than crawling out on his hands and knees, and it was a truly ingenious use of the items at hand.

The suspension line was attached to the balloon and all the knots and clips were taped up for insurance. We used a rope strung through a ring just below the neck of the balloon as a way to let the balloon up slowly and let the payloads hang from the balloon on the suspension line before launch. Then we just let one end of the rope go, which fed through the ring as the balloon began its ascent. This prevented a lot of sudden acceleration, which would have happened if the balloon had just been released, and the payloads would have been yanked out of our hands.

We had told Dave, KA5ZAM, that we wanted one of the locals, maybe one of the Boy Scouts or school kids, to be the one to let go of the launch string. It would be kind of like pushing the button to launch a rocket. Dave brought his 8-year-old grandson, Carter Reid, to do the honors. Carter, son of C. K. and Cindy Reid, is a second grader at Itasca Elementary School. From the photo, you can see that he was ready for the job by wearing his leather work gloves. What you can't see is the huge smile on his face. He did such a great job. It wouldn't be surprising if Carter follows in Dave's footsteps and earns his ham radio license one day!

After a five-year hiatus, we were up in the air again. As we watched the balloon go up, we knew we would have to get it again and had made preparations for that. As we picked up things around the hangar, we got reports from the APRS station that it was ascending slower than we had anticipated. At first we thought the balloon might have had a slow leak in it, but the ascent rate seemed stable. The slower ascent rate meant that it would land farther down range. As the balloon passed 60,000 feet, many of us left the airport to start the hunt.

While on the chase, we were particularly impressed by how well the GPS worked. It kept seven or eight satellites locked in for almost the entire flight. The cross-band repeater was very popular and



First look at the radio package. Where's the ATV package? In front, Melissa, KM5R, and David, KC5UYR.

Posing with the prize. Front row, left to right: (unidentified), Melissa, KM5R, and Guy, KC5GOI. Back row, left to right: James, KF5WT; Mark, N5UWM; David, KC5UYR; and Terry, N5RSE.

we had folks from all over Texas and Oklahoma using it. The ATV worked wonderfully as well. We even got to see the balloon burst. What a sight!

Houston, We Have Another Problem...

Yes, things were going far too well not to have another visit from Murphy! Those of us who were DFing noticed that the package was coming down more slowly than anticipated. Those of us who were watching the ATV understood why. It seemed that the ATV package came down to the ground in much less time than the capsule package. Somehow the two packages had become detached from one another. Most of the DFing teams didn't realize it until the capsule package was recovered minutes after it had landed and saw that the ATV package was not there.

The DFing teams did a very good job of finding the capsule package even though they had to go more than 20 extra miles to get to it. Unfortunately, the ATV package didn't have any RF sources on it except the 1255-MHz ATV transmitter, and no one was set up to DF on that band. A few went to look for the ATV package but to no avail. We had forgotten to put any identification on the ATV package. As a result, even if it were found, there was no way for the discoverer to know where to return it. It seemed at this point that our return to high-altitude weather ballooning was only a partial success. There was much speculation about what had caused the separation. We also decided to meet the following weekend for a flight review debriefing.

Persistence

At the next club meeting we watched the video of the descent of the ATV package. It looked as if it had become separated almost as soon as the balloon burst. We timed the descent, and it occurred to us that we might be able to make an estimate as to where it came down. One of the GPS data strings that the capsule package sent gave us horizontal direction and speed. We took the reciprocal of the direction and made up our own derived winds-aloft data file. We then used BALLTRAK to determine the landing speed of the ATV package (about 34 mph—*ouch!*) and the landing site. We plotted it on a map and that showed it was near Brazos Point, Texas. There was also a unique road formation seen in the ATV video just before landing. Efforts were made to identify the roads using TerraServer, but we didn't find anything. We then decided that we would go out to look for it after the debriefing meeting the following Sunday.

Several folks in our club had helped look for the *Columbia* shuttle wreckage earlier in the year, so they were used to looking for things out in a field. Doug, KG5OA, and Tommy, W5TCD, went in an airplane to look from the air. As we flew toward Brazos Point, we saw the road formation from the plane that we had seen in the video. It was a gravel quarry. We were definitely in the right area. We searched for nearly three hours before it got dark. We found a cooler and a rock, but no ATV package.

Bill, WM5U, visited the local sheriff and distributed pictures of the ATV package with our contact information on the back. Even so, for the second time in as many weeks we went home empty handed.

The next morning, however, our emotions turned to elation. We got a call from Bill, KG5IE, who told us that the ATV package had been found by the manager of the gravel quarry. The manager had picked it up and put it in his office, so there was no way for us to find it even though we had been in the right place. Harold, K5SXK, drove down to get it, and by Monday evening we had the ATV package back at the club. It was in pretty good shape. The styrofoam wasn't in great shape, but the equipment looked pretty good. The only real damage was a capacitor lead had pulled out of the bottom of its can when it got bent over. We were very, very lucky!

Conclusion

"All's well that ends well," they say, and so it was with NTBP Number 10. It was a fantastic experience, and lots of folks had fun contributing to the success of our return to high-altitude amateur radio ballooning. Everyone at the Lockheed Martin ARC is anxious to do another flight, and plans are in the works for a launch next spring.

A balloon project is a great activity for a radio club. It involves most facets of the hobby and appeals to the general scientific curiosity that we amateurs seem to have. It also provides a great educational opportunity for youngsters to be a part of something unusual, interesting, and educational. It shows them a good reason to pursue an amateur radio license. Most of all, a balloon project is just plain fun for all. It seems that there is no limit to the experiments one could conduct.

Notes

1. Crasswell, Jay, "The PortaPeater," *QST*, April 1997, pp. 37–39.

2. See the following URLs: <http://yahoogroup0s.com/w5sjz/> and <http://www.qsl.net/w5sjz/>. ■

CQ's 6 Meter and Satellite WAZ Awards

(As of September 15, 2003)

By Paul Blumhardt,* K5RT, CQ WAZ Award Manager

6 Meter Worked All Zones

No.	Callsign	Zones Needed
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	1,2,3,6,7,10,12,18,19,23,24,26,29,31,32
26	W1AIM	16,17,18,19,21,22,23,24,26,28,29,30,34
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

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

CQ offers the Satellite Work All Zones award for stations who confirm a minimum of 25 zones worked via amateur radio satellite. Last year 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: WAZ Award Manager, Paul Blumhardt, K5RT, 2805 Toler Road, Rowlett, TX 75089. 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 Paul Blumhardt. Applicants sending QSL cards to a CQ Checkpoint or the Award Manager must include return postage. K5RT may also be reached via e-mail: <k5rt@cq-amateur-radio.com>.

**CQ WAZ Award Manager, 2805 Toler Road, Rowlett, TX 75089; e-mail: <k5rt@cq-amateur-radio.com>*

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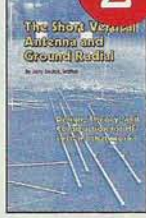

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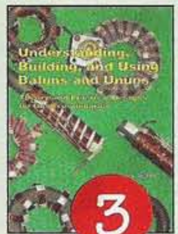

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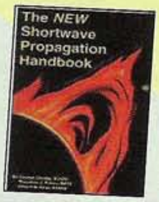

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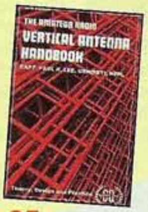

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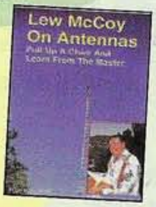

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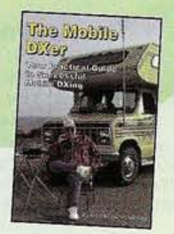

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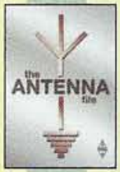

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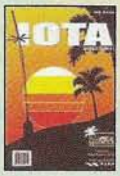

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By Tomas Hood,* NW7US

PROPAGATION

The Science of Predicting VHF-and-Above Radio Conditions

The Fall Meteor Shower Season

Is it possible to predict propagation conditions and DX openings on the frequencies above 30 MHz? Are there reliable models that enable us to forecast sporadic-*E*, aurora, troposcatter, and other known propagation modes?

After many decades of on-the-air experience, the amateur and scientific communities are still struggling to find a practical understanding of the complex modes of propagation unique to VHF and above. While there have been decades of weak-signal and long-range (DX) operation on VHF, most of this historical information is contained in contest and special-event logs. More significantly, most of this data is sparse and the number of operators limited. There is no historical, worldwide data, simply because there hasn't been a large enough population of VHF operators active in weak-signal long-distance DXing. The research done by the scientific community is helpful, but also limited to very specific areas. Therefore, there is a great opportunity for us amateur radio scientists to unlock the secrets of propagation on these higher frequencies.

True worldwide exploration of propagation on the amateur radio bands above 30 MHz has only recently become a reality. The number of active, on-the-air amateurs on VHF/UHF is only now reaching a level high enough to support true research of regional, national, and worldwide VHF/UHF DX. A concerted effort is under way to record daily activity worldwide. More accurate DX clusters where grid-square information is recorded for both ends of the QSO, e-mail reflectors, and on-line forums for real-time discussion of current conditions, and repositories of logs, are all ways we are increasing our knowledge. In addition, detailed geomagnetic and solar data—as well as real-time monitoring of the ionosphere, weather, and propagation—is at our disposal via the internet.

I've begun to organize links to existing projects, DX clusters, research results, on-line data resources, and real-time observations at my web page, <http://vhf-prop.hfradio.org/>. Take a look and join the community of modern amateur scientists working toward unlocking the secrets of propagation on the bands above 30 MHz. We need as many on-the-air operators using as many modes of propagation on as many VHF and UHF bands as possible.

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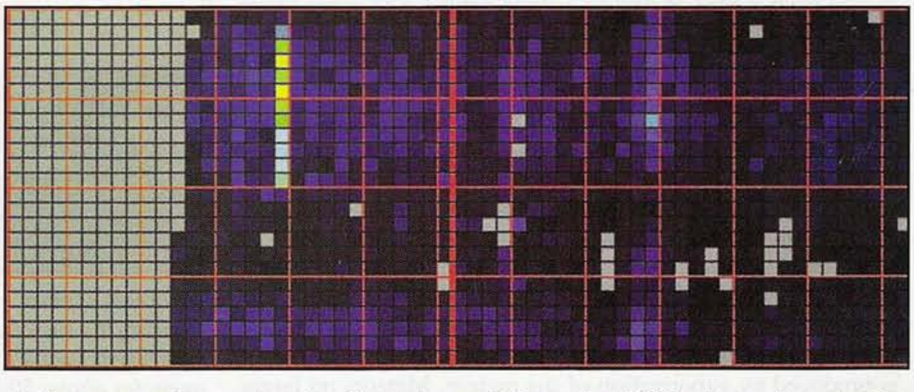


Radio meteor observations for November and December 2002. the horizontal axis shows the day of the month, progressing from left to right. Every five days a red vertical line is drawn. the vertical axis is the hour of the day. Brown squares indicate missing data. Note the high activity on November 19, during last year's Leonids meteor shower. This image is provided courtesy the Astronomical Observatory, University of Ghent (http://allserv.rug.ac.be/~pdegroot/meteor/mc1_02.html).

The *Leonids*

One of the largest yearly meteor showers occurs during November. Appearing to radiate out of the constellation of Leo on the night and morning of November 17–18, the *Leonids* is known to create intense meteor bursts. Since the source of the *Leonids,* the Tempel-Tuttle comet, passed closest to the Sun in February of 1998, the years following were expected to produce very strong displays. The greatest display since 1998 was the peak of 3700 per hour in 1999. Every year since has been significantly less spectacular. However, a few forecasters think that we still might have a meteor storm with an hourly rate of thousands sometime in the next several years. If this year is more typical of the last few, we'll see a rate of several hundred per hour. The visuals might only be 10 to 20 per hour, but when we are talking about meteor scatter radio propagation, we count the smallest meteor-formed plasma clouds that will support VHF radio signals.

There is a prediction this year that the Earth will pass through the 15th revolution of the Tempel-Tuttle comet on November 13, five days earlier than the normal *Leonids* shower. The prediction of Esko Lyytinen and Tom van Flandern (http://leonid.arc.nasa.gov/1998.html), calls for a possible peak of up to 250 visual meteors per hour. Recently, Jeremie Vaubaillon of the Institut de Mecanique Celeste et de Calcul des Ephemerides, France, confirmed Esko's calculations. Based on these calculations, the normal *Leonids* shower could produce a ZHR (Zenith Hourly Rate) of up to 50 per hour. The ZHR refers to the expected number of meteors that will be seen in an hour under ideal conditions, such as a moonless sky without any interfering artificial illumination. For those of us who are interested in working meteor-scatter propagation, the ZHR helps us gauge the general level of activity of a shower. A far greater number of non-visual meteor bursts that will support propagation of VHF signals will occur.

The best time to work meteor scatter

off the *Leonids* is around 11:30 PM, local time, in the Northern Hemisphere. Alaska and the Pacific Northwest could be the best area to work the first, November 13, peak. For the normal peak, at 0150 UTC November 18, the best location will be the eastern side of North America.

Working Meteor Scatter

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

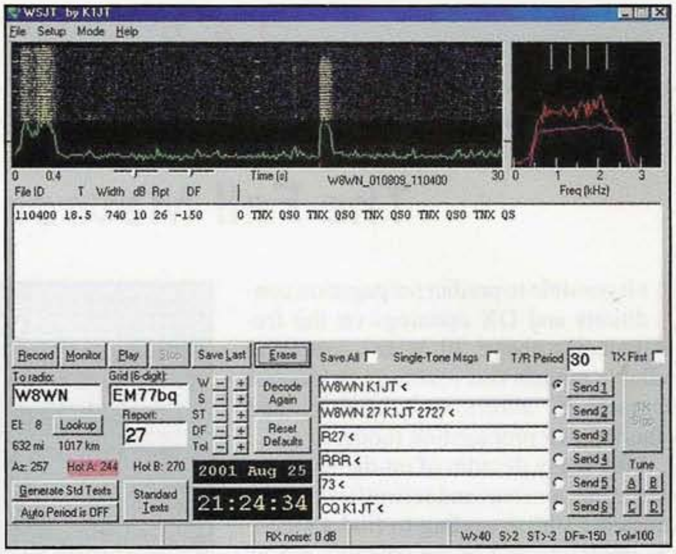
Meteor-scatter propagation is a mode in which radio signals are refracted off these trains of ionized plasma. The ionized trail is produced by vaporization of the meteor. Meteors no larger than a pea can produce ionized trails up to 12 miles in length in the *E*-layer of the ionosphere. Because of the height of these plasma trains, the range of a meteor-scatter contact is between 500 and 1300 miles. The frequencies that are best refracted are between 30 and 100 MHz. However, with the development of new software and techniques, frequencies up to 440 MHz have been used to make successful radio contacts via these meteor trains. On the lower frequencies, such as on 6 meters, contacts may last from mere seconds to well over a minute. The lower the frequency, the longer the specific "opening" made by a single meteor train. A meteor train that supports a 60-second refraction on 6 meters might only support a few seconds of refraction for a 2-meter signal. Special high-speed methods are used on these higher frequencies to take advantage of the limited available time.

A great introduction on working meteor scatter by Shelby Ennis, W8WN, may be found at <http://www.amt.org/ Meteor_Scatter/shelbys_welcome.htm>. OZ1RH wrote "Working DX on a Dead 50 MHz Band Using Meteor Scatter," a great working guide, which may be found at <http://www.uksmg.org/ deadband.htm>. W4VHF has also created a good starting guide at <http://www.amt.org/Meteor_Scatter/letstalk-w4vhf.htm>. Links to various groups, resources, and software are at <http://www.amt.org/Meteor_Scatter/default.htm>.

The next big meteor shower after November's *Leonids* is the yearly *Geminids,* which is active between December 6 and 19, with a possible ZHR of 60, peaking on December 14 at 1510 UTC. After this one comes the *Ursids,* which is active between December 17 and 26. Following this one is the *Quadrantids,* or *Quads,* which is active between December 28 and January 7 with a ZHR of about 50 and peaking on January 4 at 0450 UTC. In addition, there are many smaller showers during the fall meteor shower season. Check out <http://comets.amsmeteors.org/ meteors/calendar.html> for a good look at what is in store.

Sporadic-*E* this Fall

The 2003 summer sporadic-*E* season was unprecedented. Two essential ingredients made this exceptional opportunity



A screen-capture photo of WSJT running in FSK441 mode showing the end of a QSO between K1JT and W8WN. The WSJT software is useful for meteor-shower weak-signal work on frequencies above 50 MHz, because of the extremely short working time off the meteor train. (Image from <http://pulsar. princeton.edu/~joe/K1JT/>)

possible: There are a greater number of weak-signal DX operators on VHF than ever before, and there were many daily sporadic-*E* openings throughout the entire summer. History was made during this season, with records broken for sporadic-*E* contacts as high up in the bands as the 220 MHz.

While the sporadic-*E* season is over, being mostly a summertime phenomenon, there is normally some sporadic-*E* activity during late December and early January. It is well documented that sporadic-*E* occurs most often in the summer, with a secondary peak in the winter. These peaks are centered very close to the solstices (December 21 being the next one). The winter peak can be characterized as being five to eight times less that the summer sporadic-*E* peak. Since the sporadic-*E* activity was so intense this last summer, can we expect exceptional sporadic-*E* propagation during December?

We do not yet fully understand the causes of sporadic-*E*. Scientists are still pursuing the cause, or more likely the multiple causes, of sporadic-*E*. As far back as 1959 ten distinct types of sporadic-*E* and at least nine different theories of causation were offered. The classification of distinct types has been retained, but since the 1960s, the wind-shear theory has become one of the most accepted theories.

Simply, the wind-shear theory holds that gaseous ions in the *E*-layer are accumulated and concentrated into small, thin, patchy sheets by the combined actions of high-altitude winds and the Earth's magnetic field. The resulting clouds may attain the required ion density to serve as a reflecting medium for VHF radio waves. Although most research has confirmed a close association between wind shear and sporadic-*E*, not all aspects of the sporadic-*E* phenomenon can be explained, including its diurnal and seasonal variations.

If wind shear is one of the most pronounced causes of sporadic-*E*, what is the trend of our global weather patterns for the autumn of 2003 in the Northern Hemisphere? Weather experts

The 2003 Microwave Update Conference, Washington State

I had a chance to speak at the 2003 Microwave Update Conference (http://microwaveupdate.org/) on September 27, 2003. The conference was in collaboration with the Pacific Northwest VHF Society (http://www.qsl.net/pnwvhfs/). What an experience! In attendance were some of the history-making weak-signal VHF/UHF DXers I've heard so much about. I had a chance to hear the current banter about microwave technology and components and regulatory issues (mostly related to band sharing). My presentation, entitled "Predicting Propagation on 50 MHz and Up," was a challenge, because the audience was made up of those who cut their teeth on the very modes of propagation I discussed, and they are the ones who are pushing the limits of our knowledge. You can take a look at my presentation at my new page, <http://vhfprop.hfradio.org/>.

predicted that 2003 would be a year of strong hurricane activity. They based this on the confluence in time of La Niña, with a multidecadal pattern of tropical rainfall that supports hurricane activity. For the past few years the presence of El Niño has suppressed hurricane activity in the Atlantic. However, as El Niño petered out in March and April, signs of cooling in the Pacific Ocean in May indicated La Niña was close on its heels. The stepping in of La Niña at the beginning of the hurricane season is a situation that has only arisen twice in the last eight hurricane seasons. Both 1998 and 1999 had moderate to strong La Niña episodes during the months between July and December, according to NOAA. Hurricane Mitch, for example, was one of the strongest storms ever recorded in the Atlantic and first began as a tropical depression on October 22, 1998, according to the National Climatic Data Center.

La Niña's typically cooler-than-normal temperatures in the Pacific Ocean influence the global atmospheric conditions and make for an active Atlantic hurricane season. In El Niño or neutral years, wind directions and speeds create a high vertical wind shear between the lower and upper atmospheres, such that the weaker westerly jet stream winds cut off the tops of storms that develop in the strong easterly trade winds. When La Niña enters the scene, it tends to strengthen the upper-level winds and cause the lower trades to lose their gusto.

"La Niña tends to make winds more uniform as you go up through the atmosphere," says senior research scientist Gerry Bell of NOAA's Climate Prediction Center. He adds, "La Niña contributes to more hurricane activity primarily by acting to decrease the vertical wind shear in the heart of the main development region."

Looking at the data for the summer, La Niña did not play a significant role. Yet neither did El Niño. The Climate Prediction Center reports that sea-surface temperature anomalies in the Niño regions increased during early June through early July, but then decreased during the last half of July and remained fairly steady during August.

Could this change from the typical El Niño activity of the last few years to the neutral activity (if not La Niña activity) of 2003 be correlated with the increased sporadic-*E* activity of this last summer? If so, then we can expect a continuation of the strong sporadic-*E* activity during the second yearly peak, during December. According to the Climate Prediction Center, the possibility of a development of either El Niño or La Niña is quite low through the last months of 2003. You can view an up-to-date outlook on these conditions at <http://www.cpc.ncep.noaa.gov/products/predictions/>.

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 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 may also view live radar displays of the same area. These graphs help identify sporadic-*E* clouds existing in the higher latitudes. One use for this would be the detection of a variation of sporadic-*E*, known as auroral-*E*.

Michael Hawk has written an informative overview of sporadic-*E*. It may be read online at <http://www.amfmdx.net/propagation/Es.html>. We'll dig deeper into sporadic-*E* in an upcoming issue of *CQ VHF*.

Field Aligned Irregularities

Often, directly after sporadic-*E* events, a unique and relatively unexplored mode of propagation known as Field Aligned Irregularities (FAI) develops. FAI is an area of electrons vertically aligned with the Earth's magnetic-field lines. These electrons are often directly created by the sporadic-*E* event.

Propagation of signals from 50 MHz to at least 144 MHz is possible, even if the Maximum Usable Frequency (MUF) of the sporadic-*E* opening did not reach much above 50 MHz. FAI openings may last for several hours, and from the research conducted so far, it has been found that FAI tends to work best from 8 PM to midnight, local time.

To work FAI, you and the distant station should point your antennas toward a common scattering region where there is an active or recent sporadic-*E* reflection point. Then begin turning your antenna slightly to either side to maximize reception. Most of the time, the point you end up aiming at is not a direct line toward the distant station. Rather, it is skewed quite a bit off of the straight-line bearing. FAI signals are typically weak and very fluttery. Doppler shifts of up to 3 kHz have been observed. While some FAI might be strong enough to support a simple Yagi 100-watt signal, you will want to have higher power and a higher gain antenna for reliable results. Because FAI exists in the *E*-layer, path distances of up to 1400 miles are possible.

If you have worked FAI, please send me a report. I would like to collect your reports and summarize them here. We'll explore FAI in greater depth in the coming year.

The Solar Cycle Pulse

Geomagnetic activity is finally settling down as expected during the quiet fall and winter season. The smoothed planetary *A*-index from December 2002 through February 2003 reads 17, 18.2, 18.9, clearly climbing as expected during 2003. The monthly readings from March 2003 through August 2003 are 21, 20, 26, 24, 20, and 23. It is anticipated that September and October readings will continue a trend downward, based on the daily observations of lower geomagnetic activity. The planetary *K*-index (*Kp*) during the first part of October often remained between 1 and 2, while the planetary *A*-index (*Ap*) was often, and for long periods, lower than 10. This gives rise to very quiet days.

The observed smoothed sunspot numbers from June 2003 through August are 77.4, 85.0, and 72.7, all somewhat up from low activity from February through May. The smoothed monthly 10.7-cm (preliminary) numbers from January 2003 through August are 144.0, 124.5, 132.2, 126.3, 129.3, 129.4, 127.8, and 122.1. These numbers reflect the steady decline in solar Cycle 23. Don't expect *F*-layer openings this fall and winter. The smoothed monthly sunspot numbers forecast for November through January are 51.2, 48.4, and 44.2, while the smoothed monthly 10.7-cm is predicted to be 103.8, 100.2, and 96.7 for November 2003 through January 2004.

How's DX?

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

Until the next issue, happy weak-signal DXing. 73, Tomas, NW7US

DR. SETI'S STARSHIP

Or was it? Rigorous analysis showed Ehman's prized catch to exhibit all of the characteristics we would expect of a radio signal from a distant planet. All, that is, except one—repeatability. The signal was there, briefly, for just over a minute, and then it was gone forever. Over a hundred follow-up studies later, it has yet to reappear, which leaves us with a problem of sample size. A single event, never repeated and not independently confirmed, may be tantalizing, but it does not constitute proof. The statistician says that when n = 1, all bets are off, and the "Wow!" has been observed only that one time.

If it was indeed what we think it was, why didn't it repeat? By rights, it shouldn't have—not yet. You see, Big Ear achieved its incredible sensitivity by scanning a minute area at a given time—only a millionth of the sky. Now let us assume that the "Wow!" was broadcast into space by a distant civilization, using a transmit antenna, which is the equivalent of Big Ear. You can see that like a bright torch shone in some random direction, this signal would illuminate a scant one millionth of its sky. What are the chances that these two great antennas, one transmitting and the other receiving, would be pointed at one another at the same time? The statistician says that's a million-to-one long shot, squared—one chance in a million million.

We've looked again a hundred times. So what? We have neither scratched the surface nor even felt the itch. All the world's SETI projects to date, multiplied a thousand-fold, might just begin to have a chance to detect the next "Wow!" that washes up on our shores.

That's assuming the "Wow!" is indeed what it appears to be. In more than 25 years of follow-on analysis, we have contemplated numerous alternative hypotheses, from satellite interference to lunar and planetary reflections to equipment malfunction to deliberate hoax, and assigned each—except two—a low probability. We are confident that the "Wow!" was either some previously undiscovered natural astrophysical phenomenon or a valid SETI hit.

Either possibility is an exciting discovery; if only we knew which it is. Maybe some day we will. For now, we amateur SETIzens can only wonder and keep searching for the next "Wow!"

There is one other possibility, a hypothesis that scientists hesitate even to discuss, and it is the historian in me that led me to it. The "Wow!" signal was detected on the evening of 15 August 1977. The following day, Elvis was found dead. Could this have been the Mother Ship calling him home? Ah, but we'll never know, will we?

As a sad footnote to this whole affair, just 20 years after Elvis died, so did Big Ear. The land underneath that beautiful 3½-acre telescope was sold to a developer, and Big Ear was bulldozed under to make room for a commercial golf course.

You see, we have more than Elvis to mourn!

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By Dr. H. Paul Shuch,* N6TX

DR. SETI'S STARSHIP

Searching For The Ultimate DX

The Night That Elvis Died

"Wow!" Dr. Jerry Ehman exclaimed, barely able to conceal his excitement. Then he wrote it down, the most important word he was ever to pen, right there in the margin of the computer printout: "Wow!"

Although Jerry Ehman was not a licensed radio amateur, he was doing what we hams do best—searching for the rare DX. On that August evening a quarter of a century ago, he might well have found it.

The object of Ehman's excitement was a page covered with letters and numbers, recently spewed out of a computer at Ohio State University's legendary Big Ear radio telescope. Where most observers would have seen only random data, the mathematics professor and volunteer radio astronomer instantly recognized the hallmarks of artificiality, which he had long sought. "Just maybe," Ehman thought, "we finally have here proof of extra-terrestrial intelligence."

Big Ear had already been scanning the skies for four years in what was to become the world's longest-running SETI (Search for Extra-Terrestrial Intelligence) experiment ever. An all-sky survey would ultimately sweep the sky around the clock for fully 25 years in search of that elusive fish in the cosmic pond . . . and there it was, in the data printout for the evening of 15 August 1977, compelling evidence that we are not alone.

The "Wow!" signal (named for that most important word Ehman ever penned) is the stuff of legend, the most promising and best known of dozens of SETI candidate signals analyzed over the four decades since SETI was born. This signal was even featured in an episode of the television series "The X-Files," only this detection was not science fiction, but cold, hard scientific fact.

(Continued on page 82)

**Executive Director, The SETI League, Inc., <www.setileague.org>
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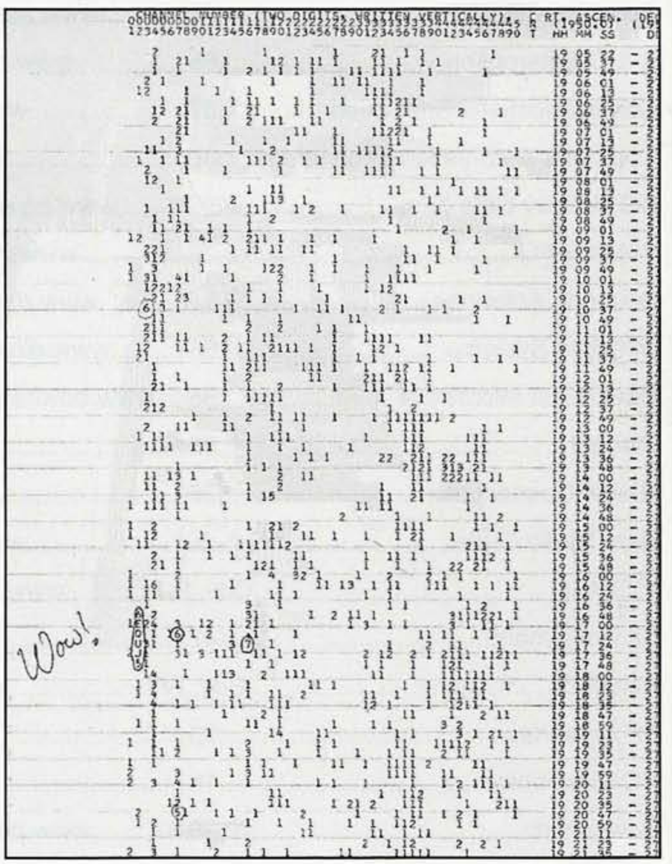
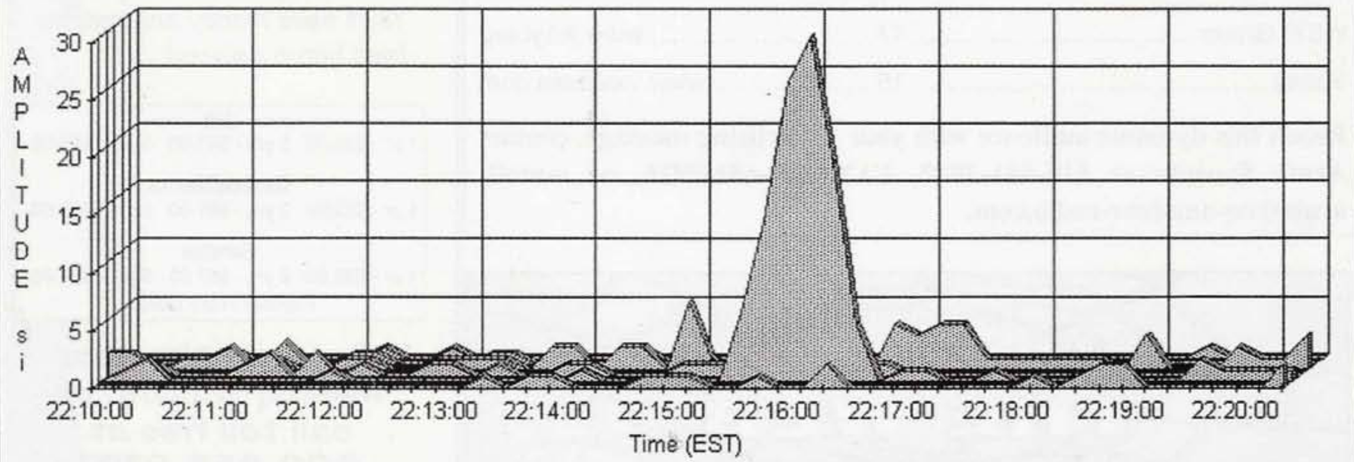


The enigmatic Ohio State University "Wow!" signal printout, complete with Dr. Jerry Ehman's famous annotation. (Big Ear image)



Plotting the raw "Wow!" amplitudes over time and frequency, we see a pattern that nature could not have produced using any mechanism that we know and understand. (SETI League image)

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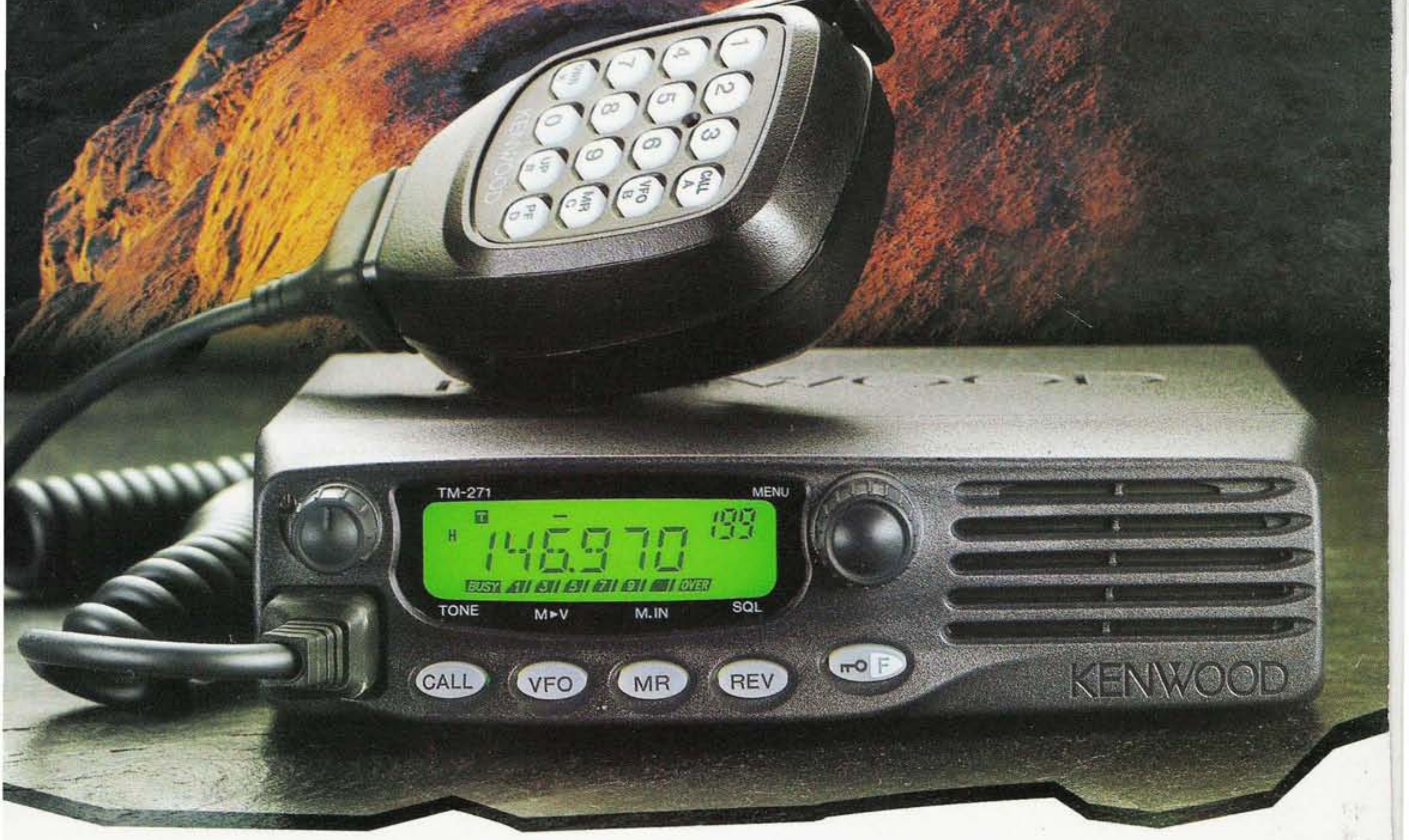

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