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CQ VHF

Ham Radio Above 50 MHz

www.cq-vhf.com

Spring 2002

We're Back!

- KAØY's 42 ft. Dish– A Moving Experience
- Let's Go Roving!
- JT44: Revolutionary EME Software

On The Cover: see pp. 9 & 64

■ VHF/UHF Weak Signal ■ Microwaves ■ Amateur Satellites
■ Repeaters ■ Packet Radio ■ Projects ■ Interviews
■ Plus...Reviews, Product News, and much more!

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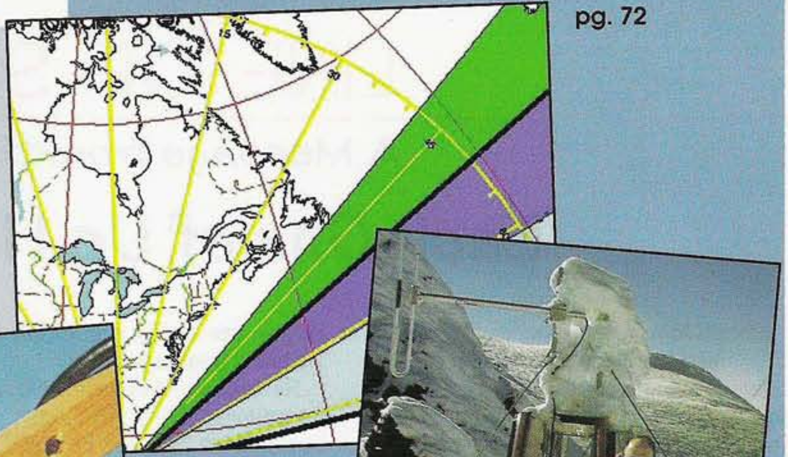

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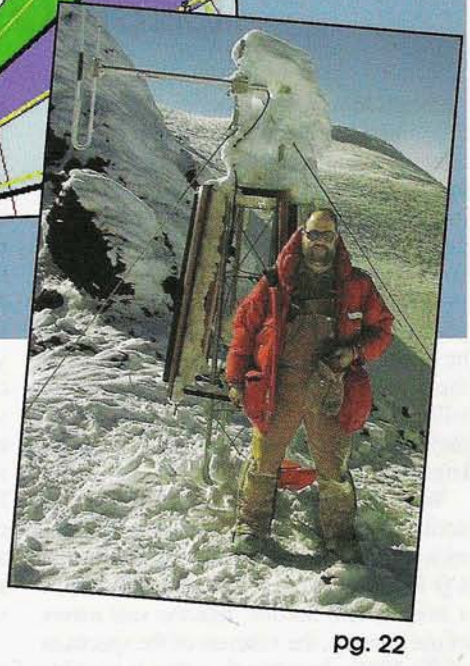

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CQ VHF Ham Radio Above 50 MHz

LINE OF SIGHT

A Message from the Editor

Each One of Us Has a Story

CBS News Correspondent Steve Hartman has made a reputation for himself going around the country looking for stories to tell. His method of locating his storytellers is a bit odd, throwing a dart at a map of the U.S. and following that dart's location to a phone booth in the targeted town where he randomly picks a telephone number from the phone book. After he chooses the name, he makes the call. If the person who answers is agreeable to telling his or her story, Steve arranges an interview with that person and then has his latest tale to tell.

While *CQ VHF* is not run on such a random basis, we have a few concepts in common with Steve's methodology. First, we at *CQ VHF* recognize that all of us hams have a story to tell. Second, like the vast nature of our country, the vastness of the spectrum of the VHF+ ham bands makes it possible for each of us to (almost independently of one another) create our own story. Finally, like Steve Hartman at CBS, it's our job at *CQ VHF* to tell your stories.

As we all know, we have a great deal of ownership of both our individual and our collective stories. At its original inception, *CQ VHF* began to tell our stories as amateur radio operators who specialize in communicating on the frequencies above 50 MHz. The magazine presented the tales of developers, entrepreneurs, contest teams, pioneers—of our heroes. We as readers looked to our heroes to guide and inspire us as we too looked at what was available in this spectrum for us to tackle, for us to use in creating our own stories.

Then it happened. The marketplace changed. We at CQ Communications were caught, as the saying goes, between a rock and a hard place. We could not afford to keep the magazine going and we could not afford *not* to keep the magazine going, so we did the next best thing: We merged *CQ VHF* into *CQ* magazine.

Hindsight is 20/20. Hindsight revealed that while it made economic sense to us at CQ Communications, to you, our readers, it made no sense. Your outcries of having lost your identity as VHF+ enthusiasts inside the pages of *CQ* magazine rose to a crescendo and remained unabated until the announcement of the return of *CQ VHF*. As you can see by way of this magazine, we heard your cry.

Having served for nearly eleven years as the editor of *CQ*'s "VHF Plus" column, I was both honored and humbled to be chosen by our publisher, Dick Ross, K2MGA, to be the editor of the resurrected *CQ VHF*. In my years of service to CQ Communications I have made many friends among you, particularly within the weak-signal community. I have heard your stories at the various conferences I attended across this country. I have visited some of you overseas in countries such as Bosnia, Costa Rica, Cuba, Ecuador, and Mexico. In my column I have told your stories, stories of accomplishments, humorous stories, and sad stories of our heroes who are no longer with us.

What I have not been able to do much of in *CQ* is present your technical work. My column (rather, *your* column) always seemed to run out of room long before I ran out of your stories. Despite my pressing *CQ*'s Managing Editor Gail Schieber, K2RED, Editor Alan Dorhoffer, K2EEK (SK), who hired me, and now Editor Rich Moseson, W2VU, for more space in which to tell more of your stories, the answer was usually no. When it was yes, though, I quickly gobbled up the additional space with more and more of your input.

Now I am delighted to have a whole magazine in which to present your stories, in greater depth. I have room as well for your technical thoughts and ideas.

As your new editor, I will tell your stories by letting *you* tell them. Together we will report on your accomplishments, your ideas, your goals, and your entrepreneurial endeavors. We will share your technical knowledge and your projects with our fellow VHFers.

A couple of ground rules: First, this is not the old *CQ VHF* magazine. It is notched technically higher than the original version, because that is what you asked for. Second, although it is of a more technical nature, it honors and respects our new hams, because they are the lifeblood of the future of our hobby. Therefore, occasionally something may seem to be explained too simply for some of us. This is done in order for our new hams to get up to speed with the rest of us. In short, no one is to be left behind in the pursuit of our goals in this niche of our hobby.

As I pestered my *CQ* magazine editors for more space for my column, so it is that I am already pestering the rest of the staff of *CQ VHF*. In particular, I am urging Arnie Sposato, N2IQO, our Advertising Manager, to sell more ads, and I am requesting more pages from my boss, Publisher Dick Ross, K2MGA, or perhaps if everything works out as well as we hope, someday we can go bimonthly instead of quarterly.

With all of this pestering on my part, I want to leave out no one. Therefore, it's my turn to pester you, our readers. You wanted the magazine back. You have it. Now send me your stories!

I have already been in contact with some of you in order to bring this issue together. I am very pleased with its content. There is a lot of originality and creativity and even a couple of human-interest stories to boot. I am sure that those of you who asked for a higher technical level will be pleased with what you see. At the same time, I am sure that those of you who are new to the hobby will also be pleased with the magazine's inclusiveness.

Nevertheless, for us to get to the next issue of this magazine, and the next and the next, we need your ongoing input. Unlike Steve Hartman, I do not own a set of darts. Therefore, I will not be randomly chasing down stories. In contrast, I will be looking to you to contact me. Again, here is my plea: *Please send me your stories!*

In return for my receiving your stories, I commit to you that I will do my best to have them published as quickly as possible within the constraints of *CQ VHF* being a quarterly magazine. Furthermore, as your editor I will do my best to be of service to you and to make you look really great in print.

I look forward to a long and prosperous future for this resurrected version of *CQ VHF*. I look forward to learning still more about our wonderful hobby by reading your stories. Finally, I look forward to meeting and getting to know you as you tell me and the rest of the VHF+ world your wonderful stories of accomplishments on the VHF+ ham bands.

73, Joe, N6CL

"CQ VHF—Take 2"

It was a great idea: A full-fledged magazine tailored specifically to the needs and interests of the 300,000 Amateur Radio licensees in the USA alone whose interests or license class drew them to the amateur bands above 50 MHz. Launching on the heels of the inception of the first code-free amateur license in the USA, the concept was a sure winner. Or so we thought in 1995 when we first planned the monthly edition of *CQ VHF*. Who was it that said, "The best laid plans of mice and men oft times go awry." Robert Browning, I believe, but with a bit of a Scottish brogue in the original.

And awry the plans did go, indeed. Paper prices soared 82% in seven months, the newsstand industry began to come apart at the seams, postal rates jumped over 10%, insurance rates went up over 20%, the Amateur Radio Industry hit a speedbump, and as if those weren't enough to digest, in 1999 *CQ* editor K2EEK died suddenly. He needed to be replaced, and we already had on staff the best editor in the Amateur Radio business, Rich Moseson, W2VU, albeit as editor of *CQ VHF*. It was a tough but obvious decision. With its multiple business woes, and with its editor needed to head our core product, *CQ VHF* had to go.

But here we are again! Why? How?

We never lost our belief in the editorial viability of *CQ VHF*, but we needed a different business plan. The magazine you hold in your hand is the result of a year's research and planning which led to the development of a dramatically different business model, one which is economically driven by the reader and largely independent of the vagaries of the advertising community and the turmoil of the newsstand market.

As a quarterly magazine, the economic prospects for *CQ VHF* are solid. Editorially, I'm confident you'll agree that the new *CQ VHF* under the stewardship of editor Joe Lynch, N6CL, is a rock-solid package that will appeal to a wide range of serious VHF+ operators and enthusiasts, perhaps even more so than the original *CQ VHF*. Freed of much of the original mandate to address equally the new VHFer and the advanced operator, this new product is quite extraordinary.

Please tell your friends about the new *CQ VHF*, and just as important, urge them to subscribe. Those subscriptions will help ensure a long life for *CQ VHF*.

For now, though, sit back and prepare to enjoy. Welcome to the new *CQ VHF*!

Dick Ross, K2MGA
Publisher

. . . Message from the boys in the back room

Welcome Back . . . to YOUR Magazine

The folks who read the original *CQ VHF* were a pretty diverse lot, with interests ranging from FM to satellites to moonbounce to microwaves, and just about everything in between. But there were two things they had in common—they loved *their* magazine and they were not happy when we were forced to cease publication at the end of 1999. In fact, many of our readers at that time—many of *you*—felt personally offended that we had taken away something of *yours*. It served us right, I guess, since one of our goals when we started the magazine back at the end of 1995 was to create a magazine that was an ongoing dialog with and among its readers.

Let me make one thing clear: Shutting down the original *CQ VHF* was *not* something we *wanted* to do. The economic realities of the ham radio marketplace at the time forced our hand, and frankly, the situation didn't turn the corner until recently. But one thing never changed—your commitment to wanting *your* magazine back again. We heard you and decided we had to try to figure out a way to bring back *your* magazine in a way that made economic sense. We hope we've got the right formula this time. But our success depends on your ongoing support.

We realize, of course, that your support depends on our bringing you the kinds of articles that you want and need in every issue. You've told us over and over that you like the original magazine's friendly and informative approach, but that you'd like it even better if the articles went a little deeper technically. Our new Editor, Joe Lynch, N6CL, has succeeded remarkably well in crafting an inaugural issue that's just what you asked for. Joe has brought together a tremendous roster of authors and a range of topics that should include something for just about any ham with an interest in operating "Ham Radio Above 50 MHz."

You take VHF ham radio seriously. So do we. You are the new mainstream of amateur radio. We are committed to again being your voice and representing the broad range of VHF ham radio to the rest of the hobby. I am confident that *CQ VHF* is in good hands—not only Joe's but yours as well.

Rich Moseson, W2VU
Editorial Director

LETTERS TO THE EDITOR

What can I say? *Thank you, thank you* for the return *of CQ VHF!* I had subscribed from sometime during its first year to the last, and those I missed before I started my subscription I picked up at newsstands. I really loved that magazine and now its back. Being a weak-signal nut, this magazine will fit me just right. Again, thanks! *—Lee Kemp, N5TIF*

I was licensed in November of 1999 and was very pleased to pick up a copy of *CQ VHF*, a magazine that talked to me about the things I was capable of doing as a Technician. Then poof! It was gone. Sure, other magazines talk about the world above 50 MHz, but they can't provide the depth that I'm looking for. It will be so nice to have a magazine back that doesn't look at VHFers as beginners (although some of us are), but as an invaluable segment of the hobby. Thanks for your consideration!

—Buzz Fisher, KB1EPQ

I am very happy to hear that *CQ VHF* is coming back as a more technically oriented magazine. I hope that there are lots of UHF and microwave articles. I would really love to see a regular column by Joe Reisert, W1JR. His column in *Ham Radio Magazine* was always very interesting. In fact, I still have more than five years of issues of *Ham Radio* that I refer to on a regular basis. Joe's contributions to the "Microwave" reflector have been very much appreciated and very helpful. A regular column would be great!

—Woody Winstead, KJ4SO

Editor's note: *The above letters were received after our announcement of the return of CQ VHF. Prior to our announcement we received in excess of 120 e-mails requesting that the magazine return. Below is a sampling of some of those e-mails.*

Thanks for soliciting comments on a possible *CQ VHF* revival. I bought, off the shelves, every issue produced starting in 1997 until the last issue. Each and every issue had numerous articles of interest. The clarity of some of the antenna project articles gave me the boost of confidence needed to build my own antennas. After buying so many issues, I knew which day the magazine actually arrived at the local bookstore!

A couple of things have changed. I am now a General and spend much of my time on HF. Subsequently, I started my first subscription to *CQ* last year. Even though my *CQ* and *QST* reading is interesting and informative, I still miss *CQ VHF*.

I was not aware of *CQ VHF* until nearly the time when it was discontinued. I was about to take out a subscription when it was announced that it was being discontinued. I would like to see *CQ VHF* stage a comeback even if it is quarterly and by subscription. I would like to see more technical articles specifically oriented to construction and with the "average" ham's ability in mind (*HR* was too engineer-level oriented when it was around). Bring it back with a "fanfare" introduction so that people will be aware that it exists!

—Al Morris, WB8FEQ

When I first got licensed, my favorite magazine was *CQ VHF*. It is what got me into VHF contesting, and got me interested in operating 6 meters and 23 cm. I was very disappointed to see it go. I think bringing it back in a quarterly format with some more technical articles would be a great service to the community. It would be a great inspiration to newly licensed Techs as well as a great resource for VHF+ operators. *—Bill Arcand, KB1EFZ*

I'd subscribe to *CQ VHF* in a heartbeat. I already have a *CQ* subscription, and used to read *CQ VHF* before it went out of business. I also like the idea of more technical content, as there's not a whole lot on the market now with technical content. Naturally, I'd prefer it monthly (or maybe even bimonthly), but will take what I can get. *—Robert Cain, N4IXT*

I used to get *CQ VHF* over here in Australia and it would be good to see it back again.

—David Christmas, VK4DJC

I've been looking over my dad's old copies of *CQ VHF* magazine. This was a great magazine. I've been a ham for just over a year now. VHF operating is wonderful. I would really like to see this magazine return to publication. Quarterly would be fine.

—Chris Woodin, KB1FTD

Please bring back *CQ VHF*. We don't have any current publications adequately serving the VHF and above community.

—Bill Seabreeze, W3IY

I hope that *CQ VHF* will be again published! I'll surely subscribe. If you are interested, I can also contribute with some technical material. *—Marco Pavia, IK2CFR*

In response to your inquiry about bringing back the magazine *CQ VHF*, I would be one to subscribe. I am a newly licensed Tech and I would be very interested in a magazine that would be strictly about that area of communications. *—Earl Wendt, KC8STR*

I'd love to see *CQ VHF* come back. I'd been looking for it recently as a Christmas gift. My son KC2BRN and I would share two magazines, one of them being *CQ VHF*. I couldn't find it in a newsstand in Lake Placid where I had purchased it previously. Let me know when it's available again.

—Marty Bausman, KC2BRO

I was heartbroken when they took away the magazine. VHF/UHF is getting more popular every day now, and 6 meters has been real good lately. It would be nice to have the magazine back. *—Jonathan Wallen, KF4HOU*

By all means, bring back *CQ VHF*. The higher technical level sounds great. I would support it. Please e-mail me if you do bring it back. *—Michael F. Behning, KC8CUI*

If you publish it as good as it was or better, I'll subscribe. All the best to you and yours.

—Rod Scott, W7ROD

I would be interested in another *CQ VHF* even if a quarterly. I enjoyed it the last time.

—Dave Koch, KG7CN

I am writing you this letter in an attempt to convince you that it is entirely worthwhile and perhaps even vital to ham radio that *CQ VHF* be brought back into existence. First of all, most of the other ham radio magazines carry very little, if any, information on the world above 50 MHz. Also, it is important that the new Technician class licensees have a magazine from which they can receive information; obviously, a magazine with a 20-page special on 160 meters and a review on the latest 20-meter antenna and HF rig would not help a Tech class operator interested in how to work DX on 6 meters, or tell what 2-meter weak-signal omni-directional antenna designs are best. Please bring back *CQ VHF*. It would do everybody a favor! There has been much talk and gossip going around about this on various ham message boards, and all are in favor of bringing back *CQ VHF!* Come on, we need it! *—Fabian Carbone, KD5JDG*

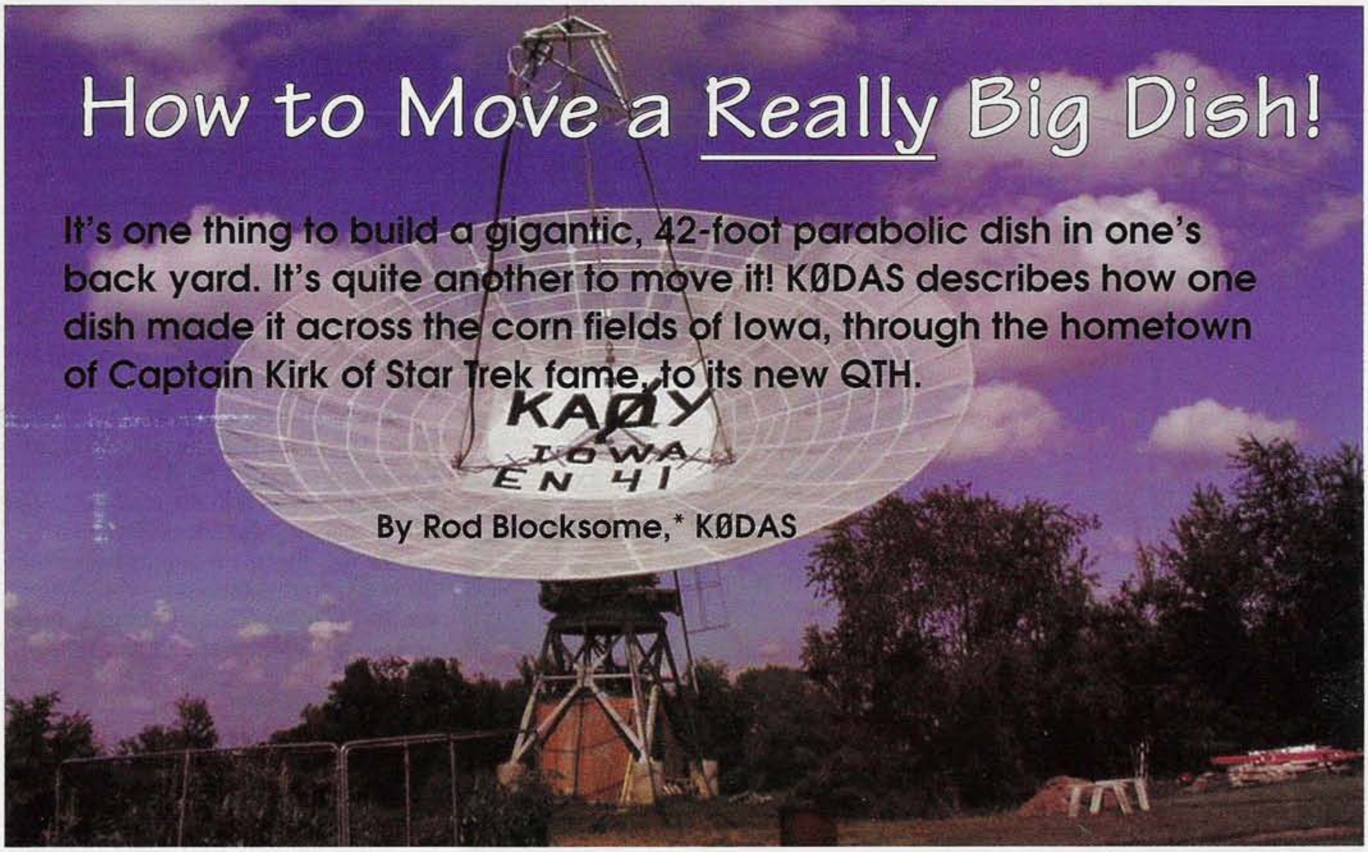
Fabian and others, we heard your cry. You convinced us, so here it is—the resurrected CQ VHF *magazine—just what inquiring and demanding VHF+ operators ordered!*

—N6CL

CQ VHF *welcomes comments and suggestions from readers. We'll print a representative sampling as space permits, and we reserve the right to edit letters for length or style. All letters must be signed and show a return mailing address or valid e-mail address. Writers' names will be withheld from publication upon request. Address correspondence to Letters,* CQ VHF, *25 Newbridge Road, Hicksville, NY 11801; or via e-mail to <n6cl@ cq-vhf.com>. Please specify that it is a letter for* CQ VHF.

How to Move a Really Big Dish!

It's one thing to build a gigantic, 42-foot parabolic dish in one's back yard. It's quite another to move it! KØDAS describes how one dish made it across the corn fields of Iowa, through the hometown of Captain Kirk of Star Trek fame, to its new QTH.



By Rod Blocksome,* KØDAS

During the spring of 1980 a magnificent 42-foot parabolic dish antenna arose amid the lush cornfields of Iowa. Designed and constructed by my friend Ken Kucera, KAØY, his gigantic 42-foot dish antenna was entirely homebrew and fully steerable by using a Navy-surplus 5-inch gun mount, which tipped the scales at a hefty 10 tons! I reported the construction details in the May 1982 issue of *QST*, and an aerial view of Ken's dish graced the cover of that edition.

Ken's objective was to have a dish that was large enough to work earth-moon-earth (EME) on frequencies as low as 2 meters. The dish was a success from the start, netting many "firsts." Included among these was the first two-way SSB EME QSO on 220 MHz. By 1986 Ken had worked all 50 states on 432 MHz, and during the following year he completed the Worked All States award on 220.

In 1988 Ken moved into town. Even though Ken's son remained on the farm, keeping it in the family, Ken was not able to get back there to reactivate the dish. Consequently, the KAØY EME signal from the big dish fell silent. The farm finally was sold in 1994.

Four years later Ken bought back the dish from the farm's new owner. Finally he owned his big dish again. His next project was to move that monster antenna!

Early on a quiet Sunday morning in September 1998, Ken and his crew of helpers loaded the huge dish onto a farm trailer. Very carefully they towed it through the Iowa countryside and through the town of Riverside, Iowa to his QTH. (You *Star Trek* fans will recall that Riverside, Iowa is the future birthplace of Captain Kirk.)

The dish occupied the entire width of the road during the adventurous excursion, and Ken's work of art hung over the ditches on either side of the road. Despite several road-sign and tree scrapes, the big dish finally arrived in Ken's yard.

This product of Ken's skill in antenna design and construction was an immediate small-town sensation! Wide-eyed kids, barking dogs, and curious neighbors gathered to watch the spectacle move down Main Street and into Ken's front yard.

Although the neighbors were *Star Trek* fans, they were less than enthusiastic about the prospect of seeing this 42-foot monster antenna in their town. After all,

The beginning of the journey of KAØY's EME dish from the countryside farm to the town of Riverside, Iowa. (Photos by the author)

**690 Eastview Drive, Robins, IA 52328*

The 42-foot dish cautiously approaches Main Street in Riverside.

The dish moving crew at the QTH of KAØY in Riverside.

the model of the *Starship Enterprise* in the Riverside city park is only 20 feet long.

There were no town ordinances against the antenna, but the anti-antenna sentiment continued to increase until it was just a matter of time before a little trouble was likely to occur right there in Riverside city. Because Ken's getting back on EME took precedence over fussing with his neighbors, in December 1999 he bought a small amount of acreage out in the country.

Once again, the dish was readied for a road trip. This time its transport was delayed for several months because of bridge repairs on the only road that could safely accommodate the antenna.

Like the Phoenix rising from its ashes 20 years after its birth, the rebuilding of the EME antenna finally began in the spring of 2000. Photographs of the rebuilding process can be viewed on <http://www.k2ah.com/ka0y50'dish>.

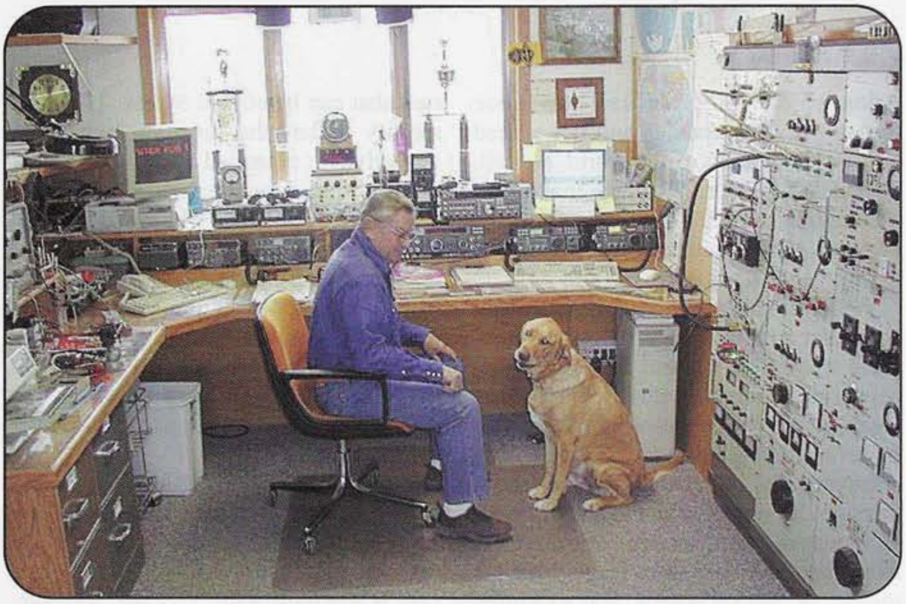
Several improvements were incorporated in the reinstallation process. The most noteworthy was expansion of the dish diameter to a full 50 feet! In order to allow quick feed-point antenna changes from the ground, a tiltable tripod feed system with fiberglass poles was built. The gun mount was outfitted with new three-quarter horsepower DC servomotors and interfaced to computer control of azimuth and elevation. Automatic tracking of the moon with a pointing accuracy of 0.2 degree was achieved. The dish surface was covered with new 1/4 inch wire mesh, sufficient for operation up to 1296 MHz.

The T/R relay and low-noise pre-amps are located at the feed point, thus requiring two feed lines between the ham shack and the antenna. Andrews 1 5/8 inch foam heliax was used for the transmit line, and 7/8 inch foam heliax was used for the receive line. The main parameters of Ken's EME station are presented by band in table 1.

	1296 MHz	432 MHz	222 MHz	144 MHz
Antenna Gain	43.7 dB	34.1 dB	28.4 dB	24.6 dB
Feed Antenna	K2AH Horn, circular polarization	HB Horn with polarization switching and rotation	Bow Tie with polarization rotation	Bow Tie with polarization rotation
Transmitter Power	450 watts	1000 watts	800 watts	1000 watts
Receiver NF	0.27 dB	0.20 dB	0.3 dB	0.2 dB
Transmitter Equipment	4x7289 tube PA	HB pair 8874 tubes	HB pair 8874 tubes	HB pair 8874 tubes
Receiver Equipment	WD5AGO dual-stage pre-amp	WA7CJO design pre-amp	W6PO design pre-amp	VE7BQH design pre-amp

Table 1. KAØY EME station capabilities.

Riverside's model of the Starship Enterprise.



Ken Kucera, KAØY, and his faithful "K9" assistant at his EME station.

The new dish became operational in the fall of 2000, just in time for the EME contest! Ken worked 95 stations—all on 432 MHz. Just before Christmas the station was brought up on 1296 MHz for the first time. As of October 23, 2001 Ken has completed 162 QSOs in 21 countries and in 20 states on 1296 MHz EME.

Today it is fashionable to look at the "value added" aspect of any operation or process. What might we consider "value added" from this antenna odyssey? I submit the following for your consideration:

1. It serves as a benchmark for other hams who dream of big antennas and wonder if they could ever possibly build one. The answer from Ken is an emphatic "Yes! If I can do it, so can you."

2. Ken's "big gun" EME station provides a means for low-power, small-antenna stations to make EME contacts successfully, thus infecting a new generation of hams with the "EME bug."

3. Unless your antenna project is bigger or crazier than this one, you can use this article to soften your spouse's resistance to almost any project you may have in mind. Just point out the virtuous, patient understanding that Ken's wife obviously possessed in order to endure relocation simply because of an antenna. ■

JT44
Revolutionary EME Software

This past March, K1JT introduced a revised version of his revolutionary WSJT software for weak-signal communications. The new version includes features specifically designed to enhance, among other types of propagation, EME, or earth-moon-earth communications. The following is an edited version of K1JT's original article, which appeared in a recent issue of "Cheese Bits," the monthly newsletter of the Mt. Airy VHF Radio Club (the "PackRats"). It is used with permission from both the Mt. Airy VHF Radio Club and K1JT.

By Joe Taylor,* K1JT

In February 2000 I reactivated an old interest of mine in specialized VHF communications techniques[1], in particular, meteor scatter. I joined the small group of North American hams who are using high-speed CW (HSCW) for meteor scatter on the 6- and 2-meter bands. Using the available software, I made many dozens of contacts on these two bands over distances of 600 to 1200 miles, while gaining considerable respect for this mode of high-speed communications.

It wasn't long, however, before I realized the limitations of the HSCW mode. Part of the problem is that HSCW has never been widely accepted in North America. Even more important from a technical point of view, on-off Morse Code keying at the speeds necessary to make good use of very short meteor "pings" simply is not an efficient way to convey information.

Keying sidebands increase the effective bandwidth of an HSCW signal in inverse proportion to the keying speed, and at high speeds the received signal-to-noise ratio suffers accordingly. Convinced that it could be done better, in April 2001 I set out to develop a software package that would optimize the effectiveness of amateur meteor-scatter communications under perfectly ordinary, non-meteor-shower conditions.

Early releases of the resulting software were an instant hit on both sides of the Atlantic. The program has now gone through several updates and has spread to most other areas of the world, as well. Called WSJT (for "Weak Signal Communication by K1JT"), Version 1 of the program was described in detail in the December 2001 issue of *QST*.[2]

WSJT enables one to use a personal computer running the Windows® operating system to control an SSB transceiver and communicate digitally, using weak-signal propagation modes, with other similarly equipped stations. The computer is interfaced to the radio through the sound card and a serial port. Its modes of operation are quite different from the setup-and-then-forget-about-it modes of packet radio, for example. WSJT requires operator skills not unlike those needed for any other sort of marginal, push-the-envelope weak-signal communications.

The New (updated) Software

The current revision of WSJT is v1.9.4, a beta release of code that will soon be a major new release, Version 2.0. In addition to the program's highly successful FSK441 mode, the one designed for meteor-scatter work, the program now includes a new mode called JT44. JT44 is designed for communicating with signals that are very weak but more or less steady in amplitude.

Using this protocol at both ends of the path, WSJT can copy signals that are 10 dB or more below the weakest CW signals that can be copied by ear. This sensitivity makes the program extremely attractive for extended tropospheric scatter, ionospheric scatter, and EME propagation on the amateur VHF and UHF and microwave bands.

Already during the first two weeks of JT44's availability, a number of 2-meter EME QSOs have been made with it. In addition, numerous contacts have been made on all of the VHF bands in the 400–800 mile range, often at QRP power levels.

One of the early EME QSOs was my own first-ever contact off the moon on March 23, 2002. This contact took place on 144 MHz, with GM4JJJ at the other end. It was quite a thrill for me, and, surprisingly, it was also quite easy: less than ten minutes elapsed from moon rise in New Jersey to reception of final RRRRs by both stations. Although I am hardly QRP, my station is not what is generally considered to be in the EME class—about 400 watts to four 9-element Yagis, without elevation control.

The new signaling mode is called JT44 because it encodes messages using 44 distinct tones. Moderately tight synchronizing is required, with both computer clocks being set to within about ±1 second of the correct time. Transmit and receive periods are computer controlled and last for 30 seconds each, starting on UTC half-minutes. Transmitted audio starts at 1.0 second into the half-minute and lasts for about 25 seconds; the remaining four seconds of the 30-second transmission

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period provide idle time for T/R switching, EME propagation delay, and compensation for computer clock errors.

The JT44 message format involves 135 equal intervals of time, each about 0.19 second long, in which a single tone is transmitted. In 69 of the intervals the tone frequency is 1270.5 Hz, which is used as a synchronizing frequency. The remaining 66 intervals transmit tones at any of the frequencies (N+120)*10.7666 Hz, where N is an integer between 1 and 43. Different values of N correspond to the digits 0–9, letters A–Z, and special characters ./#?$ and <space>. The 66 character intervals are used to convey a 22-character fixed-length message, which is repeated three times over.

The 69 sync-tone and 66 character-tone intervals are interleaved according to a pseudo-random sequence that has the desirable mathematical property of allowing the receiving station to synchronize in time, as well as in frequency, with the transmitting station. Detecting and aligning the sync-tone pattern is the principal "secret weapon" of JT44; in practice, it allows the software to accommodate frequency offsets between transmitting and receiving stations as large at ±600 Hz, and relative clock errors in the range –2 to +4 seconds. An asymmetrical time range was chosen to enable WSJT to readily accommodate the extra 2.5 seconds of EME propagation delay.

Using slightly more than half of the transmission time for the synchronizing tone costs approximately 1.5 dB in signal-to-noise ratio. This turns out to be an excellent trade-off in practice. It means that transmissions will "sync up" reliably at the receiving end, even when the S/N is around –25 dB relative to the received noise power in a 2500 Hz bandwidth. Note that by comparison, the minimum CW signal strength that can be copied is about –11 dB relative to the same noise level. JT44 can get through with solid copy when you cannot even hear the other station's signals.

Single letters in the 22-character message will have worse signal-to-noise ratios than that of the sync tone by a factor equal to the square root of 23, or 6.8 dB. However, that loss can be made up by averaging the received character-tone spectra over many 30-second reception periods. For such incoherent averaging, each doubling of the number of periods buys you 1.5 dB in S/N. Four periods get you 3 dB improvement, 16 periods get 6 dB, and so on. If the signal strength remains fairly steady, these numbers mean that good copy of any reliably synchronizable message can be achieved in about 15–20 minutes.

On the Air

So much for theory. How does JT44 do on the air? I already have given a few examples of the kinds of contacts that are being made by the (as of this writing) hundred or so hardy souls who have been actively using and helping me to debug the beta-release software. Let me complete this article by describing the information presented in the accompanying screen shot made a few hours after my first-ever EME QSO, that being with David Anderson, GM4JJJ.

The picture corresponds closely to what David would have seen in real time, as the QSO progressed, at his station. I reconstructed the screen appearance as shown by having the program open and read selected audio files from the complete set that were recorded during our contact and e-mailed to me by David shortly afterward.

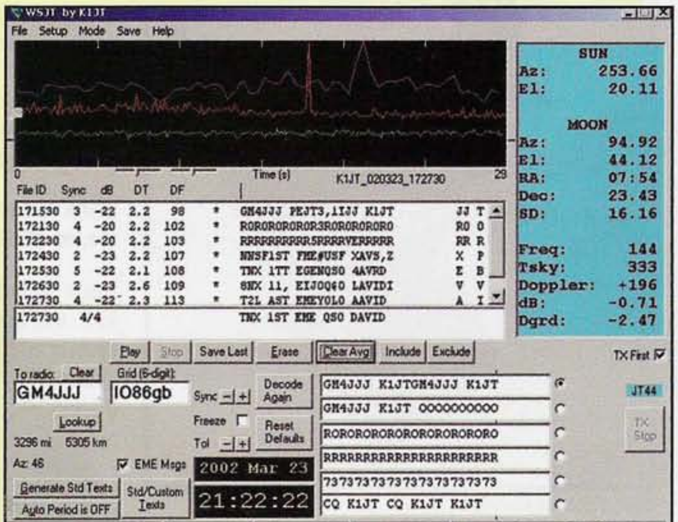
The picture shows the main screen of WSJT when it is running in JT44 mode. Useful information about the sun, moon, and galactic-sky background is presented in the blue panel at the upper right. The graphical display at the top shows the signal strength received over the 30-second interval (green line); the spectrum of the best candidates for the JT44 synchronizing signal, over a ±600 Hz range relative to the nominal 1270.5 Hz (red line); and the amplitude of the decoded synchronizing signal over the time-delay range from –2 to +4 seconds (blue line). All of the graphs apply to the most recent 30-second receiving interval.

The large text box in mid-screen displays WSJT's attempts to decode the very weak received EME signal. Each line corresponds to a different 30-second reception period. The various columns give the UTC time, synchronizing quality measure, signal strength in dB, apparent time offset DT in seconds, frequency offset DF in Hz, and the decoded message.

The first line shown, for example, was recorded at time 17:15:30 UTC. The sync quality was 3 (anything above 1 is likely to be valid, and more is better). The signal strength of K1JT at GM4JJJ was –22 dB, and the measured clock offset was 2.2 seconds. (The true EME propagation delay is about 2.5 seconds; the remainder is the difference in clock errors at the two stations.) The measured frequency offset is +98 Hz, in this instance a combination of the two-way Doppler shift and calibration errors in the two radios. Finally, we see the decoded 22-character message, which in this case had been transmitted as "GM4JJJ K1JTGM4JJJ K1JT."

The first GM4JJJ and the second K1JT both were copied perfectly. The second and third lines in the text box show the exact messages received by GM4JJJ a few minutes later, at 17:21:30 and 17:22:30, and show that our QSO was completed in just a few minutes.

(Continued on page 16)



The main screen of WSJT when it is running in JT44 mode. This screen shot was made a few hours after K1JT's first-ever EME QSO, which was with David Anderson, GM4JJJ.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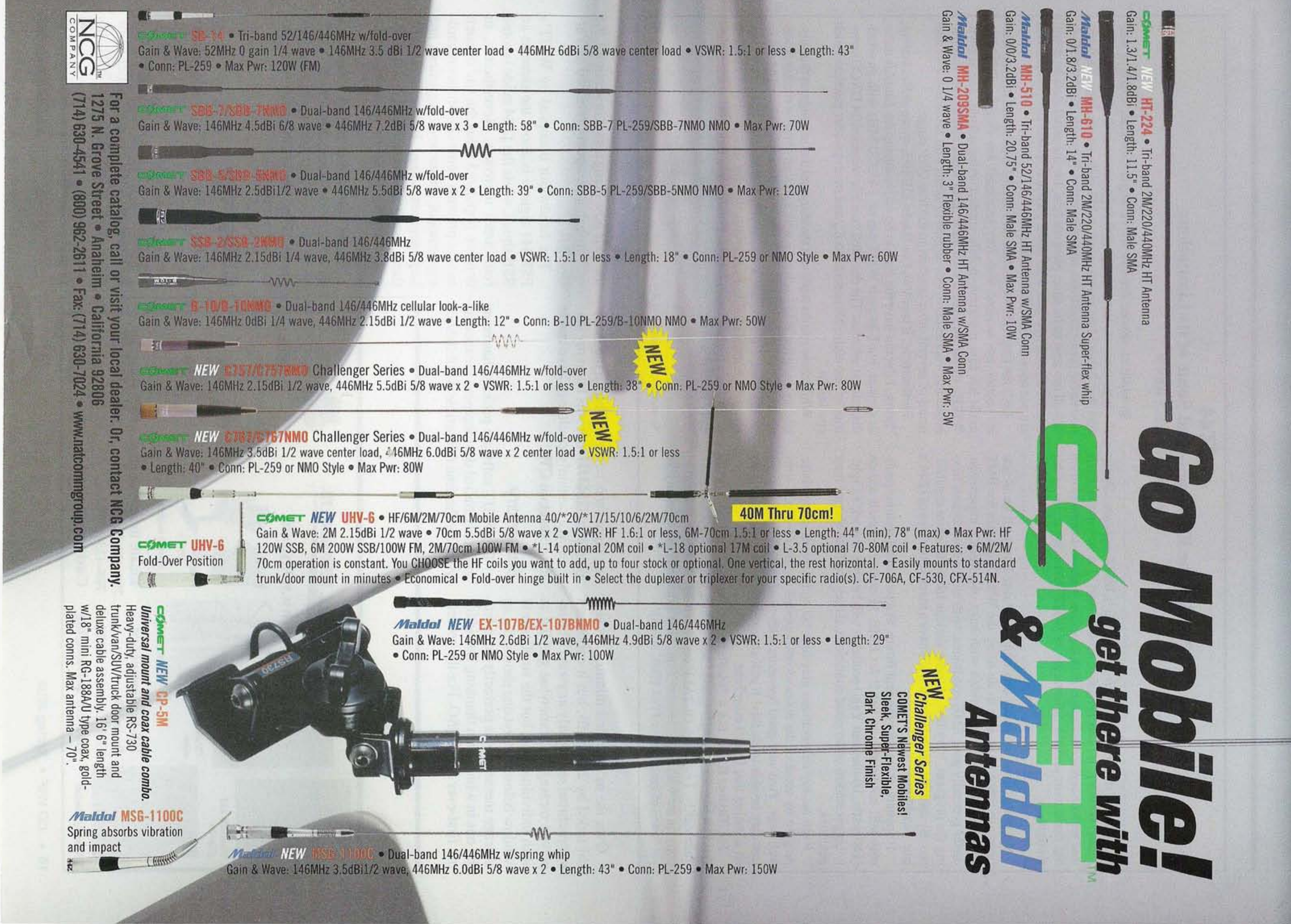
COMET SB-14 • Tri-band 52/146/446MHz w/fold-over
Gain & Wave: 52MHz 0 gain 1/4 wave • 146MHz 3.5 dBi 1/2 wave center load • 446MHz 6dBi 5/8 wave center load • VSWR: 1.5:1 or less • Length: 43" • Conn: PL-259 • Max Pwr: 120W (FM)
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JT44
Pushing the Envelope—and Some of its Limitations

By Shelby Ennis, W8WN*

As one of the beta testers for Joe Taylor's WSJT software, Shelby Ennis, W8WN ("If I can't crash it, nobody can!"), a very active EME and meteor-scatter operator, is in a unique position to comment on the limitations and the advantages of WSJT. Here are a few of his thoughts. —*N6CL*

As of this time, we really don't know for sure how well small stations are going to be able to do using the WSJT software for EME contacts. (This is being written with only one week's experience, under generally poor EME conditions, with only a few stations having the program. Very few of these stations have elevation capabilities. By the time this is in print, we'll have a much better idea of JT44's true capability).

It appears, at least for the near future, that two small stations probably will not be able to use it for EME. However, a small station (150 watts, 16-element Yagi) probably will be able to work a slightly bigger station under good conditions, if they can both elevate their antennas.

Even so, my observations may turn out to be overly pessimistic, judging by some of the notes recently posted on the JT44 real-time web page. Two very good operators with small but efficient stations just may be able to do this! It still amazes me to be able to get copy on a station that I can't even hear.

Joe Taylor, K1JT, has a "medium-size station," and he worked David Anderson, GM4JJJ (good EME station, but not huge antenna), quite easily. I ran with DL2ALF on March 23, 2002. He got partial copy on me with his 9-element Yagi. That's the smallest antenna I've yet heard of receiving a JT44 EME signal.

In addition, several fellows with a single Cushcraft 13B2, or similar type antenna, have had partial copy on several other stations. I feel that I should be able to work a 400-watt, single, long Yagi station under good conditions, and quite possibly even a smaller station. It's all too new to be sure. Nevertheless, for the small station, it will require a good operator with some patience. These are qualities that are not necessarily in abundance.

Let's not forget, however, that the FSK441 high-speed meteor-scatter section has worked with tiny antennas! Joe Goggin, K9KNW, made his first maritime-mobile contact using a halo; Joe Brown, WØDB, threw together a 4-element quad when visiting his parents' home and worked ten of eleven HSMS skeds with 100 watts. I've also heard of several other contacts in the true QRP range.

Furthermore, Klaus Von Der Heide, DJ5HG, wrote to Joe, stating, "Sorry, I did not have the time to be active during the *Leonids* meteor shower, but I let your WSJT run on 144.370 MHz with an omnidirectional antenna. The decoded.cum file recorded 24 DXCC countries in one night. No aurora, no E_s, and no tropo ever produced such conditions."

While these results represent the marginal, I don't suggest that anyone try using the WSJT software with a ground plane or similar antenna, as vertical polarization isn't likely to do any good on 144 MHz. At the least, I'd consider a 4-element, horizontally polarized Yagi, about the normal minimum antenna to use for meteor-scatter contacts using Joe's pioneering software. Finally, less than 100 watts makes daily meteor-scatter contacts very difficult.

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Over the next several minutes my signal faded by 2 or 3 dB, but it continued to synchronize properly anyway. The received message is somewhat garbled in each individual line, but the smaller text window below the first one shows that an average message was perfectly decoded, the one in which I am thanking David for my first-ever EME QSO. For the record, my signal was never audible in the headphones at GM4JJJ, nor was his at my station. We certainly could not have made the contact on CW.

Summary

The WSJT software package has been under continued development for about a year. By the time this article is published, the code now being tested in version 1.9.4 will probably be openly released as Version 2.0.

The bandwidth occupied by WSJT's FSK441 signals is about the same as an SSB signal, while the JT44 mode is some four times narrower. Nevertheless, in densely populated areas the use of such modes presents some challenges regarding protocol, frequency assignment, and band-segment usage. In true ham spirit, these issues are being tackled in a cooperative manner in different regions of the world.

As the software is further developed, look for more information on the WSJT home page, <http://pulsar.princeton.edu/~joe/K1JT>, and via this and other amateur radio media.

Bibliography

1. Taylor, Joe, K2ITP, "Working Ionospheric Scatter on 50 MHz," *QST*, December 1958, p. 58.

2. Taylor, Joe, K1JT, "WSJT: New Software for VHF Meteor-Scatter Communication," *QST*, December 2001, pp. 36–41. ■

Taking Your VHF+ Contest Station on the Road

It's springtime and the VHF+ operator's mind turns to preparing for the summer contests. For those of us who have a less-than-ideal home station, the rover contest station can provide a better way to operate the contests. W7DHC gives us a thorough description of how the ideal rover station should be equipped.

By Jim Aguirre,* W7DHC

Many of us don't live in an "ideal" weak-signal VHF environment, a place with good elevation, clear horizons, and so forth. Not a problem! Take your VHF+ contest operation on the road as a rover. The rover class offers a great opportunity to go where the action is, and increasingly, VHF+ contest operators are doing so with outstanding results.

Just like setting up a contest station for fixed operation, setting up a rover station can be as simple or as complex as you want to make it. In many ways, it's like a mobile setup, but there are some important differences.

The W7DHC rover with 50, 144, and 222 MHz loops mounted on the rear mast. Mounted on the "headache rack" are 432 MHz loops, plus a 903 MHz Yagi, 1296/2304 MHz planar antennas, and a 3456 MHz looper. (Photos by the author)

The Radios and Powering Them

First, be sure that your radio equipment is mounted so that it's convenient to use and won't be flying around loose in a panic stop. With all the different vehicles out there, it's impossible to be specific about how you should mount your gear. Just make sure that you can use it effectively while in motion without taking your eyes off the road or otherwise being distracted, or have one person drive and another operate. Safety is the most important aspect of a well-designed rover setup. Don't compromise.

Next, you'll need to provide sufficient power to operate your gear. Serious rovers usually run at least eight bands—frequently more. In my vehicle I have three or four transceivers: a Yaesu FT-847 for 50, 144, and 432 MHz; an ICOM IC-706MKIIG for backup; and another 706—the older MKII—serves as an IF for the transverters. I usually carry a Yaesu FM dual-bander as well to pick up some extra points from the HT folks.

Transverters for 222, 903, 1296, 2304, and 3456 MHz also need to be powered, as do brick amplifiers for all bands except 50 MHz. The FT-847, logging laptop, and a pair of GPS units usually draw power from the vehicle battery; the rest rely on auxiliary batteries.

For auxiliary power I carry three Group 27, 12 VDC deep-cycle batteries and a Honda generator for charging them. In most contests I can get by without recharging, but the generator provides a safety factor. It can also be used to provide 120 VAC for a conventional power supply at stops along the way.

Why three deep-cycle batteries? Two are connected in parallel to double the 12 VDC current capacity, and the third is run in series to provide 24 VDC for the 903 amplifier—a converted cellular-service unit. If you have any 24/28-volt equipment, this is a handy way to provide power for it.

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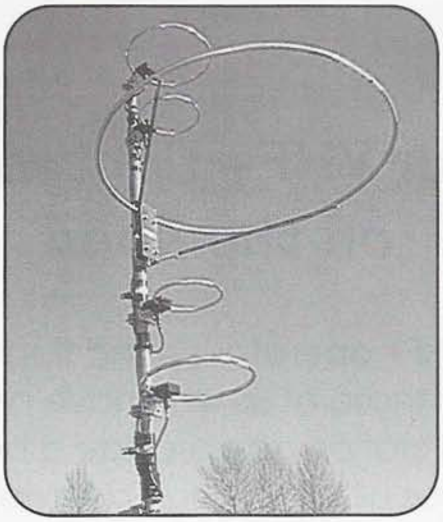
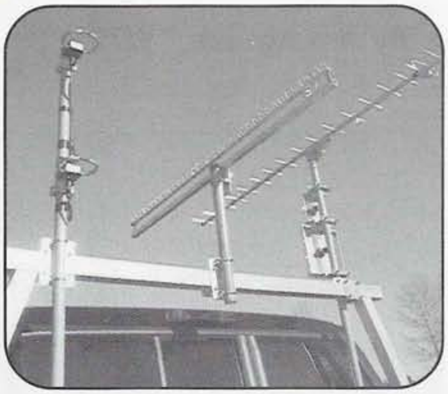
e-mail: <w7dhc@centurytel.net>

Loop stack on rear-mounted tilt-over mast with 144 and 222 MHz pairs mounted above and below the single 50 MHz loop. The stack can be removed easily and replaced with a mast for Yagis when needed.



Close-up of the loop stack.



A closer look at the antennas mounted on the "headache rack" behind the cab: a pair of 432 loops (left), with 3456 looper in the center, and 903 Yagi above the 2304 and 1296 planar antennas.

Use heavy-gauge power leads from the auxiliary batteries to a power distribution box. For runs of any length, use #8 or #6 wire to cut down on voltage drop. I use 30-amp Anderson PowerPole® connectors at the distribution box and on each power cord going to individual pieces of equipment. The 75-amp versions provide easy disconnect capability at the battery and distribution box ends of the main power cable.

I've been using Anderson PowerPole® connectors for many years and they're great. Modular in construction, they can be mated together to form single or multiple pairs of polarized connectors. They come in various colors—including red, black, and green—so it's easy to tell apart power and ground leads.

There are a couple of cautions, however. Being modular, these connector pairs can be assembled so that opposite polarity mating is possible. This is usually not a problem for a rover station, because you likely will assemble all your connectors yourself and can ensure that they're all done to the same standard.

There are many groups around the country using these connectors (including ARES), and unfortunately, there are *two* assembly standards in use—red-on-the-right and red-on-the-left. If you borrow a piece of gear for your rover operation and it comes with PowerPole® connectors installed, be sure the colors match before you plug it into your system.

Don't forget to fuse the power leads at the batteries. For safety I use 60-amp Maxi-Fuses® at each battery terminal. You can get inline Maxi-Fuse® holders and high-amperage fuses at your local NAPA auto-parts store. Be sure to carry spare fuses. Despite the rover rules limiting competitors to not more than two people in the vehicle, "Murphy" always rides along!

You should also consider how to keep the auxiliary batteries safely in place, preventing overturning (acid spills are nasty) and shifting. If your vehicle is a pickup truck like mine, batteries can be placed in a simple 2×4 frame in the truck bed to keep them in place. For other types of vehicles, put batteries in the trunk, in the back of the van, etc. In all cases, securing them in place is essential. *Caution:* Putting batteries in the passenger compartment is not recommended!

Power leads can be run into the passenger compartment in various ways. One really useful technique, especially with sliding windows in the back of a pickup cab, is to use a section of foam pipe insulation and put it over the edges of the glass. You can then run the power leads—and coax, too—into the window. Closing the glass with the foam in place will provide a seal without damaging the cable. Use a suitable length of dowel or stick to keep sliding rear windows from reopening. The same trick can be used for routing coax through roll-up windows. Just roll up the glass against the foam and you have a weather seal.

Many vehicles also have suitable entry holes in the firewall and floor if you look carefully. They are usually sealed with pop-out rubber plugs. If you bring power in through these openings, be sure to protect the cable against sharp edges by using a rubber grommet. Some silicone sealer or Coax-Seal® will weatherproof the entry.

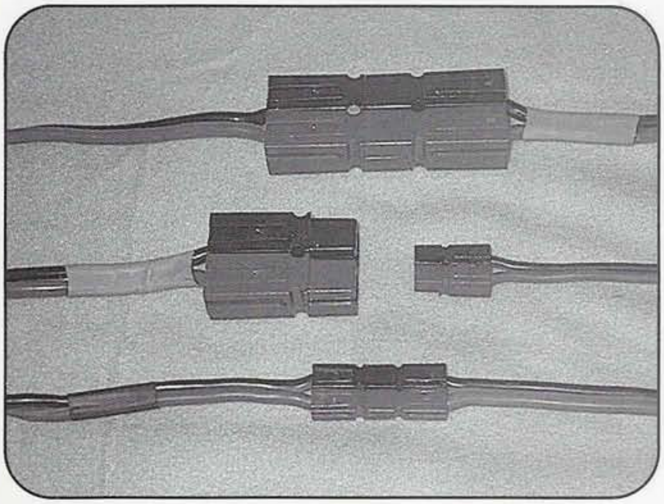
Antennas and Mounting Them

The next thing you'll need to deal with is antenna mounting. Since most fixed-station contesters will be using horizontal antennas, your rover antennas need to be horizontally polarized as well in order to avoid substantial cross-polarization loss—as much as 20 dB! This also means antennas will be larger and have more wind load than most vertical whips, requiring stouter mounts.

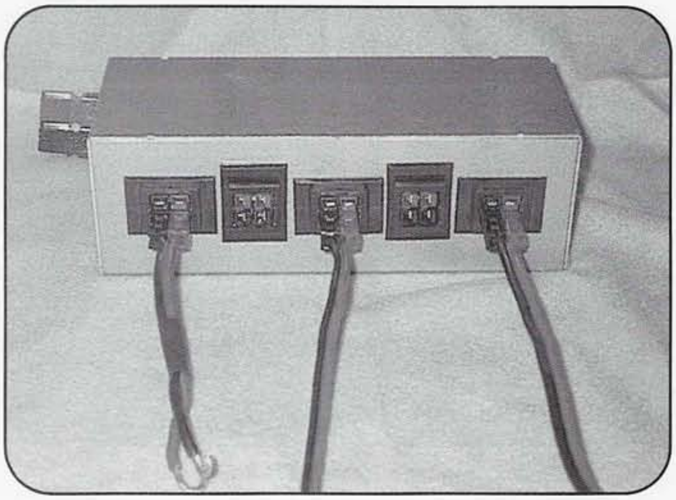
My favorite mounting scheme is an insert that goes into a square-tube trailer-hitch receiver. Square-tube receivers are available to fit just about any vehicle, so if you don't already have one, you might consider having one installed. It could even do double-duty actually pulling a trailer!

Some careful measurements and a little help from your local trailer-hitch installer or welder should be all it takes to produce a very workable mast mount that will slide into the receiver. I've even eyed those hitch-mounted bicycle racks as a possible mast mount.

Depending on the type of vehicle, there are several other ways to mount antennas. If your vehicle has a roof rack—and many

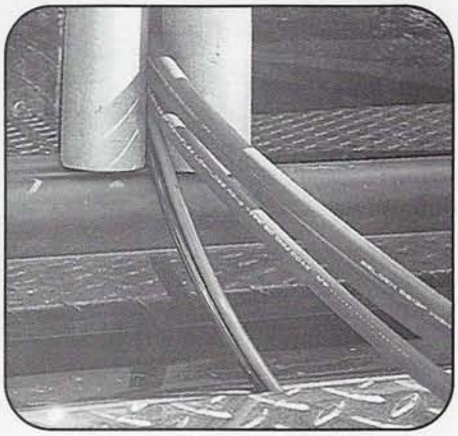


Anderson PowerPole® connectors in 30A and 75A versions.



Power distribution box for auxiliary batteries with ten pairs of Anderson PowerPole® connectors installed.

A simple 2×4 wooden frame keeps the auxiliary batteries in place. Plywood bottoms in the outer sections use the weight of the batteries to anchor the frame, along with a 2×6 crosspiece.



Foam pipe insulation provides an effective weather seal for coax and power cables passing through the truck's sliding rear window.

SUVs do—that's a place to start looking. You may need to stiffen it up a bit and you'll probably have to fabricate some brackets to secure a mast to the rack, but that's generally pretty easy. Because there are so many different roof-rack configurations, it's not possible to be specific here. Don't overlook clamp-on racks; they can be used on most vehicle types.

For pickups, another possibility is to use a so-called lumber or "headache rack." That's one of those protective racks that mount on the bed rails just behind the rear window to keep lumber and other bulky items from breaking the glass. They're not cheap, but if you need one anyway, it's a great place to hang antennas. If you're handy, you can build one for a lot less than they are priced at at the truck stores.

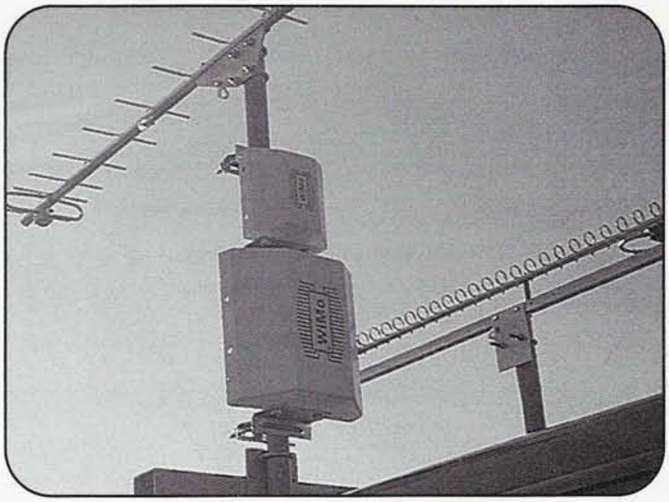
Some folks have also used heavy-duty magnetic (mag) mounts—in particular, the four-magnet types—to secure a short mast to the metal roof of their vehicle. I'd add some synthetic rope lines to make sure that the mast stays upright at road speed. If these possibilities won't work for you, you'll need to figure out some other kind of mast mount. A little ingenuity can go a long way.

A TV mast can be used to support the loops, although a fiberglass tube is lighter and just as strong. A good source of fiberglass tube is Max-Gain Systems. Check its website <http://www.ms4u.com>. They are great folks to work with. The 1.25- or 1.5-inch diameter tubes are just about perfect for supporting even a multiple-antenna stack.

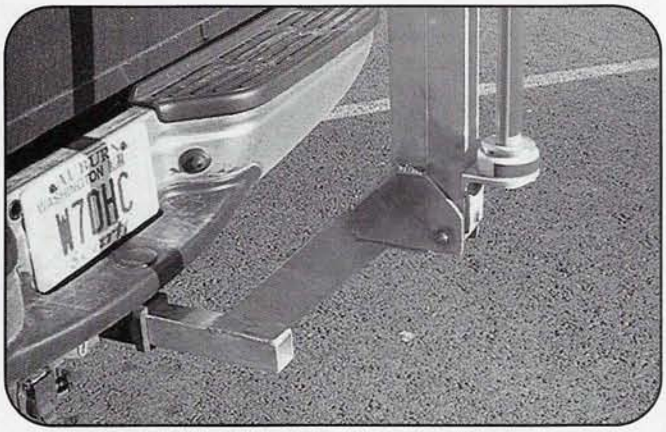
Fiberglass electric fence rods, obtainable from your local farm-supply outlet, work great for guys. Because they are rigid, only two are needed if you mount them about 60 degrees apart. You can also use aluminum tubing or EMT in a similar fashion. You'll need to fabricate clamps or other mounts that will let you secure them to the vehicle's rear bumper or other solid location as well as to the mast.

Remember to keep your mast height below the maximum for the area of the country in which you will be traveling—usually 14 feet or less. I prefer to keep my masts to not more than 11 feet in overall height to clear overhanging limbs, low undercrossings, and gas-station canopies. Whatever height you choose, be sure to check your overhead clearance before proceeding whenever there are possible overhead obstructions.

The simple mast-mount insert used previously.



Close-up of the Wimo 1296 and 2304 planar antennas mounted below the 903 Yagi.



Close-up of the lower mast section. This is the rotating tilt-over unit that replaced the simpler unit previously used.

Most rovers use horizontal loop antennas for the VHF and UHF bands. Generally, this is the best way to go for a rover because these antennas are omni-directional and have just a bit of gain. They also can be set up in pairs, or more, for additional gain. The trade-off is usually height of the stack and strength of the supporting mast. Some manufacturers—including KB6KQ, Par Antennas, M^2, The Olde Antenna Lab, and others—offer loops for 50, 144, 222, and 432 MHz.

Antennas for the bands above 432 MHz come in a variety of types. Because they will be smaller in size, there are also more mounting options available. Some popular antennas for these bands include short Yagis and loop Yagis (known in VHF+ circles as loopers), "Big Wheels," panel (or "planar") antennas, and horns. Most of these antennas are directional—the "Big Wheel" being the exception—so you will need to decide whether to mount them on a rotating mast, or just rotate the whole vehicle when necessary. Dish antennas can be used effectively when you are stopped, but they present too much wind load to be left up when traveling.

If you decide to use Yagis and loopers, keep the boom length fairly short unless you have a way to support the ends. Remember that you probably will be traveling the interstate highways at some point, and that will expose the antennas to 65–70 mph "winds." Flopping antennas definitely are not good!

Recently, panel, or "planar," antennas have become available for several of the microwave bands. Originally designed for point-to-point communication—usually data links—they work well as mobile antennas, too. German antenna purveyor Wimo offers 902/903, 1296, and 2304 units at reasonable prices, although the shipping is a bit costly.

If you are considering ordering any of these antennas, I suggest you buy all three and save on the shipping. You probably will find a ready market at the next hamfest for any you don't need. Several other manufacturers have 3.4 GHz planar units available, but verify that they are horizontally polarized to avoid cross-polarization loss.

Big Wheels can be purchased from Wimo and The Olde Antenna Lab, or they can be homebrewed. "Horns," or feedhorns, are usually homebrewed, although you can find some commercial units listed on e-Bay (http://www.ebay.com) from time to time. They are commonly mounted inside the vehicle pointing out a window or used on large camera tripods when stopped.

With some creative thought you can find a way to put rover antennas on any vehicle. Be prepared for some strange looks as you pass people on the highway, though. You probably can also count on a police officer or two asking what you're up to, but I've never had one give me a hard time. They're just curious.

Have Fun!

Hopefully, some of the foregoing will get your creative juices flowing and you'll put together a rover setup for the next contest. Once bitten by the bug, I suspect you'll make roving a habit. I sure have! ■

Manufacturer Information

KB6KQ Loop Antennas: 70 Arrowhead Drive, Carson City, NV 89706 (775-885-7885; <www.kb6kq.com>).

M^2 Antennas: 4402 N. Selland, Fresno, CA 93722 (559-432-8873; <www.m2inc.com>).

Max-Gain Systems, Inc.: 221 Greencrest Court, Marietta, GA 30068-3825 (phone/fax 770-973-6251; <www.ms4u.com>).

Olde Antenna Lab: 41541 Dublin Drive, Parker, CO 80138 (303-841-1735; e-mail: <w6oal@aol.com>).

Par Antennas: P.O. Box 645, Glenville, NC 28736 (828-743-1338; <www.rf-filters. com>).

Wimo: <www.wimo.com>.

By Jerome Doerrie, K5IS

OP ED

One Reader's Opinion

Setting the Hook

Many newspapers around the US print a page entitled "Op Ed." The Op Ed page usually runs opposite the editorial page, hence its name. Sometimes the name takes on a double meaning when the author of an Op Ed piece presents a viewpoint opposite to that of the editor. The purpose of the page is to give a writer an opportunity to express a view or propose an idea for discussion in a format longer than what is normally found in a letter to the editor. Because there are many views and ideas floating around that are worth considering and discussing, this will be a regular feature in CQ VHF.

—N6CL

Some of our best ideas often come to mind while we are under the influence—of eating ice cream! The members of the Tri-State Amateur Radio Group of Northwest Oklahoma celebrate the conclusion of club meetings with an informal session at an ice cream parlor. We discuss the important things in life: ham radio, DXing, mobile operations, repeaters, "fox" hunting, or the merits of the various flavors of ice cream! A heavy helping of teasing is always included:

"I have been thinking..."

"I wondered what I was smelling! It must be insulation charring!"

"You're overloading your circuits!"

"No, I have something important to say."

"Last time your 'important' got us stuck in the mud and muck at the land fill, when the 'fox' was on the other side of town!"

"You clowns! What I am trying to say is that I noticed we have quite a few new hams who have gotten their licenses, but who never come back to a club meeting or get on the air."

"I hate to admit it, but you have a point. What do you make of this, Old Timer?"

"I remember thhat back when I started, it took a lot of encouragement before I became proficient enough to be able to make contacts on my own. I felt inferior because I knew so little and everyone else seemed to know so much. We called this 'key' or 'microphone fright.' This sounds like the same thing to me."

"What can we do?"

"Ham radio is often compared to fishing. Cast a CQ into the air and see what you catch, if anything. There are many species of fish and a variety of techniques that work for catching each kind. There are many sub-interest groups in ham radio and techniques that are better for each. Our task is to teach the neophyte the techniques for selecting bait, fishing, and setting the hook for landing a QSO."

Between bites of ice cream, going back for seconds, and taking a few side trips in the discussions, we developed a plan of activities.

We borrowed our first activity from the American Radio Relay League's idea of a certificate for the first contact. Each new ham is initiated into our First Contact Club. When a person qualifies for his (or her) first license, before the excitement can wear off, we take the person aside, give him a hand-held, and personally help him contact someone on the repeater to celebrate the accomplishment! When the callsign appears on the internet, the secretary prepares a certificate and awards it to the person at the next club meeting. Thus, each new ham is fully initiated, complete with license, an on-the-air contact, and the first certificate!

The dictionary defines the word *fun* as "providing amusement, enjoyment, implying laughter, indulging in play." To encourage fun and fellowship while teaching good operating skills, we hold a series of games on the club repeater. We encourage each person to participate in every game. If a person does not have any radios, the club has units that can be rented for three months at $10 or 10 contacts a month.

The rules require a log containing the name, location, date, band, mode, time, and point value for each game. We exchange QSL cards for the contacts. The time period runs from the close of our Friday night net to the close of the next net. Each local contact is worth 1 point; mobiles are 2 points, and stations over 50 air miles from the repeater are worth 5 points. The first game requires 10 contacts, the second game requires 15 contacts, and the third game requires 20 contacts.The logs and QSLs are turned in at the next club meeting. At the following club meeting certificates are presented for each week's top three places.

On a random basis each year, which is a polite way of saying when the Game Chair finally remembers, Mobile Month is announced during a meeting. Using only our club repeater, we see who can make and log the most contacts with mobiles before the next club meeting. This contest has a rather surprising collateral effect: Mobile hams driving through are surprised by the number of people wanting to talk with them!

Another game is our Work the Alphabet Award. We collect contacts using the last letter of the callsign for each of the 26 letters of the alphabet (for example, K5OA, W5JLB, KY5C, . . . KB5FAZ). Contacts may be made on any of the area repeaters or on simplex from any location to any location. There is no time limit for this award. The necessary log should contain the date of contact, callsign, name, location, and another fact about the person contacted. Members of the ARRL have the option of applying for the ARRL Friendship Award.

Hamming is a social activity. By making it seem like play, we use fun and fellowship to teach log keeping, QSLing, simple contesting, and operating skills, and we end "microphone/key fright." Nothing compares to the joy of having a contact come back to you via the magic of ham radio!

Hopefully, this article will give you or your club some ideas of your own for developing games—and ultimately setting the hook that gets the new ham on the air with confidence and coming back to your club meetings! ■

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IRLP: The Internet Radio Linking Project

Has the internet killed ham radio? Not according to Paul Cassel, VE3SY. For him, just the opposite is true. In this article Paul outlines an exciting new mode of communications—linking of ham radio to the internet.

By Paul Cassel,* VE3SY

You turn on your 2-meter rig after a several-year absence from VHF and hear a QSO between VK3JED and WYØX. You think you have tourists visiting your town until you hear Nate, WYØX, is in Denver, Colorado on his way to work at 7 AM and Tony, VK3JED, is talking about going to bed, as it's past midnight at his QTH. You think you are hearing an HF link, but with quality like that of a local FM station, you ask some questions and find out that you have discovered the growing world of the Internet Radio Linking Project (IRLP).

Thanks to this growth and the availability of high-speed internet connections, we have a new and powerful tool for secure, reliable repeater linking. By enabling our FM repeaters and selected simplex channels with IRLP, we can provide instant on-demand-linking worldwide with one or more repeaters. If you're concerned about cost, this entire project definitely fits into a "ham approved" budget of under $125, including the IRLP hardware and software.

The Internet Radio Linking Project is an exciting new technology that is rapidly becoming the standard for Voice Over IP (VoIP) repeater linking, bringing many users back to ham radio on our VHF/UHF and SHF bands. Thanks to IRLP worldwide repeater linking, this new technology is also becoming a tremendous catalyst for bringing new, young blood into our hobby. Now hams with a simple HT or mobile setup can enjoy worldwide coverage with excellent audio quality as they talk with their friends across the country and around the world.

Many dedicated HFers claim that IRLP is not real radio. Others claim this is the breakthrough that will be looked back on as the technology that revitalized the interest of teenagers in ham radio.

A recent pass of the International Space Station over Chapel Hill, North Carolina and its scheduled QSO with the Phillips Middle School was transmitted via IRLP to 38 repeaters around the world, including two in Australia, where a group of VKs got up to listen at 3 AM their time. Just prior to the school QSO, it was very exciting to hear a brand new 9-year-old ham make her first QSO after having received her license that morning. I'm sure this will remain forever fixed in her mind after talking from her father's car in south Texas to a ham in Canada.

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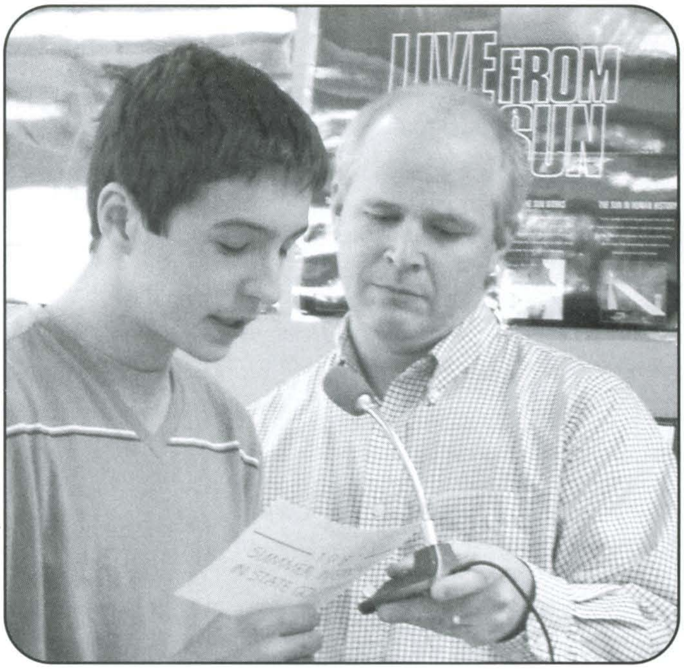


Aliosha Silivra, KG4FTR, speaking with the International Space Station from Chapel Hill, North Carolina on November 9, 2001. The contact was relayed worldwide via IRLP.

Then there is the daily pile-up for a rare DX contact with KC4ACV in McMurdo Station, Antarctica. More on this topic will be covered later.

How is This Happening?

This question is heard daily as new nodes come online and local repeater users are not aware of what they are hearing. When they are briefed and receive the URL for IRLP <http://www.irlp.net>, they find that IRLP is the brainchild of Dave Cameron, VE7LTD, of Vancouver, British Columbia, Canada.

In 1998 Dave was experimenting with various Voice Over IP amateur applications but became frustrated with the unreliable operation of Windows®-based VoIP applications. At that time, all Windows®-based linking software used VOX and allowed non-amateurs easy access to amateur radio frequencies via a PC headset or microphone.

Eight months after Dave started his design work, he created the IRLP network on a Linux platform; it is now on Version 2 of his hardware and software. The network slowly started growing around British Columbia and Canada's east coast and then continued into the US, Australia, the UK, and the Caribbean. As this issue of *CQ VHF* hits the streets, IRLP will be approaching 400 active nodes worldwide, and it continues to grow by leaps and bounds.

Using the IRLP Network

To connect to another repeater or reflector (we call them *nodes*) you simply dial a DTMF on-code.[1] Within a few seconds after the authentication PGP keys have been exchanged, the called node will identify its callsign and location in plain voice. If the node is currently engaged in another connection, you will receive a voice message telling you to which station the other repeater is connected. If the other node has enabled call waiting, they will hear a very brief message when the local PTT drops reporting which node attempted a call.

Before placing a call, you can check the status of any node in real time at <http://status.irlp.net>. This page updates in close to real-time, so it is always current and auto refreshes every five minutes.

Just as with any linking system, IRLP is subject to some minor delays, which mostly are tone-squelch related. (To dispel internet delay myths, the audio delay over the internet is about the same as you experience when using a digital cell phone).

When finished with a QSO, announce your callsign and dial the OFF code. A voice message indicating the link is dropping will play. There are always a number of nodes left connected to the Denver CO Reflector, allowing you to place a CQ or QRZ-type call with an excellent chance of speaking with someone somewhere in the world.

New Excitement in the Air

The most satisfying aspect of listening on IRLP is hearing the excitement in the voices of people both young and old who had become bored with conventional FM repeater operation. Probably the phrase most often heard on IRLP is "Where did you say you were located" or "How is this happening?" When you hear these questions, you know you have a first-time user on IRLP and a chance to pass the word. For the newbies, as the story and excellent audio quality unfold to them, you can hear the excitement grow in their voices. Very satisfying indeed!

It is not unusual for first-time users with Technician licenses to often hold off replying to a distant station, believing they are tied into a repeater with an HF link not covered by their license.* When told what is happening, the excitement in their voices provides great reward for the efforts of IRLP proponents.

Last Two Please—*Not!*

Who would ever believe the need to take a list to work DX in Antarctica on 2 meters? Recently there was such a pileup on various repeaters around North America, and this author took over the task of (God forbid and forgive me) "List Manager" to handle the calls from hams across the US and Canada. This is the exception rather than the rule, but many hams who have been on HF for years have been making their first contact with Antarctica via IRLP rather than on HF.

The McMurdo Station Antarctica Node

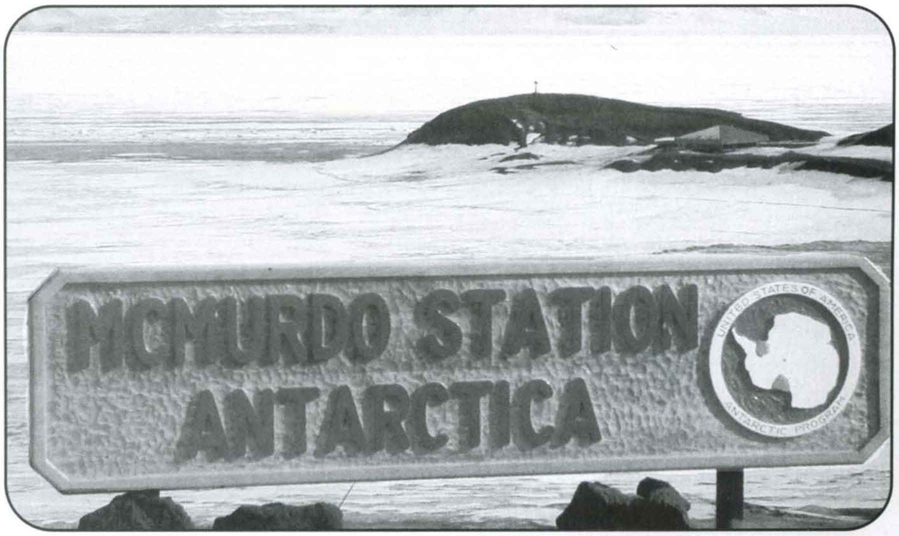
The continent of Antarctica became QRV October 23, 2001, and in the first two weeks logged over 1000 contacts with VHF/UHF operators around the world. Chuck Kimball, NØNHJ, built the node at McMurdo Station using a Motorola GM300 Mobile Radio on 146.520 carrier squelch, on a simple 1/4-wave antenna. Chuck said via e-mail that the setup covers most of the town area quite well, even though it's more than a mile across town.

Chuck went on to say, "Our internet is a part of a T1 that connects us back to the United States via an Intelsat Satellite. The T1 provides all of our phone service, several dedicated data circuits, and about 650K of bandwidth for the internet. It's used for moving science data from many research projects back to the States.

"We are on the south side of a volcano and cannot see the northern horizon, so we have a remote ground station on another island about 20 miles away. Our connection travels via microwave to Black Island (the ground station—the satellite is only 3 degrees above the horizon). It travels via the satellite to a ground station in Washington State. It then is connected via a fiber network to a NASA facility, where we are interconnected with the internet."

Chuck had seen some references to internet linking for ham radio a couple of years ago, but he hadn't gotten very far in researching it. Last year at McMurdo, Chuck found out that Dave Cameron had come out with Version 2 IRLP boards and had them available, so he ordered two before leaving "the ice" in late January 2001.

When asked how often they get to activate the IRLP node, Chuck said, "There are only about four hams active on 2



McMurdo Station town-limit sign. (Photo by NØNHJ)

**Technicians may use repeaters with HF links as long as the frequency on which they are transmitting is above 50 MHz. The control operator of the linked repeater must have HF privileges and the Tech becomes a third party.—ed.*

Chuck, NØNHJ, beside a VHF repeater antenna and solar panels used at McMurdo Station, Antarctica. (Photo by NØNHJ)

meters, so there are a lot of unanswered calls. Most of us work six days a week, nine hours a day, so there is not a lot of free time for ham radio operation."

IRLP Reflectors

In this article we have been referring to reflectors. A reflector is a Linux server that allows multiple nodes (repeaters) to be linked together at the same time. As of press time, there were nine reflectors. They are located in Toronto, Ontario; Saskatoon, Saskatchewan; Vancouver, British Columbia; Fredericton, New Brunswick; Denver, Colorado; Raleigh, North Carolina; Las Vegas, Nevada; Yellowknife, Northwest Territories (Canadian Arctic); and Sydney, New South Wales, Australia. Most reflectors are hosted by public-service-minded companies that offer extreme broadband facilities to support the requirements of corporate accounts, and of course are more than adequate to host a reflector.

The bandwidth requirement for a reflector is directly related to the number of simultaneously connected nodes. During a recent International Space Station pass and QSO with Barbara Pedersen, KE4JZM's science class at Phillips Middle School in Chapel Hill, North Carolina, with 40 nodes connected, the bandwidth being used on the Raleigh reflector was just shy of two megabytes.

The reflector most used worldwide is in Denver, Colorado. Also known as Reflector 2, it always has a number of US, Canadian, Australian, and Caribbean repeaters connected, so any conversation that occurs on one repeater is heard on all connected stations.

CANWARN[2] net controllers in southern Ontario are linking themselves via IRLP using the new Ontario Reflector hosted by Group Telecom in their Toronto Central Office. This allows the CANWARN controllers to rapidly exchange severe weather information between themselves and the Environment Canada Toronto Severe Weather Desk without interfering with the local CANWARN nets. The east coast reflector, located in Raleigh, North Carolina, is designed to handle east coast repeater linking during the hurricane season.

Listening from Your PC

This author provides a live stream of the audio being transmitted by Reflector 2. Because this Denver reflector has the most activity, you can get a good idea of how the audio sounds and how the network works relative to your local repeater. You will be surprised how clean the network is, with no courtesy tones, drop out tails, or CW IDs. All of these annoying extraneous items are suppressed on the IRLP network, so all you hear is user audio and your LOCAL ID and courtesy tone.

To listen, point your browser to <http://www.kwarc.org/listen/> for details and a direct link to the Live365 server which handles the streaming.

Active Nodes Around the World

The "Locations Active on IRLP" box with this article shows places around the world that are active on IRLP as of this writing, sorted by callsign. As for DX stations, you can look for KC4USV in McMurdo Station Antarctica and two dozen repeaters in the "land down under" (Australia and New Zealand). When working these stations, it reminds you of the movie *Back To The Future,* as most QSOs with VK/ZL land are taking place tomorrow.

There are numerous nodes in England, as well as in Trinidad and The Commonwealth of Dominica (not the Dominican Republic), where it is not unusual to hear Bernadine, the mayor of the capital city Roseau, on the air promoting the "Nature Island. You also may hear J79 stations from neighboring St. Lucia accessing the Roseau repeater across the Caribbean.

There are numerous nodes throughout the Hawaiian Islands, Alaska, and the Canadian Arctic as well. New nodes are now on the air from Scotland, Sweden,

Locations Active on IRLP

Callsign	City	Prov./St.
9Y4AT	Valsayn	Trinidad
9Y4SRR	San Fernando	Trinidad
9Z4CG	San Fernando	Trinidad
AB7TJ	Minden	NV
AC4RZ	Easley	SC
AC7DE	Helena	MT
AE4GB	New Port Richey	FL
AF4TZ	Nashville	TN
AH6CP	Honolulu	HI
AH6GR	Maui	HI
AH6JA	Hilo	HI
AH6LE	Mt. Angel	OR
AI7J	Ogden	UT
GØFUO	Mexborough	SY
GØXEL	Manchester	—
G4BVV	Maltby	SY
G4CUI	Sheffield	SY
G4EID	Southport	MER
G4NJI	Rotherham	SY
G8UVE	Burnley	LA
GB3LV	London	UK
GB3US	Sheffield	SY
J73CS	Roseau	Dominica
J73D	Roseau	Dominica
K0PCG	Des Moines	IA
K1DF	Albany	NY
K1IMD	Long Island	NY
K1IMD	Riverhead	NY
K3TAT	Media	PA
K4KSA	Tampa Bay	FL
K6IOK	Auburn	CA
K6IXA	Atwater	CA
K6JSI	San Diego	CA
K6JSI	San Diego	CA
K6JXY	San Marcos	CA
K6KCP	Sacramento	CA
K6RTL	Sacramento	CA
K6UB	Saratoga	CA
K7SDC	Castle Dale	UT
K9DRF	Peoria	IL
K9IP	Indianapolis	IN
K9WZ	Plymouth	IN
KA1UAG	West Lebanon	NH
KA2JZO	Bordentown	NJ
KA3KCJ	Downingtown	PA
KA3VMA	Drexel Hill	PA
KA6UAI	Palomar Mtn	CA
KA7STK	St. George	UT
KB2FAF	Cortland	NY
KB3HF	St. Peters	MO
KB5DBR	Ponca City	OK
KB6JAG	Hemet	CA
KB6THO	Pasadena	CA
KB7LVC	Boise	ID
KB7RSI	Las Vegas	NV
KB8JXX	Anchorage	AK
KCØMDI	Rolla	MO
KC4IBT	Vero Beach	FL
KC4USV	McMurdo Station	—
KC7BSA	Fruitland	ID
KC7GHT	Phoenix	AZ
KC7ZWG	Seattle-Tacoma	WA
KC8NCE	Grand Haven	MI
KD4BBM	Miami	FL
KD4RAA	Raleigh	NC
KD4RAA	Raleigh	NC
KD4Z	Orlando	FL
KD6GDB	Santa Monica	CA
KD6LVP	Beaverton	OR
KD6YYJ	San Jose	CA
KD7BCS	Medford	OR
KD7EFG	Murray	UT
KE4EUE	Chesterfield	VA
KE6DGM	Norwalk	CA
KE6PCV	Los Angeles	CA
KE6WUK	Sunset Ridge/LA	CA
KF3DY	Wellsboro	PA
KF6FM	Riverside	CA
KF6JEE	Woodcrest	CA
KF6SWL	Omaha	NE
KG4OKL	Huntsville	AL
KG4QAC	Tampa	FL
KG6EAO	Kapaa	HI
KG6EVO	Tahoe City	CA
KH2BI	Pasadena	CA
KH6FV	Honolulu	HI
KH6GMP	Kailua Kona	HI
KH7R	Henderson	NV
KL3K	Anchorage	AK
KU6V	Fremont	CA
M1ERS	Sheffield	SY
MM1BHO	Castle Douglas	Scotland
NØPSR	Denver	CO
NØSZ	Boulder	CO
N1HUI	Branford	CT
N2BJ	New Lenox	IL
N2CKH	Lakewood	NJ
N2LKV	Stony Point	NY
N2MH	West Orange	NJ
N3APP	Erie	PA
N3IO	Malvern	PA
N3IO	Philadelphia	PA
N3RJC	Lansdowne	PA
N4GLB	Upstate	SC
N4HAJ	Kinston	NC
N4IRS	Stuart	FL
N4MSE	Dallas	TX
N4NEQ	Atlanta	GA
N4PJR	Jesup	GA
N4XQM	Atlanta	GA
N5CWH	Gilbert	SC
N5IUF	Dallas/Ft.Worth	TX
N5LEZ	Electra	TX
N6ICW	Sacramento	CA
N6JVH	Los Angeles	CA
N6JVH	North Hills	CA
N6KNW	Santa Clarita	CA
N6SEX	N/A	CA
N6SEX	Sacramento	CA
N7BFS	Spokane	WA
N7CK	San Manuel	AZ
N7GZT	Columbia	SC
N7HQZ	Ferndale	CA
N7LZM	Kennewick	WA
N8BC	Painesville	OH
N8DNX	Stutsmanville	MI
N8HEE	Charlotte	MI
N8OJ	Marietta	OH
N9CZV	Show Low	AZ
N9EP	Barrington	IL
N9GPY	Culver	IN
N9OIG	Union Grove	WI
N9TSW	Des Plaines	IL
N9UWE	Danville	IL
NE1H	Atlanta	GA
NH6HF	Lihue	HI
NJ2FM	Hopatcong	NJ
NV7RM	Reno	NV
REF1	Toronto Reflector	ON
REF2	Denver Reflector	CO
REF4	Yellowknife	NWT
REF5	Sydney	NSW
REF900	Vancouver	BC
REF921	Raleigh	NC
REF925	Las Vegas	NV
REF930	Saskatoon Reflec.	SK
REF931	Fredericton	NB
SARA	Province Wide	AB
SK6RAB	Oxaback	SW
VA2RLP	Baie-Comeau	QC
VA3BBB	Windsor	ON
VA3BJD	Oakville	ON
VA3CTR	Markham	ON
VA3EWC	Barrie	ON
VA3LU	Thunder Bay	ON
VA3MME	Omemee	ON
VA3RVU	Brampton	ON
VA3SCR	Innisfil	ON
VA3SCR	Innisfil	ON
VA3SCR	Innisfil	ON
VA6IRL	Lethbridge	AB
VA7HAM	Penticton	BC
VA7LPG	Nanoose Bay	BC
VA7MAR	Mackenzie	BC
VA7OKN	Vernon	BC
VA7RDX	Vanderhoof	BC
VE1BAS	Orleans	ON
VE1CRA	Charlottetown	PEI
VE1II	Truro	NS
VE1KK	New Glasgow	NS
VE1NSG	Halifax	NS
VE1WN	Greenwood	NS
VE1WRC	Amherst	NS
VE1WY	Lindsay	ON
VE2BRR	Montreal	QC
VE2CRA	Ottawa	ON
VE2REA	Quebec City	QC
VE2RJS	Montreal	QC
VE2TPE	Baie-Comeau	QC
VE3ADT	Milton	ON
VE3BIP	Belleville	ON
VE3DJD	Burlington	ON
VE3DPL	Norwich /Delhi	ON
VE3EI	Cornwall	ON
VE3IRL	Toronto	ON
VE3KBR	Kingston	ON
VE3KD	Sault Ste. Marie	ON
VE3KNA	Franktown	ON
VE3KR	Nobleton	ON
VE3MOT	Toronto	ON
VE3MUS	Huntsville	ON
VE3NUU	Monkland	ON
VE3OAK	Oakville	ON
VE3ORX	Orangeville	ON
VE3OVQ	Guelph	ON
VE3PGC	Cornwall	ON
VE3PNO	Toronto	ON
VE3RAK	Toronto	ON
VE3RBM	Kitchener	ON
VE3RPT	Toronto	ON
VE3RWN	Bethany	ON
VE3SEX	Almonte	ON
VE3SUE	London	ON
VE3SY	Petersburg	ON
VE3TST	Stittsville	ON
VE3ULR	Toronto	ON
VE3WFM	Waterloo	ON
VE3XTX	Owen Sound	ON
VE3YYS	Ottawa	ON
VE4FFR	Flin Flon	MB
VE4SRR	Swan River	MB
VE4UMR	Winnipeg	MB
VE5CC	Saskatoon	SK
VE5CMR	Saskatoon	SK
VE5IOU	Prince Albert	SK
VE5MLR	Meadow Lake	SK
VE5RAD	North Battleford	SK
VE5SCR	Swift Current	SK

VE5SKN	Saskatoon	SK	VO1AAA	New Harbour	NF
VE5WM	Regina	SK	VO1BWP	Corner Brook	NF
VE6COM	Lethbridge	AB	VO1HHR	Grand Falls	NF
VE6KJM	Airdrie	AB	VO1KEN	St. Johns	NF
VE6LGL	Grande Prairie	AB	VY1RHJ	Haines Junction	YT
VE6LH	Calgary	AB	VY1RW	Whitehorse	YT
VE6LT	Red Deer	AB	WØGFQ	Palm Springs	CA
VE6MHU	Medicine Hat	AB	WØKU	Golden	CO
VE6MPR	Banff	AB	W1CDO	Seattle	WA
VE6PRR	Peace River	AB	W1ET	Hanover	NH
VE6RGP	San Diego	CA	W1IMD	Portland	ME
VE6RJZ	Canmore	AB	W1QWT	Scituate	MA
VE6RPT	Calgary	AB	W2CNY	Syracuse	NY
VE6SBR	Edmonton	AB	W2ISB	Liverpool	NY
VE6TE	Red Deer	AB	W4DOC	Atlanta	GA
VE6TOT	Canmore	AB	W4RPT	Nashville	TN
VE6TRC	Ft. McMurray	AB	W4VM	Huntsville	AL
VE6WRT	Calgary	AB	W6DXX	Palm Springs	CA
VE6XZ	Calgary	AB	W7AOR	Las Vegas	NV
VE6ZV	Calgary	AB	W7AOR	Las Vegas	NV
VE7BHI	Port Alberni	BC	W7FDF	Tucson	AZ
VE7CAP	Cranbrook	BC	W8HDU	Lima	OH
VE7DQC	Prince Rupert	BC	W8JL	Marietta	OH
VE7FFF	Prince George	BC	W9ADS	Champaign	IL
VE7KU	Port Alberni	BC	W9BCC	Wausau	WI
VE7MFS	Coquitlam	BC	W9CEQ	Aurora	IL
VE7PQD	Parksville	BC	W9DXN	Dixon	IL
VE7RAM	Tappen	BC	W9SH	Fishers	IN
VE7RAP	Comox	BC	WA1NVC	Framingham	MA
VE7REE	Penticton	BC	WA2ZPX	Middletown	NY
VE7RGF	Grand Forks	BC	WA3ADI	Havertown	PA
VE7RHS	Vancouver	BC	WA3KOK	Washington	DC
VE7RIA	Victoria	BC	WA3UMY	Lexington Park	MD
VE7RJZ	Invermere	BC	WA4HND	Grand Junction	CO
VE7RMR	Maple Ridge	BC	WA6JFK	Los Angeles	CA
VE7RMT	Victoria	BC	WA6LA	Palos Verdes	CA
VE7RNA	Chemainus	BC	WA6LA	Palos Verdes	CA
VE7RTS	Kamloops	BC	WA6LCN	Marinwood	CA
VE7RVN	Vernon	BC	WA6RQD	Oceanside	CA
VE7TSI	Kamloops	BC	WA6RQD	Oceanside	CA
VE7UHF	Richmond	BC	WA6SUP	Sacramento	CA
VE7URG	Vancouver	BC	WA6TMJ	Hanover Park	IL
VE7VIC	Victoria	BC	WA6TWF	Santiago Peak	CA
VE8NWT	Yellowknife	NWT	WA6VPL	Lompoc	CA
VE8YK	Yellowknife	NWT	WA6WDC	Sun Valley	AZ
VE9ACP	Fredericton	NB	WA7SPY	Sacramento	CA
VE9ARZ	Fredericton	NB	WB2BQW	New Windsor	NY
VK1RBM	Canberra	ACT	WB2HWW	Queens	NY
VK2RAG	Gosford	NSW	WB2NBU	Palm Beach Gar.	FL
VK2RBM	Sydney	NSW	WB2WPA	Naples	FL
VK2RCZ	Sydney	NSW	WB3EHB	Camden	NJ
VK2RIC	Lismore	NSW	WB4IVB	Corbin	KY
VK2RMP	Wollongong	NSW	WB5EKU	Los Angeles	CA
VK2RMR	Mt. Riverview	NSW	WB5TUF	Houston	TX
VK2RTZ	Newcastle	NSW	WB6ARE	Cedar Park	TX
VK2TTA	Wahroonga	NSW	WB6EGR	Burbank	CA
VK2WAG	Wagga Wagga	NSW	WB6EGR	Santa Clarita	CA
VK3HEG	Ballarat	VIC	WB6HII	Eureka	CA
VK3JED	IRLP-Experimental	VIC	WB7RES	Caldwell	ID
VK3RGL	Melbourne	VIC	WB8CXO	Akron	OH
VK3RMH	Melbourne	VIC	WB8NXP	Southfield	MI
VK3RPU	Arthur's Seat	VIC	WD6AWP	Huntington Beach	CA
VK3WRM	Merbein	VIC	WD8CIK	Hollywood	CA
VK4BAB	Ipswich	QLD	WJ2W	Terre Haute	IN
VK4RCA	Cairns	QLD	WR2ROC	Rochester	NY
VK5UJ	Adelaide	SA	WR6AVM	Honolulu	HI
VK6AMS	Karratha	W.A.	WR6HMB	Half Moon Bay	CA
VK6RAL	Albany	W.A.	WR6JPL	Pasadena	CA
VK6RFM	Fremantle	W.A.	WX7Y	Castle Dale	UT
VK6RNC	Perth	W.A.	WYØX	Centennial	CO
VK6XAA	Collie	W.A	ZL2LD	Masterton	NZ
VK7AX	Ulverstone	TAS	ZL2WKI	Palmerston North	NZ
VK7DY	Tea Tree	TS	ZL3TMB	Christchurch	NZ
VK8RTE	Darwin	NT			

Japan, Ecuador, and the Netherlands, and other countries around the world will soon join the IRLP family.

A Look Under the Hood

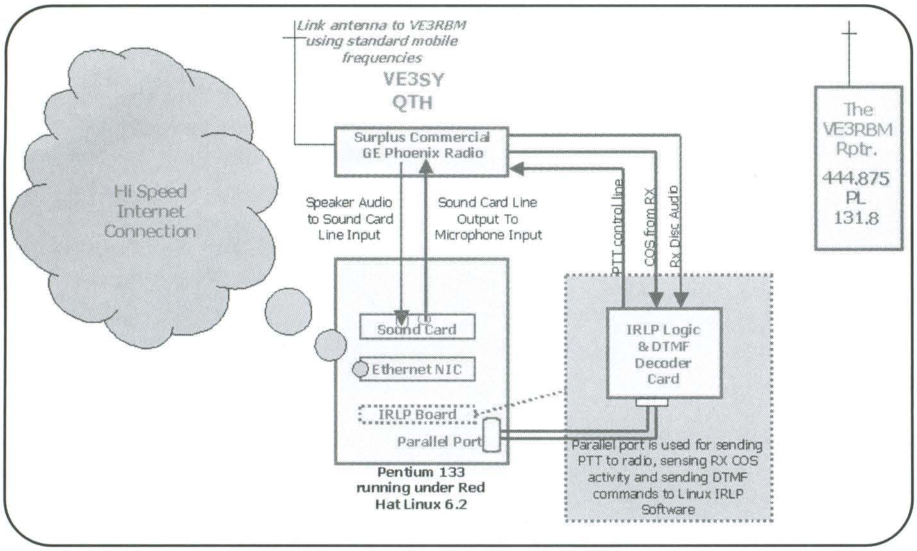
An IRLP node can be interfaced either directly with a repeater or via a link radio, in which case the IRLP hardware/software takes the audio from the receiver and feeds it into the Line-In of the sound card, where it is converted into ADPCM[3] digital data. The Linux PC then converts this digital information into packets assigned IP addresses for the destination node.

These packets flow through the internet to the destination Linux PC, where the packets are decoded. The signal is then sent from the sound card's Line-Out to the transmitter microphone audio circuit of the link radio, which then transmits the audio over the local repeater. The transmitter is keyed as soon as these TCP/IP (Internet Protocol) packets start to arrive. As soon as the data stops, the link radio un-keys and the process reverses.

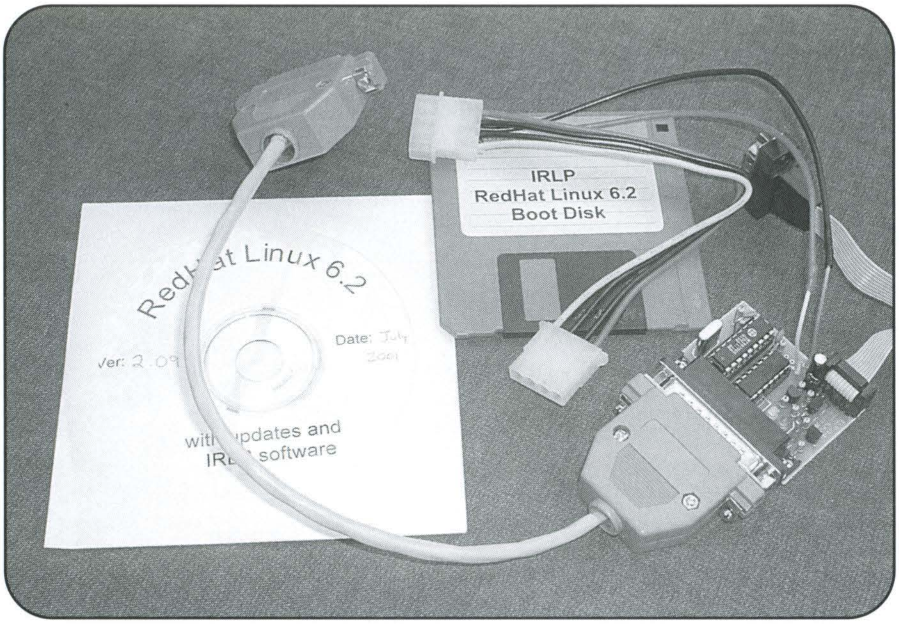
Each connection request with another node or reflector is challenged for a PGP encryption key to validate that the originating node is a valid station. This very secure method of real-time validation assures only licensed nodes are able to connect with another node or reflector.

The underlying audio processing technology in IRLP is a freeware application called "Speak Freely." Speak Freely produces VoIP audio streaming and is very similar to other VoIP software packages such as Microsoft NetMeeting, VocalTec iPhone, and the M0CSH iLINK, with one major difference: It runs under Linux, not Windows®; unlike iPhone and iLink, *no* access is possible from a PC. To avoid third-party issues in some countries, *all IRLP communications are by design radio-to-radio with no access possible from a PC.*

Linux was Dave's operating system of choice for the IRLP system, as it allows the best in reliability, programmability, efficiency, and functionality. Because our repeaters don't need anything even close to MP3 audio quality, IRLP is using a low-bitrate VoIP to communicate. Most nodes use an encoding system that requires only 32 KB/s of bandwidth; however, some nodes with extremely limited bandwidth use a GSM encoding method that only requires 10 KB/s, albeit at the cost of some audio quality. A full-time internet connection with DSL, cable modem, or ISDN is required for such a connection.



Most IRLP nodes are located remotely from the repeater to allow access to residential rates for DSL or cable modems. To link the IRLP node audio to a repeater, a link radio is normally used. Here in Canada we are able to link in-band. However, local regulatory restrictions may apply in other countries.



The IRLP hardware and software.

The control of the radio is performed using a small custom logic board, designed by VE7LTD, connected to the computer's parallel port. This board samples the received audio for Touch Tone audio, detects when the link receiver is active, and feeds the TX PTT line to the link radio. All of the command I/O between the PC and the IRLP board is handled by a connection to the PC's parallel port. IRLP is the only VoIP system that provides instant and positive COS and PTT signals to the network. No VOX is used in IRLP.

The whole system is DTMF (touchtone) controllable. The control codes lie embedded in a separate program that reads the DTMF tones from the decoder located on the interface controller board and activates various parts of the software. DTMF codes are used to enable/disable linking, open/close links, and set identifiers. Every site has the ability to customize its connection codes and connect directly to any other site(s), either using direct connections or reflector sites.[4]

Don't Be Afraid of Linux

As you read this, you may say, "But I know nothing about Linux!" Well, speaking first hand, don't worry at all about understanding Linux as a prerequisite to establishing an IRLP node. When I decided to build our first node here in Kitchener-Waterloo, Ontario, I did not even know how to spell Linux. However, because I had most of the bits and pieces and a high-speed T1 connection, I went ahead anyway and ordered the hardware and software.

The software can be installed from a bootable floppy or from the bootable CD; both are provided. The easy-to-follow, step-by-step instructions are in very plain English, making it a breeze to get your machine up and running. As soon as you can establish a link to the internet, you send off an e-mail to the install team indicating you are ready for the IRLP installation. One of several installers around the world will open a secure telnet session with your Linux box and configure the node and install the 512-bit PGP authentication key. If you leave your PC speakers connected, you normally will hear a node connect. In my case it was Pete, VK2YX, in Australia, who provisioned my node, so I heard his local node connect greeting and we were QRV on IRLP.

Incorporated into the IRLP service are regular updates of new host files, as well as IRLP software enhancements and updates. These all occur automatically as part of the daily housekeeping when all of the nodes call home looking for updated files. It is not unusual for uptime of an IRLP node computer to be measured in years rather than hours or days with some Windows® configured machines.

Red Hat security updates are assured as part of the automated weekly maintenance, which includes checking for new updates for your version of Red Hat.

Minimum Requirements

To host an IRLP node you will need a full-time, high-speed internet connection (DSL or cable works well); a dedicated Linux computer (a 486 DX100 or better); 32 meg of RAM; a 1 gigabyte hard drive; the IRLP custom software/hardware; and a link radio or direct connection to a repeater.

Each node on the IRLP network is assigned an ID code, and a central DNS name server keeps track of the IP addresses[5] in use by all nodes. Don't be concerned about robbing bandwidth from your home use, as the IRLP requirement is less than 40k bits, just slightly above the capability of a V.90 dial-up modem.

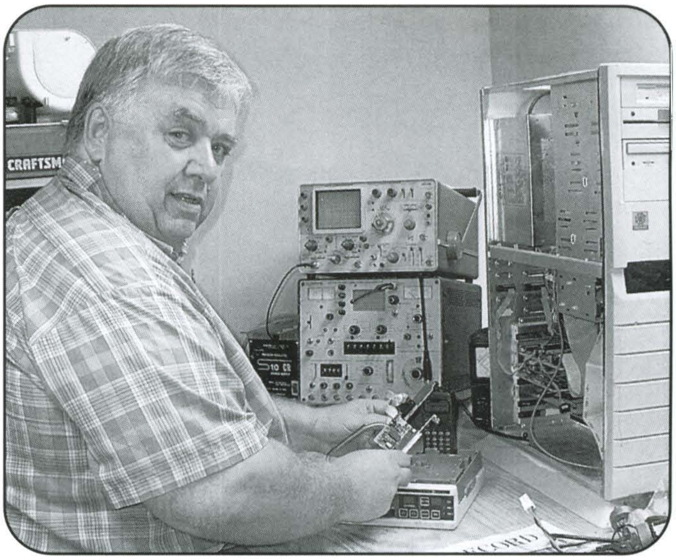
Summary

This exciting new technology has already begun to prove itself as a tremendous catalyst to bring young new hams into our hobby. Where else can you witness an open, worldwide VoIP wireless network using a free and open protocol such as IRLP?

As we all know, it has been a real challenge for us to draw kids into our hobby, as they can talk 24/7 on iPhone or iLink connections over the internet. Now, compared to other alternatives, they can enjoy far superior reliability and audio quality and be talking around the world from their HTs as they walk down the street.

There is not a day that goes by when you will not hear a new 12- to 16-year-old having the time of his/her life working DX on an HT. The excitement in their voices speaks volumes for what this technology will do for amateur radio. What a great tool IRLP can be to enhance our success in bring young kids into ham radio.

Since our club in Kitchener, Ontario brought our node on line, our membership has been given a real boost. Many former members see the excitement coming back into the hobby, and many new members are joining to be part of the IRLP system. The VE3RBM repeater has gone from possibly two QSOs per week to our busiest repeater and is now dedicated to IRLP use.



The author interfacing an IRLP board to a radio and PC. (Photo by VE3RE)

However, don't get your HF equipment packaged up ready to list on e-Bay just yet. IRLP is just another tool to enhance our hobby, much like FM repeaters brought many new hams into the hobby back in the 1960s. This author is a very active HF operator but still loves the mobile and HT DX activity now possible via IRLP.

I would like to personally thank the IRLP designer, Dave Cameron, VE7LTD, for his assistance in preparing this article and for his dedication to this wonderful project. I would also like to thank Jim Price, WW4M, for his valuable grammatical assistance in proofreading the article.

In my humble opinion, IRLP is still *Real Radio!*

If this article has piqued your interest and you seek additional information, please browse the official IRLP website at <http://www.irlp.net>. Also, feel free to contact the IRLP designer, Dave, VE7LTD, at <dcameron@irlp.net> or the author at <paul@ve3sy.com>.

References

<http://www.irlp.net> – Internet Radio Linking Project website

<http://www.kwarc.org/listen/> – Information on IRLP streaming audio feed

<http://www.speakfreely.org/> – The VoIP SpeakFreely website

<http://www.kwarc.org/irlp/> – IRLP user guidelines

Footnotes

1. Since default node codes are public in some areas, other areas also require a pre-access code.
2. CANWARN is similar to the US SkyWarn system.
3. ADPCM is the same digital protocol used by the phone companies for long- distance service.
4. A reflector is a Linux-based PC sitting on some serious bandwidth which allows multiple audio streams to multiple repeaters.
5. IP is the TCP/IP packet address routing code used by all packets of data flowing on the internet. ■

2001

A Year To Remember for 6 Meters

Major *F2* Activity Arrives on the Magic Band

While many were decrying the "abysmal" performance of sunspot Cycle 23, those faithful to the Magic Band were still staying tuned. As WB2AMU describes, they were not disappointed.

By Ken Neubeck,* WB2AMU

The year 2001 held many surprises for 6-meter operators. On the band there was the usual sporadic-*E* activity during the summer months; this included some openings into Europe and South America from the east coast. An unusual sporadic-*E* opening occurred on February 20 and lasted all day; northeast US stations worked into the South and the Midwest.

Then toward the end of March the sun erupted! Major solar flares and CMEs (Coronal Mass Eruptions) were spit out of the sun and headed toward the Earth's magnetic field, which resulted in high geomagnetic activity during which the *K*-index values exceeded 7 for several hours. As a result, some very significant aurora openings, which also reached up to 2 meters, occurred on March 30 and 31 and April 11. There were some additional aurora openings in the summer months, including an opening during the June VHF contests.

At the end of the summer sporadic-*E* season in August, however, the question on the minds of most 6-meter operators was what kind of *F2* activity there would be in the fall. Would it be the same as or worse than what was experienced in fall 2000?

F2 Arrives in Force!

Many 6-meter operators who came on the Magic Band during the mid-1990s had not yet experienced significant levels of *F2* propagation on 6 meters, and they were looking forward to the peak of the current solar cycle (Cycle 23). However, the supposed peak year of 2000 saw only moderate levels of *F2* conditions on 6 meters during November and December. There were a few days when east coast US stations worked into Europe and the west coast. Even so, there was no sustained period of activity lasting more than a few days.

The solar flux values in November and December rarely reached 200 (the magic number for 6-meter *F2* activity) for any extended period of time. These openings were nothing in comparison to what was seen during the last solar cycle (Cycle 22), much to the disappointment of many 6-meter operators.

Thus, by spring 2001, when many of the propagation predictors felt that the peak had passed, there were low expectations for the upcoming fall months of 2001. A continued decline in the solar flux values was expected by many of the propagation experts. Surprisingly, it turned out that the values were consistently high for fall 2001—above 200. The increase in these solar flux values during fall 2001 suggested that Cycle 23 would have a double-peak.

It was to be expected that most of the openings would occur during the daylight hours while many were at work. For this reason and others pertaining to operating time constraints, the internet became a very important tool for spotting 6-meter openings. For me, while I have internet access at my work QTH, I don't have a station at my desk. Therefore, it was convenient to listen to these openings using a setup in my car while parked in the parking lot.

Based on my experiences in 2000, I knew that a simple vertical setup on the car was not always sufficient for working *F2* openings, particularly when there were pile-ups and a little gain in the signal was needed. As a result, I set up a 2-element Yagi on a mast into an umbrella stand at lunchtime. This proved to be effective in November 2000 during a CW QSO with PYØFF on Fernando de Noronha.

This arrangement was too obvious to leave outside during normal working hours, plus it potentially could fall down. Therefore, I developed a way to hang the antenna from a pine tree in the corner of the parking lot. I arrived at work early and set up the beam in the tree. Then I monitored the internet sites for spots that identified when a 6-meter opening was in progress.

Occasionally, in addition to my one-hour lunch break, I was able to go outside to the car during the work day and take a "radio break." I performed this daily routine (or ritual) for three months during the *F2* season. Perhaps this behavior seems eccentric to some, but many of us long-time 6-meter operators knew that this was a very special time, and it was best to take advantage of it as much as possible.

On October 30 at 11 AM when I took one such 6-meter radio break, I was able to work FR5DN on Reunion Island. I had heard European and Caribbean stations coming in early that morning, but the pile-ups from stateside US were tremendous. Because of an experience I had had ten years ago during the fall of 1991, I was hopeful that things would really start to pick up throughout November. They did—big time!

On Sunday, November 4 there was a very strong one-hour European opening which allowed me to work several stations in the UK, the Netherlands, and Denmark using 20 watts and a dipole. The next week the pattern fell into the following daily

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e-mail: <wb2amu@cq-vhf.com>

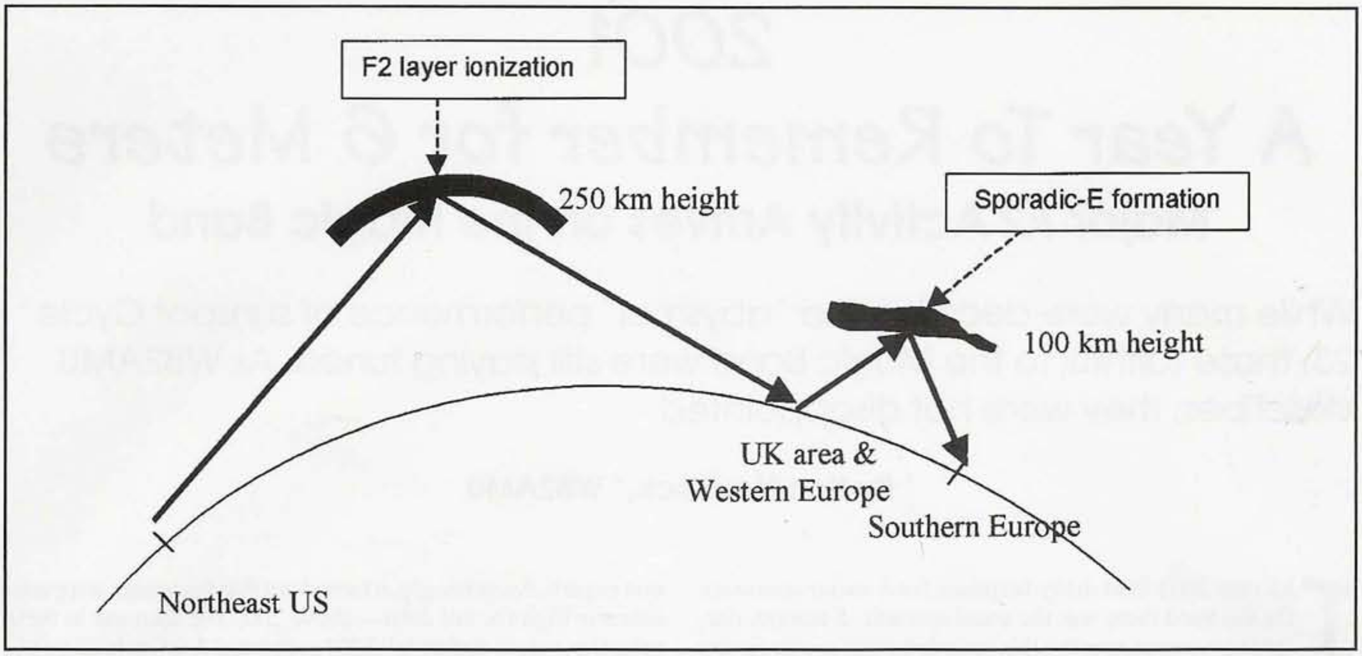

Figure 1. Pictorial description of combined F2 *and sporadic-*E (Es*) opening on January 3, 2002 between the northeast US and southern Europe.*

routine for the most part. There was some *F2* skip to Europe during the mid-morning hours from around 9 to 11 AM local time (1400–1600 UTC). By noontime the skip swung around toward the west, and I was able to work stations in Washington, Oregon, California, and British Columbia, Canada.

On a few occasions the skip stretched out, and I heard Alaska. I finally was able to work my first Alaska station, KL7FZ, on 6 meters on November 12 at 1:30 PM. I heard reports of many west coast US stations working into Japan later that day.

I continued my daily routine of arriving early at work and setting up my portable 2-element Yagi in the pine tree in the corner of the parking lot. (In addition, I took a few days off and monitored activity from my home QTH.) Usually, the beginning of my noon lunch hour was the time when the skip started to change from east to west, and as a result I had to change the direction of my "tree beam." Typically, this was when I often heard the OX3SIX beacon in Greenland. Then I heard the west coast beacons, such as VE7FG in British Columbia.

One can actually sense the movement of *F2* skip. By watching the internet reports, it could be seen that the Midwest lagged the east coast by an hour or so with regard to European openings.

November continued to be a very good month for *F2* activity, which occurred almost daily. In January 1991 I heard a nice 30-minute opening into Europe, and at the time I thought the opening was so special. In November and December 2001 I experienced openings into Europe which featured strong signals for over two hours! I worked many stations using a vertical antenna while I was mobile.

On some days the propagation was better toward Europe in the morning, while on other days it was better toward the west coast of the US in the afternoon. During this time I think I worked just about every 6-meter operator in grid square CN87 in the state of Washington! Many operators were truly surprised at the consistency of the openings.

The ability to observe daily *F2* propagation on the Magic Band was unbelievable, which is an idea that would have been scoffed at by many in the past. I observed 20 days of *F2* propagation in November and 30 days of *F2* in December. As a result, my DX country count on 6 meters started to climb .

The *F2* activity did not let up when January 2002 began. Many operators continued to work Europeans and the west coast during the first week of the month. On January 4 I worked several stations in the Mediterranean area, covering Spain and France, along with rare 6-meter DX such as ZB2EO and ISØGQX. This opening occurred well after the local sunset of the European stations, from 1700 UTC on, so most likely there was sporadic-*E* skip linking up with the *F2* path. See figure 1 for a pictorial description of how this can happen.

The next day, January 5, at 1400 UTC I was able to work into central Europe via another *F2*/sporadic-*E* link up. I worked YL3AG, LY2BH, and LY2BAW. YL3AG's CW signal was over 599! Then an hour later I worked D44TD on Cape Verde on SSB. The day was capped off nicely when I worked into the Northwest Territories of Canada, contacting VE8NSD.

By the second week of January the *F2* started to weaken a bit, corresponding with drops in the daily solar flux values. However, things started to pick up again by the 15th.

As the *F2* activity continued, the VHF community hoped that some of this activity would be witnessed during the annual ARRL VHF contest held on the third weekend of January. On the first morning of the contest the 6-meter band was open between the US and Europe until one hour before the contest was to begin, so even though the propagation gave out, there was some hope that *F2* would appear sometime during the contest period. I did hear KB7WW from Washington coming in by *F2*, but the signal was not strong enough to work.

The next morning I had hopes that Europe would come in on 6 meters during the contest. Imagine the thought of this! There were some brief openings, and I did hear OZ4VV being worked by one contester in Rhode Island. Later the TF3SIX beacon was coming in strong. Eventually, TF3AX came on sideband in the phone portion, and he was swamped.

At noontime in the east, the west coast started coming in at modest strength. Even though I was only running 10 watts and a 2-element beam as a QRP portable station, I managed to work K7RAT, N6RZ, K7CW, and VE7SL during the one-hour opening.

It is recognized by most in the VHF community that *F2* activity in a VHF contest can occur only during the January contest, and even at that, only once every ten years. Even so, the *F2* activity this year continued through the end of January, up to the time of this writing.

On many of the days from November 2001 to January 2002, some of the better-equipped UK stations consistently came in to the east coast and the Midwest of the US. These included Calum, GMØEWX; Tony, GW4VEQ; Alan, GIØOTC; Neil, GØJHC; Gordon, GI6ATZ; Dave, MMØAMW; and Conrad, GØRUZ. These UK stations made a significant impression due to the large number of stations they have worked in the US. For example, GMØEWX has worked 93 of the 100 grids in the EM grid field (this 100-grid field covers most of the southeast and south-central US), and GIØOTC has worked 90 of the EM grids. These were worked over a period of three months, compared to a handful of these grids worked over the past ten years by two-hop sporadic-*E* propagation.

The reports I have given here represent a small sampling of the *F2* activity that was heard. Many other hams did much better and worked more DX stations during the three-month period from very late October 2001 through early February 2002. For example, Tim Havens, N1RZ, in New Hampshire, completed his 6-meter DXCC after only 13 months on the band! He and others in that state seem to have been in the ideal spot for capturing many of the *F2* openings from Europe and into the west coast.

A number of my fellow 6-meter friends in the New York City, New Jersey, and Long Island area had many banner days on 6 meters; among them were Dave Ripton, K2SIX; Frank Moorhus, AA2DR; and Brian Rowe, KB2VQU, as well as Jay Buscemi, K2OVS, who finally worked his 100th country on 6 meters after many years on the Magic Band. At the end of the last cycle there were perhaps 100 hams (mostly non-US) who had achieved 6-meter DXCC. With the recent flurry of *F2* activity the number now should be about 500.

Things Learned from The 6-Meter F2 Activity

One of the big factors with regard to this cycle as compared to the last one was the presence of many more 6-meter operators. This increased presence is directly related to 6 meters now being a common band in the newer HF rigs.

In addition, as I pointed out above, the internet has played a key role during this cycle. For example, the internet was key in alerting me that *CQ VHF* contributing editor Gordon West, WB6NOA, in California, was looking for me on 6 meters one afternoon while I was working. I managed a short ten-minute break, and using my tree beam I found Gordon at 59 plus on SSB. No doubt the internet and the presence of many more hams were key factors in increasing the number of stations who were worked via *F2* as compared to the number of stations worked during the previous cycle.

From my daily activity it became apparent to me that the solar flux value generally has to be over 200 for several days in order to achieve the occurrence of regular *F2* 6-meter activity on a daily basis. The daily sunspot count can fluctuate widely; it is the solar flux value that dictates regular openings. Also, it appears to me that the year following the sunspot peak is better than the year leading up to the peak.

While this cycle was thought to be dead at the beginning of 2001, as mentioned above, it turns out to be a double-peak configuration. The solar flux values were notably higher for November and December 2001 than they were for the same months in 2000. Significantly more openings and more stations were worked during this latter period. For example, I worked about 50 stations during 19 days of activity in 2000 and about 250 stations during 50 days of activity in 2001.

Some things became apparent after hearing the same patterns over the course of three months. They are:

• At the peak of the season (around the winter solstice) there are very well-established *F2* paths that exist between the northeast US and the UK, and between the northeast US and the west coast, which follow the track of the sun during the day. These paths were noted to be much narrower than the area of coverage heard on 10 meters and the other HF bands, which suggests that a much smaller area of the *F2* layer was dense enough to reflect 6-meter radio waves.

This anomaly also followed a seasonal pattern regarding the Earth's positioning with regard to the sun. The *F2* paths tend to move toward the higher latitudes as the winter solstice approaches. Thus, stations in Iceland and Nordic countries, as well as stations in Alaska and the NWT, are worked from the northeast US. The *F*-layer has a peak during the winter season (called the winter anomaly), and the peak *F2* paths seemed to occur in areas that were farthest from the sun—i.e., the farthest north.

• There was a very distinct daily pattern for my area in the northeast which occurred as follows:

* 8 AM to 12 PM local time, northeast US to the UK.

* 11:30 AM to 2:30 PM local time, northeast US to the west coast.

* Southern path into the Caribbean and northern part of South America could occur at any time of the day.

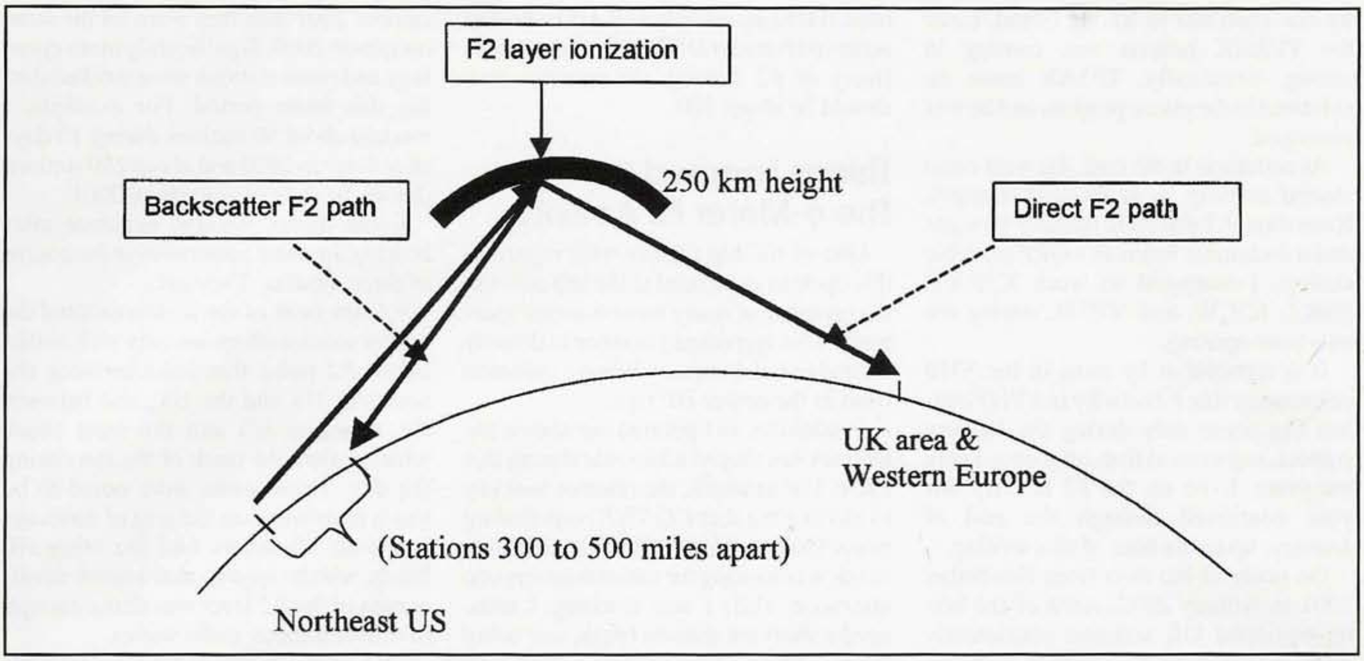

Figure 2. The F2 backscatter mode.

Regarding *F2* skip direction, which followed the daily path of the sun, the same local times applied to other areas as well.

• This cycle may not have reached the levels the previous cycle reached. However, the *F2* activity was facilitated by the increased number of hams who were on 6 meters in this cycle, compared with the last cycle.

• There was some very good backscatter on many of the *F2* openings. Stations that were 300 miles away (by direct line) could be worked by pointing one's antenna toward the *F2* formation and coming back. For example, I was able to work upstate New York and Canada by this mode from my home QTH on Long Island while pointing my beam toward Europe.

As it turns out, it was possible to hear many stations by backscatter before hearing stations by direct *F2* paths, which gave many alert operators a "heads up" regarding a potential *F2* opening. See figure 2 for a pictorial description of *F2* backscatter.

• The 10-meter band was not necessarily the best indicator of whether there was *F2* activity currently happening on 6 meters. Signals that were super strong on the 10-meter band did not always mean that 6 meters was open, and vice versa. I saw this general lack of correlation during the 10-meter contest around my local noon hour when I was working Europe on 6 meters but not hearing that much from Europe on 10 meters.

• DX stations spread out very well throughout the entire band during the better openings, sometimes going above 50.250 MHz. DX stations in general did a good job of preventing excessively crowded QRM situations by spreading out on the band.

• In December, despite the high solar activity there was no aurora activity, and this extended into the mid-latitude areas of the Northern Hemisphere. During the last ten years only two aurora events were observed in December. The lack of aurora (and the causal high geomagnetic activity) was beneficial to the *F2* activity that occurred during the entire month.

• The really long-range DX on 6 meters (distances exceeding 10,000 miles, such as the Reunion Island contact I made) seemed to be more probable in late October and early April than during the other months of the winter season. Most likely this is because of the higher *F2* activity around the equatorial zones at these times of year, making potential two-hop *F2* skip possible. During the heart of the *F2* season, the only extensions beyond normal single-hop *F2* seemed to occur when a sporadic-*E* link was present. (Sporadic-*E* has a minor winter season from November through January.)

• Finally, with the excellent *F2* conditions and widespread participation of stations, it became clear that the main part of the *F2* season for east/west propagation for stations in the mid-latitude areas of the Northern Hemisphere ran from October 30 through February 6, a period of approximately 100 days. Even though the solar flux values remained over 200 after February 6, *F2* activity was spotty at best, unlike that seen during the aforementioned 100-day period.

What Can We Expect From This Point On?

As mentioned above, after February 6 the *F2* activity on 6 meters diminished significantly. However, there may be a few spotty openings during late spring and fall of this year. Aurora activity will continue to occur, typically during the early spring and early fall months. Overall, sporadic-*E* will be unchanged, with the major summer season beginning in May and continuing through August for stations in the Northern Hemisphere.

It is possible that some hams who have received a taste of 6-meter *F2* activity may lose interest in 6 meters as the *F2* activity fades on the band (sort of like *F2* withdrawal). However, it is important to realize that long-range contacts can be made via sporadic-*E* that begins in May, although more listening will be required throughout the day to catch the openings.

Finally, the dedicated 6-meter operator should continue to stick with the band over the course of the solar activity decline, looking for sporadic-*E* and aurora activity.

It was great for many of us 6-meter operators to experience these *F2* conditions during this past fall and winter. For many of us long-term, dedicated aficionados of the Magic Band, we could only have dreamed of such conditions in past cycles! ■

CQ VHF *Interview:*

Chip Angle, N6CA, Speaks His Mind on 6-meter DXing

Working DX on the Magic Band takes both patience and some operating techniques different from those which are used on HF. One important difference is the DX window. Chip Angle, N6CA, among others, proposes a larger DX window. Recently, *CQ VHF* Features Editor Gordon West, WB6NOA, interviewed Chip to allow him to clarify his views on the 6-meter DX window.

By Gordon West,* WB6NOA

Who is Chip Angle, N6CA? Chip is one of the better-known and more active West Coast weak-signal operators. His operating from HF frequencies through 24 GHz includes several VHF+ firsts and several world records for contacts between the West Coast and Hawaii. A brilliant engineer, Chip owns Angle Linear,† a designer and manufacturer of linear radio frequency (RF) products and peripherals for communications.

In business for more than 20 years, Angle Linear's customers include business, cellular, trunking, aerospace, education, science, deep space and space shuttle, radio astronomy, and amateur radio entities and individuals. Hams worldwide use many of his products.

Chip cares deeply about amateur radio and its future, in particular operating on the VHF+ ham bands. In this conversation with CQ VHF *Features Editor Gordon West, WB6NOA, Chip turns his attention to the 50 MHz ham band and his views on how best to use it.* —*N6CL*

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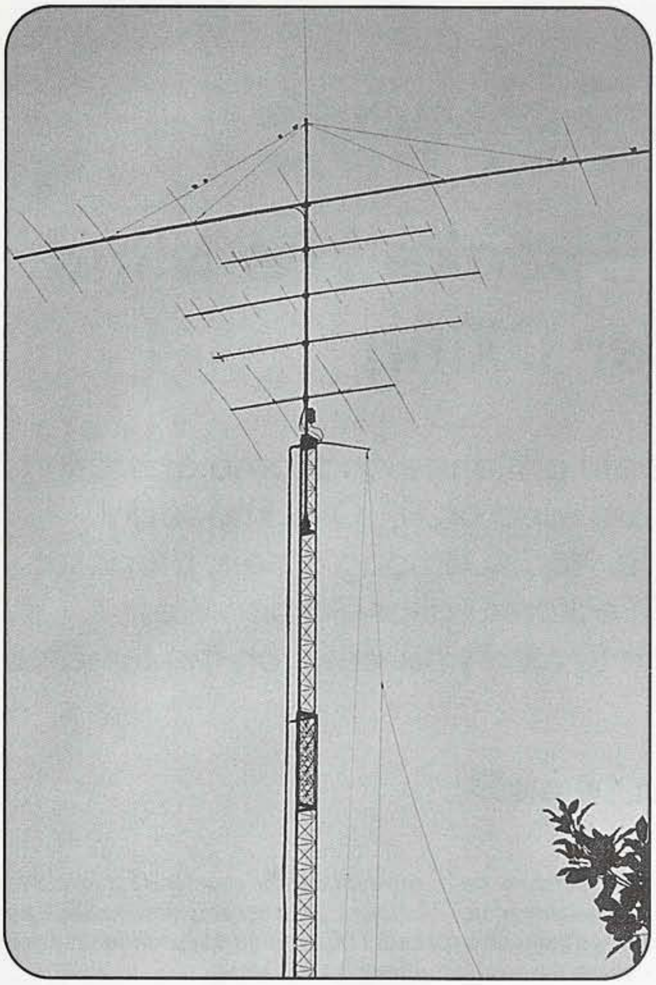
Last November was perhaps the greatest month in the history of the 6-meter band for *F2* and sporadic-*E* band openings throughout the world. Veteran 6-meter DXers claim that the *F2* activity exceeded daily duration and distances in 1957. DX conditions last November, coupled with 6-meter capabilities built into the popular HF transceivers of today, gave us sunrise-to-sunset, long-haul DX from 50 MHz up to an astonishing 50.300 MHz.

"*Spread out!*" was the order of the day last November, so the DX "window" was just about anywhere on the weak-signal portion of the band.

CQ VHF Features Editor Gordon West, WB6NOA (right), interviews well-known West Coast VHF+ DXer Chip Angle, N6CA.



This array tells only part of the story of the many firsts and world records Chip, N6CA, holds.

Spring 6-meter band conditions now get us back to normal, where almost everybody parks on 50.125 or 50.110 MHz, listening for activity. The DX window? Somewhere below .125, and a hotly debated subject when you get "caught" blasting a SSB CQ *below* .125. Just ask well-known "wider window" advocate Chip Angle, N6CA!

CQ VHF: Chip, where do you think the domestic calling frequency should be?

Angle: 50.150 MHz. This gives us *more* room to listen for *real* DX. The DX I am talking about is *F2* and multi-hop sporadic-*E* coming in from Europe, South America, and over the Pacific Ocean from Asia.

CQ VHF: You don't classify strong *E*-skip stations from within the U.S. as *real* DX?

Angle: USA short-skip stations on single- and double-hop sporadic-*E* are not what I would classify as long-haul DX. In fact, many seasoned HF low-band operators who come up to 6 meters may not realize how far 6-meter ground waves travel. Someone working stateside contacts on .125 or slightly higher can clobber any *real* DX reception to an operator 50 miles away who is trying to listen within the DX window, which is presently a few kilohertz away, and compared to HF work, 6-meter ground wave can be 50 dB stronger or more.

CQ VHF: Therefore, the best way to get some very-long-haul DX is *not* to call CQ?

Angle: Exactly. A CQ call down close to our present narrow DX window keeps the rest of us from being able to listen.

CQ VHF: How do you and a few of the other well-known, long-haul DXers end up with those rare contacts down in the DX window?

Angle: First, we anticipate a DX opening by listening in the mornings to the northeast, and swinging clockwise around like a compass to the northwest at the end of the day. We listen for the beacons below 50.080 MHz, but most important, we watch selected sites on the internet.

CQ VHF: Which sites?

Angle: The primary one I use is the N1RZ 6-meter page, which is a server dedicated to 6 meters. I also watch the OH2AQ cluster, which is worldwide. We watch only the 6-meter part of it, and finally the 50 MHz Prop Logger, depending on the time of day.

CQ VHF: I imagine you also listen to 50.110, the international DX calling frequency, too?

Angle: I *do* listen, but I pay a lot more attention to my local liaison radio, where some of us discuss what we are hearing on the band. There are times when a station just 70 miles away is beginning to hear international DX come in, yet I don't hear anything. Then a few minutes later they hear nothing, and I have the DX.

CQ VHF: Incoming 6-meter sky waves are that selective? Seventy miles makes a difference after the signal has traveled 7,000 miles?

Angle: Absolutely. One minute you have it, and the next minute they have it! Even our opening to Reunion Island 16,400 miles away and Vietnam at 8000 miles was selective.

CQ VHF: To work this DX it had better be beyond North America to qualify for the DX window below .125?

Angle: Correct. In a survey during the last solar cycle, Bill Tynan, W3XO, came up with the idea of the DX window by surveying serious 6-meter operators in the country. The 25 kHz window was considered wide enough. 50.100 to 50.125 MHz would be non-domestic DXing only. The DX calling frequency would still be 50.110 MHz.

CQ VHF: What's the problem with the present DX window?

Angle: The problem is the domestic calling frequency at 50.125 MHz. It would be much better if it were moved up to 50.150 MHz.

CQ VHF: 50.150 MHz?

Angle: Yes, domestic calling at 50.150 MHz because the typical single-sideband signal is rather wide, especially if it's coming from a ground-wave station less than 50 miles away. If we are trying to run a noise-blanker down in the DX window, we get clobbered and won't hear the weak signal.

CQ VHF: Please give me an example.

Angle: A good example is a station on 50.120 MHz coming in from Europe, and a local rag chewer on 50.125 MHz talking to another local about how the band finally went dead a few minutes ago. When that local station is 40 over 9 and 80 dB out of the noise, there is no way you can listen just 5 kHz away. Getting the domestic calling frequency well away from the DX window would be a major advantage to any op with a big beam up at least 70 feet trying to pull in *real* DX.

CQ VHF: What is the objection to moving the domestic calling frequency to 50.150 MHz and using the original 25 kHz as a guard zone for weak DX below it?

Angle: Some people just don't want to move. They have no problem working domestic single-hop and double-hop *E*-skip at 50.125 MHz and higher. Mobile units know that 50.125 MHz is a good spot to call CQ and probably find someone domestically listening in on that frequency. Hams with larger beam antennas wanting to work all states certainly may find 50.125 MHz a great spot for calling CQ Rhode Island, CQ Hawaii, or CQ Alaska. Probably the biggest resistance to changing the domestic calling frequency is the operator with an omni vertical on the roof who can't see any reason *not* to call on .125. Many times the operator will receive an answer and continue to stay on .125, clobbering those of us just 5 kHz below working *real* DX.

CQ VHF: Working all states isn't DX?

Angle: It's a lot of fun but really not *real* DX, so why move?

CQ VHF: One ham tried to convince me that the maximum usable frequency cutoff was so sharp that hooking up with a *real* DX station down on 50.110 MHz might mean the DX signal had no chance of getting through at, let's say, 50.150 MHz. Is the MUF cutoff that critical?

Angle: I have never seen this happen. I have moved many a DX station up more than 200 kHz, and they continue to hold their signal strength.

CQ VHF: I most definitely can agree with you. During last November's extraordinary band opening between the west coast and Japan, I kept going higher and higher with this one Japanese station, and although our signal strengths were relatively weak, he didn't drop out abruptly.

Angle: Don't get me wrong; I think

talking mobile on 6-meter skip is fun and great, but take it off .125, and move well up the band in case you're driving anywhere near my place when I'm trying to listen in the DX window just a few kilohertz away. Besides that, any mobile antenna is about 20 dB down from a single Yagi—even as low as 20 feet!

CQ VHF: Okay, how about another reason for taking the domestic calling frequency to 50.150 MHz?

Angle: For one thing, you could exercise your wrist a little more to the left and right by being able to move slightly lower down or hopefully slightly higher up the band as soon as you made contact on domestic calling 50.150 MHz.

CQ VHF: What are they doing in Europe?

Angle: The European DX window is 50.100 to 50.130 MHz. It seems logical that we should keep *both* our windows compatible. I then would like to see 50.130 to 50.150 MHz as domestic CW. That would get it out of the bottom part of the band, again giving us relief from ground-wave signals right next to weak incoming beacons and SSB voice.

CQ VHF: Was there a problem with the present CW window?

Angle: For DX, yes, because most *real* CW DX contacts were between 50.080 to 50.095 MHz and there was extreme QRM from domestic CW stations from 50.095 to 50.100 MHz. These domestic stations, probably due to a non-real DX type of antenna, had no idea that DX was coming in just above the noise level all around them, and they weren't watching the internet. Domestic CW has been a major interference problem, but I doubt that it will ever get moved.

CQ VHF: What other interference are you finding in the present DX window?

Angle: Harmonics from television color-burst crystals ending up on 50.111, -112, and -113 MHz—something like the 14th harmonic—and every TV set, along with many appliances, use them.

CQ VHF: I can relate to that. The only time I ever heard 50.111 MHz in the clear was when I was maritime mobile 100 miles offshore. What else is causing problems in the DX window?

Angle: Off-frequency cordless phones, baby monitors, birdies from computers, FAX machines, and broadband wireless, you name it. It always seems to end up at the very bottom of our 6-meter band.

CQ VHF: Besides all the squeaks and squawks on the bottom end of 6 meters, what do the seasoned 6-meter DXers with major-size antennas worry about when band conditions get hot?

Angle: There are some excellent high-frequency operators who have heard about the excitement on 6 meters and start calling CQ for DX without considering how strong their ground waves are. On 40 meters, for example, the ground waves are relatively weak 50 miles apart. On 6 meters, however, the ground waves are extremely strong even up to 100 miles away, and if they're calling CQ on 50.125 MHz, it might be impossible to hear the real DX just 5 kHz away.

CQ VHF: What is the key to great *real* DX?

Angle: Don't call CQ. *Listen*! Get on the computer and pre-arrange your contact via the internet, or at least see on what frequency the distant station is presently operating. Chat with stations and let them know you are looking for them. DX stations also like to know someone is interested in working them.

CQ VHF: Therefore, a CQ down on the DX window is not appropriate?

Angle: No, it's not. Those who call CQ incessantly usually end up working no one. Let the DX call CQ! They [those who call CQ] also spoil it for the rest of us who are trying to listen carefully for a distant station as seen on the computer. Even up at .125, a CQ or rag chew wipes us out within the DX window.

CQ VHF: Final thoughts?

Angle: Learn how the band operates by *listening* first and learn about 6-meter propagation. Log onto the internet and look for indicators that the DX may be coming your way. Set up schedules over the internet. It's far easier to work real DX when you know exactly what frequency they're on. You're looking for them, and they're looking for you.

CQ VHF: The internet has pretty well replaced HF 6-meter liaison comms?

Angle: Yes, it has. 28.885 MHz may no longer be the hot bed of 6-meter band-opening announcements. It has been the international QRP calling frequency on 10 meters. Most serious 6-meter DXers no longer hang out at 28.885 MHz. However, they watch the internet rather closely. Of course, DXpeditions without the internet may indeed announce their 6-meter intentions on 28.885, so don't give up that frequency totally.

CQ VHF: Final closing thoughts?

Angle: With the terrific band conditions we have been experiencing, and with the many new radios with 6 meters, we all need to exercise *spreading out* and working higher up the band to minimize interference to those stations in the super listening mode down in the DX window.

CQ VHF: That seems logical to me, but why are there some hams who might oppose changing the domestic calling frequency from 50.125 up to 50.150 MHz? What's the problem?

Angle: They probably don't want to change because they didn't think of it first. Second, they don't want to be told what to do. Third, they have had a habit of sticking on a particular frequency near the window and didn't realize there is a problem. Last, back to the first observation: Hams just don't like being told they can no longer operate somewhere and must move off frequency. I think we all need to accept change, and if it makes some sense and won't hurt domestic skywave contacts, then indeed, move up 25 kHz for domestic calling at 50.150.

Jack Henry, N6XQ, reminded me that in the fall European DX was moving above .200 in an effort to find clearer frequencies to work the west coast—amazing. Let's spread out and give everyone around the world some breathing and *listening* room.

CQ VHF: Thanks, Chip, for spending the time with me for this interview in your 6-meter wall-to-wall radio and test-equipment garage. ■

Some 6-meter DX websites

via Chip Angle, N6CA

http://6m.dxers.info/spot/index.html

http://oh2aq.kolumbus.com/dxs/50.html

http://dxworld.com/50prop.html

http://www.big.or.jp:80/~ham/pubhtml/dxcl50.html

http://www.ham-radio.com/n6ca

CQ VHF *Reviews*

The Ten-Tec 1260 6-Meter FM Transceiver Kit

By Peter J. Bertini,* K1ZJH

Photo A. The T-Kit 1260 6-meter FM transceiver with mobile mounting bracket and hand microphone.

Most of us are familiar with Ten-Tec, Inc. and its reputation as a respected and popular manufacturer of quality amateur, commercial, and military communications products. What is a better-kept secret, however, is the company's growing line of amateur-related kit offerings, dubbed "T-Kits."

The T-Kits cover the gamut from simple projects, such as active antennas, to more advanced offerings which include shortwave receivers, transverters, and VHF FM transceivers. I had the pleasure of building the T-Kit 1254 AM/SSB receiver a few years ago, and I jumped at the opportunity to do a review of the T-Kit 1260 6-meter FM transceiver kit.

Many of the kits share a common enclosure, reducing setup costs and keeping the prices reasonable. The case features a rugged, wrap-around metal clamshell construction—no cheap plastic here!

The Ten-Tec 1260 is a 5-watt 6-meter FM transceiver kit. Even though it's a kit, don't be misled; this is a full-featured transceiver offering 15 programmable memories with scan, standard and non-standard offsets, and CTCSS (subaudible tone encoding).

The T-Kit 1260 is fully packet-ready. A 5-pin DIN data interface is present on the rear apron and is compliant with current ARRL guidelines.[1] This ensures compatible pre-emphasis and modulation level for data tones. Also, the RX audio, PTT, and Busy/Mute levels are brought out for easy interfacing.

Operation is simple and intuitive. Looking at photo A, at the bottom left on the front panel is the four-pin microphone connector. The two small knobs are for setting the volume and squelch.

Did I mention that the radio features an internal 3-inch speaker and an external speaker jack on the rear panel? The large control at the right performs several functions. It allows tuning in 2.5/5-kHz steps across the radio's 50.095 to 54 MHz operating range, tuning each of the 15 memory channels, and also is used to program the transmit CTCSS when it is required for repeater access. Whether the radio tunes in 2.5- or 5-kHz steps, an internal dip jumper sets the steps.

A five-digit, sunlight-filtered LED display shows the frequency. Discrete LEDs indicate TX, Busy, Offset status, and whether a transmit CTCSS tone is active.

Everything you need to get on the air—the mobile mounting bracket, fused power cord, and microphone—is included. Not included are the power source, 9-volt memory battery, and an antenna. The radio requires a 13.8 VDC source with a 2-amp rating. Reverse-voltage protection is provided by an internal diode and external fuse on the power cord.

**20 Patsun Road, Somers, CT 06071-1810*
e-mail: <radioconnection@juno.com>
[1]March 1994, ARRL Ad Hoc Committee on Digital Communications.

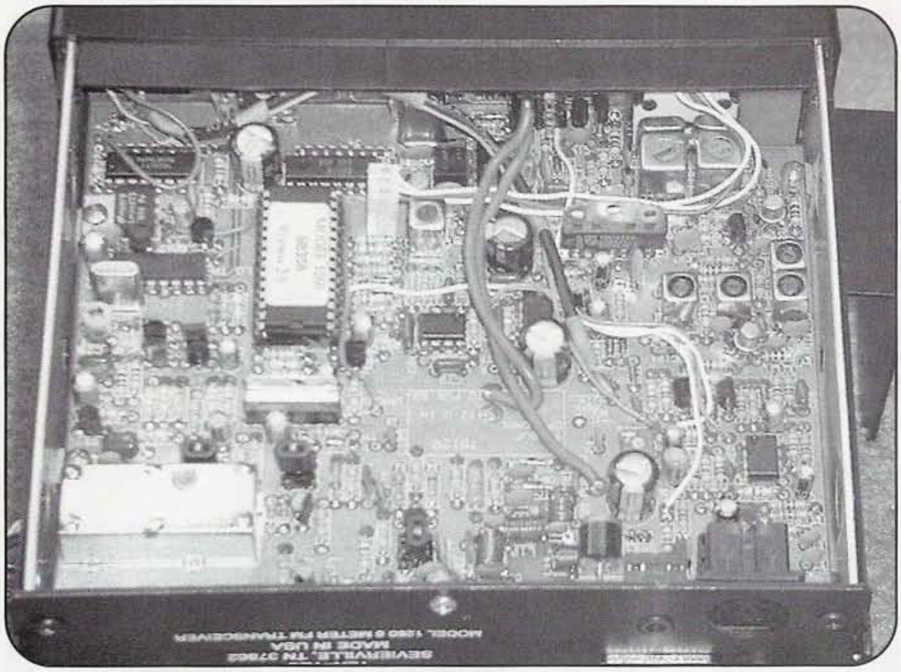


Photo B. Interior view of the T-Kit 1260 PC board. If things look crowded, they are! Resistor and capacitor counts each total over 100 pieces! Add in the numerous transistors, ICs, and other components, and you can see why this radio is intended for the more experienced kit builder.

Unlike the 2-meter and 1.25-meter FM T-Kits, FCC regulations prevent Ten-Tec from offering an optional higher power internal PA for 6 meters.

Why a Kit?

The 1260 is an advanced undertaking, and Ten-Tec rates the kit for experienced builders. I spent a few hours each evening over a two-week period assembling and testing the kit. I'll be honest: If your goal is based solely on saving a few dollars by building a kit, you'll find that it is a very poor payback, considering the time and effort required to do a proper assembly job. For those who like to build kits, the assembly process and experience of learning how the set works are the rewards.

If you've enjoyed building kits in the past, you will enjoy the challenge of successfully building your own 1260. The manual is well laid out and is a *must read* before any assembly is begun. There are 48 pages in the assembly portion of the manual alone! There are addendum sheets with minor changes that should be noted before starting the kit; if you do not, you *will* run into problems later.

The kit assembly spans eight "phases," as they are called. Each phase corresponds to the completion of one of the transceiver's major subsections. At the end of each construction phase the builder can power up the radio, and test and align that section of the radio. For example, at the end of phase two the VCO is tested and aligned. Finding a problem at this early stage eliminates a lot of tedious troubleshooting at a later date!

I'll say it again: *Read the manual before doing any assembly.* Ten-Tec sagely warns that more experienced technicians often are overconfident and more likely to run into problems because they tend to gloss over the manual, leading to mistakes that often are tedious to correct.

The PC board (photo B) is silk-screened and shows the component outlines and reference numbers. It also is masked to lessen the likelihood of unwanted solder bridges.

Each step in the manual has two check-off boxes. This feature permits the builder to check off each step as it is completed, and then to do a second check to verify again that each part is installed correctly as each phase nears completion.

With even the diode cathode bands indicated on the silk-screen, there is no excuse for mistakes *if* you take your time and double-check your work. The manual also contains a *component reference index* section which gives each component's reference number, description, and what it does in the circuit. More important, it shows the exact phase and step number where the part was installed. This is a great aid when checking to see that parts are indeed installed in the proper locations.

Count the Parts!

It is also very important to make sure that each and every part is present and accounted for! Imagine the confusion if when you reach the last step you have too many or too few parts! Did you forget a step, or is that really an extra part supplied by mistake? Some of the resistor values are hard to read, as the tan hue of the resistor bodies results in some confusion when trying to differentiate between colors such as red and orange.

In order to avoid placing a 1 kΩ resistor where a 10 kΩ resistor is called for, or vice-versa, I verified the resistor value using a digital ohmmeter before committing it to the soldering iron. Removing a part without damaging it or the board is a very tedious and difficult task!

Tools Needed

The 1260 kit is designed for ease of assembly. Only a few small tools—Phillips-head and flat-blade screwdrivers, side-cutters, and long-nose pliers—are needed for the assembly. A small wrench or set of nut-drivers is needed to tighten the mounting hardware for the On/Off switch and rotary controls.

A magnifying glass is handy, and I suggest using a temperature-controlled soldering iron with a tip intended for fine PC-board work. Keep the iron's tip clean and properly tinned. The PC board uses plated-through holes, so most of the mechanical solder strength will be in the solder bond between the plated hole and component lead.

Be careful to use the iron tip to heat the leads and PC board run, and ensure that the solder wicks into the plated holes when soldering. Very little solder is needed for a good connection.

Easy Alignment

Ten-Tec really had its act together when it designed this kit. A minimum amount of test equipment is needed! Most alignment is performed using a voltmeter, and the receiver alignment can be done using an off-the-air signal if no signal generator is available. The only tuning is the VCO alignment (one coil), and peaking the receiver's RF stages while using your voltmeter when monitoring a weak signal.

The VCO reference oscillator runs at 4 MHz and can be set to a frequency counter or by zero beating the oscillator to a good CW/SSB-capable communications receiver. The transmitter tuning is broad-banded and requires no alignment.

Problems Encountered

During the VCO testing and alignment my sloppy, temporary power hookups came apart and hit against runs on the PC board, promptly destroying the synthesizer IC. Removing the IC was a delicate task, and something I would not relish doing again. I also managed to break the volume and squelch controls due to carelessness. In all instances the Ten-Tec parts department was very courteous and prompt in getting me up and running as quickly as possible! The main point is that these problems could have been avoided had I exercised greater care and not rushed.

Troubleshooting

The best time to find and correct mistakes is when double-checking your work at the end of each of the construction phases. Hopefully, any defective components will show up during the testing portions of these phases. Unexpected problems do happen, though, and fortunately the manual contains a detailed troubleshooting guide to help you isolate and repair most problems you may encounter.

Components are warranteed for one year. If you cannot resolve a problem in a completed kit, the factory will inspect and repair the unit for a minimum $20 service charge. No charge applies if the problem is caused by a defective part.

Kits may be returned for a refund, less shipping, within 30 days, providing they are unassembled and in original condition. Thus, if upon examining the kit you don't feel confident that you are capable of building it, you have the option of returning it *as received* for a refund.

On The Air!

A few quick tests on the transmitter verified that it easily made its rated 4- to 5-watt output power, and the receiver is hot! I measured 12-dB quieting at 0.2 μV according to my Cushman CSM50A service monitor. The receiver uses two dual-gate MOS-FETs, one in the RF amp and the second in the first mixer stage.

The receiver is dual conversion, with a 10.7-MHz first IF and a second IF at 455 kHz. Two crystal filters at the first IF and a 455-kHz ceramic filter at the second IF provide selectivity. The deviation measured a tad over 5 kHz, but my voice is heavy and I tend to talk close to the microphone.

Once confident that the 1260 was working as intended, I hooked up an outdoor antenna and made some calls on the local 6-meter repeaters. The 6-meter FM activity in this area is rather sporadic, but after making two or three calls I finally was able to raise a few QSOs! Most stations commented that the 1260 had good-sounding audio. I wish I had had the opportunity to work some band openings, but in the short time between the kit's completion and my deadline, I wasn't lucky enough to be able to do so.

The T-Kit 1260 sells for $195.00 factory direct. You can reach Ten-Tec at 1185 Dolly Pardon Parkway, Sevierville, TN 37862 (phone 865-453-7172; fax 865-428-4483; sales <sales@Ten-Tec. com>; web <www.Ten-Tec.com>). ■

Understanding Parabolic Dish Reflectors

We've seen them everywhere. No longer unique to ham radio or listening for extraterrestrial communications, parabolic dishes pop up on rooftops, windowsills, front lawns, and even have been seen attached to a baby carriage for an outing in the park. Have you ever wondered how they work? VE3ERP tells us how.

By *George Murphy*,* VE3ERP

We live in a world surrounded by parabolic dish reflectors—on microwave towers, on residential satellite TV antennas, in flashlights, in photoflood lamps, and on those strange-looking devices used by football coaches who are trying to listen in on the opposing team's private, whispered conversations on the playing field. Did you ever wonder how parabolic reflectors work? For a demonstration, the next time you are watching TV in a room full of noisy kids, cup your hand behind your ear, then adjust your hand until the TV sound comes up and the kids' noise reduces. You have just shaped your hand into a parabolic reflector.

How It Works

The distinguishing feature of a parabolic curve is its focal point. Each incoming energy wave traveling parallel to the axis of a parabolic dish and hitting the dish is reflected (just like a carom shot in billiards) at the same angle it arrived on a path that passes through the focal point (figure 1).

This results in a high concentration of energy at the focal point. It is similar to what happens when you use a magnifying glass to focus the sun's rays on a campfire because all the campers have quit smoking and no one has any matches.

Conversely, energy transmitted from a source located at the focal point of a parabolic dish is reflected by the dish on an outward path parallel to the axis of the dish. This results in a concentrated outgoing beam of parallel energy waves such as those produced by a flashlight.

Does Size Really Matter?

As a receiving antenna, size definitely *does* matter. The larger the diameter of the dish, the more efficient a receiver it is, because like a fish net, it has a larger energy capture area than a smaller dish or net. This is why radio telescopes are so huge; they are searching for tiny voices of tiny green people thousands of light years away.

** 77 McKenzie Street, Orillia, ON L3V 6A6 Canada*
e-mail: <ve3erp@encode.com>

As a transmitting antenna, the efficiency of a parabolic dish varies with the nature of the energy source and proper illuminations of the reflector by the feed located at the focal point. Efficiency is highest when the energy is being emitted from a point source, such as a lamp filament. It still produces a concentrated beam of energy that is highly directional, because the energy waves do not fan out as they go.

A larger diameter transmitter dish does not change the amount of energy being transmitted, only its density. Parabolic antennas are very effective when used as transmit/receive antennas at both ends of a common link. This can be seen on microwave towers where parabolic antennas of modest size are used to transmit and receive signals over large distances.

Which Shape To Choose?

The shape of the reflector is determined by the acceptance angle (figure 1). Angles less than 90 degrees (figure 2) result in a dish that is relatively easy to make using a lightweight framework covered with a suitable reflective fabric or mesh.

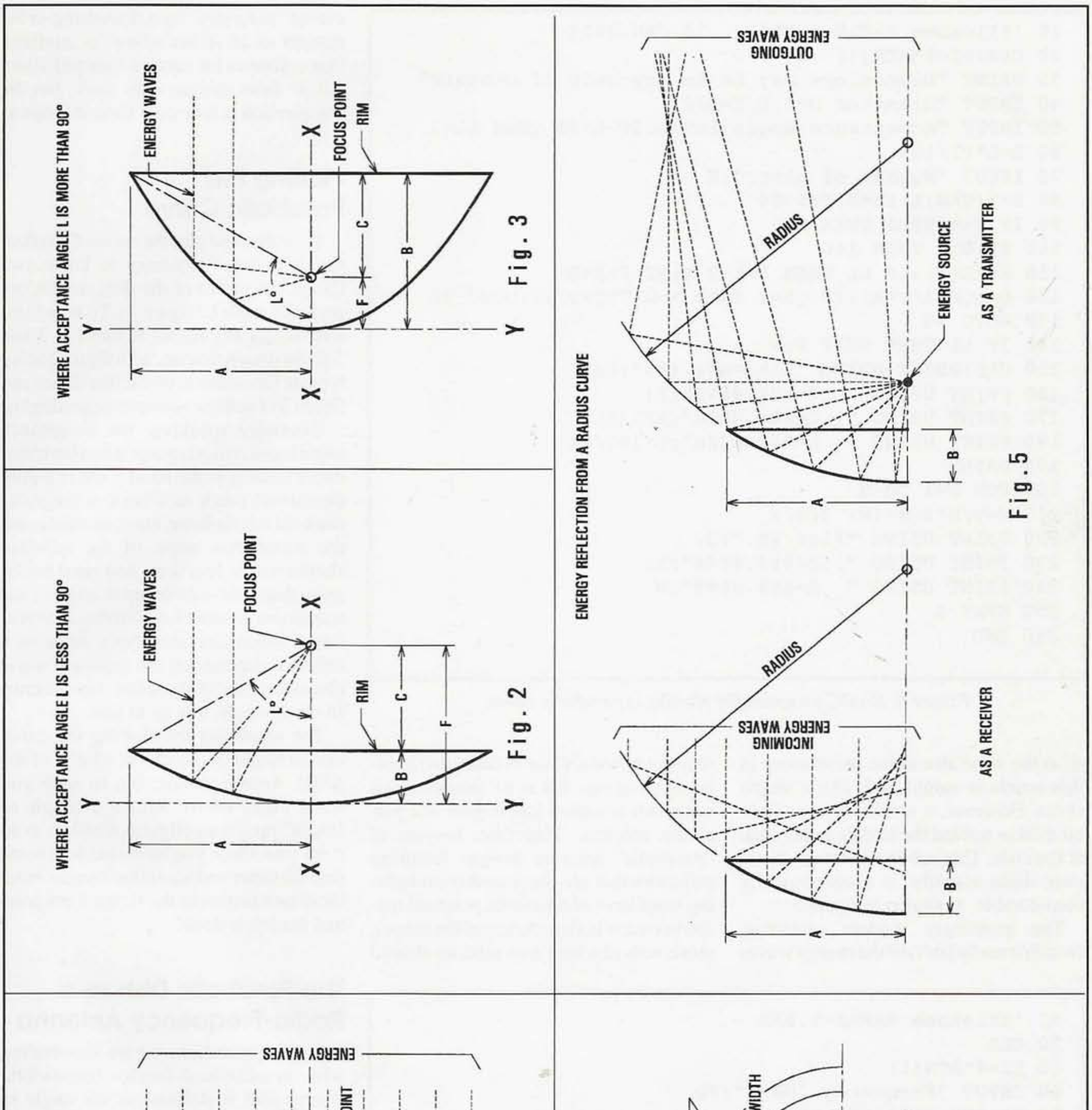
The main drawback is the need for some sort of mechanical extension to support the transducer at the focal point, while at the same time offering a minimum obstruction to the energy waves passing around it. This shape is widely used in radio frequency applications.

Acceptance angles more than 90 degrees (figure 3) result in a mechanically superior device where the transducer can be enclosed completely and mounted directly to the apex of the reflector. The dish is usually injection-molded plastic or a metal spinning, which for practical purposes limits its size and requires a point, or at least omni-directional, energy source.

This type of antenna is difficult to homebrew, and it tends to be heavy for its size, compared to a shallow dish. Deep-dish reflectors are used mainly in lighting and acoustical applications.

Which Shapes *Not* to Choose

As can be seen in figure 2, the parabolic curve of a shallow reflector looks very much like a simple radius. In fact, if superimposed on a radius of the same A and B dimensions, if print-



Figures 1–5. Configurations of curves and energy waves discussed in the text, where A = radius of dish, B = depth of dish, C = distance of focus point from mouth of dish, F = distance of focus point from bottom of dish, and L = acceptance angle in degrees.

```
10 'filename PARAB-1.BAS     16 JAN 2002
20 CLS:PI=4*ATN(1)
30 PRINT "Dimensions may be in any unit of measure"
40 INPUT "Diameter D=";D:Y=D/2
50 INPUT "Acceptance angle L=";L:IF L>90 THEN LL=1
60 L=L*PI/180
70 INPUT "Number of plots";N
80 B=Y/TAN(L):X=0:T=1000
90 IF T<=.0001 THEN 140
100 IF B=0 THEN 140
110 X=(X+T):IF LL THEN F=X-B ELSE F=X+B
120 Q=SQR(4*F*X):IF Q>=Y THEN X=X-T:T=T/10:GOTO 90
130 GOTO 90
140 IF LL THEN SWAP F,X
150 CLS:PRINT USING "DIA.=###.###";D;
160 PRINT USING "  F=###.####";F;
170 PRINT USING "  C=###.####";ABS(B);
180 PRINT USING "  L=###.###ø";L*180/PI
190 PRINT
200 FOR Z=1 TO N
210 W=Y/N*Z:X=(W)^2/4/F
220 PRINT USING "Plot ##.";Z;
230 PRINT USING "..B=###.####";X;
240 PRINT USING "  A=###.####";W
250 NEXT Z
260 END
```

Figure 6. BASIC program for plotting a parabolic curve.

ed at the same size as the illustrations in this article it would look like a single curve. However, it would be just a little bit thicker toward the middle rather than at the ends. This subtle difference, however slight visually, is mathematically considerable, as shown in figure 5.

The seemingly random scattering (which it really isn't) of the energy waves may not be too serious in audio and lighting applications, but at RF frequencies it can result in a huge loss in gain in a parabolic antenna. Therefore, beware of "parabolic" antenna designs featuring reflectors that are purchased from lighting suppliers (who have no practical reason to ensure high accuracy of the shape), those with ribs bent into random-shaped curves "naturally" by a drawstring in the manner of an archer's bow, or anything that collapses for ease of transportation. All of these designs may work, but the big question is *how well.* Caveat Emptor!

Plotting the Parabolic Curve

To design and plot the curve of a reflector, it is only necessary to know two things: the radius of the dish and the acceptance angle L (figure 1). To help visualize acceptance angles, figures 1, 2, 3, and 5 all are drawn to scale, with figure 2 being typical, for instance, of satellite dishes and figure 3 of antique automotive headlights.

Generally speaking, the acceptance angle is not critical except when the transducer located at the focal point is highly directional (such as a horn, waveguide, cardioid microphone, etc.), in which case the acceptance angle of the reflector should not be less than, and need not be more than, one-half the apex angle of the transducer's cone of sensitivity. The preferred shape and acceptance angle of a reflector depends on the application and characteristics of the other components. In other words, it is up to you.

The equations for plotting the curve can be found in any recent edition of the *ARRL Antenna Book,* but to save you some math, I have written a couple of BASIC programs (figures 6 and 7) to do it for you. Once you have decided on the dish diameter and acceptance angle, enter these two factors in the figure 6 program and the job is done!

The Parabolic Dish as a Radio-Frequency Antenna

In RF applications we are also dealing with an additional factor—beamwidth. Beamwidth is defined as the angle in degrees between half-power points (3 dB down) on the antenna radiation pattern as seen on a Smith chart (figure 4). Enter the desired bandwidth and the frequency of operation in the figure 7 program, and the dish diameter is calculated for you. Enter this diameter and your choice of acceptance angle in the figure 6 program, and you are finished.

Guys, if you want to build one of these in your back yard without your wife knowing what you are up to, tell her you are building her a revolutionary new type of self-flushing bird bath out of wire mesh so she won't have to clean it. ■

```
10 'filename PARAB-2.BAS
20 CLS
30 PI=4*ATN(1)
40 INPUT "Frequency (MHz)";FQ
50 WL=299.7925/FQ/.3048
60 PRINT "Wavelength in feet=";WL
70 INPUT "Desired beamwidth in degrees";W
80 D=70*WL/W
90 PRINT
100 PRINT "Dish diameter in feet=";D
110 PRINT "Dish diameter in inches=";D*12
120 PRINT
130 LF=1/LOG(10) 'factor for log to base 10
140 G=10*LOG(.55*(PI*D/WL)^2)*LF
150 PRINT "Gain over an isotropic antenna in dB=";G
160 PRINT "Gain over a dipole in dB=";G-2.15
```

Figure 7. BASIC program for calculating parabolic antenna dimensions and gain.

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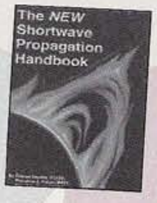

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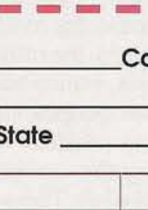

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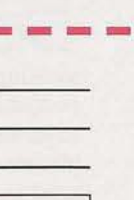

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The Station Controller

Do you have too many radios you want to put on the air and not enough ways to control them? In an attempt to bring some order to the chaos of the overcrowded shack, AF1US shares his design for taking the ultimate control of one's station.

By Gary Palamara,* AF1US

Photo 1. The Station Controller gives the operator independent push-to-talk and frequency up/down controls, plus a choice of microphones and other options. (Photos by AF1US)

Being unique and perhaps complex individuals, we seem to want different things out of our hobby. Luckily, amateur radio has a lot to offer. For me, the most fun comes from working SSB DX. I enjoy the pile-ups, the casual rag chews, and everything in between. In the shack, station accessories such as computers, voice keyers, and other peripherals only add to the pleasurable experience. Not being satisfied with using a PTT hand or desk microphone, I enjoy the convenience of using a boom mic or even the occasional headset. The problem with using either of the last two options is that of controlling the radio's operation.

Several years ago I built my first "Station Controller." Since then my station controller has gone through several design changes. In the current design the Station Controller (photo 1) gives one the flexibility of controlling any brand of radio, while providing several features that are not offered commercially.

* *P.O. Box 791, Farmingdale, NJ 07727*
e-mail: <morningstar@monmouth.com>

Before describing the circuitry of the controller, let me say that this project was designed specifically to work with a Kenwood radio. Of course, one can build the Station Controller to work for any brand of transceiver.

In an attempt to make the controller's operation "universal" and adaptable for relatively quick radio changes, special connections, called *headers,* were added. These headers allow the transfer from one brand of radio to another without having to rewire the entire control box.

For those who prefer only one manufacturer, it is possible to eliminate the headers entirely and direct wire the unit. However, Murphy's Law says that as soon as the project is finished, some other company will come out with a new model radio. At this point, you'll toss brand loyalty to the wind and start reaching for the soldering iron. Furthermore, if you build this project for a club station, the last thing you want to do is "lock" yourself into building the controller for a specific brand of radio.

The Station Controller consists of several independent sections: Radio Control, Status Indication, Audio Monitoring, and Microphone Selection. All of the parts are housed in a sloped-front metal cabinet. The size and shape of the control box are not critical and one can build the controller in any suitable enclo-

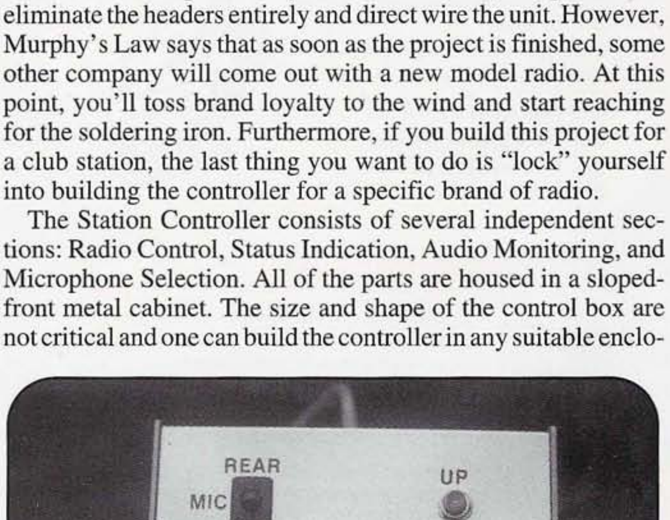
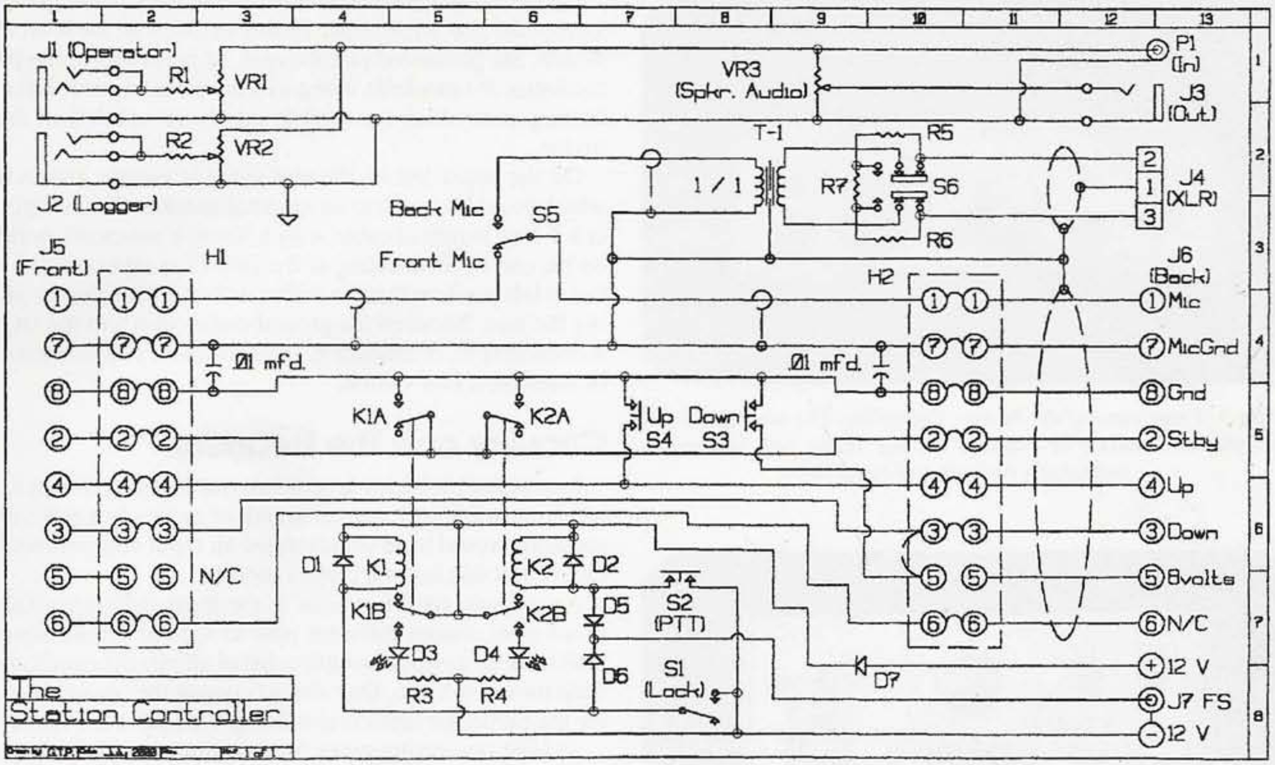


Photo 2. Top-panel controls on the Station Controller allow one to select a microphone, key the transmitter, change frequency, and even control speaker volume.



Parts List

Part ID	Description	Quantity	Source/Part #
S1	Red SPST (Lock) pushbutton switch	1	Mouser / 10PP422
S2	Red SPST (Momentary) pushbutton switch	1	Mouser / 10PA343
S3, S4	Red SPST (Momentary) switch	2	Mouser / 104-0012
S5	SPDT Switch	1	Mouser / 103-4023
S6	DPDT Switch	1	Mouser / 10TC618
K1, K2	DPDT 12V Relay	2	RadioShack / 276-249
D1, D2, D5, D6, D7	Switching Diode, 1N914 or equiv.	5	RadioShack / 276-1620
D3, D4	Red LED	2	
R1, R2, R7	100 ohm, 1/2-watt resistor	3	
R3, R4	1200 ohm, 1/2-watt resistor	2	
R5, R6	22K ohm, 1/2-watt resistor	2	
VR1, VR2	5K ohm linear taper pot	2	RadioShack / 271-1714
VR3	500 ohm linear taper pot	1	Mouser / 31VC205
J1, J2	1/4" stereo phone jack, chassis mount	2	RadioShack / 274-312
J1, J2 (see text)	1/8" stereo phone jack, chassis mount	2	RadioShack / 274-246
J3	1/8" mono phone jack, chassis mount	1	RadioShack / 274-251
J4	3-pin XLR jack, chassis mount	1	RadioShack / 274-013
J5	8-pin male mic jack, chassis mount	1	RadioShack / 274-025
J6	8-pin female mic plug	1	Hosfelt Electronics / MC8P
J7	RCA phono jack, chassis mount	1	Mouser / 16PJ035
	Binding post (red/black)	1	RadioShack / 274-718
H1, H2	16-pin DIP	2	Mouser / 544-16P-02
H1, H2	Header cover	2	Mouser / 544-16160
H1, H2	16-pin DIP socket (wire wrap)	2	Mouser / 575-293316
T1	600-ohm 1:1 audio transformer	1	Mouser / 429-7216
	9-conductor shielded cable	16 inches	All Electronics / 9C/S28

Figure 1. Schematic of the AF1US Station Controller.

sure. I purchased mine at a local hamfest. To shield from RF interference I would strongly suggest not using a plastic box.

A quick tour around the control box should help explain all of the functions. On the top panel of the controller (photo 2) are two rather large push buttons (S1 and S2), which provide for "PTT" (momentary) and "Lock" operation of the transmitter. Above each button are status indicator LED diodes, which light when either S1 or S2 is depressed.

To the right, VR3, in the lower right-hand corner, adjusts the external speaker volume. Two smaller momentary push-button switches, S3 and S4, which are located in the upper right-hand corner, provide up/down frequency control. Switch S5, which is located in the upper left corner, selects audio from either the Front or Rear microphone connections.

On the lower front panel of the control box (photo 3), Connector J5, located on the left side, provides the port for the

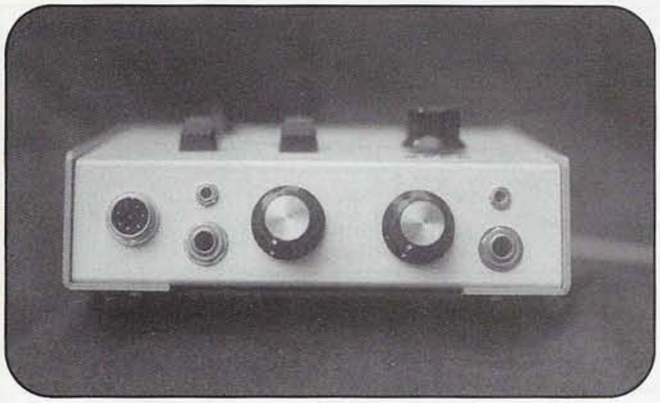


Photo 3. Front view of the Station Controller. The standard 8-pin microphone connector is shown at the left, along with front-panel headphone controls and connectors.

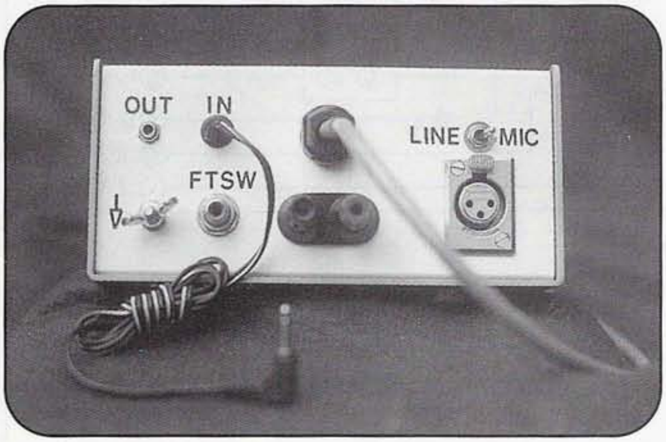


Photo 4. Rear-panel connections include jacks for a speaker, a footswitch, DC power, and an XLR microphone connector, along with a switch to select mic-level or line-level input.

standard 8-pin connections found on the radio itself. Next to J5 are two connectors, collectively shown on the schematic (figure 1) as J1. These connectors are "Stereo" 1/8 and 1/4 inch phone jacks and are for headphone operation. Next to the J1 pair of jacks is VR1, which adjusts the headphone volume.

To the right of the panel are VR2 and the J2 pair of connectors, which is a mirror image of the volume and headphone jacks described above. These connectors and volume control are provided should you have a guest in the shack or be fortunate to have a "logging" person during a contest.

While most headphones are equipped with the standard 1/4 inch plug, occasionally one will find the 1/8 inch plug on some headphone models. As a matter of accommodating both plug types, I chose to wire in the extra set of connectors right from the start of my constructing the controller.

On the lower right-hand corner of the back panel (photo 4) is located the rear microphone connector, J4, with the level control switch, S6, positioned just above it. At the center of the panel is connector J6 (attached), along with a red binding post and a black binding post which are used to supply 12-volt DC to the controller.

On the upper left of the rear panel is located connector J3, which provides audio to an external speaker. To the right of J3 is a 3-foot length of cable with a 1/8-inch monaural audio plug on the end for connecting to the radio's speaker output. At the lower left position there is a 10/32 bolt and wing nut for grounding the unit. Between the ground connection and the DC input an insulated RCA connector, J7, is installed. This connector may be used for a foot switch.

Circuitry and The Headers

Interesting problems arise when one is trying to make a project compatible with several brands of radios. In a perfect world someone would have standardized all input connections for all radios, but this is not a perfect world.

As one can see from table 1, the three radio manufacturers listed have chosen different pins to use for similar functions. This is by no means a complete list of all pin-out configurations used for every radio. One should consult the operating manual for the particular radio that is being used prior to construction.

At least one saving grace for the moment is that most radios (excluding the ICOM 706 models) are using the same round 8-pin connector for the front-panel microphone connector. Rather than using adapters for every radio type, I've chosen to use "headers" as input and output interfaces with the control box. Headers solve radio-swapping problems in an elegant manor by allowing one to interface the inner workings of the control box to any of the pins of the 8-pin connectors. I liken the headers to "Rosetta Stones" providing the correct "key" for the controller to work with the outside world.

Headers are relatively inexpensive and small enough that several sets of pre-built headers may be stored inside the control-box chassis where they won't get lost. Each header consists of three pieces. The header itself (photo 5) looks like the bottom end of a 16-pin "dip" (dual inline package) IC, with convenient connections provided for soldering wires on the topside. The second part is a small cover to protect the connections to the header. Finally, there is the 16-pin dip socket into which the headers plug.

As shown in the schematic, the headers are wired straight across from pin to pin for the Kenwood brand of radios. The pin numbers on the drawing are shown out of order with respect to the real world for circuit clarity. After building the controller, if one finds the need to use the control box with another brand of radio, the two Kenwood headers can be removed and replaced with two headers wired for Yaesu, ICOM, or another brand of radio.

This method of using headers facilitates radio changes without having to rewire the entire control box. Using the headers makes it possible to mix and match equipment from various

Rig	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8
Kenwood	Microphone	Standby	Down	Up	8 volts	N/C	Mic Ground	Ground
Yaesu	Up	Ground	Down	Fast	Ground	PTT	Mic Ground	Microphone
ICOM	Microphone	8 volts	Up & Down	Squelch	PTT	PTT Ground	Mic Ground	AF Out

Table 1. Typical pinouts of microphone connectors on major brands of amateur radio gear. Not every model of each brand is the same, so be sure to check the rig's manual before wiring things together.

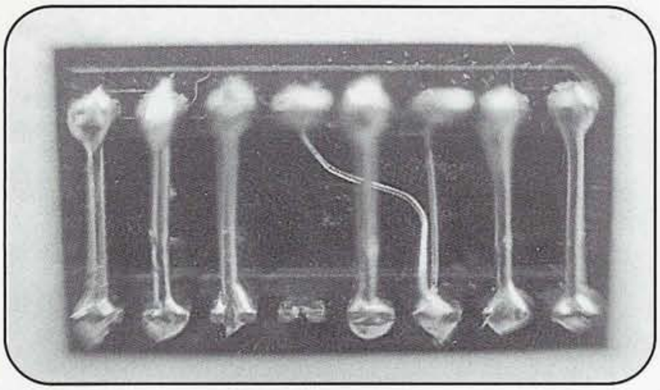


Photo 5. Close-up view of the H2 header wired for Kenwood radios. Wiring varies for different types of radios (see text for details).

manufacturers. If one wants to test one brand of microphone with another brand of radio, plug the microphone into the front panel, choose the appropriate header for that brand of microphone, and interface it to a radio of a different manufacturer. This procedure simplifies the possibilities for experimentation and discovery.

Microphone Selection

I have provided S5 on the top panel of the controller for microphone selection. However, one may use a standard PTT hand microphone or desk microphone. In order to make that choice, plug the microphone into the front-panel connector and use it as it normally would be used.

With a headset or boom-type microphone, either option gets the microphone off the operating desk and places the microphone directly in front of the operator. The desk is clear for items such as notepaper or logging keyboards. The hands are free to type, write, or hold a beverage. By providing several microphone options, the station can accommodate almost any situation, while also providing a backup microphone should problems present themselves. In addition, some A/B testing might be desired.

For my rear microphone input I have chosen an audio industry standard XLR type connector, Switchcraft D3F or equivalent. This connection, in conjunction with the circuitry around S6 and T1, provides a wide range of options when connecting a radio to the outside world.

Usually professional audio equipment uses balanced low-impedance lines and the D3F type of connector. A balanced microphone line can reduce hum and noise by providing better common-mode rejection, which is especially important in RF-rich environments. Balanced low-impedance lines may also run over much longer distances without loss (just like RF ladder line). Transformer T1 changes the balanced microphone input to unbalanced audio inside the control box. The resistors associated with S6 (R5, 6, and 7) provide approximately 50 dB of attenuation, should one want to interface the radio with an external microphone preamplifier, audio compressor, or equalizer.

Whether a cable is used at RF or audio frequencies, any time the shield of a cable is also used for carrying current, an unbalanced situation occurs. With balanced audio lines, two wires carry the audio signal from the microphone element to the transformer; the shield of the cable is used for noise suppression only.

If RF does manage to infiltrate the shield of a balanced microphone cable, the noise signal is common to both audio-carrying lines. In order for the interference to pass through the transformer, each end of the primary of T1 would have to be 180 degrees out of phase with respect to the other end of T1. Since the noise reaches both ends of T1 in phase, it can't make its way through the transformer, and the noise is suppressed. This is known as common-mode rejection, and transformers work great for that purpose.

Audio Monitoring

The controller provides three level controls for monitoring the audio output of your radio. With most radios, speaker audio is lost when one plugs in a pair of headphones. Sometimes folks like to stop by the shack and listen to what's going on with the bands. One might also encounter a situation in which an operator wants to use a headset boom mic while someone else (such as a logging person in a contest) is content with hearing signals through the speaker. With the Station Controller, audio may be sent to the speaker even if headphones are desired.

Audio from the radio's speaker output jack is routed into the control box via Plug P1 and through potentiometers VR1, 2, and 3, respectively. Potentiometers VR1 and 2 are headphone volume controls for the operator and the logger position and route the audio to the front-panel jack pairs J1 and J2.

Because the headphone audio is derived from the radio speaker output, audio loading is a must. Resistors R1 and R2 are in series with the voice coils of the headphones. These resistors, in conjunction with the headphones, act as voltage dividers to reduce the audio output to a safe listening level.

Potentiometer VR3 provides a convenient way of controlling an external speaker output, which is independent of the headphones. If the VOX control is being used, potentiometer VR3 gives an operator wearing a headset just enough audio for the speaker, so as not to trigger the VOX circuitry.

Radio Control and Status Indication

The primary objective of the Station Controller is the ability to control all of the station's operating parameters. Push-button switches S1 and S2 as well as the foot switch and Frequency Up/Down buttons S3 and S4 provide easy access to most of the transceiver's functions.

The positive side of the 12-volt line is present at the junction of the transmit relay coils of K1 and K2 and diodes D1 and D2, as well as the wiper side of relays K1B and K2B. The negative side of the 12-volt line is attached to one side of the PTT and Lock push-buttons S1 and S2. When either S1 or S2 is depressed, the circuit path for the relays is completed, allowing either relay K1 or K2 to energize.

Relays K1 and K2 are double-pole/double-throw relays. Each relay circuit is divided into two halves. Relays K1A and K2A control the operation of the radio. By connecting between ground and Standby pin 2, the radio goes into transmit.

The other half of the relay contacts provides voltage for the status indicators, LEDs D3 and D4. For example, if one presses the Lock button S1, relay K1 energizes and the contacts of relay K1A close, which puts the radio on the air. At the same time, K1B also closes and 12 volts is applied to light D3.

Likewise, with the operation of the PTT push-button S2 and relays K2A and B, as the "A" side of the relay closes, which puts the radio in the transmit mode; as the "B" side closes, LED D4 lights. Resistors R3 and R4 are current-limiting resistors for the LEDs. LEDs D1 and D2 suppress the "fly-back" voltage as the field of relays K1 and K2 collapse upon de-energizing.

Diodes D1 and D2 are reverse-biased because the collapsing field voltage of relays K1 and K2 is opposite in polarity to the energizing voltage. Diode D7 prevents diodes D1 and D2 from being destroyed should the DC voltage be accidentally reversed (I discovered this fix the hard way.).

Located on the back panel of the control box is jack J7, an RCA jack, which facilitates foot-switch operation. The body of jack J7 is insulated from ground using small nylon washers. By connecting the center pin of jack J7 to the negative 12-volt line, both relays K1 and K2 now have a return path to the negative side of the 12-volt line through diodes D5 and D6. With both relays energized, the radio goes into the transmit mode, and simultaneously both LEDs D3 and D4 illuminate. Therefore, any time the foot switch is depressed, both status indicators light simultaneously, which provides a little added feature to distinguish between hand- and foot-control operation.

Push-buttons S3 and S4 are for radio up/down frequency control (photo 5). Diode D3 does not connect directly between the Ground pin 8 and the down pin 3 of the 8-pin connector J6. Rather than a direct connection, it connects to pin 5 and then is bridged across to pin 3 inside the header. This arrangement facilitates the ICOM design of placing a small 470-ohm resistor in line with the down button.

With ICOM radios the Up Frequency button connects between ground and standby. By placing a 470-ohm resistor between ground and standby, the radio goes down in frequency. To use the controller with an ICOM radio, an ICOM header can be built with the appropriate wiring and 470-ohm resistor installed. If the button is wired directly to the Down Frequency line 3, one would not be able to insert the 470-ohm resistor.

Construction

Many, if not all, of the parts can be found in most well-stocked parts drawers. Although most of the parts in the controller are not critical, it is important that one use only the highest quality parts for construction. Push buttons and relays will see plenty of work over the years, especially after 24 or 48 hours of use in a contest. Because S1 and S2 will be used a lot, one should select push buttons that have a "soft feel." It is a good idea to pre-wire as much of the construction as possible prior to installation. After each section is completed and checked, one can install the parts as a subassembly.

Header H1 (photo 6) is mounted on a small piece of fiberglass perf board and is physically located as close to the 8-pin front connector as possible. Short unshielded jumper wires are connected between the header and the 8-pin connector on the front of the control box. In my design the distance between the header and the 8-pin connector is about 0.75 inch.

A wire harness of approximately six inches snakes through the chassis to the center perf board. All control-box wires should be as short as possible. However, an inch or two of extra wire should be left on this harness so as to allow for the removal of either of the perf boards for repair.

The center perf board (photo 7) holds the two relays, K1 and K2, as well as header H2 and other small parts. It is mounted to the chassis with a small aluminum angle, and uses 3M-brand double-sided foam tape, which is available at any hardware store. All relays and the headers are mounted to the perf board using 16-pin DIP sockets.

The DIP sockets have long leads suitable for wire-wrap projects (photo 8). The long leads make them perfect for soldering. In my design, an extra-large hole was used to strain relief the 8-wire line, which feeds the radio. The large mounting hole meant that I could pre-assemble the 8-wire line and J6, prior to mounting the perf board in the control box.

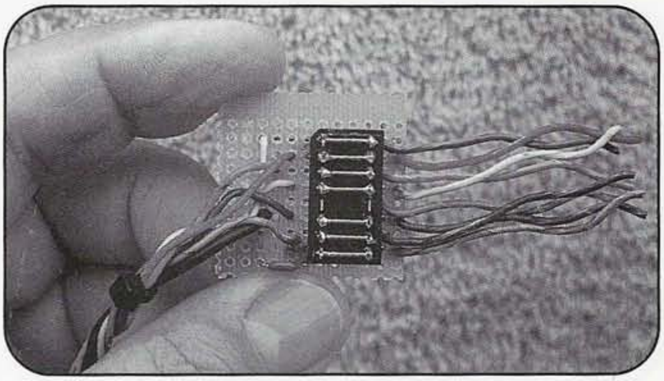


Photo 6. Close-up view of the H1 header with wires attached (see text for details).

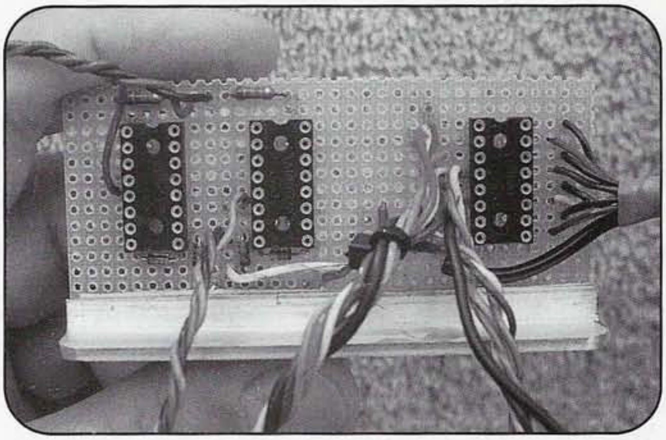


Photo 7. Front view of the main circuit board. On the left are sockets for K1and K2, with the socket for H2 shown on the right.

In addition to the Station Controller, the 8-pin jumper cable will need to be constructed to go between the control box and the radio. I used a 24-inch piece of Beldon 9504 shielded computer cable. A similar cable is available from All Electronics and is listed in the parts list. The Beldon cable has four pairs of 24-awg wire and is reasonably flexible, with a 100-percent foil shield and drain wire.

Each radio might use a different pin for microphone ground (or common). Therefore, the drain wire is connected to the microphone ground line inside the chassis and left floating at the radio end connection. When wiring a header for a particular brand of radio, one can choose the correct pin to use for "ground." In the case of Kenwood, the microphone ground connection is made to pin 7.

Grounding Problems

On most radio schematics there are various wires referred to as "Ground" or common. On a Kenwood schematic they use the nomenclatures "Ground," "Mic Ground," and other connections, such as the common side of the radio's speaker output, as well as the negative side of 12 volts and chassis ground. One might be tempted to connect all of these points together.

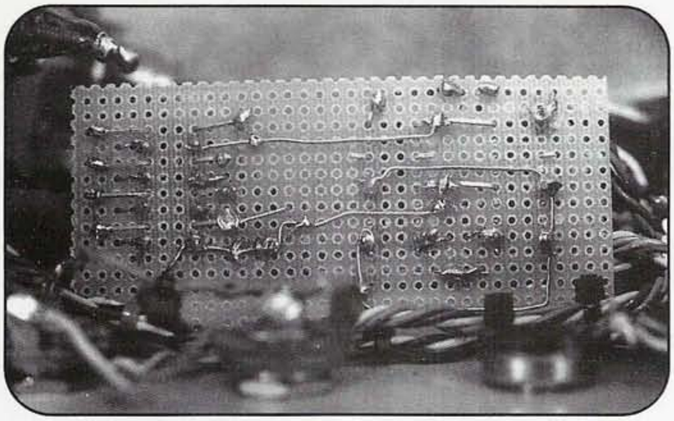


Photo 8. Rear view of the main circuit board (installed). The rear of H2 is shown on the left.

However, do not do so because all of these connections are not necessarily the same.

Connecting the "common" side of the output of the radio back to the "common" of the input probably will do more harm than good. For example, if a headset/mic configuration is used, it will need at least four wires—two wires for the headphone audio and the shielded microphone line.

If the speaker common line is combined with the microphone shield, it may cause a problem with the radio's monitor circuit, in particular, preventing one from hearing the transmit audio. Also, the microphone shielding is compromised because the shield for the microphone has speaker voltage floating on it. It is important to remember that any time a shield of a cable (or even a chassis) is used to transfer voltage, the shielding qualities are compromised.

With the exception of the speaker circuit, I have kept the various "common" connections "floating" off the chassis. Even the Foot Switch connection J7 and the black binding post for the negative 12 volts should be held off chassis ground while building the controller. It is better to start out with all of these points floating off the chassis rather than tying everything together. Let any combining of grounds and common lines take place inside the radio, rather than inside the control box.

Some radios are famous for having finicky grounding schemes. Therefore, complete testing of the control box is the only way to know whether or not there is a problem. It is best to experiment with combining various grounds only if there is a problem with hum or noise infiltration. If it is necessary to ground the control box, use the $^{10}/_{32}$-inch ground lug for the connection and fasten a short piece of copper braid directly to the ground stud on the back of the radio.

Note on the schematic that between pins 7 and 8 of the headers (Mic ground and ground) two 0.01 µFd capacitors are installed so as to remove any potential between those pins. My chassis is composed of two halves (top and bottom). A strap is installed inside the control box from the $^{10}/_{32}$-inch ground connection on the back of the chassis to a bare-metal section on the bottom of the control box so as to ensure a complete shield.

Options

As mentioned earlier, the Station Controller can be customized so as to suit one's situation or preference. For example, two 8-pin connectors can be installed in place of the XLR connector. This would make it possible to switch between a handheld PTT microphone and a headset microphone. If this is the preference, it is also necessary to install another set of headers to use with the new 8-pin connector in order to facilitate the brand changes.

After all construction has been completed, make sure to check out all the circuitry prior to connecting the unit into the system. Also, make sure all the functions work as they should and that the transmit audio is free from hum or RF infiltration.

Building the Station Controller provides some convenient features that are not often available in the shack. For example, if operating a contest, each feature has the potential to give the station a competitive edge while making the hours of operating more enjoyable. ■

Resources

Parts for this project may be obtained from the following sources, among others:

All Electronics Corp., P.O. Box 567, Van Nuys, CA 91408 (phone 800-826-5432; fax 818-781-2653).

Hosfelt Electronics, Inc., 2700 Sunset Blvd., Steubenville, OH 43952 (phone 614-264-6464; fax 614-264-5414).

Mouser Electronics, 958 N. Main St., Mansfield, TX 76063 (phone 800-346-6873; fax 817-483-0931; e-mail: <sales@mouser. com>; web: <http://www.mouser.com>).

RadioShack—local outlets around the country, or <http:// www.radioshack.com>.

CQ VHF Interview:

Working Cuba on 2-Meter FM and "Periscope Propagation" on Six

A Conversation with Arnie Coro, CO2KK

One of the best-known VHF voices from Cuba is that of Arnie Coro, CO2KK. Arnie is also a fixture on the HF ham bands and the international shortwave broadcast bands, where he hosts two programs on Radio Havana: "DXers Unlimited" and "Breakthrough," a science and technology program. In addition, Arnie is *CQ* magazine's Antennas Editor. He also will be a regular contributor to *CQ VHF*. Elsewhere in this issue is his first contribution.

By Rich Moseson,* W2VU

Recently, CQ VHF *Editorial Director Rich Moseson, W2VU, had the opportunity to spend time with Arnie Coro, CO2KK, and talk to him about operating VHF from Cuba, as well as an interesting 6-meter propagation theory that Arnie calls "periscope propagation mode." Arnie's comments below also illustrate the resourcefulness and ingenuity of hams in a country where commercially built gear is either unavailable or unaffordable. Plus, we learn that if you want to work Cuba on 2 meters, you might want to try ... FM. —N6CL*

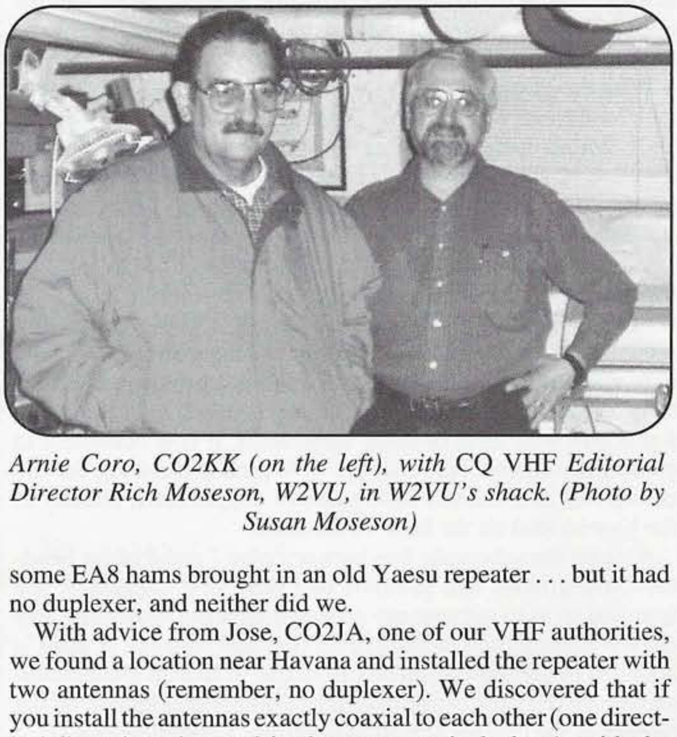
You might call CO2KK a "Renaissance radio man"—an active ham on HF and VHF, in international broadcaster, and a respected authority on antennas and propagation. *CQ VHF* recently had a chance to chat with him.

CQ VHF: How many VHF weak-signal operators are there in Cuba?

CO2KK: That is a very good question. There are very few *weak-signal* operators in Cuba, but something very peculiar has developed—the quest for working DX using 2-meter FM. People are not familiar with 2-meter transverters for their HF radios, and parts for transverters are not available, so the people, out of the motivation that DX brings, have developed a passion for 2-meter FM DXing.

Since 1988, the 2-meter band has developed at a faster pace than any other amateur band in Cuba. In 1988 or '89, we got our first 2-meter repeater, donated by hams from EA8. *(Arnie notes that Cuba and the Canary Islands have "very fluid relations," due in large part to the fact that some 600,000 Cubans can trace their origins to the Canary Islands.—ed.)* On one trip, some EA8 hams brought in an old Yaesu repeater . . . but it had no duplexer, and neither did we.

* *Editorial Director,* CQ VHF
e-mail: <w2vu@cq-vhf.com>



Arnie Coro, CO2KK (on the left), with CQ VHF *Editorial Director Rich Moseson, W2VU, in W2VU's shack. (Photo by Susan Moseson)*

With advice from Jose, CO2JA, one of our VHF authorities, we found a location near Havana and installed the repeater with two antennas (remember, no duplexer). We discovered that if you install the antennas exactly coaxial to each other (one directly below the other and in the same vertical plane), with the receive antenna as high as possible and with a good ground plane (8–12 radials instead of the typical four), the transmit antenna directly underneath by 10–20 wavelengths, and the last 10 feet of the cables going through a steel pipe (we never figured out why), there is no desensing and the antenna provides unbelievable sensitivity for receive. We also found that using double-braid coax further increases the isolation.

As a result, 2-meter activity picked up. The first generation of equipment used by government agencies was made available to amateurs, and people began to convert them for ham use. Next, a newer generation of computer-programmable radios became available. This led to tremendous growth of 2 meters. Some people learned to make resonant cavities from aluminum irrigation pipe.

People started working 2 meters via repeaters. Then they found ways to reach the best sites, those used by TV stations. More repeaters came on the air, including one on a high-rise building in downtown Havana (a former hotel) that provided HT coverage to the whole city. Next, we learned that high-voltage aluminum cable could be made into 3, 4, and 5-element beams.

We found out that whenever there was tropo ducting, we could work way out, to Houston, other Caribbean islands, South Florida. That led to a culture of 2-meter DXing using FM. We even have twice-a-year contests, one of which coincides with the ARRL June contest, but again, nearly all of the activity is on FM.

CQ VHF: What about activity on 6 meters and other bands?

CO2KK: Now, after lots of work, there are two people—CO8DM, Douglas, and CO8LY, Ed, an air-traffic controller—in eastern Cuba who are very active on 6-meter weak signal. Ed is also a very good CW op. However, they have poor antennas. In the Havana area there's me, Oscar (CO2OJ), and three others: CO2LP, but he speaks no English and only works the openings to Argentina; CO2YY, who speaks good English but has young kids and limited time; and CO2AD, who also speaks good English.

There is very little 6-meter FM activity, except for a small group of hams in Cienfuegos who use it for local contacts. They're on some oddball frequency, because that's where the surplus equipment they got came out when they retuned it for the 6-meter band.

On 432 MHz there is practically no activity except for a few people with 70-centimeter HTs, and there is no microwave activity at all. I am working on getting more people on 6 meters CW.

CQ VHF: What is the typical range you can work from Cuba on 6 meters? When the band is open, where does it open to?

CO2KK: We have TEP (trans-equatorial propagation), and despite what some people say about it being linked to the sunspot cycle, we seem to get it the same regardless of where we are in the sunspot cycle. Every year, from February to the spring equinox and from early September to late October, the band opens to Argentina, Uruguay, Chile, and sometimes Brazil. But for us, TEP equals LU (Argentina). It has to do with Cuba's location in relation to southern Argentina, relative to the magnetic equator.

E-skip is wonderful on 6 meters. We get the most unbelievable openings. Sometimes we can hear stations 100–150 miles away—which means that 2 meters is also open, because the shorter the skip the higher the frequency of the opening—plus single-hop to Central America, where 6-meter activity is growing, to Mexico and the southeastern US, plus double-hop to the northwestern US.

In June and July we can hear Europe. Some people say it's triple or quadruple hop, but I disagree. I believe it's due to a tilted *E*-layer at both ends of the path, what I call "periscope propagation mode." It's the only logical explanation from an ionospheric propagation point of view.

The energy budget tells the whole story. If you have a 100-watt transmitter and a 10-dB gain antenna, you have 1 kilowatt ERP. One kilowatt cannot support three-hop *E*-skip, if you consider the energy needed to go up to the ionosphere, get reflected back once, get reflected off the ocean, go up to the ionosphere again, get reflected again, bounce off the ocean again, etc. Even if it could, three hops from Cuba will only get you near the coast of Portugal, not onto the European continent. Yet we hear signals from Spain and other countries.

My theory is that near where you are there is a tilted *E*-layer. It acts as a tilted mirror, sending your signal into a "waveguide" between the top of the *E*-layer and the bottom of the *F*-layer. As in any duct, it travels a great distance with very little attenuation. When there is the same effect at the other end, the signal is received *strongly* many thousands of kilometers away.

On 2 meters, we get *E*-skip into the US, Puerto Rico, and Mexico. Often, US hams don't believe they're really working Cuba. They think somebody is joking with them. We monitor empty channels on the FM broadcast band, and when we start hearing stations come in on those empty channels, we know it's time to start looking for DX on 2 meters.

There are 100 or so Cuban hams active on 2-meter FM who like DXing. Only Oscar and I do 2-meter weak signal, and Oscar spends more time on 2-meter SSB than CW.

CQ VHF: What do you think is needed to better promote VHF weak-signal activity?

CO2KK: The thing, I think, that will really help promote VHF weak signal is to do a lot of promotion in the DX community. Look at the IOTA (Islands On The Air) program, for example. It's been well promoted to DXers and working islands has become popular. A simple converter with a VHF receiver could bring lots of people up, especially with CW. Oscar has been experimenting with PSK-31 on 6 and 2 and has been successful.

We must try to make more people know about 6-meter propagation, how things happen on six. Tropo ducting on six is rarely discussed, but it can extend your range quite nicely, out to 100–120 miles on a daily basis with just a 3-element beam on each end.

I talk to many hams about 6 meters, especially Latin American hams. There is a new generation of Latin American hams who own HF radios with 6 meters, but they don't have the slightest idea of what to do on those bands. When I work them on 10 meters, I always try to do a little lecture about working 6 meters: "Do you have an antenna for 6 meters?" "Do you know where to listen for DX on 6 meters?" This often results in having to write letters with diagrams and explanations of 6-meter antennas. Wire antennas are very easy to make and very effective when 6 meters is open.

CQ VHF: What's your favorite aspect of VHF DXing?

CO2KK: Doing propagation research, trying to forecast possible band openings, especially on six, but also on two. I find it so interesting and challenging, especially when you realize that the world's professional propagation researchers are only concerned with F_2 below 30 MHz. There's not much money or interest for research above 30 MHz.

CQ VHF: How many countries and grids have you worked on 6 and 2?

CO2KK: I don't know. I've been collecting cards in two shoeboxes, but I've never counted. I've decided to count them after I retire. Then I'll have the time, and if I qualify for some awards, I might apply for them.

Closing Thoughts

My visit with Arnie was, without question, one of my most interesting ever, and again reflected the magic of ham radio. Arnie was in the United States to speak at the Colorado QRP Club's banquet, and then went to visit his son here on the east coast. (A story on that part of the visit is in the May issue of *CQ*.)

"Too bad you can't come to New York and visit us," I wrote in one e-mail. Arnie responded, "My son will be happy to drive me there. When are you available?" Thus began a whirlwind day and a half, starting with my family and me taking them to dinner, followed by a drive to the CQ offices the next morning and the day spent talking about a wide array of subjects, mostly focused on radio and computers (what *else* do hams talk about?).

The amazing thing is that until then Arnie and I had communicated only via e-mail, although his voice was familiar from having listened to him on "DXers Unlimited." However, as soon as he walked into the lobby of his hotel where we met for dinner, it was like we were old friends simply picking up where we'd left off in a previous conversation.

There is something special about the bonds of ham radio that cannot and should not be overlooked. We are from different countries, different cultures. Yet as hams, we are friends the moment we meet. Especially in the current world situation, the importance of this worldwide brotherhood cannot be overestimated. *Adios, amigo.* ■

Announcing:

The 2002 CQ World-Wide VHF Contest

Starts: 1800 UTC Saturday, July 20, 2002
Ends: 2100 UTC Sunday, July 21, 2002

I. Contest Period: 27 hours for all stations, all categories. Operate any portion of the contest period you wish.

II. Objectives: The objectives of this contest are for amateurs around the world to contact as many amateurs as possible in the allotted 27-hour period, to promote VHF, to allow VHF operators the opportunity to experience the enhanced propagation available at this time of year, and for interested amateurs to collect VHF Maidenhead grid locators for awards credits.

III. Bands: All authorized amateur radio frequencies on 50 MHz (6 meters) and 144.00 MHz (2 meters) may be used as authorized by local law and license class.

IV. Class of Competition:

For all categories: Transmitters and receivers must be located within a 500 meter diameter circle or within the property limits of the station licensee's address, whichever is greater. All antennas used by the entrant must be physically connected by wires to the transmitters and receivers used by the entrant. Only the entrant's callsign may be used to aid the entrant's score.

1. Single Op—All Band. Only one signal allowed at any one time; the operator may change bands at any time.

2. Single Op—Single Band. Only one signal allowed at any one time.

3. Multi-Op. A multi-op station is one with two or more operators and may operate 6 and 2 meters simultaneously with only one signal per band.

4. Rover station. A Rover station is one that is manned by no more than two operators, must travel to more than one grid locator, and must sign "Rover" or /R. The spirit of this class is to encourage operation from rare grid locators by persons who are inclined to do so. It is not the intent of this class to encourage one operator to move from one super station to another super station in another grid locator in order to compete in this category.

5. QRP station. Anyone operating a station running 25 watts output, or less, is eligible to enter this category. There are no location restrictions. You may operate from your home QTH or from the highest mountain you can find.

Stations in any category except rover may operate from any single location, your home location, or any protable location. Rover stations by definition must operate from portable locations in at least two grids.

V. Exchange: Callsign and Maidenhead locator grid locator (4 digits, e.g., EM15). Signal reports are optional and need not be included in the log entry.

VI. Multipliers: The multiplier is the number of different grid locators worked per band. A "grid locator" is counted once per band. *Exception:* The rover who moves into a new grid locator may count the same grid locator more than once per band as long as the rover is himself or herself in a new grid locator location. Such change in location must be clearly indicated in the rover's log. It is required that rover category operators maintain separate logs for each grid locator location.

A. The rover who changes location during the course of the contest is free to contact as many other stations as he or she wishes. The rover becomes a new QSO to the stations working him or her when that rover changes grid locator.

B. The grid locator is the Maidenhead grid locator to four digits (FM13).

VII. Scoring: One (1) point per QSO on 50 MHz and two (2) points per QSO on 144 MHz. Work stations once per band, regardless of mode. Multiply total QSO points times total number of grid locators (GL) worked.

Rovers: For each new grid locator visited, contacts and grid locators count as new. Final Rover score is the sum of contact points made from each grid locator times the sum of all grid locators worked from all grids visited. The intent is to mirror the original Rover scoring rules.

Contest entrants may not transmit on 146.52 MHz, or your country's national 2 meter FM simplex calling frequencies, or commonly recognized repeater frequencies for the purpose of making or requesting contacts. Contacts made within your own country, in the DX window of 50.100–50.125 MHz, are discouraged. Contacts made on the SSB calling frequencies of 50.110 MHz, 50.125 MHz, and 144.200 MHz are discouraged. Contest participants are required to use UTC as the logging time.

Example 1. W1XX works stations as follows:

50 QSOs ($50 \times 1 = 50$) and 25 GL's (25 multipliers) on 50 MHz

35 QSOs ($35 \times 2 = 70$) and 8 GL's (8 multipliers) on 144 MHz

W1XX has 120 QSO points ($50 + 70 = 120$) $\times 33$ multipliers ($25 + 8 = 33$) = 3,960 total points.

Example 2. W9FS/R works stations as follows:

From EN52: 50 QSOs ($50 \times 1 = 50$) and 25 GL's (25 multipliers) on 50 MHz

From EN52: 40 QSOs ($40 \times 2 = 80$) and 10 GL's (10 multipliers) on 144 MHz

From EN51: 60 QSOs ($60 \times 1 = 60$) and 30 GL's (30 multipliers) on 50 MHz

From EN51: 20 QSOs ($20 \times 2 = 40$) and 5 GL's (5 multipliers) on 144 MHz

W9FS/R has 230 QSO points ($50 + 80 + 60 + 40$) $\times 70$ multipliers ($25 + 10 + 30 + 5$) = 16,100 total points

VIII. Awards: Certificates suitable for framing will be awarded to the top-scoring stations in each category in each continent. Certificates may also be awarded to other top-scoring stations who show outstanding contest effort. Certificates will be awarded to top-scoring stations in each category in geographic areas where warranted.

Geographic areas include states (U.S.), call areas (Japan), provinces (Canada), and countries, and may also be extended to include other subdivisions as justified by competitive entries.

IX. Miscellaneous: An operator may sign only one callsign during the contest. This means that an operator cannot generate QSOs by first signing his callsign, then signing his daughter's callsign, even though both callsigns are assigned to the same location.

A station located exactly on a dividing line of a grid locator must choose only one grid locator from which to operate for exchange purposes.

A different multiplier cannot be given out without moving the complete station at least 100 meters.

X. Log Submissions: You may request log sheets from: CQ VHF Contest, 25 Newbridge Road, Hicksville, NY 11801. Include an SASE with your request.

Completed logs must be postmarked no later than September 1, 2002 to be eligible for awards. All logs should be mailed to: CQ VHF Contest, 25 Newbridge Road, Hicksville, NY 11801 USA.

We strongly encourage logs to be submitted on disk or sent via e-mail. We prefer an electronic log. If you submit your log in electronic form, we prefer one of the commonly available logging programs. Since this contest is not yet supported by the Cabrillo format, you must also submit an electronic summary sheet.

Disks: If you use a computer, please send your IBM, MS-DOS compatible computer disk. A disk containing your files may be submitted in lieu of a paper log. All disks must be accompanied by a paper summary sheet satisfying all logging instructions. Label your disk clearly with your call and category.

You may submit your electronic log via e-mail to **<cqvhf@cqww.com>**. Questions may be sent to **<questions@cqww.com>**.

By Kent Britain,* WA5VJB

ANTENNAS

Connecting the Radio to the Sky

Pitfalls in Antenna Construction and Mounting: The Helix

For years we've seen the NASA telemetry helical antennas, those nicely built antennas formed around a central rod with pegs every so often to support the helix. They're pretty antennas, but kind of hard to build with simple tools. We came up with some other ways of building helical antennas, but if the results of the 40 or 50 helixes I have tested in antenna contests are lumped together, we find *the easy ways don't work!*

Ten years ago I was sent some carefully designed prototype helical antennas for an early Phase 3D (the name for the satellite project that after launch and successful orbiting became AO-40) design. The performance of these antennas was very poor, and it took me almost ten years to understand why.

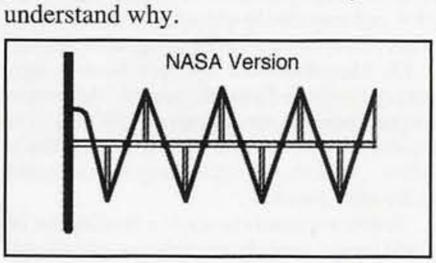


Figure 1. A traditional helical antenna.

The conventional helical antenna software programs are for designing a free-space helix (figure 1). These programs assume that helical wire is hanging out there all by itself. In most cases, however, hams mount the helix on a dielectric surface. One very important design parameter for a helix is the "turns ratio." Simply put, it's how many turns per foot you put in the coil.

The early Phase 3D antennas were beautifully built with metal tape on a fiberglass tube (figure 2). If you've ever worked with PC boards, you will understand that the metal transmission line on the board material has a velocity factor somewhere between 0.3 and 0.8; with fiberglass it's about 0.6. Therefore, the wave was only traveling along the helix about 60 percent as fast as the equations expected it to travel. Next, the fiberglass tube is a dielectric. The tube itself slows down the wave as it propagates along the antenna. Measurements with .031-inch fiberglass show that the radiated wave is slowed down about 20 percent within the antenna.

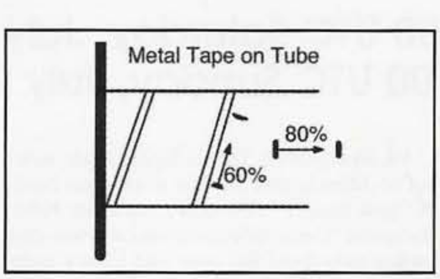


Figure 2. Metal tape on a plastic tube.

The bottom line is that while the diameter of the helix is unchanged from the basic equations, the antenna appears 120 percent longer and the helical wire appears 166 percent longer than expected. It's even worse if the plastic is thicker than 0.031 inch, which kind of messes up the turns ratio!

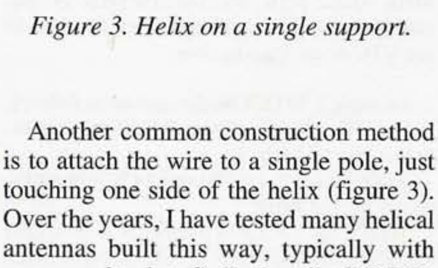


Figure 3. Helix on a single support.

Another common construction method is to attach the wire to a single pole, just touching one side of the helix (figure 3). Over the years, I have tested many helical antennas built this way, typically with poor results, but S. T. Jewell, G4DDK, noticed what was going on. The maximum signal was not along the helix, but angled away in the direction of the boom. The mounting pole was dragging the wavefront and bending the signal. Because of this offset from the helix, as the signal continued along the helix it couldn't continue to reinforce the wavefront. Again, there was poor gain and a skewed beam.

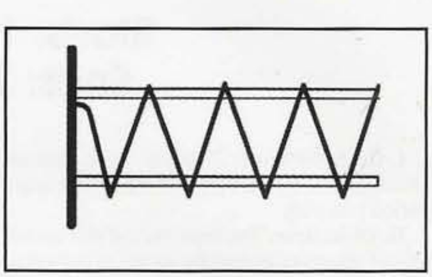


Figure 4. Helix with two supports.

It has been suggested that the cure would be to use two support rods (figure 4). This method is better, but we're back to the same problem as when one puts the helix on a tube—the dielectric is slowing down the wavefront. Again, you are altering the turns ratio. Unless you plan to redesign the antenna completely, the supports should contain as little material as possible. It's something like soda straws or Styrofoam; it's a great electrical solution, but not a good mechanical one.

I'm starting to understand why all those NASA telemetry helical antennas use a pole up the middle of the antenna with just a few mounting pegs. Maybe they had this figured out 50 years ago after all.

With a few hours on a network analyzer and more time on an antenna range, one can design a helix wrapped on a plastic tube. There are some serious scaling factors, though, which have been overlooked! I don't even want to start on the effects of Acme PVC versus Brand X irrigation plastic pipes. Practical helical antennas can be developed, but it's going to take serious work to minimize the amount of plastic in the antenna and create a standardized design with little parts substitution.

Mounting Cross-Boom Yagis

Looking at the AMSAT bulletin boards shows that this topic gets a lot of mileage. The best way to mount a crossed Yagi is to end mount it, which keeps all stray

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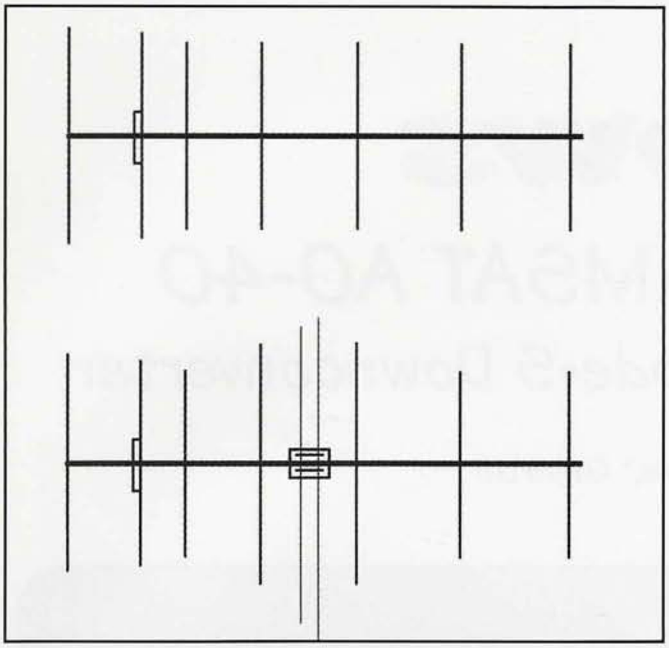


Figure 5. Yagi structure and the effect of a mounting mast.

pieces of metal out of the antenna. End mounting is limited to shorter antennas, however. Here is how the longer cross-boom Yagis can be mounted with excellent results.

Let's start with an example of what is going on in the structure of the Yagi (figure 5). A non-resonant piece of metal near the Yagi really has little effect on the pattern of the antenna. If the metal is placed near the tip of a Yagi element, the loading effect of the metal makes the Yagi element electrically longer. It is important to note that the tips of the elements are most sensitive to the effects of nearby metal objects.

Antenna Company XYZ has spent hundreds of hours developing an antenna with dimensions to the nearest hundredth of an inch, and now elements appear that are inches longer. This kind of messes up the pattern. Probing a Yagi on the antenna range with a small piece of metal, it's very easy to see that a Yagi is most sensitive near the element tips. If we can keep metal away from the element tips, the effect is very small.

When the antenna is mounted in a "+" configuration, the metal mounting boom skews the pattern of the horizontal Yagi. There is no effect at all on the vertical Yagi. Just by rotating the Yagi to an "X" configuration, the effect on the Yagi patterns is near zero, and the effect is balanced between the two Yagis. The circularity of the antenna pattern is unchanged.

The following steps can be used to mount a crossed Yagi with a metal boom (figure 6):

1. Mount the elements in an "X" configuration.
2. Use the smallest practical diameter mounting mast.
3. Cut off the mast as close to the Yagi brackets as practical. (You don't want the mounting mast to go all the way through the Yagi if you can avoid it.)
4. Run the coax back along the boom of the Yagi and along the mounting mast. Keep the bend in the coax tight between the boom and the mast, but not so tight as to damage the coax.

Next time, more antenna analysis. ■

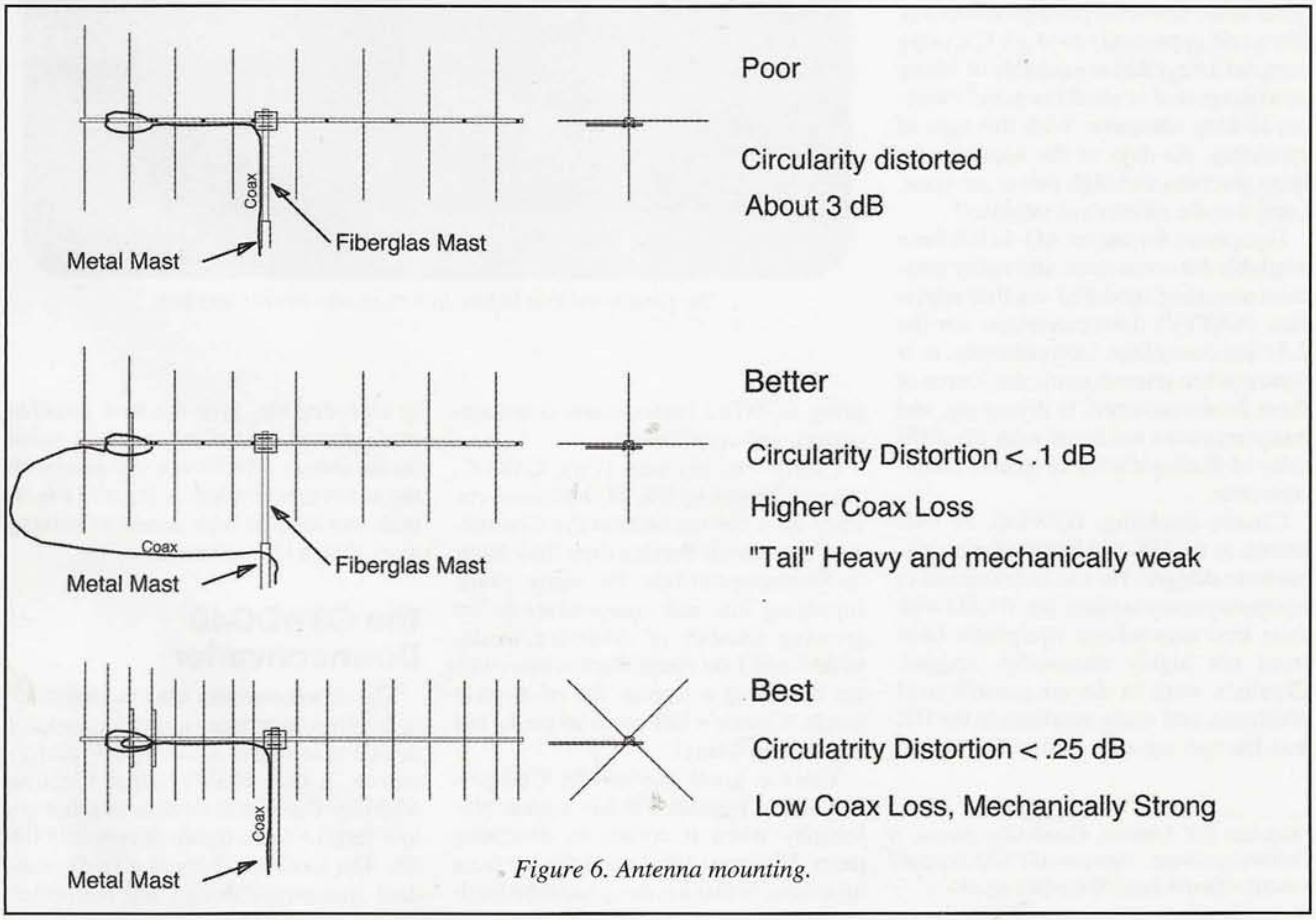


Figure 6. Antenna mounting.

The G3WDG AMSAT AO-40 2.4 GHz–144 MHz Mode-S Downconverter

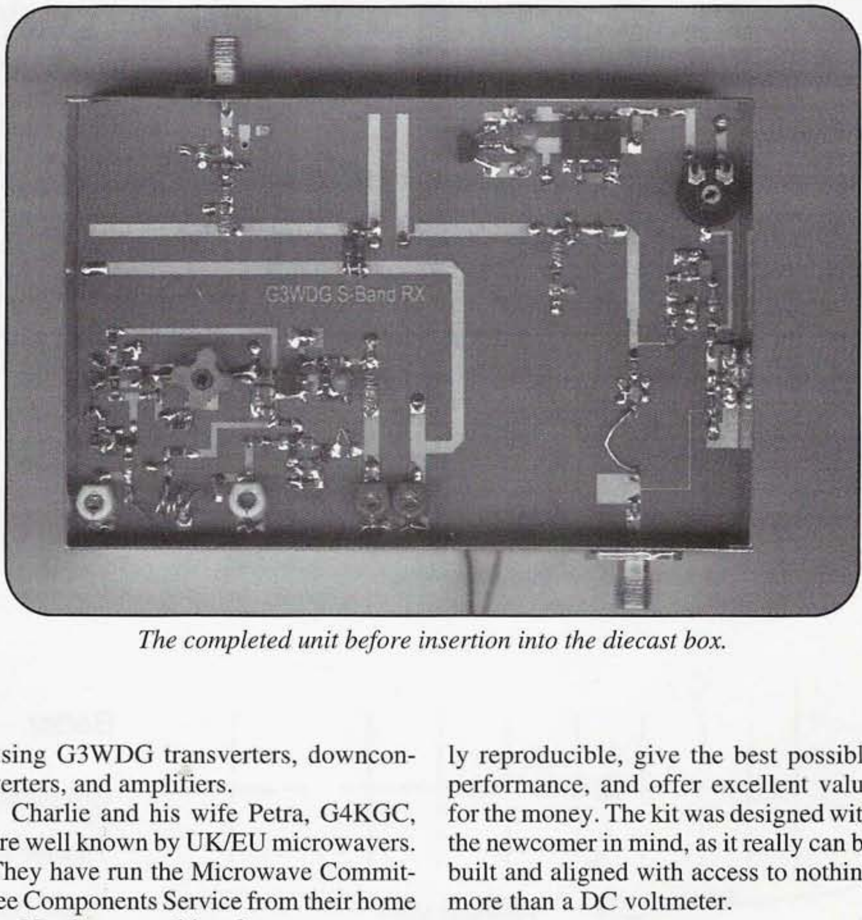
By Simon Lewis,* GM4PLM

The recent commissioning of the AMSAT AO-40 spacecraft has been very exciting and a real demonstration of the capabilities of AO-40's microwave transponders. These operations have shown that very small ground-station antennas combined with compact, low-power stations are easily capable of successfully operating via AO-40.

This commissioning opens a whole new era for amateur satellite operations and gives those who own postage-stamp-size lots a real opportunity to work DX using compact arrays that are capable of sitting on a garage roof or small lawn space without looking obtrusive. With this type of capability, the days of the necessity for large antennas and high power are gone. Long live the microwave satellites!

Equipment for use on AO-40 has been available for some time, and many amateurs are using modified satellite television (SATTV) downconverters for the 2.4 GHz downlinks. Unfortunately, as is typical when interest soars, the source of these downconverters is drying up, and many amateurs are faced with the difficulty of finding a suitable receive downconverter.

Charlie Suckling, G3WDG, is well known in the UK and Europe for his microwave designs. He was instrumental in equipping many stations on 10 GHz with their first narrowband equipment built from his highly successful designs. Charlie's work in the microwave field continues, and many amateurs in the UK and Europe are now active on AO-40 using G3WDG transverters, downconverters, and amplifiers.



The completed unit before insertion into the diecast box.

Charlie and his wife Petra, G4KGC, are well known by UK/EU microwavers. They have run the Microwave Committee Components Service from their home in Northamptonshire for many years, supplying kits and components to the growing number of amateurs worldwide—and I do mean worldwide—who are becoming active on the microwave bands. Charlie's kits seem to get to just about everywhere!

There is good reason why Charlie's kits are so popular. He has a great philosophy when it comes to designing them. His latest kit is no different from his others, in that it is designed to be totally reproducible, give the best possible performance, and offer excellent value for the money. The kit was designed with the newcomer in mind, as it really can be built and aligned with access to nothing more than a DC voltmeter.

The G3WDG40 Downconverter

The downconverter uses the latest RF technology to produce a simple, compact design that offers amazing RF performance. It uses HEMT (High Electron Mobility Transistor) devices to achieve a low receive noise figure of typically 0.6 dB. The local oscillator is a fairly standard Butler-type design and multiplier.

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Post-mixer image rejection uses a printed-circuit filter in a fashion similar to the "no tune" designs that appear to be so popular in US designs. A standard G3WDG-designed IF amplifier is on the board. The PC board has a small negative DC generator for the HEMT bias rail.

The downconverter is supplied as a complete kit, which includes the PC board, all mounted components, and the small tin-plate housing. The RF connectors are not supplied. These are left out because most microwavers use different combinations in their stations. The kit comes packed inside its small tin-plate case, complete with a handbook detailing how to build and align the kit. Delivery was quick, and the kit arrived safely in a large, padded postal bag.

Charlie loves to get the best out of his designs. Thus, the downconverter uses the latest RF technology and components, allowing the best possible performance. Conversion gain is approximately 38 dB, and the noise figure measured 0.6 dB—very impressive! The IF frequency selected is 144 MHz, which allows the downconverter to be connected to any 2-meter multimode transceiver. A 70 cm IF option should be available by the time this review appears in print. Details of how to feed DC power to the unit via the IF connection are in the instructions.

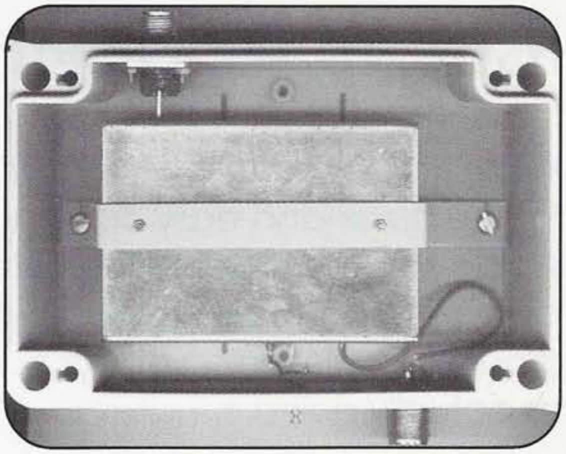
The downconverter is built on a single double-sided PTFE PC board which is not too cramped. Construction is quite straightforward, and it took me approximately six hours over three evenings to complete it, taking things nice and easy. It follows standard microwave techniques that can be found in the kit handbook and also in the Radio Society of Great Britain's *Microwave Handbook.* If you haven't built microwave equipment before, it is worth reading some of the construction information on Charlie's site (http://www.emn.org.uk/mcs.htm) before you start.

Assembly and Testing

The kit is very easy to assemble, but could not be classed as an absolute beginner's kit. However, an intermediate-level kit builder who can solder correctly and follow a simple set of instructions to the letter can assemble it fairly easily. Some basic hand tools are required, along with a fine-tip soldering iron and very fine solder.

Alignment is very simple and requires a few basic voltage checks and presetting some trimmer capacitors and a variable inductor to positions listed in the instructions. No test equipment is required if the unit has been built according to the instructions, as the kit was designed with newcomers to microwaves in mind, and it is unlikely they will own an array of test equipment.

The beta unit supplied was aligned using the suggested procedure. It was almost perfect when tested against full test equipment. In operation, the beta converter has performed very well. I connected the unit to my Yaesu FT-847 and supplied the downconverter with 12 VDC.



The completed downconverter inside the weatherproof box.

A suitable case was obtained from Radio Spares. This small IP65-rated die-cast box has a nice set of mounting lugs on the case lid to allow it to be mast mounted, and I even fitted it with a spare mast clamp I found in a drawer! The inside of the case is insulated with polystyrene, and two bags of silica gel placed inside the case absorb any moisture. The downconverter generates a small amount of heat and this should ward off any tendency for dampness to form inside the box. A photograph of the completed unit is shown before insertion into the die-cast box.

The downconverter was mounted behind an 80 cm offset satellite dish and fed via a small five-turn helical antenna. This has proven to be very successful and produces an excellent noise-free signal in the shack. In addition, there is no requirement for a preamp, as the noise figure and sensitivity of the unit provide plenty of performance and there is enough IF gain to allow for extend cable runs and still provide excellent signals.

Overall, the kit goes together easily, is simple to align even with no test equipment, and performs exceedingly well. I highly recommended it, and with the addition of a simple SATTV dish and an easily built feed, it will provide excellent signals from AO-40. This downconverter provides high performance at a very affordable price, and it would be my first choice when recommending one for Mode S.

The G3WDG040 kit is available from the Microwave Components Service. Their online catalog may be viewed at <http://www.emn.org.uk/mcs.htm>. No price had been set at press time, but Charlie's kits are always reasonable.

Additional websites of interest are AMSAT-UK: <http://www.amsat-uk.org> and AO-40 Operating and Antennas: <http://www.g6lvb.com>. ■

Cheap 435-MHz AMSAT Antennas

Kent Britain, WA5VJB, *CQ VHF*'s "Antennas" columnist, is always one for the quick-and-easy construction article. In this one he describes a simple-to-build antenna for satellite communications. The construction details in this article are spun with Kent's usual whimsical style, which should make reading about building the antennas almost as enjoyable as actually doing it.

By Kent Britain,* WA5VJB

For those of you who followed the old *CQ VHF,* in this article we will be revisiting the family of cheap Yagis with new and updated designs. For you new subscribers to *CQ VHF,* I would like to welcome you and introduce you to what we affectionately call "Cheap Yagis." This family of Yagi antennas was developed using NEC software and spending many hours on the antenna range. The object was to see how simple we could make the antennas and still maintain excellent performance.

The most common question asked by readers of the previous series of articles was "How does that driven element work?" Take our word for it; it works just fine. One way to think of it is three quarters of a folded dipole, or sort of a J-pole on its side. A highly specialized version of the Cheap Yagi has even been awarded US Patent Number 6307524. Don't worry; this patent won't affect any of the ham projects.

Normally, a Yagi has some kind of complex driven element to get the proper impedance match to coax. The Cheap Yagi design uses the loading effects of the other elements to match a high-impedance driven element to 50 ohms. Therefore, the spacing and the lengths of the other elements provide the proper driven-element impedance—not trimmer caps, lengths of coax, or shorting stubs.

Balancing good gain, good front-to-back ratio, and a good SWR is a product of a lot of computer time and a lot of antenna-range time. The end result of all this work is a very simple antenna with very good performance that can be built for a just few dollars. Now for a construction project.

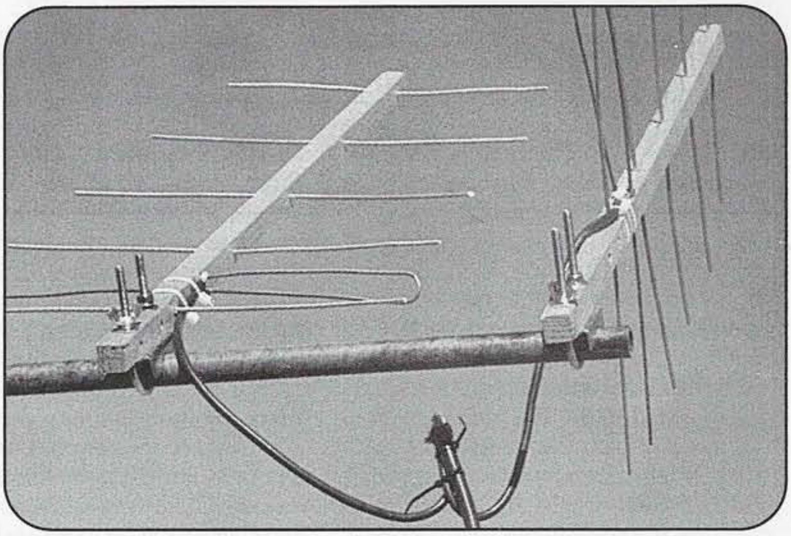


Photo A. Constructed with a wood boom, these 435 MHz AMSAT Yagis are about as cheap to make as possible. (Photos by the author)

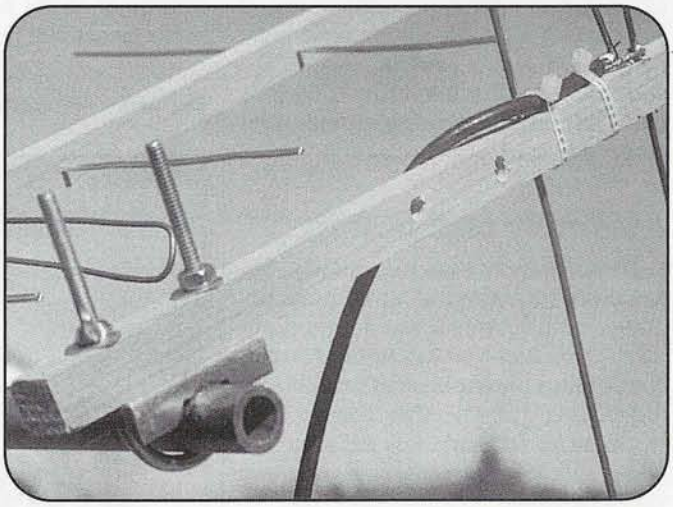


Photo B. The driven element uses #10 bare-copper wire, which makes it possible to solder the coax directly to it.

435 MHz Yagis for AMSAT Stations

These 435 MHz Yagis for AMSAT stations are about as cheap to make as possible (photo A). The boom can be made from 1/2" × 3/4" or 3/4" × 3/4" wood. A metal boom would require special correction factors. A PVC boom is kind of weak. Hey, wood is cheap, and you don't have to worry about any of those correction factors. If you plan to mount the anten-

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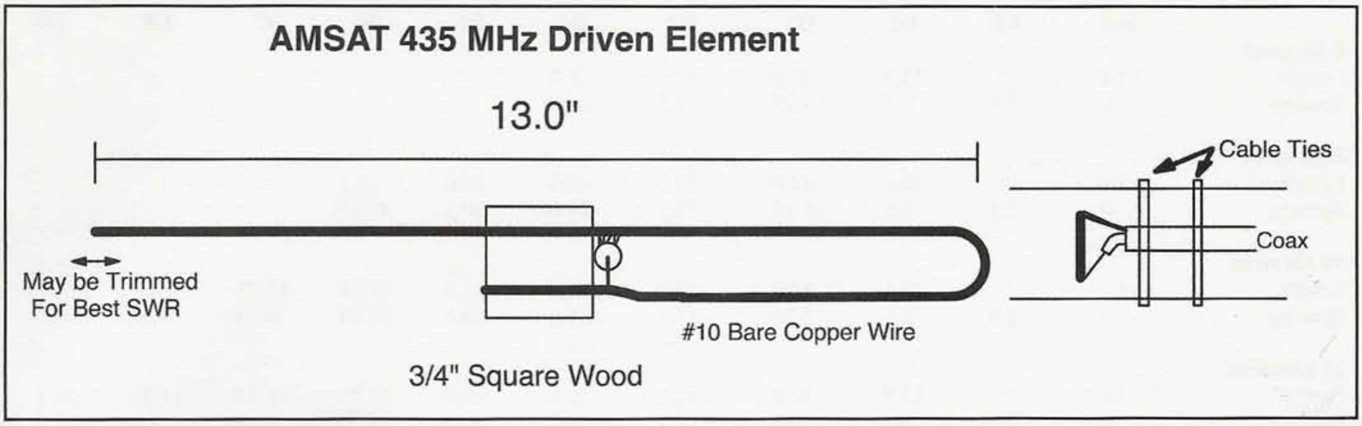


Figure 1. (Left) The driven element using #10 copper wire; (right) securing the coax to the boom.

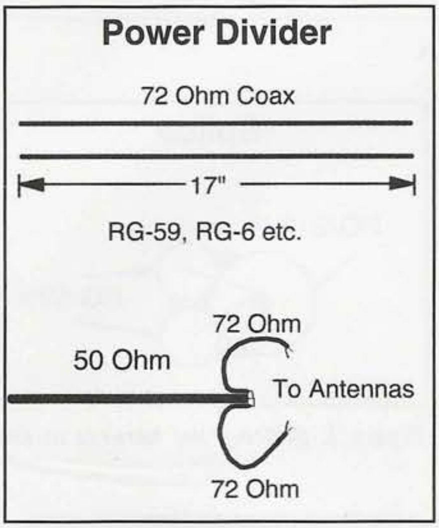


Figure 2. Constructing the phasing harness.

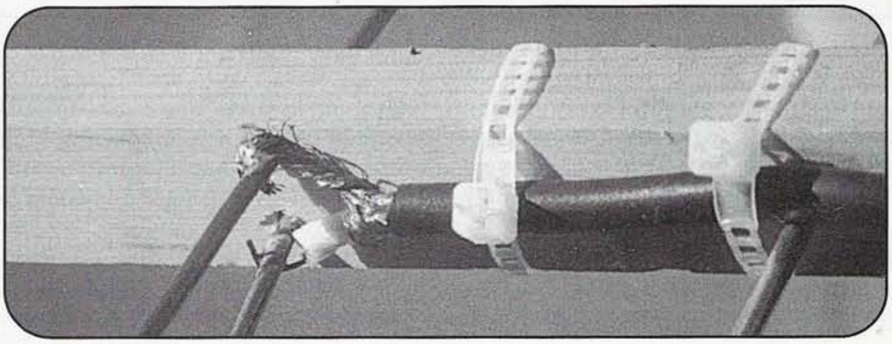


Photo C. Coax splicing onto the driven element.

na outside for an extended period of time, a good coat of spar varnish, clear coat, or even house paint will greatly extend the life of the antenna.

The elements are made from Radio Shack aluminum ground wire. A 40-foot roll will make a lot of antennas for about $5.00. You can use #10 bare copper wire, or most any 1/8-inch diameter wire. If you must use 3/16-inch wire or rod for the elements, leave the reflector the same length, but make the directors 0.2 inch shorter. The driven element is made of #10 bare copper wire (photo B and figure 1). The driven element is a lot easier to build if you can just solder the coax to it. Elements are secured with a drop of glue or an overcoat of paint.

I've included dimensions for four different versions of the AMSAT Cheap Yagi; 6-, 8-, 10-, and 11- element versions are included in table 1. My NEC antenna-modeling program predicts 11.2 dBi gain for the 6-element version, 12.6 dBi for the 8-element, 13.5 dBi for the 10-element, and 13.8 dBi for the 11-element antennas. These predictions are very consistent with the antenna-range results.

The patterns are also very clean. The 6-element has a 30 dB front-to-back ratio, and all the others should be over 40 dB front-to-back. The biggest field test of these designs was six years ago when N5EM constructed an array for Field Day using 16 of the 11-element versions. I understand they had a killer signal!

The Next Step: Stacking and Circular Polarization

Making the Phasing Harness (figure 2). The phasing harness is made from two lengths of 72-ohm coax, which is an odd quarter wavelength long and lets you feed both antennas in phase. If the coax lengths seem too long, it's because the velocity factor of 72-ohm coax is higher, about 0.8, so a 1/4-wave line is longer than in most 50-ohm coax cables. I tried using a 1/4-wavelength power divider, but the cable just wasn't long enough. A 3/4-wavelength power divider worked out quite well. You need two pieces of coax, each 17 inches long. The 17 inches includes the inch or so you use at each end. I used two lengths of RG-59. RG-6 also works okay, but these days it's hard to find any RG-6 that does not use aluminum shielding. Copper-shielded RG-6 is acceptable, provided you can find it.

Connect the center conductors of the two pieces of the phasing harness to your 50-ohm feedline, and connect all the shields together as well. Be careful to avoid shorting the shields to the center conductors.

My coax splicing (photo C and figure 3) may not be up to NASA specs, but it works. If you want to use BNC or N connectors, by all means feel free. I just wanted to show that you don't have to use connectors. My splice job probably has less loss at 435 MHz than PL-259 connectors, which is why I try to avoid PL-259s any time I can. A little RTV sealant and some electrical tape would be a good idea if you plan to use the antennas outside for an extended period of time. Once the connections were made, I also used a tie-wrap to keep everything in place.

The main 50-ohm feedline can be any length of coax. I used RG-213, but RG-

	Ref	DE	D1	D2	D3	D4	D5	D6	D7	D8	D9
6 Element											
Length	13.4	*	12.4	12.0	12.0	11.0					
Spacing	0	2.5	5.5	11.25	17.5	24.0					
8 Element											
Length	13.4	*	12.4	12.0	12.0	12.0	12.0	11.1			
Spacing	0	2.5	5.5	11.25	17.5	24.0	30.5	37.75			
10 Element											
Length	13.4	*	12.4	12.0	12.0	12.0	12.0	11.75	11.75	11.1	
Spacing	0	2.5	5.5	11.25	17.5	24.0	30.5	37.75	45.0	52.0	
11 Element											
Length	13.4	*	12.4	12.0	12.0	12.0	12.0	11.75	11.75	11.75	11.1
Spacing	0	2.5	5.5	11.25	17.5	24.0	30.5	37.75	45.0	52.0	59.5

**Driven element for all versions see figure 1.*
All dimensions are in inches.

Table 1. Dimensions for the 435 MHz Cheap Yagi.

214 or any other good grade of coax will work. I usually go out of my way to avoid RG-8, because most of that stuff gets very lossy after a few years, which certainly could be a topic for a future article. I only have one piece of RG-8 in my entire station. (It has terminal lugs on each end, and it is used to ground a roof-top tower!)

One versus Two. You can build both antennas on one boom, making it a crossed Yagi. The use of 3/4-inch-square wood is best. Just make the boom 6 1/2 inches longer, and mount one antenna 6 1/2 inches ahead of the other. I prefer to use two antennas, because they are much easier to store in a corner of the garage,

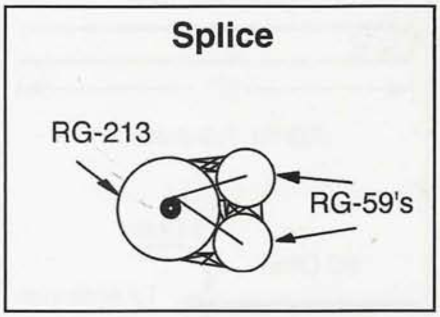


Figure 3. Splicing the harness to the feedline.

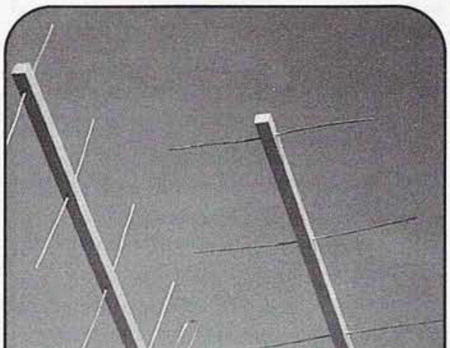
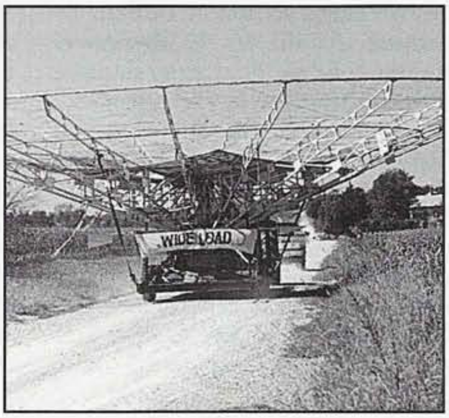


Photo D. Mount the antennas as far apart as the phasing harness will allow.

On The Cover



The gigantic, 42-foot parabolic dish belonging to Ken Kucera, KAØY, found its latest resting place in the corn fields of Iowa. How do you move a 42-foot dish not once, but twice, complete with twists and turns through the countryside and the town of Riverside? Very carefully indeed, as the inset photo shows. Read this story by Rod Blocksome, KØDAS, beginning on page 9 in this issue. (Photos by KØDAS)

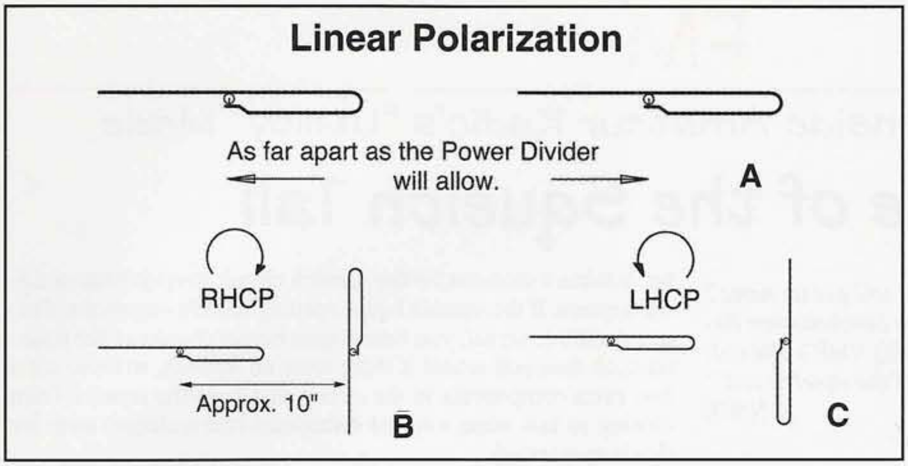


Figure 4. Mounting the Yagis for various types of polarization.

they are easier to throw in the back of the car, and you have four polarization choices when you mount them.

Mounting Your Yagis. Mount the antennas as far apart as the phasing harness will comfortably allow (photo D). For linear vertical or linear horizontal polarization, mount the antennas parallel, with the driven elements the same distance from the mounting boom, which will give you about $2^1/_2$ dB more gain than an individual antenna. You often will hear claims of a 3 dB improvement, but this number is ideal, assuming no loss in the power divider and the antennas at an impractical spacing.

The other way to mount the antennas will generate circular polarization (figure 4). By having one antenna $^1/_4$ wavelength in front of the other and both driven by the same phase, a circular-polarized (CP) wave will be generated. Make the boom on one of the antennas about 8 inches longer at the back. Drill another set of mounting holes $6^1/_2$ inches behind and 90 degrees to the other mounting holes. Now by just slipping the U-bolt from the front holes to the back holes, and rotating the antenna 90 degrees, you have a CP 435 MHz antenna. If you think that right-hand CP (RHCP) might work better than left-hand CP (LHCP), then by flipping over either of the antennas 180 degrees, you will reverse the phasing, and it's now LHCP.

Now for the technical guys who are good at picking fly specks out of pepper: Yes, the few inches of horizontal separation between the two antennas does mean that when looking 30 or 40 degrees off axis from the antenna, the antenna is elliptically polarized (sort of an egg-shaped circular polarization). The whole idea is to point the antennas where they work best!

There are fancy ways of generating switchable polarization, but you can build a pile of Cheap Yagis for the cost of just one coax relay.

Next time we'll go into the theory behind these simple antennas a bit more, and future issues will contain still more cheap (and not so cheap) construction projects. ■

By Gary Pearce,* KN4AQ

FM

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

The Tale of the Squelch Tail

Have you ever wondered how the squelch tail got its name? Gary Pearce, KN4AQ, the new editor of the Southeastern Repeater Association's Repeater Journal, *and* CQ VHF*'s FM column editor, takes us on a tour of the "tale of the squelch tail."*
—N6CL

The term *squelch tail* is all wrong. They got it backwards. If anything, it ought to be called the *squelch nose* or maybe the *squelch head,* but *squelch nose* is funnier. I'll explain all of this somewhere in the middle of this column, so keep reading.

Squelch (skwelch) *n.* 1. a crushing retort, rebuke, etc. *vt.* to suppress or silence completely (*Webster's New World Dictionary*).

One of the most under-appreciated controls on most FM rigs is the lowly squelch knob. Squelch may be a simple subject, but count on me to make it complicated . . . and you thought my job was just the other way around! It also looks as if the Webster folks don't have FM radios, or they'd have a better definition for squelch, the noun. My radio hasn't rebuked me lately. They did okay on the verb.

What is Squelch?

You know what *not* having squelch is. On an FM receiver, it's a really loud roar of noise coming from your speaker, as loud as or louder than the voices you really want to hear. That loud noise is the result of a lot of amplification. It's pretty unpleasant to listen to an unsquelched FM receiver, so you turn up the squelch control to keep the darn thing quiet until a signal comes along. However, what have you really done?

You have adjusted a circuit in your radio that is sampling the noise. The circuit rectifies some of that noise and uses the voltage developed to open a switch (an electrical switch, not a mechanical one). That switch turns off the audio amplifier, so no noise gets to the speaker. When a signal appears, that background noise is reduced, the rectified voltage goes down, and that switch closes, sending audio on to the speaker.

"Ah hah!" a few of you are thinking. That can't be right! Just the other day the local repeater got hung up and was blaring open-squelch all morning, but my squelch didn't close on that noise even after I turned it all the way up. Why not? Hey . . . double ah-hah! Why doesn't that squelch rectify the sound of people talking and pop the audio closed on each voice peak?

The squelch circuit uses a filter to sample a fairly high frequency of noise, maybe in the 6 to 8 kHz range. The voice frequencies are cut off above 3 kHz, and so is the noise that's passed through the repeater's audio chain when its squelch is stuck open. Thus, your squelch circuit doesn't see any of that as noise at all.

Simple so far, but it gets a little more complex. We have to deal with mobile signals, sometimes weak ones, with a lot of flutter. It takes a moment for the squelch circuit to open when a signal appears. If the squelch keeps opening and closing on that fluttering mobile signal, you would miss bigger chunks of the transmission than you would if there were no squelch, so there are a few extra components in the circuit that keep the squelch from closing so fast when a signal disappears (the technical term for this is *hysteresis*).

The desired result of this little delay is that the squelch doesn't close during those brief signal dips, making the mobile's signal easier to understand. A somewhat unwanted result is a short burst of noise at the end of each transmission, also known as the squelch tail!

Here is where I begin my campaign. That little burst of noise you hear at the end of a transmission is not squelch. It is the absence of squelch. The squelch is the silence that begins a moment later! This little burst of noise doesn't follow the squelch, like a tail. It precedes the squelch, like . . . a nose. From now on, then, I declare that the burst of noise following each transmission will properly be called the *squelch nose.*

Cutting Off The Squelch Nose

(To Spite Your Face?)

Some receivers have a longer squelch tail—err, nose—than others. I really loved those squelch tails—err, ah . . . I mean noses—when I first heard them. I think that was on the old 1950s show *Highway Patrol* with Broadrick Crawford (10-4). I loved them in my old tube-type Motorola equipment in the 1960s. Even so, not everyone loves them as much as I do (and I think I'm a little worn on them myself). Thus, some techniques have been developed to get rid of the little buggers.

Motorola developed a dual-gate squelch circuit for the Micor receiver. It measures signal strength so that when a signal is strong, there is little or no delay in the squelch closing. When a signal is weak, the delay is active, and you hear a normal squelch nose.

Some of the fancier repeater controllers do it another way. They add a bit of digital delay between the receiver and transmitter and put their own audio gate in the circuit. When the mobile's signal drops on the input, the burst of noise goes slogging through the delay circuit. However, the "Hey, there's no signal here anymore, so I guess the repeater transmitter can drop" voltage from the repeater's receiver races ahead of that delay and nips the audio off before the noise burst can exit the delay. The repeater's audio goes from voice to silence, at least as long as the user's signal is full-quieting.

(This is a good time to clear up a misconception. That short period of time that a repeater transmitter stays on the air after the user's signal has dropped is *not* the squelch tail! A lot of people call it that, but they're using the term wrong. What is it then? Well, one repeater manual I have calls it *hang time,* although basketball fans might be confused by the term. Another term I've heard is *dropout delay.* The lack of a good,

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common word is probably what led to so many people to call it the squelch tail. Now that I've changed that term to squelch nose, the term squelch tail is available and may properly be applied to the repeater's hang time.)

Squelch . . . By Any Other Name

So far I've described squelch as if it were the be-all and end-all of getting rid of that loud roar, but it isn't. There are many alternatives, all of them forms of squelch. In fact, the one I've been talking about is properly called *noise squelch,* because it works off the level of noise being received.

S-meter Squelch: A few radio models have an option of tying the squelch circuit to the S-meter. You set the squelch to open when the S-meter reaches a certain level, from a low of S-1 all the way up to full scale. This gives you a broader range of action for squelch, allowing you to reject strong signals that would open the conventional noise squelch even when turned up all the way. This type of squelch is usually not as sensitive to weak signals, though.

Another popular form of squelch is **Tone Squelch.** That goes by several names: CTCSS, PL, and just "tone" are the common ones. Instead of sampling a bit of noise, the receiver looks for a low-pitched tone riding along with the voice audio on a received signal. If the correct tone is present, that switch is closed and the audio heads to the speaker. If the correct tone isn't there, the speaker stays quiet. There are 38 or more tone frequencies that are used, ranging between 67 and 250 Hertz. Most modern amateur VHF-FM radios come with built-in tone encoders, and many also have tone decoders.

CTCSS can also be used to accomplish squelch nose elimination; simply turn off the tone a moment before turning off the transmitter. The receiver audio shuts off before the transmitter goes off, so there's no noise. The ubiquitous Radio Shack HTX-202 offered this feature, and it's included in many Family Radio Service (FRS) radios, but few ham radios have it.

A bit of history: In the early days of FM, CTCSS was generated with a mechanically vibrating reed, both for sending and receiving. The reeds were very sensitive and selective, but at the end of a transmission the receive reed would take a while to "coast" to a stop, resulting in a very long squelch nose. To solve this problem, at the end of a transmission the sending reed would be shifted 160 degrees in phase for a moment. The receive reed would stop cold, the audio switch would close, and the signal would drop before the receive reed could start up again. This clever Motorola technique was called Reverse Burst. The old timers are getting a bit misty right now.

A newer form of tone squelch is **Digital tone squelch**, or **DPL**. This method superimposes a bit of data on your signal that is decoded at the receiver. A few ham manufacturers are now offering digital tone squelch (with their own trade names), but unless you have one of those radios, it's incompatible with everyone else. Motorola developed DPL for commercial use back in the 1970s. Just as PL uses different sub-audible frequencies for each user, DPL uses different "code words" to distinguish between users. The code words are 23 bits long and transmitted at about 135 bits per second. If you listen to DPL, it sounds like hum with hiccups!

DPL codes are defined by three octal digits (octal digits are 0 through 7). This would imply that there are 512 DPL codes (000 through 777), but that's not the case, as some of these codes involve long strings of ones or zeros in the data stream, making implementation of the encoder and decoder different. Thus, there's a subset of codes that at most only have seven ones or zeroes in a row that actually get used in practice. There are about 130 of these codes, still many more than what's possible with analog tones.

Touch-tones can be used as a form of squelch. Many amateur FM radio models have incorporated this feature, and most call it touch-tone paging. A decoder in the receiver keeps the receiver quiet until the correct sequence of touch-tones is received. Then the audio opens, and the conventional noise or tone squelch takes over.

Finally, more and more radios are using something called **automatic squelch**, or what appears to be squelch with no control at all. Automatic squelch is really a form of noise squelch, and I don't know what trick circuit they have going, but in my ICOM W32 handheld, it seems to work most of the time. I didn't think I was going to like that. Diddling with the squelch control seemed to be a favorite pastime of mine. However, it turns out that I like having the chore taken out of my hands—as long as it works.

That's the "Tale of the Squelch Tail." Remember, though, from now on it's officially the Squelch Nose! ■

By Tom Webb,* WA9AFM

SATELLITES

Artificially Propagating Signals Through Space

You Can Work 'em even if You Can't See 'em!

Almost every time I'm approached and asked, "How do I get started in satellites?" the first subject that is broached is equipment. I then quickly redirect the discussion to tracking software, because you can't work a satellite unless you know when and where it will be in view—i.e., what time, what azimuth, and what elevation.

I always encourage satellite "newbies" to get a good tracking program first and then experiment with it to become familiar with the orbital characteristics of the amateur satellites in which they might be interested. In keeping with this theme of encouragement, the subject of this inaugural "Satellites" column is satellite tracking software—what's out there, what computer power will you need, where to get it, and what can it do for you.

In The Beginning: BPC
(Before Personal Computers)

A bit of history would be a good place to start. The personal computer (also known as the PC) really didn't begin making an appearance in the amateur radio shack until the early 1980s. The Atari, Apple, Commodore, and Radio Shack series gave us "bird chasers" (the colloquialism for we hams who regularly pursue satellite operating) a more accurate source of tracking information. The programs were short and to the point—no fancy graphics and no rotor control, just time, azimuth, and elevation.

Prior to the advent of the PC, tracking literally was done by hand using the "OscarLocator." This rather primitive, but effective device consisted of a polar projection map. A satellite footprint (also known as a *spiderweb*) showing azimuth and elevation rings and printed on clear plastic was centered on your geographic location. Over the map and the spiderweb, a ground track overlay for the satellite you planned to work was mounted with a pivot point centered on the North Pole. The beginning of the ascending orbit was placed on the predicted point of equatorial crossing. Indices on the overlay gave the time from equatorial crossing until acquisition. The ground-track overlay also plotted the satellite's path through the footprint, giving you the time, azimuth, and elevation of the pass.

This arrangement was cheap and pretty effective if you had a very accurate station clock. The main disadvantage of the OscarLocator was you had to have an overlay for each satellite (although there weren't that many at the time).

As PCs and their power increased, more sophisticated tracking programs became available from commercial and volunteer developers. Graphics, automatic updates of Keplerian elements (more on those later), rotor and transceiver control, and projection of mutual access windows became routine features. Let's take a look at some of the current tracking software.

Nova For Windows

First released in 1996 at the Dayton Hamvention®, Nova For Windows is one of the most versatile and sophisticated satellite-tracking programs available. Nova was developed by Dr. Michael Owen, W9IP, and Dr. C. J. Knickerbocker, both of whom are on the faculty of St. Lawrence University. Nova runs on a 386 or better CPU, needs 4MB of RAM and 12MB of disk space, and yes, it is compatible with Windows® 95 through XP.

Nova has outstanding displays with Mercator projections or orthographics, better known as the *view from space*. The user's ingenuity is only limited by the creativity of the display setup—a window for each satellite, all the satellites you work in one window, digisats in another window, low-earth-orbit satellites in yet another, and so forth.

One of the interesting features is the *voice announcement*. When Nova is running, the appearance and setting of a satellite of interest to you can be announced by Nova.

Nova has 14 drivers for rotor control already loaded. There are no terminate and stay resident (TSR) programs to load; a pull-down menu gives you the rotor controller of your choice. Setup and calibration are accomplished through a series of user-friendly pages. Rotor control can be configured for automatic or manual operation. An onscreen display allows manual rotor control with your mouse. Either the Radio Amateur Satellite Corporation (AMSAT) or the National Aeronautics and Space Administration (NASA) Keplerian elements can be loaded manually or automatically without editing.

A "Nova For Windows®" demo version can be downloaded from the Northern Lights Software Associates web page <http://www.nlsa.com>. If you want a registered version, the cost is $50 for AMSAT members, or $60 for non-members. A portion of the purchase price goes to benefit the amateur satellite program when you order through AMSAT.

STS Orbit Plus

STS Orbit Plus was developed and released by David Ransom in 1991; its predecessor, STS Orbit, which is no longer supported, was released in 1988. STS Orbit Plus is designed to emulate the giant display at mission control at NASA. STS Orbit Plus is used by NASA, the US Air Force, and space enthusiasts around the world.

Originally developed to track space shuttle missions (hence the name STS), the program will track one primary satellite and 32 other satellites at the same time. STSPLUS will display either an orthographic or rectangular map. More recent versions have a "Night Vision" mode, which displays the maps in red to protect night vision—an important feature if you are trying to do visual observation of spacecrafts as they pass overhead.

The program is highly accurate and meets strict USAF requirements of locating a satellite ±.5 km over a 24-hour period. It's used by the USAF Central Computer complex at Cape Canaveral/Patrick AFB, Department of Defense C-Band Radar Network, and numerous other NASA and aerospace control facilities. STSPLUS, in conjunction with the STSUPDAT utility, will automatically update STSPLUS with Keplerian elements in the NORAD/NASA two-line elements only. The AMSAT format is not processed.

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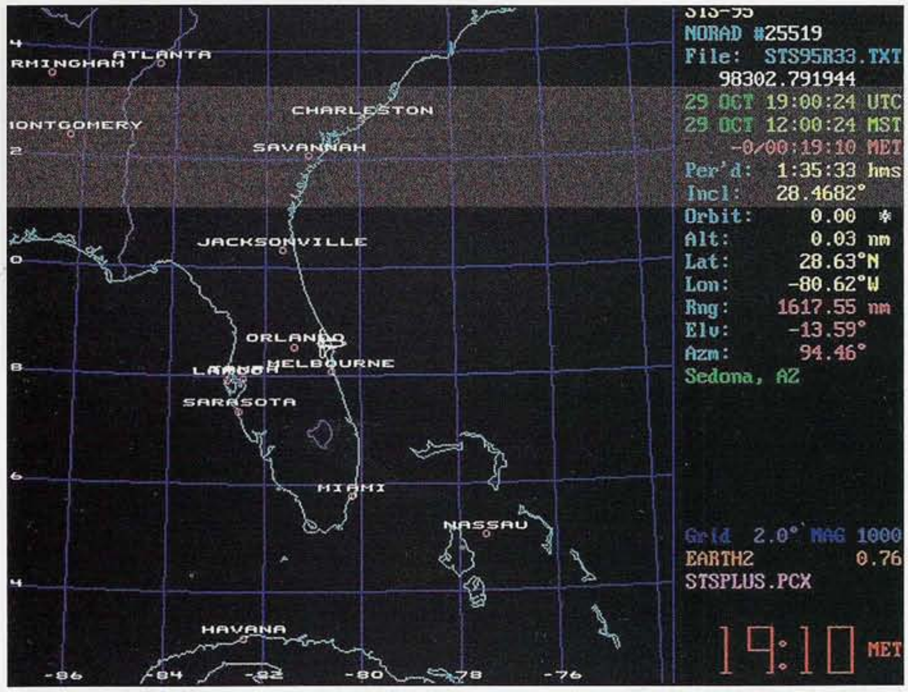

STSPLUS with display centered over Cape Canaveral. The STS-95 is awaiting launch. (Courtesy of David H. Ransom, Jr.)

STSPLUS does not require any registration. It can be downloaded from the STS site <http://www.dransom.com/stsplus.html>, or it can be ordered on 3.5-inch disk for $20 from AMSAT Headquarters (850 Sligo Avenue, Suite 600, Silver Spring, MD 20910-4703; phone 301-589-6062; fax 301-608-3410 [if ordering by fax, include your AMSAT membership number if any and your daytime EST phone number along with credit card information]). STSPLUS is compatible with Windows® 95 and 98. However, Windows® NT and 2000 will need special utilities available from the STS website.

QuikTrak

QuikTrak was one of the earliest tracking software packages. It began its long run in the satellite-tracking field in 1979. QuikTrak's author, Bob McGwier, N4HY, first developed the program for the Commodore VIC 20 computer and two years later for the Radio Shack TRS-80. The IBM version was developed in 1982. Although in Version 5.02 it is still a DOS-based program, which will run under the current popular operating systems, it has the usual expected features found in more sophisticated tracking packages.

Don't discount QuikTrak because it is DOS-based. By being DOS-based, it allows you to run the program on an older, and much less expensive, computer. Thus, you could afford to install a dedicated satellite-tracking computer in the shack. Just think of it—24/7 satellite tracking.

QuikTrak can be purchased through

Coming Up in CQ VHF Ham Radio Above 50 MHz

Here are some of the articles that we're working on for future issues of *CQ VHF*:

- "Improved Results for the Directed Directional Weak-Signal Net," by Gordon West, WB6NOA
- "Project Starshine," by Bobette Doerrie, N5IS
- "Are Your Batteries Charged?" by Bob Shrader, W6BNB
- "Working DX With a Heathkit Twoer," by Bob Witmer, W3RW
- "How to Transform a Transformer," by George Murphy, VE3ERP
- "An Aviator's Solution to Shack Noise," by Michael Schell, KF2LF
- *CQ VHF* Reviews: K1EL K10+ CW Keyer Kit, by Simon Lewis, GM4PLM

We Want Your Articles!

CQ VHF depends on its readers to be its writers as well. If you have an article idea, please send a brief description to Editor Joe Lynch, N6CL, via e-mail to <n6cl@cq-vhf.com> or by postal mail to 1621 N. Sheridan Rd., Tulsa, OK 74115. Include an SASE (self-addressed stamped envelope) for a mailed response.

the AMSAT website <http://www.amsat.org>. The cost is $25 for AMSAT members and $35 for non-members.

InstantTrack

InstantTrack is one of the all-time favorite tracking programs of the satellite community. First developed in 1989 by Frank Antonio, N6NKF, it has maintained a strong following. Like QuikTrak, it is a DOS program allowing you to use a less-expensive computer and have a dedicated tracking machine. It was recently upgraded to Version 1.50.

InstantTrack provides either text or map displays. Map displays may be shown either cylindrical or orthographic, and there is also a star-filled map. The maps are full color, high resolution, easy on the eyes, and just as easily interpreted. The database comes preloaded with 1754 cities from which you select an observer location, and the program can support a database of up to 200 satellites. You also can set your computer's clock with a National Institute of Standards and Time (NIST) service via your modem. The program can control your rotors with a TSR running in the background.

InstantTrack is the sentimental favorite of the satellite community. It can be downloaded from the AMSAT website <http://www.amsat.org> and registration is $30 for AMSAT members and $50 for non-members.

Tracking with a Mac

Although a vast majority of the tracking software available is for the IBM-type computer, Macintosh fans are not left out of the picture. MacDoppler (released in 1997) and MacDopplerPRO (released in 1999) are two outstanding tracking packages for the Mac. Developed by Dog Park Software, Ltd., of Toronto, Ontario, Canada, both programs have features similar to other current tracking programs, including the ability to control the frequency of your satellite radio to compensate for Doppler frequency shift. MacDopplerPRO has the added feature of a 3D projection of the Earth, plus it tracks up to 16 satellites simultaneously.

Either program can be downloaded from the Dog Park Software website <http://www.dogparksoftware.com> and then registered through AMSAT. MacDoppler can be registered by AMSAT members for $40, non-members $50. MacDopplerPRO can be registered by AMSAT members for $65, non-members $75. Add $10 to either charge for a diskette copy of the program.

Packet Satellites

If your interest lies in working the various packet satellites, also known as PACSATs, WiSP is the program you should check out. Besides the tracking functions, WiSP also tunes the radios, listens for the designated satellite, manages the message files, and controls your azimuth and elevation rotors. It can do all of that unattended! Developed in 1994 by Chris Jackson, ZL2TPO, WiSP combines the features of "PB" and "PG," two separate software packages which initially provided amateurs with PACSAT capability.

For Mac fans, MacPacSat, from Dog Park Software, has features similar to WiSP, including the capability to decode amateur satellite telemetry data. WiSP can be downloaded from the AMSAT website <http://www.amsat.org>. A 16-bit version for Windows 3.1 is available for $40 for AMSAT members and $50 for non-members. The 32-bit version for Windows® 95 and up is available for $50 for AMSAT members, $60 for non-members. MacPacSat can be downloaded from the Dog Park Software website <www.dogparksoftware.com> and registered through AMSAT for $60 for AMSAT members, $70 for non-members.

Satellite:	AO-40
Catalog number:	26609
Epoch time:	02079.31559189
Element set:	0206
Inclination:	007.2928 deg
RA of node:	123.2165 deg
Eccentricity:	0.7933515
Arg of perigee:	031.8524 deg
Mean anomaly:	357.9470 deg
Mean motion:	01.25597194 rev/day
Decay rate:	-2.72e-06 rev/day^2
Epoch rev:	00637
Checksum:	314

Figure 1. An example of an AMSAT Keps format.

Keplerian Elements

Regardless of which tracking software you employ, information on the orbital characteristics of the various satellites you plan to work must be provided to the program. This information is called *Keplerian elements,* or *Keps* for short (figure 1). Keps were named in honor of Johannes Kepler, a 17th century physicist and mathematician who developed Kepler's Three Laws of Planetary Motion.

MacDoppler displays the position of STS-109 and the Hubble Space Telescope (HST). (Courtesy of Dog Park Software, Ltd.)

```
DECODE 2-LINE ELSETS WITH THE FOLLOWING KEY:
1 AAAAAU 00 0 0 BBBBB.BBBBBBBB .CCCCCCCC 00000-0 00000-0 0 DDDZ
2 AAAAA EEE.EEEE FFF.FFFF GGGGGGG HHH.HHHH III.IIII JJ.JJJJJJJJKKKKKZ

KEY:
A-CATALOGNUM
B-EPOCHTIME
C-DECAY
D-ELSETNUM
E-INCLINATION
F-RAAN
G-ECCENTRICITY
H-ARGPERIGEE
I-MNANOM
J-MNMOTION
K-ORBITNUM
Z-CHECKSUM

AO-10
1 14129U 83058B 02069.11201782 .00000279 00000-0 10000-3 0 08687
2 14129 025.8362 223.6026 6074727 231.4854 056.6256 02.05866939140920

UO-11
1 14781U 84021B 02073.96336852 .00004652 00000-0 67848-3 0 7744
2 14781 98.0721 41.6824 0008796 217.7926 142.2666 14.76256154965951
```

Figure 2. Keplerian elements (Keps) for every object in Earth orbit are determined by NORAD based on observations by various space surveillance radars. This is an example of the NORAD two-line format.

Keps are, in a very real sense, a snapshot of the orbital parameters of a satellite. Keps tell the software the exact position of the satellite at an exact time and date. From that information the software can then predict future positions of the satellite.

Regular, frequent updating of your Keplerian elements is always a good idea, but don't be concerned if you go a couple of weeks without one. Keps for every object in Earth orbit are determined by NORAD (North American Aerospace Defense Command) based on observations by various space surveillance radars. An example of the NORAD two-line format is shown in figure 2.

Most software will automatically update Keps without having to edit extraneous material. Back in the "old days," any nonessential information had to be removed from the Kep files, as the older, DOS-based software was unable to distinguish nonessential data from required data.

NORAD provides this information not only to NASA and other government agencies, but also to the general public. There are several sources of Keps, one being the AMSAT website <http://www.amsat.org/amsat/keps/>. You can also subscribe, via the AMSAT website, to regular delivery of Keps via e-mail.

If You're Really Serious…

One other strong suggestion I make to folks wanting to get into amateur satellite work is to get a copy of *The Radio Amateur's Satellite Handbook* by Martin Davidoff, K2UBC. This is the bible of amateur satellite communications. Published by the American Radio Relay League, the book is available through a variety of amateur radio supply houses or can be ordered for $25 from AMSAT Headquarters.

I would like to thank Martha Saragovitz of AMSAT Headquarters, Don Agro of Dog Park Software, and Robert McGwier, N4HY, for their assistance in preparing this column. ■

About The Author

Tom Webb, WA9AFM, was first licensed in 1961 as WN9AFM and now holds an Extra Class license. He is a graduate of Southern Illinois University, Carbondale, with a Bachelor of Science in Mass Communications; he also holds a Master of Arts degree in Management from Webster University, St. Louis, Missouri.

A retired USAF officer, Tom had various duty assignments with NORAD, Strategic Air Command, Air Forces Iceland, Tactical Air Command, and Aerospace Defense Command involving command, control, and communications. He also served as a battlestaff member onboard the E-3 "Sentry" AWACS. He is a Life Member of AMSAT, a current member of the ARRL Public Relations Committee, and holds WAS for satellite. Currently, Tom is a Senior Site Director for Webster University at Tinker AFB, Oklahoma.

BEACONet
Spanning the Atlantic on 2-meter PSK-31?

What has remained elusive for ham radio for decades is the terrestrial path from the US east coast, across the Atlantic, to Europe and northern Africa. Hints of propagation have teased us for years, but with no results. Now W2EV proposes a possible way of bridging that Atlantic propagation path.

By Ev Tupis,* W2EV

Imagine a fully automated, computer-controlled PSK-31-based "ether tester" capable of not only probing the North Atlantic for band openings around the clock, but also actually engaging in keyboard-to-keyboard QSOs once a path is established.

The internet research component of the organization The Search for Extraterrestrial Intelligence (SETI), SETI@home, has the right idea—recycling "unused" computing power into the search for extraterrestrial (ET). SETI@home "borrows" your computer for periods of time to do analysis of data that SETI have collected from its observations.

Simply stated, this "borrowing" takes place almost transparently to your using your computer by way of a program running in the background while you are not using the computer. Once you start using your computer, the SETI@home program stands by while you use your computer. Once it detects that you are through using the computer, it resumes its operations with the computer.

Amateur radio can directly benefit from the SETI@home strategy. Amateurs typically let their equipment sit dormant for a vast majority of any given 24-hour day. Here is an opportunity to put that "unused" time to great use for the furtherance of the state of the art of amateur communications and propagation study on the 2-meter band.

Spanning the Atlantic Ocean on 2 meters using all-terrestrial means has been a dream in the amateur community for a number of years. By adopting the SETI@home philosophy, we place ourselves in a position to learn many lessons about the transatlantic path and how to optimize our efforts. The trick is for operators on both Atlantic coasts to get in the habit of aiming their antennas into the open ocean and participating during normally inactive times, letting their computers do the probing and eventual alerting when something is received.

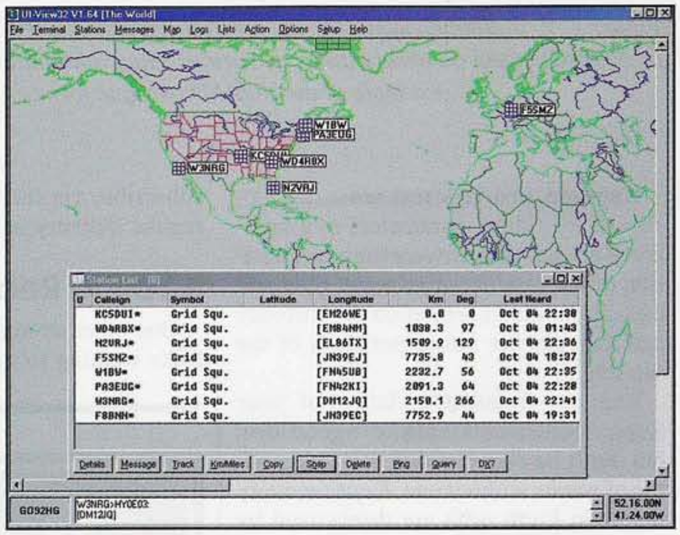

Figure 1. A screen shot of a BEACONet^31participant.

The Vision

Combine the following items: a 2-meter SSB transceiver capable of 100+ watts of RF output, Windows®-based PC with soundcard, PSK-31 interface to connect the two, 8- to 18-element Yagi antenna, special PSK-31 software driver (free!), specially configured APRS[1] software (also free!), and the warm summer Atlantic Ocean water. By activating the system 24/7, we have the makings of *the* amateur radio "killer application" for potentially attaining the seemingly unattainable.

The system can operate around the clock, constantly probing for any hint of a tropospheric duct forming across the Atlantic Ocean. If (when) signals begin to propagate, the computer not only can capture the event for posterity, it can also

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alert the operators and allow them to engage in a PSK-31-based keyboard-to-keyboard QSO!

There are many factors yet to consider, including how to get the word out to amateur radio enthusiasts who live on the islands of the open Atlantic, including the Bahamas, Bermuda, the Azores, and the Canary Islands. Having them actively participating in this project would provide for intermediate "markers" should the band begin to build. This can provide very useful data to consider when adjusting strategies for even greater chances of success.

Another consideration is frequency of operation and transmitting strategy. Coordinating operation within the same country is often problematic; coordinating operation between continents is geometrically more so.

As such, and using the KH6HME 2-meter CW beacon in Hawaii as an example (figure 2), it is suggested that North America *transmit* and Europe *listen*[2] (although transmitting with high power when the station is attended is fine as well). This would allow for landing on a frequency that may not be "totally available" in IARU Region 1, especially when keeping in mind that antennas will be pointed into open ocean, where the potential for QRM to other users of the frequency is slight at best. In addition, this system is not power or frequency restricted in the way that CW-based propagation beacons are. In the US, participants are governed by FCC Rules, Part 97.221: Automatically controlled digital stations. After all, it is a fully functional digital communications system!

The Software System

This project utilizes PSK-31 "middleware" that is capable of scanning the PSK waterfall, looking for streams to lock on to and decode. Even so, it is necessary for participants' transceivers to be accurate in frequency to about 500 Hz. The scanning software will do the rest of the work.

A specially configured version of APRS[2] software called *UI-View* will take the data as decoded by the PSK-31 system, parse it, and display the results directly on a computer screen. A computer map of the world will be populated with icons representing the location of any signal that is decoded. Participants will be able to visually and audibly observe the project's progress in real-time, even being able to save logs of what is decoded! UI-View will automatically control the transmit-side of things, too.

The Proof of Concept

The system described already exists and is fully functional on the 10-meter amateur band. This allows for a testing ground for anyone who may wish to hone his or her activity a bit before making the move to 2 meters.

The service is called BEACONet^31[3] and is homed on 28.131-MHz, USB + 1500 Hz PSK audio. Figure 1 is an actual screen shot from one of these participants. Imagine this type of display and documentation on a 2-meter transatlantic path! As of the time of this writing, there are even enthusiasts who have begun to establish a BEACONet^31 presence on the 6-meter band at 50.291-MHz USB + 1500 Hz PSK audio, just above the PSK-31 calling frequency.

This system works. We now simply are faced with generating interest in moving to the 2-meter band to attempt the assumed impossible transatlantic path!

The Protocol and Frequency

Each BEACONet^31 transmission contains valuable information. A typical transmission takes the following form:

FOR INFO HTTP://GO.TO/BEACONET
W2EV>HY0E02-15:[FN03XD]^5DA5

The first line contains preamble text. This allows the PSK-31 scanning system sufficient time to find and lock on to the PSK-31 stream prior to the "payload" being sent. The second line is the "payload." It contains the station callsign in plain text. A "Configuration Code" comes next (HY0E02-15). Embedded inside is the following: the frequency of operation, power output, antenna contribution, antenna height AAT (above average terrain), and antenna pointing vector. Between square brackets is the transmitter's 6-character Grid Locator, followed by a CRC checksum to assure accurate decoding. In all, each transmission takes about 20 seconds. Each station transmits at least 6 times an hour (once every 10 minutes).

The 2-meter frequency of operation is still under consideration as of the time of this writing. Several possibilities are being discussed, each with its own set of issues to consider.

The Potential

Several similarities can be drawn between the unexplored North America to Europe path and the well-established Hawaii to west coast path, which is successful almost on a yearly basis.

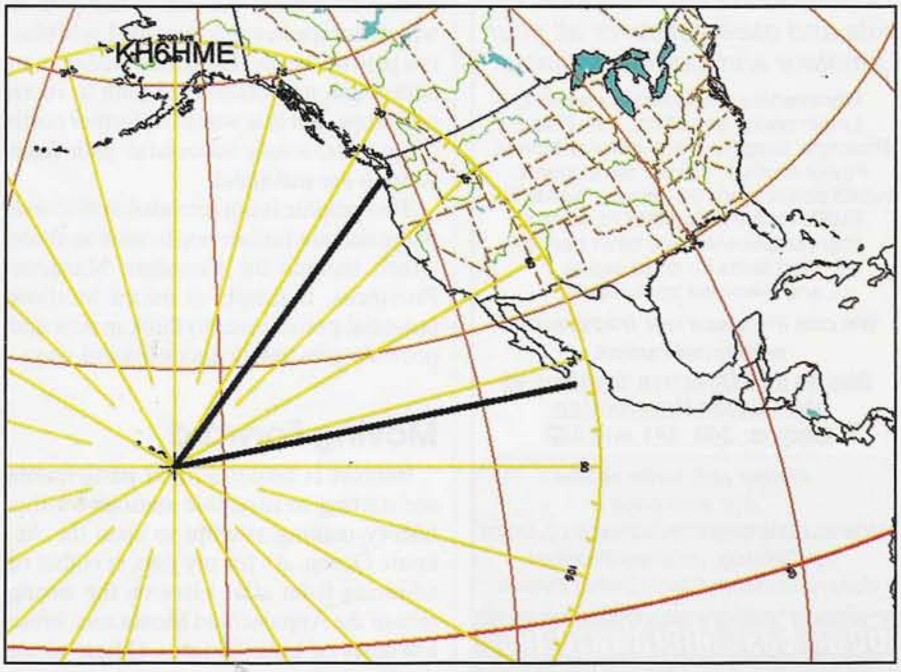

Figure 2. The well-known and well-used trans-pacific propagation path between Hawaii and the west coast of southern Canada, the US, and the tip of Baja California, Mexico.

Meteorologically, high pressure forms along the California to west coast path, forming a duct that allows propagation.

Along the USA's eastern coastline a similar phenomenon occurs in mid-to-late summer. It is referred to as a Bermuda High. At times such events are so intense that they are referred to as "Omega blocking Highs." When that strong, they tend to block the normal west-to-east flow of weather at these latitudes.

Incredibly strong 2-meter DX propagation along the east coast is normally associated with this event. In addition, the 1500 km path between the Canary Islands and the UK "opens" regularly during this same time of the year. The only question is if the two phenomena can be linked to make things truly interesting.

Geographically, a path similarity exists as well. Figure 2 depicts the view of the path from Hawaii to North America. The path has been proven to work from the tip of the Baja, California peninsula in the south, all the way to Washington State to the north. Compare that to a similar map (figure 3) showing the geometry from Florida to Europe (one of several possible paths). The resemblance is uncanny.

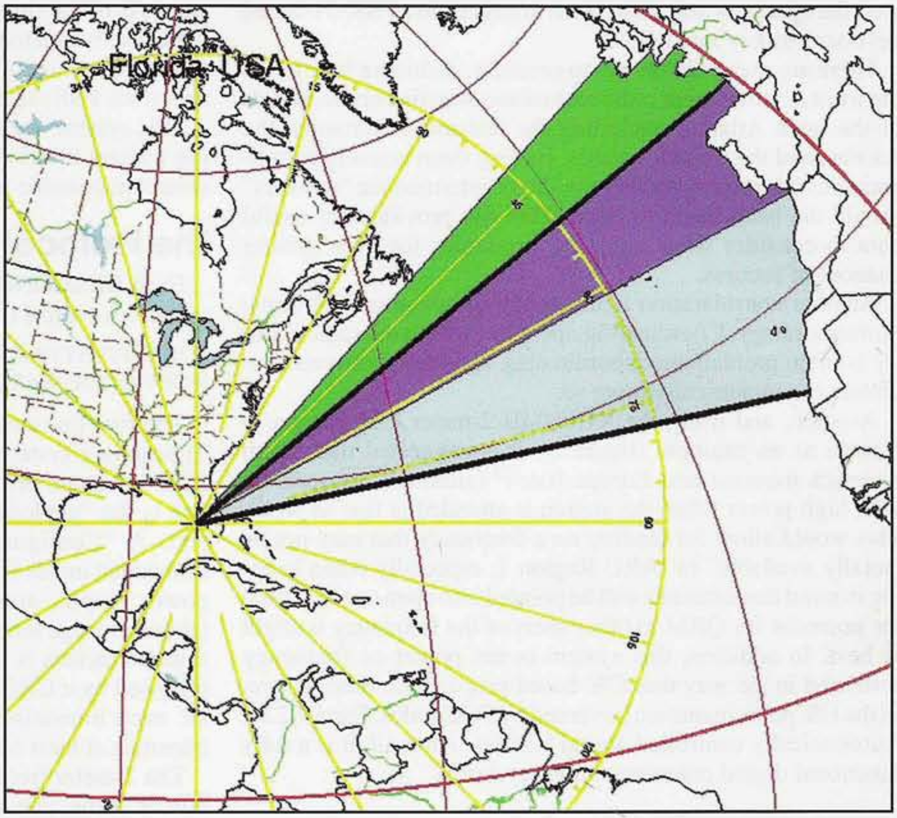

Figure 3. Potential unexplored 2-meter propagation path between the southern US and Europe and northern Africa.

The area shown in blue (both shades) is the area encompassed by the same bearings that have been successful on the KH6 path. Dark blue is the part of that path in which Europe lies specifically. Light blue is a path to Africa. The green wedge is an additional, non-obstructed path to more of Europe, but that would be farther north of any previously successful path from KH6 to the mainland.

This graphic is not intended to discount paths that are farther north, such as those which include the Canadian Maritime Provinces. It simply is meant to allow potential participants to think in new and possibly previously unconsidered ways.

Moving Forward

Interest is building, and participants are starting to assemble stations for this history-making attempt to span the Atlantic Ocean. As for my part, it is that of admiring from afar. I live on the wrong side of the Appalachian Mountains, in the lowlands of Lake Ontario. Others along the North American ocean coastline are destined to enjoy the fame of attaining this "impossible dream." If you are one of those people, then we welcome your participation. Even if you are not located on the ocean, participation as far inland as the high peaks of the Appalachians should be possible. Join in!

Visit the BEACONet website at <http://go.to/BEACONet> to download the free software and set-up instructions for this project. While you are there, be sure to subscribe to the e-mail remailer so that you can stay in contact with other BEACONet enthusiasts as we all work to contact our "Bonnie" who "lies over the ocean" using all-amateur terrestrial means. History will be made. Will your callsign be written along with it?

Footnotes

1. APRS is a trademark of Bob Bruninga, WB4APR.

2. Although this system uses APRS software, it should not be confused with the APRS service. By definition, the APRS service protocols are quite incompatible with this application.

3. BEACONet and its variants are copyright Ev Tupis, W2EV. Unauthorized use is prohibited. ■

The Handie-Talkie Saver Diode and Battery Module

Technical Correspondent Arnie Coro, CO2KK, will be a regular writer for *CQ VHF*. Elsewhere in this issue is an in-depth interview with Arnie by Rich Moseson, W2VU, *CQ VHF*'s Editorial Director. Here Arnie discusses safely recharging one's HT via a car battery.

By Arnie Coro,* CO2KK

The 2-meter band handie-talkie and its newer brother, the dual-band 2-meter 70-cm version, are unquestionably the world's most popular amateur radio equipment. Battery operation of the handhelds provides unique possibilities for handling emergencies, but sometimes—many times, actually—the battery's energy supply comes to an end at the worst possible moment (Mr. Murphy at work, you know!).

This shortcoming is why it is always a good idea to keep in the HT pouch a cable that allows one to pick up power from the car or any other 12-volt source that might be found. Such a power cable must be provided with the appropriate type of connector for the HT, and it is a essential to add a series polarity protection diode, even though you are going to lose around 700 mV, because of the diode's forward voltage drop! The series diode protection will prevent the opposite polarity voltage from reaching the HT and damaging the radio when you need it most.

If you are a perfectionist, then use a Schottky low-forward-drop series diode. Whatever the type of diode, silicon or Schottky, remember to use a diode of the adequate current rating, as the newer handhelds sometimes are very powerful and will take a lot of current.

Keep in mind that not all handie-talkies operate on 12 volts, so your power cable must include a voltage regulator if your radio uses 9.6, 7.2, or any other voltage that is not 12 volts. Also, note that if you take the power from the car when the engine is running, the voltage may soar to as high as 16 volts, so it is a good idea to include a typical three-legged regulator to keep your radio from been fried by too much voltage.

Typical handhelds also can be equipped with *internal* added polarity-reversal protection, which is something easy to implement if you are familiar with modern electronics. The polarity-reversal protection diode can be fitted *inside* the HT, something that will bring peace of mind, as you are then sure that the radio will never accept the wrong polarity.

Even in the case where your power cable has a *silicon* series protection diode and the handheld has *another* similar diode included, your voltage drop would be around 1.4 volts, something that will barely reduce the output power on transmit and have absolutely no effect on receive.

The worst possible scenario of 1.4 volts forward voltage drop will also have a certain advantage during an emergency, as the output-power transistor of the HT will run cooler when you really need it to provide maximum reliability.

"Keeping the module in your car's glove compartment or in the handheld's transport pouch will ensure that you are ready for emergencies without worrying about damaging your HT by powering it with the wrong polarity."

A Better Way of Doing It

One nice way of providing emergency power to your HT from external automobile or gel-cell batteries is to do some careful surgery on an old battery, and carefully place inside it the polarity-reversal protection diode and a variable voltage regulator that you can set at your convenience *(Be very, very careful when dealing with lead-acid batteries.)*. The power-up cable exits the battery case at a convenient point and ends in a pair of good-quality crocodile clips or a car cigarette-lighter power pick-up connector.

It is also a good idea to add an LED power-up indicator, and even one of those nice little ICs that tell you by a flashing LED when the voltage is lower or higher than certain preset limits.

Keeping the module in your car's glove compartment or in the handheld's transport pouch will ensure that you are ready for emergencies without worrying about damaging your HT by powering it with the wrong polarity. Also, please remember the environmental regulations regarding the disposal of the old nickel-cadmium cells that you remove from the battery case.

This easy-to-implement emergency-power pick-up module will be a nice weekend project, and one you can make part of your ham radio club's next meeting. ■

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A Computerized Analysis of VHF-and-Above, Free-Space Radio-Wave Propagation

Have you ever wondered how you made contact with a distant station, only to be stifled in your investigation by the lack of the proper computer software? John Magliacane, KD2BD, analyzes the use of the SPLAT! software and its ability to realistically predict paths of communications between differing free-space operating points.

By John A. Magliacane,* KD2BD

There's an old adage in radio that when it comes to antennas "Height is Might." This is particularly true on VHF and higher frequencies. Just what effect does antenna height have on communication range? How high is high enough? Is location as important as height? How do obstructions and their distance from a receiver or from a transmitter site affect their significance in attenuating RF signals? To answer these questions, let's examine the basics of RF propagation and analyze the effect of the Earth's shape on RF-energy propagation to determine the role antenna height and location have on path loss and communication reliability.

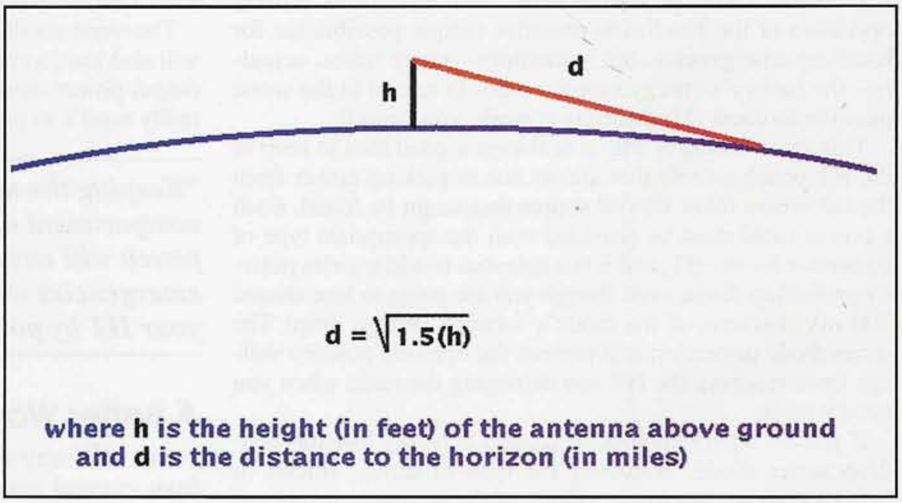

Figure 1. A straight-line tangent to the Earth's surface defines the maximum possible line-of-sight distance to the horizon across a smooth Earth surface.

RF-Signal Propagation

As radio experimenters, we have learned over the years that there is a wide variety of means by which RF may propagate energy in free space between a transmitter and receiver. Propagation may occur along the surface of the Earth through the atmosphere, or by reflection, or by scattering from natural or artificial reflectors.

Radio handbooks of decades past concluded that contrary to HF, communication on VHF and higher frequencies was limited strictly to line-of-sight distances only. We have discovered through population of these frequencies that this statement is not entirely true. In fact, it is not uncommon to communicate over hundreds of miles on 2 meters and shorter wavelengths using CW or SSB with roof-mounted Yagi antennas and less than 100 watts of transmitter power.

Under such conditions, each station is situated well below the other's horizon. Communication takes place through a variety of mechanisms such as diffraction, refraction, and scatter, rather than a direct line-of-sight path. Over-the-horizon communication on VHF and higher frequencies is certainly possible, especially when using narrow-bandwidth emissions and sensitive, low-noise receivers.

We have also discovered that propagation over such paths can be very lossy and highly variable. As a consequence, it is difficult to predict the signal-to-noise ratio that can be achieved at a given distance from a transmitter radiating a known amount of RF energy over an obstructed path. While generally unimportant to amateurs making casual radio contacts over arbitrary distances, such data is crucial when designing wide-area wireless networks or point-to-point radio links.

Even worse is that the path loss between the transmitter and receiver changes almost constantly over lossy paths because of varying weather condi-

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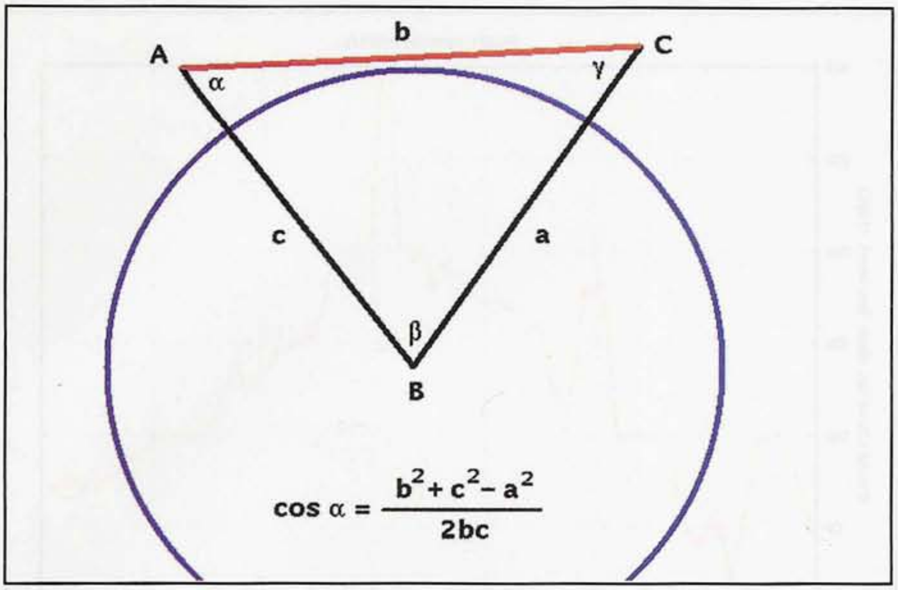

Figure 2. The Law of Cosines can be used to describe the elevation angles associated with antenna structures based on their height and separation.

tions and other factors such as reflections from aircraft in flight. Features such as buildings and terrain also play a role, since they often produce reflections and introduce multipath distortion, which serves to reduce the quality and impair the effectiveness of wide-bandwidth modes such as high-speed data and video communications over long distances.

Therefore, it makes sense that when reliability, quality, and efficiency are primary goals in designing a communication system, a situation that provides a geometric line-of-sight path between transmitter and receiver, while introducing the least number of uncontrollable variables, yields the optimum condition under which communication can take place on the VHF and higher frequencies.

A Smooth Earth Model

If the Earth were perfectly smooth, determining the minimum height requirements to obtain a line-of-sight path between a transmitter and receiver location would be a simple matter. As illustrated in figure 1, given that the Earth has a mean radius of approximately 3959 miles, the distance, *d*, in miles from a given point of elevation, *h*, to the horizon is approximately equal to the square root of 1.5 times the height of the antenna in feet.

For example, an antenna 30 feet in height will cover a radius of approximately 6.7 miles from the transmitter, assuming a receiver at ground level. A receiver having an antenna 30 feet above ground will realize an above-the-horizon, line-of-sight path to the 30-foot high transmitter out to a maximum distance of 13.4 miles. This distance is simply the sum of the transmitter radius (6.7 miles) and the receiver radius (6.7 miles), given their respective antenna heights.

It is interesting to note that if a transmitter needs coverage to the horizon out to the distance equal to the radius of the transmitter and receiver combined in this case (13.4 miles), it would require an antenna height of 120 feet. In other words, doubling the maximum line-of-sight distance an antenna will cover requires a four-fold increase in antenna height. This outcome is because the line-of-sight distance is a function of the square root of antenna height. An added consequence of this relation is that the rate at which the coverage area of a transmitter or receiver builds with increasing antenna height diminishes as the antenna is raised higher and higher above ground level.

The equation previously described performs well over a hypothetical smooth Earth, such as over the open water, provided there are no land masses along the path. Communication beyond those predicted through this simple Earth model is possible through atmospheric refraction.

In some cases, a hypothetical Earth model having a radius of four thirds that of the Earth's true radius is used to predict the maximum communication distance possible through refraction. This is sometimes referred to as a radio line-of-sight path. Such paths generally are less reliable than those based on a geometric line-of-sight path because the radio line-of-sight path is dependent upon the refractive index of the atmosphere, which is not constant and cannot be defined with any degree of confidence.

A Rough Earth Model

As we all are aware, the Earth is far from smooth. The hills and valleys that constitute much of the Earth's land make the issue of predicting line-of-sight distances and coverage areas more complicated than previously described.

In reality, it is not only necessary to determine whether antenna heights are

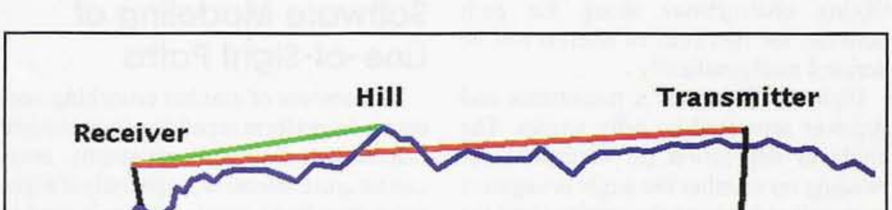

Figure 3. Obstructions can be identified by calculating elevation angles among the transmitter, the receiver, and the terrain separating them.

sufficient to span the distances involved, it is also necessary to determine whether obstructions because of terrain exist anywhere along the path between the transmitter and receiver locations. If obstructions exist, it often is useful to determine what antenna heights must be employed to achieve adequate clearance above the obstructions to ensure that a desirable line-of-path between the two points of interest can be established.

The first step in solving this problem is to look at the geometry among the transmitting antenna, receiving antenna, and the Earth in more general terms than those discussed earlier. Figure 2 illustrates an example of how the Law of Cosines can be used to model a point-to-point communication link along the Earth's surface. Triangle ABC is formed among the transmitter, the receiver, and the center of the Earth.

The line between the center of the Earth (point B) and point A form side C of the triangle. The line between the Earth's center and point C form side A of the triangle. The great-circle path along the surface of the Earth between point A and point C forms side B. If the lengths of all three sides are known, then the interior angles of the triangle can be determined using the Law of Cosines (see figure 2).

Of particular importance are angles alpha (α) and gamma (γ), since they determine the elevation or depression angles between a normal (right angle) to the center of the Earth and the remote antenna locations. If these angles can be determined, then the conditions for identifying obstructions along the path between the two sites of interest can be defined mathematically .

Figure 3 illustrates a transmitter and receiver separated by hilly terrain. The angle of depression (or elevation, depending on whether the angle is negative or positive) between the receiver and the transmitter can be determined by knowing the length of each side of the triangle as demonstrated earlier in figure 2. In this example, side c is the sum of the Earth's radius, the terrain's altitude above mean sea level, and the height of the receiving antenna above ground level. Side a is the sum of the Earth's radius, the terrain's altitude above mean sea level, and the height of the transmitting antenna above ground level. Side c, as indicated in figure 2, is the great-circle distance between the transmitting and receiving locations. By knowing the latitude and longitude of both antenna sites, side c can be calculated.

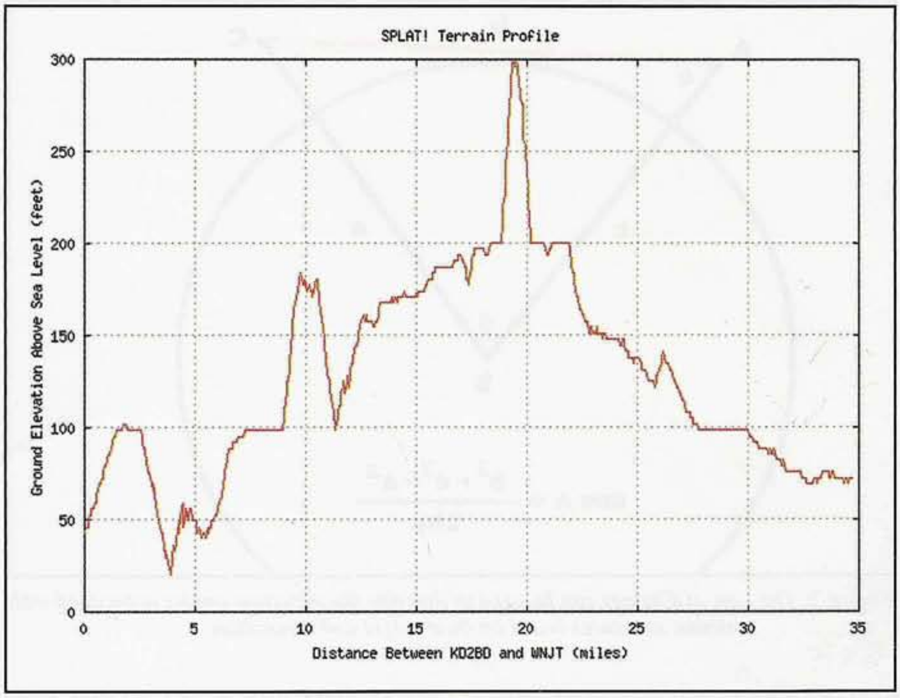

Figure 4. A terrain profile generated through SPLAT! software. Ground elevation data is plotted as a function of distance from the receiver location.

Topology data can be employed to provide a terrain profile between the two sites, making it possible to calculate elevation angles between the receiver and each element of the profile in the direction of the transmitter. If a terrain feature that forms an elevation angle greater than that formed by the transmitter from the perspective of the receiver is identified, then that feature can be identified as an obstruction.

Software Modeling of Line-of-Sight Paths

The amount of number crunching necessary to perform repetitive line-of-sight calculations over wide geographic areas can be quite intensive, especially if high-resolution Earth topology data is used in the process. Fortunately, modern computers perform well in math, and these computers can be put to good use on such tasks fairly easily.

Topology data can be combined with cartographic and other information to produce topographic maps, graphs, and reports useful to communication network designers and site engineers wishing to determine coverage areas of their transmitters and repeater systems. Modern computing makes it possible to determine overlapping areas of coverage within networks of repeaters, estimate minimum antenna height requirements to cover a specific distance given the geographic locations of the sites involved, and select appropriate radiation patterns for the antennas used at each site, depending upon the coverage desired.

There are a number of software applications that can be utilized to determine geometric and radio line-of-sight paths between points of interest based on a knowledge of the Earth's terrain. Some applications are low cost, while others are expensive. Some are proprietary, while others follow an open-source philosophy. Some applications appear to be designed with more concern for exciting the user with colorful features, icons, and dialog boxes than for producing accurate, meaningful results over useful distances.

One effort to overcome the issues of cost, accuracy, and fluff is an open-source terrain analysis software application known as SPLAT!, an acronym for Surface Path Length And Terrain. Being licensed under the GNU General Public License, SPLAT!'s source code is neither hidden nor proprietary, but rather freely available and open to active and continuous peer review. Anyone wishing to contribute bug fixes or new features to SPLAT is free to do so, provided that the program and any derivative works remain non-proprietary and freely available.

SPLAT! analysis software was writ-

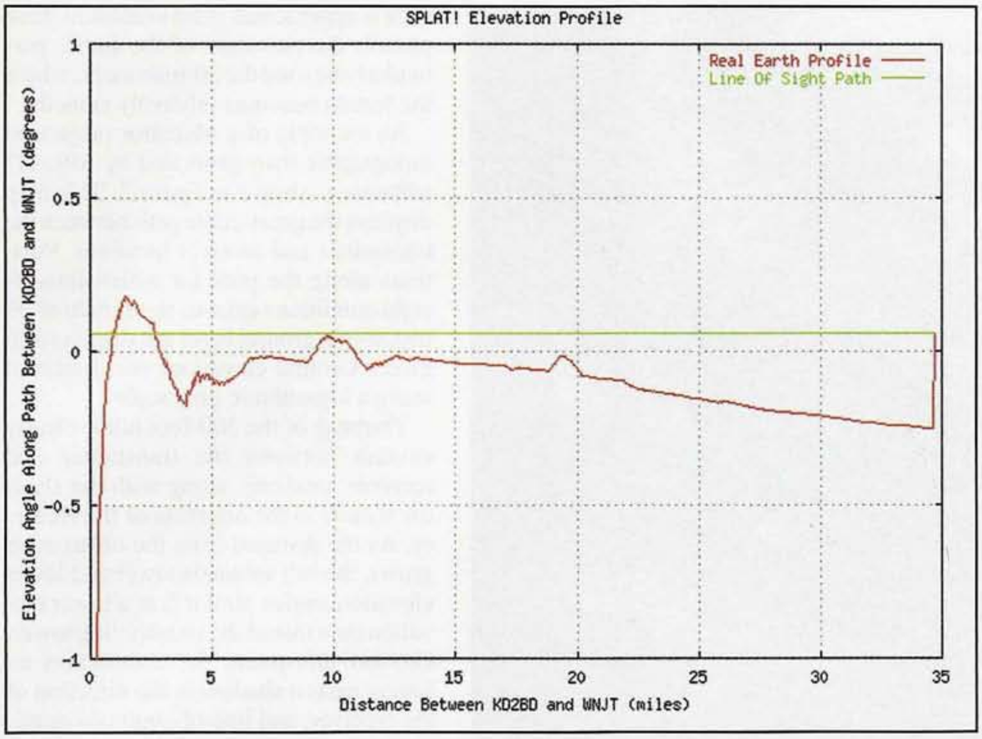

Figure 5. An elevation profile generated through SPLAT! software. Elevation angles from the perspective of the receiver location are plotted as a function of distance from the receiver.

ten and developed under the Linux operating system. It was originally created in 1997 for performing site analysis. Portable and modular coding have since allowed SPLAT! to develop into a powerful tool with many more general-use features than those originally conceived. Its recent entry into the world of Linux-based open-source software is sure to continue this trend even further.

Computer-Aided Path Analysis

Terrain-analysis software such as SPLAT! can assist us in better understanding the effects of terrain on line-of-sight communication paths. For example, figure 4 illustrates the terrain profile over a nearly 35-mile distance between a receiver (KD2BD) and a UHF television station (WNJT). The transmitting antenna at WNJT is located 990 feet above ground level and 1062 feet above mean sea level. The receiving antenna at KD2BD is located 30 feet above ground level and 72 feet above mean sea level.

Under these conditions, even with the extreme height of the transmitting antenna, a clear line-of-sight path between the transmitter and receiver locations does not exist, and a weak signal is the result. SPLAT! recommends raising the receive antenna at least 49 feet above ground level to achieve an unobstructed path to the transmitter.

Figure 4 clearly shows that the largest profile between the receiver and transmitter sites is a hill nearly 300 feet above sea level in the middle of the path. At first glance, one might be inclined to believe that this sudden spike in terrain is responsible for the obstruction detected by SPLAT! at the receive location. Receivers with 30-foot high antennas at the base of the hill just beyond the hill will be in a shadow area. Obviously, raising the antenna even to 200 feet at these locations will not be of much help in clearing the 300-foot obstruction. Is the 300-foot hill responsible for producing a shadow that extends nearly 20 miles to the receive site?

Further investigation shows that the 300-foot hill does not play any role whatsoever in obstructing the path between the transmitter and receiver in this example. In fact, SPLAT! identified a total of eight terrain features that are responsible for obstructing the line-of-sight path between WNJT

Figure 6. Raising the antenna to 50 feet above ground level clears the local obstructions, setting up a line-of-sight path to the transmitter.

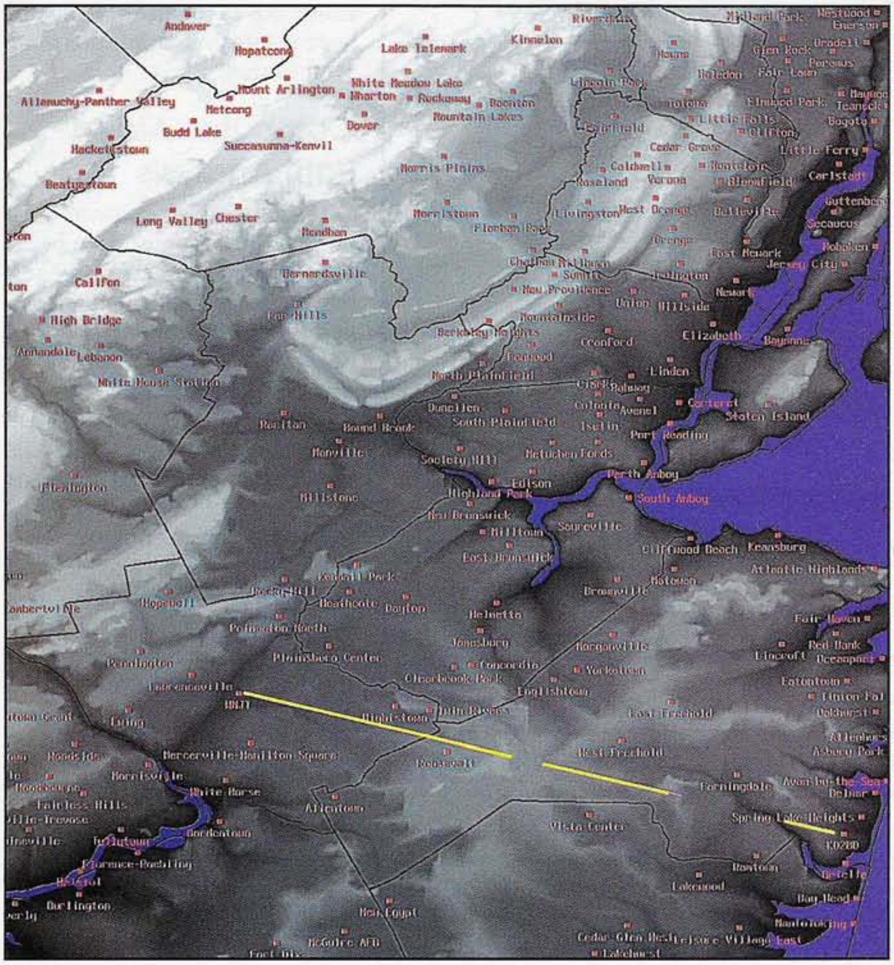

Figure 7. A topographic map generated by SPLAT! displaying the line-of-sight path between transmitter and receiver locations. Notice how the higher terrain features cast shadows along the path between the two sites.

and KD2BD. All the obstructions identified are located within two miles of the receiver location.

Figure 5 illustrates the same path as that shown in figure 4, but now elevation and depression angles from the perspective of the receive site are plotted as a function of distance from the receiver. The tall spike at the far right is WNJT's 990-foot transmitting tower. The green line that extends across the graph to the top of the tower represents the elevation angle required for a straight line-of-sight path from the receiver to the transmitter. SPLAT! reports this angle to be +0.0587 degrees.

Observe that the terrain within the first few miles of the receiver location forms much greater elevation angles than that required to reach the transmitter. As such, the terrain close to the receiver serves as an obstacle to the line-of-sight path. Reception at 30 feet, therefore, is through refraction, diffraction, and scatter around local terrain, and it is quite weak and variable as a result. The 300-foot hill, visible about 18 miles from the receiver, turns out to be one of the most insignificant features of the entire profile as a result of its distance from the receiver. By contrast, terrain that is only slightly higher than the receive antenna serves as a considerable obstruction when located in close proximity to the receiving location.

Figure 6 demonstrates how raising the receive antenna to a height of 50 feet above ground level clears the nearby obstructions, thus providing a straight, unobstructed line-of-sight path to the transmitter. Observe how the obstructions in close proximity to the receiver change apparent shape as compared to those illustrated in figure 5. This undoubtedly affects the level of RF received by means of diffraction off the top and sides of the obstruction as the receive antenna is raised and the point of clearance is approached. Also evident in these plots is the curvature of the Earth, particularly beyond the 20-mile mark, where the terrain becomes relatively smooth.

An example of a Mercator projection topographic map generated by SPLAT! software is shown in figure 7. This map displays the great-circle path between the transmitter and receiver locations. Positions along the path for which line-of-sight conditions exist to an altitude of 30 feet above ground level are displayed in green. Ground elevations are displayed using a logarithmic gray scale.

The peak of the 300-foot hill is clearly evident between the transmitter and receiver locations, along with the shadow it casts in the direction of the receiver. As the distance from the obstruction grows, the hill subtends lower and lower elevation angles until it is at a lower elevation than that of the transmitting tower. Beyond this point, the obstruction no longer casts a shadow in the direction of the receiver, and line-of-sight communication is once again possible.

One of the most important lessons we can learn from these examples is that antenna height is very important to line-of-sight communication paths, but location is equally important. A site close to a transmitter but in the shadow of a nearby obstruction may receive a much weaker signal than a site farther away that is beyond the shadow of the same obstruction, ground elevation and antenna height notwithstanding. Ironically, the most significant obstructions are those generally closest to, and higher than, the site in question.

Analyzing a Repeater's Coverage Area

When we try to picture the service area of a transmitter or repeater, we generally think in terms of the radiation pattern of the antenna used at the transmitter or repeater site. If an omnidirectional antenna is used, a circular coverage area perfectly centered about the transmitter or repeater site quickly comes to mind. However, such an idealistic view of radiation pattern and service area realistically can only occur over open water, where hills and valleys do not exist. Over land, the situation is much more complicated. As we will see, the effects of terrain can produce quite surprising and unexpected results.

An example of a Mercator projection, line-of-sight coverage map generated by SPLAT! software is shown in figure 8. In this figure, the coverage of a repeater utilizing an antenna atop a 350-foot tower is shown. The area of coverage is in green and is based on a receiver having an antenna 30 feet above ground level.

Note that although an omnidirectional antenna is used at the repeater and assumed by SPLAT!, the coverage is anything but omnidirectional. Some locations in close proximity to the repeater are in shadow areas because of nearby hills to the north of the repeater site, whereas locations in other directions are better served, despite their greater distances from the repeater.

Coverage over the water is excellent and extends clearly out to the horizon because of the absence of terrain over the ocean. The noticeable bulge in coverage out to the east is not an effect of terrain, but rather is the result of the map being linear in terms of geographic bearings, rather than surface distance.

The map shown in figure 8 covers a two-degree latitude by two-degree longitude region of Earth. With a resolution of 3 arc seconds, it contains a total of 5,760,000 discrete points of elevation. The recursive calculations required to analyze this region and generate a line-of-sight coverage map of this magnitude take about an hour using a 100-MHz Pentium processor, or about 8 minutes using a 750-MHz Pentium III.

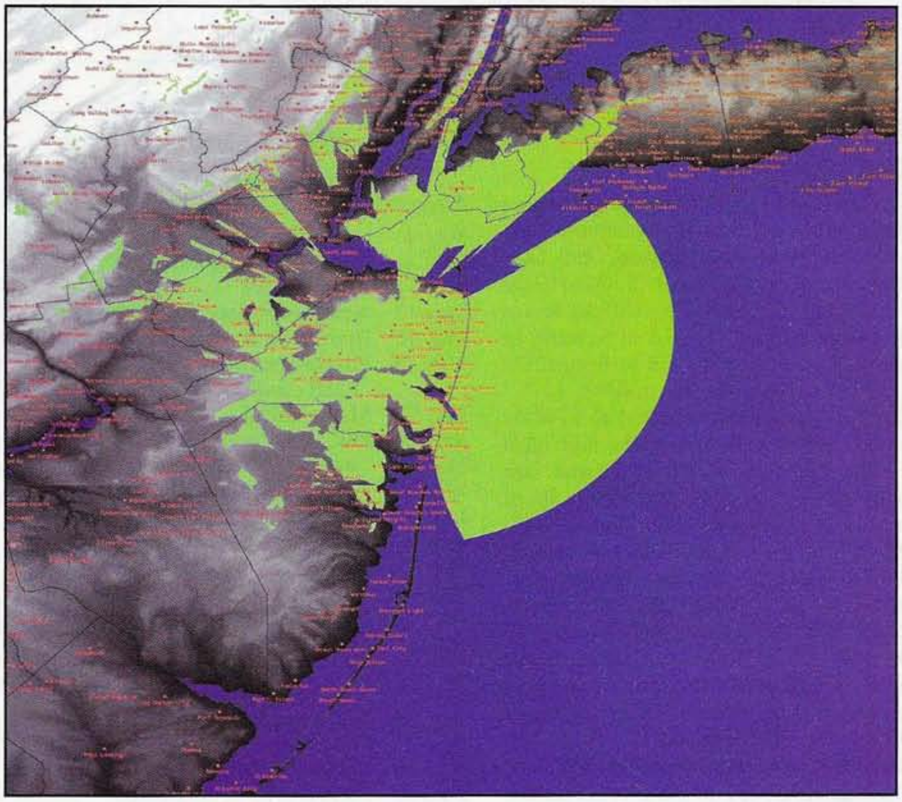

Figure 8. A line-of-sight coverage map for an omnidirectional repeater system generated by SPLAT! Notice how profoundly the terrain affects the shape of service area of the repeater.

Closing Thoughts

Before leaving this subject, it should be pointed out that while geometric line-of-sight paths are highly desirable in providing reliable and predictable communication at VHF and higher frequencies, they are not always 100 percent reliable. The reason for this occasional unreliability is that even if an unobstructed path exists between a transmitter and receiver, the path involves propagation through a section of atmosphere that possesses a refractive index different from that which one would expect in a vacuum. The longer the path, the more variable the refractive index is likely to be.

Certain weather conditions may result in superrefraction or ducting of radio signals, resulting in a sharp increase in signal strength to levels above what may be predicted for free space. Subrefraction may occur, in which case radio signals may be bent toward the Earth into obstructions, resulting in a sharp reduction in signal strength at a distant location despite the geometric line-of-sight conditions. Because of this degradation of signal strength, it is sometimes helpful to employ frequency, height, and polarization diversity in the design of communication systems in an effort to circumvent these variables.

It should also be mentioned that a line-of-sight condition along the surface of the Earth does not necessarily guarantee signal strengths comparable to those of free space, nor those predicted through the inverse square law. Ground reflections, man-made obstructions, Fresnel zone clearances, and vegetation, aside from atmospheric refraction, can reduce expected signal levels over line-of-sight paths to those more closely predicted through an inverse fourth relationship, rather than the inverse square law. (See "References" for more on these additional factors.)

Conclusion

In conclusion, radio propagation over geometric line-of-sight paths on VHF and higher frequencies is not 100 percent predictable, but it is far more reliable than over obstructed paths. Antenna location, as well as height, is crucial in planning a transmitter, repeater, or remote-receiver site. Modern terrain analysis software can be used for site engineering and for helping to visualize the effects of terrain and antenna height on site performance.

Finally, while enough signal-propagation variability exists on VHF and higher frequencies to make DXing exciting and challenging, these frequencies also represent an excellent arena for engineering highly dependable communication networks for the times and situations in which such dependability is needed.

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"Predicting Radio Horizons at VHF," Billy Walker, W5GFE, *QST*, June 1978.

"Predicting the Coverage of a Repeater," Louis L. Taylor, W5MKG, *QST*, December 1977.

The SPLAT! software website: <http://www.qsl.net/kd2bd/splat.html>. ■

QUARTERLY CALENDAR OF EVENTS

Conventions and Conferences

Dayton Hamvention®: As always, expect a great time at the Dayton Hamvention®, May 17–19, at the Hara Arena, Dayton, Ohio. Digital forums will be held from 8:15 AM to 12:30 PM on Friday in Room 1. The AMSAT forum will be from 8:15 to 9:45 AM on Saturday in Room 1. The ATV forum will be from 12:30 to 2:30 PM on Saturday also in Room 1.

The VHF forum will be from 1 to 4 PM on Saturday in Room 2. Among the highlights are: 1 PM—Tri-State Search and Rescue, Bob Spratt, N8TVU; 1:30 PM—WSJT High Speed Communications Software, Joe Taylor, K1JT; 2 PM—Cheap Yagis, Kent Britain, WA5VJB; 2:30 PM—UK Microwave Group, Sam Jewell, G4DDK; 3 PM—1296 EME, Avoiding the Pitfalls, Bruce Clark, KØYW; and 3:30 PM—The K8GP Contest Station, Owen Nelson, W6LEW. During the convention there will also be plenty of other forums of interest to the VHF+ operator.

Dayton Weak Signal Banquet 2002: The Weak Signal Group, which meets Monday nights at 0200 UTC on 3.843 MHz, would like to invite everyone coming to the Dayton Hamvention® to their 10th annual banquet. They have reserved a room that will seat 125 for Friday night, May 17, from 6–11 PM, at the Holiday Inn North, Waggoner Ford Rd. exit off I-75. It is likely that the banquet is sold out by now, but if you need more information, contact Tom Whitted, WA8WZG, at <wa8wzg@wa8wzg.com>. This is one of the largest gatherings of VHF weak-signal enthusiasts in the U.S.

CSVHFS 2002 Conference: The Central States VHF Society's Annual Conference will be held July 26–28 at the Sheraton Four Points near the airport in Milwaukee, Wisconsin. This year's conference is hosted by the Badger Contesters, the Wisconsin and northern Illinois VHF/UHF weak-signal group. They are working hard to create a conference rich with interesting presentations, fun activities, and great fellowship. More information may be found at the society's website: <http://www.csvhfs.org>.

Contests

Spring Sprints: The East Tennessee DX Association will again be sponsoring the Spring Sprints. Following are the dates and times for the two contests in May. The Microwave Sprint will be on Saturday, May 4, from 6 AM until 1 PM local time. This includes all amateur frequencies above 903 MHz. Please include band data in summaries and logs. *Note:* Use of the Liaison Frequency is encouraged. The 50 MHz Sprint will be from 2300 UTC Saturday until 0300 UTC Sunday (May 11–12). Logs for both contests should be e-mailed to: <springsprints@etdxa.org>. Paper logs go to: ETDXA, Jeff J. Baker, KG4ENR, 8218 Foxworth Trail, Powell, TN 37849. Complete rules may be found at <http://www.etdxa.org>.

VHF+ Calendar

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

May 4	Last quarter Moon
May 5	Poor EME conditions
May 7	Moon apogee
May 12	New Moon; poor EME conditions
May 16	Highest Moon declination
May 19	First quarter Moon; very good EME conditions
May 23	Moon perigee
May 26	Full Moon; poor EME conditions
May 29	Lowest Moon declination
June 2	Moderate EME conditions
June 3	Last quarter Moon
June 4	Moon apogee.
June 9	Poor EME conditions
June 10	New Moon
June 12	Highest Moon declination
June 16	Very good EME conditions
June 18	First quarter Moon
June 19	Moon perigee
June 23	Very poor EME conditions
June 24	Full Moon
June 25	Lowest Moon declination
June 30	Moderate EME conditions
July 1	Moon apogee
July 2	Last quarter Moon
July 7	Poor EME conditions
July 9	Highest Moon declination
July 10	New Moon
July 13	Moon perigee
July14	Very good EME conditions
July 17	First quarter Moon
July 21	Very poor EME conditions
July 22	Lowest Moon declination
July 24	Full Moon
July 28	Moderate EME conditions
July 29	Moon apogee

**EME conditions courtesy W5LUU.*

ARRL June VHF QSO Party: The dates for this contest are June 8–10. Complete rules are in the May issue of *QST*. Rules may also be found on the ARRL website <http://www.arrl.org>. Many are making plans to activate rare grids. For the latest information on grid expeditions, check the VHF reflector <vhf@w6yx.stanford.edu> on the internet. This is by far the most popular VHF contest. For weeks prior to the contest, postings are made on the VHF reflector announcing rover operations and grid expeditions. It is a contest that will give plenty of opportunities to introduce the hobby to those who are not presently working the VHF+ bands or who are not amateur radio operators.

SMIRK Contest: The SMIRK 2002 QSO Party, sponsored by the Six Meter International Radio Klub, will be held from 0000 UTC June 15 to 2400 UTC June 16. This is a 6-meter-only contest. All phone contacts within the lower 48 states and Canada must be made above 50.150 MHz; only DX QSOs may be made between 50.100 and 50.150 MHz. Exchange SMIRK number and grid square. Score 2 points per QSO with SMIRK members, and 1 point per QSO with nonmembers. Multiply points times grid squares for final score. Awards will be given to the top scorer in each ARRL section and country. Send a legal-size SASE for a copy of the log forms. Log-sheet requests and log entries (postmarked by August 1) should be sent to Pat Rose, W5OZI, P.O. Box 393, Junction, TX 76849-0393. For more information see the SMIRK URL at <http://www.smirk.org>.

Field Day: The ARRL's classic, Field Day, will be held on June 22–23. Complete rules for this contest may be found in *QST* and on the website <http://www.arrl.org>. Gone this year from the rules is the Novice-Technician separate station category. In place of it is a new Get On The Air (GOTA) category that is to be operated by Novices, Technicians, generally inactive hams, and non-licensees under the direct supervision of a control operator. In years past tremendous European openings have occurred on 6 meters. Also, as happened in 1998, tremendous sporadic-*E* openings may occur. Certainly, this is one of the best club-related events to get new people involved in the hobby.

***CQ* VHF Contest**: The rules for this *CQ* magazine sponsored contest to be held on July 20–21 are on page 57 in this issue.

Meteor Showers

The following is a list of showers known to be active during the months of May through July. The *eta-Aquarids* peaks on May 5 at 0530 UTC, with a Zenith Hourly Rate (ZHR) of approximately 30. The *June Lyrids* peaks on June 16 with an unknown time and ZHR. The *Pegasids* peaks on July 9 with an unknown time and a low ZHR. The *July Phoenicids* is a Southern Hemisphere shower that peaks on July 13 with an unknown time and a low ZHR; the International Meteor Organization reports that this shower is a better radio shower than visual shower. Toward the end of the month of July you should start seeing increased meteor-scatter activity caused by the *Perseids*, which peaks on August 12–13. The summer issue of *CQ VHF* will contain more extensive coverage of this shower.

Advertisers' Index

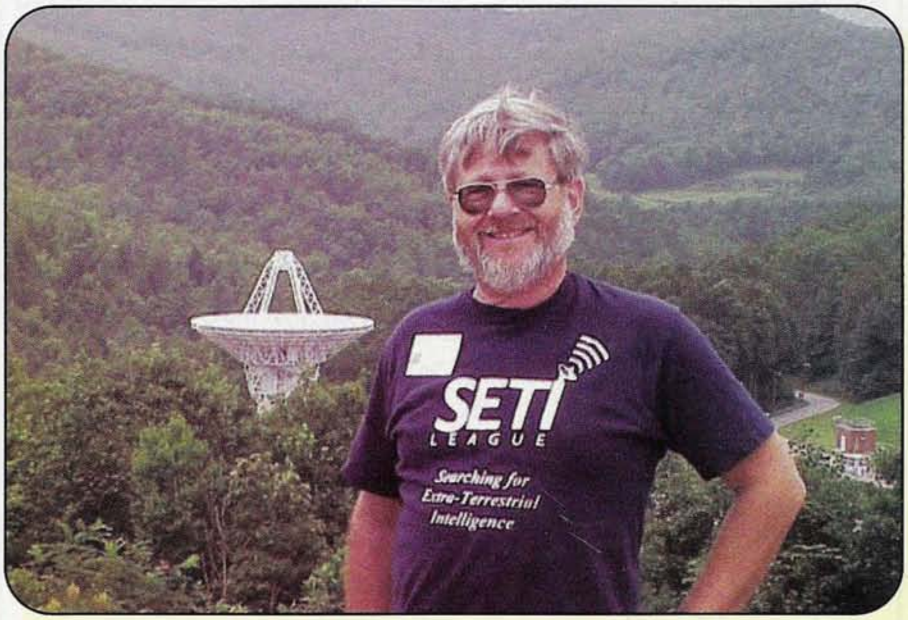
Reach this dynamic audience with your advertising message, contact Arnie Sposato at 516-681-2922, FAX 516-681-2926, or e-mail: arnie@cq-amateur-radio.com.

By Dr. H. Paul Shuch,* N6TX

DR. SETI'S STARSHIP

Searching For The Ultimate DX

Star Voyager



The author seen with one of the twin 26-meter dishes at the Pisgah Astronomical Research Institute (PARI) in North Carolina, the world's largest private radio observatory, which is run entirely by radio amateurs. (SETI League photo)

You are a star voyager. You share your starship Earth with six thousand million other human passengers as you hurtle across space and time at 86,400 seconds per day, the Speed of Life. Your ship is adrift in a vast ocean of four hundred thousand million stars, which we call the Milky Way. How can you look out at those other suns and not wonder about the creatures inhabiting their starship planets? The question "Are We Alone?" is as old as our species, yet it is only within an eye blink of human history that we have begun to develop technology to seek a meaningful answer.

Welcome to "Dr. SETI's Starship," a column about the quest for our cosmic companions. I am H. Paul Shuch, N6TX, Executive Director of the international SETI (Search for Extra-Terrestrial Intelligence) League, and it is my privilege to lead you on this journey. Please join me in a quest for the ultimate DX. In the months ahead we will explore the scientific and technological breakthroughs which lead us to now envision a universe teeming with life. We will review the early efforts of the SETI discipline, discuss the various searches now underway, grapple with the challenge of recognizing what we see, and speculate on the impact that extra-terrestrial contact may have on our own starship and its future course. First, however, it is necessary to establish a few ground rules.

My personal background is in amateur radio. Through it, I became interested in radio astronomy. I use radio telescopes (sensitive microwave receivers, powerful computers, and elaborate antennas) to sift through the cosmic static in search of patterns which nature cannot produce by any mechanism known to us. This is probably not the only way to search for evidence of other civilizations in the cosmos, but these are the tools available to me. In recent years a number of phenomena (reported sightings, abductions, the Roswell incident, crop circles, Area 51, etc.) have defied explanation. These matters are certainly interesting, and may be worthy of further study by qualified experts. We in the SETI community are primarily radio astronomers, though, arguably qualified to recover and analyze microwave signals. Beyond that we claim no particular expertise. We will continue to concentrate on what we know best, and encourage others to do the same.

CQ VHF enjoys a worldwide readership. If you've read this far, you have doubtless determined that my urbane, cosmopolitan manner notwithstanding, I am unmistakably a Yank. Despite our honorable editor's best efforts to Anglicize my writing, I write as I speak, in idiomatic American. I beg the indulgence of our non-American readers, who no doubt find my style rather quaint. My point is, we speak languages which at the very least have common roots, which is more than we can expect when we attempt to communicate across the gulf of interstellar space.

The above statement begs the question "How can we ever hope to learn anything useful from a species with which we have absolutely nothing in common?" The optimist in me answers that our cosmic companions, if indeed they exist, share more in common with us than you could possibly imagine. For one thing, we share all natural laws. One lesson astronomy has taught us is that the laws of the universe are pretty much the same Out There as they are Down Here. We may even share a shred of common biology, if the late Sir Fred Hoyle's theories about directed panspermia are correct. That is, life on Earth very well may have been seeded from beyond. Recent fossil evidence found within meteorites which fell on Earth from Mars suggests that life (at least at the microbial level) well may permeate the cosmos. We may have just met our distant ancestors, encased in rock.

If that is the case, then we readily can imagine who that distant DX might be—beings not so unlike ourselves, living in the light of distant suns, looking out toward us across the gulf of space and time, and wondering, "Are We Alone?"

73, Paul, N6TX

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

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