ISSN 1085-0708

CQ VHF

Ham Radio Above 50 MHz

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Spring 2004

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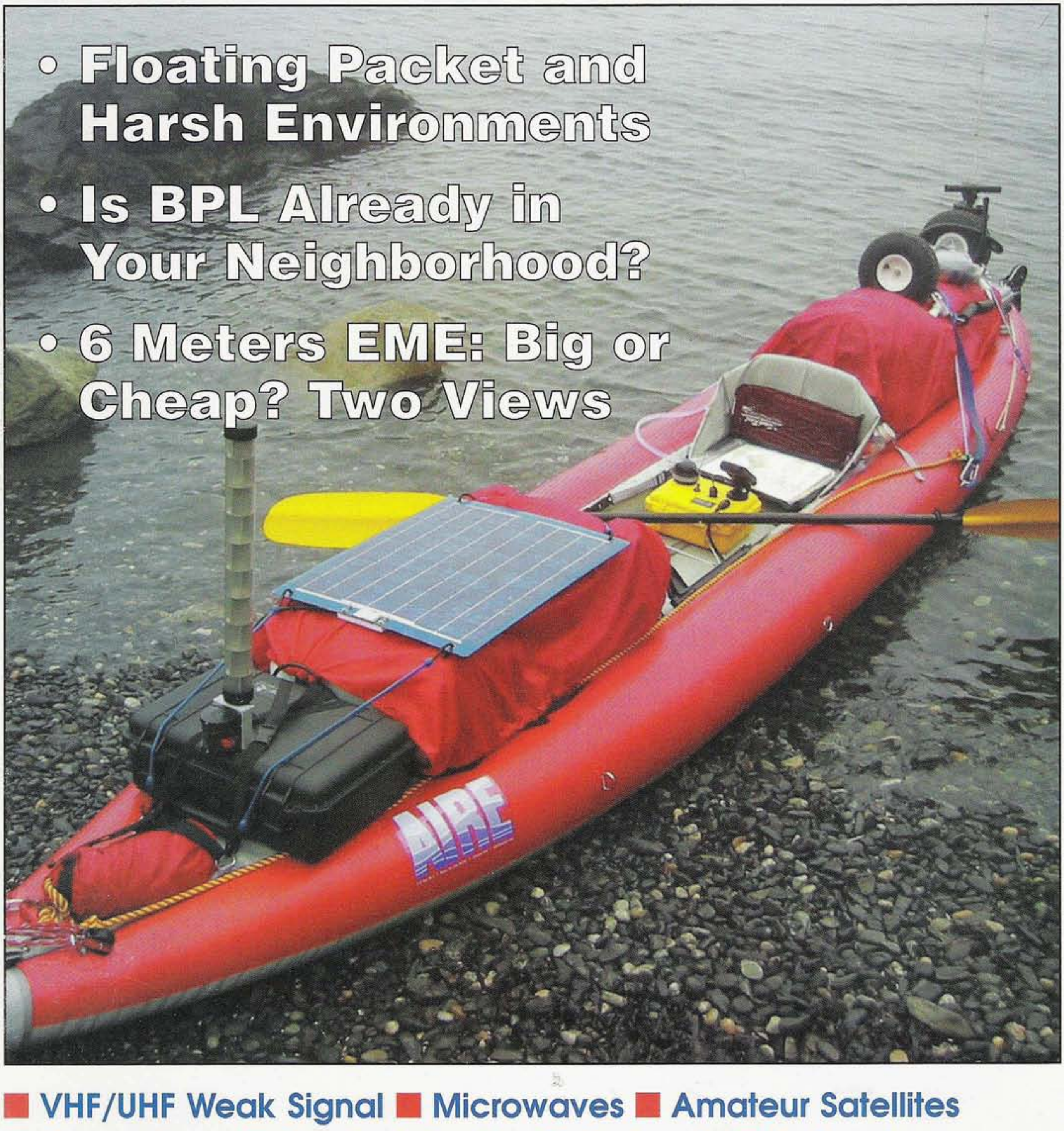
- Is BPL Already in Your Neighborhood?
- 6 Meters EME: Big or Cheap? Two Views



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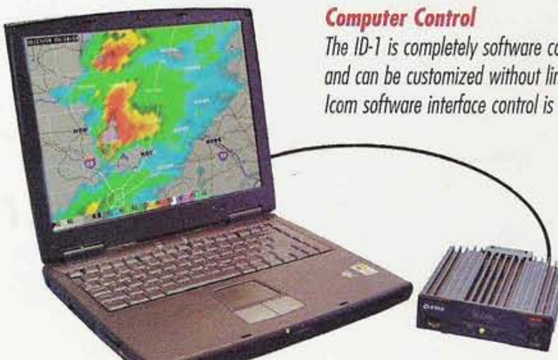

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computer not included

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A publication of

CQ Communications, Inc.
25 Newbridge Road
Hicksville, NY 11801 USA.

Offices: 25 Newbridge Road, Hicksville, New York 11801. Telephone: (516) 681-2922. FAX: (516) 681-2926. E-mail: cq-vhf@cq-vhf.com. Website: http://www.cq-vhf.com. CQ VHF (ISSN 1085-0708) is published quarterly (4 times a year) by CQ Communications, Inc. Periodical postage paid at Hicksville, NY and additional offices. Subscription prices (all in U.S. dollars): Domestic—one year $25.00, two years $45.00, three years 65.00; Canada/Mexico—one year $35.00, two years $65.00, three years 95.00; Foreign—one year $38.00, two years $71.00, three years 104.00. Government Agencies: Subscriptions to CQ VHF are available to agencies of the United States government, including military services, only on a cash with order basis. Requests for quotations, bids, contracts, etc., will be refused and will not be returned or processed. Entire contents copyrighted CQ Communications, Inc. 2004. CQ VHF does not assume responsibility for unsolicited manuscripts. Allow six weeks for change of address.

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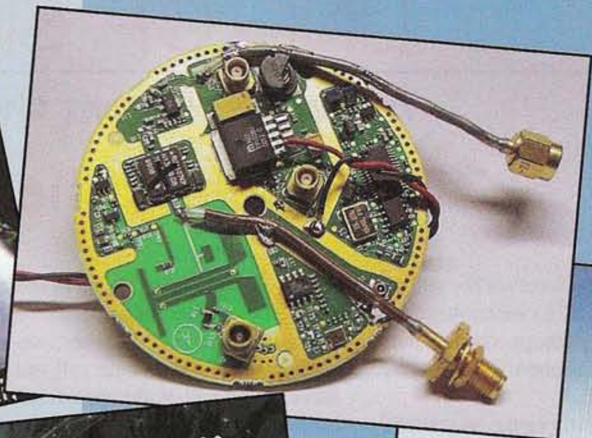

COLUMNS

DEPARTMENTS

CQ VHF Ham Radio Above 50 MHz

LINE OF SIGHT

A Message from the Editor

BPL: Who is the Enemy?

In examining all of the facets of Broadband over Power Lines (BPL) technology and the FCC's NPRM, perhaps a better question to ask is: What is the enemy? My answer is our apathy.

As it always is with any cause, so it is with BPL. A tiny minority of hams is involved in the defense of our frequencies. A principal player in the fight is the ARRL. Devoting hundreds of man hours and its resources, the League is pushing on, chasing down leads to trial sites, writing letters to *Wall Street Journal* columnists, corresponding with mayors and other community leaders about the adverse effects of BPL, and all the while trying to garner support from other interested industry. If it were not for the League, we probably would not even have known of the looming threat to our frequencies. It is ironic, though, that there are some who simply sit on the sidelines and pay their dues to the League and comment, "That's what we pay them to do."

Thankfully, there are volunteers willing to spend their own time and use their own resources to track down test sites and document what they experience. In this issue of *CQ VHF*, "FM" columnist Gary Pearce, KN4AQ, has documented the work of one such group of volunteers. Devoting his space in this issue to the cause, Gary relates what happened when he discovered a test site in his own area. It is fascinating and eye-opening reading.

While Gary's work is really appreciated, there are some who might say that they are unable to do the kind of research and legwork that Gary and his crew were able to carry out. My answer is that there is something each one of us *can* do. You are reading this issue after the deadline for initial comments on the NPRM has passed. However, the reply deadline is not until June 2. You still have time to write a reply comment responding to the comments that already have been posted.

No doubt there will be postings from utility company interests that state that their tests have indicated that the predicted interference issues have not proved out. As one's reading of Gary's article will indicate, in his case, the tests were conducted in an ideal setting, using underground utilities, and in a neighborhood where there is very little likelihood of ham radio operators living there due to antenna restrictions in the neighborhood's covenants. In addition, a small-scale test will in no way demonstrate what will happen with a full-scale roll out of a BPL service. A small-scale operation uses only a limited portion of the total spectrum. It is far easier to notch out problematic frequencies in such a small-scale operation than it will be when the entire spectrum is being used for a wide-scale operation.

These two flaws in the logic of the utility company reporting on the lack of interference are issues that can be addressed in a reply comment. There are other technical issues that can also be addressed, even in a reply comment. Elsewhere in this issue of *CQ VHF* is an Op-Ed piece by Charles Osborne, K4CSO, that addresses some of these issues.

In conveying our concerns, we should not stop with the FCC. In my April "VHF Plus" column in *CQ* magazine I urged you to write to your congressmen and senators. In this editorial, I repeat my urging. It is particularly important that we contact those representatives and senators who serve on their important respective FCC oversight committees.

Regarding the House of Representatives, the following (in alphabetical order) are members of the House of Representatives' Energy and Commerce Committee's Subcommittee on Telecommunications and the Internet: Joe Barton, TX; Charles F. Bass, NH; Michael Bilirakis, FL; Mary Bono, CA; Rick Boucher, VA; Christopher Cox, CA; Barbara Cubin, WY; Jim Davis, FL; Nathan Deal, GA; Peter Deutsch, FL; John D. Dingell, MI; Michael F. Doyle, PA; Eliot L. Engel, NY; Anna G. Eshoo, CA; Vito Fossella, NY; Paul E. Gillmor, OH; Bart Gordon, TN; Gene Green, TX; Edward J. Markey, MA; Karen McCarthy, MO; Charles "Chip" Pickering, MS; Bobby L. Rush, IL; John Shimkus, IL; Cliff Stearns, Vice Chairman, FL; Bart Stupak, MI; W. J. "Billy" Tauzin, Ranking Member, LA; Lee Terry, NE; Edolphus Towns, NY; Fred Upton, Chairman, MI; Greg Walden, OR; Ed Whitfield, KY; Heather Wilson, NM; and Albert R. Wynn, MD.

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If your representative's or senator's name appears above, then send him or her a letter. Please write today, explaining your opposition to the FCC's proposal for Access BPL. Write reasoned and intelligent letters explaining the harmful effects of the interference and the potential impact relating to *homeland security*. These last two words are the current buzzwords and may just get their attention.

A far more reasonable approach to rural broadband Internet service is the use of microwave linking of communities. While this can be problematic to those of us who operate weak-signal microwave communications, cooperation with the local community leaders can help all concerned in developing a relatively interference-free system.

Hopefully, all of this opposition can buy us some time. The more time passes, the more likely it is that alternative means for rolling out rural broadband Internet service will be developed. If sufficient alternative means are developed, then those who are investing their funds will find that there is less profit to be made in BPL than was first predicted and thus will make their decisions to invest their funds elsewhere.

While BPL is primarily going to affect HF operations, indirectly it will affect all of us ham radio operators. Therefore, it is imperative that all of us join the fight to preserve our ham radio spectrum. Take the time to write a response to the FCC and a letter to your legislative representative.

Finally, take time to write a letter to the ARRL's CEO, Dave Sumner, K1ZZ. Dave has worked tirelessly trying to get all of the information out to all hams, and he deserves a kind acknowledgement for all of his efforts. He can be e-mailed at <k1zz@arrl.org>, or snail-mailed at the League's address: 225 Main Street, Newington, CT 06111.

73 de Joe, N6CL

ANAHEIM, CA
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delaware@hamradio.com

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John N5EHP, Mgr.
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- 102 alphanumeric memories
- Enhanced Rx performance

IC-756PROII All Mode Transceiver
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- Selectable IF filter shapes for SSB & CW
- Enhanced Rx performance
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- Multiple DSP controlled AGC loops
- Advanced CW functions
- 101 alphanumeric memories

IC-V8 2M Transceiver

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- 107 alphanumeric memories
- Customizable keys
- Auto repeater
- PC Programmable
- CTCSS encode/decode w/tone scan
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- 101 memories

IC-2100H 25N 2M Mobile Transceiver
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- Backlit remote control mic
- Mil spec 810, C/D/E*[1]
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- 113 alphanumeric memories

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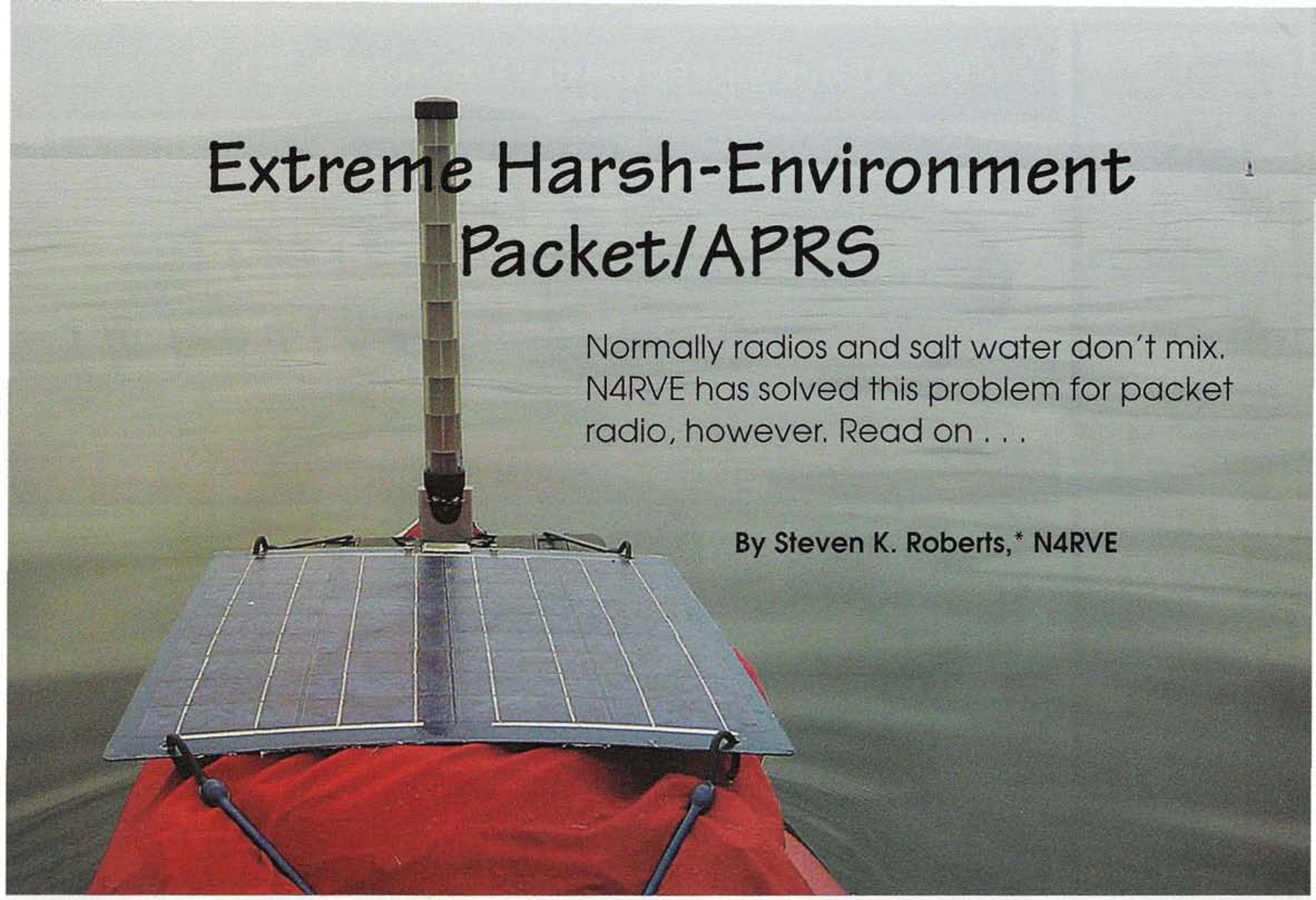
Extreme Harsh-Environment Packet/APRS

Normally radios and salt water don't mix. N4RVE has solved this problem for packet radio, however. Read on . . .

By Steven K. Roberts,* N4RVE



Our familiar off-the-shelf packet radio gear is nifty but delicate stuff, not the kind of hardware that can take heavy environmental abuse. This isn't a problem in the shack or for mobile applications, but have you ever wanted to take a tracker into the jungle or paddle it through dumping surf? This article describes a packet rig that is regularly exposed to salt water, along with the robust power system that supports it.

Adventure Tracking: A Bit of Context

APRS is a strange phenomenon. Think about it: If the government required us all to have real-time location-trackers affixed to our vehicles, it probably would (and should) trigger a full-scale revolt. Big-brotherish implications aside, the geek-appeal of this technology is unmistakably seductive, and it has spawned a microculture of folks whose every movement is trackable . . . not only by fellow hams, but also by anyone with a web browser.

Back in the 1980s, I used to fantasize about exactly this. I spent most of that decade pedaling 17,000 miles around the U.S. on a computer-laden recumbent bicycle (*CQ VHF* cover photo, April 1998), but back then it was challenging enough just to maintain an ongoing textual narrative on the primitive online services of the day (a process that has now been re-invented as blogging). I remember pedaling along, imagining the logical evolution of this: Readers watching a live display of my location on a slowly scrolling zoomable map, multiple telem-

Photo A. Bubba the kayak beached on Strawberry Island during a recent solo six-day tour. The three Pelican boxes contain packet/APRS, navigation, and power-management gear.

**Nomadic Research Labs, Camano Island, Washington*
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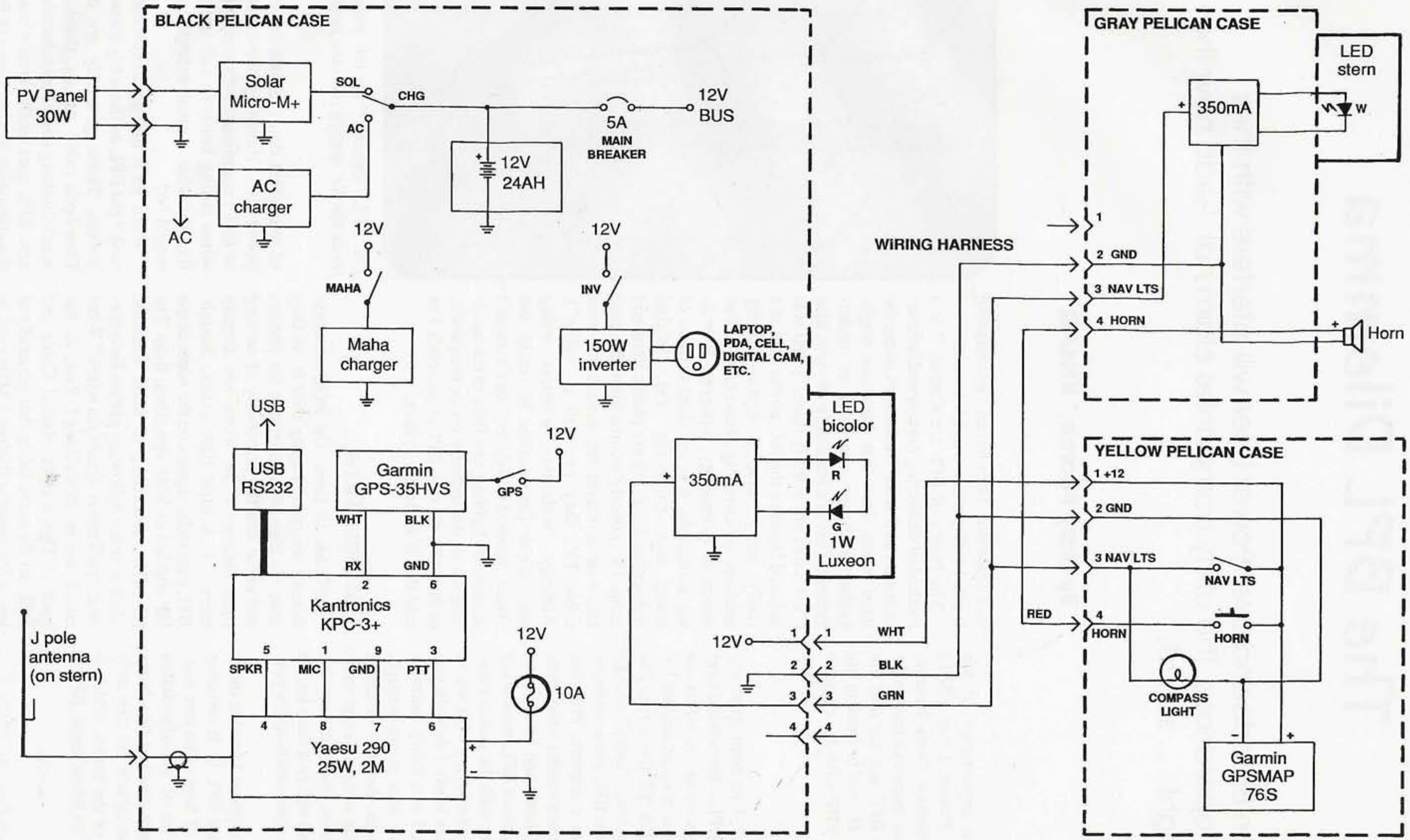


Figure 1. Wiring diagram for the complete kayak system. A simple waterproof harness integrates the three Pelican cases containing all electronics.

(Continued on page 76)

The BPL Dilemma

Hams claim Broadband over Power Lines will interfere with their on-the-air operations. The utility companies claim not. Read how they are both right . . . sort of.

By Gary Pearce,* KN4AQ

Because of the importance of the Broadband over Power Lines (BPL) issue, "FM" columnist Gary Pearce, KN4AQ, devotes his space this time to the investigation of a BPL test site and the surrounding area. He will be back in the next issue of CQ VHF *with his regular column material.* —*N6CL*

Since last fall, I've been up to my eyeballs in BPL—Broadband over Power Lines—and its effect on amateur radio. If you're up on current TV culture, you can call it "HF Eye for the FM Guy." Our area has been "lucky" enough to host one of the few BPL trials, courtesy of my local power company, Progress Energy, and equipment vendor Amperion. Several other local hams and I have been very busy learning about BPL, measuring the effects, working with the power company and vendor, and relaying what we've learned to our fellow hams. I thought you might be interested in a fairly intimate review of what I've been going through. It's not nearly over, but the deadline looms. They say that writers should write about what they know, and right now this is what I know. This will be a deep breath for me, and maybe some catch-up for you. Here we go.

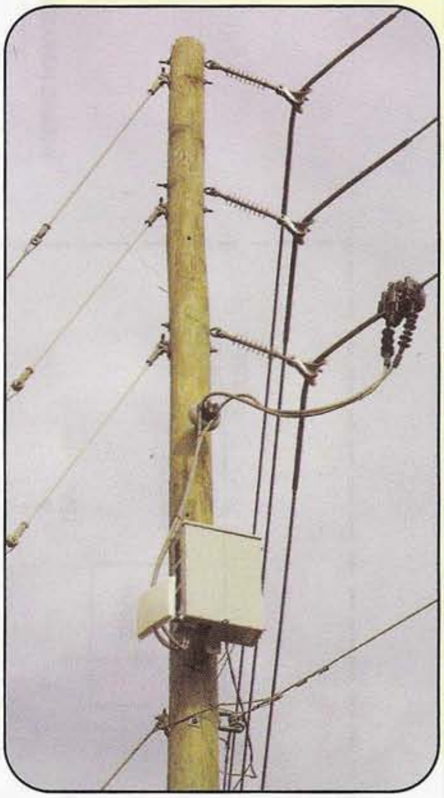
Here we stop. I suppose I need to make sure you know what BPL is. It certainly has been the buzz of ham radio this winter, but there's a lot of misinformation about it. I'm always running into hams who have heard the initials but they only have a fuzzy idea of the basics, which is not surprising. For 99.9% of hams, BPL is still academic. They haven't encountered it yet. I will provide a quick tutorial.

*116 Waterfall Court, Cary, NC 27513
e-mail: <kn4aq@arrl.net)>

The basics of BPL are simple. It is a method of delivering high-speed internet to homes and small businesses using the local power lines that crisscross neighborhoods either overhead or underground. This is a brilliantly obvious idea ("the wires are already there!") that was delayed because the AC power grid is a really noisy, crappy signal-delivery medium for anything above 60 Hz. The march of technology, however, is making it feasible. It is the third method of doing that, following DSL (Digital Subscriber Line) on the phone lines and cable TV (nobody's come up with a cute name or acronym for broadband over cable TV; they just call it "cable"). Actually, wide-area wireless using microwave frequencies is really the "third" method of delivery, but it doesn't seem to be lighting any fires in the imaginations of the industry press, the public, or the FCC, the way BPL is (too bad). I'm told that it's a better system.

This Little Flaw...

BPL has lit fires. The FCC commissioners are mostly agog over it, as they love the idea of competition for phones and cable and the possibility of serving rural citizens ("the wires are already there..."). A little flaw exists, though. BPL puts radio signals on the wires in the HF and lower VHF spectrum, from 2 to 80 MHz, according to most vendors. Mull over the following phrase for a second: "puts radio signals on wires." What could we be describing? You, in the back...? That's right! Radio! Cable and DSL do the same thing, but generally at lower frequencies (below 3 MHz) and in either a shielded cable or a balanced pair of wires that don't radiate (much). The power lines! Haven't you ever looked up at that magnificent infrastructure, long wires strung between tall towers, and thought what a great antenna system it would be?



The BPL "injector" on this power pole feeds the RF energy onto the power line.

Well, let's not go overboard. They won't put BPL on those big transmission towers. Those generally are carrying fiber-optic cable already, thanks to forward-thinking engineers a decade or two ago. BPL goes on the local wiring, from the substation to your home or business, across your back yard or beneath your

This is the BPL hardware inside the ground-mounted pedestal.

front yard. It doesn't radiate like a kilowatt into a rhombic, but it does radiate, and it's regulated by Part 15. How it radiates, and how well, will come out as our story unfolds.

BPL appeared on the collective amateur radio radar screen in the U.S. some time last year. The more astute among us saw it long before then. I probably read Dave Sumner, K1ZZ's October 2002 *QST* editorial entitled "Radio Smog," which talked about general pollution (the physical kind in the air and water) and good old power-line noise, and introduced the concept of BPL . . . gently, so as not to create mass panic. He didn't call it BPL back then. In 2002 the initials BPL only meant Brass Pounder's League, an exalted position that a CW operator can attain for passing lots of message traffic. If the editorial made any impression on me, it was probably something like "Sure . . . no way that's ever going to happen."


Bill Godwin; Will Roberts, AA4NC; Tom Brown, N4TAB; Frank Lynch, W4FAL; and Amperion's Garrett Durling measure BPL signal levels from the ground-mounted pedestal.

It was already happening in Europe and Asia, and in early 2003 power companies around the U.S. were building trial areas to see what this was all about. In April, the FCC issued a Notice of Inquiry, asking if Part 15 needed to be modified to accommodate BPL. Thousands of hams responded. I was late to the party, but I finally got on the FCC website and said something about the need to pay attention to the interference problem.

Eye Opener Number 1

The ARRL's Lab Manager, Ed Hare, W1RFI, was on the case early. Last summer, he equipped a car with radios, a shortened dipole, and a video camera. He visited some of the trial areas. The video is available for download on the ARRL web page (www.arrl.org) and plays on all the usual media players on your computer. I finally got around to downloading it, and suddenly I was very interested in BPL. To a ham, it was frightening.

We've been battling noise on the ham bands since the beginning. Heck, a lot of the noise was there long before we had receivers to detect it. Over the decades we've created a lot more of our own. Power-line noise is a familiar ham complaint. Computers and clock/processor-based devices have escalated the man-made RF noise problem since the late '80s. What I saw on Ed's video took things to a new level. Heck again . . . it skipped a level or ten. This was an exponential leap in interference. Ed recorded crackling and clattering with S-9 signals that extended over hundreds of kilohertz. You can see him spinning the dial on his TS-440, flying across the spectrum, and the noise never changes. I played this video at a radio club meeting and jaws dropped. It seemed like the future of amateur radio dropped. Then anger rose. The FCC Notice of Inquiry drew more than 5000 comments and reply comments, mostly from angry hams, but some from a BPL industry claiming that there was no interference problem at all!

Then it got personal. A short article in the business section of the local newspaper and a TV news report or two announced that Progress Energy, the power company for much of eastern North Carolina and a big part of Florida, had quietly been testing BPL almost in my back yard. Actually, it was on the other side of town, where a small test occurred over a few blocks in a new subdivision. In a review to the FCC, the utility noted that there were "no reports of interference." Well, duh! Nobody knew about it. No hams lived in the new, severely antenna-restricted neighborhood. Even if a ham had heard it, the person wouldn't know what it was, so why would the power company be called? It didn't sound like power-line noise (more on what it sounded like in a minute).

As Public Information Officer for the local club and ARES group, I began contacting the press that carried the story, and I wrote some bulletins for quick distribution on area club mailing lists. Area hams reacted by writing and calling Progress Energy to protest the development of this technology—technology we really didn't know much about, except that it could fill the ham bands with garbage.

A few local hams did more than just file general protests. Our

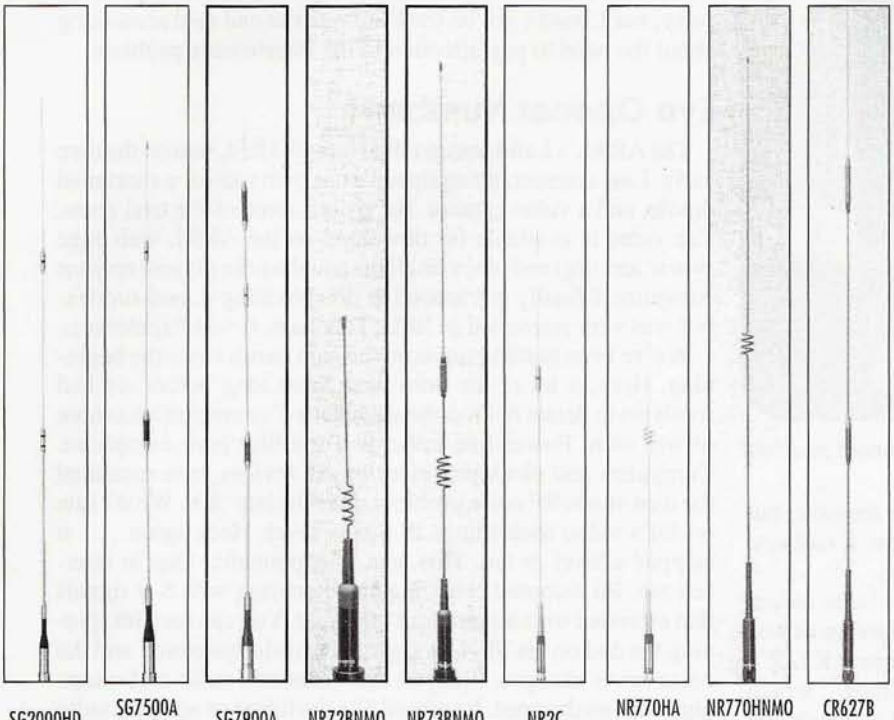
(Continued on page 80)

DIAMOND ANTENNA

DIAMOND'S STATE-OF-THE-ART

VHF/UHF And HF/VHF Mobile Antennas–Maximum Performance Without Compromise

You've seen the rest...now own the BEST!



HV7A Mobile Antenna System

For New HF/VHF transceivers NEW!
(Such as: IC706 series and FT100)

Optional Loading Coils

HVC7	40m
HVC14	20m
HVC18	17m
HVC21	15m

Recommended Antenna Mounts: K400C or K600M

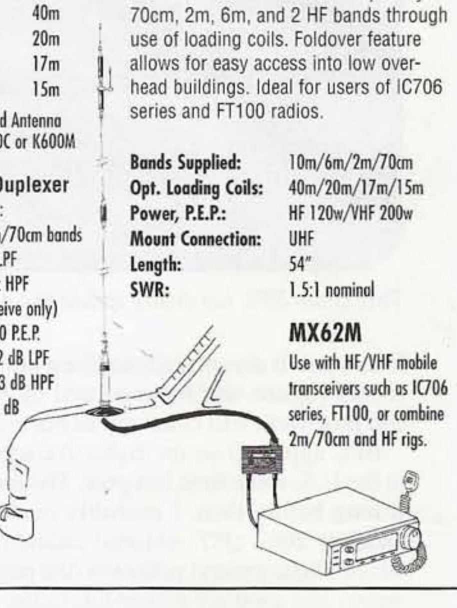
The NEW HV7A has 5 band capability: 70cm, 2m, 6m, and 2 HF bands through use of loading coils. Foldover feature allows for easy access into low overhead buildings. Ideal for users of IC706 series and FT100 radios.

Bands Supplied:	10m/6m/2m/70cm
Opt. Loading Coils:	40m/20m/17m/15m
Power, P.E.P.:	HF 120w/VHF 200w
Mount Connection:	UHF
Length:	54"
SWR:	1.5:1 nominal

MX62M Duplexer

Specifications:
HF/6m & 2m/70cm bands
1.6-56 MHz LPF
76–470 MHz HPF
(76–120 receive only)

Watts:	600 P.E.P.
Loss:	0.2 dB LPF 0.3 dB HPF
Isol.:	50 dB



MX62M

Use with HF/VHF mobile transceivers such as IC706 series, FT100, or combine 2m/70cm and HF rigs.

SPECIAL FEATURES:

- Factory pre-tuned/no adjustment
- Highest Performance antennas
- NMO and UHF (PO) base styles
- 24 Kt gold plated connector pin
- No grounding required unless noted
- Fold-over feature on most models

FOLD-OVER

Patented One-Touch Fold-over Feature
(Not available on NR72BNMO, NR73BNMO, & NR770SA.)

MODEL	BAND (MHz)	WATTS	CONN.	HT. IN.	ELEMENT PHASING
NR72BNMO*6	2m/70cm	100	NMO	13.8	1/4λ, 1/2λ
NR73BNMO	2m/70cm	100	NMO	33.5	1/2λ, 1-5/8λ
NR770HA7	2m/70cm	200	UHF	40.2	1/2λ, 2-5/8λ
NR770HNMO8	2m/70cm	200	NMO	38.2	1/2λ, 2-5/8λ
NR770RA	2m/70cm	200	UHF	38.6	1/2λ, 2-5/8λ
SG7000A*6	2m/70cm	100	UHF	18.5	1/4λ, 6/8λ
SG7500A	2m/70cm	150	UHF	40.6	1/2λ, 2-5/8λ
SG7500NMO	2m/70cm	150	NMO	41.0	1/2λ, 2-5/8λ
SG7900A*	2m/70cm	150	UHF	62.2	7/8λ, 3-5/8λ

* Not recommended for Magnet Mount
6 Grounding required.
7 NR770HB same specifications but in black finish.
8 NR770HBNMO same specifications but in black finish.
9 52-54MHz only

MODEL	BAND (MHz)	WATTS	CONN.	HT. IN.	ELEMENT PHASING
NR2C	2m	150	UHF	55.5	1/2λ+1/4λ
SG2000HD*	2m	250	UHF	62.6	1/2λ+3/8λ
SG6000NMO*6,9	6m	150	NMO	39	1/4λ
CR224A*6	2m/1-1/4m	150	UHF	68.5	7/8λ, 2-5/8λ
CR320A*6	2m/1-1/4m 70cm	200 100/200	UHF	37.4	1/4λ, 1/2λ 2-5/8λ
CR627B*6,9	6m/2m/	120	UHF	60	1/4λ, 1/2+1/4λ/
CR627BNMO*6,9	70cm	120	NMO	60	2-5/8λ

1/4λ rated in dBi.

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• UPS Shippable • High Wind Rating • Fiberglass Radome • DC Grounded • Stainless Hardware

X500HA (UHF-Conn.) X500HNA (Type-N Conn.)

Ruggedized Base/Repeater Antenna

COAX CONNECTION AT BASE END

HEAVY DUTY BASE/ RADIAL ASSEMBLY

STRONG JOINT COUPLINGS

X50NA

The X50NA is an excellent choice where ruggedness is required in a medium-gain, dual-band, base/repeater application.

Features

- Wide frequency bandwidth
- Heavy duty fiberglass radome
- Stainless steel mounting hardware and radials
- Type-N Cable connection
- Compact size for easy mounting/ installation

Specifications:

Freq.: 2m: 144–148MHz
70cm: 440-450MHz
Power: 200 watts
Wind Rating: 135 MPH (no ice)
Height: 5.6 feet

X500HNA

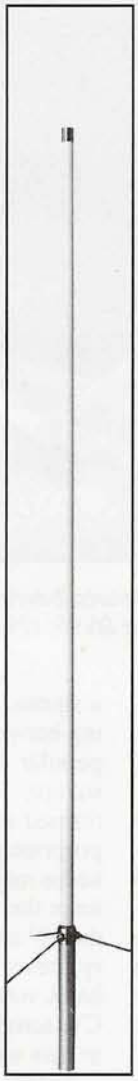
Diamond Antenna's best base station repeater antenna. Designed for strength and performance, the X500HNA is pretuned to achieve maximum gain in both the 2m and 70cm amateur bands.

Features

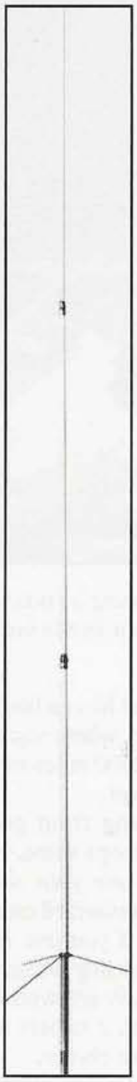
- Heavy duty fiberglass radome
- Overlapping outer shells for added strength
- Stainless steel mounting hardware and radials
- Strong–waterproof joint couplings
- Type–N Cable connection
- Wide band performance

Specifications:

Freq.: 2m: 144–148MHz
70cm: 440-450MHz
Power: 200 watts
Wind Rating: 90 MPH (no ice)
Height: 17.8 feet



X50NA



X500HNA

DIAMOND Mono-Band Base/Repeater Antennas

MODEL	BAND (MHz)	WATTS	CONN.	HT. FT.	RATED WIND MPH (No. Ice)
CP22E [1]	144	200	UHF	9.0	90
DPGH62 [1,6]	50	200	UHF	21.0	78
F22A	144	200	UHF	10.5	112
F23A	144	200	UHF	15.0	90
F718A [2]	440	250	N	15.0	90

DIAMOND Dual-Band Base/Repeater Antennas

MODEL	BAND (MHz)	WATTS	CONN.	HT. FT.	RATED WIND MPH (No. Ice)
X50A	144/440	200	UHF	5.6	135
X50NA	144/440	200	N	5.6	135
X200A	144/440	200	UHF	8.3	112
X510NA [3]	144/440	200	N	17.2	90
X510MA	144/440	200	UHF	17.2	90
X500HNA	144/440	200	N	17.8	90+
X700HNA	144/440	200	N	24.0	90
X2200A	144/222	150	UHF	11.5	112
U200	440/1240	100	N	5.9	135

DIAMOND Tri-Band Base/Repeater Antennas

MODEL	BAND (MHz)	WATTS	CONN.	HT. FT.	RATED WIND MPH (No. Ice)
U5000A	144/440/1240	100	N	5.9	135
V2000A [4,6]	52/144/440	150	UHF	8.3	110
X3200A [5]	146/222/440	100/200	UHF	10.5	112
X6000A	144/440/1240	100/60	N	10.5	112

1 Heavy duty aluminum construction.
2 F-718A: 440-450MHz., F718L: 420-430MHz.
3 X510NJ: 144-147/430-440MHz.
4 1/4λ rated in dBi.
5 2m: 146-148; 100 watts
6 52-54MHz. only; DPGH62 adjustable from 50-54MHz.

Mast requirement: 1.4"-2.4".

BAND: 144=144-148MHz., 222=222-225MHz., 420=420-430MHz.,430=430-440MHz., 440=440 450MHz., 1240=1240-1300MHz.

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Loops for Omni Weak-Signal Work

Are you in a tight space for a weak-signal antenna installation? A loop antenna may be the solution.

By Gordon West,* WB6NOA

Omnidirectional loops are good, but the horizontal beam is better. That's a fact: If you are going to squeak a long-range VHF or UHF signal to that station 1500 miles away through a tropospheric duct, the horizontal beam cannot be beat. If signals are coming in just above the noise floor from that distant tropo station, the beam will hear it, and even a stacked pair of loops *won't.*

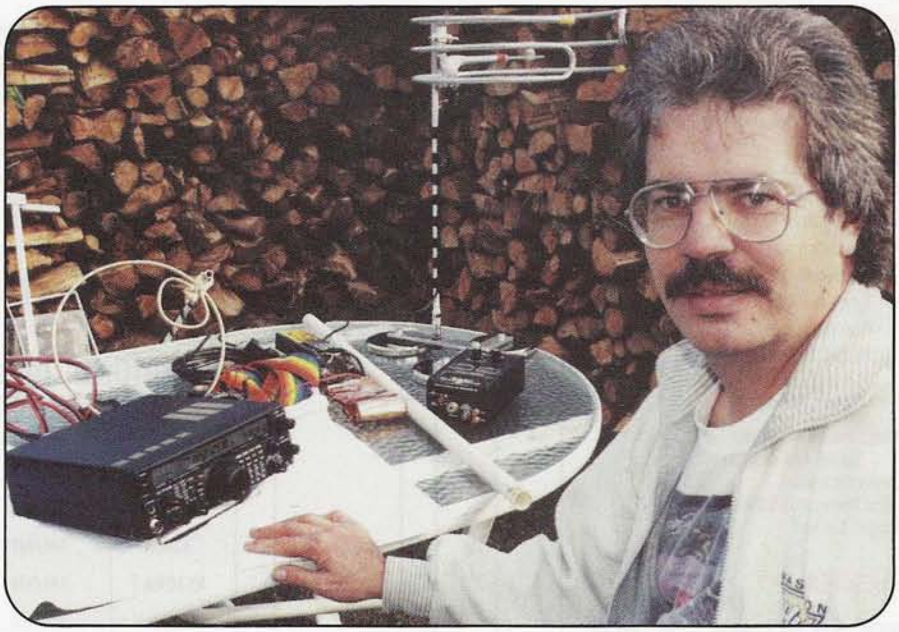
The horizontal loop has its place in the record books, however:

- Loop-to-loop mobiles over 2500 trans-Pacific miles
- 1500-mile beacon loop reception
- 1200-mile sporadic-*E* loop contact
- Loop-to-loop auroral contacts

Even the high-power VHF/UHF rover stations with their mobile beams rely on the loop's omnidirectional characteristics with horizontal polarization to find mountaintop and desert hot spots. Just ask Pat Coker, N6RMJ, who uses his mobile loop as he drives from the desert to the sea, discovering multiple tropo layers as he heads up and down the mountainside.

Another loop-antenna user is airplane pilot William Alber, WA6CAX. "I run both a 2-meter loop as well as a 432-MHz loop on the belly of my Cessna, and I have hooked up with other 2-meter stations running a base-station beam up to 300 miles away," comments Alber. "I also use the 2-meter horizontal loop for determining the upper and lower limits of the tropospheric duct between here and Hawaii. The KH6HME beacon that comes through every July and August is usually strongest when I enter the duct at about 1500 feet,"

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



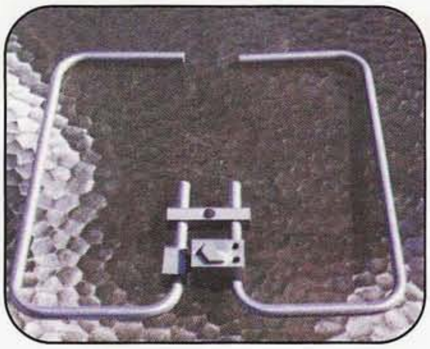
Chip Margelli, K7JA, testing a vintage Saturn 2-meter heavy-duty loop antenna that was bought new in the box for $6.95! (Photos by the author)

adds Alber, explaining that he can literally see the inversion layer where signals from the Hawaii beacon 2500 miles away begin to swamp his receiver.

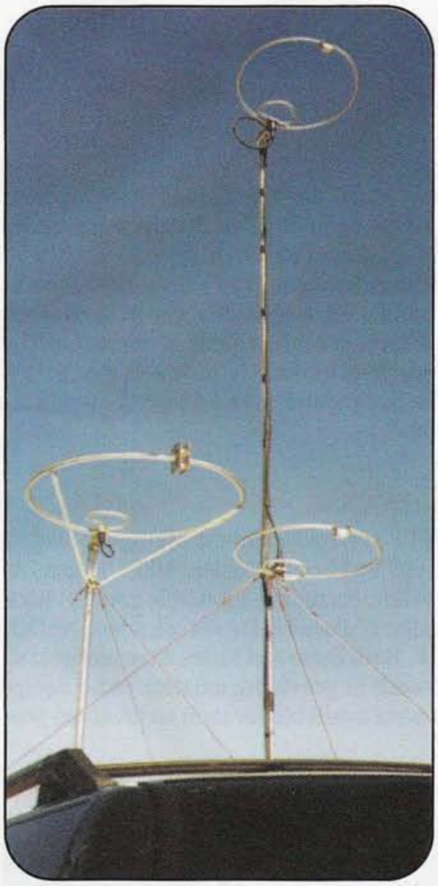
When signals are strong from good propagation conditions, loops shine. For mobile in motion, loops are your solid answer for a horizontally polarized omnidirectional signal. Also, if you live in a condo or an apartment building where no outside horizontal beam is allowed for weak-signal SSB work on 2 meters and above, the loop is a superb choice.

The most simple, yet precise, configuration of the loop looks like a *halo*—electrically much like a halfwave dipole bent around in a circle or configured as a square, with a *critical* capacitive tuning between two to five picoFarad. The popular M^2 antennas are formed in a square. The popular KB6KQ loop is formed as a halo. Both antennas have a proprietary sealed feedpoint, which keeps moisture from detuning the antenna in the rain. During loop testing, both the M^2 and the KB6KQ loops are factory preset for the bottom portion of the band, where most weak-signal SSB and CW activity takes place. There is no need to fuss with tuning.

Another version of the halfwave loop is from Par Electronics and is called the Omniangle. Par was looking to improve bandwidth and create less rain detuning



An M^2 square-configuration loop antenna.



On the KB6KQ van are 2-meter stacked loops with a single 6-meter loop on the left.

in summer Florida wet weather. Par claims the bandwidth and resistance to rain sensitivity are a result of the longer length of the plastic tip shrouding. The Par Omniangle antenna pattern becomes elliptical if the square section is made shorter and the rods made longer, or vice versa. At the proper dimensions as supplied by Par, the pattern is very close to a perfect circle, much like the M^2 and KB6KQ loops.

Yet another version of a horizontal loop antenna is the Big Wheel. It looks like a big cloverleaf, with each "leaf" 80 inches long, made of 3/8-inch tubing or solid aluminum. When assembled, the distance between the upper and lower tuning plates is 1 1/2 inches. The stub turns out to be about 2 1/2 inches long and should be adjustable. The Big Wheel antenna was popular in its time, but its extra-large size didn't seem to contribute any big increase in antenna gain. It did give us a much more omnidirectional radiation pattern than the smaller loops. The one-wavelength loop uses the center point for both balance and support, and a 50-ohm impedance match.

You should see many of these turnstile omnidirectional antennas from ham homebrew designs available at local hamfests. Each one is a work of art!

Industrial-strength loops with multiple elements are created by The Olde Antenna Lab of Denver. Again, these are horizontally polarized, half wavelength in design, but there is an additional radiation element that offers a bit more omnidirectional gain and very stable matching and resonance.

The Tests

The big question is always which loop performs the best for both gain in all directions, as well as staying omnidirectional no matter which way you point the vehicle. We went down to the shoreline and tested all of these antennas with some interesting results. Our test crew was Chip Margelli, K7JA, and a host of hams 100 miles away along the coastline, members of the Western States Weak Signal Society (http://www.wswss.net).

Our first test was to see the importance of polarization to a distant station running horizontal. With cross-polarization we couldn't even hear the other horizontal stations. When we switched from our mobile 3 dB gain back to the 0-dB gain omnidirectional horizontal loop, the signals popped in instantly. This should serve as a powerful reason to match your mobile SSB 2-meter and 432-MHz transceiver to a horizontal antenna for SSB and CW. You won't hear anything with a vertical antenna when everyone else is running horizontal.

Our next test involved driving the communications van around in a circle with each type of single loop mounted at least one wavelength above the roof. This would be a check for a good omnidirectional pattern:

M^2 loop—minor nulls
KB6KQ loop—minor nulls
Olde Antenna Lab loop—perfect, no nulls
Par Electronics Omniangle loop—minor nulls
Tillo-Curri Big Wheel Antenna 3—ultra-minor nulls

Our next test was to see how each loop picked up a beacon coming in from Yuma, Arizona to the southern California coastline. With a small horizontal 3-element Arrow Antenna beam, the beacon was 6 dB out of the noise. When we switched to the loops, the signal level was maybe 2 dB out of the noise.

All the loops were almost identical in weak-signal reception. We figured that the larger surface-area loops would do a lot more to pull in the distant beacon station, but to our surprise, each style loop was nearly the same. We just couldn't believe it.

To confirm our results, we went on the air with each loop to a battery of distant base stations throughout the southland. We would drive in circles, yakking using

Continued on page 74)

Where the Horizontal Action Can be Found

If you are new to VHF/UHF weak-signal SSB operation, here are the hot spots to tune any weekend and most evenings around 7 PM local time:

50.125 USB
144.200 USB
222.100 USB
432.100 USB
1296.100 USB

Tune at least 100 kHz above and below these frequencies, listening to horizontally polarized, continuously transmitting beacons sending their CW identifier. These beacons make for your perfect test station when testing and trying out loops that you might homebrew for yourself, or loops that have been pre-manufactured, pre-drilled, and pre-matched for the weak-signal portion of each band. Also, if you have never tried SSB on the lower portion of each VHF/UHF band, monitor the frequencies I just gave you, give a brief CW call, including the city in which you are located, and the fact that you are in the weak-signal portion of the band for the first time. Then expect numerous stations to come back to you and give you great signal reports on the hidden loops in the attic or your mobile loop or two on your vehicle. Shift off to a nearby working frequency and enjoy all that horizontal omnidirectional polarization can do for you mobile or with those loop antennas hidden in your attic.

Slow Scan TV in Space

In this article the authors take us from the very beginnings of amateur radio SSTV to its inclusion aboard the Mir Space Station. Also presented is an overview of SpaceCam on the International Space Station, the next generation.

By Farrell Winder,* W8ZCF, Don Miller, W9NTP, and Hank Cantrell, W4HTB

Amateur radio Slow Scan Television (SSTV) was conceived (invented) by Copthorne Macdonald, W4ZII, who now holds the call VY2CM. In September 1957 he began the design and construction of a low-cost SSTV system adapted to the standard amateur radio voice-channel bandwidth. This work was undertaken as a personal project in an independent problem course at the University of Kentucky.[1] Cop was soon joined by Dr. Don Miller, W9NTP, who, along with others, contributed to many advancements, including color. Now, over a period of some 46 years, many systems have been devised, including standalone hardware systems and software programs working in conjunction with a computer and radio transceivers.

Basically, SSTV is an arrangement wherein a photographic image is scanned and stored in memory. It is then scanned again, producing audio tones, which are transmitted over amateur radio voice channels. At the receiving end the tones are reconstructed to produce TV images of excellent quality.

Over many years of development, SSTV has been accomplished entirely by amateur radio enthusiasts who have devoted their time and financial resources to this mode of operation. The definition of SSTV as provided by the FCC to W9NTP is "SSTV is the transmission of a *live* picture over a voice communication channel in real time."

The Mir SSTV Amateur Radio Project

The idea to put an SSTV system aboard the Mir Space Station was initiated in early 1997 by Farrell Winder, W8ZCF, and Dr. Don Miller, W9NTP. After discussing a possible concept for a system, a conference call was placed to Dr. Dave Larsen, N6CO, and Miles Mann, WF1F. Both Dave and Miles were recognized for their contacts and work in providing amateur radio equipment to Mir. No funds were available for such an involved pro-

**6686 Hitching Post Lane, Cincinnati, OH 45230*
e-mail: <fwinder@one.net>

[1]*See "New Narrow Band Image Transmission System,"* QST, *August & September 1958.*

Photo A. Gennadiy Padalka talking to amateur radio operators in the U.S. Over his left shoulder can be seen the SSTV system. The large, square white image is the 5-inch LCD screen. The rectangular bluish screen just above it is the SSTV transmitter (Kenwood TM-V7A).

Photo B. One of the photos of Earth taken from Mir. It was received by WAØZBL on February 21, 1999.

Photo C. This picture shows Alexander Kaleri, U8MIR, at the crew work desk, which also doubles as a stove and dinner table. The MAREXMG SSTV system is just to the right of Alexander's watch band, above his head. The image was received by Gerald Klatzko, ZS6BTD, in Johannesburg, South Africa, on April 23, 2000.

Mir's Accomplishments

Mir was launched on February 2, 1986 and was de-orbited on March 20, 2001. The following are notable accomplishments of Mir:

Mir SSTV Project, 20,000 images sent to Earth from the Mir Space Station.

Provided the Mir crew with two-way image access, which helped the crew's morale.

Generated new interested in amateur radio operations around the world.

Provided shortwave listeners with a new, exciting mode. (You do not need a license or complex equipment to receive images from space).

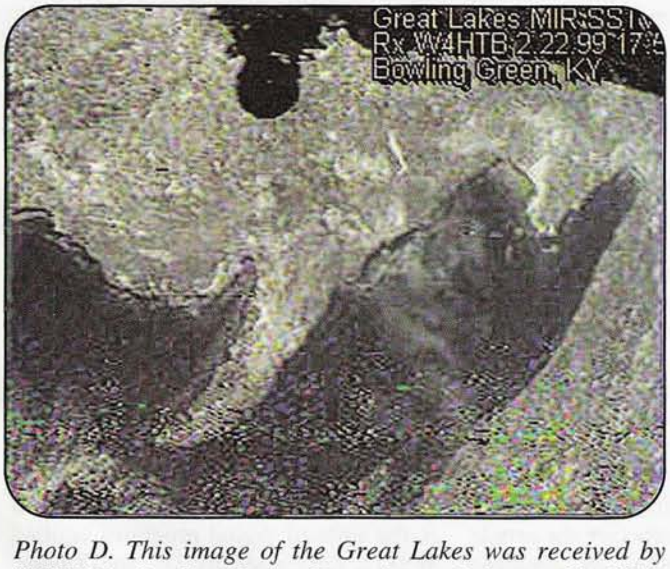


Photo D. This image of the Great Lakes was received by W4HTB in Bowling Green, Kentucky, on February 22, 1999.

Photo E. Commander Sergei Andeyev liked to look out his window every morning just to make sure his return Soyuz rocket was still there. The image was received by W8ZCF in Cincinnati, Ohio, on December 12, 1998.

Photo F. Sergei and Jean-Pierre posed for a picture while talking to Miles, WF1F. Miles would routinely send the Mir crew pictures of their families via SSTV. Miles received this image on August 22, 1999.

ject, but generous contributions came from the Kenwood Corporation for the TM-V7A transceivers, Tasco Electronics for the TSC-7 scanners and docking stations with LCD displays, and PictureTel Corp and Apple Computer for cameras.

The engineering and development of the Mir SSTV system consumed many months to achieve the desired performance. Hank Cantrell, W4HTB, designed and built the automated controller, which provided the Mir station ID, RØMIR, and allowed unattended capture and sending of picture transmissions. Hank also did the mechanical design and integrated the autocontroller with the radio and docking station. SSTV image format Robot 36 was used as the primary transmission mode. Robot 36 requires approximately 36 seconds to send a color image. The controller was configured to send a new picture every 2 min-

(Continued on page 66)

Welcome to 6-Meter EME!

6 Meters' Longest Path Comes of Age

With declining sunspot numbers, DX on 6 meters is becoming more rare. Add to that the fact that Europe is always difficult to work from the Northwest. Read how W7GJ has solved these problems by way of the Moon.

By Lance Collister,* W7GJ

What do you do on 6 meters during the solar cycle minimum when conditions in most places around the world are like they always are in western Montana? Don't put away the 6-meter equipment for ten years. Make long-path contacts instead. I mean *really* long-path contacts, such as 800,000 km! Many 6-meter operators assume that they don't have a station that is capable of EME (Earth-Moon-Earth communications, or *moonbounce*) and therefore never consider trying it. Many who are willing to try it, however, are surprised to learn that they actually do have the capability of sending signals to the moon and back. Working real long path on 50 MHz is now very possible, bringing unquestionable magic back to the "Magic Band"!

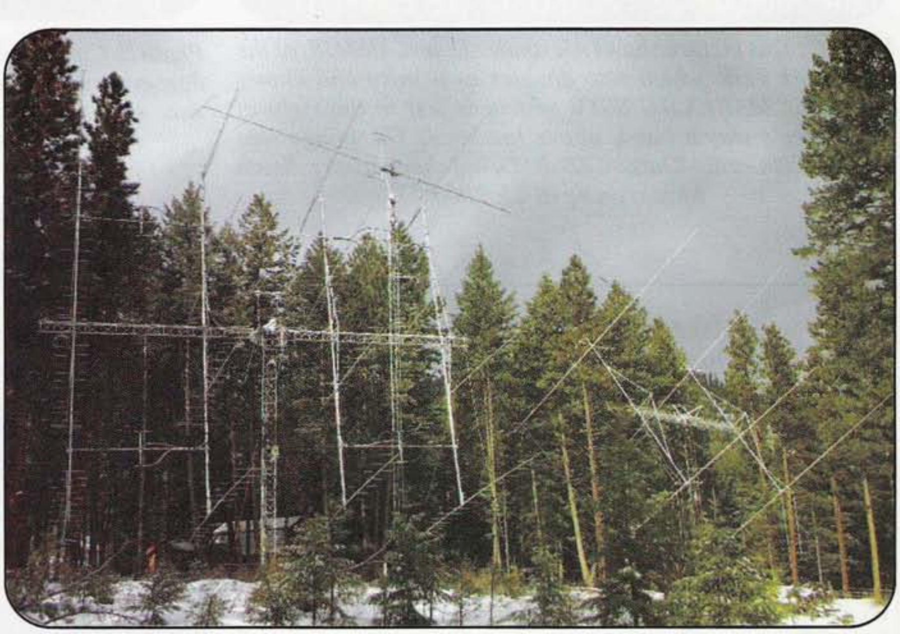


Photo A. W7GJ EME antennas on AZ/EL mounts (left to right): 16 × 17 elements for 2 meters at a height of 27 feet, 11 elements for 6 meters at a height of 70 feet, and 4 × 9 elements for 6 meters at a height of 32 feet. (All photos courtesy the author)

In the three decades since the first 50-MHz amateur moonbounce contact by W5SXD and K5WVX in 1972, the playing field has changed dramatically. An option previously open only to very few of the world's largest stations, moonbounce contacts are now within reach of most well-equipped 6-meter stations. Until recently, an accomplishment such as making an EME contact on 6 meters was about an "S unit" or two beyond the reach of most stations. When it comes to something such as 6-meter moonbounce, where signals are just on the threshold of detectability, 5 to 10 dB is a huge amount. However, several very significant developments have combined to make this out-of-this-world type of 6-meter propagation practical today. Among these are the following:

Antennas. Computer-optimized antennas have significantly improved both receive and transmit capabilities. The difference between the old, ubiquitous 5-element beam of 30 years ago and the computer-optimized, long-boom 5-element Yagi of today is not only substantial but also noticeable even during non-EME contacts! Also, for those who are not inclined to homebrew antennas, there are now some manufacturers of very high-performance computer-optimized 6-meter antennas.

Equipment. Recent developments in equipment have incorporated 6 meters into many new HF transceivers, and the band is also included in a growing number of new HF amplifiers. Inexpensive power tubes from Russia *(see the article "Russian Power Tubes in Amateur Radio," parts one and two, by Paul Goble, ND2X, in the Fall 2003 and Winter 2004 issues of* CQ VHF*—ed.)* have made it very easy to develop a "legal limit" type of power output on 6 meters, and new inexpensive transistors provide excellent performance from very affordable receiver preamplifiers. The ready availability of such equipment has made it very easy to assemble a first-class 6-meter station using "off-the-shelf" equipment.

Software. New weak-signal digital-signal-processing (DSP) software that can be run in Windows® has further narrowed the gap. The specialized weak-signal computer program of JT65 (included in the suite of digital programs entitled WSJT), developed by Dr. Joe Taylor, K1JT, provides an improved sensitivity

*e-mail: <w7gj@bigskyspaces.com>

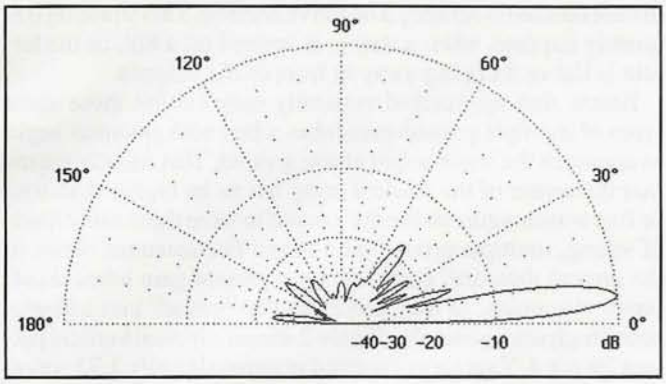


Figure 1. Ground-gain lobes of typical single-beam antenna 3.5 wavelengths above ground.

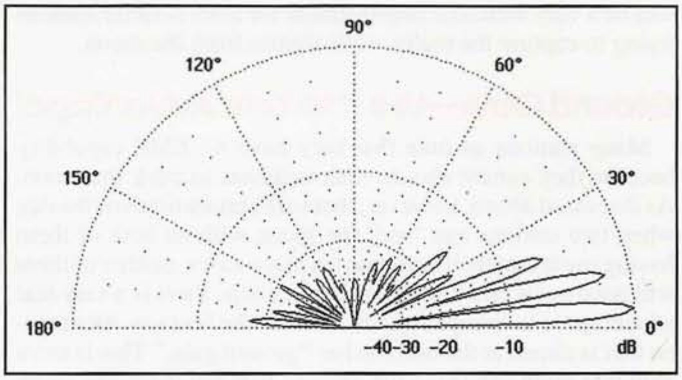


Figure 2. A typical vertical pattern for my 4-Yagi array centered at approximately 1.75 wavelengths above the ground.

of more than 10 dB compared to CW, the previous mainstay for weak-signal work. This innovation has turned very difficult weak-signal accomplishments such as 6-meter EME into very real possibilities for many hams.

Consumer Electronics. Of course, it doesn't hurt one bit that many households have switched to either cable television or satellite reception of television signals, and old 49-MHz portable phones are being displaced rapidly by inexpensive 900-MHz or 2.4-GHz portable phones. For a long time, the 6-meter band has held the reputation as the most difficult amateur band to operate safely without causing interference. Now, many of these most vulnerable household appliances are being improved through newer technologies, making the 6-meter ham band again much more attractive.

Common Moon Window

The most basic requirement to make a contact via the moon is that both stations must be able to see the moon at the same time and aim their antennas at it. Because the moon is visible to roughly half the Earth at any particular time, it is possible to contact stations halfway around the world, which basically means you can contact someone anywhere in the world using moonbounce. Also, because the moon rises and sets every day, there are at least two times each day when you can aim your antenna at the moon without elevating it off the horizon.

Declination Changes

Everyone knows that because the Earth is tilted on its axis, the sun appears to move north and south in the sky over the course of the year as we orbit the sun. Similarly, the moon moves north and south in the sky as it completes its monthly orbit around the Earth. This apparent deviation (referenced with respect to an imaginary plane going through the Earth's equator) over the course of each month is called the *declination.* One result of this changing declination is that the length of the "common moon window" between two locations on the Earth changes every day.

What this means for moonbouncers is that you are provided with at least one time each month when the moon is on the horizon for both stations at the same time, so both stations can keep their antennas on the horizon while they both are aiming at the moon.

Station Requirements

In short, a station with 1 KW output, a sensitive receiver or an external preamplifier, the ability to run the JT65 weak-signal digital mode, good low-loss feedline, and a good single Yagi (over 1.5 wavelengths long) is an excellent candidate for successful 6-meter EME contacts. My first 6-meter EME contact was made using a homebrew 7-element Yagi only 20 feet above the ground. After a number of attempts during my moonrise, I finally completed a CW contact with SM7BAE, who, in addition to having the largest 6-meter array in the world, was very patient. However, that was in the days before WSJT and JT65. Although there still is nothing easy about 6-meter EME, using JT65 instead of CW considerably increases the chances of success.

Such a single Yagi station should now be able to complete contacts with other similar-size stations when the moon is on the horizon for both stations. The simplest way to assess your capabilities and target other stations you can work is to use the very convenient "EME Calculator" that is found on the "EME ECHO MODE" screen of the WSJT program. Whether or not your station is already wired with a computer interface unit that will allow you to operate digital modes, you can certainly download the WSJT program and run the EME Calculator!

I usually suggest that a station have an antenna with 14 dBd gain if he is interested in reliably working similar-size stations. That 14 dBd gain can include ground gain if he is primarily interested in operating on the horizon. With 1500 watts output and 14 dBd from my single long Yagi, I could detect my echoes more than half the time when pointed skyward, and I could often hear my CW echoes weakly during good conditions. Of course, when the moon passed through my ground-gain lobes during moonset or moonrise, signals were significantly louder.

If you want to be able to contact stations smaller than yours, or if you want to run less power yourself, you will have to make up for the gain on your end with a larger antenna. With my array of four long Yagis, I have completed contacts with numerous single-Yagi stations running between 400 and 600 watts and with stations using larger antennas using only 100 watts.

If you want to be able to hear weak signals well, you also probably will want a good, low-noise external receive preamplifier. Most of the more popular transceivers that include 6 meters are optimized for handling many strong stations rather than being most sensitive to detecting weak signals. During periods of the month when EME conditions are the best, the addition of a low-noise preamplifier will be a very welcome improvement for most 6-meter stations trying to capture the really weak signals from the moon.

Ground Gain—Use It to Your Advantage!

Many stations assume that they have no EME capability because they cannot elevate their antennas to track the moon. As discussed above, however, there are certain times of the day when two stations can "see" the moon without both of them having to elevate their antennas (in many cases, neither of them will need to elevate the antennas). Actually, there is a very real advantage in keeping antennas aimed at the horizon. An antenna that is aimed at the horizon has "ground gain." This is extra gain that often can make the antenna perform more like twice (or even four times) as many antennas! This extra 3–6 dB is available only at certain elevations and depends on the local terrain, the ground conductivity, and the height of the antenna above the ground. The signals reflected up to the antenna create "ground-gain lobes," and when the moon passes in front of one of these lobes, the signals can be enhanced greatly. That is exactly how smaller stations are able to complete moonbounce contacts: They keep their antennas aimed at the horizon and wait for the moon to move into their ground-gain lobes.

Notice in figure 1 that the first two lobes shown for my single Yagi have substantially higher gain than the third lobe. The third lobe is roughly equivalent to the "free-space gain" of the antenna (how the antenna would perform if it were elevated and pointed skyward). I have completed 6-meter EME contacts with many single-Yagi stations while the moon was in their second ground-gain lobe. In the example shown in figure 1, the second ground-gain lobe can be seen as having over 4 dB more gain, compared to the third lobe, and only about 1.5 dB less gain than the lower, "main" lobe. Actually, for a number of reasons (discussed below), the second ground-gain lobe sometimes even works better for EME than the main lobe.

The closer the antenna is to the ground (or some other object or antenna below the antenna that looks like ground), the higher the ground-gain lobes are raised. Conversely, the higher the antenna is above the ground, the lower the ground-gain lobes. Also, it is not unusual for an antenna that is only a few wavelengths high to have an excellent lower ground-gain lobe if the

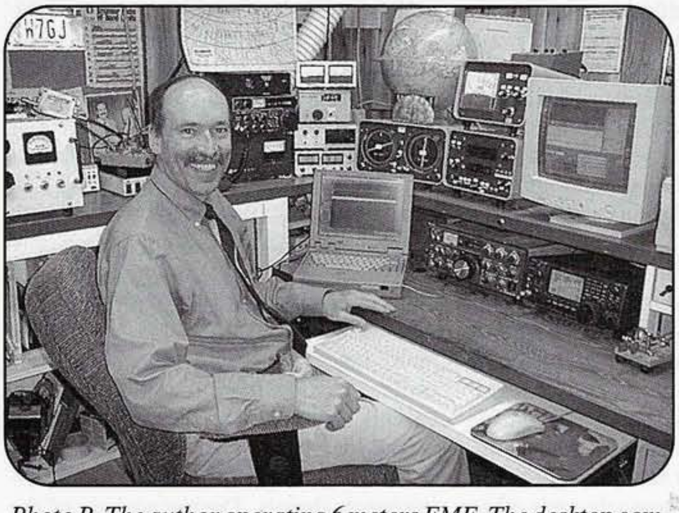


Photo B. The author operating 6 meters EME. The desktop computer monitor displays JT65, while the laptop monitors the receiver audio using Spectran.

distant horizon is actually a negative horizon. This situation frequently happens when a station is located on a hill, or the terrain is flat or dropping away in front of the antenna.

Beams that are stacked vertically only exhibit these same types of multiple ground-gain lobes when both antennas begin to approach the same height above ground. This usually means that the center of the stacked array has to be higher than four or five wavelengths above the ground to have these same kinds of strong, multiple ground-gain lobes. For antennas closer to the ground than that, each beam has ground-gain lobes at different elevations, so they cancel and/or "smear" into a single, broader ground-gain lobe. Figure 2 shows a typical vertical pattern for my 4-Yagi array centered at approximately 1.75 wavelengths above the ground.

You can see the advantage that a single Yagi offers for EME: The two very good ground-gain lobes offer twice as many chances for the moon to line up with a lobe while the antenna is aimed on the horizon. For an antenna that is used on the horizon, one single, long Yagi serves as an excellent EME antenna.

Conditions Affecting 6-Meter Moonbounce

Six meters is perhaps the worst and most unreliable band for EME because of all the things that can adversely affect the propagation at 50 MHz. You can easily understand why conditions may change rapidly, and success may result only after numerous failed attempts. Because signals are usually only marginal anyway, attempts at EME should be scheduled to try to avoid as many of these disruptive factors as possible. For that reason, most of the 6-meter EME activity happens during times when conditions appear to be most favorable, and people generally do not waste their time running schedules during poor conditions. Among these challenging conditions are the following:

Noise. One of the most common challenges faced by 6-meter operators, especially if they keep their antennas on the horizon, is local noise. Power-line noise, interference from strong local broadcast stations, industrial noise sources, automobiles, and household appliances (such as thermostats, motors, computers, etc.) all can make it difficult to hear weak signals. Ideally, attempts at EME should be scheduled when local noise is at its minimum.

Terrestrial Propagation. Aside from local noise, there are numerous types of phenomena in the atmosphere and the ionosphere that can interfere with 6-meter signals as they travel out to the moon and back again. Propagation, such as sporadic-*E*, *F2*, aurora, and a generally disturbed geomagnetic field (a high *Kp*-index or even a high *A*-index) all have been found to adversely affect 6-meter signals. Local temperature inversions can "trap" signals along the Earth, rather than allow them to head out toward the moon. Many of these adverse effects are difficult to predict in advance, while others can be avoided by selecting the correct time of day or by watching space and local weather forecasts. In many cases, elevating an antenna (or using the second ground-gain lobe on a single Yagi aimed at the horizon) will reduce these adverse effects by sending the signal through less atmosphere/ionosphere.

Extraterrestrial Propagation. Faraday rotation is rotation of the polarity of the signals as they pass through the ionosphere. Often the polarity repeats itself in about 15 minutes, but it can be "stuck" for long periods in which propagation will appear to be "one-way" or wrong for both stations. This is something that cannot be controlled or predicted, but needs to be anticipated.

Monthly Lunar Cycle. Perhaps the most predictable factors related to EME conditions involve those connected to the orbital motion of the moon. Every month the moon moves close to the Earth (perigee) and away from the Earth (apogee). The difference in signal-path loss between these two spots is over 2 dB, a very significant difference. On top of that, the moon also moves through quieter and noisier parts of the sky. At 6 meters, this background noise can be significant and can mask the weak signals you are trying to detect. The combination of these two factors, compared to the ideal situation of the moon being at perigee and in front of a quiet sky, is called the amount of *degradation.* An estimate of this degradation is shown on the JT65 screen, as well as in my TRACKER moontracking program.

Schedules

Currently, most 6-meter EME contacts are made by setting up schedules with other stations in advance. Because of the relatively small number of stations active at any given time and the various operating and propagation conditions that have to be taken into consideration, this usually seems to make the most sense. Schedules are usually set up via e-mail, or through dedicated real-time websites such as the JT44 EME page at <http://www.chris.org/jt44eme.htm>. Because almost all 6-meter EME activity uses the weak-signal JT65 mode, which does not tolerate QRM, most frequencies are agreed upon well in advance and frequencies with known or expected activity are avoided. In addition, there are other local band-use plans and government regulations that further restrict the use of digital modes and/or EME weak-signal operation, so a suitable frequency often must be coordinated in advance, depending upon each station's location.

Active Stations

With the advent of JT65 mode, there are a growing number of stations capable of operating 6-meter EME. Also, with the declining solar cycle, an increasing number of 6-meter DXpeditions are adding 6-meter EME to their toolkits. Over a third of my "Magic Band" countries have been worked using EME, and a couple of those—such as CY9DH and

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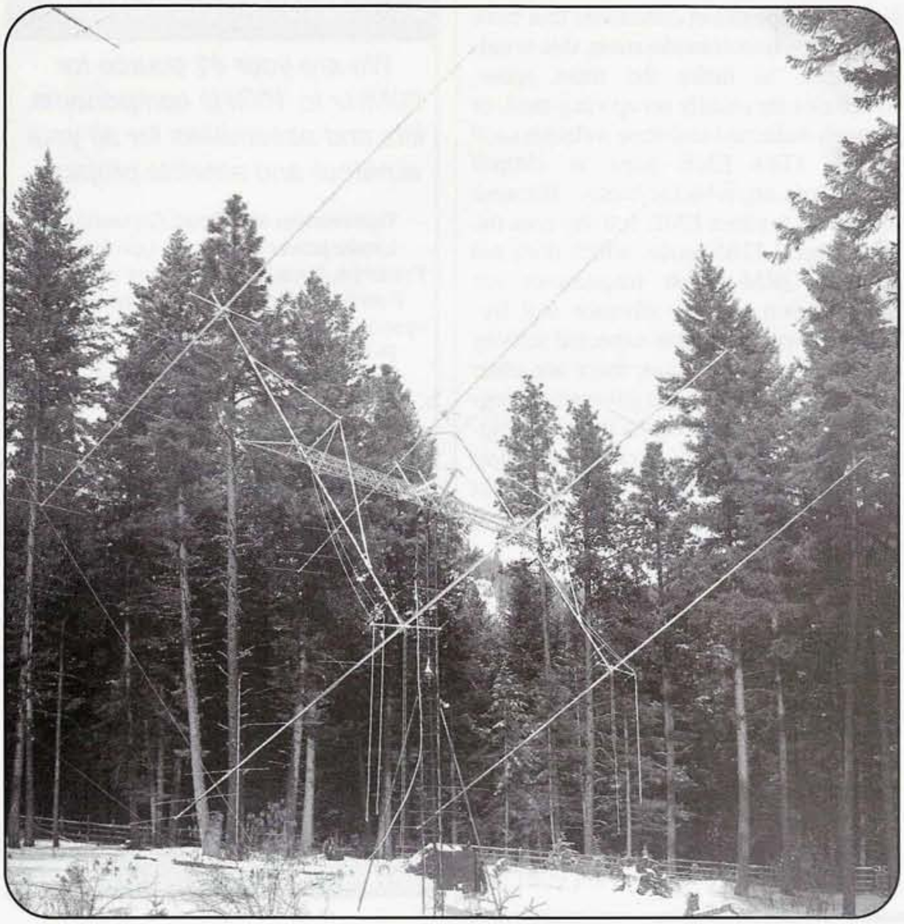

Photo C. The author (barely visible) standing at the base of his 4-Yagi 6-meter EME array, manually positioning the antenna after untying it.

ES8X—have been via 6-meter EME contacts with DXpeditions. With the recent regulation changes granting Japanese 6-meter operators permission to operate EME, there are now many very capable JA stations coming on the air. Currently, a few of the most active 6-meter EME stations in this country are KR7O, W1JJ, and WA4NJP. Overseas, consistently active stations include LY2BAW, ZS6NK, SM7BAE, MØBCG, PY1RO, JM1SZY, SP6GWB, and others. One way to find potential schedule partners is to watch for "spots" of stations (on internet 6-meter activity pages or on the OH Summit) being heard via the moon.

The First Step: Testing for Echoes

If you are interested in determining whether your station is capable of 6-meter moonbounce, you can start simply by listening for your own echoes. Just send a few dashes on CW when the moon is near the horizon passing through your ground-gain lobes, and see if you can hear your signals returning from the moon approximately 2.5 seconds later. Don't become too discouraged, however, if you don't hear them right away, or if they are not very consistent. As you can see from the above, there are many factors that will cause them to come and go. If you can detect your CW echoes, you most certainly can contact similar-size stations under similar conditions.

If you are set up for digital modes, the easiest way to test for echoes is to use the WSJT "EME ECHO MODE." Echo mode will automatically test for your echoes and display a record of precisely how strong they were.

Conclusion

Although 6-meter EME is very challenging and unpredictable, it is also very fulfilling and exciting when it works! For me, it is a very welcome alternative to terrestrial propagation, which comes along far less often out here in Montana. If you want to experience some real magic, consider giving 6-meter moonbounce a try. You just might be very pleasantly surprised at the DX you can work. See you on the moon! ■

Resources

The following are some links to provide a starting point for those interested in specifics regarding some of the subjects discussed in this article:

6-meter preamplifiers:
<http://www.hamtronics.com>
<http://www.lnatechnology.com/>

HF/6-meter KW power amplifiers:
<http://www.hfpower.com/new/a1000.htm>
<http://www.yaesu.com/indexVS.cfm?cmd=DisplayProducts&ProdCatID=102&encProdID=47ZAY%2Bq1XfE%3D&DivisionID=65&isArchived=0>
<http://www.icomamerica.com/amateur/amps/index.html>

Dedicated 6-meter power amplifiers:
<http://www.command1.com/products.htm>
<http://www.intertronicsolutions.com/amateur/>
<http://www.pollak.sulinet.hu/elektro/pa_rev/pa_rev.htm#high_vhf>

Computer-optimized antennas:
<http://www.m2inc.com/index2.html>
<http://www.tridentantennas.co.uk/Frames/Mainframe.htm>

Free moontracking program to calculate common window times and degradation:
<http://www.bigskyspaces.com/w7gj/tracker.htm>

Free JT65 digital communications program for weak-signal work:
<http://pulsar.princeton.edu/~joe/K1JT/>

Interface units between computer and radio to operate digital modes:
<http://www.westmountainradio.com/>

Free programs to display received audio spectrum:
<http://www.weaksignals.com/>

More information about 6-meter EME and using digital modes:
<http://www.bigskyspaces.com/w7gj/>
<http://www.on4ant.com/>

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Keys, Keys, Keys
by Dave Ingram, K4TWJ

You'll enjoy nostalgia with this visual celebration of amateur radio's favorite accessory. This book is full of pictures and historical insight.

Order No. KEYS $9.95

Understanding, Building & Using Baluns & Ununs
by Jerry Sevick, W2FMI

The successor to the popular and authoritative *Baluns and Ununs*. Great deal of new tutorial material, also includes new designs not in his previous book, and crystal clear explanations of howand why they work.

Order No. 2BU $19.95

Heathkit - A Guide to the Amateur Radio Products
by Chuck Penson, WA7ZZE

This greatly expanded Second Edition is a must for collectors and Ham history buffs, but is a terrific trip down memory lane for any Ham who was there or wishes he had been. Pick up this 328-page volume and you won't be able to put it down!

Order No. HEATHKIT $29.95

The Short Vertical Antenna and Ground Radial
by Jerry Sevick, W2FMI

This small but solid guide walks you through the design and installation of inexpensive, yet effective short HF vertical antennas. With antenna restrictions becoming a real problem, this book could keep you on the air!

Order No. SVERT $10.00

The Mobile DXer
by Dave Mangels, AC6WO

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McCoy on Antennas
by Lew McCoy, W1ICP

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Order No.MCCOY $15.95

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by W3ASK, N4XX & K6GKU

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AMSAT OSCAR-E Project Spring 2004 Status Report

This status report about AMSAT OSCAR-E ("Echo") is an update to the article in the Summer 2003 issue of *CQ VHF* and is being simultaneously published in the March/April 2004 issue of the *AMSAT Journal*.

By Richard M. Hambly,* W2GPS

This status report about AMSAT OSCAR-E ("Echo") is a companion article to the presentation given at the Maryland-DC area Annual AMSAT Meeting in March 2004 and to previous articles published in the *AMSAT Journal,*[1,2,3] the AMSAT *Proceedings,*[4] and *CQ VHF* magazine.[5,6,7]

The Latest News

On December 8, 2003, a team led by Jim White, WDØE, and Mike Kingery, KE4AZN, arrived at SpaceQuest in Fairfax, Virginia to begin the process of integrating Echo's various hardware and software subsystems. After two weeks of long hours and hard work, the team had the core systems working and had successfully tested much of the experimental hardware.

During January and February, the Echo integration team continued working with the designers of the flight and ground software, and with the developers of the S-band transmitter and the digital voice recorder to finalize Echo and get it ready for flight.

In mid-February, we received the news that the primary payload for our launch was experiencing delays, so the launch window has been pushed back to a two-month period beginning June 28, 2004. While disappointing, this will give us time to further refine the software and to get the experimental payloads installed and fully tested.

Operations and Capabilities

As has been reported in previous articles, Echo will offer a wide range of capabilities that will support interests from "EasySat" operations to scientific experiments. In anticipation of Echo's launch, an operations committee has been formed to determine the initial operating schedule for Echo after commissioning is complete. The initial proposed schedule is as follows, but keep in mind that this is preliminary and subject to change at any time.

Photo A. Project manager Dick Daniels, W4PUJ, watches over integration team leader Jim White, WDØE, at SpaceQuest on 18 December 2003.

FM voice repeater mode will be active all the time on one channel (exception, see experimenters' day below), 145.920-MHz uplink with 67-Hz PL tone and 435.225 MHz downlink, 1 watt minimum. This mode will use CTCSS keyed mode, which means that the transmitter comes on only when it hears a 67-Hz PL for one second or more and stays on for up to ten seconds after the tone disappears. The transmitter power is controlled automatically by software and may be as high as 6 watts output when sufficient DC power is available.

Digital mode will also be active all the time on one channel (exception, see experimenters' day below), 145.860 MHz uplink at 9600 baud, 435.150 MHz downlink also at 9600 baud. The transmitter will be set to 1 watt all the time. The software on the satellite will be set to run a store-and-forward bulletin-board system (BBS) using the callsigns PACB-11 for broadcast and PACB-12 for the BBS. Echo's digital mode is just like that of UO-22—a store-and-forward BBS using the PACSAT Protocol Suite. The digital downlink also will contain periodic real-time telemetry, and Echo's

*e-mail: <w2gps@amsat.org>

entire orbit data will be available in its file system for download. It is also possible that Echo will broadcast periodic APRS status messages.

Experimenters' day is every Wednesday (UTC). Any other mode that Echo is capable of implementing may be in use on Wednesday from about 0000 UTC to about 2359 UTC. Modes will be scheduled a week or more in advance. If no experiment is scheduled, Echo will be in the default experimental mode, which is digital operation using 1268.700-MHz uplink at 9600 baud and 2401.200-MHz downlink at 38,400 baud. We expect the most common other experimental modes to be Mode L/S FM voice and Mode L/S with 9600-baud uplink and 38,400- or 76,600-baud downlink.

There are many other possible modes that can be implemented by using Echo's various capabilities in creative combinations. As has been published before, Echo's capabilities include:

- Mode V/U, L/S, and HF/U operation. Modes V/S, L/U, and HF/S are also possible.
- Analog operation, including FM voice.
- Digital modes. Store-and-forward operation is planned. Many speeds are possible. but 9.6K, 38.4K, 57.6K, and 76.8K bps are the most likely.
- PSK-31 repeater mode using 10-meter SSB uplink and UHF FM downlink.
- Four VHF receivers and two UHF high-power 8-watt transmitters.
- Can be configured for simultaneous voice and data.
- Has a multi-band, multi-mode receiver.
- Can be configured with geographical personalities.
- Advanced power-management system.
- Digital Voice Recorder (DVR).
- Active magnetic attitude control.

Technical Review

Echo's internal subsystems have received some refinements since they were described in the last article (Summer 2003 *CQ VHF*). Thanks to Mike Kingery, KE4AZN, we now have a really useful block diagram for Echo, as shown in figure 1. There you will see that Echo is made up of:

- Four VHF receivers
- A multi-band multi-mode receiver (SQRX)
- Two UHF transmitters
- Six demodulators and two modulators
- RF switching, RF cabling, and phasing networks

Not shown in this diagram are:

- Integrated flight computer (IFC)
- Batteries, BCR, regulators
- Wiring harness

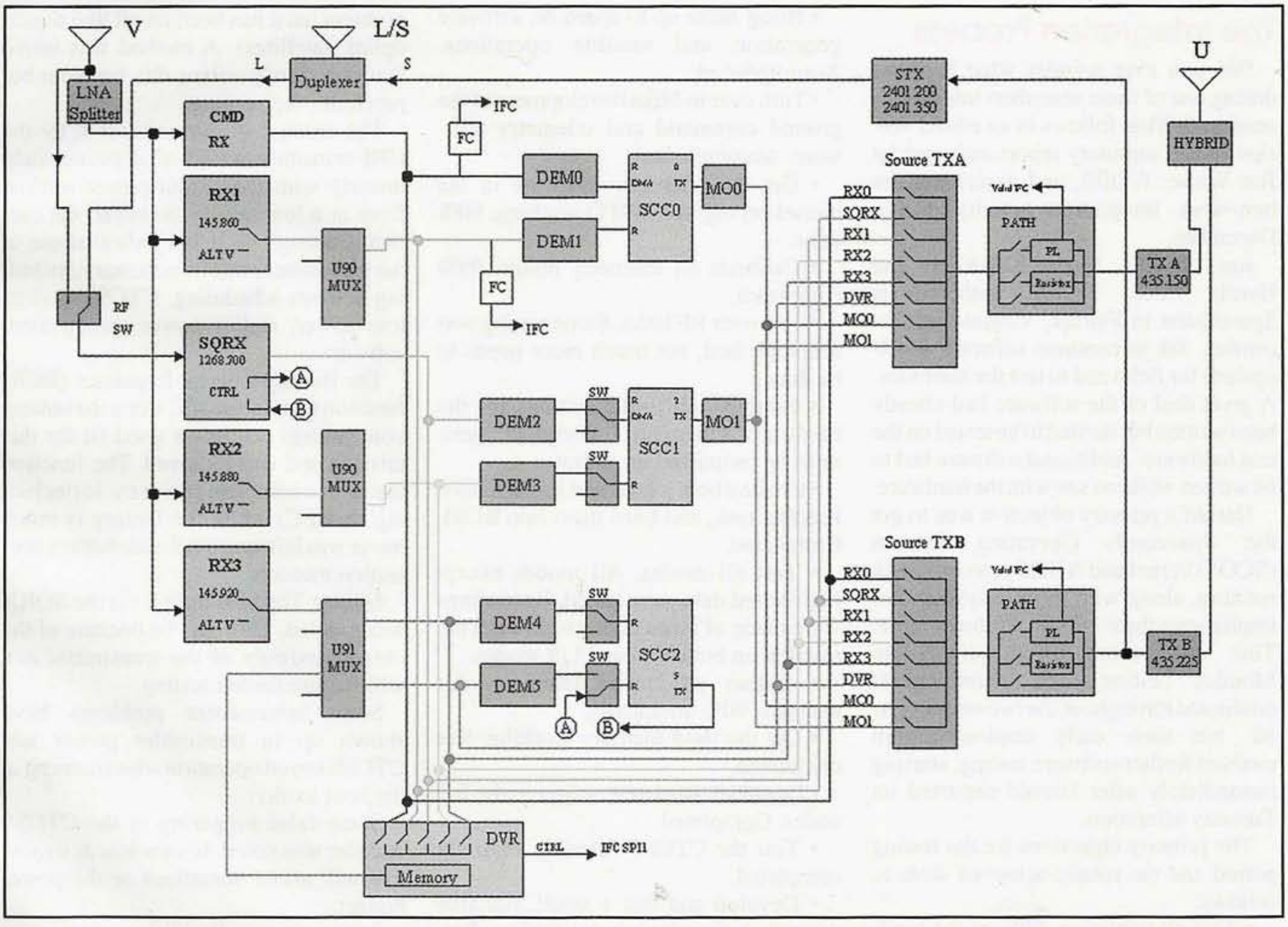

Figure 1. Echo block diagram by Mike Kingery, KE4AZN.

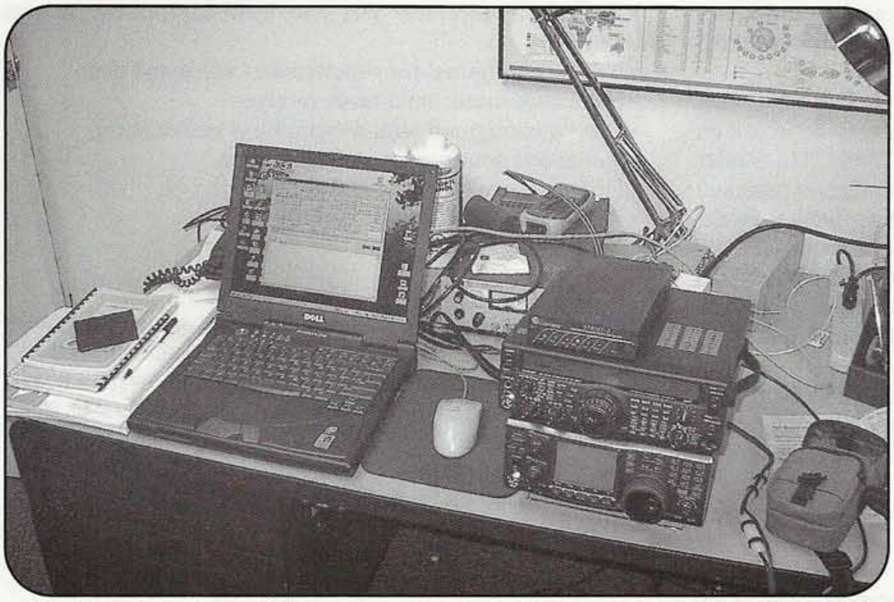

Photo B. This photo by Mike, KE4AZN, is of a satellite station set up at SpaceQuest for RF testing with Echo. There were great signals from across the room.

- 56 channels of telemetry
- Magnetic attitude control

The Integration Process

Did you ever wonder what happens during one of these marathon integration sessions? What follows is an edited version of the summary report authored by Jim White, WDØE, and describing the two-week integration activity during December.

Jim, WDØE, Mike, KE4AZN, and Harold Price, NK6K, gathered at SpaceQuest in Fairfax, Virginia on December 8th to continue software development for Echo and to test the hardware. A great deal of the software had already been written but needed to be tested on the real hardware. Additional software had to be written while on site with the hardware.

Harold's primary objective was to get the Spacecraft Operating System (SCOS) kernel and AX.25 protocol stack running, along with the file system that implements the PACSAT Protocol Suite. This was accomplished quickly on Monday. Testing on those components continued throughout the two-week period, but their early implementation enabled further software testing, starting immediately after Harold departed on Tuesday afternoon.

The primary objectives for the testing period and the results achieved were as follows:

- Test all hardware. 90% of the hardware was tested. Two minor problems were found and corrected. Some hardware remains untested because of lack of time or lack of software.
- Bring Mike up to speed on software generation and satellite operations. Accomplished.
- Turn over to Mike development of the ground command and telemetry software. Accomplished.
- Get the telemetry software in the housekeeping task (PHT) working. 90% done.
- Calibrate all telemetry points. 95% completed.
- Test over RF links. Some testing was accomplished, but much more needs to be done.
- Establish all initial settings for the hardware. Completed. Forty-six items must be initialized on startup.
- Create a boot loader and initial housekeeping task, and burn them into ROM. Completed.
- Test all modes. All modes except high-speed data were tested. Recordings were made of voice contacts through the satellite on both V/U and L/S modes.
- Gather pre-launch telemetry for analysis. 90% completed.
- Get the flash memory working. Not completed.
- Establish, burn, test, solder in the fire codes. Completed.
- Test the CTCSS filtering. Partially completed.
- Develop and test a small, portable ground station for remote testing. Partially completed.
- Test the Windows® version of the Ground Station program (ground end of the boot loader). Partially completed.

Important findings: The two downlink frequencies we initially chose were too close together for some operational modes. New operational frequencies were chosen and have been submitted for coordination. (These new frequencies are reflected in this article.)

With the exception of two small problems found and corrected, the hardware was rock solid.

We were able to add two jumpers to the Integrated Flight Computer (IFC) board to connect the "valid" tone signals from the CTCSS decoders to IFC I/O inputs. These can be sensed and used to activate the transmitters for FM repeater operation, if desired.

We made modifications to the IFC to move the SQRX receiver to the second SCC port that is equipped with DMA. This will facilitate high-speed digital uplinks, particularly on L-band.

A large number of interrupts from receivers hearing noise continues to be a problem (as it has been on all 9k6 digital uplink satellites). A method was tested that completely solves this problem but precludes digipeating.

The amount of current drawn by the UHF transmitters falls off approximately linearly with the output power setting. Even at a low setting, however, the current is enough such that judicious use of the transmitters will be necessary, including perhaps scheduling, CTCSS keying, low power, and/or power management software.

The Battery Control Regulator (BCR) function to reset the IFC when the battery voltage sags was not a good fit for this mission and was removed. The function that does a complete power cycle (including the IFC) when the battery is much lower was left in as a fail-safe battery protection measure.

Issues: The SSB uplink via the SQRX was garbled. This may be because of the close proximity of the transmitter and will require further testing.

Some intermittent problems have shown up in transmitter power and CTCSS keyed operation when running in the boot loader.

Some false triggering of the CTCSS decoder was noted. It's unclear as to how that will affect operations or the power budget.

Action items: Build the temperature decode software.

Test the RF links from a distance to get a more realistic test.

Perform calibration of torque-rod feedback, transmitter power output, transmitter current draw, SQRX speaker, received signal-strength indicator, BCR low-voltage line current, and 3.3-volt line current.

Fix the telemetry points that are not working.

Write and test torque-rod automatic control.

Test and integrate final S-band transmitter hardware and test/calibrate telemetry points.

Test battery management flight software.

Write and test the transmitter CTCSS triggered keying software.

Test high-speed data uplinks and downlinks.

Write and test BCR set point code.

Test SQRX 9600-baud uplink.

Glue on reflector cubes. These are part of a new experiment that will facilitate laser tracking.

Test for reported variation in transmitter output power from boot loader.

Write and test battery-current decode software.

Create the "final" telemetry list and publish the results so all users can decode Echo's telemetry.

Create a free telemetry decoder program and make it available to the users.

Obtain and test a fully developed Ground Station program from Skip.

Get more time on all the hardware.

Finish the command software.

Complete and test a small, portable digital ground station for remote testing.

Further test SSB up via SQRX.

Measure S-band power consumption.

Change the CTCSS decode tone, test.

Test the SQRX and VHF receiver-1 input lines and adjust the software (these lines had been switched).

Further test the digital uplinks without the frame search mode and with real antennas on the receivers.

An additional goal for Harold was to create software to utilize the flash memory for program storage.

Post-Integration Work

As this is written in mid-February, work continues on the Echo satellite. Action items are getting resolved and the satellite is working very well.

The CTCSS tone has been changed to 67 Hz to make it the same as SO-50. Jim implemented software that samples the "valid tone" line every second and keys the transmitter when it hears one. The hang time is 10 seconds. This is functionally equivalent to a terrestrial repeater with a kerchunk filter and a 10-second tail. This eliminates nearly all the false triggering that was seen during integration testing. Included in the advantages is that it will reduce power use.

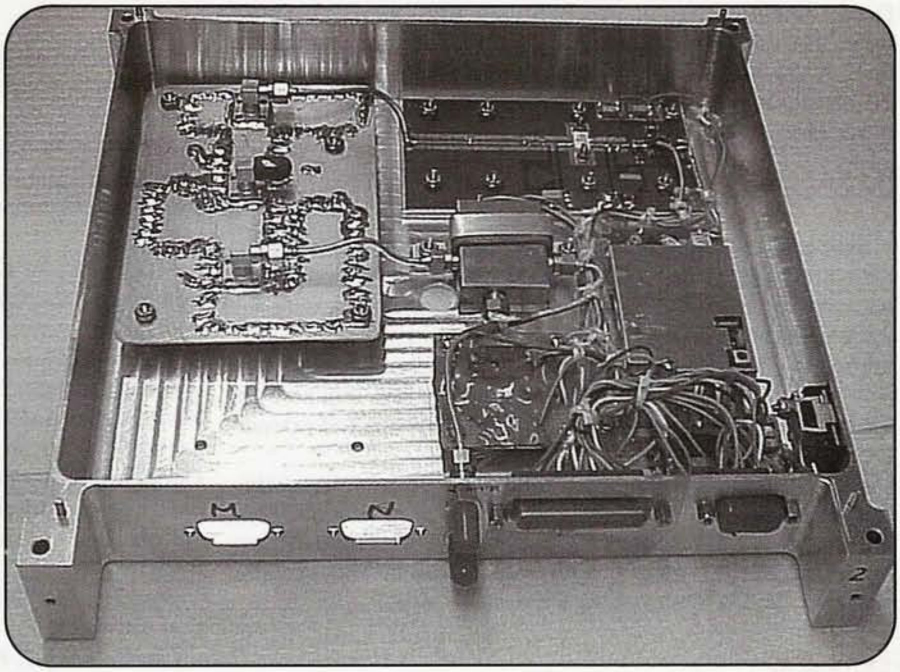

Photo C. Echo's S-band flight hardware. Chuck Schultz, KE4NNF, designed the exciter, and Harold Sanderson, KT4XK, designed the power amplifier. Lou McFadin, W5DID, mounted and wired the modules. (Photo by Stan Wood, WA4NFY)

Jim has found and eliminated several bugs in the flight software, mostly in the telemetry area.

An interaction between various modulator settings has been fixed. Each setting is now completely independent.

Mike has made significant improvements to the ground-station command software and has started on the telemetry decoder. He added the tricky code for the temperature calculations and it works fine. We should be able to release the telemetry definition preliminary file soon; it will be done through the Echo Operations Committee.

Stan reports that they are nearing completion on the final S-band flight hardware.

Skip completed the last of the features in the Ground Station program.

The HF/2-meter signal splitter, RF switch, and active FET preamp have been finished and installed. These support the use of the SQRX on both L-band and other bands, such as 10 meters.

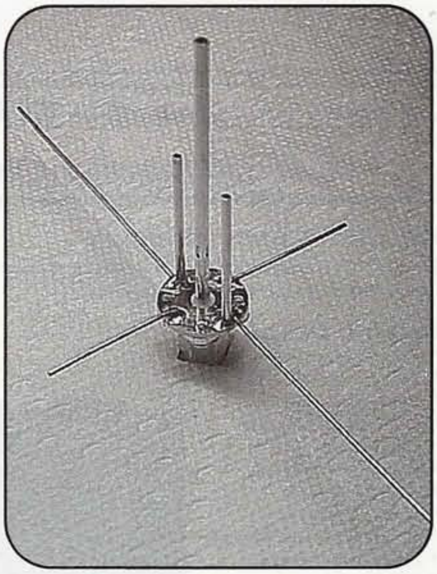

Photo D. Dual-band L-band and S-band antenna designed by Stan, WA4NFY.

The dual-band L/S antenna is finished. The L/S-band antenna is shown in photo D. It is an open-sleeve design and works like a quarter-wave stub on both bands. The center element works on L-band, while the two stubs work on S-band. The entire antenna mounts on a male SMA flange-mount connector. All parts are gold- or silver-plated brass. The screws are stainless steel. It looks like the radials on the L/S antenna will be 1/2 inch or more above the solar cells. As an additional precaution, SpaceQuest has decided to put cover glass on these cells.

Late-Breaking News

Stan has completed the design and construction of the splitter + preamplifier that will allow the 18-inch whip antenna to be shared by the SQRX multi-band receiver as well as with the 2-meter uplink receivers. On Saturday, February 14th, an integration fit check was performed successfully to ensure that this new module will fit into the receiver tray, as it is mounted on the bottom of the Echo's top cover, directly above and extending into the receiver tray.

On Thursday, February 19th, another fit check of the receiver tray was performed successfully, with all the modules this time, including the splitter + preamplifier and the Digital Voice Recorder (DVR), which is a multi-board stack. This was the first time the DVR was inside the receiver tray.

Launch

Echo's launch is now planned for summer 2004. The launch will be on a Dnepr LV (SS-18) rocket from the Baikonur Cosmodrome in Kazakhstan.

Volunteers

The following individuals deserve special recognition for their contributions and for their support during the integration phase of the Echo project:

Jim White, WDØE, for his technical contributions, for his leadership skills, and for the many hundreds of hours he has invested as the integration team leader. Jim's contribution cannot be overstated.

Mike Kingery, KE4AZN, for his on-site support of integration testing, including the loan of his satellite station, and for developing command and telemetry ground-station software.

The SpaceQuest team has provided great support, especially Mark Kanawati, N4TPY, and Dr. Dino Lorenzini, KC4YMG, who are also AMSAT members and volunteers.

Harold Price, NK6K, for his donation of the Spacecraft Operating System (SCOS) kernel and file system and for his on-site support during this effort.

Bob Diersing, N5AHD, for his timely work on the boot loader.

Skip Hansen, WB6YMH, for his efforts on the ground-station software.

Chuck Schultz, KE4NNF; Harold Sanderson, KT4XK; Lou McFadin, W5DID; and Stan Wood, WA4NFY, for their work on the S-band transmitter and L/S-band antenna system.

The AMSAT project management team for their assistance, especially Rick Hambly, W2GPS, and Dick Daniels, W4PUJ.

David Bern, W2LNX, for his assistance with the ground-station hardware.

Conclusion

AMSAT OSCAR-E (Echo) has continued to evolve and mature. Nearly all of its modules are built and undergoing testing. The software is working well and being refined. Initial system integration is complete and action items are being resolved. By this summer the Echo satellite should be in orbit, providing communications services to the ham community and serving as a platform for testing new concepts in space communications.

Notes

1. Rick Hambly, W2GPS, "AMSAT OSCAR E, A New LEO Satellite from AMSAT-NA," *AMSAT Journal,* May/June 2002, pp. 5–11.

2. Richard M. Hambly, W2GPS, "AMSAT OSCAR-E Project Status Update, A New LEO Satellite from AMSAT-NA," *AMSAT Journal,* November/December 2002, pp. 14–17.

3. Richard M. Hambly, W2GPS, "AMSAT OSCAR-E Project Summer 2003 Status Report," *AMSAT Journal,* July/August 2003, pp. 11–14.

4. Richard M. Hambly, W2GPS "AMSAT OSCAR-E Project Fall 2003 Status Report," *Proceedings of the AMSAT-NA 21st Space Symposium,* October 2003, pp. 70–78.

5. Rick Hambly, W2GPS, "AMSAT OSCAR E, A New LEO Satellite from AMSAT-NA," *CQ VHF* magazine, Summer 2002, pp. 13–20.

6. Richard M. Hambly, W2GPS, "AMSAT OSCAR-E Project Status Update, A New LEO Satellite from AMSAT-NA," *CQ VHF* magazine, Winter 2003, pp. 12–13, 72–74.

7. Richard M. Hambly, W2GPS, "AMSAT OSCAR-E Project Summer 2003 Status Report," *CQ VHF* magazine, Summer 2003, pp.14–16, 80–82. ■

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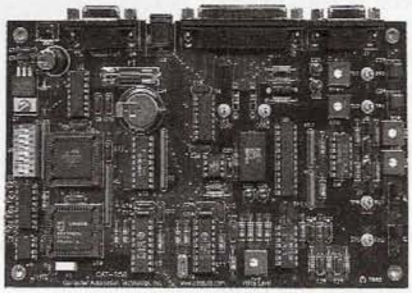

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New 2004-08 General Class Manual & Audio Course:

GORDON WEST REORGANIZES Q & A FOR LOGICAL LEARNING

The 2004-08 *General Class* study manual by Gordon West, WB6NOA, takes a new approach to presenting the Element 3 question pool. Rather than following the numerical order of the questions as released by the NCVEC Question Pool Committee, West has *reorganized the book into 35 logical topic groups* that will help students better understand real-world, HF amateur radio operating practices.

"The benefit of our reorganization is to help those upgrading to the worldwide bands to study the questions in a logical progression that builds their understanding of HF amateur radio operation," Gordon explains.

The new book includes all 431 Element 3 questions and answers as released by the Question Pool Committee. The material is valid from July 1, 2004, through June 30, 2008. Each of the questions and four possible answers is followed by "Gordo's" unique, upbeat description of the correct answer. *Key words are highlighted in blue* to aid learning. The book also *includes more than 150 addresses of helpful, educational websites.*

"When the Question Pool Committee added nearly 50 questions to the old General class question pool, the new Q & A's were simply dropped in, with many questions about specific subject areas separated and moved out of place from a logical teaching plan," Gordon comments. The reorganization of the entire General class question pool takes questions on similar topics and groups them together for faster, more meaningful learning.

Questions Follow Seminar Format

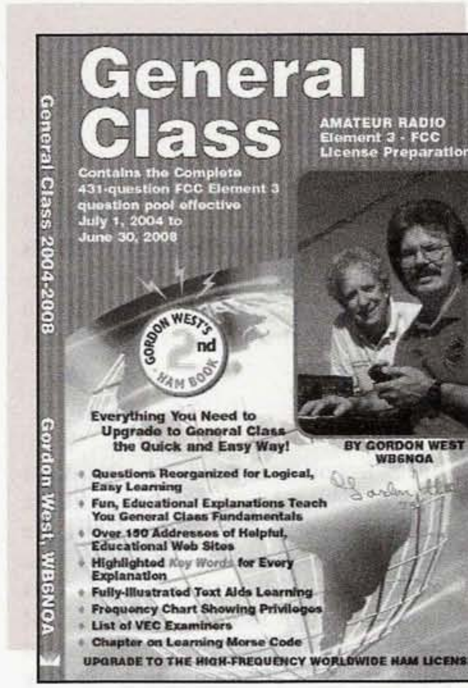
West is well known for the enthusiastic teaching methods he employs in his weekend amateur radio training classes. The progression of Q & A's laid out in his new *General Class* study manual parallels the order of how he teaches ham radio in his popular weekend, upgrade seminars. The grouping of similar questions into topic areas facilitates learning a specific subject that might be covered by 10 almost-the-same Q & A's scattered throughout the question pool. This unique reorganization of the entire pool also facilitates in seeing graphs, diagrams, and explanations all grouped in one subject area.

The 35 topic groups begin with the basics – "Your New Frequencies" and "Giving Ham Exams" – and progress through sections on electronics, radio wave propagation, repeaters, satellites, and end with questions on antenna and RF safety.

Another feature of the new book is the inclusion of more than 150 addresses of helpful, educational websites that encourage everyone studying the book to expand their knowledge of specific topics, such as satellite or repeater operations, or electronics. The Appendix includes a cross-reference of the entire question pool so instructors and others can easily find individual questions by their question number.

Audio Course & Software

In addition to his book, West also has recorded a new audio theory course for the 2004-08 General class question pool. The course is now on 4 audio CDs. Gordon's enthusiastic teaching style comes through on these CDs, which are full of the sounds of ham radio operations on-the-air. *"These CDs are really great for those upgrade ham applicants who spend a lot of time in their car or truck,"* he explains. The audio course follows the same order of Q&A's as presented in the study manual, and lets students listen in on various outtakes of various ham radio modes. The audio course is a great study companion to the *General Class* book, too.



Because new General Class operators will gain privileges on the high frequency bands, the audio theory course includes a special 15-minute segment on radio wave propagation. This "live radio" audio section takes the listener on a tour of the airwaves with the sounds of double-hop E-skip, long-haul F2 layer propagation, and other phenomena, including frequencies as high as 6 meters.

The W5YI Group, distributor of West's amateur and commercial radio study materials, also has new software to accompany Gordon's *General Class* book. The software allows students to study at their PC, take practice exams, and scores exams to show areas where they need further effort to master the material. Gordo's fun explanations of answers is included on the new software.

The new Gordon West *General Class* Element 3 study manual, audio course, and software and book package are available from all amateur radio dealers, and from **The W5YI Group on the web at www.w5yi.org or by calling 800-669-9594.**

Instructors and clubs that offer General class courses are invited to register with W5YI by sending an e-mail to instructors@w5yi.org. W5YI will post a listing of your club's class dates and location on its web site so that potential students will know where and when classes are being offered. In addition, free teaching aids including band plan posters, frequency charts and wall maps, along with special manufacturer promotional discounts on radios for students, and other free information is available through W5YI Group.

The Frontlines: HSMM

Part 2 – Developments in Amateur Radio

One of the major advantages of operating 802.11 under Part 97 rather than Part 15 regulations is the feasibility of operating legally with more RF power output and larger, high-gain directive antennas.

By John Champa,* K8OCL

In the Winter 2004 issue of *CQ VHF* we reviewed some of the many current and proposed applications of High Speed Multi-Media (HSMM) radio networking. Let's now move on to examine the operational aspects of the HSMM state-of-the-art.

HSMM Area Survey

It is important to find out what other users of the band, both licensed amateurs and unlicensed (Part 15) stations are doing in your area before designing your community HSMM radio network. This would be tough to do on 2 meters FM using a simple scanner receiver, as most repeaters are not transmitting most of the time. However, on HSMM it is very simple! All active repeaters (APs) are constantly sending out a beacon known commercially as the ESSID. In HSMM practice this is simply the ham station callsign (and perhaps club name) entered into the software configuration supplied with the CD that comes with the repeater. Thus, every HSMM repeater is also a continuous beacon.

As a minimum evaluation, a simple local area survey using free NetStumbler software (http://www.netstumbler.com/index.php) downloaded and running on your laptop PC should be conducted. Connect one of the popular 2.4-GHz mobile magnetic-mount vertical antennas to a pigtail. Connect the pigtail to your radio interface card, or RIC (that is the wireless PCMCIA card with external antenna port[s] which can be purchased at most office-supply stores for about $80). Insert the RIC into the laptop (after loading its software), and the laptop into your dashboard power plug. You can also interface your GPS with mapping software into your laptop so as to provide a map of the area signal sources (see samples in the following links: <http://www.techtv.com/news/internet/story/0,24195,3398350,00.html> and <http://www.windley.com/2002/09/02.html>).

Drive around your community. Better yet, let your XYL or ham friend operate the vehicle while you operate the HSMM area survey gear. That is a safer approach. This methodology will at least identify and automatically log what other 802.11 station activity is in your area. Note that when planning your HSMM operating, even moving two to three channels away from such activity may not be sufficient to avoid interference, especially if you are running what in HSMM is considered high power (typically 1800 mw RF output). You may want to use a different polarization with your antenna system. For example, many HSMM stations use horizontal polarization, because much WLAN activity is vertically polarized.

If you have access to a private aircraft, you might even try doing the area survey from the air! As mentioned in the previous article, many HSMM radio amateurs use 446.00-MHz FM for voice coordination, but any clear FM simplex channel will work for this purpose.

HSMM Radio Antennas

Horizontal Polarization: As mentioned previously, most of the unlicensed implementations of 802.11 equipment use vertically polarized antennas, so in many locations amateurs may find that the use of horizontally polarized antennas is helpful in avoiding interaction. Again, an HSMM area survey is highly recommended.

Space Diversity: Another aspect of HSMM antenna design that warrants further amateur radio experimentation is space diversity. Some APs already have this capability built in; it simply is seldom used on outdoor links. The APs come with two rubber-ducky antennas and two antenna ports, a primary and secondary. Which signal input is used depends on which antenna is providing the best signal-to-noise (S/N) ratio at the specific instant. Experimentation using two outside high-gain antennas spaced ten or more wavelengths apart may be worthwhile in improving data throughput on long links, which tend to experience more multi-path signal distortion. This multipath effect is caused by multiple signal reflections off various objects in the path of the linking signal. The use of space-diversity techniques may help ameliorate this effect and improve the data rate on the link.

Circular Polarization: One would think that two OSCAR-40 stations with patch-fed circularly polarized antennas on 2.4 GHz and in close proximity to one another would be in an excellent position to experiment with circular polarization using HSMM techniques. However, most OSCAR-40 stations have a good deal of non-related electronics at or near the feed point of their 2.4-GHz downlink antenna, such as one-way low-noise receive pre-amplifiers, 2.4-GHz to 144-MHz receive converters, etc., which make them unsuitable for such testing without some extensive rewiring or switching. Nonetheless, the use of circular polarization created by the same means (see below) at both ends of the

*Chairman of the ARRL Technology Task Force on High Speed Multimedia (HSMM) Radio Networking; Moon Wolf Spring, 2491 Itsell Road, Howell, MI 48843-6458
e-mail: <k8ocl@arrl.net>*

link, and its ability to enhance propagation of HSMM radio signals, warrants further study by radio amateurs.

Mixed Antenna Design Problem: This is the possibility of a unique situation when using HSMM radio with certain antennas which requires more amateur radio study. It is often thought that as long as both antennas at the ends of an HSMM radio link are of broad-bandwidth design (the HSMM signal is 22 MHz wide) and of the same polarization (usually horizontal) then this is acceptable and all is okay. While this may be true for other wide signals, such as analog ATV VSB (vestigial sideband) signals or analog ATV-FM signals, it may not be true with even more broad-bandwidth high-speed digital signals. Some evidence seems to indicate that, for example, the use of a horizontally polarized dish antenna with a dipole feedpoint at one end of the link and the use of a horizontally polarized long loop Yagi at the other end (again both broad-bandwidth antennas and both horizontally polarized) may nonetheless introduce a problem (higher BER, or bit error rate) because of symbol errors caused by the manner in which each antenna manipulates the radio-signal wave front. Again, further radio amateur experimentation with HSMM radio signals is warranted to determine the impact of using mixed antenna types on the radio link.

Running Higher Power

One of the major advantages of operating 802.11 under amateur radio Part 97 regulations rather than unlicensed Part 15 regulations is the feasibility of legally operating with more RF power output and larger, high-gain directive antennas to further increase the effective radiated power (ERP). Using the minimum power necessary for communications has always been a good operating-practice guideline for hams. However, the use of higher ERP makes for more robust signal margins, which may be required to achieve certain emergency communications objectives.

Using higher output power in HSMM radio, especially on the shared 2.4-GHz band, is also a last resort for other reasons. Amateurs should try using more directional and higher gain antennas instead of running more power output whenever more robust links are required for EmComm operations in support of RACES, ARES, etc. It is best to run the minimum power needed to maintain the communications, and we also must be considerate of others who may be using the band, both amateur and non-amateur. Use only the minimum power needed for the link.

If the HSMM radio link analysis (see the link calculations portion of <www.arrl.org/hsmm/> or go to <http://logidac.com/gfk/80211link/pathAnalysis.html>) clearly indicates that additional power is required, then what may be needed is a bi-directional amplifier (BDA). This is a super-fast switching pre-amplifier/amplifier combination that is usually mounted at the end of the antenna pigtail near the top of the tower or mast. A reasonably priced 2.4-GHz, 1800-mw output BDA is available from the FAB Corporation (www.fab-corp.com). It is designed specifically for HSMM microwave amateur radio experimenters. (*Note:* Be certain to specify "HSMM" when placing your order!) This additional power output should be sufficient for nearly all amateur operations, even those supporting EmComm which may require more robust signal margins than normally needed by amateurs. Please note that because of strict Part 15 regulations prohibiting the use of such devices by unlicensed individuals, a copy of your amateur license may be required when placing your order and the shipment may only be made to your license address in the FCC database.

Other High-Power Considerations: When using a BDA and operating at higher than normal power levels on some of the lower channels in the 2–5 channel range (these channels are arbitrary channels for Part 15 operation and are not required for amateur radio use, but they are hard-wired into the gear, so we are stuck with them), if your station is next door to an OSCAR 40 station, you may need to take extra steps in order to avoid interfering with the weak downlink signal from the satellite. Even when totally avoiding the use of channel 1 (center frequency of 2412 MHz ±11 MHz), 802.11 does have signal sidebands. The use of an output filter may be required to avoid causing QRM to the amateur satellite downlink. On the other hand, when operating in the upper channels in the 2–5 channel range and using high power, some of your sidebands may go outside the amateur band, which stops at 2450 MHz. From a practical point of view, whenever using a BDA, it is good practice to install a tuned filter on the BDA

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output. Such filters are not expensive and they are readily available from commercial sources.

In addition, if interference to the OSCAR-40 downlink station is a problem, keep in mind that the hours of OSCAR-40 availability can readily be predicted and a cooperative schedule of operating can be developed. Amateurs living close by frequently do this type of coordination on the HF bands. Again, an inexpensive low-power transceiver left on continuously and monitoring 446.00-MHz FM simplex is a handy approach to facilitate such HSMM coordination.

There is one further point to consider: Depending on what other 802.11 operating may be taking place in your area, it may be practical to only run higher power when using highly directional antennas which allow operating over and around the Part 15 activity in your area. Before considering running higher power, again, it is highly recommended that an area site survey be conducted using a mobile HSMM rig (laptop + RIC + pigtail + 2.4-GHz magnetic-mount antenna) running NetStumbler software (www.netstumbler.com) or other wireless sniffing software. This area survey will allow you to determine what 802.11 activity is in your area and what channels are being used and at what ranges from your station. This information will help you avoid any interaction with them.

Information Security

When operating HSMM radio, your station and your computer become one single device, much as in the case of software-defined radio (SDR). Amateurs in general are the finest folks you might ever meet, but there are a few exceptions. Plus, there are others who are not amateurs who may try to hack into your HSMM station. Thus, each HSMM station (PC + RIC), as is the case with any PC used to surf the Internet, should be equipped with an *anti-virus program* that is updated regularly. Reasonably priced anti-virus programs are readily available from number of sources.

It is very important is to use a *firewall* software program on your HSMM radio station PC. We recommend that it be configured to allow all outgoing traffic, but to restrict all incoming traffic without specific authorization. Commercial personal firewall products are available from Symantec®, ZoneLabs®, and McAfee Network Associates®. Here is a link to a list of freeware personal firewalls: <http://www.webattack.com/freeware/security/fwfirewall.shtml>. A list of shareware personal firewalls may be found at: <http://www.webattack.com/Shareware/security/swfirewall.shtml>.

HSMM Microwave Radio Frequencies

What frequency do you set on the AP?

Where *not* to go: The HSMM Working Group (WG) recommends to everyone—all users, both licensed and unlicensed—that they avoid using channel 1 (center frequency of 2412 MHz). Use of this channel may cause interference to the AMSAT OSCAR-40 satellite downlinks in the immediate area.

The WG also recommends that amateur radio stations avoid the use of channel 6 (center frequency of 2437 MHz). This is the most common default frequency used by the majority (>80+ %) of Part 15 unlicensed stations for wireless local area networks (WLAN). Although the center frequency of channel 7 (2442 MHz) is within the amateur band, remember that 802.11 spread-spectrum modes are 22 MHz wide, so part of the signal would fall outside the amateur band.

At present, that leaves channels 2, 3, 4, and 5 as acceptable for amateur radio HSMM experiments. Which specific channel you select depends on other activities in your area. You need to consider OSCAR-40 stations, FM-ATV, WISP (wireless internet service providers), your neighbor's WLAN, and others users of this shared band. The most popular frequency used by U.S. amateur radio microwave stations for HSMM research is 2427 MHz (channel 4). However, keep in mind that the spread-spectrum signals are 22 MHz wide. This does not include the sidebands, which are considerable. Most of the inexpensive 802.11 gear is unfiltered, so it has rather considerable sidebands. If you live in the country, this may not make any difference. However, if you live in a congested urban area, you need to remember that while the channels are only 5 MHz apart, the channel signal with its sidebands is much wider. Again, an area survey prior to starting up is highly recommended. Find out what other users of the band are in your area. As mentioned previously, because of the sidebands associated with unfiltered spread spectrum, even moving to channel 4 may not guarantee that you don't QRM your OSCAR-40 neighbor, so you may also need an output filter. If you don't have access to a spectrum analyzer for your area survey, then at least do an area survey using an appropriate RIC, your best directional antenna, and NetStumbler software, as described previously, before choosing an operating channel.

HSMM on the 900-MHz, and 3.5- and 5-GHz Ham Bands

Now available are relatively inexpensive commercial converters and amplifiers which will convert 802.11 signals on 2.4 GHz to the amateur 900-MHz and 3.5-GHz bands (see: <http://www.teletronics.com/tii/products/udc/udc_table.html>).

The 900 MHz amateur band (see the PDF on the RFLinx website <http://tinyurl.com/vtx6> for details) should offer ranges and signal propagation more similar to what hams experience on the 440-MHz band. However, the 900-MHz amateur band provides only one channel, but at least it is away from the vast majority of Part 15 traffic. This may be the best band to use to provide inter-city links on the Hinternet. Comtelco® is one source of 900-MHz antennas (http://www.comtelcoantennas.com/index.htm). Again, more HSMM radio amateur experimentation is warranted.

The 3.5-GHz amateur band will get HSMM entirely out of the frequency range of all Part 15 traffic, but should have similar ranges and signal propagation when compared to the 2.4-GHz band. Again, further HSMM radio amateur experimentation on this band is encouraged.

The 5.0-GHz amateur band may be a good band to use for HSMM in some areas. There will be significantly less Part 15 traffic on this band, but ranges may be slightly less than on 2.4 GHz.

In Part 3 (Hinternet Infrastructure) of this series we will discuss some other considerations in HSMM radio:

- Proposed HSMM Network Infrastructure
- HSMM Interface with ICOM D-STAR systems
- Recommendations

For complete details on the many sources and types of inexpensive gear and antennas to get started in HSMM radio, see *How To Get Into HSMM,* pp. 30–36 in the Fall 2003 issue of *CQ VHF,* and check out <http://www.arrl.org/hsmm/>.

QUARTERLY CALENDAR OF EVENTS

Contests

Spring Sprints: These short-duration (usually four hours) VHF+ contests are held on various dates (for each band) during the months of April and May. May's dates and times are as follows: Microwave, May 1, 6 AM to 1 PM local time; and 50 MHz, May 8, 2300 UTC Saturday to 0300 UTC Sunday. Sponsored by the East Tennessee Valley DX Association, information on these contests can be found on their website at <http://www.etdxa.org>. Click on the VHF/UHF link to get to the contest information.

The **2 GHz and Up World Wide Club Contest**: Sponsored by the San Bernardino Microwave Society, this contest runs from 6 AM on May 1 to 12 midnight on May 2 (36 hours). The object is for worldwide club groups of amateurs to work as many amateur stations in as many different locations as possible in the world on bands from 2 GHz through Light. Rules are available at: <http://www.ham-radio.com/sbms/club_contest/2GHzUp.pdf>.

The **Six Meters Marathon 2004** is open to all amateur radio operators worldwide. The objective is to work as many DXCC entities as possible on 6 meters between 8 May (0000 UTC) and 8 August (2400 UTC). The results will be updated continuously at <http://www.50mc.tk>. For further information, contact Hannu Saila, OH3WW, e-mail: <marathon@saila.org>.

Six Club Contest: The Major Six Club Contest will be the first weekend in June, from 2300 UTC, June 4 to 0200 UTC, June 7. All logs are due 30 days from ending date of the contest and they go to <w4wrl@aol.com>. For further information see: <http://6mt.com/contest.htm>.

ARRL June VHF QSO Party: The dates for this contest are June 12–14. Complete rules are in the May issue of *QST*. Rules can also be found on the ARRL website (http://www.arrl.org). Many are making plans to activate rare grids. For the latest information on grid expeditions, check the VHF reflector (vhf@w6yx.stanford.edu) on the internet. For weeks in the run-up to the contest postings are made on the VHF reflector announcing rover operations and grid expeditions. It is a contest that will create for you plenty of opportunities to introduce the hobby to your friends who are not presently working the VHF-plus bands or are not hams.

SMIRK Contest: The SMIRK 2002 QSO Party, sponsored by the Six Meter International Radio Klub, will be held from 0000 UTC June 19 until 2400 UTC June 20. 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. Exchange SMIRK number and grid square. Score 2 points per QSO with SMIRK members and 1 point per QSO with nonmembers. Multiply points times grid squares for final score. Awards are given for the top scorer in each ARRL section and country. Send a legal-sized SASE for a copy of the log forms. Log requests and logs should be sent to Pat Rose, W5OZI. Send entries by August 1 to Pat, P.O. Box 393, Junction, TX 76849-0393. For more information see: <http://www.smirk.org>.

Quarterly Calendar

May 2	Moderate EME conditions
May 4	Full Moon
May 6	Moon Perigee
May 9	Very Poor EME conditions
May 11	Last Quarter Moon
May 16	Moderate EME conditions
May 19	New Moon
May 21	Moon Apogee
May 23	Poor EME conditions
May 27	First Quarter Moon
May 30	Moderate EME conditions
June 3	Moon Perigee and Full Moon
June 6	Moderate EME conditions
June 9	Last Quarter Moon
June 13	Poor EME conditions
June 17	Moon Apogee and New Moon
June 20	Moderate EME conditions
June 25	First Quarter Moon
June 27	Moderate EME conditions
July 1	Moon Perigee
July 2	Full Moon
July 4	Moderate EME conditions
July 9	Last Quarter Moon
July 11	Poor EME conditions
July 14	Moon Apogee
July 17	New Moon
July 18	Moderate EME conditions
July 25	First Quarter Moon. Moderate EME conditions
July 30	Moon Perigee
July 31	Full Moon
Aug. 1	Moderate EME conditions
Aug. 7	Last Quarter Moon
Aug. 8	Poor EME conditions
Aug. 11	Moon Apogee
Aug. 15	Good EME conditions
Aug. 16	New Moon
Aug. 22	Moderate EME conditions
Aug. 23	First Quarter Moon
Aug. 27	Moon Perigee
Aug. 29	Moderate EME conditions
Aug. 30	Full Moon

—EME conditions courtesy W5LUU

Field Day: ARRL's classic, Field Day, will be held on June 26–27. Complete rules for this contest can also be found in *QST* and at: <http://www. arrl.org>. In years past tremendous European openings have occurred on 6 meters. Also, as happened in 1998, great sporadic-*E* openings can occur. Certainly, this is one of the best club-related events to involve new people in the hobby.

CQ WW VHF Contest: This year's CQ WW VHF Contest will be held from 1800 UTC July 17 to 2100 UTC July 18. Complete rules can be found elsewhere in this issue.

The **Mid Summer Six Club Contest** will be held between 2300 UTC, July 16 and 0300 UTC, July 18. All logs are due 30 days from ending date of the contest and they go to <w4wrl@aol.com>. For more information go to: <http://6mt.com/contest.htm>.

There are two important contestsin August: The **ARRL UHF and Above Contest** is scheduled for 7–8 August. The first weekend of the **ARRL 10 GHz** and above cumulative contest is scheduled for August 21–22. The second weekend is September 18–19. Complete rules for these contests can be found in the July issue of *QST*, or on the web:<www.arrl.org>.

Conventions and Conferences

Dayton Hamvention®: This year's Dayton Hamvention® will be held as usual at the Hara Arena in Dayton, Ohio, May 14–164. For more information, go tot <http://www.hamvention.org>. N6CL is scheduled to be one of the speakers for the VHF forums.

Ham-Com: The annual Ham-Com Hamfest will be held June 18–19, in Arlington, TX. As always, the North Texas Microwave Society will present a microwave forum. For more information, see the Ham-Com website at <http://www.hamcom.org>/.

This year's **Central States VHF Society Conference** will be held in Mississauga (Toronto), Ontario, Canada, July 22–25, at the Delta Meadowvale Resort and Conference Centre. For more information, go to: <http://www.csvhfs.org>.

The 11th **International EME Conference** will be held on the campus of the College of New Jersey, in Ewing, NJ, August 6–8. For more information, see: <http://www.qsl.net/eme2004/>.

The 2004 **TAPR/ARRL Digital Communications Conference** will be held September 10–12 at the Airport Holiday Inn in Des Moines, Iowa. You'll find more conference information on the web at <http://www.tapr.org/dcc/>.

Calls for Papers

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

The 38th annual **Central States VHF Society Conference** will be held July 22–25 at the Delta Meadowvale Resort and Conference Centre in Mississauga (Toronto), Ontario, Canada. The deadline for submitting final papers is May 1. Submit your proposal as soon as possible to Bob Morton, Technical Chairman and V.P., at <ve3bfm@ csvhfs.org>.

The 11th **International EME Conference** will be held on the campus of the College of New Jersey, in Ewing, NJ, August 6—8. Submit your proposed paper/talk topic as soon as possible to Marc Franco, N2UO, at <eme2004@qsl.net>.

The 2004 **TAPR/ARRL Digital Communications Conference** will be held September

(Continued on page 73)

Introducing:

The Sporadic-*E* Files

In part one of this series, WB2AMU explains the *E*-region reservoir and the transport theory of sporadic-*E*.

By Ken Neubeck,* WB2AMU

No matter how you look at it, sporadic-*E* is the major VHF propagation mode for much of the world. However, while it is extremely important for hams on 6 and 2 meters and occasionally on 220 MHz, it is probably the most misunderstood mode and the one about which many myths are circulated.

It is important to first understand that sporadic-*E* is not a single phenomenon, but rather is a collection of individual phenomena that contribute to the overall complex phenomenon. It thus would be of benefit to list the known facts that have been determined through radio observations, as well as the scientific studies that have taken place over the course of the past decades. The vehicle to cover this topic will be a series of articles in *CQ VHF,* each of which will discuss a particular aspect of sporadic-*E* along with the facts that have been determined concerning the specific aspect covered.

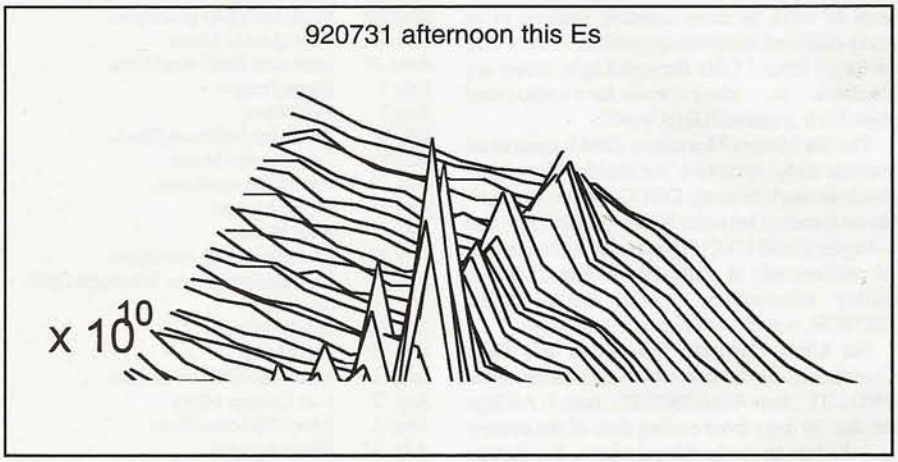

*Figure 1. This plot of a sporadic-*E *formation during July of 1992 was made in northern Europe using EISCAT radar. It can be seen that the thin sporadic-*E *layer is descending toward the 100-km mark due to tidal forces. (Plot courtesy of Dr. S. Kirkwood)*

The Basic Behavior of Sporadic-*E*

Before we discuss the transport theory of sporadic-*E* in this initial article, we will provide a simple overview of the basic behavior of the phenomenon as observed by hams on the VHF bands.

For the temperate zones of the Earth, sporadic-*E* has two seasons, a major summer season and a minor winter season. They are separated by significant absence of the phenomenon during the spring and fall equinox. For stations in the northern temperate zone, the summer season starts around May 1st and ends more or less around mid-August. During some parts of June and July, sporadic-*E* may appear as a daily event, usually lasting for several hours. The winter season is less distinct as far as specific start and end dates, but generally it appears on an occasional basis in late October and lasts through mid-January. It is the major propagation mode for 6 meters during these time periods and also sometimes for 2 meters. The mode makes for lots of fun on these VHF bands during the summer months, as has been documented in *CQ VHF* over the past several years!

Sporadic-*E* has been of intense interest to the scientific community as well as hams. In 1962 Ernest K. Smith and Matsushita published the book *Ionospheric Sporadic-E* (Pergamon Press), which was dedicated entirely to the phenomenon. Dr. Smith had previous experience with this phenomenon; his doctoral thesis, published during the late 1950s, was entitled "World Occurrence of Sporadic-*E*." Both works remain a valuable starting point for someone first studying the phenomenon. However, it is important to realize that much of the data at that time was collected by ionosondes (or sounding stations) and radio observations, the best that could be accomplished at the time. Since then significant data has been collected through the use of rocket probes sent into the ionosphere, as well as EISCAT radar plots. Figure 1 is an example of an EISCAT plot.

Many elements are responsible for the formation of sporadic-*E*. These include metallic ions, wind shear, tidal waves, oxygen ion levels (at a height of 80 to 100

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

km above Earth), and geomagnetic coefficient (the difference between geographic areas). To put it simply, sporadic-*E* is a very complex natural phenomenon in addition to a complex mode of radio propagation.

The *E*-Region Reservoir and the Transport Theory

The effects of wind shear and the discovery of metallic particles in the *E*-region have been documented in many papers on sporadic-*E*, dating back to the 1960s. In this article, we are going to concentrate on some aspects of the current theory of sporadic-*E* formation that scientists are supporting.

In recent years, major observations made using radar have provided some important clues as to the movement of sporadic-*E* ions in the *E*-region. Many of these observations were made at the higher latitudes, where upward-moving sporadic-*E* layers have actually been reported by a number of authors using the EISCAT radar setups at Tromso and the Sodrestrom facilities in northern Europe. Based on these observations, an empirical model describing the vertical transport of sporadic-*E* ions into the *F*-layer and over the geomagnetic poles was developed by scientists Bedly and Watkins (presented in a 1997 paper).

The basic model states that at the higher latitudes those sporadic-*E* ions which are not neutralized or oxidized at the 90-km level (the top part of the *D*-region) are transported upward via prevailing ionospheric winds along with field lines. Typically, these ions travel in a northeasterly direction toward the geomagnetic pole. The ions reach the *F*-layer over the pole and then descend to the nighttime *E*-region on the other side. The model assumes no impediment along the path of the *Es* ions as they travel toward the polar *F*-layer.

Indeed, this model for the higher latitudes could very well explain many of the sporadic-*E* occurrences for the lower latitudes of the temperate zone. In the region of 80 to 100 km above Earth there are resident O_2^+ and NO^+ molecules. Sporadic-*E* ions are "made" when the neutral-charged metals from meteor ablation are ionized through a charge exchange or recombination process with these resident molecules. If these metal ions are in an atomic state, they can be re-ionized and lifted back into higher portions of the ionosphere to be part of the *E*-region metal ion reservoir. Those metal particles which remain neutral or become oxidized eventually will fall out of the ionosphere and toward the Earth.

The model would explain why sporadic-*E* is predominant during the summer rather than the winter months. At the 90-km mark and below, the level of atomic oxygen is lower during the winter months due to lack of production by solar radiation. Thus, during the winter the rate of neutralization or oxidation is increased, and there are fewer ions formed through recombination and available to be transported back into the *E*-region reservoir. The opposite effect takes place during the summer, when there is more atomic oxygen available for recombination at 90 km. Thus, the *E*-region reservoir of metal ions is predominant during the summer and is capable of providing ions for the production of many *Es* formations.

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It is also likely that there is a daily pattern involving changes in the oxygen level at the 90-km height which causes the two peaks of sporadic-*E* (mid-morning and early evening) during summer days. These peaks appear to track with changes in the chemical processes in the 80- to 100-km area of the ionosphere when the sun rises and when it sets.

The concept of a reservoir of metallic ions being present in the *E*-region would not change significantly even during intense meteor showers, as shown by a study conducted by scientists Baggedly and Steel in 1967. This particular study showed that there were no trends of either overall decrease or increase of *Es* due to meteor shower activity. It must be remembered that those meteor particles which are not burned and thus remain in the *E*-region are in a neutral state. Therefore, a reservoir model for *Es* ions in the *E*-region would explain the consistent nature of the phenomenon in which losses of metallic ions from the *E*-region due to oxidation are compensated by a daily influx of meteor particles that enter the *E*-region. The metal particles are not ionized until they reach the 90-km level and then are transported to higher altitudes as per the model. The model fits the observation of hams and scientists regarding the symmetrical behavior between the Northern and Southern Hemispheres with regard to sporadic-*E* occurrences. Accompanying this article is a presentation of a graphical look at the transport theory of sporadic-*E*.

As more and more instrumentation is developed, this model can be proven and further refined based on observations. There was the hope that satellites recently sent up to measure the characteristics of the ionosphere would provide the data required to define sporadic-*E*. However, problems arose that have prevented this data from being collected. Eventually, there will be better instrumentation that will collect this data in the pursuit of answers.

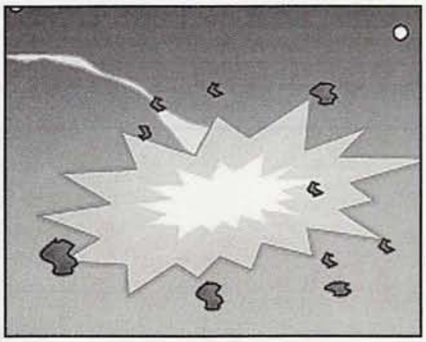
Of course, a big question is whether such a reservoir of ions exists in the *E*-region in any form during the equinox period. In the next installment of "The Sporadic-*E* Files" we examine the complete drop in sporadic-*E* activity during the equinox months in the Northern Hemisphere, in particular the months of March and September, and look at the possible causes of this lack of activity.■

The Sporadic-*E* Files

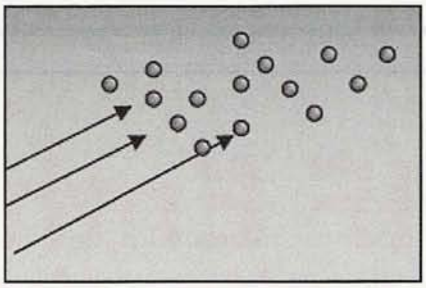
By Ken Neubeck, WB2AMU

Topic #1: The basic mechanisms of the summertime sporadic-*E* season

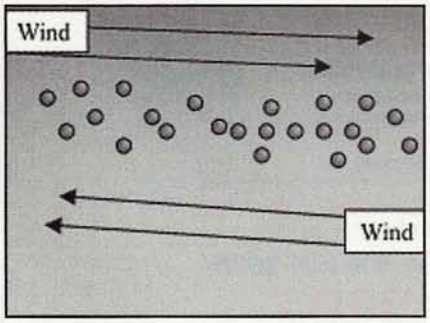
Sporadic-*E* ions come from metallic particles (typically iron and magnesium) that result from meteor ablation in the *E*-region of the ionosphere. These particles eventually will fall down to the level of 90 km above the Earth.



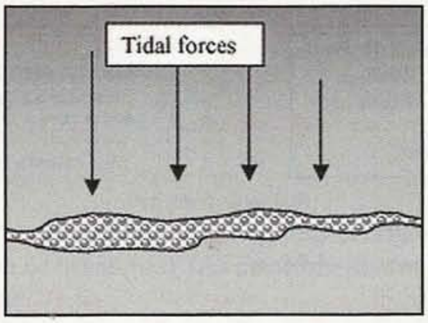
At a height of around 90 km some particles are oxidized and fall down to Earth, while the remaining particles combine with existing oxygen ions (the oxygen ions are at their highest levels during the summer). Ionospheric winds then transport these metallic ions upward into the *E*-region at above 100 km.



Between 100 and 120 km, the action of opposing ionospheric winds causes the effect of wind shear, resulting in the accumulation and compression of these particles into thin stratified layers. Each layer is like an invisible ion mirror that is capable of reflecting radio waves. The higher the density of a layer, the higher the frequency of the radio signal that can be reflected.



The lifetime of a sporadic-*E* layer is limited, on the order of a few hours or more. This is because of the gravitational effects of tidal forces that push the layer down to the lower altitudes until it reaches 90 km and dissipates. Some ions are oxidized and fall to Earth, while others recombine with oxygen ions and again return to the *E*-region reservoir of ions.



Ken Neubeck, WB2AMU, has written several articles on VHF propagation, including the book Six Meters, A Guide to the Magic Band *(Worldradio Books), and is co-authoring with Gordon West, WB6NOA, a book on VHF propagation for CQ Communications which is due to be released shortly.*

CQ's 6 Meter and Satellite WAZ Awards

(As of March 15, 2004)

By Floyd Gerald,* N5FG, CQ WAZ Award Manager

6 Meter Worked All Zones

No.	Callsign	Zones Needed
1	N4CH	16,17,18,19,20,21,22,23,24,25,26,28,29,34,39
2	N4MM	17,18,19,21,22,23,24,26.28.29,34
3	JI1CQA	2,18,34,40
4	K5UR	2,16,17,18,19,21,22,23,24,26,27,28,29,34,39
5	EH7KW	1,2,6,18,19,23
6	K6EID	17,18,19,21,22,23,24,26,28,29,34,39
7	KØFF	16,17,18,19,20,21,22,23,24,26,27,28,29,34
8	JF1IRW	2,40
9	K2ZD	2,16,17,18,19,21,22,23,24,26, 28,29,34
10	W4VHF	2,16,17,18,19,21,22,23,24,25,26,28,29,34,39
11	GØLCS	1,2,3,6,7,12,18,19,22,23,25,28,30,31,32
12	JR2AUE	2,18,34,40
13	K2MUB	16,17,18,19,21,22,23,24,26,28,29,34
14	AE4RO	16,17,18,19,21,22,23,24,26,28,29,34,37
15	DL3DXX	1,10,18,19,23,31,32
16	W5OZI	2,16,17,18,19,20,21,22,23,24,26,28,34,39,40
17	WA6PEV	3,4,16,17,18,19,20,21,22,23,24,26,29,34,39
18	9A8A	1,2,3,6,7,10,12,18,19,23,31
19	9A3JI	1,2,3,4,6,7,10,12,18,19,23,26,29,31,32
20	SP5EWY	1,2,3,4,6,9,10,12,18,19,23,26,31,32
21	W8PAT	16,17,18,19,20,21,22,23,24,26,28,29,30,34,39
22	K4CKS	16,17,18,19,21,22,23,24,26,28,29,34,36,39
23	HB9RUZ	1,2,3,6,7,9,10,18,19,23,31,32
24	JA3IW	2,5,18,34,40
25	IK1GPG	1,2,3,6,7,10,12,18,19,23,24,26,29,31,32
26	W1AIM	16,17,18,19,20.21,22,23,24,26,28,29,30,34
27	K1LPS	16,17,18,19,21,22,23,24,26,27,28,29,30,34,37
28	W3NZL	17,18,19,21,22,23,24,26,27,28,29,34
29	K1AE	2,16,17,18,19,21,22,23,24,25,26,28,29,30,34,36
30	IW9CER	1,2,6,18,19,23,26,29,32
31	IT9IPQ	1,2,3,6,18,19,23,26,29,32
32	G4BWP	1,2,3,6,12,18,19,22,23,24,30,31,32
33	LZ2CC	1
34	K6MIO/KH6	16,17,18,19,23,26,34,35,37,40
35	K3KYR	17,18,19,21,22,23,24,25,26,28,29,30,34
36	YV1DIG	1,2,17,18,19,21,23,24,26,27,29,34,40
37	KØAZ	16,17,18,19,21,22,23,24,26,28,29,34,39
38	WB8XX	17,18,19,21,22,23,24,26,28,29,34,37,39
39	K1MS	2,17,18,19,21,22,23,24,25,26,28,29,30,34
40	ES2RJ	1,2,3,10,12,13,19,23,32,39
41	NW5E	17,18,19,21,22,23,24,26,27,28,29,30,34,37,39
42	ON4AOI	1,18,19,23,32
43	N3DB	17,18,19,21,22,23,24,25,26,27,28,29,30,34,36
44	K4ZOO	2,16,17,18,19,21,22,23,24,25,26,27,28,29,34
45	G3VOF	1,3,12,18,19,23,28,29,31,32
46	ES2WX	1,2,3,10,12,13,19,31,32,39
47	IW2CAM	1,2,3,6,9,10,12,18,19,22,23,27,28,29,32
48	OE4WHG	1,2,3,6,7,10,12,13,18,19,23,28,32,40
49	TI5KD	2,17,18,19,21,22,23,26,27,34,35,37,38,39
50	W9RPM	2,17,18,19,21,22,23,24,26,29,34,37
51	N8KOL	17,18,19,21,22,23,24,26,28,29,30,34,35,39
52	K2YOF	17,18,19,21,22,23,24,25,26,28,29,30,32,34
53	WA1ECF	17,18,19,21,23,24,25,26,27,28,29,30,34,36
54	W4TJ	17,18,19,21,22,23,24,25,26,27,28,29,34,39
55	JM1SZY	2,18,34,40
56	SM6FHZ	1,2,3,6,12,18,19,23,31,32
57	N6KK	15,16,17,18,19,20,21,22,23,24,34,35,37,38,40
58	NH7RO	1,2,17,18,19,21,22,23,28,34,35,37,38,39,40
59	OK1MP	1,2,3,10,13,18,19,23,28,32
60	W9JUV	2,17,18,19,21,22,23,24,26,28,29,30,34
61	K9AB	2,16,17,18,19,21,22,23,24,26,28,29,30,34
62	W2MPK	2,12,17,18,19,21,22,23,24,26,28,29,30,34,36
63	K3XA	17,18,19,21,22,23,24,25,26,27,28,29,30,34,36
64	KB4CRT	2,17,18,19,21,22,23,24,26,28,29,34,36,37,39

Satellite Worked All Zones

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

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

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

Rules and applications for the WAZ program may be obtained by sending a large SAE with two units of postage or an address label and $1.00 to the WAZ Award Manager: Floyd Gerald, N5FG, 17 Green Hollow Rd., Wiggins, MS 39577. The processing fee for all CQ awards is $6.00 for subscribers (please include your most recent *CQ* or *CQ VHF* mailing label or a copy) and $12.00 for nonsubscribers. Please make all checks payable to Floyd Gerald. Applicants sending QSL cards to a CQ Checkpoint or the Award Manager must include return postage. N5FG may also be reached via e-mail: <n5fg@cq-amateur-radio.com>.

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

By Tomas Hood,* NW7US

PROPAGATION

The Science of Predicting VHF-and-Above Radio Conditions

The Wind-Shear Theory

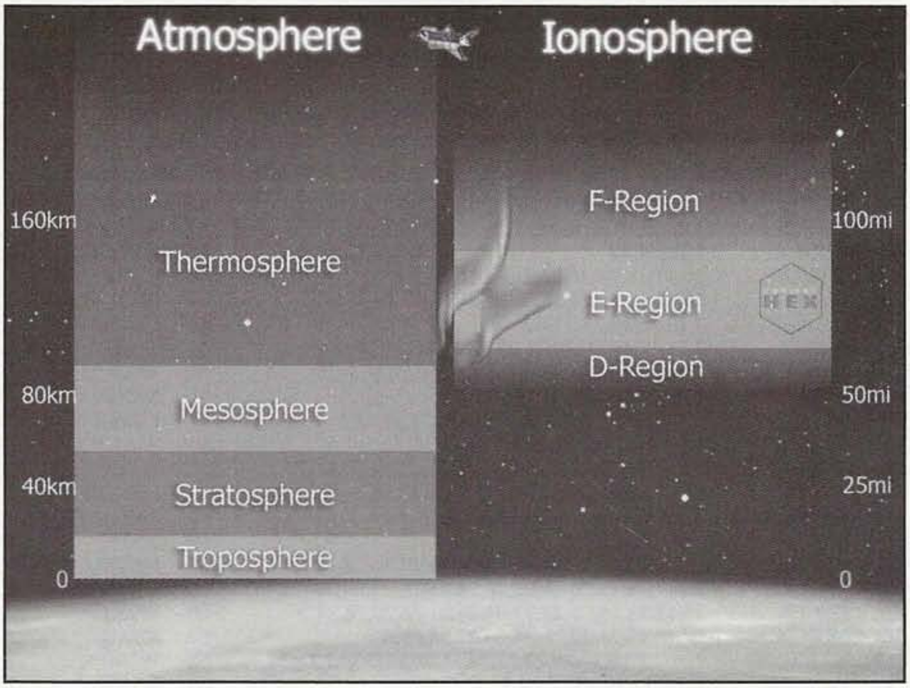
As we move from April to May, and into June, long-distance VHF and sometimes UHF propagation opens up by a mostly summer-time phenomenon called *sporadic-E*. Sporadic-*E* (*Es*) is the term given to the mode of propagation where clouds of highly dense ionization develop in the *E*-layer of the ionosphere. These clouds might be very small, but regardless of their size, they seem to drift and move about, making the propagation off these clouds short and unpredictable. It is well documented that *Es* occurs most often in the summer, with a secondary peak in the winter. These peaks are centered very close to the solstices. The winter peak can be characterized as being five to eight times less than the summer *Es* peak.

Scientists are still pursuing the multiple causes of sporadic-*E*. As far back as 1959, ten distinct types of sporadic-*E* and at least nine different theories of causation were offered. The classification of distinct types has been retained, but since the 1960s the wind-shear theory has become one of the most accepted theories.

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

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

**P.O. Box 213, Brinnon, WA 98320-0213*
e-mail: <cq-prop-man@hfradio.org>



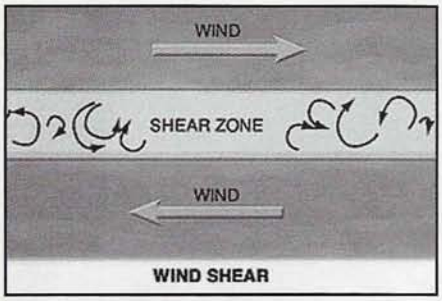
The E*-layer (*E *region) of the ionosphere is where sporadic-*E *propagation occurs, while tropospheric propagation modes occur at a much lower altitude, below 20 miles. (Courtesy of the Horizontal E-region eXperiment [HEX])*

If wind shear is one of the most pronounced causes of sporadic-*E*, what is the trend of our global weather patterns for 2004 in the Northern Hemisphere? Since warmer ocean waters cause less wind shear, we would have to watch the Pacific and Atlantic Ocean temperature trends from December 2003 through the summer of this year.

The period between 1995 and 2003 has been the most active for Atlantic hurricanes in the historical record. Since 1995, seven of the nine hurricane seasons have been above normal (the exceptions being the El Niño years of 1997 and 2002). In the years when El Niño dominated (1997 and 2002), the presence of El Niño suppressed hurricane activity in the Atlantic. The sporadic-*E* summer season of 2002 was intense. There seems to be a clear correlation between the increased wind shear (resulting in less hurricane and severe storm activity) and *Es* activity.

In 2003 the prediction was that El Niño would again dominate. However, as El Niño petered out in March and April, signs of cooling in the Pacific Ocean in May indicated La Niña was close on its heels. The stepping in of La Niña at the beginning of the hurricane season is a situation that has only arisen twice in the last eight hurricane seasons. Both 1998 and 1999 had moderate to strong La Niña episodes during the months between July and December, according to NOAA. Hurricane Mitch, for example, was one of the strongest storms ever recorded in the Atlantic and first began as a tropical depression on October 22, 1998, according to the National Climatic Data Center.

La Niña's typically cooler-than-normal temperatures in the Pacific Ocean influence the global atmospheric conditions and make for an active Atlantic hurricane season. In El Niño or neutral years, wind directions and speeds create a high



In the E*-region, when a wind-shear zone develops, clouds of dense ionization may form. These ionized clouds move and change rapidly and can be dense enough to support VHF propagation. (Courtesy NASA)*

vertical wind shear between the lower and upper atmospheres such that the weaker westerly jet stream winds cut off the tops of storms that develop in the strong easterly trade winds. When La Niña enters the scene, it tends to strengthen the upper-level winds and cause the lower trades to lose their gusto. "La Niña tends to make winds more uniform as you go up through the atmosphere," says senior research scientist Gerry Bell of NOAA's Climate Prediction Center. "La Niña contributes to more hurricane activity primarily by acting to decrease the vertical wind shear in the heart of the main development region."

Looking at the data for the summer of 2003, La Niña did not play a significant role. However, neither did El Niño. The Climate Prediction Center reports that sea-surface temperature anomalies in the Niño regions increased during early June through early July, but then decreased during the last half of July and remained fairly steady during August 2003.

Weather experts predict that 2004 will be a year of slightly elevated hurricane and storm activity in the Atlantic region, but that neutral conditions will exist into the summer in the El Niño Southern Oscillation (ENSO). The ENSO refers to the seesaw shift in surface air pressure at Darwin, Australia and the South Pacific Island of Tahiti. When the pressure is high at Darwin, it is low at Tahiti, and vice versa. El Niño and La Niña are the extreme phases of the southern oscillation, with El Niño referring to a warming of the eastern tropical Pacific and La Niña a cooling. If the El Niño influence is slight, there could well be an increase in hurricane conditions.

Based on these predictions, I expect moderate to occasionally strong sporadic-*E* starting in May, and peaking in July and August 2004. According to the Climate Prediction Center, the possibility of a development of either El Niño or La Niña is low during 2004. You can view up-to-date climate information at <http://www.cpc.ncep.noaa.gov/products/predictions/>. The ENSO page is at <http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_advisory/>.

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

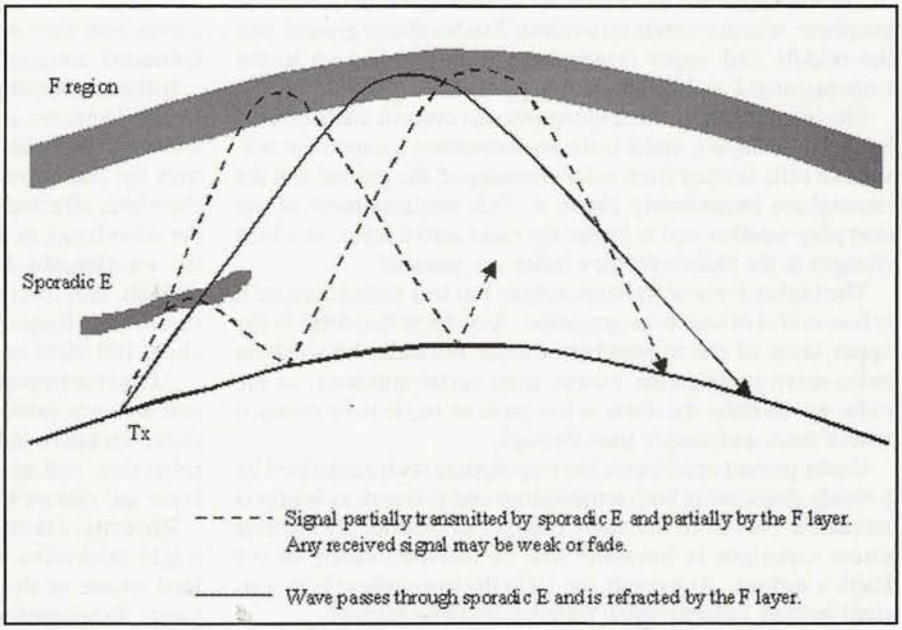
In addition to live reporting, there is a very powerful resource available on the internet. Check out <http://superdarn.jhuapl.edu/>. SuperDARN (Super Dual Auroral Radar Network) is an international radar network for studying the Earth's upper atmosphere and ionosphere. Using the SuperDARN real-time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

Tropospheric Propagation and VHF DX

Propagation on VHF and higher frequencies is typically thought of as "line of sight." Is it possible to receive these signals beyond the horizon?

Most propagation on VHF and above occurs in the troposphere. There are a number of well-documented modes of tropospheric propagation. The most common is line-of-sight propagation, which, depending on the height of the transmitting and the receiving antennas, can extend to about 25 miles. When you work simplex FM or FM repeaters in your local area, you are hearing typical line-of-sight tropospheric propagation.

Diffraction, where radio waves are somewhat bent back toward the Earth, is a mode of propagation that allows the VHF/UHF signal to follow the curve of the Earth out beyond the horizon, to about 70 miles. Knife-edge diffraction in mountain areas is a better-known, but



Dense clouds of ionization can cause unique signal paths to develop, but these may be subject to a high level of fading and may not last very long, since the clouds are ever changing and moving. (Courtesy IPS, Australia) special case of diffraction. Another mode which extends the line of sight to about 70 miles is "refraction," where radio waves are bent toward the Earth due to the changing density, temperature, and humidity of the atmosphere.

This slight bending of radio waves by refraction is similar to the bending you see when you dip a pencil into a glass of water. The refractive index of water is different from the refractive index of air. The object seems to bend once it enters the water because of the differences in the speed of the light waves through the different densities of each medium. Diffraction and refraction of radio waves combined extends the line-of-sight range, but signals will experience a lot of fading.

Troposcatter is yet another VHF/UHF mode of propagation. This mode can extend the range of a signal to up to hundreds of miles. This mode requires higher power and high-gain antennas in order to ensure reliable communication. It relies on the scattering of the radio signal off many small disturbances and areas of differing refractive indexes.

There also are the more rare tropospheric modes of propagation, such as temperature-inversion propagation and tropospheric ducting. Temperature-inversion propagation can extend the signal out to about 150 miles or so. When temperature and humidity suddenly increase at higher heights, it could cause radio waves to be reflected back to Earth. Ducting via the troposphere can propagate signals great distances, such as from Hawaii to California. In tropospheric ducting, radio waves are trapped in a type of natural wave-guide between an inversion layer and the ground or between two inversion layers. Ducting causes very little signal loss, and often signals are only heard at each end of the wave-guide.

Dual diversity antenna system used in troposcatter propagation by the US Army. (Courtesy of US Army)

The Troposphere

The troposphere is the lowest layer of our atmosphere, bounded below by the Earth's surface and above by the tropopause. It extends from the Earth's surface to a height of slightly over 7 miles. Almost all of the weather phenomena occur in this region.

The troposphere is best divided into two layers: the lower troposphere, which extends up to about 2 miles above ground, and the middle and upper troposphere from 2 miles up to the tropopause at 8 to 12 miles above ground.

The lower layer of the troposphere can contain ducts created by inversion layers, and it is the most common location for convective cells formed from solar warming of the ground and the atmosphere immediately above it. This contains most of our everyday weather and is by far the most active layer, in which changes in the radio refractive index are greatest.

The higher layer of the troposphere has less turbulence, so it is less useful in scatter propagation. Any ducts that form in the upper layer of the troposphere cannot normally be used for radio-wave propagation except from aerial antennas, as the radio waves enter the ducts at too great an angle to be retained within them and simply pass through.

Under perfect conditions, the troposphere is characterized by a steady decrease in both temperature and pressure as height is increased. However, the many changes in weather phenomena cause variations in humidity and an uneven heating of the Earth's surface. As a result, the air in the troposphere is in constant motion, causing small turbulences to be formed.

These turbulences, or eddies, are most intense near the Earth's surface and gradually diminish with height. They have a refractive quality that permits the refracting or scattering of radio waves with short wavelengths. This scattering is what provides enhanced communications at VHF and higher frequencies.

In the relationship between frequency and wavelength, wavelength decreases as frequency increases, and vice versa. Radio waves of frequencies below 30 MHz have wavelengths longer than the size of normal weather eddies. HF radio waves are, therefore, affected very little by tropospheric turbulences. On the other hand, as the frequency increases into the VHF range, the wavelengths decrease in size. If the wavelength is small enough, they become subject to tropospheric scattering. The most usable frequency range for tropospheric scattering is from about 100 MHz to 10 GHz.

Above the tropopause, changes in temperature and water content are very small indeed, resulting in very little alteration in radio refractive index. Therefore, there can be little scatter or refraction, and no real assistance to propagation until the *E*-layer and meteor trails are attained, above 60 miles or so.

Recently, David Dunham, WA1CUH, proposed that there might exist refraction of VHF and higher frequencies in ionized ozone or the *D*-layer in the stratosphere (see "Ozone Layer Propagation: Pondering the Possibility," *CQ VHF,* January 1999, pp. 32–38). David has produced evidence that stability and low wind speeds in the troposphere and stratosphere could have resulted in very little scatter until the radio waves reached ionized ozone or the *D*-layer.

Tropospheric Ducting

The term *tropospheric ducting* refers to the stratification of the air within the troposphere. When layers form within this region of air, the refractive index between each layer causes a refraction of VHF and UHF radio waves. If the layers form in just the right way and at the right height, a natural wave-guide is created. A tropospheric duct develops.

As with most matters of propagation, it is not always possible to determine whether tropospheric propagation is ducting or non-ducting. Ducting usually has characteristics similar to sporadic-*E* propagation in that the distant station will be noticeably stronger than closer stations that are not accessible by the duct. Tropospheric ducting results in surprisingly strong signals for the distance. Ducting is typically very geographically selective. Normally, stations working a duct are quite close together in space, at both ends of the duct.

Tropospheric ducting requires low-angle entry into the duct. If your takeoff angle is high, you are not likely to be able to use the duct, as the radio waves will shoot straight out of the upper side of the duct. Ducting also uses only the lowest part of the troposphere. Ducts are most common below 1 mile, and very rarely accessible above 2 miles. If you have a mountain in the way, then look for something beyond simple ducting. Ducting is most likely to occur over water, during high-pressure, anticyclonic, conditions, when the air is relatively still. It is unusual at longer wavelengths, because the ducts have to be larger to be effective. You'll be very lucky to observe any tropospheric ducts on low VHF, for example on 6 meters.

Another important issue when trying to decide the mode of propagation across the VHF bands is whether it could have been ionospheric, such as by sporadic-*E*. Generally, sporadic-*E* will be much stronger on similar bearings when you listen to lower frequencies. If there is no sign of any enhancement of propagation on lower VHF frequencies, you can usually be quite confident that the mode was tropospheric.

The summer season in the Northern Hemisphere is when most tropospheric ducting occurs. On a normal spring day, air pressure, temperature, and water vapor in the air decrease with height. The weather is relatively cool and breezy. Signals on VHF and above are from local sources, and reception is "normal." However, late in the summer the weather is much hotter, with slow-moving high-pressure systems spanning several states and causing stagnant air masses. You can see a brown haze in a layer in the air above containing smoke and smog that has become trapped in a stalled air mass. This is a good visual cue that stratification has occurred, and the chances of your working tropospheric ducting are high.

Some amazing stories are told of oil rigs and cities over 75 miles away that can be seen during these hot summer periods. This is well beyond normal line of sight. What's more incredible is that these objects are seen upside down! Light is being ducted far beyond the horizon, trapped between the boundaries of the stratified layers. If the radio wave is small enough (the frequency is high enough), they too can be ducted far into the distance.

Tropospheric ducting forms each year between Hawaii and the U.S. West Coast, and from San Francisco to Los Angeles, Denver to Dallas, Texas to Florida, the Great Lakes to the eastern seaboard, from the Great Lakes to Texas, Nova Scotia to Miami, and from the Midwest to the Southeast.

The most common region for high-pressure systems, where ducting is most likely to develop, is between 30 and 45 degrees latitude above and below the equator. Most of the United States, as well as the regular summertime highs of the Pacific and Atlantic regions, favor tropospheric ducting. If the local weather-forecast map shows mean-sea-level atmospheric pressure in millibars, look for tropospheric possibilities when a stalled high-pressure cell in your area reaches 1025 millibars over the path in which you are interested. Of course, it is most likely to occur when this high-pressure cell develops over moist air. This is why the path between Hawaii and the West Coast has made possible communications on VHF with as little as 5 watts, over a path of 2500 miles.

Advanced visual and infrared weather maps can be a real aid in detecting the undisturbed low clouds between the West Coast and Hawaii or farther during periods of intense subsidence-inversion band openings. This condition occurs also over the Atlantic. There is a great resource on the internet that provides a look into current conditions. Bill Hepburn has created forecast maps and presents them at <http://www.iprimus.ca/~hepburnw/

tropo_xxx.html>, which includes maps for the Pacific, Atlantic, and other regions.

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

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

Meteor Showers

The *Eta Aquarids* meteor shower will occur in May 2004. The *Eta Aquarids* will peak during the morning of May 5, but start around April 21. This shower has a peak rate of up to 20 to 50 meteors per hour. Most meteor showers are at their best after midnight. After midnight you are on the leading edge of the Earth and are meeting the meteors head-on. Before midnight, you're on the trailing edge of the Earth and the meteors have to catch up to you. As a result, not only are more meteors seen in the pre-dawn hours, but their impact speeds encountering the Earth's atmosphere are much higher and the meteors are generally faster and brighter. This causes greater ionization, which is what you use to refract a radio signal. Look for 6- and 2-meter openings off the ionized meteor trails.

There are some other showers in May that may yield some propagation. These include the *Epsilon Arietids,* April 25 to May 27 with the peak on May 9 and 10; the May *Arietids,* from May 4 to June 6, peaking May 16/17; the *Omicron Cetids,* active from May 7 through June 9, peaking between May 14 and 25; and the May *Piscids* from May 4 through 27, peaking on May 12 and 13.

June has three moderate showers, as well. The *Arietids,* which is active from about May 29 through June 19, may peak with a ZHR (Zenith Hourly Rate) of 60 on June 7, 2004. The *Zeta-Perseids* shower starts around May 20 and continues through July 5, peaking with a ZHR of 40 on June 9, 2004. The *beta-Taurids* will peak on June 29. Signs of most of these peaks were found in radio data from 1994–2000, although some are difficult to define because of their proximity to other sources, while the *Arietids* and *Zeta-Perseid* maxima tend to blend into one another, producing a strong radio signature for several days in early June. There is a slight possibility for a June *Lyrids,* which peaks on June 15 and 16, but this is an uncertain forecast.

July has only minor showers, with a possible moderate one, the *Southern Delta Aquarids,* which runs from about July 14 through August 18, peaking July 28 and 29. The minor showers include the *Alpha Lyrids* from July 9 through 20, peaking on July 14/15; the July *Phoenicids,* July 9 through 17, peaking on July 14/15; the *Alpha Pisces Australids* from July 16 to August 13, peaking July 30/31; the *Sigma Capricornids* from June 18 through July 30, peaking off and on between July 10 and 20; the *Tau Capricornids,* which runs from June 25 to July 29, peaking on July 12/13; and the *Omicron Draconids* from July 6 to 28, peaking on July 17/18.

For more information, take a look at <http://www.imo.net/calendar/cal04.html>. Check out <http://www.meteorscatter.net/metshw.htm> for a very useful resource covering meteor scatter and up-coming showers.

TE Propagation

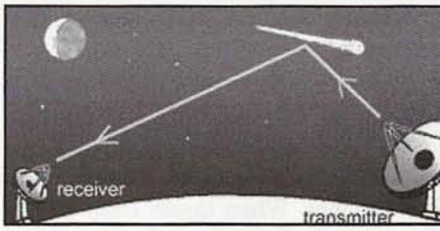
A seasonal decline in transequatorial (TE) propagation is expected during May. An occasional opening may still be possible on VHF. The best time to check for VHF TE openings is between 9 and 11 PM local daylight time. These TE openings will be north-south paths that cross the geomagnetic equator at an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

Sound Samples

Would you like to hear the received signals of several different modes of propagation? Check out <http://www.dd3dj.de/sound-samples.htm>, where Dirk presents a collection of sound files of VHF communication via the different modes of propagation.

The Solar Cycle Pulse

Geomagnetic activity settled down after the wild period of late October and early November of 2003. The sunspot activity fell off quite a bit, and the flux levels dipped very low after the peak of 153 for both October and November. By February 2004, the flux was down to 107



Artist's concept of radio meteor observation. Meteor trains reflect transmissions from stations that are over the horizon and normally are impossible to detect. Whenever a meteor passes by with the correct geometry, propagation becomes possible on VHF frequencies between very specific locations. During meteor showers, the high number of these meteor trains provides more opportunity for propagation. (Courtesy NASA)

and the monthly sunspot count was 46.

The smoothed planetary *A*-index (*Ap*) readings from June to August 2003 are 21.8, 22.3, and 22.4, continuing the expected increase during 2003. The monthly readings from December 2003 through February 2004 are 18, 20, and 13. The readings will see a trend downward during the winter months.

The observed smoothed sunspot numbers from December 2003 through February 2004 are 47.0, 37.2, and 46.0, generally lower than the last reporting period. The smoothed monthly 10.7-cm (preliminary) numbers from December 2003 through February 2004 are 115.1, 114.1, and 107.0. The smoothed monthly sunspot numbers forecast for May through July 2004 are 35.1, 32.3, and 30.6, while the smoothed monthly 10.7 cm is predicted to be 95.1, 90.7, and 87.8 for the same period.

Feedback, Comments, Observations Solicited!

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

You are welcome to also share your reports at my public forums at <http://hfradio.org/forums/>. Up-to-date propagation information is found at my propagation center, at <http://prop.hfradio.org/>. Until the next issue, happy weak-signal DXing.

73 de Tomas, NW7US

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By Joe Moell,* KØOV

HOMING IN

Radio Direction Finding for Fun and Public Service

Get Better Performance From Your Doppler Set

Instant transmitter hunting . . . just add a receiver! Well, it's not quite that simple, but Doppler sets are indeed a quick way to get started in VHF and UHF mobile radio direction finding (RDF). Because they attach to ordinary mobile or hand-held FM transceivers and require no rotating parts or holes to be drilled, you can join the hunt in minutes, even in a rental car.

Doppler RDF sets for ham radio are easily identifiable by their array of three to eight vertical antennas. Four of them in a square pattern is the most common arrangement (photo A). A switching circuit connects them to the narrowband FM receiver one at a time in rapid sequence to simulate a single whip moving on a circular track. Due to the Doppler Effect, this apparent motion of the receiving antenna applies periodic frequency modulation to all incoming signals. The display unit detects the phase of this imposed FM with respect to the antenna switching sequence. This reveals the direction of the incoming signal relative to the vehicle heading. Because the simulated rotation rate is about 30,000 RPM, Dopplers can capture bearings on signals lasting only a fraction of a second.

If you need to track very weak signals or signals with no carrier, such as single-sideband voice, forget about using a Doppler. It is also not a good choice if you will be doing your tracking on foot or going after signals below 50 MHz. If you need to do RDF remotely from a mountaintop radio site or go after horizontally polarized signals, there are more effective methods to consider. However, if you want to jump into your vehicle and quickly find a strong VHF-FM or UHF-FM hidden transmitter, spurious signal, or jamming station, then a Doppler set may be just the right tool for you.

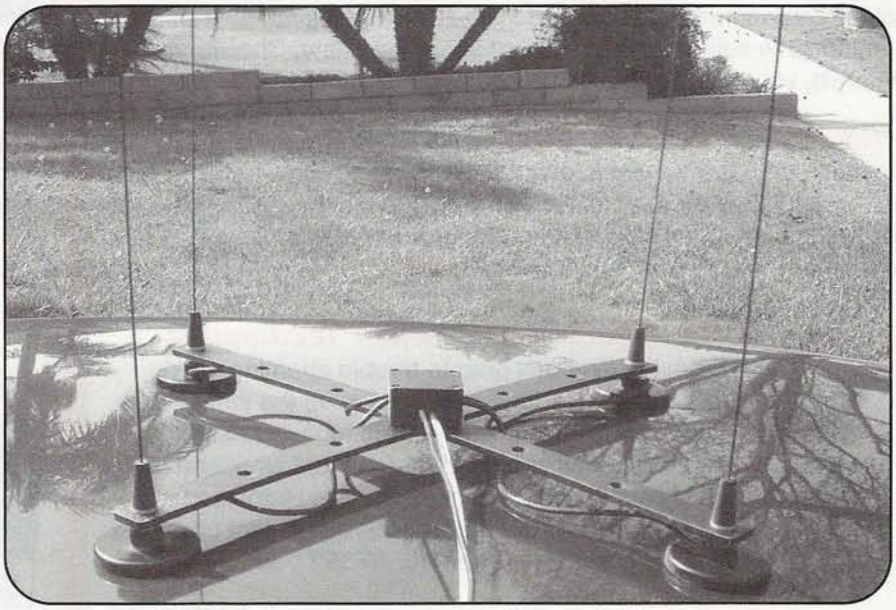

Photo A. This DFjr antenna array has been modified with a NØQBF one-piece ABS plastic crossarm to replace the stock aluminum arms. As in the original arms, there are holes for placement of the whips for the 2-meter, 125-cm, and 70-cm bands. Separate quarter-wavelength whip sets for each band ensure that the antenna elements are near resonance. (KØOV photo)

The Series Continues

In honor of the 200th anniversary of Christian Doppler's birth, I began a multi-part "Homing In" series on Doppler RDF technology last year (in the February, March, May, July, and August 2003 issues of *73 Magazine*). My goals were to increase hams' understanding of how Doppler RDF sets work, to dispel some of the myths about them, and to help hams optimize their Doppler installations for best performance in competitions, enforcement, and search-and-rescue applications. I began with a biography of this important Austrian physicist, who had keen insight into how waves are perceived when source and observer are in relative motion. I showed that Doppler RDF sets do indeed follow the principles and equations propounded by Christian Doppler, even though practical units simulate antenna movement electronically by switching a ring of stationary elements.

In part 2, I showed why the fundamental frequency of the induced Doppler tone is always the same as the array rotation rate in revolutions (or cycles) per second. That tone must fall within the audio passband of the receiver. Tone amplitude (FM deviation) must be high enough to provide good signal-to-noise ratio for the zero-crossing detector, but not so high as to be corrupted by phase distortion in the receiver's discriminator and audio circuits.

As few as three elements can achieve good bearing accuracy in a well-designed Doppler set. More than three elements do not provide better accuracy by themselves, but to the extent that they allow array size (radius of rotation) to increase, they will improve signal-to-noise ratio if the VHF-FM receiver's IF bandwidth accommodates higher Doppler tone deviation.

Most Doppler RDF experimenters concentrate on improving the signal-processing and display circuits in their setups. That's okay, but just as in other forms of ham radio communications, it's the antenna system that makes or breaks a Doppler from a performance standpoint. As I explained in part 4 of the

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

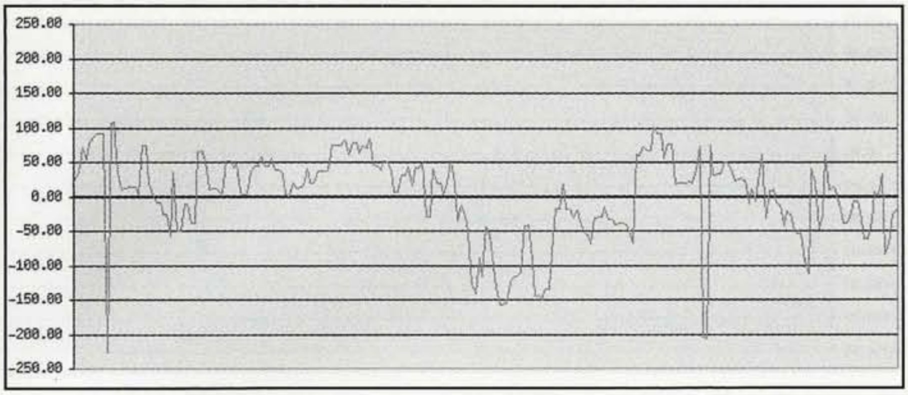

Figure 1. NØQBF's chart of bearing fluctuations along a 5-mile test track with an unmodified mag-mount Doppler array as supplied with the DFjr RDF set. His software plots the difference between displayed bearing and actual computed bearing at 200 points along the route. (Courtesy NØQBF)

series, there is one principle that is paramount, but not intuitive: An ideal Doppler RDF array is perfectly non-directional in amplitude. Due to AM-to-PM conversion in the receiver's limiter stages, any factor that causes the strength of the signal at the receiver input to vary as the Doppler array is electronically "rotated" will result in the bearing display being jumpy, hard to interpret, and perhaps even downright unreliable when used in a moving vehicle.

Unwanted amplitude directivity can be caused by improper positioning of the array on the vehicle, mutual coupling among the elements, and improper feedline routing. Another cause that is frequently overlooked by both amateur and professional designers is termination impedance (loading) of switched-off elements in the array.

How bad are these directivity-induced fluctuations? They would be hardly noticeable if there were no terrain features or objects to reflect the signal. However, such an environment rarely occurs. Almost anywhere that you are likely to drive, there will be a plethora of these reflected signal sources, commonly called "multipath."

For a given amount of multipath, the effect on a particular Doppler installation depends on a number of factors, including the receiver's IF filtering and discriminator performance. The sharpness of the audio bandpass filter in the Doppler display unit also plays an important part. Observing the fluctuations by eye under varying terrain conditions isn't a very scientific way to compare Doppler arrays. It's much better to test in a consistent environment and to record the actual fluctuations. This isn't difficult if the Doppler set has serial directional data output.

There are several formats for serial-bearing data streams. Perhaps the most popular at present is the "Agrelo" format, named after the manufacturer of the DFjr Doppler set introduced in 1996. In this format, the 360-degree azimuth range is described by 256 bits, each bit representing about 1.4 degrees. Format is "%xxx/y" where xxx is the relative bearing rounded to the nearest degree and y is the quality of the bearing. Quality is a computed function of the spread of the data points in the sample period and ranges from 1 (worst) to 8 (best).

No More Splattered Bearings

Years ago, tests like this would be done with data plotted on an analog strip-chart recorder, complete with a motor, pens, ink, and special paper. Nowadays it's simple (and much less messy) to let a PC or PDA do the work. Figure 1 is a PC-generated "strip chart" of a stock DFjr's bearing fluctuations along a test track as taken by Mike Musick, NØQBF, who lives near St. Louis, Missouri. Mike and I have experimented with and corresponded about various Doppler arrays for over a dozen years.

I don't know the details of Mike's test track, but it's probably similar to mine. There are two that I use to test 2-meter Dopplers and other VHF and UHF RDF sets. Both are conveniently located here in Fullerton and make use of local repeaters. Each is about two miles from the repeater and is about a mile long. In either case, I drive directly toward the repeater's transmitting antenna, observing bearing indications on the repeater output signal. One track is in a suburban business area with the repeater antenna visible in the distance. The other is on a residential street with the repeater tower obscured by a rise in the road.

For calibrating mobile Dopplers and for observing their readout accuracy and steadiness, your vehicle must be in motion. This increases the effective baseline of the antenna system by averaging the fluctuating indications, either by eyeball or by averaging circuits in the Doppler set. When moving directly toward the test signal, it's easy to calibrate the display for a straight-ahead indication.

There is a lot of bearing fluctuation in figure 1, suggesting that Mike's array was directional in amplitude—not good. He had already selected his vehicle roof mounting and optimized his cable rout-

Photo B. The Larsen mag-mount antenna base at left has a metal foil bottom to provide RF capacitive coupling to the car body. There's no foil on the DFjr Doppler antenna magnet at right. (KØOV photo) ing for non-directivity, so he became suspicious of the RF path for the counterpoise on the DFjr's supplied antenna set.

NØQBF wrote, "With each new generation of whips, Agrelo Engineering improved electrical contact between the coax shields and the magnet covers. However, the magnets themselves are nonconductive and there are vinyl covers on them to protect the vehicle's finish." Mike realized that this resulted in very little RF coupling from the shields to the ground plane provided by the vehicle roof. Most mag-mount antenna suppliers cover the magnet with grounded foil to provide capacitive coupling to the vehicle body (see photo B), but this was not done on DFjr arrays.

NØQBF disassembled his array and sandpapered the paint from the magnet holders. Then he covered them top and bottom with copper-foil shielding tape (#1181 from 3M Company, which has conductive adhesive). He ran the test track again and got the results of figure 2.

What an improvement! The original array had errors of greater than 50 degrees a significant percentage of the time and a region of 100 to 150 degrees error. The modified-magnet array was less than 50 degrees off all the time, except for a couple of short flickers. If you saw the predicted amplitude directivity pattern of a Doppler array with reactive termination in part 5 of this series, this won't come as a surprise. A capacitance-meter check showed Mike that his mod had reduced the series reactance in each whip base from 10 ohms to about 2 ohms.

Analysis of figures 1 and 2 showed improvement in standard deviation of the bearing error from 63 degrees to 41 degrees, but Mike wasn't satisfied. He wondered about the aluminum crossarm that holds the DFjr whips in position and provides mounting for the RF switch box. Could it create unwanted coupling between the whips and thereby produce amplitude directivity?

Mike removed the crossarm, carefully positioned the whips on the vehicle roof without it, and drove his test track again. Results were encouraging, so he fabricated a replacement crossarm from ABS plastic. With the whips and switch box mounted on it, he drove his test track and got the plot of figure 3. Bearing fluctuations beyond 50 degrees were rare, even in the heavy multipath area near the end of his track.

"Standard Deviation is now down to 24 degrees," Mike wrote. "The cumulative changes are really evident on APRS map plotting. There is a little wobble from the multipath, but my old 'splattered bearing' problem has completely gone away."

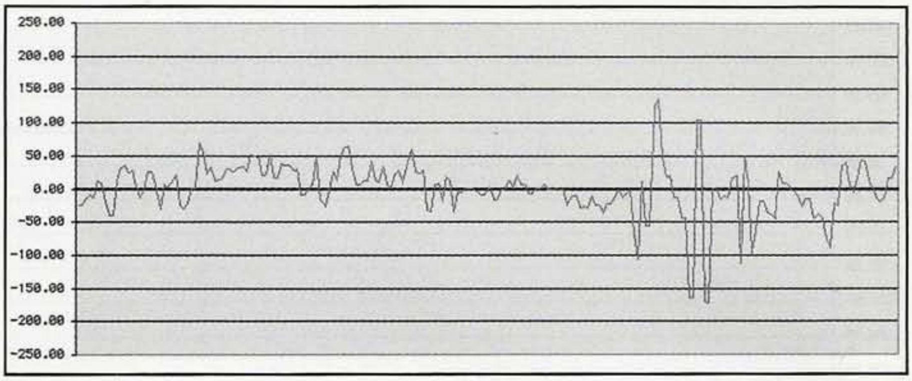

Figure 2. Plot of DFjr array modified with copper-foil tape to increase capacitive coupling through the magnets to the metal vehicle roof ground plane. (Courtesy NØQBF)

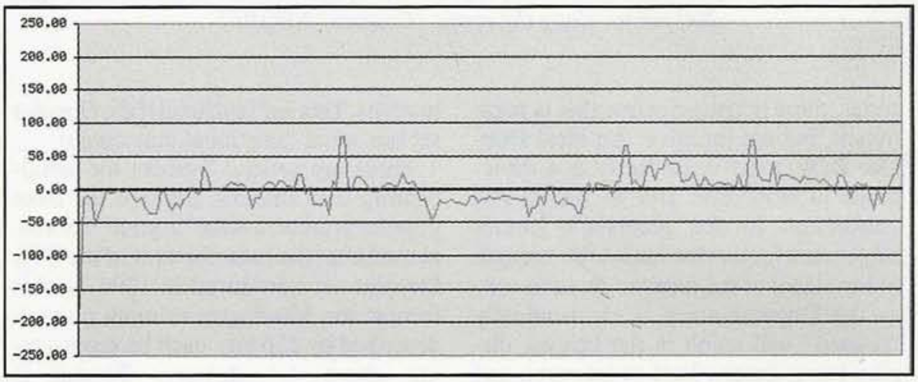

Figure 3. Eliminating the aluminum crossarms in addition to increasing the capacitive coupling produced astonishingly better multipath performance in the DFjr. (Courtesy NØQBF)

Is that the best this array can do? Probably it is, because the DFjr's RF switcher uses monolithic RF preamps with nominal input impedance of 50 ohms. I showed in part 5 that this termination results in 5-dB amplitude directivity in the best case. Mike is now experimenting with a switcher design using Hittite monolithic RF switches to eliminate the 50-ohm termination of switched-off whips. The dual PIN diode switch circuit on my "Homing In" website (www.homingin.com) is also a good choice because it provides high-impedance termination of switched-off whips, giving directivity of 1.6 dB or less.

Check Your Mag-Mounts

How good is the coupling and symmetry of the ground plane in your mobile Doppler array? If it has mag-mount whips, verify that there is conductive foil covering the magnets. If not, add foil tape as NØQBF did. Make sure that the coverage is complete and that the foil or tape is firmly connected to the coax shield. Any wrinkles in the foil will decrease the capacitive coupling. Not only must the coupling be excellent on each magnetic base, but the base-to-vehicle capacitances of each one must be equal if unwanted directivity is to be avoided. After any modifications to your Doppler array, be sure to recalibrate the system, just as you should do when you change receivers, vehicles, or ham bands.

Dipole elements ought to provide better RDF performance than quarter-wavelength whips, because there would be no inter-element coupling through the ground plane. Vertical dipoles are seldom seen on mobiles, because a dipole array is twice as tall and much less "stealthy" than a whip array. However, fixed-site VHF Doppler antennas usually use dipoles. For a home-based Doppler, consider an array like the one by Vincent Fiscus, KB7ADL,

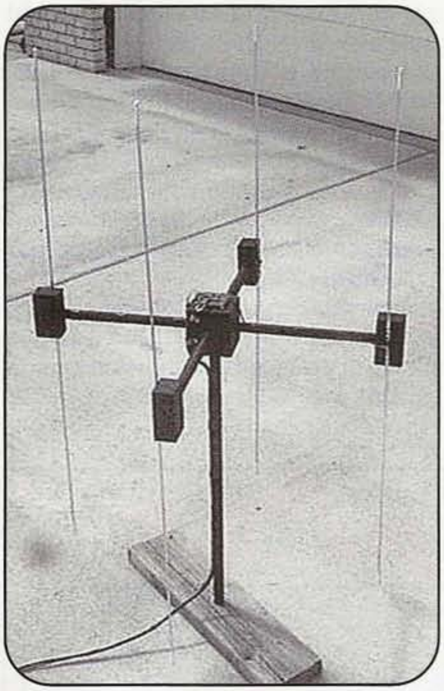

Photo C. For fixed installations, a Doppler array of dipoles helps minimize coupling between elements. This one was built by Vincent Fiscus KB7ADL. (Courtesy KB7ADL)

shown in photo C. He used the PIN-diode switch project on my "Homing In" website. For best possible whip isolation, I recommend placing a ferrite balun at the feedpoint of each dipole.

If your Doppler's self-test features include stepping the RF switcher to each whip individually, as does the DFjr, you can perform a quick-and-dirty check of array directivity. While monitoring through the array a steady but not very strong signal, such as a distant repeater, observe the S-meter readings as the array is stopped on each whip in turn. If there are significant differences in signal strength on one or more whips, you have unwanted directivity due to array placement, ground plane, or termination issues. Another possibility is a failed component in the switcher. Some users have reported preamp failures in DFjr arrays caused by static discharge. An even more likely cause of preamp or PIN switch failure is accidentally transmitting through it.

So what has happened to the DFjr? The idea of an inexpensive processor-enhanced Doppler set with serial data output for APRS was quickly and enthusiastically embraced by hams, but technical and production problems kept the flow of finished units down to a trickle. Finally in late 1998, Agrelo Engineering closed its doors and disappeared, leaving buyers high and dry. NØQBF and I were

National Foxhunting Weekend Is Almost Here

Whether you prefer to fly the freeways or beat the bushes in search of hidden transmitters, be sure to get together with other hams in your locality for foxhunting fun during the 7th annual CQ National Foxhunting Weekend (NFW). On May 8–9 ham clubs and non-club groups across the country (and elsewhere in the world) will hold mobile and on-foot RDF contests.

There are no formal rules for the NFW. You can be as creative (and sneaky) as you like, as long as your hunts are fair and safe for everyone. For some ideas, read this year's announcement and the results of last year's NFW in the April 2004 issue of *CQ* magazine. After your hunt, be sure to write up the results and send them to me, along with some candid photos of the hiders and hunters. Maybe yours will be included in my follow-up article.

Joe, KØOV
CQ NFW Moderator

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soon inundated with inquiries about the company that we couldn't answer because we didn't know the answers ourselves. Mike has compiled a web page of advice for owners of DFjrs and those who may find a used one on sale. Read it at <www.pocketaprs.com/dfjr_advice.html>. Also take a look at Mike's PocketAPRS program for PDAs, which is full of RDF-related features.

Hams can now buy other inexpensive Doppler sets with even more features plus Agrelo-format data output for APRS support. An example is the MicroFinder by AHHA! Solutions <www.ahha-doppler.com>. Watch for more on this and other Doppler products in future "Homing In" columns.

Many thanks for your responses to the Doppler series. It has stimulated some interesting and useful dialogue about optimizing Doppler performance. For instance, Jim Bixby, ex-WØEUM, responded to part 2 of the series, in which I stated that optimum whip spacing for a 4-element "square" array was just under one-quarter free-space wavelength on a side, constrained by amplitude and signal-to-noise ratio of the Doppler-induced tone into the NBFM receiver. Jim went at it a different way, basing his analysis on the linearity characteristics of typical VHF-FM receiver limiter and discriminator stages. He came to exactly the same conclusion for optimum array size. (Whew!) Read his analysis at <http://home.san.rr.com/bix/Gribix/Technical/OptAntDim.pdf>.

Your comments and questions on any RDF topic are welcome. Send them via e-mail or postal mail to the addresses on the first page of this column. ■

California Welcomes The Nation's Best Foxhunters . . . and Those Who Want to Be

Is this the fastest growing form of ham radio competition? It combines ham radio technology with good exercise outdoors. It's suitable for anyone of any age, with or without a ham radio license. Most hams call it on-foot "foxhunting," but it's also known as "radio-orienteering" and ARDF. The sport is popular in two dozen countries around the world, with national and international championships every year.

For the fourth year in a row, the best radio-orienteers in the USA will gather to see who is best in the nation and who will represent our country at the World ARDF Championships. There will be plenty of newcomers, too, seeking to learn how to be champions of the future. This year's event organizer is the Santa Barbara Amateur Radio Club (SBARC).

An optional training camp starts the action during the weekend of June 12–13 with map-and-compass orienteering at Mount Pinos in the Los Padres National Forest. The next two days of the camp will be in Griffith Park, Los Angeles, where students will learn course strategies, route choices, and bearing-taking.

The main events get under way on Wednesday, June 16 as competitors arrive at the headquarters site near Gorman, California. The next day they fine-tune their skills and align their direction-finding equipment using short courses on both the 2-meter and 80-meter bands. Opening ceremonies, and a drawing for the starting order are that evening. Friday brings the full-length 2-meter competition at a "secret" location, followed on Saturday by an 80-meter event of similar size in a different venue. Closing ceremonies take place Saturday evening and the competitors take their medals home on Sunday.

The USA Championships conclude just in time for final selection of ARDF Team USA 2004 members, who will travel to Brno in the Czech Republic for the 12th ARDF World Championships from September 7–12. USA's team positions will be filled based on performances in the 2004 events in California and the 2003 events in Ohio.

General Chair for the 2004 USA Championships is Marvin Johnston, KE6HTS, one of North America's ARDF pioneers. A member of USA's first team to the ARDF World Championships (Hungary, 1998), he has been on the team ever since, making trips to compete in China in 2000 and Slovakia in 2002. He won medals at the last two USA ARDF Championships.

SBARC has an abundance of ARDF talent, including club President Jay Hennigan, WB6RDV, who won gold in his age category on both 80 and 2 meters at the 2003 USA Championships. Another SBARC medal-winning foxhunter is Scott Moore, KF6IKO, who won bronze on both 80 and 2 meters in Cincinnati. SBARC is collaborating with the Los Angeles Orienteering Club for preparation of maps and organization of the start/finish areas of the competition.

Radio-orienteers from all over the country plus visitors from abroad are expected to attend the USA Championships. The competitive courses are open to anyone of any age, with or without an amateur radio license. Gold, silver, and bronze medals will be awarded in five age categories for males and four for females, in accordance with rules of the International Amateur Radio Union. Don't expect to see any Doppler sets, as most participants prefer lightweight, flexible Yagi antennas for 2 meters and loop or ferrite rod antennas for 80 meters.

Bob Frey, WA6EZV, co-chair of the last year's USA ARDF Championships in Ohio, presents a bronze medal for third place in the 2-meter competition to Marvin Johnston, KE6HTS, at the closing ceremonies. Marvin will be presenting lots of medals this year as event chair for the USA ARDF Championships in southern California. (KØOV photo)

Read all about the excitement of participating in the USA Championships by reading my "Homing In" column in the Winter 2004 issue of *CQ VHF*. Then get more details on this year's championships and register online at a special website set up by SBARC. You can get there quickly by link from the "Homing In" website: <www.homingin.com>. There you will also find information on other local, national, and international radio-orienteering events, including this year's World ARDF Championships in Slovakia. You can subscribe to a group e-mail list for updates and discussions of plans for the Championships.

If you prefer snail-mail, write to Santa Barbara Amateur Radio Club, P.O. Box 3232, Santa Barbara, CA 93130-3232, attention Marvin Johnston, KE6HTS.

Announcing:

The 2004 CQ World-Wide VHF Contest

Starts: 1800 UTC Saturday, July 17, 2004
Ends: 2100 UTC Sunday, July 18, 2004

I. Contest Period: 27 hours for all stations, all categories. Operate any portion of the contest period you wish. (*Note:* Exception for QRP Limited.)

II. Objectives: The objectives of this contest are for amateurs around the world to contact as many amateurs as possible in the contest 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. Single-Op All-Band QRP. There are no location restrictions – home or portable – for stations running 10 watts output or less.

4. Single-Op QRP Portable Limited. This is the "Hilltopper" QRP category for all-band portable stations, who are limited in time to a maximum of 6 hours continuous. Backpackers and portables who do not want to devote resources and time to the full contest period are encouraged to participate, especially to activate rare grids. Any power source is acceptable.

5. Rover. A Rover station is one which is manned by no more than two operators, travels to more than one grid location, and signs "Rover" or "/R" with no more than one callsign.

6. 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.

Stations in any category, except Rover and QRP Limited, may operate from any single location, home or portable.

V. Exchange: Callsign and Maidenhead grid locator (4 digits, e.g., EM15). Signal reports are optional and should 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.

A. A rover station 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.

Example 1. K1GX 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

K1GX 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 country. 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.), provinces (Canada), and countries, and may also be extended to include other subdivisions as justified by competitive entries.

Unique, handsome plaques will be awarded to the highest scoring stations. For more information on the CQ VHF Contest Plaque Program see <http://www.cqww.com/ VHF plaques.htm>.

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.

Making or soliciting QSOs on the national simplex frequency, 146.52 MHz, or your country's designated national simplex frequency, or immediately adjacent guard frequencies, is prohibited. Use of commonly recognized repeater frequencies is prohibited. Recognized FM simplex frequencies such as 146.49, .55, and .58, and local-option simplex channels may be used for contest purposes.

Aeronautical mobile contacts do not count.

Contestants should respect use of the DX window, 50.100–50.125 MHz, for intercontinental QSOs only.

UTC is the required logging time.

X. Log Submissions: Log entries must be submitted by September 1, 2004 to be eligible for awards. Submit your electronic log in the Cabrillo format created by all major logging programs. Send via e-mail attachment to <cqvhf@cqww.com>. Subject line: Callsign [used in the contest] only.

Those using paper logs are urged to utilize "web forms," which allows you to transcribe your logs for entry on-line and automatic Cabrillo submission. Web forms are at <http://www.b4h.net/cabforms/cqwwvhf_cab.php>.

For those without e-mail access, paper logs may be submitted to: CQ VHF Contest, 25 Newbridge Rd., Hicksville, NY 11801 USA. Questions may be sent to <vhf-questions @cqww.com>.

By Kent Britain,* WA5VJB

ANTENNAS

Connecting the Radio to the Sky

From Cheap Yagis to Cheap Patches

Previously we have covered Cheap Yagis. I've wanted to expand into Patch antennas, but I never quite figured out how to solder the coax to aluminum foil on styrofoam.

This project starts at your local building-supply store. You're going to need a sheet of 1/2-inch insulating siding. Look at it very closely. You need aluminum foil on both sides for the 900-MHz and above antennas. On most versions, one aluminum-foil side is obvious, but the other side has the aluminum foil between a layer of plastic and a layer of cardboard. Next, you need a roll of aluminum-foil tape. The aluminum tape is often found in the air-ducts section. Last, you need some sheet tin or sheet brass. I get mine at a local hobby shop, and .010-inch to .032-inch thickness can be used, along with a length of coax, of course.

The electrical connection between the coax and the patch is almost as much a capacitive connection as a resistive connection, but keep the tin tabs wide and the coax will couple well.

Square vs. Rectangle

Most Patch antennas are square, but you can increase their bandwidth a bit by making the patch a rectangle. The wider the rectangle, the wider the bandwidth. Don't get too carried away, however, as you can excite some bazaar high-order modes in the patch. A 1-to-1 (square) ratio makes the most compact antenna. A 1.5- to-1 has good bandwidth, and a 2-to-1 ratio should only be used if you have the test equipment to make sure it's really working on the frequency you think it is.

Ground Plane

A Patch antenna likes a big ground plane. All these antennas would benefit from an even larger ground plane behind the patch, but the performance improvement would be small. Hey, if you have the room and the extra styrofoam, go ahead. If space is tight, you can trim a bit off the four sides of the ground plane, but you're on your own.

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

Impedance Match

The very center of the Patch is a null point, zero ohms. You can put a bolt or a wire right through the center of the patch, short it to the ground plane, and nothing will happen. Some antennas take advantage of this and support a sheet-metal patch on a threaded rod over a ground plane. If it's important for the

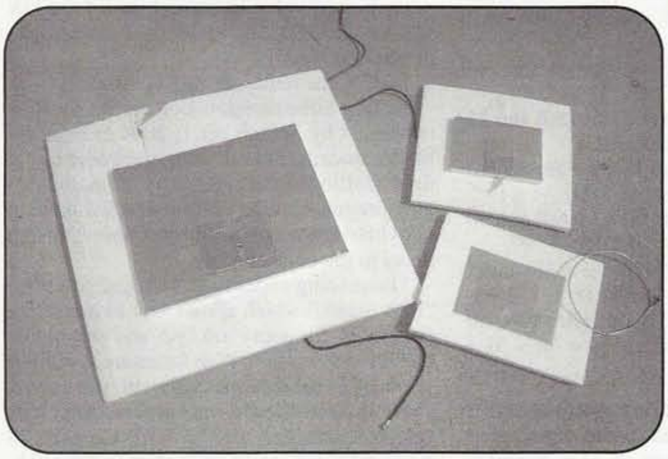

Photo A. Cheap Patches.

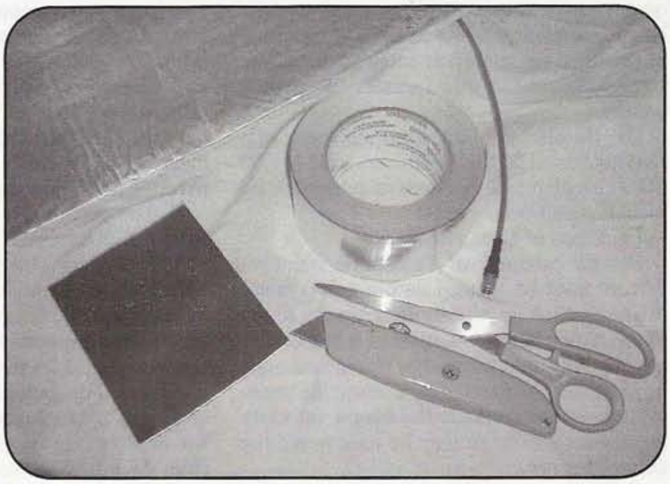

Photo B. Building materials for the Cheap Patch antennas.

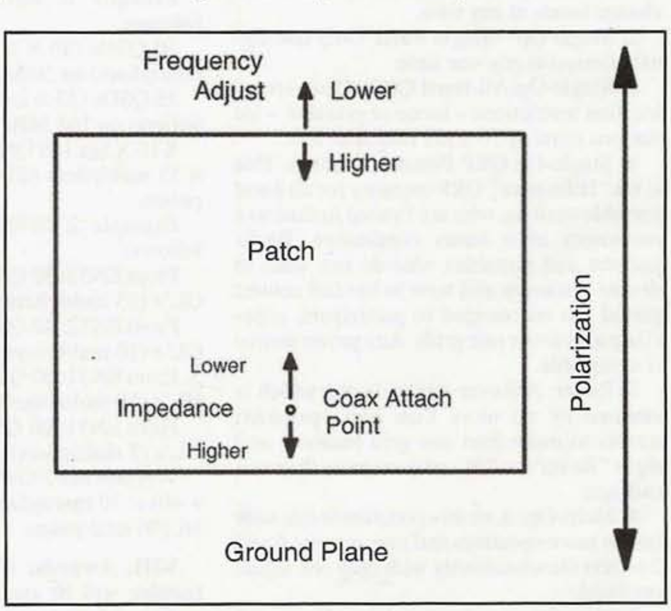

Figure 1. Critical dimensions for a Patch antenna.

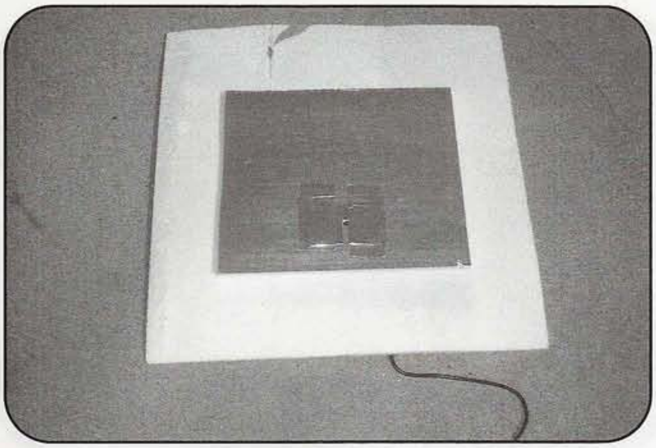

Photo C. A 420- to 450-MHz Patch antenna..

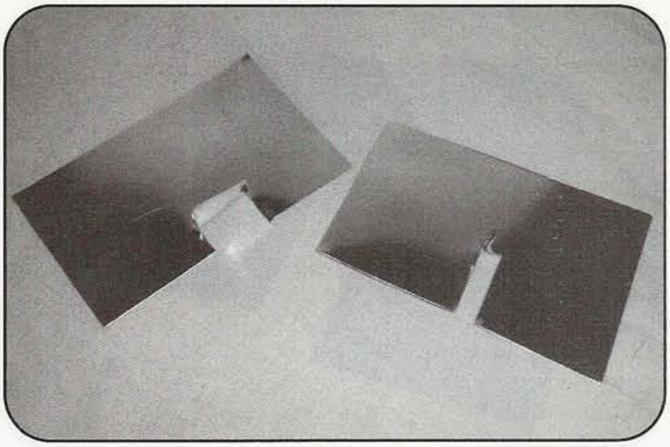

Photo D. Photo of the coax solder tabs.

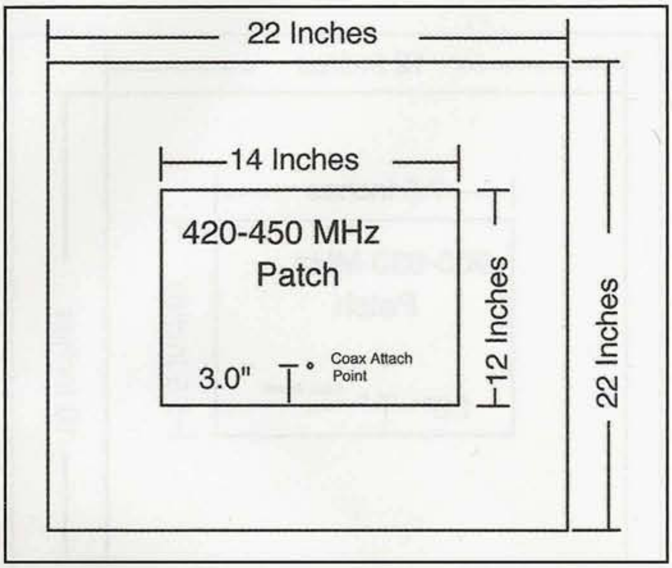

Figure 2. Dimensions for the 420- to 450-MHz Patch antenna

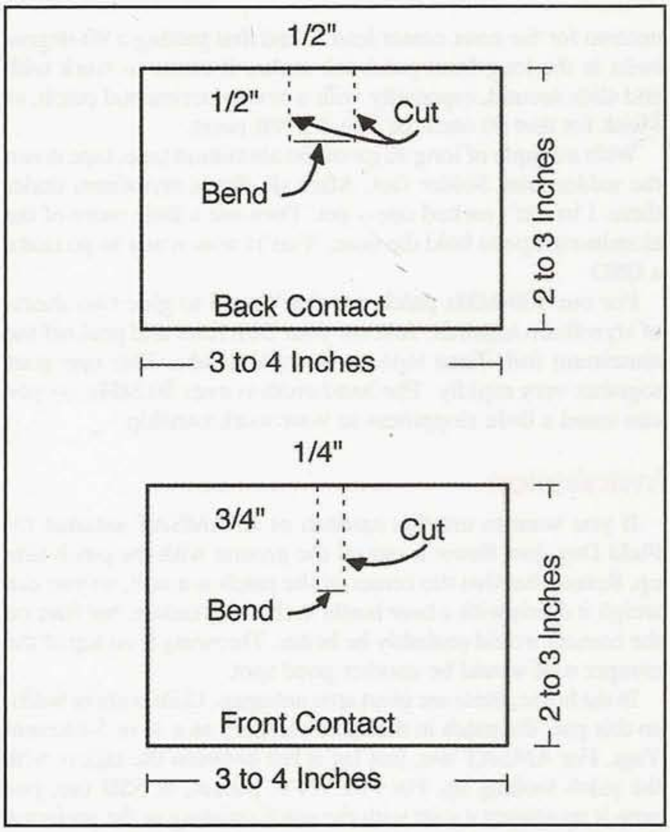

Figure 3. The coax solder tabs.

patch to be at DC ground, a wire from the center to the ground plane makes an excellent DC short. At the same time, the impedance at the edge of the patch can run as high as 300 ohms. Therefore, if you work your way back between the edge and the center, you can find the 50- or 72-ohm point.

Tweaking SWR

In Figure 1, I show the two critical dimensions for center frequency and impedance match. Trimming the top edge will increase the frequency just like trimming the top of a whip antenna. Moving the match point up and down will find that SWR dip. If you just build it to the dimensions, the SWR should be less than 2 to 1, and typically better than 1.5 to 1. I know, for you chaps who like to think in dB return loss like I do, these patches have been tweaked to –40-dB RL just messing around on the network analyzer. It isn't particularly practical, but it's fun to do.

Construction

At 450 MHz, the antenna needs to be thicker than 1/2 inch. Consequently, we are going to glue two 1/2-inch sheets together. I have used White Glue, Gorilla Glue®, and the Silicon RTV-type glue. The water-based glues work well, but it takes a long time for the glue to dry. The RTV types are probably best, but don't use more than you really need or it can change the frequency a bit. You're welcome to experiment with glues, but remember that we are gluing styrofoam here. Many glues, such as Super Glue® or model-airplane glue, quickly melt the styrofoam into a sticky mess.

Cut your ground plane and your patch. Next peel off the aluminized plastic. Glue them together; put a few books, bricks, etc., on the patch; and call it a night.

The next day, cut out and bend up your coax tabs. Both tabs need only two cuts. The bottom tab needs to be just enough to solder the coax shield to it. The front tab needs to be long enough to come out the back of the patch to become the solder con-

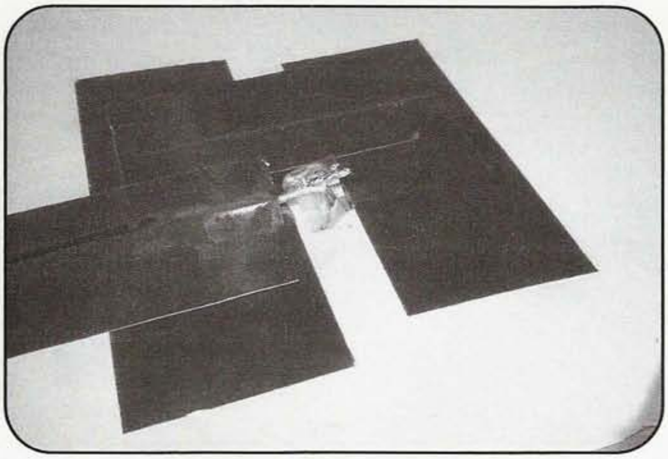

Photo E. Coax soldering.

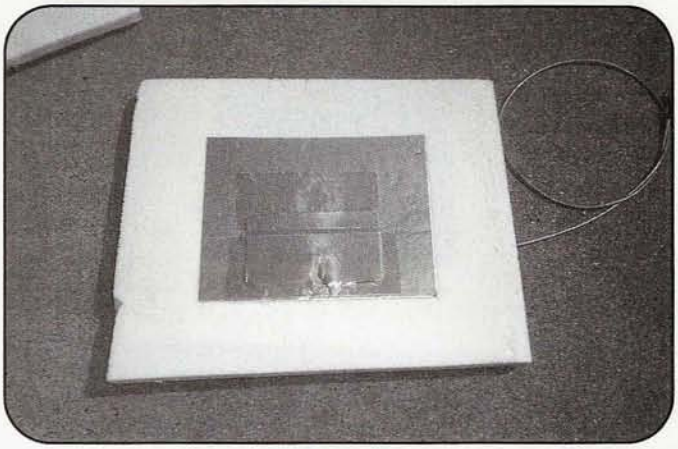

Photo F. The 900-MHz styrofoam Patch antenna.

nection for the coax center lead. I find that putting a 90-degree twist in the long front patch tab makes it easier to work with and slide around, especially with a new experimental patch, as I look for that 50 ohms or 1-to-1 SWR point.

With a couple of long strips of the aluminum tape, tape down the solder tabs. Solder fast. After all, that's styrofoam under there. I haven't melted one—yet. Then use a little more of the aluminum tape to hold the coax. You're now ready to go make a QSO.

For our 900-MHz patch, we don't need to glue two sheets of styrofoam together. Just cut your trim lines and peal off the aluminum foil. Then tape on the solder tabs. This one goes together very rapidly. The bandwidth is over 50 MHz, so you can stand a little sloppiness in your workmanship.

Installation

If you want to use this antenna as an AMSAT antenna for Field Day, just throw it out on the ground with the patch side up. Remember that the center of the patch is a null, so you can weigh it down with a beer bottle in the very center, but four on the corners would probably be better. Throwing it on top of the camper roof would be another good spot.

In the home, these are great attic antennas. Gain is about 9 dBi, so this puts the patch in the same category as a 4- or 5-element Yagi. For AMSAT use, just lay it flat between the rafters with the patch looking up. For FM, ATV, packet, or SSB use, just prop it up against a joist with the patch pointing in the preferred direction. Heck, you could even put a nail or staple in the area around the ground plane. Mounted outside, the sun eats the styrofoam pretty fast and these antennas don't like being wet.

Polarization

Linear polarization is determined by where the patch is fed, not by the shape of the patch. Feed the patch from the bottom or the top for vertical polarization; feed the patch from the side for horizontal polarization.

Roger Cox, WBØDGF, had written an excellent DOS program for designing Patch antennas. I have been using Roger's program for years and found his results accurate to the limits of my measurements. Patch16.EXE can be downloaded from <http://www.ntms.org> or <http://www.funet.fi/pub/ham/antenna/>.

For the styrofoam antennas, I've been using an Er (dielectric constant) of 1.05 and a loss factor of .001, which allows a bit for the glue. As I build more antennas, I'm sure these numbers will be refined somewhat, and there may be some difference in materials from Home Depot versus Lowe's do-it-yourself (DIY) hardware stores. With these very thick patch antennas, the tab going to the front patch adds some inductance, which the Patch16 software program doesn't consider. With the styrofoam antennas, the tap's point usually wants to be higher impedance, or closer to the edge of the patch than the computer predicts. If you're doing something new, you'll probably need to move the attach point in and out a bit. The tape seems to hold to the aluminum foil better than the foil holds to the styrofoam. Pulling off the tape usually results in pulling off the patch. I found that cutting the tape around the whole tab works best.

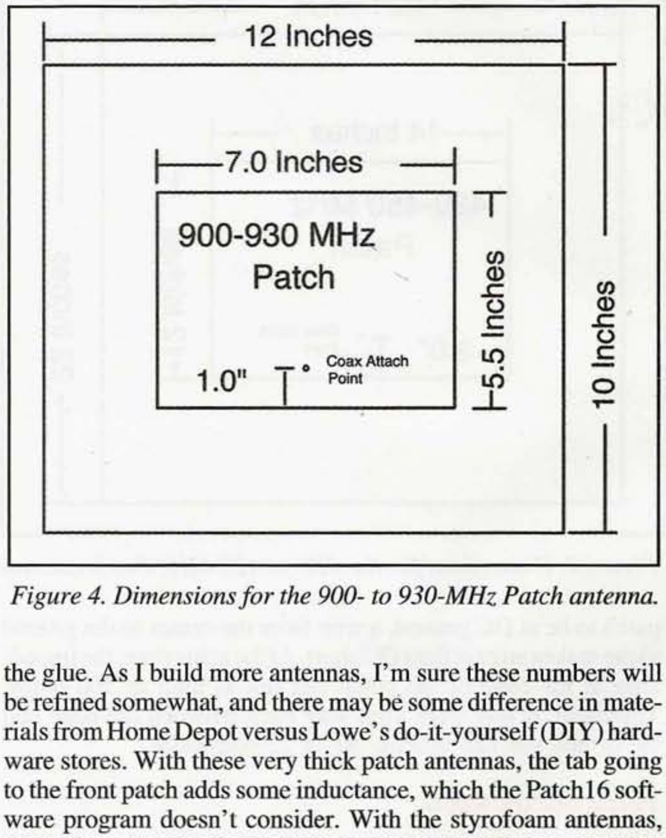

Figure 4. Dimensions for the 900- to 930-MHz Patch antenna.

What's Next?

Now that I have a basic design to play with, we'll be looking at more frequencies, circular-polarized Patches, and maybe even stacked Patches working on multiple bands. These can go as low as 222 MHz using styrofoam siding, or up to 1296 MHz. By using just the sheet tin, we can make 2.4-GHz versions. Back to the workbench! ■

By Chuck Houghton,* WB6IGP

Surplus Components to Construct A 1296-MHz Transverter

In the Winter 2004 issue of *CQ VHF* I described a phase-locked synthesizer reprogrammed to 1152 MHz. This is a conversion that does not require exotic test equipment to change the synthesizer from its commercial frequency and mode of operation into one for amateur use. The 1152-MHz frequency is important not only for upper-microwave bandedge markers, but also as a local oscillator (LO) when coupled with a 144-MHz, 2-meter multimode radio. Construction of a 1296-MHz transverter cannot be far away. It is simplified by putting to use an older multimode 2-meter transceiver as a transverter IF driver. The "formula" is 1152 MHz from the synthesizer (low side LO injection) plus 144 MHz equals an operational frequency of 1296 MHz.

While appearing to be quite technical, the synthesizer conversion described last time is easy to follow, producing a very accurate and stable low-phase-noise source for SSB operation or any other mode you care to use as a marker or for dual use in a 1296-MHz transverter construction project.

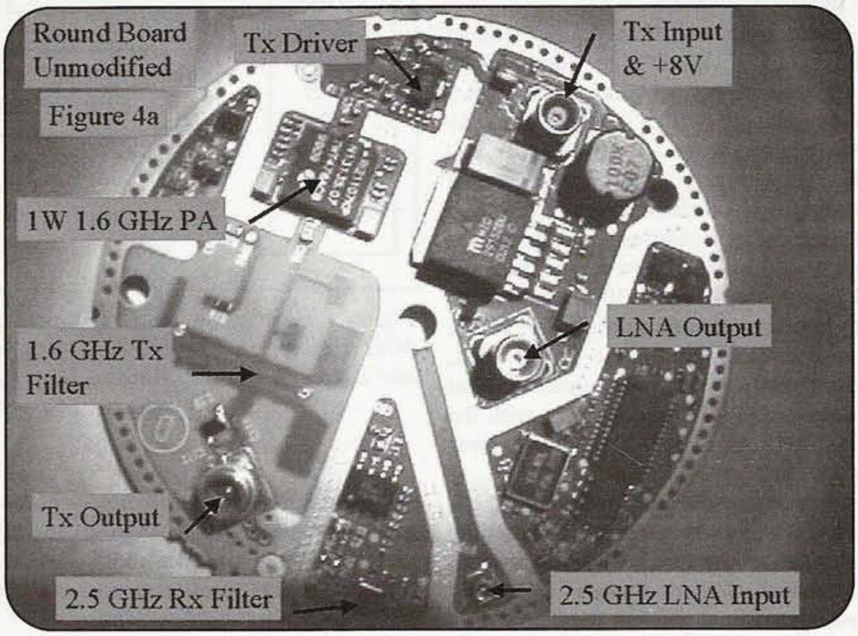

Photo A. My 1296 transverter for our microwave group's 1296 rig show and tell. The power supply and synthesizer are located under the main chassis frame. Photo shows bottom left: the mixer, bi-directional 1296 IF strip just above the mixer (gold-color PC board), relay for DC switching, and SMA coaxial relay. Top center is the 1240- to 1300-MHz filter, the preamp is just below the SMA relay, and the round power 1-watt amp is top right. (Photos by N6IZW)

This project was first brought forth by the San Diego Microwave Group when we were discussing improving interest and activity on the higher microwave frequencies. It was decided to attempt the construction of a different band microwave converter each month. While this sounds like a very ambitious project, we think that from a homebrew point of view it presents quite a challenge to our members and will warm up quite a few soldering irons during those cold months in garage ham shacks. To assist our microwave group and increase participation, we provide some of the component parts critical to this project, such as key surplus PC boards. This provides a starting point and incentive towards completion of the transverter.

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

Our group is not an official registered club. There are no dues and no rules, just camaraderie in the pursuit of a common interest—amateur radio and microwave operation. We have been meeting for over ten years. We meet each Monday at 9 PM on the local Palomar repeater (146.73 –600, no PL normally required) with the permission of the Palomar Amateur Radio Society. Kerry Banke, N6IZW, is our net control. The exception is the third Monday of the month, when we meet for our once-a-month meeting at Kerry's home. Swapping electronics issues, equipment calibration, and repair of equipment are normal using Kerry's array of test equipment. The goal is to give assistance and promote interest in construction ideas using surplus material. Projects include working transceivers from 1296 MHz up through 47 GHz and a full-duplex laser communicator. The challenge this time was to make a 1296-MHz transverter before the next month's meeting.

The Driver

First, let's cover the driver for these converters, our 2-meter transceiver. Normally, a 2-meter multimode radio is used as an IF strip to drive the converter with low power. A suitable radio is the Yaesu FT-817. This very popular rig has a low-power output setting of about 150 to 200 milliwatts to drive a converter's mixer quite well—normally nothing over +10-dBm input power to a precious microwave mixer. The low-power setting for a 2-

meter driver is most desirable, and many 10-watt rigs such as the old Kenwood TS-700 and similar can be modified to work at this lower output power level, which is required for mixer injection. Bells and whistles are not necessary in a 2-meter rig for converter operation. Older rigs will work just fine and can be obtained for quite a bargain, as they are less desirable for repeater use because they do not have PL tones available. However, for a converter driver they make a great microwave IF driver transceiver.

It just happened that over a period of two years I was able to obtain three Kenwood TS-700s at local swap meets. I discovered that the modification to reduce power to the 150- to 200-mw output level was quite simple and also could be removed in a minute to return the radio to its original condition. The modification to allow low power was accomplished by installing a 10-dB attenuator of 1/4-watt resistors on the input of the power-amp compartment driver coax, unsoldering the center conductor and placing the 10-dB pad in series with the coax and amp input. This was a five-minute job.

I also obtained a multimode ICOM IC-260A. It had a low-power switch, which worked out just fine. It was decided to permanently solder the switch in the low-power position to prevent accidental high power from destroying a mixer.

The mods to these radios were quite simple and reduced the maximum output from the normal 10 watts to 150 mw. This is an ideal power level to drive the mixer of a converter for any microwave frequency. (Other multimode radios might not be as easy to modify. Check them out as best as you can, and if they are inexpensive, add them to the collection anyway.) Keep an eye out for older multimode radios for 2 meters and even 440 MHz. If you want a great IF system to use with any microwave converter you may be contemplating, these radios can be obtained for a quite reasonable cost.

Would you believe another multimode radio that Kerry and I both found was an HT? Specifically, the radios were Santec LS-202 HTs. Mine was a junker, as it was missing the power-amp transistor, which was a special mounting and was unobtainable, making repair not possible. This was still a very desirable item to me, as it was a multimode HT with both normal FM and SSB capabilities. I placed a 10-pF chip capacitor across the base to collector of the missing power-amp transistor and the HT put out 100 mw of power, making a great SSB IF strip for my 10-GHz converter. Cost was $30. Sure, the knobs were small and calibration was difficult, but it worked very well.

Keep your eyes open for bargains and don't pass up those older 2-meter multimode transceivers. Get them out of the closet, knock the dust off them, put them to use in these simple converters, and enjoy the microwave mode of operation using modest-cost older equipment. Of course, if you have one of the Yaesu FT-817s, it's back to somewhat small knobs

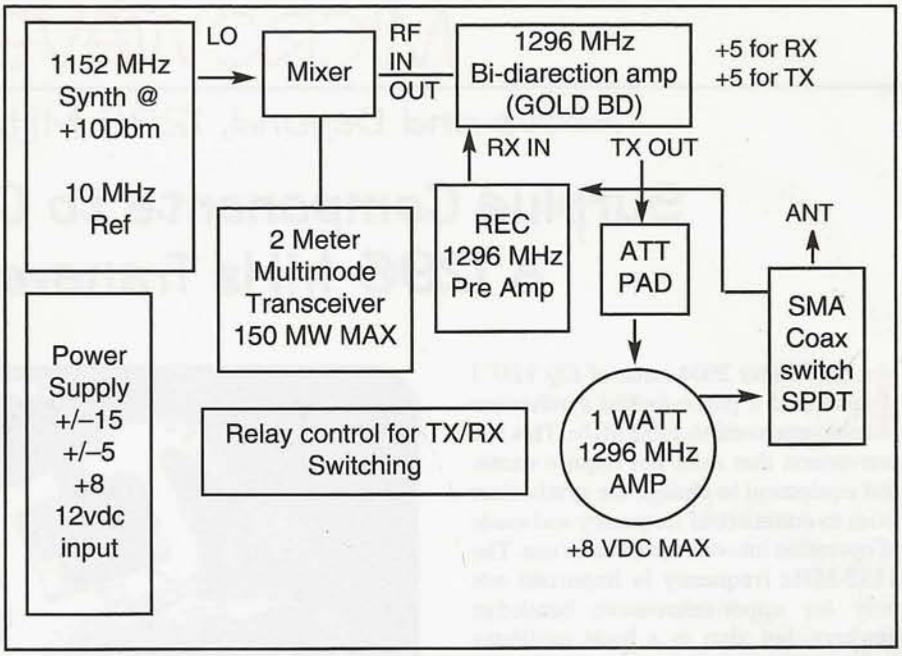

Figure 1. Block diagram of transverter components used in construction of the 1296-MHz transverter. Use whatever components you might have on hand, as there is no one correct method of construction. By using whatever parts you can adapt to the project, you will save some big bucks.

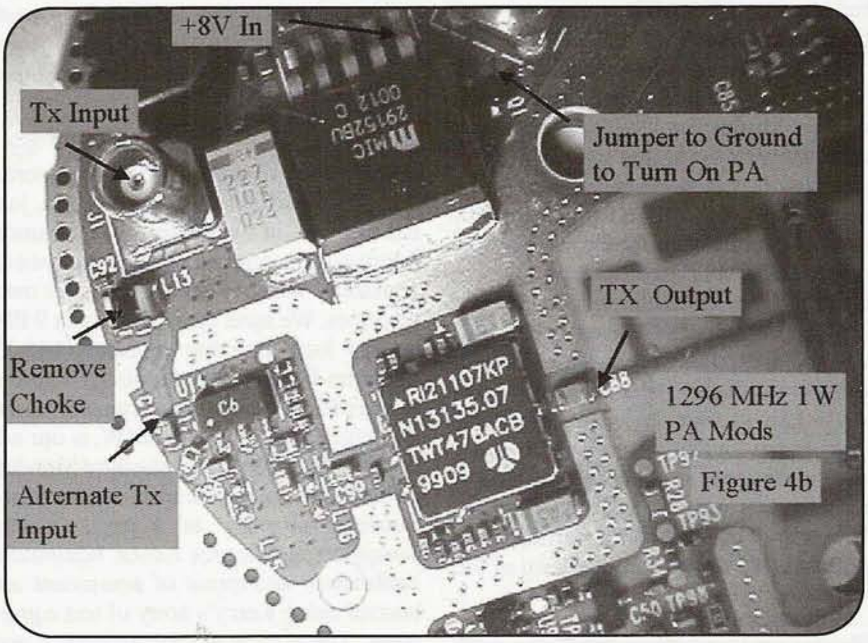

Photo B. Layout of unmodified Round Board, a 1-watt power amplifier used in the converter for 1296 MHz.

and large computer-driven menus, allowing you to customize the radio and making it a great choice for a new IF system. I have one, and I wish I could obtain another for dedicated IF use in my converter systems. The Yaesu FT-817 is top dog in my book.

The 1296-MHz Challenge

What did it take to construct the first rig for our 1296-MHz challenge? We presented the LO for 1152 MHz. Couple that to drive the LO port of a mixer, connecting the IF port of the mixer to your IF system, a 2-meter, low-power modified multimode transceiver. Developing some sort of IF (1296 MHz) gain device to amplify the mixer output to produce power to drive a power amplifier would be a nice addition here. Also, some preamplification in the receive mode at 1296 MHz along with a low-noise preamp would finish off the project. Oh, yes . . . a coaxial relay for switching from transmit to receive, and regular old relays for turning the power on and off for transmit and receive, would complete the basic no-frills converter for 1296 MHz.

First, to make things easy, from Qualcomm surplus we put together a bidirectional IF amp that normally functions in the 700- to 1700-MHz range. This switching IF amplifier can be cut out of a portion of a circuit board with a regular pair of scissors. We call this surplus Qualcomm board the small "Gold Board." This modified portion of the circuit board will give you a single port for switching for both transmit and receive by the control of application of +5 volts on either the RX or TX control line. The other end of the amp is the dedicated transmit-out port and a separate RX receive input to a preamp receiver amplifier, simplifying control switching. This Gold Board was made available to our group members, and we have boards available from the author for others interested in this project. For a full, detailed list of various projects on which our group has worked, go to <http://www.ham-radio.com/sbms/sd/projindx.htm>. If you want further details on the 1296-MHz project, go to Kerry, N6IZW's great conversion material near the end of the projects listing.

Now we will cover in detail an amplifier for 1296 MHz that produces 1 watt of power and can be converted quite easily from its original application at 1600 MHz. Again, the boards can be obtained from the author. The 1-watt 1296 amplifier board is what we call the "Round Board" due to its being just under 3 inches in diameter. The conversion is quite simple and only requires some short sections of .085 hardline coax to bring out the input and output of the amplifier circuitry. A PC-mounted RFC (radio frequency choke) is removed to gain access to the input of the driver-stage transistor. There is a chip capacitor isolating the input, so direct connection can be made to ground and the input chip capacitor of this final-amplifier driver stage.

This stage has about 12 dB of gain and should be driven in RF power by at least –10 dBm. Higher power is not required and will only cause instability if driven to hard. Drive in the –10 dB range is just right. The circuitry on the input to the transistor driver and its components is left intact, in its original condition. The only modification needed is to cut away the power-amp output filter, leaving its isolation chip capacitor intact. With an X-Acto® knife, cut the large green PC-board filter away from the output chip capacitor. You do not need to remove more than 1/4 inch or so to separate the filter from the output amp. A nearby convenient gold ground strip anchors the .085 hardline coax, and the center of the coax is soldered to the output of the amp chip capacitor where the green filter was cut away from the chip capacitor. See

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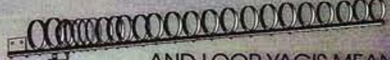

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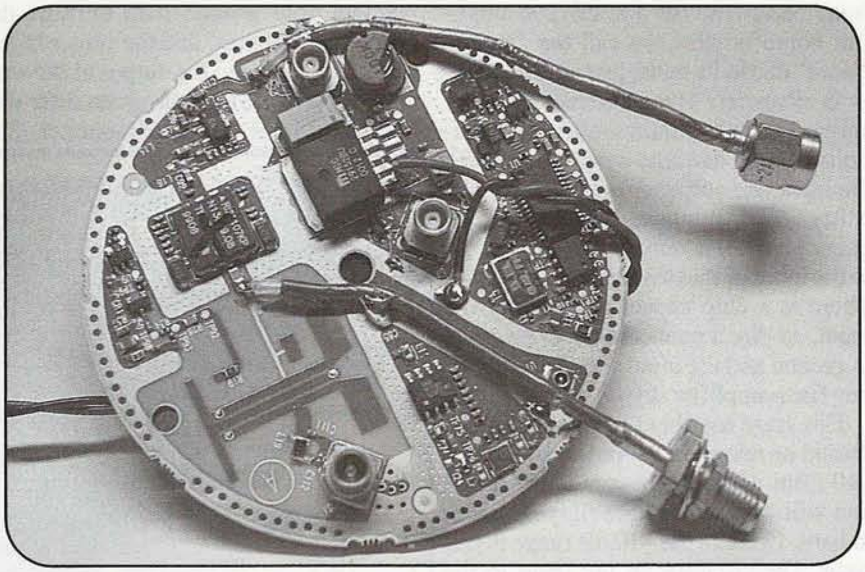

Photo C. Round Board with labels attached to show where modifications are to be made on the 1-watt power amplifier PC board.

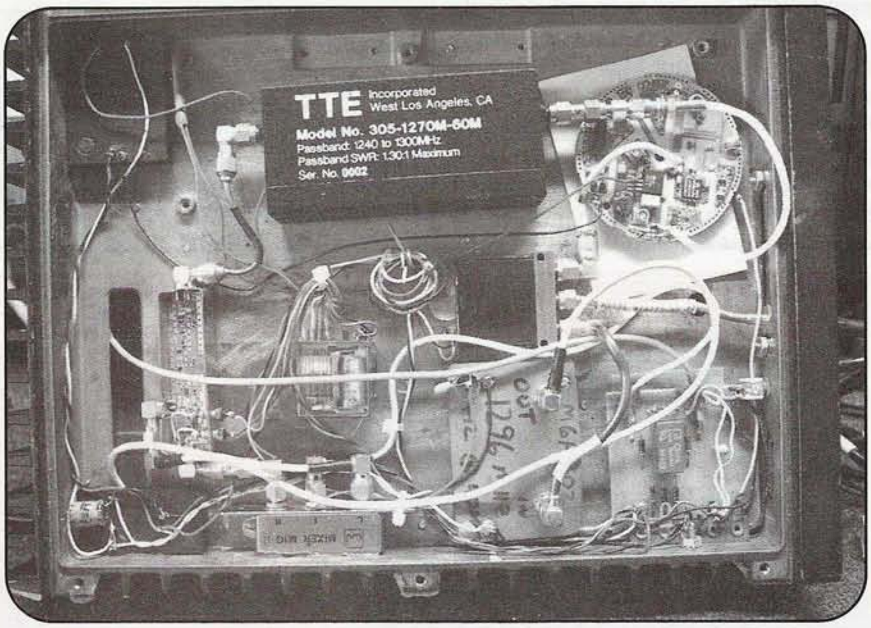

Photo D. Fully modified 1-watt power amplifier using .085 hardline coax to bring out to external SMA connectors the input and output of the power amplifier.

photos B, C, and D for details of the conversion and photo D for lead attachment.

To turn on the amp in the transmit condition a ground must be connected to the farthest right transistor pin near the center of the PC board just between the power regulator and the center coax connector on the board. Position the board with the center coax connector up in the 12 o'clock position and the regulator just to the left. This transistor resides in the "V" area between that coax connector and the regulator. Ground the transistor pin nearest to the coax connector. Provide +8 volts DC at about 800 ma to regulator pins 1 and 2 shorted together for DC power input. Take a look at the website provided earlier for full-color pictures and more detailed information.

For the club's 1296-MHz rig-building-project day, in my transceiver I used a simple toggle switch to activate a multi-contact relay for transmit and receive functions. The relay controlled power to the power amp and power to the coil of a miniature SMA coaxial relay for antenna switching and the +5-volt control for directional control of the bi-directional IF amp Gold Board. Photo D shows the top part of the half shell housing all parts of the converter. The bottom portion houses the 12-volt power supply and the 1152-MHz synthesizer. The top shows the mixer preamp's bi-directional 1296 amplifier relays and power amp. Forgive me for not "squaring up" my wiring dress. Components such as relays and other flat devices are held in place with silicon RTV left to dry overnight. The only item not RTVed to the metal frame is the power amp, which is bolted to dead ground for stability and good grounding. In this first attempt I used flexible, miniature coax cable from the junk box instead of the.085 hardline coax that I recommended for the 1-watt amp. In later conversions .085 was used.

The main components needed for this project are the synthesizer modified to 1152 MHz; a mixer which could be as simple as an SRA-11 Mini Circuits Mixer; the Gold Board to recover the 1296 bi-directional IF amp; an RF low-noise preamp for receiving; and, of course, the 1-watt amp Round Board for some 1296-MHz horsepower on transmit. Add two relays, one coaxial, and a power supply and you have a 1296-MHz transverter for playing games at the next club meeting. I will be bringing my rig and 2-meter transceiver (an ICOM 260A), along with a 12-volt battery and a very simple dipole for garage QSOs, to our next microwave group meeting.

And Finally . . .

As I stated earlier, I will make available some of the key elements to construct the 1296-MHz converter. The bi-directional Gold Board is $20; the 1296-MHz 1-watt Round Board is $15; the synthesizer is available for $35; plus $5 for priority post and packing charges. For California destinations, please include California sales tax of 7 3/4%. Personnel checks are okay; please make them out to Chuck Houghton.

If you have any questions or comments, feel free to e-mail me at <clhough@pacbell.net> and I will try to answer as best I can. I am fortunate to have a high-speed DSL connection, so large files and photos are not a problem.

Now let's see if 2304 minus 144 MHz equals a 2160-MHz LO. I am getting ahead of myself, though. I have to save something for the next column, and to get on another band of interest in the next San Diego Microwave Group Garage QSO Party. 73, Chuck, WB6IGP

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Practical Projects

Edited by Dr. George Brown, M5ACN

RSGB 2002 Ed, 224 pages

Packed with around 50 "weekend projects," Practical Projects is a book of simple construction projects for the radio amateur and others interested in electronics. Features a wide variety of radio ideas plus other simple electronic designs and a handy "now that I've built it, what do I do with it?" section. Excellent for newcomers or anyone just looking for interesting projects to build.

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Edited by Roger Balister, G3KMA.

RSGB, 2002 Ed., 128 pages

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By Tom Webb,* WA9AFM

SATELLITES

Artificially Propagating Signals Through Space

Getting to the High Frontier

As you may have read in the article "AMSAT OSCAR-E Project, Spring 2004 Status Report," by Rick Hambly, W2GPS, elsewhere in this issue, Echo is assembled and ready to fly. Building a satellite is just half the project. Once you have the construction finalized, the components integrated, and the vehicle certification complete, then you have to get it into space with a proper orbit. As you will soon see, this can be a very daunting task, including all of the factors that go into launching a satellite into space.

Location, Location, Location

As with real estate, location of a launch site is critical to the success of launch. At present, there are just over a dozen major launch sites around the world (see Table 14.8 of the *Radio Amateur's Satellite Handbook*). When a satellite is launched, you want to take advantage of every possible factor to help the launch vehicle achieve escape velocity and reach orbit. To maximize this boost, the ideal launch site would be located on the equator, launching to the east, to take advantage of the Earth's rotation.

The latitude of a launch site will also determine the inclination of the satellite's orbit. For example, Kourou, French Guiana is only 5 degrees north of the equator, making it virtually a perfect location for geostationary satellites, which orbit in the equatorial plain—i.e., zero degrees inclination. Likewise, Plesetsk, Russia at 63 degrees north is the best spot to launch satellites destined for high elliptical (Molniya) orbit, typically 63 degrees. Echo will be launched from Baikonur Cosmodrome (a.k.a. Tyuratam), Kazakhstan, which is at 46 degrees north.

Another factor is open, uninhabited space east of the launch site. Although it has no impact on the boost that Mother Earth provides, if the launch isn't successful, the neighbors might get upset when an Ariane/TitanIII/Dnepr LV comes crashing down in their back yard. Thus, most launch sites are at coastal locations, launching over open water, or in uninhabited areas.

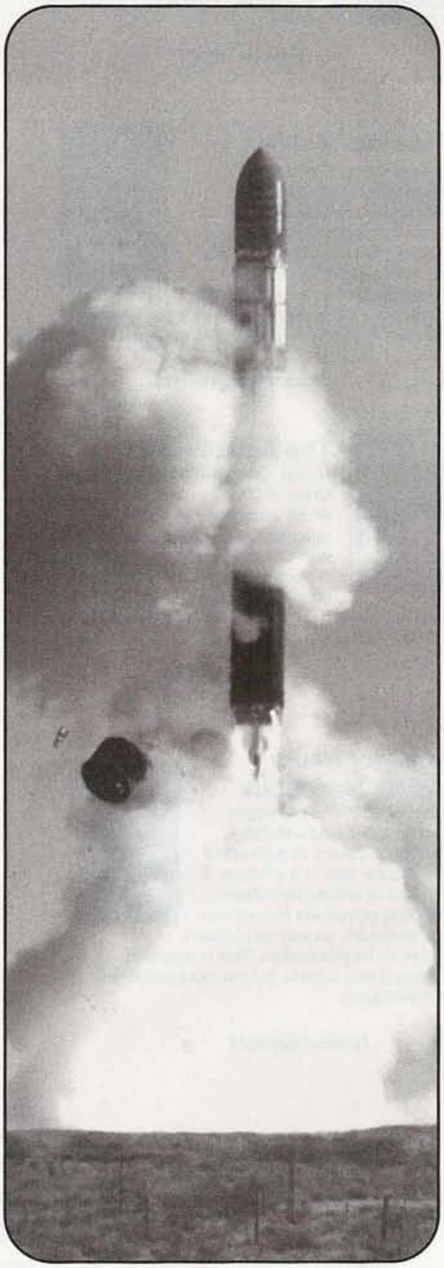
Cape Canaveral is a prime example. At 28 degrees north latitude, an eastward launch carries the vehicle out over the Atlantic Ocean. There is a certain irony attached to Cape Canaveral. When Jules Verne penned his tale "From The Earth To The Moon" in 1866, his launch site was in Florida, as the "optimum location to fire a projectile at the Moon would have to be either 28 degrees north or south latitude." Verne's launch "vehicle" was a giant cannon. Considering that it would have generated "G" forces in the thousands, a human passenger would not have survived the launch, but then it did make for a good story.

Vandenberg Air Force Base in California, and thus located on the west coast, looks out over open ocean to the south and is ideal for launches of polar-orbit satellites (weather and special mission), which require a southerly launch.

Launch Vehicles

Throughout the history of the space program, a variety of launch vehicles have provided launch opportunities for amateur satellites. The Atlas, Jupiter, Redstone, Titan, and Thor-Delta were the primary launch vehicles in the history of the space program. They were "demilitarized" missiles and usually received heavy modification for launches, strap-on boosters being the most common addition. Some of these fiery birds didn't have an enviable success rate. When John Glenn strapped into his Mercury capsule to be the first American to orbit the Earth, he did so knowing the last few Atlas launch attempts had not gone well. As the well-known movie says, though, he had the "right stuff."

The Atlas was probably the worst of the bunch, and who can forget the very public Vanguard launch attempt, which ended



The main engines of a Dnepr LV fire just as it clears the launch silo. The large, dark cylinder is the gas-generator that ejects the Dnepr from the silo prior to engine start; this is known as "cold launch," which allows the silo to be reused. (Photo courtesy of Richard Hambly, W2GPS)

*10421 SE 55th, Oklahoma City, OK 73150
e-mail: <tmwebb@cox.net>

in disaster and caused the space program to be transferred from the Navy to NASA. Most of the early launch vehicles have been retired (or the supply just ran out), but the TitanIII and Thor-Delta are still "heavy lifters" for current launches.

The early launches were free for AMSAT. We rode as a ballast—not the most noble of positions, but the price was right. In most of the early AMSAT launches, the USAF tucked the small OSCARs into a corner of the launch vehicle. As amateur satellites became larger and more commercial launches were scheduled, AMSAT birds were too big for ballast, and the price went sky high (pun intended).

At about the same time, the European Space Agency (ESA) was spinning up its launch capability with the Ariane series of launch vehicles. As they were uncertified for launch—no one would insure the launch attempt—ESA was willing to give AMSAT a ride just to prove the reliability of Ariane.

Things seemed to be looking up for the amateur satellites. There was support from a major space agency, a ride into space as a "real" satellite, and plenty of support from the amateur community. The initial Ariane launch, or campaign as ESA calls it, with an AMSAT Phase 3B bird (what was to be OSCAR 10), was to be on Friday, 23 May 1980. At launch all went well, but at second-stage separation something went terribly wrong, and the Ariane, with its payload, crashed into the Atlantic Ocean. Ironically, the AMSAT bird's telemetry was transmitting a solid signal right up to splash-down. This day entered AMSAT history as "Black Friday."

AMSAT was not to be deterred, however, and three years later a new Phase 3B satellite with the designation OSCAR-10 was launched. During separation, the third stage of the Ariane-4 rocket bumped OSCAR. The 2-meter antenna was damaged but still functioned, the orientation was a bit off, and the spin was slower than planned. This slow spin made the bird cooler than expected and caused damage to fuel lines. The "kick motor" fired successfully the first time, but the second burn wasn't attempted, as pressurization in the fuel system dropped too low for ignition.

Three years later, the main housekeeping computer failed, but OSCAR-10 soldiered on. Despite these problems, OSCAR 10 continues to operate even today, 21 years after launch.

The Ariane-5 followed the "4" series as ESA's primary launch vehicle. Times caught up with AMSAT again, and commercial launches gained priority. Consequently, it was "pay to fly."

With the fall of the Soviet Union, the Russian space program needed funding. Thus, the International Space Company (ISC) Kosmotras was formed to provide commercial launches, using "demilitarized" ICBMs (history repeats itself). The current going rate is $10–14 million (USD) per launch. The primary launch vehicle is the Dnepr, named after a major river which flows through the southwestern Ukraine.

A Ride for Echo

Echo's launch vehicle will be the Dnepr LV. As mentioned, the Dnepr began life as the RM-36 ICBM in the Soviet Strategic Rocket Force and was given the designator SS-18 by NATO.

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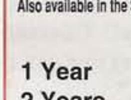

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The SS-18 was a replacement for the SS-9, which was a rough equivalent to the USAF Titan II ICBM. The SS-18 was "demilitarized," renamed the Dnepr LV, and given the peacetime mission of launching a commercial satellite.

If you go to <http://www.amsat.org/ amsat/sats/echo/article-03-11.html>, you'll be able to view three video clips, Integration, Launch, and Silo. The Integration clip shows several satellites being mounted for launch. As you can see, you don't just bolt a satellite onto a launch vehicle. Each one is placed carefully for balance and for clearance. It's a laborious task, which can take weeks, if not months.

The Silo clip shows the Dnepr being transported to its launch site. Although "demilitarized," the Dnepr is carried in an enclosed carrier to protect it from the elements (and prying eyes). At the launch site, the carrier is raised to the vertical position and the missile lowered into the launch silo. Again, although "demilitarized," the Dnepr was designed to "cold launch" from an underground silo and no effort was made to modify the vehicle to launch from a gantry. The "cold launch" concept was used by the Soviets to allow reuse of a launch silo. The USAF concept was that of a "hot launch"—i.e., the missile's engines were fired in the silo and lifted the vehicle out. The downside was that the silo was virtually destroyed in the process. The upside of this was that it made the now unusable silo an unattractive target—but so much for strategic thought and tactics.

In the Launch clip you will see the Dnepr come out of the silo with what appears to be engines blazing. In fact, the vehicle is being "blown" out of the silo by a small solid-state rocket. You'll notice the Dnepr hesitates for a split-second after clearing the silo, and then the main engines ignite and it's on its way. The puff of brown smoke is dinitrogen-tetroxide, which is the oxidizer for the vehicle propellant. The Dnepr's fuel is heptyl (a form of unsymmetrical dimethyl hydrazine). These are hypergolic fuels; when they mix, they ignite. Thus, no ignition system is required, and you have a very reliable engine start. This is the same system used in the Titan II ICBM. As a former Titan II Missile Combat Crew Commander, I can attest that both of these chemicals by themselves are very nasty!

"No Bucks, No Buck Rogers"

In the hit movie *The Right Stuff,* a test pilot explains to a reporter why the experimental aircraft program to break the sound barrier will live or die: "no bucks, no Buck Rogers." Simply put, without funding the program will not go forward. Such is the case with Echo. As we've just discussed, there are no more free rides on launch vehicles. We'll have to pay to put lift in our balloon. In fact, there is a long line of well-funded commercial programs with cash in hand waiting to get launches. The going rate at present while waiting to get launches is about $10,000 per pound, if not more.

Even though space agencies around the world recognize that AMSAT is a nonprofit organization with a noble purpose and proven expertise, there are costs that must be considered for a launch. The launch for Echo will cost about $110,000; at present AMSAT has around $60,000 in the bank. The launch delay from March to late June 2004 can work to our advantage, as it allows additional time for fund raising.

AMSAT has been innovative in its funding efforts. The most recent example was the eBay auction of a handsome brass sculpture of AO-40 rendered by the late Floyd Thorn, N5SVP. The piece brought $1225 to the Echo Launch Fund.

Your help is needed! Any donation, no matter its size, will move the launch fund toward the $110,000 goal! Contact Headquarters, AMSAT-NA (http:// www.amsat.org) or your national AMSAT organization and "give til it helps."

I'd like to take this opportunity to thank Rick Hambly, W2GPS, and Mike Kingery, KE4AZN, for their assistance in preparing this column.

Note: This is Tom's last column in CQ VHF *magazine. Tom has accepted increased responsibilities with his real job and is unable to continue working on the column. We wish to thank him for his service to the rollout of the new* CQ VHF *magazine and its subsequent two years of publishing. As of the deadline of this issue, we are looking for a replacement "Satellite" columnist. If you are interested, please contact us.—N6CL*

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A Portable EME Yagi for 6 Meters

Long on imagination but short on funds for 6-meter Earth-Moon-Earth operation? Here WD5AGO provides the solution with this rope antenna.

By Tommy Henderson,* WD5AGO

When Gerald Williamson, K5GW, the owner of Texas Towers, and I got together a month before the 2003 ARRL EME contest to discuss what we might do this time around, more bands were bought up. With Al Ward, W5LUA, in the range circle and well equipped for the microwave bands, we all examined what bands were missing; 50 and 222 MHz were the only two remaining. I had already built a portable 222-MHz EME array, but 6 meters—now *that* was a challenge!

Work began on the only possible array, a single Yagi. Most 50-ft. designs had posted gains of 14 to 15 dBi; we wanted to do better, which meant longer. We took a look at different 2-meter designs that would yield +16 dBi, and after analysis, a 2SA13 file looked promising. Redesigning the antenna for 6 meters, rounding to the nearest 1/2 inch, and repositioning elements for a good match close to 50 ohms yielded a working model with ARRL Antenna CAD. A folded dipole was to be used for the driven element due to the step impedance from 200 to 50 ohms. The antenna needed to be portable, no long-ridged booms, so insulating guy cable was used. It is more than 200 miles from Tulsa, Oklahoma to Allen, Texas, and time only allowed an 8-hour set-up time.

Most of the materials for the Yagi can be purchased from Texas Towers (http://www.texastowers.com). The Yagi is about 80 feet long and weighs about 15 lbs. Using the 3-ft. 0.5-inch tubing (see the material list in figure 1), a hole was drilled 6 inches from each end. Each element was then measured and held together with tape so the same hole was drilled through the 0.375 tubing. The guy cable was then fed through the 2-ft. spaced 0.25-inch hole, tied at the ends into a 2 × 4 wood support, and cable clamped. The elements stayed in place by using tape and tie wraps. We placed storage hooks at the ends and pulled gently toward our favorite target, the moon. With no prior testing, we copied Ray Rector, WA4NJP, on 6 meters EME, but no two-way contact resulted. We had to wait a few days later for that to happen.

The dimensions for the 6-meter Yagi are listed in table 1. I would like to thank Gerald, K5GW, for the support and Al, W5LUA, for the location and equipment to try 6 meters EME. ■

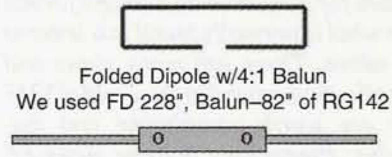
*e-mail: <thenders@tulsacc.edu>

WD5AGO 80-foot 6-Meter Yagi

50.1-MHz Yagi Parts

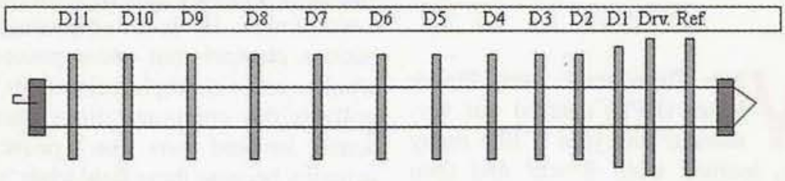
1- 45 ft of .50 x .058 Alum Tubing (cut 3')
2- 116 ft of .375 x .058 Alum Tubing (cut 4')
3- 200 ft of HPTG1200 Phillystran guy wire
4- 12-3/16 ccm cable clamp
5- 8 ft treated 2 × 4 (cut 4")
6- Coax, connectors, insulators, aluminum or brass straps for driven element

Gain ~16.4 dBi



Folded Dipole w/4:1 Balun
We used FD 228", Balun–82" of RG142

Elements are 0.5" × 3' center. Cut or slide 0.375 to equal length for total element length



The Yagi is pulled tight between two stationary objects. We experienced no more than a foot of sag. The driven element used 0.5" x 3" clamps at the ends to complete the fold; metal straps could be used. For the spacers for the folded dipole, 1/4" plexiglass was used. All parts are available from Texas Towers.

Figure 1. Diagram of the 80-ft. 6-meter Yagi, plus list of materials.

	Ele. Length	Ele. Spacing (between is given)
REF	117"	0"
DRV	114.5"	27"
D1	110.5"	11.5"
D2	108.5"	47.5"
D3	104.5"	80"
D4	104"	90"
D5	102.5"	95"
D6	101.5"	98"
D7	100.5"	100.5"
D8	100"	106.5"
D9	100"	105"
D10	101.5"	94.5"
D11	101.5"	89"

Total antenna length is about 78.7 ft.

Table 1. Dimensions for the 6-meter Yagi.

OP ED

One Reader's Opinion

A Thousand Engineers Warn a Dozen Politicians and Lawyers

By Charles Osborne,* K4CSO

Many newspapers around the U.S. print a page entitled "Op-Ed." This usually runs opposite the editorial page; hence its name. Sometimes the name takes on a double meaning, when the author has a viewpoint opposite to the editor's. Its purpose is to give a writer an opportunity to express a view or propose an idea for discussion in a longer format than what is normally found in a letter to the editor. There are many views and ideas floating around in the world of VHF that are worth considering and discussing. Please note that the views expressed herein are those of the author and do not reflect the views of CQ VHF *or its editorial staff. —N6CL*

When Broadband over Power Lines (BPL) entered our vernacular last year I, like many hams, learned what it was and then exclaimed, "They've got to be nuts! This will never work." All across the country the reaction varied, but basically, most hams shrugged and went on about their lives, figuring it would not see the light of day once it was studied in detail. Others reacted with emotion sending "You can't do this!" letters and comments to the FCC. (Yet they can do this—with the stroke of a pen—because they are the FCC.)

Field trials finally gave us a look at what the interference potential could be on a small scale. S9 +10 dB seems like a good common number that I'm seeing in print. I think as hams, though, we often view the world from an oddly skewed reality. Ours is a technical "profession." Therefore, we think everyone knows what S9 means, or that they have a "motherhood and apple pie" view of hams as public servants. Unfortunately, the growth of restrictive covenants across America says otherwise.

We hams as technical professionals do a poor job of tooting our own horn. Often as not, some politician is more likely to take the credit for our behind-the-scenes work while ARES and RACES teams are busy with the cleanup. We're humble to a fault. Therefore, while we may think a hobby of 600,000 hams is a formidable force in America, the politicians know that we're followers, not leaders. Look at how many hams are in Congress—just two! Change the rules and we'll adapt or just fade away is perhaps the FCC's unspoken plan.

However, we (and the FCC) need to step back and view this BPL thing from a world view. HF is the only communications channel that encompasses the whole world via simple technology. BPL pollutes this communications channel. Small, isolated tests won't prove this actuality because these field trials "don't scale well" to the final implementation.

I have a lot of hobby and professional interests that don't mix well with polluted spectrum: QRP, VLF, radio astronomy, WSJT, meteor scatter, aurora, EME (earth-moon-earth), and satellites, to name a few. In leadership roles in my hobby, I'm Technical Chair of the Southeastern VHF Society (www.svhfs.org), the President of the Society of Amateur Radio Astronomers (SARA, <http://www.qsl.net/SARA>), and Technical Director of the Pisgah Astronomical Research Institute (www.pari.edu). All of these interests truly cover "DC to daylight" and beyond.

Radio astronomy works with signals typically 200 dB below one milliwatt. On 6 meters QRP I've completed a 2300-mile *F2* contact using 50 microwatts. It doesn't take much interference to wipe out either ham radio QRP operations or radio astronomy.

From a VHF-and-above spectrum standpoint, what can we expect? Have you ever looked at a digital signal on a spectrum analyzer? Harmonics and sideband energy broaden even the best modulation schemes well beyond their basic modulation bandwidths. Also, how the FCC rules across many services view this broadening effect bears some discussion. In most cases FCC rules treat everything below about –60 dB on a typical spectrum-analyzer screen as in the noise and nonexistent. So many factors enter the measurement accuracy picture beyond 80 dBc (antenna efficiency factors, noise bandwidths, phase noise, and frequency stability) that it would have to be an extreme case to warrant the effort. Therefore, most rules avoid this challenge.

Below –60 dB, digital spectrums can go on for GHz, but are likely to be treated as if they don't exist. Even so, in large numbers they will add up to big interference. In a sleight-of-hand effort to get around this incongruity, BPL's low manufacturing cost targets are juxtaposed to the application of adequate filtering to control the problem.

The noise sidebands extend on the low end of the radio spectrum as well. VLF spectrum and the commercial AM radio band are the likely casualties. On the high side, VHF TV is being prepped for burial. On the other hand, I suspect the FCC considers these obsolete technologies, and BPL will just hasten their demise.

Speaking of power lines, one ironic aspect of all this BPL-proposed business of putting signals *onto* power lines is the years spent in Part 15 testing in order to keep RF interference inside products and *off* the power lines—all of this testing being done with the clear understanding that power lines are huge and problematic antennas.

Today you can walk past PCs and often hear RF interference on handhelds or spurs at HF. In keeping with the regulations of Part 15 that recognize these power lines as defacto antennas, these devices have ferrite beads installed in order to choke the signal off the few feet of cord/cable, which

**105 Reynolds Wood Drive, Brevard, NC 28712*
e-mail: <cosborne@pari.edu>

is the equivalent of or even less than a one-tenth wavelength antenna.

What would the sound that you hear in your handheld sound like with much increased power and long multi-wavelength home-wiring antennas spread across whole neighborhoods? Anything that radiates is lossy by definition. Therefore, additional signal (meaning higher power) will have to be pumped into the lines in order to counter the losses of home wiring and still maintain modem lock. This structure of power lines in this country should make America look like a million-element random phased-array antenna, meaning that the adverse effects will grow exponentially with the broader deployment. These unfavorable effects are precisely why several countries have finished their studies and banned BPL.

Here is another factor to consider: Since this is a non-licensed service that other countries are still considering implementing, it will be hard to tell where the interference is coming from—or even if it originates in the U.S. It seems that the problems associated with this service ultimately will become another synonym of pollution—that being due to the difficulty of tracing its source or point of origin.

The likelihood of reverse interference is often ignored. Licensed services' signals should be received easily on these same power lines that, thanks to the BPL service, have become transmit antennas. When Mrs. So-and-So's internet service gets jammed, it's much more likely that the neighbor with the big tower is the one who gets "tarred and feathered." Interference has always worked that way, no matter who was legally in the right.

In response to ham radio operators' interference concerns, there has been some reaction from the BPL vendors with comments that they can avoid ham frequencies via adaptive channel selection. For hams to establish communications, we have to know the channel is clear and call CQ, or hear the desired station and call them. Either is unlikely with S9+ interference blocking most of our ability to receive signals.

Here is where I see a major, but under-discussed problem with BPL: Getting the broadband internet into individual neighborhoods by all estimation will happen via fiber-optic cable. Every power transformer in the system constitutes a roadblock which must be jumpered for the 1–80 MHz signals to get where they need to go. Therefore, why should the "last hundred yards" use such a wildly inefficient means? The most efficient route is to stay with the fiber all the way to the house.

Not using fiber optics is a regulatory problem between the telcos and the power companies. When considering working out the problem, it just *looks* cheaper to use existing wiring.

In order for us hams to talk the talk of the regulatory group and make informed comments on the NPRM, we should study dBuv/m and antenna-efficiency calibrations. For our comments to be taken seriously, we must avoid emotionalism, make good scientific measurements, and emphasize other services such as aviation and military communications which also will be jammed by the signals, the same as we are, with more serious consequences. Amateurs who are in the Electromagnetic Compatibility (EMC) and Radio Frequency Interference (RFI) industry should take point and help explain that we are just warning of what may well be one of recent history's worst legislative miscalculations. Most important, do not let ham radio be made a scapegoat for this failure. We're just the messengers, with nearly a century of experience using the frequencies in question.

On the other hand, however, if BPL is implemented, we can look on the positive side. BPL should be a job-creation boom. Power utilities all will need RF engineers, a quarter million dollars worth of new test equipment each, calibrated antennas, and fleets of signal-tracing vans. The FCC will be an organization hundreds of times its current size to handle the complaints from consumers. Furthermore, we'll all need kilowatt linears to carry on even cross-town conversations. Jobs—it's all about jobs.

After all, a thousand engineers' opinions can't equal a dozen politicians and lawyers. Right? ■

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utes, yielding up to 720 pictures per day. Don, W9NTP's Wyman Research Lab finalized five systems for testing in the U.S. and Russia. After completion, Hank, W4HTB, and Chris Scott, WB9NEQ, also pilots, did two different airborne tests with Chris's airplane simulating the Mir Space Station. Excellent pictures were transmitted and received during both flights. After tests in the U.S. were completed, Miles, WF1F, delivered four systems to Russia for final environmental and electrical safety testing. Tests were completed, and the systems were given final approval for use

SpaceCam on the ISS—The Next Generation

By Miles Mann,* WF1F

Soon after the development of the Mir Tasco hardware SSTV system, the MAREX team began developing the Next Generation version of SSTV. Early in the Mir SSTV program it was realized that the only way to add some Mir crew-requested features was to migrate the SSTV project from a hardware platform to a completely software-based version of SSTV. In 1999 I contacted Jim Barber of SiliconPixls, the makers of CPIX SSTV software. Jim and I worked out the specifications for a custom-built SSTV application designed specifically for use in space. There were many reasons to use a custom version of SSTV software rather than an off-the-shelf version.

The new program was called the SpaceCam1 project, and it was designed to be very simple to use. Many of the fancy features found in today's SSTV software applications were removed intentionally to make the program easily to learn and use. Some of the new features added include image repeater, security ID (SSID), images saved by call/date/ time, large buttons for zero gravity, and more.

The basic features of SpaceCam1 are as follows:

- Transmit and receive SSTV images (formats R36, R72, Scottie-1, Scottie-2, M1)
- SSTV repeater (SpaceCam will retransmit selected images from Earth)
- Slide Show mode (adjustable time delay, disk images or live camera)
- Text overlay and guest callsigns
- SSID (images saved using the sender's callsign)

Theory of Operation: The ISS crew plugs a USB video camera into the laptop computer and then places the camera in a convenient location. The crew then activates the Slide Show mode at 2-minute intervals. The SpaceCam SSTV system takes a new snapshot and beams the image to Earth on the 70-cm satellite amateur radio band (435–438 MHz). From an orbiting altitude of 250 miles, the images sent by ISS can be received at a distance of approximately 1500 miles away. The crew can also select Slide Show mode via the disk drive and send images the crew previously has taken with digital cameras. The SpaceCam system can also be used during radio school schedules. The ISS crew can talk to a school on the 2-meter system while sending/receiving images from the school on the 70-cm SSTV system.

While the software was being developed, the MAREXMG team began submitting proposals to the ARISS team to use the SpaceCam project on the new International Space Station. The ARISS team liked the project and began to make changes to incorporate the SpaceCam software into their project plan. The SpaceCam software was only one part of the project, and we needed access to amateur radio transceivers, antennas, power supplies, and a laptop computer. The ARISS team needed to design an adapter box that would allow the laptop computers to control the Ericsson amateur radio transceivers. ARISS Hardware Manager Lou McFadin, W5DID, was assigned the task of building an audio interface box for the SpaceCam1 project. The box would allow the audio from a standard laptop PC to be plugged into the existing amateur radio station on ISS. SpaceCam1 would then be able to control the ISS Ericsson transceiver currently on board ISS and future transceivers planned as follow-on projects.

By late 2000 the ARISS team had solved most of the logistics issues and had built the first prototype audio-interfaces boxes. The SpaceCam project became an official ARISS project on March 21, 2001.

Flight Schedule: The ARISS team is actively working on developing a flight delivery schedule. NASA and Russia both have their high-priority projects lists. The amateur radio projects are of a lower priority level, and these projects can easily be moved off a flight manifest list. We will not know exactly when SpaceCam will fly until approximately 60 days before a launch. Once a project is in space, the ISS crew eventually will be given permission for a project activation schedule. The good news is that as of this writing, everything looks good for a SpaceCam launch early in 2004.

How to use SpaceCam: SpaceCam on ISS should be about as easy to use as the HF version currently in use by thousands of SSTVers around the world. There are many different versions of SSTV software currently available on the market. Most of these versions will be compatible with the Robot-36 transmission format that will be used by SpaceCam. The SpaceCam project will be transmitting from ISS on the 70-cm band. The planned transceiver on ISS is the Ericsson 5-watt FM system, which will be connected to an existing laptop computer on ISS and then to a new external antenna on the service module.

The ISS is in an orbit 250 miles above the Earth's surface. When ISS is directly over your house it is only 250 miles away. However, when ISS is down low on the horizon, it is almost 1500 miles distant. A ground station equipped with a simple mobile-style radio and a 0-dBd gain antenna system will be able to receive several images per day from ISS. During a typical 10-minute orbit pass, the SpaceCam system will send five to six images per pass. A 0-dBd radio station should be able to decode one to three images on an individual pass. A higher gain antenna system can be used to help pull in those images while ISS is on the edge of the distant horizon.

Because the Space Station is traveling at 17,500 mph, the speed of the station will cause the transmitter radio frequency to drift over 20 kHz. This drift is called Doppler Shift. You will need to learn when to change channels to follow the Doppler Shift. The transmission mode will be FM. This will help compensate for the Doppler frequency shift issues. You will only need to be within 5 kHz of the downlink signal to receive a good image. When we get closer to a real launch date, I will give more detailed instructions on how to receive the SSTV signals from ISS.

For more information on SSTV and the SpaceCam project, check the MAREX-MG web page. <www.marexmg.org>.

**e-mail: <mann@pictel.com>*

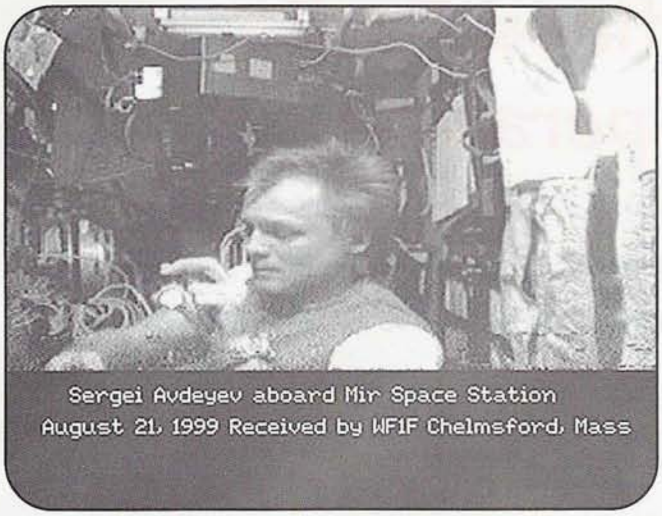

Photo G. Sergei Andeyev completed a full-year mission on the Russian Space Station Mir. His total time in space from all missions is two years. In this picture, Sergei is shutting down the Perioda module on August 21, 1999. The image was received by WF1F in Chelmsford, Massachusetts.

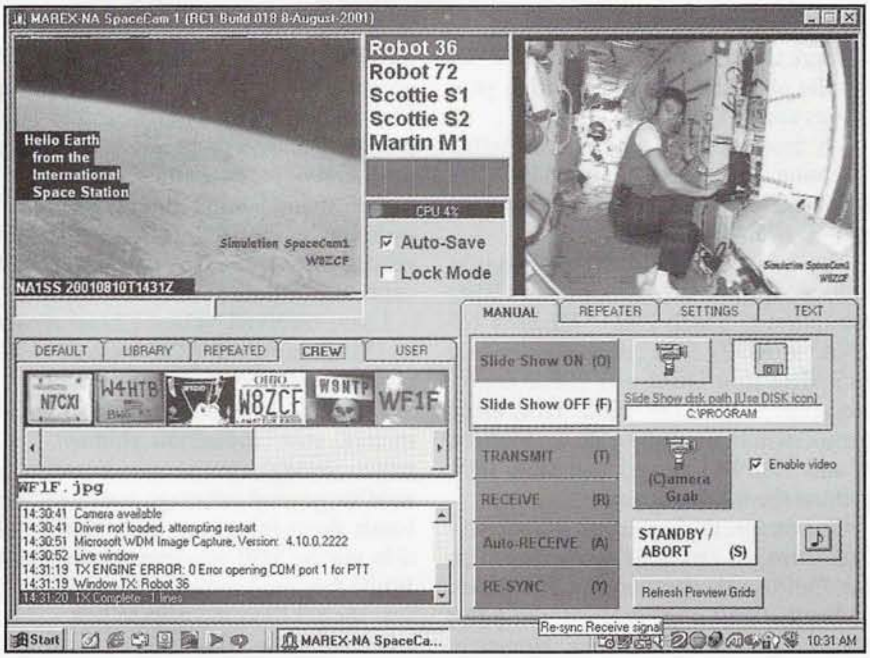

Photo H. A typical setup of pictures using the SpaceCam SSTV system, and initiated by the Mir crew, which we will see on Earth.

aboard Mir by Sergej Samburov, RV3DR, Chief of the Cosmonaut Amateur Radio Department.

Miles also stayed in Russia to train cosmonauts Gennadiy Padalka and Sergei Andeyev, who would be the first to utilize the SSTV equipment. One of the systems was delivered to Mir aboard the Soyuz and was put into operation aboard Mir on December 12, 1998. There was great excitement on the ground as stations all around the world began to receive live pictures from outer space!

The first known picture, photo A, was received by W9NTP on December 12, 1998. It showed Commander Padalka in front of the amateur radio SSTV system, which was actually sending the picture. It is estimated that over 20,000 pictures of scenes within the Mir station and of Earth were sent (see photo B, for example).

One of the last pictures from Mir was received on April 23, 2000, while it was still in orbit. The picture was received by Gerald Klatzko, ZS6BTD, in Johannesburg, South Africa (photo C). It shows Alexander Kaleri, U8MIR, at work in the station. Alex joined Mike Foale, KB5UAC, on October 18, 2003 for an approximate six-month stay aboard the ISS as the Expedition 8 crew. The SpaceCam SSTV System is hoped to be operational sometime this year. This is a software SSTV program. Photo H is a typical setup of pictures initiated by the crew, which we will see on Earth. ■

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Software Defined Radio Receiver Operation

Since its rollout, the SDR-1000 has spurred the imagination of many of its owners. Here one satellite enthusiast describes how he has adapted his radio for his particular specialty.

Gerry Rolle,* KG6RHE

After recently reading about Gerald Youngblood's SDR-1000 HF software-defined transceiver,[1] I obtained one. My experience with computer-controlled radio began last year with the ICOM PCR-1000. The software available was not really what I wanted, though. A search of the Internet produced nearly 30 different programs. The only program that actually expanded the functionality of the unit was TalkPCR.[2] However, it was still just computer control of an existing radio system. The noise of the computer did little to enhance overall operation. I was able to obtain software to control my ICOM 756 PRO II and IC-910H. There again, it was just simple computer control, no added functionality.

Enter the SDR-1000. In the simplest terms, it is a sophisticated detector in front of an analog-to-digital converter. The real magic is in the software that drives the transceiver. The computer software that comes with the unit allows decisions regarding demodulator (CW-L, CW-U, USB, LSB, AM, DSB, FM-N, Synchronous AM, DRM with additional software), IF gain, IF bandwidth, and many other features.

The SDR-1000 panel presented by the software uses an oscilloscope display for signal spectrum representation (more about this later), with many "pushbutton" switches for various selections to operate the software. It's very straightforward and intuitive.

Because it is a transceiver, all of the above modes are available for the transmit mode. Currently, the power out is approximately 1 watt, with expansion to 40 watts planned.

*e-mail: <grollesprint@earthlink.net>

There is a complete VFO-A and VFO-B suite of pushbuttons to expedite your moves across the bands.

My interest is in low-noise satellite reception, and that required a low-noise IF system to demodulate signals from the AO-40 and AO-27 birds.

The current receive configuration is as follows: from a 3-foot rectangular BBQ antenna with Patch Plate,[3] DEM .4 NF LNA[4] to ADIC 3731[5] downconverter at 145 MHz to a DEM 144-28RX downconverter to the SDR-1000. Then using a coax switch, a side-by-side comparison of the 756PRO II and the SDR-1000 yielded the following results:

On average, the beacon on AO-40 is 5–7 dB stronger on the SDR-1000 than on the 756PRO II. With no test equipment on hand, it was impossible to verify this observing only the S-meters. However, there are times when we can copy the beacon with the SDR-1000 and not with the 756PRO II. With a beacon signal from the SDR-1000, it is always more possible to drive the ao40rcv203[6] telemetry decoder with the SDR-1000 than it is with the 765PRO II or PCR-1000.

Television/monitor horizontal oscillator signals, ever present with the 756 PRO II and other receivers, are non-existent with the SDR-1000.

The SDR-1000 requires a CPU over 600 MHz. My system is a 2.8-GHz CPU, 1.2G RAM, and 256-meg video card with two sound cards—Audigy and ADC's Sound Max. The SDR-1000 requires a robust 1.5–2 amps, 13.8 volts DC.

The SDR-1000 requires some computer resources. The more RAM and video RAM you have, the smoother the operation. On my Windows® XP, the Task Manager indicates 25% CPU usage when the SDR-1000 is on by itself. However, XP seems to be very adept at multitasking, as I've had as many as eight rather large graphic-intensive programs on at the same time with never over 60% CPU usage.

The Sound Blaster Audigy soundcard is driven by the SDR-1000 and the other related software, run by the ADC soundcard.

I have received NOAA LEOs[7] as well as DRM[8] using the ADC soundcard and required software with no conflicts.

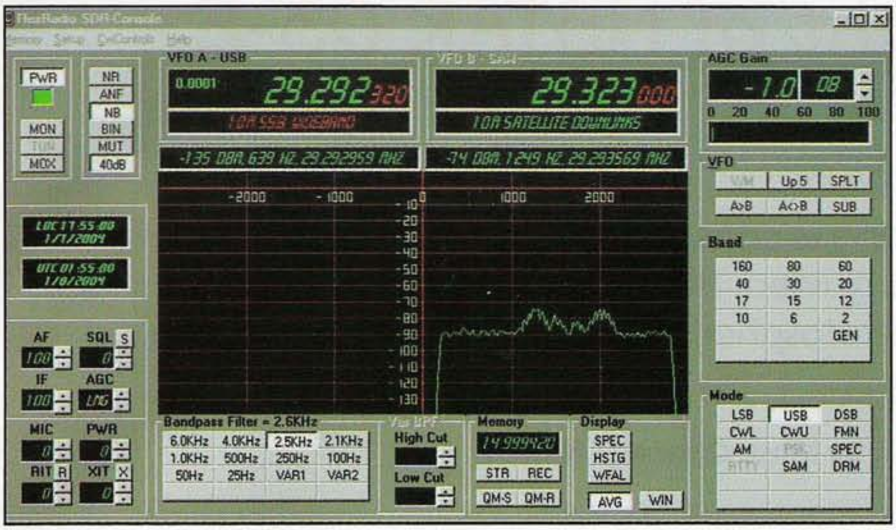
The SDR-1000 covers 160 through 6 meters, with expansion planned for 2 meters through a transverter. For the non-satellite general-coverage and lower ham bands there is some preselection available via the MFJ pre-amps in my shack. While they lend some degree of RF help, you should limit the gain to just a small increase, as the SDR-1000 needs no gain or noise-figure improvement. The RF pre-selection helps the broad bandpass filters used before the ADC unit if there is heavy QRM. My audio output goes to a W9GR DSP III unit (no longer available) at my headphones and before signal re-insertion to the computer for DRM, NOAA, or telemetry.

If you wish to vary or filter the audio output, "ClearSpeech" by Am-Com[9] works well without the flexibility of the DSP III.

There are two user-selectable filter bandpass settings capable of 1–9999 Hz if the normal selections are not appropriate for your work.

The AGC settings are Off, Long, Medium, and Slow. With the Long setting, fine adjustments can be made to signal gain, similar to an analog meter. The Off setting is for truly weak-signal work.

The latest software, Version 1.4.1,



Screen shot of the SDR-1000 transceiver.

allows for a Waterfall display, histogram or averaging. In addition, you may vary the graphs with eight different types of signal representations.

There are two internal pre-amp settings, one at 20 dB and one at 40 dB. The 40 dB will net a lower noise figure, but will affect dynamic range. As stated earlier, this unit does not require further gain.

There is a fine straightforward, easy-to-understand memory for both transmit and receive.

There are pushbuttons for STR (store), REC (recall), QM-S (quick memory temporary store), and QM-R (quick memory recall). There are no complex routines, as with some other rigs.

A few words about antenna impedance are in order. For transmitting, it is imperative to maintain a 50-ohm load at the lowest SWR possible because of the nature of the instrument amps used. The receiver is more forgiving, as it seems to respond well to the 75–50-ohm range with little or no degradation.

The software is open-source Visual Basic 6.0 and is available to the operator to modify at will. Many of the new routines developed for the SDR-1000 are contributions by owners who are programmers.

One word of caution while making adjustments: The Windows® operating system is not in real time. Therefore, make critical adjustments very slowly and wait a moment for the operating system to process your commands.

Summary

The SDR is neither for the appliance operator nor the faint of heart. It takes time to assemble and power the unit. It also takes time to interface it to the computer and soundcard, time to read the manual, and finally, time to mold it to your specific requirements. Then the fun begins as you learn to manipulate the software for optimum performance for your application.

I have covered about 80% of the flexibility and features of this unit, relating my direct experience with the SDR-1000 as it applies to my particular needs. There is much more to this unit, and I urge you to go to <www.flex-radio.com> for further details and information.

Gerald Youngblood, whose patience rivals that of the great saints, aggressively supports the unit and software. ■

Notes

1. <http://www.flex-radio.com>
2. <http://www.mahy.demon.co.uk/TalkPCR/TalkPCR.htm>
3. Robert, WØLMD, <http://www.ultimate-charger.com>
4. <http://www.downeastmicrowave.com>
5. <http://members.aol.com/k5gna/>
6. <http://www.qsl.net/ae4jy/ao40rcv.htm>
7. Software by JVComm32 1.29 by DK8JV at <http://www.jvcomm.de>
8. DRM software, DRM 2.0.3 at <http://www.drm.org>
9. <http://www.amcominc.com>

The Flight of NSTAR 03-E

As amateur radio ballooning reaches its 25th anniversary, with each launch a new milestone is gained. Here is the story of last October's launch by the Nebraska Stratospheric Amateur Radio organization.

By Mark Conner,* N9XTN

It's a quiet October morning in western Iowa—clear skies, a little fog over some of the rivers and creeks, and a light frost covering some of the freshly harvested fields. It's not quite sunrise yet, but the orange glow in the eastern sky promises us that dawn is coming soon. On this morning the members of Nebraska Stratospheric Amateur Radio organization (NSTAR) are en route to a small farm about 15 minutes east of Council Bluffs, Iowa. Before the completion of this day, our adventure will take us into the upper reaches of that sky, by way of the upper atmosphere via an unmanned balloon.

Radios and balloons have been used in tandem to explore the atmosphere for about 75 years. The earliest flights date back to the 1920s, when relatively crude radios and instruments were attached to unmanned balloons. These balloons were released so that measurements could be made at high altitudes without the need for an airplane to carry the equipment. By 1937, the U.S. Weather Bureau had a network of stations making regular weather observations using radiosondes to observe temperature, pressure, and humidity to altitudes of 100,000 feet or more. This practice continues today with about 70 National Weather Service stations in the conterminous U.S. launching radiosondes with weather balloons twice per day.

The first known amateur radio flight was in 1979, when a Canadian amateur radio club sent its radio equipment to high altitude as a radio propagation experiment. Eight years later, Bill Brown, WB8ELK, launched an ATV (amateur television) payload over Ohio to beam back pictures from altitudes high enough to show the blackness of space. Since that time, the advent of low-cost, lightweight GPS (Global Positioning System) receivers and microprocessors has opened the hobby to the inclusion of even more capable payloads containing repeaters, still cameras, camcorders, SSTV (slow-scan TV) transmitters, and a wide variety of scientific experiments.

The data from the GPS receiver is transmitted to the ground via packet radio, where it is decoded and plotted using APRS (Automatic Position Reporting System) to an accuracy within 50 feet. This real-time tracking information of our equipment lets us fly our equipment to an altitude of 20 miles or more and be blown downwind over 100 miles. As a result of our ability track our balloons, we have a high degree of confidence that we will recover everything after the flight's completion.

*mconner1@cox.net

Launching an NSTAR mission. The balloon is held by two lanyards which go through a metal ring at the balloon's neck. This suspends the payloads off the ground for a smoother launch, yet keeps the balloon under control.

A picture from the NSTAR 03-E flight taken shortly after launch. The software determines when the payload has been released and begins taking pictures automatically. The launch site is in the lower right of the picture.

Normally, VHF or UHF FM terrestrial propagation is limited to a few tens of miles at best. Sometimes atmospheric conditions such as an inversion allow further propagation if the weather is right. With the high altitudes achieved by balloons, direct reception of FM signals such as packet is possible over great distances, even with power level coming from an HT (handi-talkie, 5 watts or less). At 100,000 feet the direct line of sight is over 400 miles. In 2002 an APRS packet transmitted on the 2-meter ham band from an NSTAR payload over Iowa was received 440 miles away by a station in Norman, Oklahoma.

By 7:00 AM about eight of us were at the morning's launch site. The first half-hour or so after arrival was devoted to unloading and setup of equipment. Last-minute adjustments were made to the APRS gear in the vehicles. By sunrise, at about 7:30 AM, we were preparing to fill the balloon. With our 1000-gram balloon, we expected to reach an altitude of between 80,000 and 90,000 feet.

We planned to drive about 120 miles to the landing site, and the balloon would land about 2 1/2 hours after release. If we wanted to be there for the landing, we would have to leave right after launch. The chase team was briefed on frequencies to use for voice and data communication as well as our expected chase route.

The balloons used by most amateur radio groups, including ours, are very similar to those used by the National Weather Service. We fill the latex balloon to a diameter of 6–8 feet, but it will stretch to 20–30 feet just before it bursts. The NWS uses hydrogen for their balloons, but for safety and storage considerations, we use more expensive, but non-flammable helium. The helium cylinders contain about 290 cubic feet, and we typically empty the entire cylinder into the balloon, using a regulator to vent the 2600-psi tank pressure into our balloon.

This day's payloads were veterans of several flights. The main payload was the more complex of the two. The heart of the unit was a Basic Stamp 2p micro controller. This unit would be responsible for all our data acquisition from the sensors and the GPS, tripping the still camera, and formatting the data for transmission to the chase team. The Stamp was programmed in a form of BASIC, simple to use, yet powerful enough to handle all the tasks necessary.

Temperature sensors were arrayed inside and outside the payloads to provide information on the environmental conditions. A new pressure sensor was installed for this flight to measure the air pressure. This time we would reach an altitude where the outside air pressure would be only 5% of that at the surface.

The still camera was a small APS film camera about the size of a pack of cigarettes, and it had been modified so that the Stamp could trip its shutter electrically. The GPS unit was about the size and shape of a computer mouse. It had no display—no one was going along to read it on this trip! The TNC would take the APRS-formatted data from the Stamp and convert it to an audio signal, which would then be transmitted by a 2-meter HT. Generous amounts of foam padding were included to protect and insulate the equipment. A lunch cooler was our outer enclosure; it was insulated, made of rugged rip-stop nylon, and above all, cheap.

The second payload was suspended just below the main. A VHS camcorder peeked out a hole in the side of a second lunch cooler. This would record two hours of video once it was activated just before launch. Attached to the camcorder was a Kenwood VC-H1 SSTV unit. The unit was set to send pictures automatically at about 3-minute intervals. On previous flights, the pictures were received over 100 miles away on our 2-meter frequency with excellent clarity. The SSTV was connected to a micro HT, which would transmit about 500 mW to the whip antenna on top of our payload. Should the main payload fail, an independent APRS tracker with GPS, micro HT, and battery were also included as a backup means of tracking our equipment.

To bring the payloads back to Earth safely, a parachute would be used. Ours was made of nylon kite fabric, about 5 feet in diameter. The balloon was attached to the top of the parachute with a cord with the payloads suspended below. When the balloon burst, the falling payloads would automatically cause the chute to open. Initially, payloads fall very quickly in the thin air, at about 100 mph. As the air gets denser the parachute slows the fall, and by the time the payloads land, they are falling at about 10 mph.

Looking out over Iowa at 80,000 feet. At this altitude the balloon is above 97% of the Earth's atmosphere and the sky is black except for a blue band along the horizon.

As the balloon was being filled, the payloads were powered on for their initial checks. No one wanted the first indication of a malfunction to be seen after the balloon was released! This was also an opportunity for the chase team to check their APRS setup one more time. Within a few minutes the balloon was filled, and we tied off the neck with the cord attached to the top of the parachute. The payloads were attached to a spreader ring below the parachute, and then the whole works was walked the short distance to our release site.

It was a little before 8:00 AM when we were nearly ready. The last items on the checklist were to open the still camera shutter, to start the camcorder, and to make a final check of the payloads. A couple of glitches were seen with the data; the payload thought it had launched already. The cure for that was a quick power cycle. We did that, and after the GPS locked back in, we were ready for flight. After a count down from five, we released the balloon into the crisp October sky at 8:01 AM.

We watched the payloads drift away for a couple of minutes, and then it was time to start the chase. Armed with a prediction of the balloon's path, which was made the evening before, we knew the main roads we would be taking and how far we would have to go. For this flight, we were expecting a drive of about 120 miles in a little over two hours. With most of our trip on main roads, we expected to be close to the landing site when the payloads touched down, but probably not quite close enough to see them when they landed. Fortunately, some hams from the Des Moines area, closer to the expected landing, were already moving into position.

During the chase, we were receiving position and telemetry reports from the balloon every minute. Combined with a GPS in the chase vehicle, we knew exactly where the balloon was in relation to us. We also compared the actual track with the one forecast the night before to refine the landing-zone prediction. At this point the prediction and the actual track were relatively close. The telemetry gave us important data such as inside and outside temperature and battery voltage. While the outside temperatures were as cold as –70° F, the inside temperatures only got a few degrees below freezing, which was warm enough to keep everything functioning normally.

About a half-hour into the chase, we noticed a couple of problems. First, the backup APRS beacon had stopped sending out current position reports. It was retransmitting an old report instead. This was not critical, as long as the main payload functioned normally. Second, the SSTV signals were very weak. This was disappointing to us, as SSTV is popular with those hams who like to see in real time what our camcorder is recording. However, it was also unnecessary for tracking and recovery; at the moment nothing was indicating we wouldn't get our payloads back to fly another day.

Soon we were on US 34 heading east across southwestern Iowa. Our landing was forecast to be near Osceola, about 80 miles ahead of us. Early in the chase, the balloon was running well in front, but as it slowed down in the lower stratosphere, we caught up to it and finally passed it. At 9:39 AM my laptop sounded the alarm that the balloon had burst after reaching an altitude of 81,292 feet.

With the burst altitude and location known, we were able to make final refinements to the landing forecast. The night before, the prediction was for the landing to be west or northwest of Osceola. Now it appeared that the landing would be east of town. We relayed this information via APRS message (digipeated through the balloon) and by scratchy terrestrial simplex and repeater contacts with the Des Moines-based group now near Osceola.

At approximately 10:00 AM, the balloon was descending through 20,000 feet. We then knew that we had a slim chance of being in sight of the payload as it came down. The goal of our chase team (besides getting back our equipment, of course) was to watch the payloads drift to Earth after a two-hour chase across half of Iowa. This part would take some experience, quick decision-making (which road do we take?), and a lot of luck. A few miles east of Osceola, we took a gravel road north.

We stopped for about a minute to evaluate what was happening. The balloon was moving southeast, but because of the low-level winds, it was expected to turn northeast at some point. How soon? Where would that put the landing? We hedged our bets and move a mile north to a four-way intersection. If we stopped short of the intersection, we could choose any direction to go at the last minute. We

Near the end of the NSTAR 03-E mission. The vehicles along the road are the chase team. They drove 125 miles from the launch site to be in place as the parachute came down.

stopped again and waited briefly. As the payload descended through about 8000 feet, we saw the expected turn to the northeast. It looked like it would land in the section northwest of the intersection, so we went north again for at least a half-mile.

Now it was down to 5000 feet, and some of the chase team could see the payload and parachute as it was coming down. It was moving at only 20 miles per hour, and it appeared as though it would land close to the road. We drove to the next intersection, and we could clearly see it drifting down into a cow pasture. Because it was so close to the road, I jumped out of the car with my camera, hoping to get a good telephoto shot of the payload as it touched down. It came down just behind some trees, about 30 yards off the road, at 10:20 AM.

As the chase team parked off the side of the road, a van that was unfamiliar to us arrived. As it turned out, it was the farmer who owns the pasture in which our payloads had just landed. He happened to be driving home and saw the parachute land, too. We took a couple of minutes to explain who we were and how we had tracked the payloads to this location. Then he let us into the pasture to pick up everything.

All the equipment was intact after the landing. We powered off everything and carried the payloads out. We answered more questions, and I gave him a card with the NSTAR website on it so he could see our pictures after we had them developed. The chasers from the Des Moines area headed north and back home, while the rest of us, facing a nearly three-hour drive back to Omaha, stopped at a local restaurant for a bite to eat.

There are amateur radio ballooning groups across the U.S., and some in Canada, South America, and Europe, as well. If you or your club is interested in getting started in this aspect of amateur radio, there are many resources on the Internet to jump-start your research. Better yet, learn the ropes by participating with an existing group before starting out on your own. It's a great way to learn many of the details that are hard to convey in a short article or on a web page. ■

Resources

Nebraska Stratospheric Amateur Radio: <http://www.nstar.org>
Edge of Space Sciences: <http://www.eoss.org>
Arizona Near Space Research: <http://www.ansr.org>
List of high-altitude ballooning related links:
<http://users.crosspaths.net/~wallio/HABLinks.html>
FAA regulations regarding unmanned balloons (Part 101):
<http://www.access.gpo.gov/nara/cfr/cfrhtml_00/Title_14/14cfr101_00.html>

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Calendar of Events *(pg. 31)*

10–12 at the Airport Holiday Inn in Des Moines, IA. More conference information is at <http://www.tapr.org/dcc/>. Send submissions by August 10 to: Maty Weinberg, ARRL, 225 Main St., Newington, CT 06111, or <maty@arrl.org>.

The **Microwave Update** conference dates are October 15–16, in the Dallas-Ft. Worth, TX area. If you wish to present a paper, contact Al Ward, W5LUA, at <w5lua@arrl.net>. *Proceedings* will be published by the ARRL, and you do not have to be a speaker to have your material presented in the *Proceedings*. To have material published, submit your paper to Kent Britain, WA5VJB (wa5vjb@flash.net) no later than August 16. More information, the North Texas Microwave Society: <http://www.ntms.org>.

Meteor Showers

May: A minor shower is the *eta-Aquarids* (predicted peak on May 5). Visually, this shower will be obscured by a full Moon.

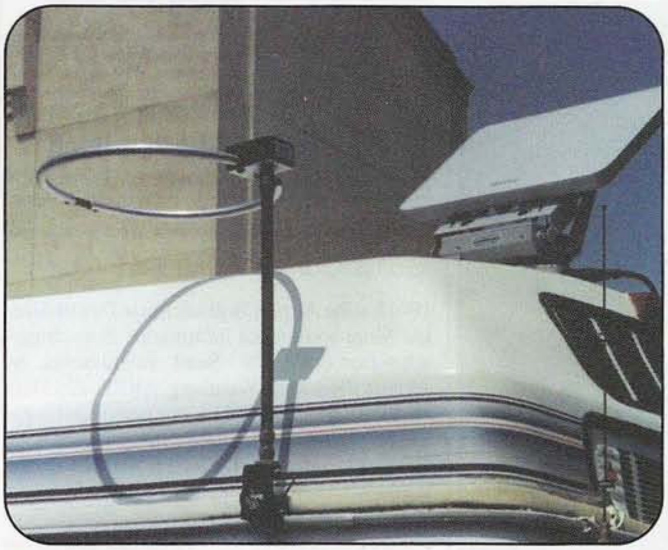
June: Between June 3 and 11, the *Arietids* meteor shower will once again be evident. This is a daytime shower with the peak predicted to occur on June 7 at 0400 UTC. Activity from this shower will be evident for around eight days, centered on the peak. At its peak, you can expect around 60 meteors per hour traveling at a velocity of around 37 km/sec (23 miles per second).

On June 9 the *Zeta Perseids* is expected to peak at around 0100 UTC. At its maximum, it produces around 40 meteors per hour. On June 28 the *Delta Aquarids S* shower is expected to peak. The *Bootids* is expected to make a showing between June 26 and July 2, with a predicted peak on June 27 at 1930 UTC. On June 29 the *Beta Taurids* is expected to peak at around 0800 UTC. Because it is a daytime shower, not much is known about the stream of activity. However, according to the book *Meteors* by Neil Bone, this and the *Arietids* are two of the more active *radio* showers of the year. Peak activity for this shower seems to favor a north-south path.

July: This month there are a number of minor showers. The most intense, the *delta-Aquarids,* is a southern latitude shower. It has produced in excess of 20 meteors per hour in the past. Its predicted peak is around July 27.

The only northern latitude shower is the *alpha Cygnids.* It is supposed to peak around July 20, but with a rate of only five meteors per hour.

August: Beginning around July 17 and lasting until approximately August 14, you will see activity tied to the *Perseids* meteor shower. Its predicted peak is around 1100–1320 UTC August 12. There will be more extensive coverage of this shower in the summer issue of *CQ VHF*.



A KB6KQ loop mounted next to the van's fiberglass roof.

A Par Electronics horizontal loop half way up the mast.

each loop for about one minute, and then there was about one minute of silence as we changed over to another loop. Would the larger size loops do better than the smaller ones? Again, on transmit everyone reported that our loops were well down from the 3-element beam pointed toward them, but each loop was about the same in incoming signal strength.

Now the big test—the estimated 3 dB of gain when you stack one loop on top of another and feed it with a specific recommended length of a matching harness terminating to a T-connector. Most manufacturers recommended an approximate 48-inch separation between loops, with a $^{3}/_{4}$-wavelength RG59 coax run to the top loop, and a $^{1}/_{4}$-wavelength RG59 coax run to the bottom loop—both coaxes to a "T" connector.

M^2 horizontal eggbeater antenna.

The first thing we found out was the need for a hefty mast to keep the top loop from swinging wildly when the vehicle was in motion or when doing donuts in our beach-side parking lot. We also found that stacked loops require a major mounting system at the base and that the lower loop needs to be a minimum of $^{1}/_{2}$ to $^{3}/_{4}$ wavelength above any major metal in the vehicle. ***Important:*** *This off-center connection requires the bottom antenna to be inverted with respect to the top antenna.* This puts the bottom feedpoint directed up, so make absolutely sure there is no way that water can pool in the feedpoint and ultimately foul your bottom loop connection.

Going from a single loop to a stacked pair of loops gave us an immediate double advantage. Our mobile signal was even more omnidirectional than before, without nulls; the distant Yuma, Arizona beacon no longer chattered in and out of our SSB squelch circuit; and the beacon now came in on the pair of loops as well as it did on the 3-element directional Arrow Antenna.

Good news on stacking! Again, stacking a pair of 2-meter loops, or going with a quad stack of 70-cm loops, requires a major mobile mounting. If your stacking shaft is too flexible, the top loop will then flip back and forth, causing your signal to flutter because it loses the capability of increased gain from not being directly over the lower loop. Even a 5-inch oscillation back and forth was noticeable when we were testing the stacked loop system mobile at rest.

The stacked pair of loops for any VHF band is strongly recommended for omnidirectional base-station use. It is also the

Classic Big Wheel 2-meter horizontal antenna.

WB6NOA is seen here setting up a pair of stacked 2-meter loops on the rear of an RV.

ideal antenna for VHF/UHF-propagation beacons. We calculated 2.2 dB gain over a single loop when the stacked pair was elevated three wavelengths above the ground. For home use, a stacked pair at 48 inches of separation will deliver a dandy VHF or UHF horizontal signal in all directions—concealed in your attic. Any condo, apartment house, and home with a pitched roof generally will have ample attic space to stack a pair of 2-meter loops, or accommodate shorter loop stacks for 70 cm and 1296 MHz. For that attic installation, a minimum of LMR-400 or Belden 9913 coax would be required to minimize feedline losses. LMR-400 and Belden 9913 run nearly as easily as conventional RG8U, and under no circumstances should you undo all that you did with the attic installation by running substandard coax such as RG8U, or worse yet, RG8X, or the unthinkable, RG58.

"I regularly work hundreds of miles on a stacked pair of loops on 2 meters horizontal SSB," comments Ken Neubeck, WB2AMU, co-author (with WB6NOA) of a new VHF/UHF propagation book available soon through CQ Communications. Our book, combined with my 60-minute CD, shows off VHF/UHF propagation at its best through the myriad of atmospheric and ionospheric conditions.

For beacon applications, a stacked pair of loops normally would be fed with a minimum of 1-inch hardline. If it is anticipated that ice loading will be a factor, closely examine each loop manufacturer's ice-loading specifications and scrutinize how the loop hangs onto the mast mount. Also, double check that the loop has no capacitive end element spacing where ice might form and drastically detune the system. Not that there are any probable enhanced tropo DX conditions during an ice storm, but detuned beacon loop antennas may present a high VSWR to the beacon transmitter, ultimately killing the output stage. You may even need to call each loop manufacturer and discuss how you plan to run each omnidirectional loop as a beacon antenna system. ■

Antenna Sources

KB6KQ Loop Antennas, Kalama, Washington (360-423-4905), <http://www.kb6kq.com>

M^2 Antenna Systems, Fresno, California (559-432-8873), <http://www.m2inc.com>

Nil-Jon Antennas, from Universal Radio, Reynoldsburg, Ohio (614-866-4267), <http://www.niljon.com>

Olde Antenna Lab, Parker, Colorado (303-841-1735), <w6oal@aol.com>

Par Electronics, Glenville, North Carolina (828-743-1338), <http://www.parelectronics.com>

QHtenna by N4QH, 275 Davis School Road, Martin, Georgia 30557 (706-356-2662), <http://www.qth.com/qhtenna>

Tillo-Curri Big Wheel Antennas, available from Purchase Radio Supply, Ann Arbor, Michigan (734-668-8696)

WiMo Antennen und Elektronik GmbH, Am Gaxwald 14, 76863, Herxheim, Germany (+49 7276 96680), <http://www.wimo.com>

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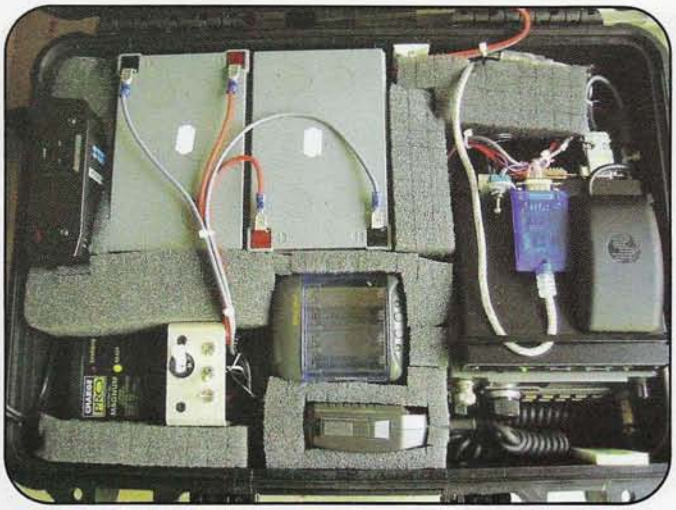


Photo B. The inside of the black Pelican case at the bow. Contents include a KPC-3+ packet TNC, Yaesu 290, USB-serial interface for Mac laptop, Garmin GPS-35, 24 amp-hours of 12-volt sealed lead-acid batteries, Micro-M+ solar charger, AC unit, Statpower inverter, Maha Ni-MH charger, bicolor navlight retrofitted with Luxeon 1-watt LED emitters, 350-mA constant-current source for same, and Mobri radar reflector.

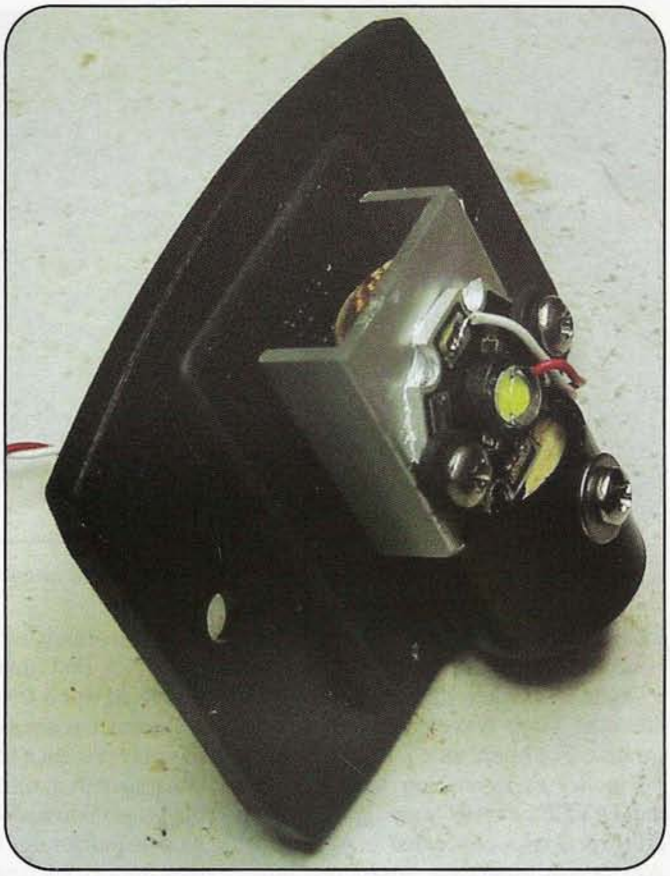


Photo C. Luxeon high-brightness white emitter retrofitted into marine sternlight. Silicon grease was used for thermal transfer, and a scrap of dowel was machined to fit original bulb socket.

etry channels presented as a virtual console, a succession of helmet-cam images playing in another window....

All of this is now pretty easy and is part of the Microship project—the technomadic adventure substrate that has replaced my tattered, overloaded recumbent bicycle (now on display in The Computer History Museum in Silicon Valley). These two amphibian, pedal/solar/sail micro-trimarans are packed with enough technology to exceed that long-ago road fantasy, but what I want to tell you about here is much simpler—a pile of off-the-shelf stuff packaged in Pelican boxes and lashed to an inflatable kayak. In the process, we can look at a few packaging techniques that will let you put APRS into all sorts of nasty places where electronic devices usually don't stand a chance.

Meet Bubba

There is an old adage that the average completion time of a homebuilt boat is 137 years. With that in mind, and needing a dinghy for shore excursions (landing gear notwithstanding), I added a 19-foot Aire "Sea Tiger" inflatable kayak to the Microship fleet. Given this quickly deployable playboat, I have been unable to resist the allure of local exploration of the endlessly interesting waters here in the Pacific Northwest.

Appropriately dubbed "Bubba," this wonderfully stable and buoyant kayak spends a lot of its time in salt water, with occasional river excursions. I carry a full suite of camping gear, as well as my laptop backpack in a sealed case, so computing horsepower under the stars is not a problem. More challenging, however, is the set of resources needed while under way: battery management, navigation lights, communications, and APRS.

As you can see in photo A, Bubba carries a few things not normally found lashed to a kayak. In addition to the two big tarped-over mounds (filled with gear in about a dozen sealed "dry bags"), there are three interconnected waterproof Pelican cases:

The black box on the bow contains a KPC-3+ packet TNC (terminal node controller), a wonderful old Yaesu 290, a USB-serial interface for the Mac laptop, a headless Garmin GPS-35, 24 amp-hours of 12-volt sealed lead-acid batteries, a Micro-M+ solar charger (using the 30-watt Solarex PV panel lashed to the forward gear mound), an AC unit for those times when I have shore power available, a Statpower inverter for laptop and digital camera chargers, a Maha Ni-MH charger for all the pocket gadgets that use AA batteries, a bicolor navlight retrofitted with Luxeon 1-watt LED emitters, a 350-mA constant-current source for same, and a Mobri radar reflector.

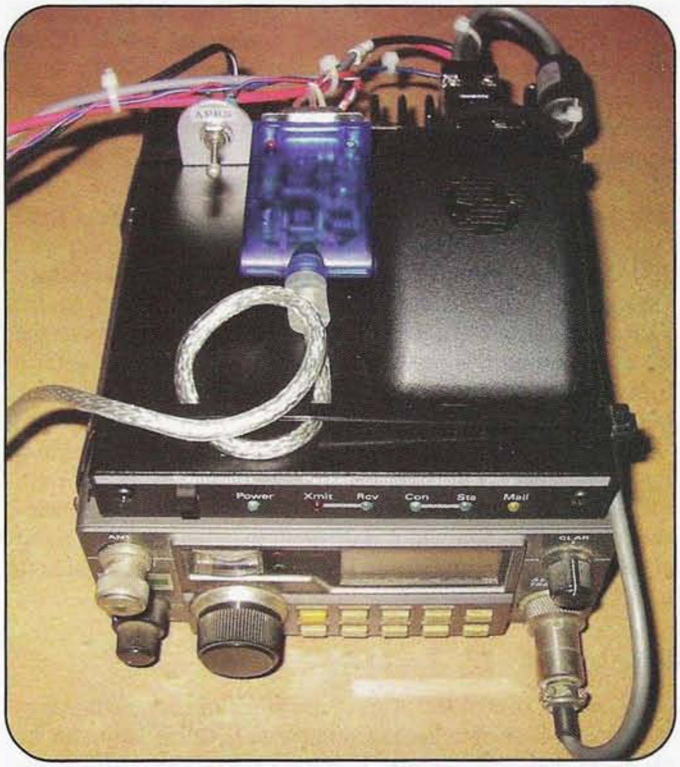
The yellow box, between my legs when I'm paddling, carries a cartographic Garmin GPSMAP-76S, separate steering compass, switch for the navlights, button for the horn, and internal foam-lined space for the Canon digital camera (in its own waterproof case), Aquarian Audio hydrophone, binoculars, and basic emergency tools.

The gray box at the stern (barely visible in the photo) carries a homebrew 1-watt white LED sternlight, 350-mA constant-current source, small yacht horn, and a fiberglass bike flag on a Hustler bayonet-mount supporting a 2-meter twin-lead J-pole. The interior of that box carries tools, patch kit, and electric air pump.

These three boxes are constantly exposed to salt water, which is about the nastiest stuff around when it comes to electronics. In fact, some wag once quipped..."Water corrodes. Salt water corrodes absolutely."

Photo D. The Pelican box at the stern carries the white LED navlight seen in photo C, as well as a bayonet-mount J-pole antenna and yacht horn. Note waterproof connector.

Photo E. Packet/APRS asembly before installation in the black box at the bow (see text for details). ⟶



Pelican boxes themselves do an excellent job of keeping out the elements, but as soon as we add connectors and external devices, we're asking for trouble. The wiring harness on Bubba was designed with the assumption that it would be soaking wet most of the time, and thus uses undersea-pluggable connectors made for oceanographic applications, integrated into a spiral-wrapped assembly that can dry out when given the chance. This cable bundle consists of four DC wires and one piece of coax.

Let's look at the wiring diagram for the system (figure 1). As much as possible, I took advantage of off-the-shelf subassemblies: One of the major lessons that has emerged from two decades of building complex machines is that life is too short to re-invent the wheel. This whole system came together in a couple of weeks, largely because I didn't insist on over-complicating anything with custom electronics, computer control, integrated user interfaces on ad-hoc networks of wireless-linked PDAs, or anything else Microship-like and *tres* geeky. As such, it's not quite as small or tight as it could be, but it works well and can be replicated easily by others who want to add these capabilities to tiny boats.

The schematic is arranged to show the three separate boxes, linked by the simple wiring harness. Most of the action is in the black box on the left half of the drawing...

Two hefty 12-volt, sealed lead-acid batteries comprise the power pack, ensuring that I have a comfortable margin of operation in this often-overcast part of the planet. Fully charged, they can run the high-brightness LED navlights for at least a week of all-night paddles (very rare!) and provide continuous APRS tracking for a few days. This is one area in which overkill doesn't bother me; it's nice to have ample power (and on a kayak, weight is not as much of an issue as on a bicycle or backpack, although I do confess to grumbling a bit when I have to drag all this stuff up a cliff for the night).

Internal wiring is very simple, and most of the action is in the vicinity of a big double-terminal strip made by Blue Sea Systems (located under a chunk of foam inside the box shown in photo B).

The primary charge source for an autonomous mobile system such as this is, of course, photovoltaic, and a Solarex MSX-30 module provides a steady couple of amps on sunny days. Because of the proximity to radios, I elected to use the Micro M+ charge controller, which generates no RFI (www.seslogic.com/ microm+.html). This comes as an easy-to-assemble kit and can handle up to 4 amps of charge current.

When in the lab, visiting waterfront friends, or ducking into a marina, I am free to take advantage of shore power with a little Guest charger from West Marine. I don't really recommend this unit, as it seems to have a fixed setpoint halfway between gel and liquid electrolyte specs and thus treats both badly, but it more or less works for now. When AC is available, I throw a toggle switch to select this as a charge source instead of solar (otherwise they interact, and I didn't want to deal with blocking diode losses and their unpredictable effects on the respective charge managers).

Raw battery voltage to everything (except the Yaesu 290, which has its own 10-amp fuse) is switched with a 5-amp circuit breaker and connected to the positive bus bar. There are two additional items in the power department: a Maha charger for the seemingly unlimited number of AA batteries in my life, and a small Statpower inverter that generates 115 VAC to feed my laptop charger, digital-camera charger, cell-phone charger, PDA charger . . . well, you get the idea. I know, it's not very efficient to go from DC to AC and back to DC, but until the industry standardizes its power protocols and provides universal conversion widgets, we are stuck with 115 VAC as a sort of *lingua franca* in such situations.

One of the key requirements for this system is safety-related. Although I don't usually choose to kayak at night (especially in busy shipping lanes), it does happen occasionally, often as a result of bad planning. When it does, I insist on being as visible as any other small craft, although from the perspective of an oceangoing freighter, that's not saying much. Being power-limited without an engine, the thought of off-the-shelf incandescent navigation lights was disturbing, as even the smallest would consume a total of 15 watts for the bow bicolor and white sternlight. Instead, I bought a couple of small Aqua Signal units from West Marine, tossed the original incandescent bulbs, retrofitted Luxeon 1-watt high-brightness LED emitters (complete with heat sinks), and then drove them with 350 mA constant-current sources made by a fellow named George Scolaro (www.geocities.com/george_tlc/led. html). These generate a bit of RFI, but it hasn't been a problem on the kayak (although it is on the Microship), and the net effect is a beautiful suite of navlights for about one-fifth the power of the traditional solution.

Photo C shows the sternlight assembly with the fresnel lens removed. This mounts on the gray Pelican box at the stern (photo D), with the constant-current source just inside the enclosure. Seeing this at night, it is difficult to believe it is but a single white LED; around camp, I use it as a utility-area light both inside and outside the tent.

Packet/APRS System

Of course, one of the primary justifications for all this was the tracker. Shown unpackaged in photo E, this is based on the excellent and very popular Kantronics KPC-3+, particularly attractive in this application because of its low current drain, general utility as a TNC, and dual-port capability, which makes it easy to switch between packet and APRS without fiddling with cables.

The TNC is grafted to one of my all-time favorite 2-meter rigs, the venerable Yaesu 290. As a long-time aficionado of bicycle-mobile and other power-limited operating environments, one of my pet peeves is the fact that almost all "mobile" rigs have a standby current drain on the order of an amp. This is simply impractical in anything other than a car, but this Yaesu radio (like its 70-cm mate, the 790) draws about 50 mA when just sitting there, yet can still put out 25 watts. As such, I don't mind leaving it on all the time, a necessity in an application such as this.

The third essential component in the tracker assembly is a GPS, and I suppose I could have run NMEA data from the cartographic unit on the yellow "console" box between my legs. I wanted the flexibility and the reliability of a stand-alone unit, however, so I opted to add a dedicated Garmin GPS-35 for APRS use. The little toggle switch shown in the photo lets me kill this to save power when using the rig for general packet operation, such as when I am doing e-mail by the campfire.

One other detail is visible in the photo: a USB–RS-232 converter. This allows use of my USB-only Macintosh iBook with the TNC.

When starting the Bubba project, my initial intent was to use one of the simple, low-power, and practically bulletproof PIC-E boards from TAPR (Tucson Amateur Packet Radio Corp.) as the APRS tracker. However, I couldn't resist the allure of added packet capability, especially since all the other components would be on board regardless.

Harsh-Environment Packaging

Now that we've taken a quick look at all the core gizmology, let's talk for a moment about the special considerations involved in taking this delicate and expensive gear into a corrosive environment. Unprotected boards would only last a few minutes, and even traditional weatherproofing techniques are not enough to defend against the *aqua regia* that splashes regularly across an enclosure, which is lashed to the bow of an inflatable kayak.

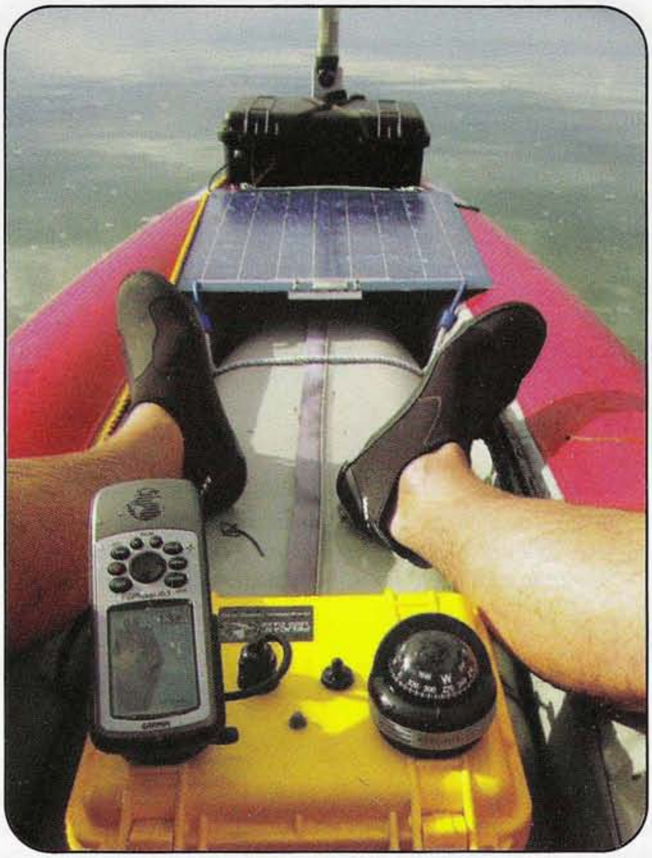


Photo F. The paddler's-eye view of unladen Bubba, cruising the waters near Camano Island, Washington.

An excellent start, of course, is the use of Pelican cases. This company has refined its technology over the years, and unmodified boxes are quite capable of protecting their contents even when submerged. The new models, such as the yellow one shown in photo F, have cam-actuated latches that are easier to use, as well as automatic pressure-relief valves that can't be left open accidentally.

All bets are off, though, when you start drilling holes and adding connectors. Even some of the seemingly robust products in the marine marketplace turn out to be unreliable in a genuinely harsh environment (not the cabin of a pleasure yacht), and a good connector, badly installed, can allow the introduction of water when the temperature drops and the box pulls a vacuum. I was fortunate enough to be able to find some undersea-pluggable connectors from Seacon (www.seacon-usa. com); these are widely used in oceanographic and other underwater applications, so I trust them. I was a little less confident of the gasketed BNC bulkhead connector for the 2-meter antenna, but so far it has held up to real-world abuse (including a pressure test). I occasionally treat it with Boe-Shield to prevent surface degradation. I fight crevice corrosion by making sure that all threaded fasteners are assembled with stainless-steel anti-seize compound.

Wherever objects are mounted to the boxes, they are either gasketed or sealed with an aggressive black silicone (don't use this around coax, as it outgasses acetic acid, and never apply it to fiberglass if you ever intend to use other adhesives, including epoxy). This was the technique used to handle the wire feedthroughs for the LED navlights, the horn, and the J-pole bayonet (another candidate for occasional treatment with Boe-Shield). The two switches on the yellow box are sealed with gasketed rubber boots.

The wiring harness is an interesting problem: It runs about 18 feet and is subjected to cyclic abrasion, seawater immersion, and occasional yanking stresses. The inline splices are all potted and wrapped with self-vulcanizing rubber tape, and the whole assembly is spiral-wrapped (allowing drainage while still providing excellent mechanical support and abrasion resistance). The RG-58 coax is hard-wired to the bayonet-mount J-pole antenna, eliminating the need for another connector, although this does make the harness much less convenient to stuff in a bag and carry around.

All this is basically playing by the rules for harsh-environment packaging, but I went just a little further (given the dollar value of the contents!). Because grit can compromise gaskets, I periodically treat the Pelican seals with silicone grease, and inside the black box there is a VCI, or vapor-phase corrosion inhibitor. This adhesive-backed, sponge-like unit slowly outgasses a substance that bonds with exposed metal surfaces, preventing oxidation; you can see the edge of it just in front of the Yaesu rig in photo B.

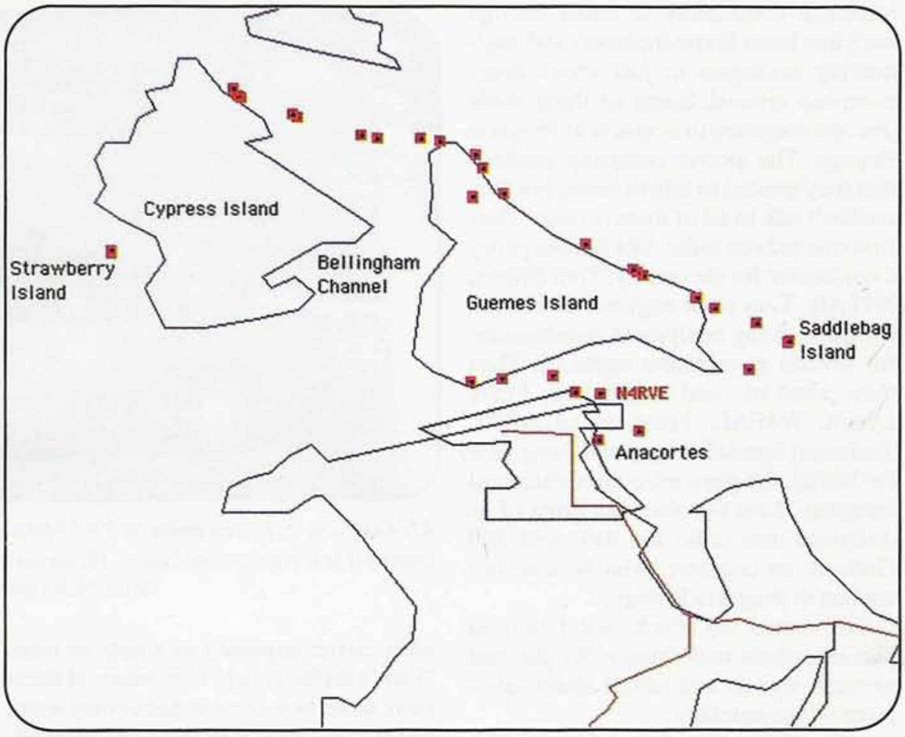


Photo G. A plot of the posits captured during an island circumnavigation with Bubba. Cypress is unpopulated, with high cliffs; coverage was very sparse after rounding the north end.

The System in Use

Having a stable power system, decent lighting, and a live tracker on a kayak has added considerably to the quality of the paddling experience. During a six-day adventure last fall, I kept my tracking page (<map.findu.com/n4rve>, courtesy of Steve Dimse, K4HG) linked from the daily update page on my website. Local friends kept an eye on my progress and popped by to meet me as I approached towns; farther away, some folks kept a window open on their desktop at work and periodically loaded the Terraserver page showing a satellite's-eye view of my current location. There was a sense that in an emergency, help would not be far away, and in camp, alone on a tiny island in the fog, I amused myself with a couple hours of fireside packeteering while sipping an adequate merlot and listening to the nightbirds. Not a bad life.

The confluence of raw nature, muscle power, and sophisticated technology has always been alluring. With a little extra attention to packaging, this can be extended into places that would normally fry the delicate electronics that have become such a seductive part of our geek lifestyles. Daily project updates and photos may be viewed at <microship.com/latestnews/live.html>.

Acknowledgements

A thank you to Steve Dimse, K4HG, for the findu.com site and map graphic; Bill Vodall, WA7NWP, for APRS configuration help and capturing posits; and Ken Glaeser, KA9YGN, for power-management help and J-pole fabrication. ■

technical community is small enough such that hams know engineers and engineering managers in just about every company around. Some of them made discrete inquiries to contacts at Progress Energy. The power company realized that they needed to talk to hams, but they couldn't talk to all of them at once. They first reached out to the ARES Emergency Coordinator for the county, Tom Brown, N4TAB. Tom is an engineer at a small company doing equipment development for several government agencies. Then they called me, and a third ham, Frank Lynch, W4FAL. Frank is an ARRL Technical Specialist, and an RF engineer for Nortel, the giant telecommunications company. Last October, the three of us discussed ham radio and BPL with Bill Godwin, an engineer, who became our contact at Progress Energy.

Bill visited my shack, and I showed him some ham radio basics. We listened to weak signals and talked about interference and notching.

Eye Opener Number 2

We learned from Bill that the Phase I trial, concluded earlier in the summer, had been successful from the company's point of view. The equipment, supplied by Amperion, worked well and provided throughput beyond expectations. We also learned that although the test was over, the equipment was still in place and some of it was still turned on. Tom and I both have HF-equipped mobiles, and we went to listen.

A ham at Progress Energy told me to listen on 10 meters along a certain stretch of road near the trial neighborhood. As I approached the site, I wondered what I was going to hear. Ed Hare's video showed a different company's technology with a different RF "signature" at each trial site, so I didn't know quite what to expect. I cranked up the volume and paid careful attention to every pop and squawk from the speaker as I tuned up and down the band. Ten meters was quiet that day, with only a few ham signals here and there.

Then I heard it, faintly at first, but quickly getting stronger as I drove. This "signature," from the Amperion system using something called the "DS-2 Chip Set," was both extremely familiar and yet like nothing I had ever heard before. It was familiar because it was just carriers—nearly pure CW carriers, although some had a little tick-tick-tick clock sound on them. I was in SSB mode, so each carrier appeared as a note or tone. What's different was how many of them there were, how close together they were, and how much of the band they occupied. A lot. Very. And All.

KN4AQ's mobile transmits on 29.6 MHz while under the active power line. The quick transmit test was inconclusive. However, AMRAD's tests show problems when amateur radio operators transmit.

This was BPL 101 for me, the beginning of the education. The signal quickly peaked at S-9 as I pulled under the active overhead power line. I pulled off the road and analyzed it. The individual carriers were about 1 kHz apart, so as I tuned up the band, I could hear beat notes from two carriers at once. There was always a BPL signal in the speaker, and they all were about the same signal strength. I tuned, and I tuned across the whole 10 meter band, and down below into the CB band. *The BPL covered it all.*

The signal did fade relatively quickly as I drove away from the power line, fading to almost nothing a few hundred feet away. The overhead line was on the main road, but the neighborhood into which I was driving had all underground power. I didn't know if the 10-meter signal fed the whole neighborhood, or even if there was anything left turned on away from that overhead line. Still, I could imagine a ham with a dipole or a beam in the air somewhere nearby. They'd get a much

Tom Brown, N4TAB, listens on 24 MHz at Roland Erickson, WAØAFW's home near the second trial area. The signal was weak, but audible on Roland's attic-mounted dipole, about a half mile from the BPL site.

Amperion's Phillip Hunt shows FCC Chairman Michael Powell the hardware inside the ground-mounted pedestal.

stronger signal than I did with my Outbacker mobile antenna. Watching Ed Hare's tape was powerful. My hearing these "invader" signals in the 10-meter band was even stronger.

Progress Energy planned a Phase II trial to begin in early 2004, and Bill Godwin promised that we would be invited to see it. This one would be bigger. It would have a new generation of technology, but mostly it would be a marketing test. Would people want this stuff? Going head to head with cable and DSL, would there be any advantages? Meanwhile, I learned more. The BPL industry was still denying that there was any interference, while the ARRL was showing that there was. Hams were fuming on message boards, plotting more revenge than strategy. On websites such as DSL Reports, a more balanced story was told, but non-hams who were writing replies called us old men practicing a dying art that should well be sacrificed for the greater good. That would be downloading music from Kazaa, sitting in chat-rooms, playing on-line video games, and maybe getting a little work done, right?

In early January we got the call. Thursday, January 15th, was our day. The location was kept secret. Tom, Frank, and I headed south from Raleigh, North Carolina early on a chilly morning (for you guys up north, it was a balmy summer day). We met Bill Godwin, several other Progress Energy engineers (some hams included), and Garrett Durling, an engineer Amperion had flown down just to meet with us. We drove out to an isolated neighborhood of brand-new homes in an otherwise rural area, and Garrett described the system.

Because this was a trial area, the data was piped in on a 5-GHz dish mounted on a power pole, and then fed into the BPL equipment to run down an overhead line along the highway for about a half mile. Then the data was pulled off, and an 802.11b Wi-Fi system bridged the highway and brought it into the neighborhood, where it was put back on the buried power line as BPL. Every 2000 feet or so the power line came up out of the ground to run through a "repeater" in a green cabinet on the ground.

Some BPL systems bring data right into the home using the power line. You plug a stand-alone box into the wall outlet and connect an Ethernet line between a port on the box and your computer. The providers promote the fact that you can plug this box into "any outlet in town" and get high-speed internet. Amperion does it a little differently. They place 802.11 Wi-Fi nodes around the neighborhood, and you hook up with a Wi-Fi card in your computer or other wireless device, such as a Palm.

All that was pretty cool, but we were interested in spectrum use. Time for school: BPL 201. The following description applies to the Amperion system, and not necessarily to other BPL technologies.

The data goes on the power line using two blocks of RF spectrum, one for upstream and one for downstream. The upstream block is 2.5 MHz wide, and the downstream block is 3.5 MHz wide. Within each of those spectrum blocks are the carriers I heard—thousands of them, completely filling the block. The blocks can be anywhere between 2 and 50 MHz, and can be as close together as 100 kHz or as far apart as opposite ends of the spectrum. Amperion tends to use frequencies above 6 MHz and below 31 MHz. At each repeater the data moves to a new set of carriers on two new blocks of spectrum. The spectrum blocks can't be reused for several power-line legs, about a mile, so they don't hear each other.

This system used 25- and 28-MHz spectrum for the overhead line, just like the Phase I system I'd heard in the fall. Sure enough, there it was when we tuned in. Once again, the signal was S-9 when we drove under the line and faded a few hundred feet away. The underground legs used other HF spectrum. I heard signals at 7, 10, 11, 15, and 18 MHz, crossing ham and shortwave broadcast bands and everything in between. One put a fat beat note on WWV while listening in AM mode. The signals on the buried line segments could only be heard while near the above-ground pedestals; about a hundred feet away was the limit. Keep in mind that this was with a mobile antenna. How much more would a home station with a bigger antenna hear? We don't know, but more than the mobile, for sure. Once again, there were no hams living in the neighborhood. We called one ham we knew who lived nearby, a little over a half-mile from the overhead line. He tuned the 10-meter band and the signal was clear, if not really strong.

A group called AMRAD (Amateur Radio Research and Development Corporation) had published details of an extensive test of reverse interference—ham radio shutting down BPL. They had a lot of, well, success, I suppose, causing problems. Low-power signals totally blanked data throughput in some cases, and higher power always did. We tried a brief test. We didn't have a computer connection, but Garrett called his NOC (Network Operations Center) and had them loop some data through the system. We keyed up on 29.6 FM with 5 watts, right under the wire that was using 28 MHz, and sure enough, it stopped. It started up again as soon as we unkeyed. Then we tried it with 100 watts, maybe hoping for a longer lasting effect. We caused a hiccup, but didn't shut it down. That's all the time we had for a transmit test. Don't read too much into the results.

The Solution!

We learned the source of our salvation, the solution to our worries. The system is frequency agile. If there's an interference problem, the NOC can move the carriers around in the spectrum and notch out some of them. I heard echoes of this when I read the NPRM released in late February; that's just what the FCC is proposing they'll have to do. How fortunate they already can. This is where the industry hangs its hat on the question of interference to hams. They can move . . . except not today. During our visit, I asked them to move this interference off the 10-meter band (and the other block of spectrum off the

12-meter band). No can do. The NOC is busy provisioning another system.

It is still on the 10-meter band as I write this column, almost 60 days later.

I'm getting ahead of myself. Our next job was to see just how significant the interference problem was. The FCC database and Street Atlas mapping program came together to help me plot all the hams in the area. One by one, from a zip code delimited list, the map filled in. There are lots of hams on the south end of Raleigh and the suburb of Garner, a bit north of the trial site. Fewer are out here in the country, but there were three hams within a one-mile radius and four more within a two-mile radius. I contacted them, found out who was active, who wasn't, and who heard the signal. Tom and I visited several of them to verify their reception. The result: Hams with simple dipole antennas clearly heard the 10-meter signal from the overhead lines up to a mile away. A ham with a large beam on an 80-foot tower heard it at a mile and a half away.

Everyone in town thought they heard it. BPL has become the new intermod—the catchall name for any squeak and squawk we think we shouldn't expect from a speaker.

We learned of a second trial area five miles to the west that they hadn't told us about. It was a similar setup, with an overhead line on 12 and 10 meters and a neighborhood with underground wiring. I plotted the locations of those hams, with similar results. There were a few more hams in the zone, as this was closer to a town. They heard about the same level of signals.

While all this was happening, the FCC released its Notice of Proposed Rulemaking (NPRM) for modifying Part 15. It was a good-news/bad-news deal. The good news: It prominently mentions the interference problem and proposes some steps that would "mitigate" it. The bad news: They think these steps will work. The steps include creating a database so anyone experiencing interference can look up and find the location and frequencies used by nearby BPL, and the "adaptive interference mitigation techniques" such as frequency agility and shutdown capability by remote control that I mentioned earlier.

The comment period on the NPRM will have closed by the time you read this, but the reply comment period should still be open.

Customer Service?

What this sounds like to me is ham radio by customer service. Congratulations on passing your exam. Here's your CSCE and a card with the phone number of your local utility. Give them a call and they'll try to have some bands clear of interference at your house by the time your ticket arrives. However, call right away.... They're a little backed up, and they're running out of spectrum.

Running out of spectrum? Well, I'm not the ultimate authority, but I did a little noodling and tried to put all the puzzle pieces together. They didn't fit.

I'll make the assumption that BPL can't operate without using ham frequencies. If it could, they'd just do it, but the interference zone from an overhead wire is at least a mile in diameter. In just about any mile-diameter circle there is an active ham, and that's in rural territory! The ham population is much denser in real suburbs or urban areas. How are they going to put up BPL and not interfere with hams, no matter how they can slice and dice their spectrum? It's a question I'll be posing to our power company after I file this story. I wish I could give you the company's answer, if they have one, and probably they will.

Even if they have a good answer, there's another problem—mobiles. How do you mitigate interference to a mobile?

This agility solution works for most of the other HF services, the ones which use specific channels that can be deleted from the carriers on the wire. Ham radio is different. We roam our spectrum, operating on whatever frequencies we choose. We look for weak signals, so just because BPL is weak doesn't mean it doesn't interfere.

The rules prohibit Part 15 devices from causing harmful interference to licensed services, and I expect future arguments to turn on the definition of "harmful":

§97.3(a)

(23) Harmful interference. Interference which endangers the functioning of a radionavigation service or of other safety services or seriously degrades, obstructs or repeatedly interrupts a radiocommunication service operating in accordance with the Radio Regulations.

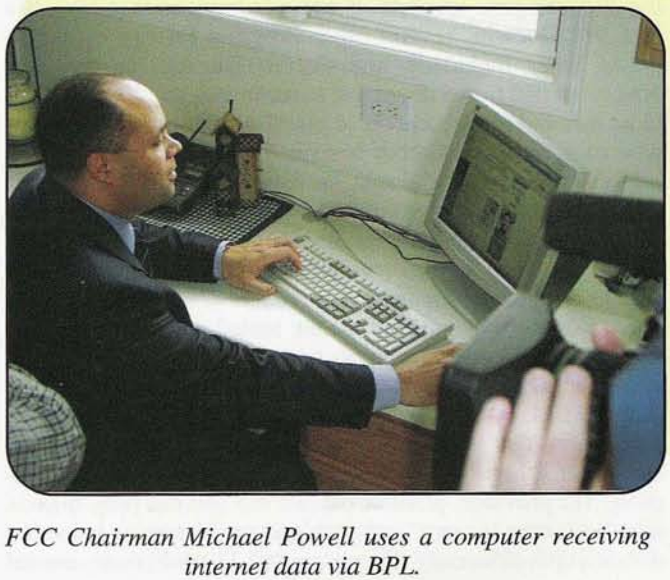
They're going to say that their weak signals aren't harmful. We're going to say they are.

Meet the Commish

Just as this episode was coming to a close, I got word that FCC Chairman Michael Powell was coming to town to see the BPL trial, an event open to the press. Tom, Frank, and I (and a few other interested hams) hastily rearranged our schedules to be present.

We arrived at the home of a trial BPL subscriber about an hour before Powell was scheduled to arrive. I introduced myself to the top BPL guy at Progress Energy, Matt Oja, and the CEO of Amperion, Phillip Hunt. There wasn't much happening yet, so we had an interesting discussion. I had realized long ago that this is serious, big business. They needed to know we hams are just as serious.

Powell arrived, along with two other top FCC officials, Robert Pepper (Chief, Policy Development) and Chris Libertelli (Senior Legal Advisor). I got to talk with the chairman for a few seconds while the Progress Energy people were getting their demo ready. He saw my callsign badge and said, "Hey,



FCC Chairman Michael Powell uses a computer receiving internet data via BPL.

KN4AQ, good to meet you!" I told him that we thought the interference problems were worse than what was being described by the FCC and the industry, to the point where we didn't think they could be solved.

I talked at some greater length with Robert Pepper, who approached me after I talked with Powell. Then, while I observed the Progress Energy presentation, Chris Libertelli stayed outside to talk with the rest of the assembled hams. He said he understood that one of our main concerns was enforcement, should BPL cause harmful interference.

Is the Game Fixed?

Something doesn't add up. The FCC admits that BPL will not be allowed to interfere with ham radio or other licensed services, per Part 15. They remain bullish on the technology, however. They have all their chips on the ability to mitigate interference. We are an inconvenient technicality.

I'm not expecting any surprises from the NPRM. Hams will say it won't work. The industry will say it will work. The NPRM should become a Report and Order with little change, and the BPL industry will be off with a pat on the back from the FCC.

Then, if I'm right, the complaints will begin. How will they be handled? How can they be? Will the FCC really tell any utility to turn off its BPL in an affected ham's area (about a square mile)? Will they address mobile problems?

A lot of hams are saying the game is fixed and the deck is stacked. Time will tell. One way or another, I'll be very happy to get back to concentrating on FM . . . and I'm keeping the phone number of my local utility handy.

Note: There is an MP3 file with a sample of what Amperion's BPL signals sound like on the air, narrated by yours truly. It's on the web at <http//www.cq-vhf.com/BPL.html>. ■

BPL Comment Deadline May 3

The FCC Notice of Proposed Rule Making on BPL, ET Docket 04-37, was published in the Federal Register on March 17. Comments are due by May 3, with reply comments due by June 1. We urge you to learn all you can from articles here and elsewhere, read the NPRM, and file comments via the FCC's Electronic Comment Filing System, or ECFS, at <http://gullfoss2.fcc.gov/ecfs/Upload/>.

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By Dr. H. Paul Shuch,* N6TX

DR. SETI'S STARSHIP

Searching For The Ultimate DX

Postcards from Beyond

If you are a regular reader of this column, perhaps by now I've convinced you to join the search for the ultimate DX. Then again, perhaps not. Quite a few of you have said to me, "It doesn't matter if I work Alpha Centauri or not. Those guys never QSL."

Some of my readers are new to ham radio and may be wondering, "What's a QSL?" Since early in the last century, amateur radio operators have observed a tradition of exchanging postal cards to commemorate their on-the-air contacts. So-called QSL cards (named for the International Morse Code signal for "confirmation") are used as proof of successful radio contact with stations, some of which are in rare and distant locations. Many operators who mount major DXpeditions or contest efforts employ the services of a QSL Manager to distribute their much sought-after cards. Now, as the world's radio hams prepare for the eventual reception of signals from civilizations far out in space, the question arises as to how those succeeding at the Search for Extra-Terrestrial Intelligence (SETI) will ever receive a QSL card.

To my knowledge, no ham has yet submitted to the DXCC administrators a card verifying contact with an alien world. Furthermore, we hams in The SETI League have decided that has to change, which is why we have just stepped up to the plate and volunteered our services as QSL Manager to ET (Extra-Terrestrial). To encourage amateur participation in the growing fields of radio astronomy and SETI, we are offering special cards to commemorate confirmed reception of a variety of extra-terrestrial signals—manmade, natural, and even alien.

As self-appointed QSL manager to ET, The SETI League will issue this card for confirmed reception of any electromagnetic emission emanating from beyond the Earth's atmosphere. Extra-Terrestrial QSL cards are available for the detection of signals in a variety of categories: natural, manmade, and some day, maybe even alien.

Here's How It Works

Any SETI enthusiast documenting radio reception of an artificial satellite, manned or unmanned space probe, natural astrophysical phenomenon, or Earth transmission bounced off the moon or another planet is eligible to apply for a QSL card from The SETI League, Inc. The cards, bearing our club callsign, W2ETI, indicate the nature of the signal being confirmed. Reception must have been accomplished with equipment normally used for, or capable of being used for, radio astronomy. In addition, the signal must be received directly from a source in space, not via relay or retransmission (for example, simply watching satellite TV, placing a telephone call that is being routed through a satellite, or determining your location with a handheld GPS receiver will *not* count for a QSL card). Even so, many amateurs do indeed have the capability to directly receive qualifying signals. I expect we'll be sending out many such cards.

We have already issued cards to those who have demonstrated reception of manmade communications and navigation satellites, beacons on space probes, shuttle and space-station transmissions, ham radio moonbounce signals, pulsars, quasars, supernova remnants, broadband emissions from the Sun, the Moon's thermal signature, interstellar gas clouds, and the hydrogen hum of the Galactic Center. However, the holy grail of SETI is a verified transmission from our cosmic companions, and no, that hasn't happened yet (*X-files* claims notwithstanding). ET's QSL will be a rare one, but we stand ready to send it out when The Call is confirmed.

In my next column, I'll be telling you how you can use those collected Extra-Terrestrial QSL cards to qualify for even more lovely wallpaper.

Amateur radio astronomers seeking a QSL card should send reception reports (including date, time, frequency, coordinates, nature and origin of signal) to SETI League headquarters, along with a stamped, self-addressed business-size envelope. QSL requests from outside the U.S. should include two IRCs (International Reply Coupons). Please state whether the signal received was natural, manmade, or alien (and be prepared to justify any claims of the latter!).

Oh, and you need not be a licensed radio amateur to participate. In the U.S., and many other countries as well, no government-issued license is required for receiving, only for transmitting. Since radio astronomy and SETI are SWL (well, actually, ETL) activities, these cards are issued merely for confirmed *reception.*

On the other hand, if you do manage to achieve two-way contact with ET, and can prove it, I think you'll be receiving a suitable acknowledgment of that accomplishment. It's called the Nobel Prize. ■

*Executive Director, The SETI League, Inc.,
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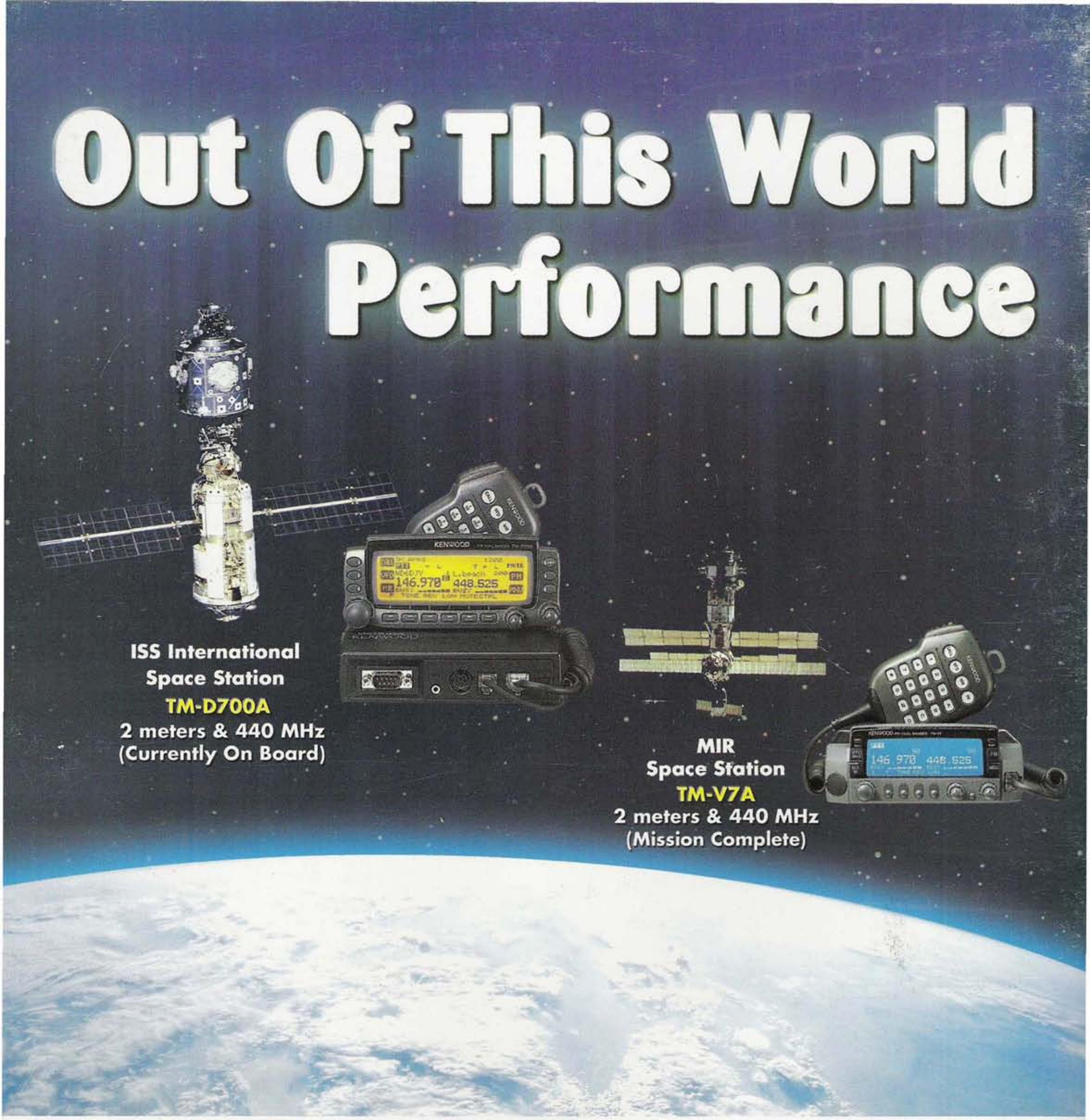

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Division Headquarters
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Customer Support: (310) 639-4200 Fax: (310) 537-8235

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