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CQ VHF

Ham Radio Above 50 MHz

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Summer 2004

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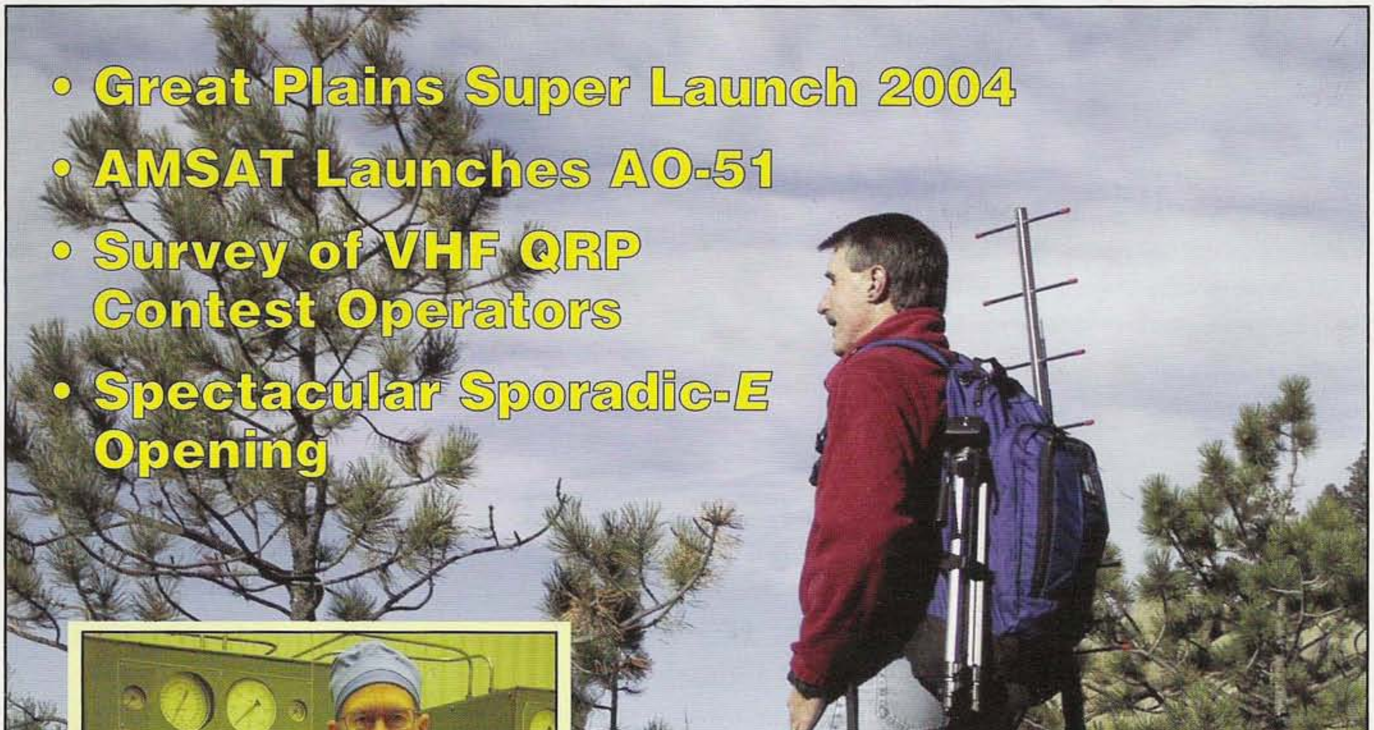
- AMSAT Launches AO-51
- Survey of VHF QRP Contest Operators
- Spectacular Sporadic-*E* Opening



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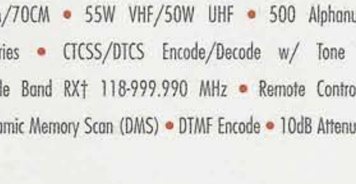

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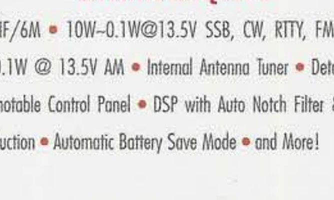

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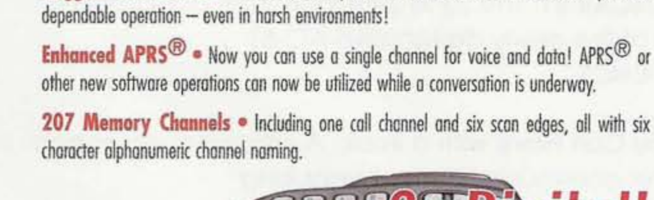

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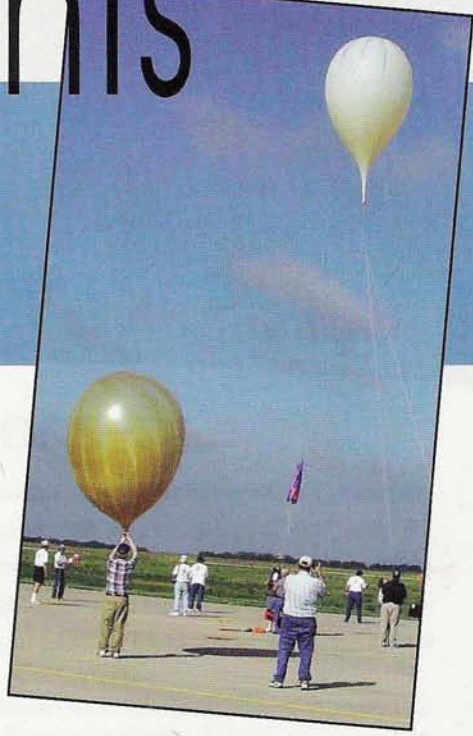

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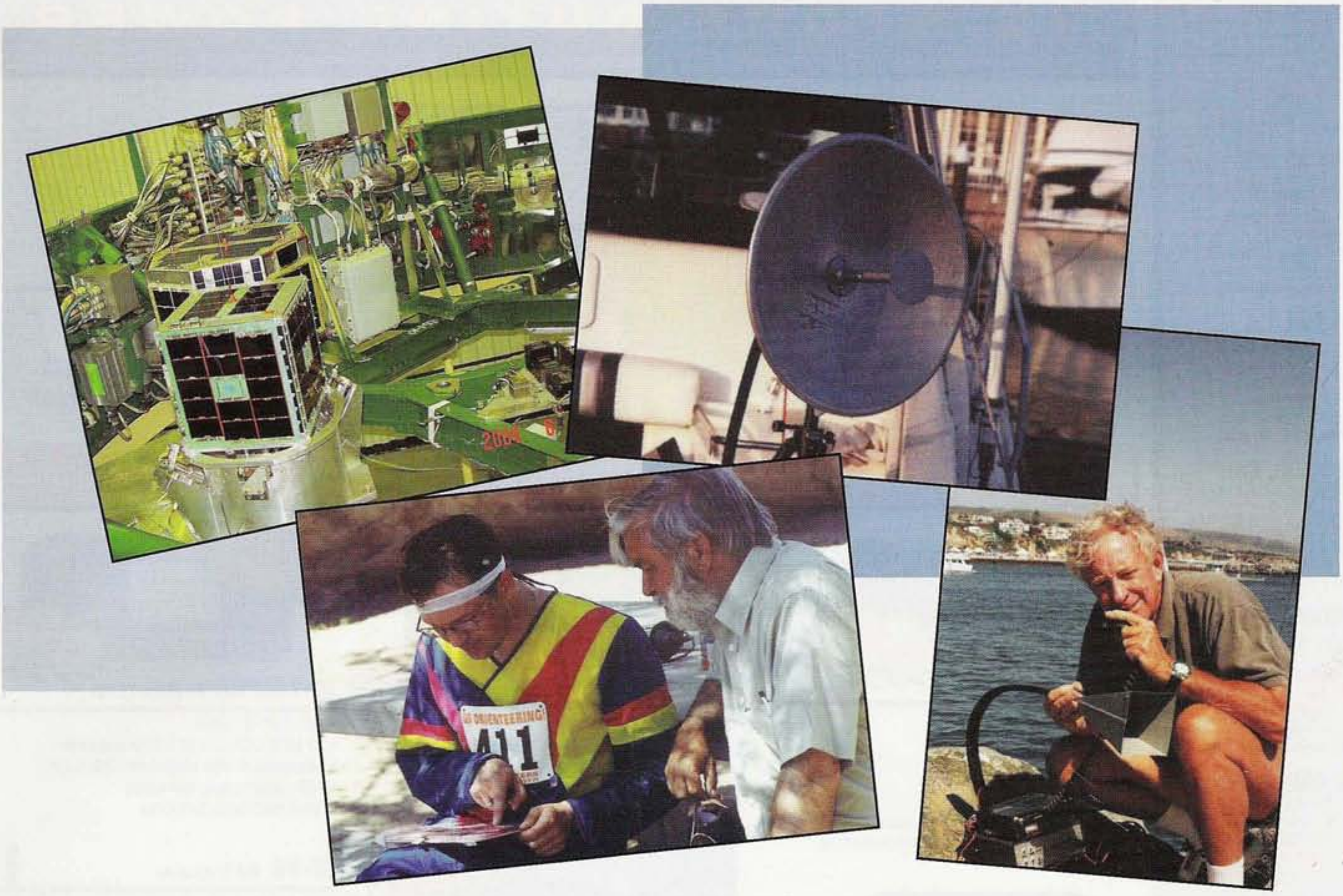
Vol. 7 No. 2

FEATURES



COLUMNS

DEPARTMENTS

On The Cover: Bob Witte, KØNR, operating QRP portable on Mt. Herman, DM79. For a survey of QRP VHF contest operators, see page 16. *(Photo courtesy of WA6TTY)* Inset: Chuck Green, NØADI, in the clean room at Baikonur, Kazakhstan preparing the Echo satellite for launch. For the story of AMSAT's newest satellite, AO-51, see page 12. *(Photo courtesy of AMSAT)*

CQ VHF Ham Radio Above 50 MHz

LINE OF SIGHT

A Message from the Editor

The Last Mile vs. The Last 30 Miles

With all of the hoopla over BPL (both pro and con), it is not without competition from other "last mile" providers. What may be the sleeper competitor, however, is WiMAX, the potential last 30-mile provider. Furthermore, here is where ham radio operators have the golden opportunity to look like heroes.

For more than a year we ham radio operators have been beating up utility companies and the FCC over BPL. On June 10, 2004 something happened at the FCC that, for me, makes it look like the FCC has heard our concerns. Seemingly off our radar screen because it is not on our frequency allocation was the creation of the Broadband Radio Service (BRS). For a press release on this FCC groundbreaking ruling, see: <http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-248267A1.doc> for a MS Word document, and go to: <http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-248267A1.pdf> for a pdf file of the same. You might also look at each of the commissioners' positive comments on the ruling. They are fascinating reading. You can find them at the FCC URL: <http://www.fcc.gov> under the June 10, 2004 date. Ironically, the comments written about BRS are very similar to what they previously wrote about BPL, that being their interest in enabling the development of broadband Internet access for the entire country and how BRS will be yet another way to bring about this development.

What does BRS have to do with ham radio? With regard to our future and BPL's threat, everything! It is within BRS that WiMAX will find a home.

What does WiMAX have to do with ham radio? While the jury is still out concerning the development of this new technology, some say that it is possible that we can develop the technology on our frequency allocations. If this is so, then this is great for utilizing unused amateur radio frequencies. Furthermore, it is great for incubation of commercial systems, which brings me to my most important point: There is something far more important for us hams in WiMAX than a new toy. It is a venue for good public relations.

Let's face it. Our image in the media right now is not the best. We appear to be a bunch of crybabies complaining about how the utility companies are trying to play fast and easy with the truth and claiming that government agencies such as NTIA and FEMA are not showing backbone in their weak stances concerning BPL interference issues. Granted, there is some truth to these complaints. However, our days of being the canary in the mine are over—mainly because the utility companies keep hiding the mines. Furthermore, our days of being David against Goliath are over as well. We have thrown more than enough stones at those giant utility companies. Now it is time to borrow a 15-year-old movie title and focus on the building of our own *Fields of Dreams.* While the original Field of Dreams was limited to a cornfield in Dyersville, Iowa, ours potentially could have many 30-mile perimeters.

Here is how: There is a small, but fast growing interest in HSMM technology—that being the use of 802.11 technology under Part 97 regulations as opposed to under Part 15 regulations. Early this past June, Walt DuBose, K5YFW, of the Texas Roadrunners Microwave Group, and Ron Cole, N5HYH, of the North Texas Microwave Society, gave a presentation to the Roadrunners at their meeting in San Antonio, Texas. They explained what HSMM is all about and how one can put together a home station and an access point (AP). They also explained the difference between operating under Part 97 and Part 15 regulations.

More recently, at the HamCom convention also this June, around ten different HSMM forums were presented. In addition, Walt DuBose, K5YFW, Assistant ARRL HSMM Working Group Chairman, and Webmaster Dr. Gerry Creager, N5JXS, of Texas A&M University, Network Infrastructure Specialist, received Certificates of Merit from the ARRL for their outstanding accomplishments.

Here is where the Fields of Dreams come into play. There are huge transferable skills between WiFi and WiMAX. Therefore, hams who are developing WiFi systems can also be in on the ground-floor development of WiMAX systems. As I stated above, amateur radio frequencies might be able to be used for incubation of WiMAX systems, which then can be transferred to commercial application on the new BRS frequencies. Even if the technology is not able to incubate on our frequencies, hams can be the ones to develop the technology on the BRS frequencies. They can get together and form micro industries for profit (since this will be a commercial operation on commercial frequencies) and set up rural systems for the purpose of supplying broadband Internet access to their neighbors. Imagine this: Hams being perceived as good neighbors for a change!

There is a fascinating ancient story of a king, his queen, the prime minister, and the queen's uncle. In this story the prime minister gets angry with the queen's uncle for his failure to give proper homage to him as the prime minister. In retaliation he gets the king to issue an irrevocable decree to destroy the tribe to which the uncle belongs. The uncle intercedes with his niece over his concerns for the future of their tribe, warning her of her responsibility and the consequences if she fails to intercede with her husband concerning the future of the tribe, concluding with this prophetic rhetorical question: "What's more, who can say but that you have been elevated to the palace for just such a time as this?"

In the end the queen is successful in getting the king to issue another decree that allows the tribe to defend itself, which effectively negates the king's former decree. For his part in the shenanigans, the prime minister is hung on the gallows that he had prepared for the queen's uncle.

What does this ancient story have to do with ham radio? With the FCC's June 10, 2004 ruling they have given ham radio the opportunity to defend itself in a positive way against the BPL threat. It is now up to us to use our creativity to make it happen. Are we going to be a part of the problem or are we going to be a part of the solution? Perhaps a bit of rewording of the uncle's question might be in order for us and our hobby: "What's more, who can say but that we are active in our hobby for just such a time as this?"

Next Issue of *CQ VHF*

New columnists: The fall issue will feature two new columnists, John Champa, K8OCL, and Keith Pugh, W5IU. You have read articles by John in several of past issues. In this issue is Part 3 of his series on HSMM communications. In the fall issue he will step in to fill the shoes of Neil Sablatzky, K8IT, who had to step down due to other obligations.

Keith Pugh, W5IU, fills the shoes of Tom Webb, WA9AFM. Tom has had an increase in job responsibilities which prevents him from doing much with ham radio. Now that Keith is retired, he is able to devote more time to the hobby. Knowing how one's schedule gets filled once one retires, I moved quickly to secure Keith before he got too busy. Keith is in charge of AMSAT's on-the-air nets and is the former Vice President for Operations for AMSAT. This is not the first time that Keith and I have worked together. When I was editor of the *QCWA Journal,* Keith was my satellite columnist. I am sure that as you already have come to appreciate John's contribution to *CQ VHF,* you also will appreciate Keith's involvement, as well.

Until the next issue . . . 73 de Joe, N6CL

Group shot of seminar participants. Notice how they are proudly displaying their newly acquired copies of CQ VHF magazine. (N6CL photo)

Great Plains Super Launch 2004

In Memory of Bob Davis, KØFPC

Each summer for the past three years, a group of balloonists has gotten together for the Great Plains Super Launch, a simultaneous launch of at least six balloons carrying amateur radio payloads into the edge of space. Started by Paul Verhage, KD4STH, in 2001, this year's launch was directed by WØZC. Here he tells about the trials and tribulations of simultaneously directing the 2004 super launch and trying to manage his own team, Project: Traveler, as well.

By Zack Clobes,* WØZC

High-altitude ballooning is a sport that has been growing in popularity quite rapidly over the past five to ten years. For those of you in the dark as to what this hobby is, it consists of around two dozen groups or individuals around the country and abroad who build, test, and fly an assortment of ham radio transmitters and scientific instruments to the edge of space.

By edge of space, I'm referring to the point in the Earth's atmosphere known as the *tropopause,* generally considered above the jet stream. The maximum altitude for these balloons is usually in the neighborhood of 80,000 to 120,000 feet above Mean Sea Level (MSL). At this point in the sky, the curvature of the Earth is clearly visible, and because we are well above most of the gases that make up our atmosphere, the sky above is no longer blue but instead is pitch black.

At these altitudes, many of the environmental factors that affect our payloads come close to reflecting those experienced in space. Air temperatures are normally –50°C, and the air pressure begins to reflect more of a vacuum than anything we find on the surface. Our payloads are exposed to more and more radiation as we leave Earth's protective shield.

Because of a variety of FAA regulations and costs associated with balloon flight, a typical payload weighs between 2 and 12 pounds and is made up of at least one insulated equipment

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Chris Krengel, KBØYRZ, proudly shows off his super tracker truck to the admiring crowd at the Great Plains Super Launch forum location, Hutchinson Community College, Hutchinson, Kansas. (WAØGEH photo)

Payloads for the balloon of Paul Verhage, KD4STH. See text for the story behind the bag of potato chips, which, incidentally, failed to open during the flight. (WAØGEH photo)

box, a parachute, and a latex "weather" balloon. These weather balloons are not your typical party balloon; they weigh over 2 pounds by themselves. Most equipment box(es) have been equipped with at least one APRS system (GPS position reporting) for use as the primary tracking system. Chase teams are usually made up of at least two vehicles with radios, TNCs (terminal node controllers), and laptops, and are used to chase the capsule across the countryside for recovery.

Many payloads also carry additional transmitters and/or experiments, such as backup beacons (CW or MCW) running either on 2 meters or HF frequencies. Some groups often carry Amateur Television (ATV), Slow Scan Television (SSTV), PSK31, film or digital cameras, camcorders, even some cockroaches—in other words, anything they can cram inside a 6-pound box.

GPSL

The Great Plains Super Launch was started four years ago by Paul Verhage, KD4STH, then from Manhattan, Kansas. Paul took the initiative to invite area balloon groups for social networking, and of course, a mass multiple balloon launch. That first Super Launch occurred near Manhattan during the summer of 2001. By 2002 Paul had moved to Idaho, but he still managed to organize another Super Launch in Manhattan that, for the first time, included a formal symposium where groups had the opportunity to put together presentations and share their information with others. By 2003 Paul began delegating many of the smaller details to a hosting balloon group, and Edge Of Space Sciences (EOSS) from the Denver, Colorado area was the first host.

T-Minus 300+ Days

The dust hadn't quite settled from GPSL 2003 when I received an e-mail from Paul asking if I would be willing to organize and host the 2004 Great Plains Super Launch. Of course I'm young, immature, and just plain stupid, so I readily agreed.

Things were pretty slow going in the beginning. I'd get an occasional e-mail from Paul regarding this or that. He soon announced that he'd found some corporate sponsorship to provide prizes for the highest altitude and the closest touchdown prediction. In fact, things were so slow that I was able to spend time with my wife in the labor room during the birth of our first child.

All of that was about to change, however. By the middle of April, things were starting to heat up and my e-mail in-box was getting full. There were many discussions to be had: What frequencies would we use? How were we going to fit eight or more APRS transmitters on the same frequency in the same place, without multiple collisions and interference? Who was going to fly what? Who was going to present what? How would we get our capsule's information onto the Internet in real-time?

T-Minus Seven Days

I'll fast forward to the week of the event, which was when things really started getting hot. I had so many e-mails coming in so fast that I didn't even see a few of them. I spent much of that week finalizing the preparation of our own capsule. I quickly saw that I wasn't going to be able to keep up with all of these demands, so I turned over much of the prep-work to my sidekick, Jon Riley, AJØNR. He handled all of the assembly and test work that normally would have consumed many of my hours in the days before the launch.

The Hutchinson Community College in Hutchinson, Kansas, provided the GPSL group with a nice multimedia auditorium for the symposium on Friday. To facilitate this, I spent quite a bit of

Balloon Alley, where a half-dozen teams prepared their balloons and payloads for launch. The alley was located behind one of the hangars at the McPherson, Kansas municipal airport. (N6CL photo)

time confirming our reservations and learning how to use the projector, document camera, computer, audience/instructor cameras, and all sorts of other bells and whistles that they had hooked up to that thing. It also occurred to me about a week before the event that I hadn't even planned for water to be available, so that prompted a frantic call to the catering service on Wednesday afternoon.

I spent my lunch hours and early evenings calling to check on the auditorium, launch sites, helium tanks, and lunch and dinner reservations to make sure everybody still had us written down. I have a habit of not trusting anyone, especially when my neck is stuck out very far!

T-Minus 36 Hours (Thursday Evening)

Thursday finally rolled around, and Paul showed up at my house with a couple of boxes of handouts. We spent the day tying up last-minute details. At around 5:30 PM a rain storm moved into the Hutchinson area and dumped almost two inches of rain in some places, just as many of the participants were arriving in town. Many of those approaching from the west, where the rain was heaviest, had to pull over and wait out the storm. This didn't dampen their spirits, though. They sloshed on through the water and made it in time for dinner.

Dinner conversations mainly consisted of reflecting on the past year, since many of these people had not seen one another, as well as a healthy dose of walking through ankle-deep water in sneakers to make it to their vehicles.

T-Minus 25 Hours (Friday Morning)

Check-in wasn't scheduled to start until 9:00 AM on Friday, but when I arrived at the community college at 7:55 AM, there were already several cars in the parking lot and people were carrying their show-and-tell items into the building. Inside I found Paul talking with a few members of the EOSS team about their new ATV transmitter package, which featured an electronic compass-stabilized video camera. In a nutshell, they used an electronic compass to drive a stepper motor so that the camera was always facing in the same direction. It's a concept that I've heard many groups discuss, but nobody had ever done much about it until then.

Paul, in return, was showing off his well-thought-out package design, which consists of a Styrofoam® frame covered by several layers of cloth and film insulation, protected by a nylon outer layer. On the side of his capsule he has a panel which consists of toggle switches for each of the primary systems within the box, a couple of status lights to give visual go/no-go indications, as well as a DB-9 port that can be hooked up to a laptop or PDA for last-minute configuration settings.

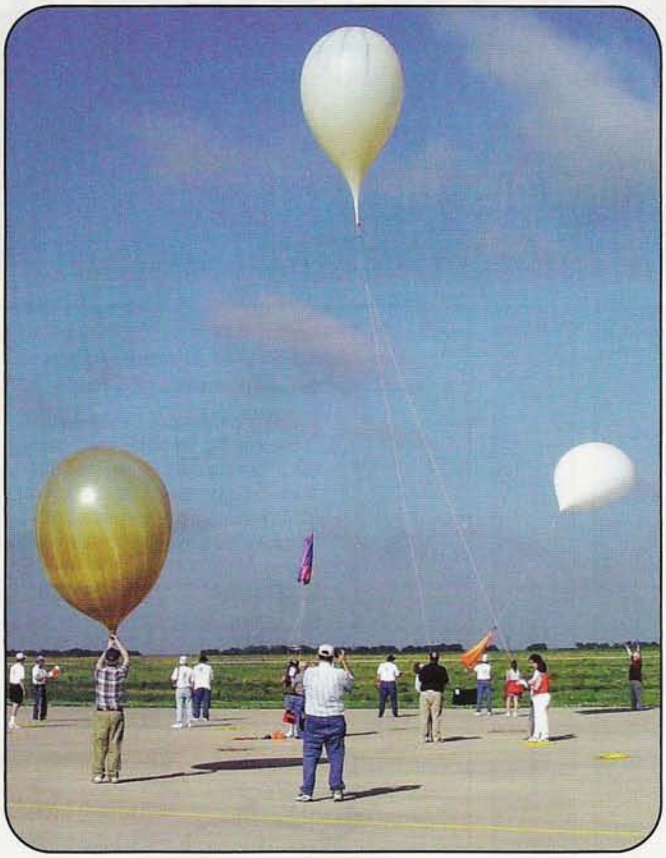
Paul also could be seen explaining the bag of potato chips with the string duct-taped to the bag, as well as the small, pink propaganda fliers hanging from the side of his capsule. Ever since he dropped a Mr. Potato Head character from his capsule during GPSL 2002, which was confiscated by the Dickinson County Sheriff's Department, Paul has had it in for Kansas and is bound to get even by bombing us with Idaho produce.

I quickly brought in my two very humble capsules and set them on the table opposite Paul's and EOSS's works of mechanical art. I did have the opportunity to show off Jon, AJØNR's Garmin GPS-18, which he had just purchased. This particular unit hasn't yet been sent up by the amateur community and it's not certain whether or not Garmin's engineers have allowed it to work over 60,000 feet. Everyone who saw it was very excited until I told them our software had some issues with it (which have been resolved) and we wouldn't be flying it at GPSL.

Bill Brown, WB8ELK, widely considered the father of amateur ballooning, was first on the itinerary for the 10:00 AM presentation. As of 9:40 AM, no one had seen or heard from him yet and that was starting to make me a little uneasy. Bill finally showed up, just in time to get his presentations loaded onto the computer and begin explaining the BalloonSat program at the University of Alabama, Huntsville, which requires students to design and test an APRS tracking system, as well as launch and chase it. It also enabled Bill to participate in many balloon launches with no out-of-pocket expenses.

Bill also passed around his MicroHunt SquawkBox 30-mW voice transmitter. He reported that this unit saved many of his students' APRS payloads after the primary transmitters failed. He also reported that MicroHunt has a CW beacon which has saved him the agony of listening to his own recorded voice being played back continuously during a direction-finding (DFing) session.

He concluded by showing some photos of recovered Ozonesonde units that he and his students had stumbled upon in their balloon-chasing adventures. He



Half of the six teams are seen in various stages of launching their balloons. (N6CL photo)

gave some vital information for others to track down Ozonesondes (which are basically considered disposable by the government) by using DFing techniques, as well as some general information on how to decode the data streams.

Next on the list was Paul, KD4STH, discussing cosmic rays. The presentation was a well-laid-out explanation of their source and behavior, and how amateur scientists can detect and analyze these particles very inexpensively. Unfortunately, it left many of us, myself included, wishing we had paid more attention in those chemistry and physics classes. He showed some basic source code and diagrams detailing how he has used a pair of $150 Geiger counters mounted within his capsule to detect the presence of cosmic rays at various altitudes.

T-Minus 21 Hours (Friday Noon)

The group took a break and headed over a few blocks to a local fast-food restaurant. The Hutchinson area had received rain almost every day over the past three weeks and at that point was running about six inches above normal for the year. Paul decided that this might be a good time to invest in some mud boots, since he had left his back home, so we ran out to the mall over the lunch break.

Arriving back at the college, Paul prepared for a short demonstration to show us why a blue sky is observed from the surface level, but it disappears as we enter thinner air. The demo was very simple, using only a projector, an aquarium full of water, and some pine oil. All in all, the demo was very straightforward but very thought provoking.

The EOSS group provided three presenters: Larry Cerney, KØANI, Marty Griffin, WAØGEH, and Mike Manes, W5VSI.

(Continued on page 77)

Members of the HABITAT team salute their balloon cluster as it ascends into the clouds. (N6CL photo)

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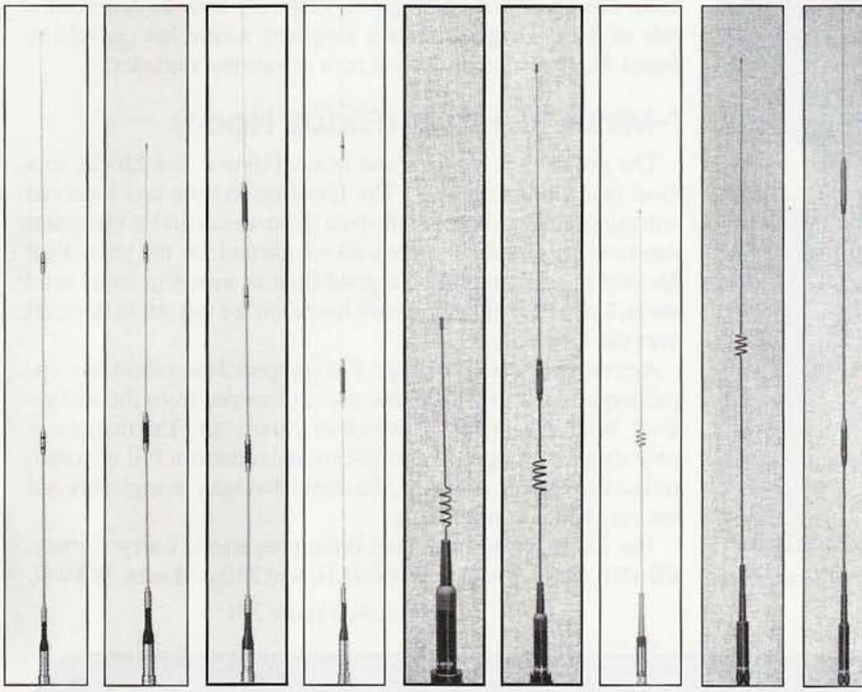

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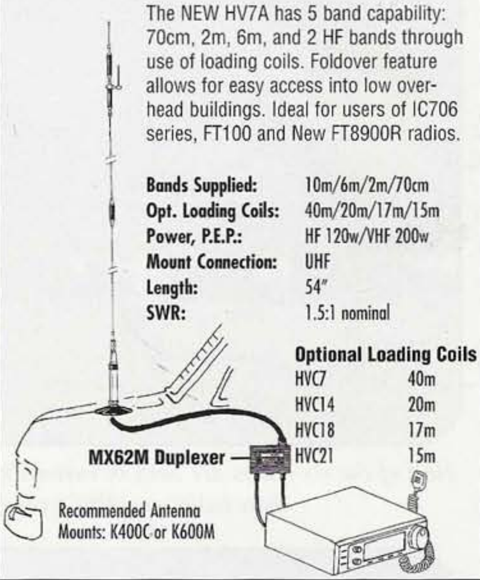
HVC21	15m



MODEL	BAND (MHz)	WATTS	CONN.	HT. IN.	ELEMENT PHASING
MR77	2m/70cm	70	MAG	20	1/4λ, 1/2λ
MR77SMA	2m/70cm	70	MAG	20	1/4λ, 1/2λ
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
NR7900A*	2m/70cm	300/250	UHF	57	1/4+1/2λ, 3-5/8λ
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
SG7900ANMO*	2m/70cm	150	NMO	62	7/8λ, 3-5/8λ
SGM510	2m/70cm	100	UHF	37	1/2λ, 2-5/8λ

MODEL	BAND (MHz)	WATTS	CONN.	HT. IN.	ELEMENT PHASING
CR8900A*6, 11	10m/6m/2m 70cm	60	UHF	50	1/4λ, 1/4λ 1/2λ, 2-5/8λ
SG2000HD*	2m	250	UHF	62.6	1/2λ+3/8λ
CR320A*6	2m/1-1/4m 70cm	200/100 200	UHF	37.4	1/4λ, 1/2λ 2-5/8λ
CR627B*6,9 CR627BNMO*6,9	6m/2m 70cm	120	UHF/NMO	60	1/4λ, 1/2+1/4λ 2-5/8λ
HF6FX*6	6m	250	UHF	40	1/4λ
HF50CX*6	6m	200	UHF	75	3/8λ
NR22L*	2m	100	UHF	96.8	2-5/8λ
NR2000NA	2m/70cm 23cm	100	N	39	1/2λ, 2-5/8λ 5-5/8λ
M285*10	2m	200	UHF	52.4	5/8λ
M685*6	6m	200	UHF	52.4	1/4λ
MG200	2.4GHz	-	N	23.6	3-1/2λ
SGM911*6,9	6m/2m/70cm	60	UHF	41	1/4λ, 1/2λ,2-5/8λ
NR124	23cm	100	N	25	4-5/8λ

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Patented One-Touch Fold-Over Feature. (Not available on M285, M685, MG200, MR77, MR77SMA, NR72BNMO & NR73BNMO)

* Not recommended for Magnet Mount
6 Grounding required
7 NR770HB same specs but in black finish.
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9 52-54MHz only
10 Tunable from 140-174MHz
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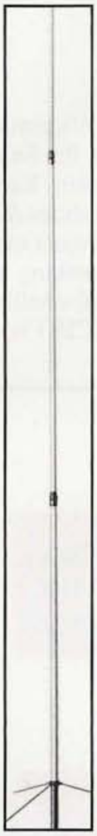


X50NA *X500HNA*

X500HA (UHF-Conn.)
X500HNA (Type-N Conn.)
Ruggedized Base/Repeater Antenna

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

COAX CONNECTION AT BASE END

HEAVY DUTY BASE/ RADIAL ASSEMBLY

STRONG JOINT COUPLINGS

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	70
DPGH62 [1]	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
G200	2.4GHz	–	N	4.8	135

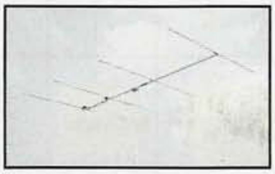
DIAMOND Dual-Band Base/Repeater Antennas

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
U200	440/1240	100	N	5.9	135

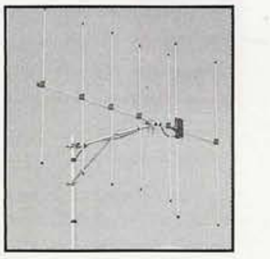
DIAMOND Tri-Band Base/Repeater Antennas

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

A502HB



A504HB



A144S5

NOTES:

1 Heavy duty aluminum construction.
2 F-718A: 440-450MHz., F718L: 420-430MHz.
3 X510NJ: 144-147/430-440MHz.
4 2m: 146-148; 100 watts
5 52-54MHz. only

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

DIAMOND Yagi Antennas

Most requirement: 1.4"-2.4"

MODEL	BAND (MHz)	WATTS (PEP)	CONN.	BOOM LNTH.	ELEMENT PHASING
A502HB	50	400	UHF	2.6'	2 element
A504HB	50	400	UHF	10.7'	4 element
A144S5	144	100	UHF	37.5"	5 element
A430S10	432	100	UHF	43"	10 element
A430S15	432	100	UHF	89"	15 element

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From ECHO to OSCAR 51

On June 29, 2004, AMSAT OSCAR 51 (AO-51), also known as ECHO, was launched from Baikonur, Kazakhstan. Here is account of ECHO's journey and launch, and a discussion of the capabilities it has to offer.

By Lee McLamb,* KU4OS

Have you ever dreamed of being part of the space program? Perhaps you've dreamed of building and operating an amateur radio station in space? At AMSAT[1] those dreams have been becoming realities since the launch of the first Orbital Satellite Carrying Amateur Radio (OSCAR-1) in 1961. AMSAT's latest project, known as ECHO, has now been officially designated as AMSAT OSCAR 51 (AO-51), continuing that proud tradition. In this article we'll follow ECHO on its final journey from Virginia in the United States through its final checkout and launch in Baikonur, Kazakhstan and discuss what capabilities AO-51 has to offer.

The ECHO project was conceived with the goal of launching a highly capable voice and digital satellite into low Earth orbit (LEO). ECHO is a 9.5-inch cube,

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e-mail: <ku4os@amsat.org>

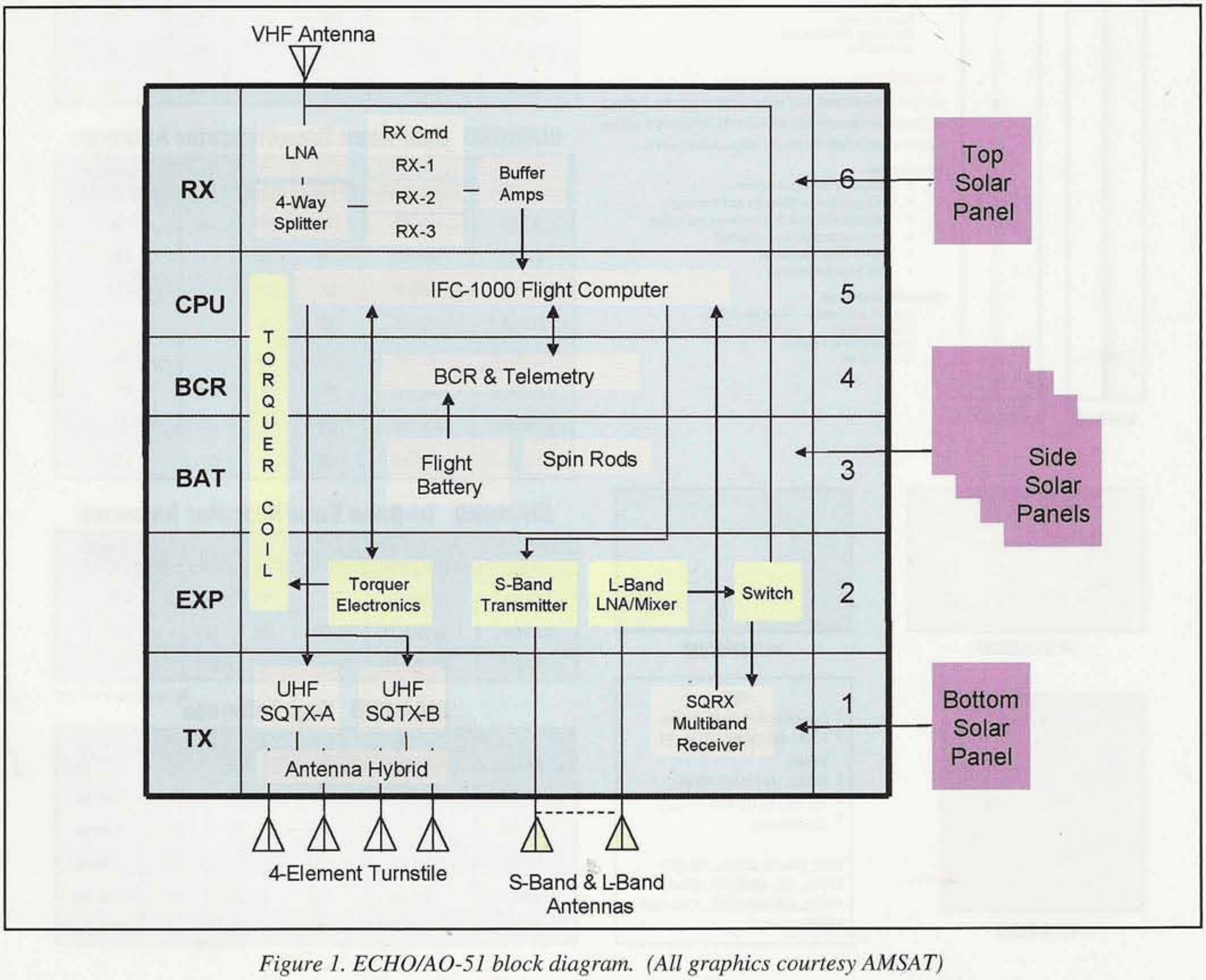


Figure 1. ECHO/AO-51 block diagram. (All graphics courtesy AMSAT)

and is what is known as a microsat. The satellite's structure is made up of a set of six stacked aluminum trays which hold the various modules. Figure 1 shows a block diagram of the satellite and also provides a layout of what is in each tray.

On June 9, 2004, ECHO was placed in the vacuum chamber at the SpaceQuest[2] facility in Virginia for an hour and pushed hard with both 70-cm transmitters running full power. Before packing ECHO for shipping, a final check of the sensitivity of all the 2-meter receivers and the wide-band tunable receiver (SQRX) was made, as well as characterizing the received signal-strength indicator (RSSI). With the final checks complete, ECHO was loaded into the shipping container, and Chuck Green, NØADI, representing AMSAT, along with the team from SpaceQuest, all of whom are also hams, and AMSAT volunteers who were escorting another group of satellites headed to New York's JFK airport for their eventual trip to the Baikonur Cosmodrome in Kazakhstan. Chuck provided the following account of his trip with ECHO:

Mode	Uplink to Satellite	Downlink from Satellite
FM Voice	145.920 MHz with 67 Hz PL tone	435.225 MHz
9600 Packet	145.860 MHz	435.150 MHz
L/S	1268.700 MHz	2401.200 MHz

Table I. The planned frequencies for AO-51's initial operation.

When you plan to fly and your hand-carried item happens to be a satellite, it pays to plan ahead. Airport security had been notified in advance that we would be bringing the three satellites. As a back up, the team also had ready the names and phone numbers of several levels of security management. The preparation paid off. Since they were expecting us, there was no problem. Security took one of the satellites and opened the box. They just poked around a bit, and then we were on our way to the Aeroflot gate for the flight to Moscow.

Once on board the aircraft, a B-777, the satellites where quickly stowed in the overhead bins. There was a bit of a buzz among the passengers about the very suspicious characters with the three white boxes. Most people seemed to believe that we were carrying donor organs. By the time the team arrived in Moscow it was June 10, and after clearing customs, we were taken to the hotel shuttle bus and then checked into the Novotel hotel.

June 11 began early at 4:40 AM. We were driven to the other side of Moscow to another airport, where our flight to Baikonur would depart. At the airport we also met the teams supporting the satellites from Italy and Saudi Arabia. The flight to Baikonur was on a Russian TU154. After clearing customs with the Kazakhs and passport control with the Russians, we then got onto a bus to take us to the Sputnik Hotel.

June 12 was a Saturday. More important, it was Russian Independence Day. There would be no chance to work on preparing ECHO for launch. That would have to wait until the next day. A tour of the city had been arranged, with the bus leaving at 10 AM. Our guide, Boris, was an ex-military officer who had spent 16 years in Baikonur. He loves this city, is very proud of the accomplishments achieved there, and very much enjoyed telling us all about it through an interpreter, Anna. The city is full of monuments. We were taken to a small observation structure overlooking the river, where the decision was made as to who would be the first man to go into space. This clearly was a place of great meaning for us.

June 13 was the first day spent working on ECHO to get it ready for launch. It was about 25 miles (40 km) to the integration facility. The bus took almost an hour and a half to get there. We went slowly because we were carrying lots of satellites. Each day the teams would be going to the integration facility and returning to the hotel on the bus, so we had to manage our work to match the bus schedule. The bus left the hotel at 8 AM and returned about 7 PM. Most days the trip would take about an hour each way.

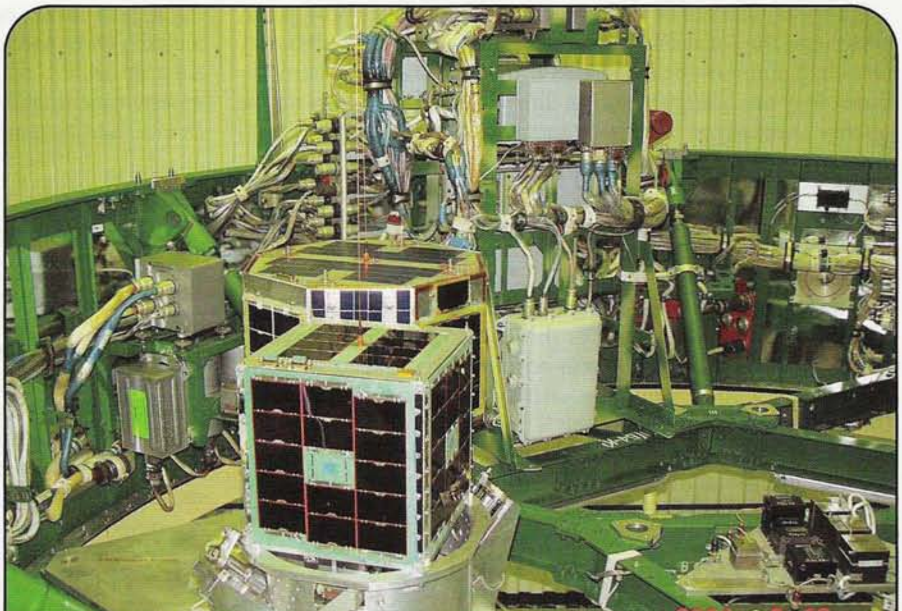
Once the team arrived at the launch site, they were given a safety briefing. During the briefing the shipping containers were cleaned and placed in the clean room. With the team dressed in clean-room garb and in the room, ECHO was taken out of its shipping case and set it up on a table. Then the bottom antennas were installed, along with the bottom solar panel, magnet, and corner reflectors.

We then turned ECHO on and successfully communicated with it over the umbilical from my computer. We then went through most of the test procedure and everything looked good. Finally, the four 2-meter receivers and two 70-cm transmitters were successfully tested.

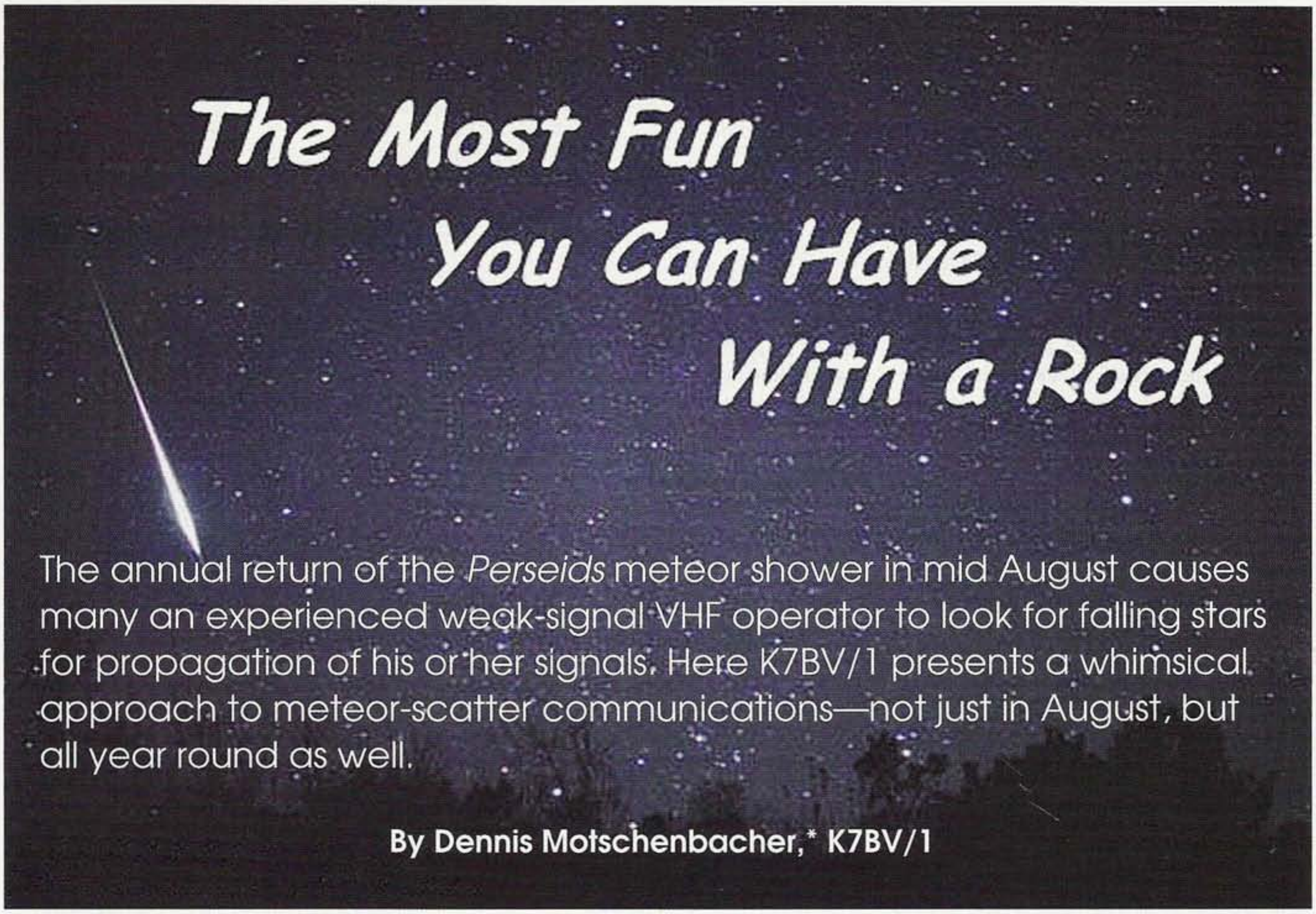
We then finished preparing ECHO. All the solar panels were installed, as well as the antennas. This was a slow process involving Loc-Tight on each screw, and there were a lot of screws holding the solar panels. Each solar panel was plugged into the satellite and the connector secured as it was placed against the body of the satellite. The antennas were then installed and secured with adhesive at their connectors. Finally, we also did a fit check by placing it on the base it would fly on to make sure everything was adjusted properly.

June 15 would be our last day working on the satellite before launch. It was time to weigh ECHO. We put it on a double-balance scale and it weighed in at 24.56 pounds (11.14 kg). ECHO was then placed on the "dispenser" plate. This was a slab of aluminum

(Continued on page 74)



ECHO placed on the dispenser plate next to the Italian satellite.



The Most Fun You Can Have With a Rock

The annual return of the *Perseids* meteor shower in mid August causes many an experienced weak-signal VHF operator to look for falling stars for propagation of his or her signals. Here K7BV/1 presents a whimsical approach to meteor-scatter communications—not just in August, but all year round as well.

By Dennis Motschenbacher,* K7BV/1

One of the biggest challenges facing a new user of the VHF bands can be overcoming boredom. This is the case for both HFers trying out that "50" button on their new rig as well as the multitude of new hams who first get on the air as Technician Class licensees.

It appears that our new Technicians generally are only pointed toward the local FM repeaters. Often, the locals who may be a close-knit group do not receive them with open arms; other times they are accepted, but in this "culture" they may not be openly encouraged to expand their horizons beyond the coverage area of the repeater.

While the world of repeaters may satisfy the needs of some, statistics clearly show that many had something else in mind when they studied for their ham radio operator license. A recent ARRL survey found that 25% of all persons obtaining a Technician license never even make one QSO! While there are a number of likely reasons for this, I maintain that numerous hams with a Technician license become discouraged and simply go away without knowing that their license could have taken them on so many more exciting VHF and UHF adventures not only across the country, but also across the globe.

I recently found myself in the second category of VHF ops. I became one of the HFers trying out the "50" button when I moved to Connecticut in the spring of 2002 to work as Sales and Marketing Manager for the ARRL. I coincidentally purchased a rig with 6-meter capability. Shortly after moving into a house on a hilltop, I leaned up a temporary 40-foot tower and lashed on a 7-element Yagi, which was recommended to me by one of my new clients, 6-meter fanatic Ray Grenier, K9KHW.

This article is about the discovery that kept me from becoming a flash-in-the-pan VHF enthusiast. Instead, I remain a dedicated VHFer and have significantly changed my discretionary time priorities, now devoting most of my time, energy, and entertainment dollars to the pursuit of VHF, 6 meters in particular, and its associated challenges and goals.

The Newbie Attacks the Band

The collective advice to this newbie from fellow ARRL staffers Dave Sumner, K1ZZ, Mark Wilson, K1RO, and Dave Patton, NT1N (now NN1N), indicated that they had been having a ball working lots of DX on 6 meters. The newness of my QTH did not give me an antenna farm already assembled. Consequently, the little temporary setup that I created for VHF seemed like a quick way to get on the air. HF antennas were months away after much needed terrain analysis, etc. Of course, being a VHF newbie, I did not realize that my friends had had all their fun during the previous year or two at the peak of the sunspot cycle.

Sometimes ignorance is bliss, though, and I attacked 6 meters like the obsessive-compulsive character that I am. Having no reference point, I chased DX entities, states, and grids night and day, not worrying about when the band and paths here and there were "supposed" to be open.

The VHF DXer group that hangs out on the DXers. Info website (http://www.dxers.info/) decided that I was such an ever-present nuisance that they had better invite me to their site so

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Reprinted from the 2004 Southeast VHF Society Conference Proceedings. This article appears courtesy of the ARRL.

that they could teach me a thing or two—and probably so that they could keep an eye on this new in-band noise source. That, they did. I encourage all new 6-meter enthusiasts to discover this awesome website and receive the best DX mentoring from the friendliest and most knowledgeable group you could hope to find.

The Band Dies and Then Opens with a Ping

Eventually, I did wring the 6-meter propagation dry, when months later the post-winter sporadic-*E* season settled in, bringing weeks of nothing but white noise to my ears. Jack Carlson, N3FZ, sensed that I needed a new challenge and invited me to leave the DXer website one evening and visit the Ping Jockey Central website: <http://www.pingjockey.net/cgibin/pingtalk/>.

Not knowing a ping from a bee sting, I was not really sure what to expect. However, Jack had been talking a lot about working numerous long-haul contacts every night using meteor scatter while I listened to nothing but hiss. My only previous experience with meteor scatter had been some surprise quick CW and SSB contacts during contests that appeared out of nowhere and disappeared just as quickly. The Wizened Ones told me that those signals had come to me via this meteor-scatter thing.

I hung in the shadows as a non-participant, watching the gang in action on the Ping Jockey Central website and quickly realized:

- There were people in the group I knew from my SSB/CW operating.
- They were, indeed, working each other over long distances.
- They were doing it using modest stations.
- They were having fun doing it.
- They all seemed like friendly people.
- Most important of all, I did not have a clue as to how to join them instead of sitting on 50.110 MHz waiting for a band opening that apparently was not going to occur for a few months.

What is a Meteor?

It clearly was time to do some Internet surfing and knowledge gathering. There are massive amounts of information about meteors on the Internet from a vast group of people devoted to visual observation and, in some cases, recording meteor events with cameras. I also found several sources of information about meteors written by radio enthusiasts.

I readily admit to being a non-techie type, so I seriously had to simplify all the input into something even I could understand. My notes read like this:

- Meteors are the same thing as falling or shooting stars, but please do not tell Tinkerbell and the kids at Disneyland.
- Millions of meteors occur in our atmosphere each day.
- A meteor is actually the flash of light one sees as a meteoroid—a particle or chunk of interplanetary matter, usually the size of a grain of sand that burns up as it enters Earth's atmosphere. Most meteoroids are so small that they vaporize completely and never actually reach Earth. If a piece does survive and makes it all the way to the surface of our planet, it is called a meteorite.
- Most meteors are seen when they are 40 to 75 miles above the surface of the Earth. They usually disintegrate at between 30 and 60 miles altitude. Some really fast-moving and maybe larger pieces of space matter may be visible at about 80 miles out, all the way down to as close as only about 12 miles. These bright, thrilling meteors are called fireballs.
- Air friction heats a meteoroid as it enters our atmosphere, causing a shining trail of gases and melted particles. Those gases are ionized, and that is what reflects and scatters RF signals for a brief time period. This phenomenon is referred to as *meteor scatter*.
- A very short signal burst heard via meteor scatter is called a *ping*.
- A ping can last anywhere from a few milliseconds to a few minutes, depending on a number of variables, such as the size and speed of the meteor source matter and the frequency that one is using.
- There are certain times of the day and the year when meteors are more abundant. Understanding the facts surrounding this truism will be part of the fun of learning how to make the maximum use of meteors to make contacts.
- The maximum distance for a meteor-scatter contact is around 1500 miles—much like single-hop sporadic-*E*.

What to Do With the Burning Rock

I learned that 50- and 144-MHz signals are readily reflected via meteor trails. Even HF 10-meter operators encounter the effects of meteors. Since the effect of the duration of meteor-scatter propagation is inverse to the frequency, the higher the frequency, the shorter the duration of the propagation. Going up in frequency we find that although there is not much activity by meteor-scatter users on 222 MHz, signals on that band seem to also play very well. Occasionally, some ops even make good meteor-scatter contacts on 432 MHz. While I don't know for sure, and it is not impossible to make meteor-scatter contacts above 432 MHz, because of the inverse relationship of propagation it is unlikely that contacts have ever been completed—even by the extremely dedicated meteor-scatter operators.

The vast availability of plug-and-play, high-performance 6- and 2-meter rigs makes these two bands the most popular among ping jockeys, producing a lot of SSB, CW, and digital mode meteor-scatter contacts. You can hear examples of meteor scatter almost any night (actually, the morning hours after people are out of bed are probably better) by pointing your 6-meter antenna at a population center 500 to 1000 miles away. You can try the same thing on 2 meters; just expect pings to be less frequent and of shorter duration than you would hear on 6 meters.

Well-known and revered VHF DXers have been using meteor scatter to make history on SSB and CW for many years. Most 2-meter Worked All States (WAS) awards are earned using some meteor scatter to extend out past tropo ducting and the occasional sporadic-*E* openings. Some also use earth-moon-earth (EME, also known as moonbounce) as a distance extender for propagation, but that's the subject of another article.

Most SSB and CW meteor-scatter contacts are made with one or both stations running high power and/or using large antenna arrays. Naturally, some contacts are made with more modestly equipped stations, but that is the exception far more often than the rule.

Meteor-Scatter Fun for All

I have already stated that SSB and CW meteor-scatter work is most easily accomplished by stations with high power and large antenna arrays. Does that mean the owner of a typical

(Continued on page 80)

QRP Operation in VHF Contests

A Survey of VHF QRP Contest Operators

This article presents the results of an e-mail survey of radio amateurs who entered recent VHF contests in a QRP category. Here is the kind of equipment QRP operators are using, how they operate, and why they enter the QRP category.

By Bob Witte,* KØNR

The QRP category is alive and well in most of the major VHF contests. I've been active on and off in that category over the last decade, but I really wasn't sure what the rest of the QRP operators were doing (see Photo A). I wondered what kind of equipment they had, where they operated from, and how they got there. More important, I wondered, "What is the attraction of QRP in a VHF contest?"

The QRP category in ARRL contests is called Single Operator Portable with an output power limit of 10 watts PEP. Also, a portable power source must be used and operation must be from a location that is not a permanent station. In the CQ WW VHF Contest, the QRP category is called Single-Op All-Band QRP and has the same 10 watts PEP power limit, but operation from a permanent station location and use of commercial power are allowed.

Kevin Kaufhold, W9GKA, recently completed a data analysis of the QRP category for the ARRL contests.[1] This analysis shows that the total number of operators active in the QRP category peaked at 84 in 1995 and has been relatively stable for the past five years (averaging 54 for the past five years). W9GKA's analysis is very thorough and provides a strong quantitative look at the operating category. The history of the CQ WW VHF Contest is not as well documented, but there were 20 QRP entries in the 2003 contest.

Survey

To investigate what QRP operators are doing in VHF contests, I surveyed the operators who turned in logs from five recent major VHF contests: 2002 ARRL January VHF Sweepstakes, 2002 ARRL June VHF QSO Party, 2002 ARRL September VHF QSO Party, 2003 January ARRL VHF Sweepstakes, and 2003 CQ WW VHF Contest. For the ARRL contests, I accessed the score information from the ARRL web site. For the CQ WW VHF Contest, John Lindholm, W1XX, provided me with the scoring information I needed.

I matched operator callsigns to e-mail addresses using on-line sources such as qrz.com. In some cases, I did web searches to find e-mail addresses. However, I was unable to locate e-mail addresses for everyone. The survey was sent via e-mail to the resulting list of e-mail addresses, with a second follow-up message a few weeks later to the non-respondents. There were 82 unique callsigns in the database, with 67 that I matched to e-mail addresses. I received 39 responses, or about half of the radio operators in the database.

The survey asked basic questions about what VHF contests the radio amateur has entered, how often the entry category was QRP, the radio equipment used, transportation to the operating site, and other details of their VHF QRP contesting. Most of the specific operating questions were aimed at the *most recent* QRP contest operation, so that the survey respondent could focus the responses on one event. Although this article reports numbers and percentages of responses, this is really a *qualitative* survey to provide insight into the operating habits of the VHF QRP operator. Don't overinterpret the statistical significance of the data.

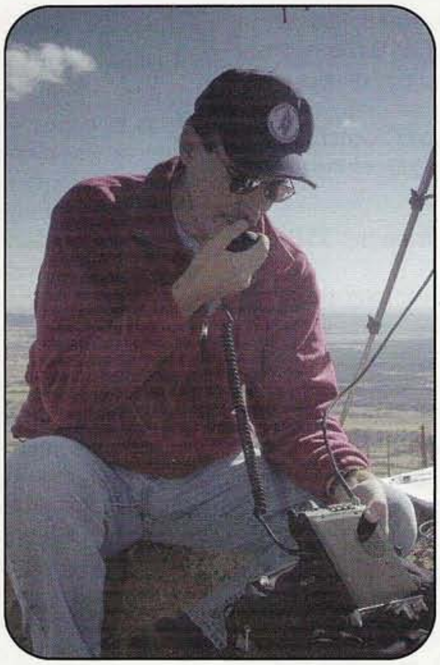


Photo A. Bob, KØNR, operating VHF QRP using a Yaesu FT-817 from Mt. Herman, DM79. (Photo courtesy WA6TTY)

In the past three years, which of these VHF contests have you entered?	
ARRL January VHF Sweepstakes	82%
ARRL June VHF QSO Party	85%
CQ WW VHF Contest	46%
ARRL September VHF QSO Party	79%

Table I. The profile of contests entered by the survey respondents.

Which Contests?

When asked which VHF contests they had entered in the last three years, the ARRL contests received the most responses (Table I). However, we need

*e-mail: <k0nr@arrl.net>

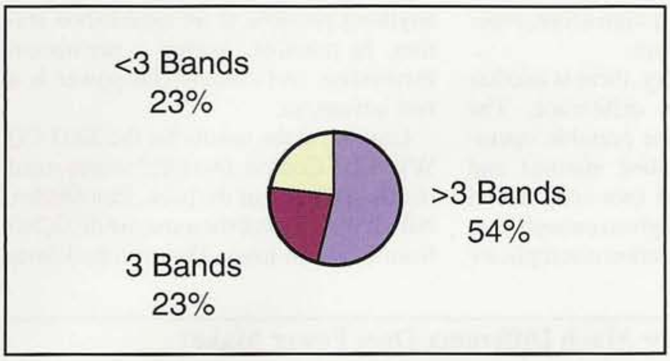


Figure 1. The stations can be grouped into three categories according to number of bands.

to be careful interpreting this result, since the survey was sent out to a higher number of ARRL contest participants than CQ WW VHF participants. However, looking at just the participants in the CQ WW VHF Contest revealed that about 70% of the CQ WW VHF contesters also participated in one or more ARRL contests. About 23% are very active VHF contesters, participating in all four contests. Only 18% reported working only one of the contests, with the remaining 59% operating two or three contests.

On average, the respondents reported that they entered VHF contests in the QRP category three times in the last three years.

Radio Equipment

I looked for groupings of station capability, and the number of bands operated seemed to be the most significant parameter (Figure 1). The type of station tended to fall into three main groups: more than three bands, three bands, and less than three bands. (Note that the CQ WW VHF Contest only uses two bands, which skews the data and will be discussed in more detail later.)

More Than Three Bands: The largest group was the 21 stations (54%) active on more then three bands. Some of these stations had capability on almost every band. The reason for this is obvious, since the ARRL contests reward operation on as many bands as possible, with higher points for QSOs and the opportunity for more grid multipliers on the higher bands. Although these stations are "portable," typically they were very well equipped and represent the work of a serious contest operator. For the ARRL contests, the high-scoring QRP entries were in this group (Photo B).

Three-Band Stations: There were nine stations active on three bands, usually 50 MHz, 144 MHz, and 432 MHz. This is consistent with commonly available HF-plus-VHF/UHF transceivers such as the FT-817, the FT100D, and the IC-706.

Less Than Three Bands: There were nine stations that had less than three bands active. Most of these respondents were reporting on their CQ WW VHF Contest entry, which naturally results in only two bands being active. Removing these entries leaves three people operating with less than three bands in the ARRL contests. Two of these people worked the contest with a handheld FM transceiver!

It is very clear that most respondents bring at least three bands to an ARRL contest, and many bring more than three bands.

The survey asked for a description by band of the radio equipment used (Table II). The most commonly mentioned transceivers were the FT-817 and the IC-706. More significant in the equipment description were 17 mentions of various transverters (Downeast Microwave, Ten-Tec, etc.). Transverters are the most common method for adding bands above 432 MHz, but they also are often used to get on 432 MHz and lower bands (usually in conjunction with an HF transceiver).

Photo B. The portable VHF station used by Pete, K9PW, in several VHF contests. (Photo courtesy K9PW)

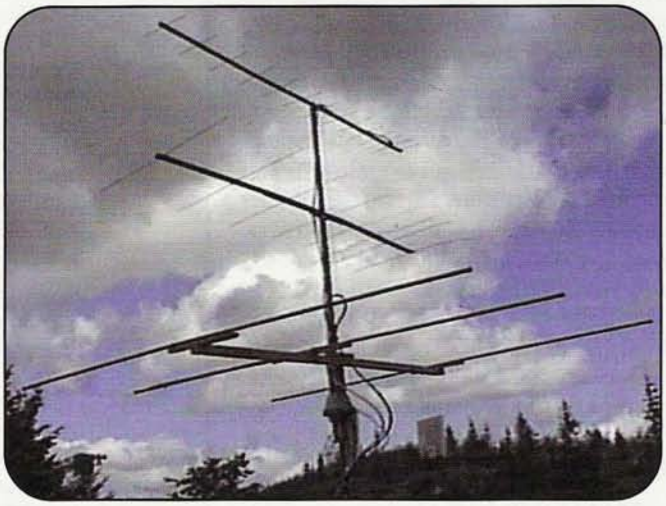


Photo C. A stack of homebrew Yagi antennas built by N3EG. (Photo courtesy N3EG)

Most operators used Yagi antennas, starting with as few as three elements on 50 MHz and more elements on the higher bands (Photo C). Most 50-MHz Yagis were 3-element, along with some 4- and 5-element beams and the occasional dipole. On 144 MHz, the minimum Yagi was a 3-element design, with most people using an antenna with 9 to 11 elements. As expected, the number of elements generally increased as the frequency increased.

Transportation and Logistics

I was particularly interested in how many people hiked or walked to their contest site compared with the use of automo-

Equipment:

Transverters (all models)	17
FT-817	6
IC-706	6
FT-736	4
FT-847	4

Table II. Equipment mentioned in the station description.

biles. Only four respondents (roughly 10%) indicated that they hiked to their operating location during their most recent VHF QRP effort. The vast majority used a vehicle to get to their operating spot. A few operated from their home location or another established station, which is allowed in the CQ VHF Contest but not in the ARRL contests.

The hiking stations were mostly in the three-band group mentioned previously. Two of the four hiker stations had an FT-817 as their main transceiver (along with a handheld radio or two). The other two hiker stations used the older single-band all-mode rigs from Yaesu and ICOM (the FT-290 series and the IC-202 series).

About 40% of the respondents indicated that they camped out overnight as part of their contest effort. During the summer months this can be pleasant. However, camping out during the January contest can be a chilling experience (Photo D)! The preferred power source was some kind of battery (56% of respondents), with AC generators (26%) and commercial AC power (13%) also being used.

CQ WW VHF Contest

The CQ WW VHF Contest uses a different format than the ARRL contests. As I examined the survey responses, the significance of these differences became clearer. The most pronounced difference is the two-band (50 MHz and 144 MHz) format of the CQ contest, which focuses the activity on the two most popular VHF bands and removes the incentive to operate on the higher bands. Someone pointed out that the CQ WW VHF Contest is the only "real VHF contest," as the ARRL contests encourage or require UHF and microwave operation to be competitive.

Good 6-meter propagation is welcome during all VHF contests but is particularly important for the CQ WW VHF Contest. The option of working all the same local stations on lots of bands to run up a high score is not available. Making lots of contacts on 6 meters offers the best chance of running up a high score, especially for QRP operators.

For the QRP category, there is another subtle but important difference. The ARRL contests require portable operation (not an established station) and portable power source (not commercial AC power). In theory, given enough time and effort, a portable station can replicate anything possible at an established station. In practice, having a permanent installation and commercial power is a real advantage.

Looking at the results for the 2003 CQ WW VHF Contest, two QRP scores stand out from the rest of the pack. Dan Milder, NØURW, achieved the top score of 33,245 from EN41 in Iowa. Dan operated from

How Much Difference Does Power Make?

It is difficult to judge how much difference power level makes during a VHF contest. Clearly, "more is better" for squeezing out those difficult contacts. Pete Walter, K9PW, holds the national QRP records for both the June and September ARRL VHF Contests. Pete has operated portable from the same location for ten different contests, sometimes with QRP levels, sometimes in the "low power" or "high power" categories.

Pete provided me with the details of his station equipment, including power output on each band. When operating in Single Operator-Portable (Class Q), Pete kept to the prescribed 10-watt PEP power level on all bands. For Single Operator Low Power (Class A), the power output was 200 watts on 50 MHz and 144 MHz; 100 watts on 222 MHz and 432 MHz; and lower power on the higher bands. When operating Single Operator High Power (Class B), Pete bumped the 50-MHz and 222-MHz power to 1 kW, and the 144-MHz power level was 700 watts. The variation in power level was more pronounced on the lower bands (50 MHz through 432 MHz) and less of a difference on the higher bands. The antennas used did not change significantly from year to year.

K9PW Contest Scores from the Same Location with Varying Power Level

Month/Year	Score	Class
Sept. 1993	222,292	High Power (B) Avg B
Sept. 1994	282,898	High Power (B) AVG Q
Sept. 1995	295,680	High Power (B)
Sept. 1996	280,370	High Power (B)
Sept. 1997	171,952	Single Op Portable (Q)
Sept. 1998	155,056	Single Op Portable (Q)
June 1999	300,040	High Power (B) Avg B
June 2000	351,918	Low Power (A) Avg A
June 2001	319,825	Low Power (A) Avg Q

The above data set does not provide us with the perfect experiment, since propagation and contest activity will vary from year to year, influencing the scores. However, we can get a good idea of how power level influences contest score by analyzing Pete's scores.

I chose to treat the June scores and the September scores as two separate groups, and not compare the two different VHF contests. Propagation in the June contest often includes some very potent 50-MHz openings that are not likely to be present in September. (K9PW's 50-MHz QSO counts confirm this theory.)

For the September contest, taking the average of the high-power scores and dividing it by the average of the Single-Op Portable scores gives us:

Average (High Power	270,310	165%
Average (Single Op Portable)	163,504	100%

Therefore, the September high-power scores, on average, ran 165% of the QRP scores.

Using a similar approach for the June VHF Contest, we have:

Average (High Power)	300,040	208%
Average (Low Power)	335,872	233%
Average (Single Op Portable)	144,384	100%

Note that the average low-power score exceeds the average high-power score. There is only one high-power score, and it happens to be lower than either of the low-power scores, probably due to other factors such as propagation conditions during the contest. Still, we see that both the high-power and low-power averages exceed 200% of the QRP (single op portable) score averages.

Summarizing, we see that Pete's worst low-power and high-power scores are higher than his best single op portable scores. A comparison of average scores shows that the low-power and high-power scores typically ran 165% to 233% of the QRP averages. Your mileage may vary.

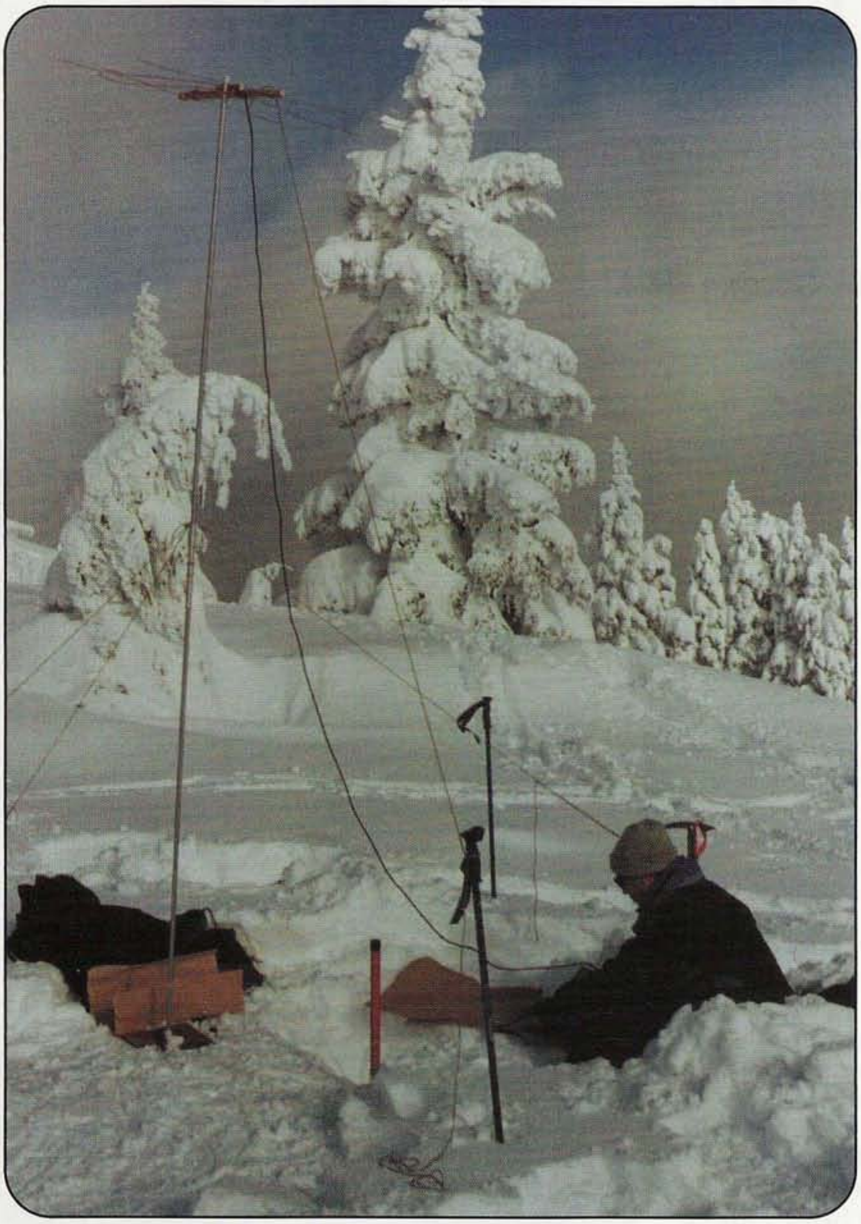


Photo D. Roger, KA7EXM, running QRP 2 meters CW from a mountain ridge in CN95 during the 1998 January VHF Sweepstakes. (Photo courtesy W7ZOI)

home using a very impressive antenna array (see <http://hometown.aol.com/seeallnoall/MyWebPage.html>). Dan used transverters mounted near the antenna feedpoints to minimize transmission-line losses. Dan worked 109 grids (70 grids on 50 MHz, 39 grids on 144 MHz) to deliver an impressive score in this "two band" contest.

John Desloge, N6MU, operated the N6NB station from DM05 in California to rack up 27,432 points and 72 grids. John had five elements on 6 meters and nine elements on 2 meters from a very good location. More information on this station is available at <http://www.n6nb.com>.

In 2003, the CQ WW VHF Contest experimented with a "QRP Hilltopper" category, defined as QRP operation limited to six hours of continuous operation. Several of the survey respondents had very enthusiastic comments about the operating category. This entry category (officially called "Single Operator QRP Portable Limited") is formally part of the 2004 contest.

But Why QRP?

The last question, and the most important one, is "Why do they do it?" The answers to that question fall into four major categories (Table III), with many

Why participate in the QRP contest category?	
The Challenge of QRP	49%
Available Equipment is QRP	26%
Operating Outdoors	23%
Can be More Competitive	23%

Table III. Reasons given for QRP VHF contest participation.

people providing multiple reasons for pursuing the QRP category. The number one reason is simply the challenge of QRP. This is consistent with the general QRP movement (not just VHF) that promotes the notion of "less is more."

The next most common response was that the available equipment happened to have QRP output power. A contester might have an FT-817 or one of the older 10-watt VHF transceivers, so they submitted their contest entry as QRP.

Almost one fourth of the respondents mentioned the fun of operating portable in an outdoor setting. Sometimes this included comments about camping, hiking, or just getting away from home for a while. For these hams, QRP means enjoying the outdoors together with ham radio.

Another consistent theme was the idea of participating in a category that was less competitive. For some people it was the possibility of setting a new section or national record. For others, the attraction is not having to compete with the 1-kW crowd.

Summary

The QRP category includes a small but active group of contesters who enjoy the challenge of low-power operating. They tend to combine radio operating with outdoor activity, some on top of their favorite mountain or other high spot.

If you'd like to find out more about VHF and QRP, there is a VHF QRP e-mail list available via Yahoo Groups at <http://groups.yahoo.com/group/vhfqrp/>.

My thanks goes to many people who helped with this article: the QRP operators who responded to my survey; Kevin Kaufhold, W9GKA, for early access to his QRP data analysis; and John Lindholm, W1XX, and Pete, K9PW, for information they provided. ■

Note

1. Kevin Kaufhold, W9GKA, "The VHF QRP Portable Category—Into the Second Decade," *National Contest Journal*, July/August 2004.

10,000 MHz on the Water

These days contacts 400 miles away on the 10,000-MHz microwave X-band are easy. Here's how.

By Gordon West,* WB6NOA

Ham activity on 10,000-MHz X-band is booming. If you live next to the ocean or if you live near a major lake, the signals are booming. X-band signals work swell out on the plains, too, and if you are fortunate enough to live on a mountainside, you may become the X-band king or queen of the hill!

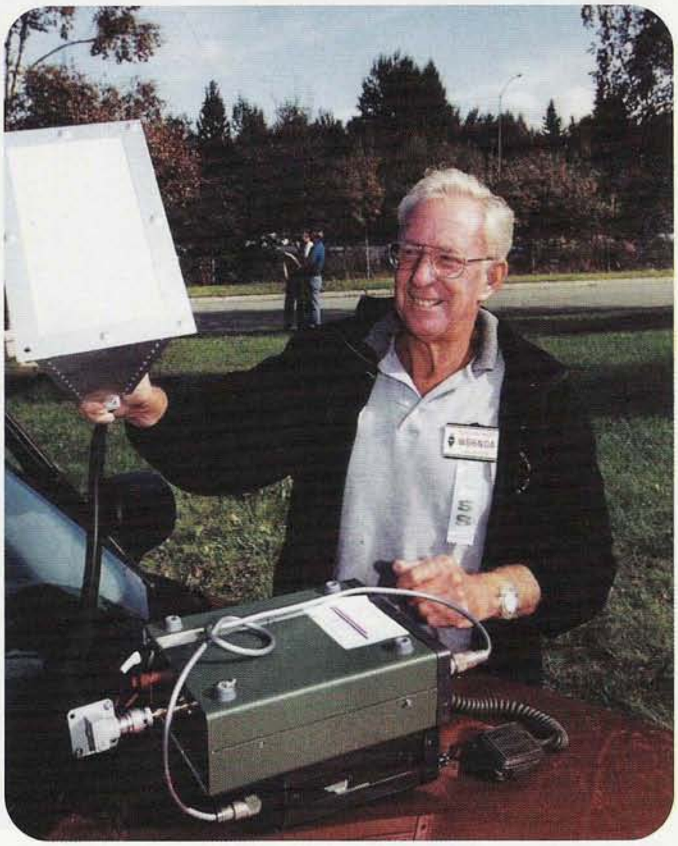
If you're surrounded by a forest, or if you live down in a valley or in an urban area surrounded by other buildings, you still have a great future on X-band because almost *everyone* goes portable. Those of us on 10,000-MHz microwave rarely work from the home QTH, and most of us always go portable to find the magic opening of the pipeline between us and a distant station up to 400 miles away. That's right: 400 miles away on the 10,000-MHz microwave X-band is easy stuff these days.

Thanks to the Modules

Technician and higher class licensees have complete access to the entire 10,000-MHz ham microwave band. The band is 500 MHz wide, which extends from 10,000 MHz to 10,500 MHz, with SSB and CW weak-signal activity located near 10,368.1 MHz.

You don't buy the equipment off your local ham radio dealer's shelf. You don't need to homebrew your station completely from scratch either. In fact, if you currently run a simple Ranger or RadioShack 10-meter SSB mobile, you already have the "operating end" of a 10,000-MHz station. Better yet, multimode, brand-new HF equipment from Kenwood, Yaesu, and ICOM makes it easier than ever to build your 10,000-MHz station, thanks to the included 432-, 144.1-, 50.1-, and 28.1-MHz SSB sensitive receivers. The little battery-operated Yaesu FT-817 is a very popular transceiver for a 10,000-MHz system, because of its *built-in* battery supply, very low-power-output characteristics needed for 10-GHz transverters, and an LCD display that is readable in the bright sunlight.

If you're new to the microwaves, a little explanation of terminology is in order here. We call the transceiver that is going to become the operating position of your microwave system the *IF*—intermediate frequency. With multi-band, multi-mode transceivers, your IF might be 432.1 MHz, or maybe 2 meters at 144.1 MHz. If you already have a favorite radio that covers one of these bands with single-sideband capability, that equipment might become your IF. However, the IF equipment you choose *must* have low-power capabilities that will never exceed 1 watt, and with some requirements, that low-power IF requirement might be just a fraction of a watt. If you accidentally leave your IF radio on high power, you will do instant damage to the next component we'll talk about, the *transverter*.



10-GHz operation in Alaska with a 26-dB horn antenna. The green box is the transverter, and the 2-meter radio under it is the "IF" radio.

A transverter is a knobless black, or sometimes silver, box that converts transmit and receive from 10,000 MHz up or down to your IF radio's transmit and receive. Let's say that you order a transverter for the 10,000-MHz band, tuning to 10,368.100 MHz. This would correspond to a 2-meter IF readout of 144.100 MHz. As you tune your 2-meter IF radio from 144.100 MHz to 144.300 MHz, the transverter would track 10,368.100 MHz to 10,368.300 MHz. All voice emission is upper sideband. While FM is indeed possible, the common weak-signal modes are sideband and CW.

The IF transceiver that you may have been using for years on 2-meter single sideband and 432-MHz sideband will continue to offer all of its performance when tied into a 10,000-

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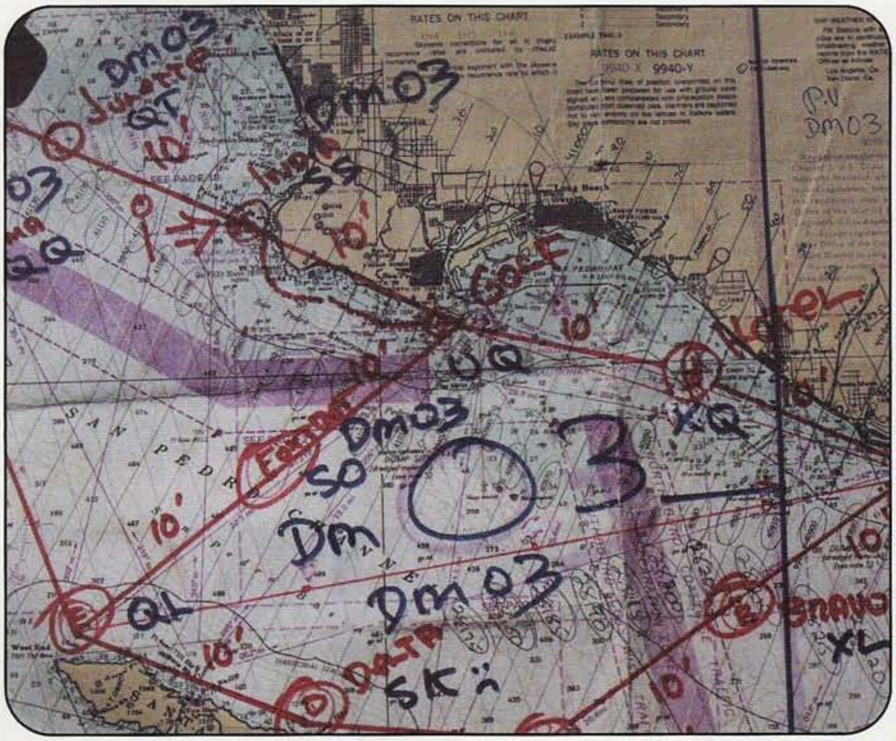


A chart of 10-GHz "every 10 miles" maritime mobile operation.

MHz transverter. Your IF shift is still there, as are the pre-amp, VFO, and memory. The only thing to watch out is to *never* go from low power to high power. That could very quickly wipe out that new transverter module. When looking at a dial reading 144.300 MHz, it will become second nature to understand that with a transverter you are now operating at 10,368.300 MHz.

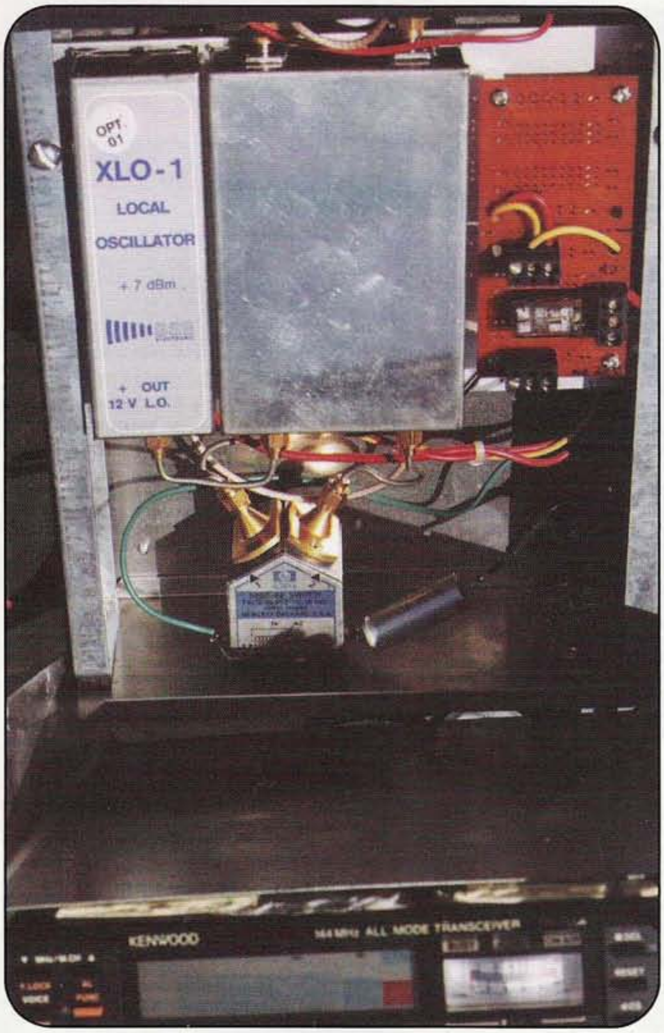
Your IF radio connects to the transverter with common coax cable. The run is usually 12 inches or less, so even RG8X is fine. You will also need to run a two-conductor T/R control line which will switch the transverter into transmit when you key your IF transceiver's microphone, cycling the transverter back to receive when you release the PTT button. You must make absolutely sure that this control line is 100% trouble-free. If you lose the T/R control to the transverter, you will be pumping transmit power into the transverter receiver, and that will be the end of your enjoyment of 10,000 MHz until you get a very expensive fix. I actually have a start-up practice of dialing an IF frequency above 148.0, where my 2-meter transceiver purposely stops transmitting, and then hitting the Push-To-Talk switch to make absolutely sure I hear the transverter relay cycling. Even though you are on SSB and not talking into the mic, keying up into the receiver section of a transverter will probably do it in.

Two well-known ham radio companies sell transverters. Some are sold as kits and some are fully assembled, tuned, and tested for a variety of IFs. If you are getting started on 10,000 MHz, the equipment is nearly plug-and-play, with a typical power output of 200 mW. I know . . . two tenths of a watt doesn't sound like much at X-band, but I have communicated over sea water beyond 400 miles to Jack, N6XQ, maritime mobile from the ocean off southern California to his portable setup in Baja, California. Most X-banders begin at 200 mW and work nearly every station they hear on X-band.

Sources of Equipment

SSB Electronics USA (<www.ssbusa.com/mkutv2.html>; telephone 570-868-5643) and Down East Microwave (<www.downeastmicrowave.com/catalog.html>; telephone 908-996-3584) are two great sources of transverter equipment for your specific type of IF radio. Call them on the phone and tell them that you are new to microwaves and that you have heard about all the excitement at 10,000 MHz from Gordon West and *CQ VHF* magazine. Ask what they would recommend to get started on the band.

Log on to the Down East Microwave web page and read the excellent pages on



The SSB Electronics 10-GHz transverter with 2.2 watts output on X-band. The SMA connections are the 10-GHz way of "plumbing" the modules and 12-volt TR relay.

The Down East Microwave 10-GHz transverter, Model #10368-144 assembled, comes with SMA relay and relay driver installed.

A dish antenna with Cassigrain feed for 10,000 MHz.

interfacing transverters. Down East has many "demi" X-band selections to get you up on 10,000 MHz with almost any SSB rig you have, from 2 meters on up! I have many ham friends who like to assemble kits. They say that Down East Microwave's equipment is easy to solder up and the instructions on kit building are the best they have ever seen. If kit building is not your thing, the company's assembled transverter #10368-144 with SMA relay and relay driver installed, 10 mw output, costs about $450 for plug and play with a 2-meter SSB rig such as the Yaesu FT-817.

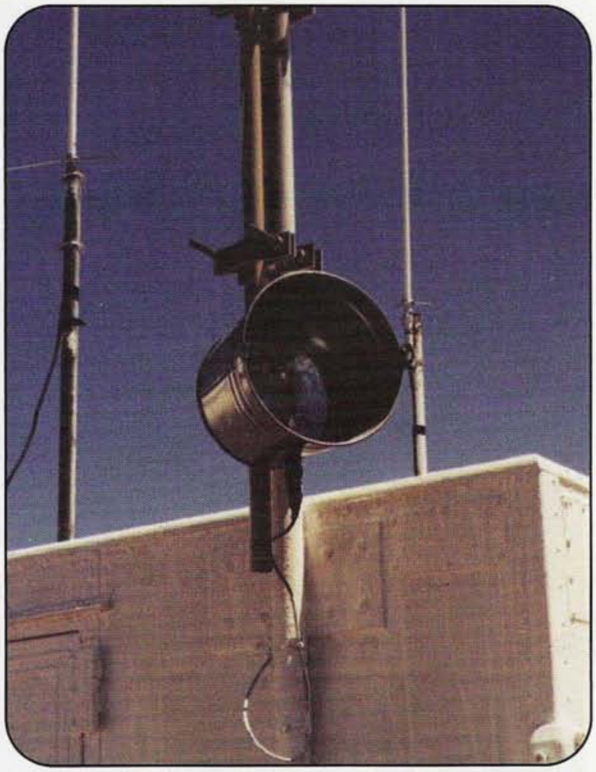
Down East welcomes phone calls to discuss the system that might be best to get you up and going on 10 GHz! Before you call, though, go to the website and read interfacing transverters section mentioned above.

Over at SSB Electronics, well-known microwave contester Gerry Rodski, K3MKZ, says to call *him* specifically to work up a 10-GHz system for matching your 2-meter and up SSB radio with his pre-assembled DB6NT MKU 10 G2 one-module system! The new "one box" module pumps out 200 mw on 10 GHz and includes a built-in IF relay plus TX on control voltage for other stages you may wish to add later. SSB Electronics offers power amps for your 10-GHz system from 1 watt output to 10 watts out! Call Gerry at his home/office (570-868-5643) and tell him what rig you have and whether you want to assemble your own boards for 10 GHz or want to buy the one module that is ready to go for a simple hookup.

Gerry contests on 10 GHz and up with the K3YTL and K3EAR groups. His 16-year-old SSB Electronics is the U.S. distributor for many leading products from Europe, including DB6NT/Kuhne, Beko, Procomm, Wimo/SHF Yagis, and a host of parabolic antennas to pump your X-band signals over hundreds of miles. Log on to his informative web page and drool over all the equipment for 10 GHz and higher!

You will also need to discuss microwave antennas, which may consist of a direct-satellite-looking dish, or maybe (as I discussed) a simple feed horn that will get you on the air for some remarkable contacts. An 18-inch direct-broadcast satellite dish with Chaparral feed might offer 31 dBi gain, and a little 6-inch long horn about 20 dB gain. You will quickly learn

WB6NOA looks on during tests of a 10-GHz phased array antenna system.



A homebrew 10-GHz "searchlight" feed. ⟶

that coax is *out* and waveguide is *in* at 10,000 MHz! Flexible waveguide left over from the early days of marine radar is a great way to "plumb" most horns or dish antenna systems. If you're going to mount your transverter directly to the back of the dish, rigid waveguide may work nicely.

Just acquiring the equipment, however, is not enough to get you on the air. Regional microwave societies have X-band hams who will go out of their way to bring you into their shack and help you plumb your system.

August and September 10-GHz Weekends

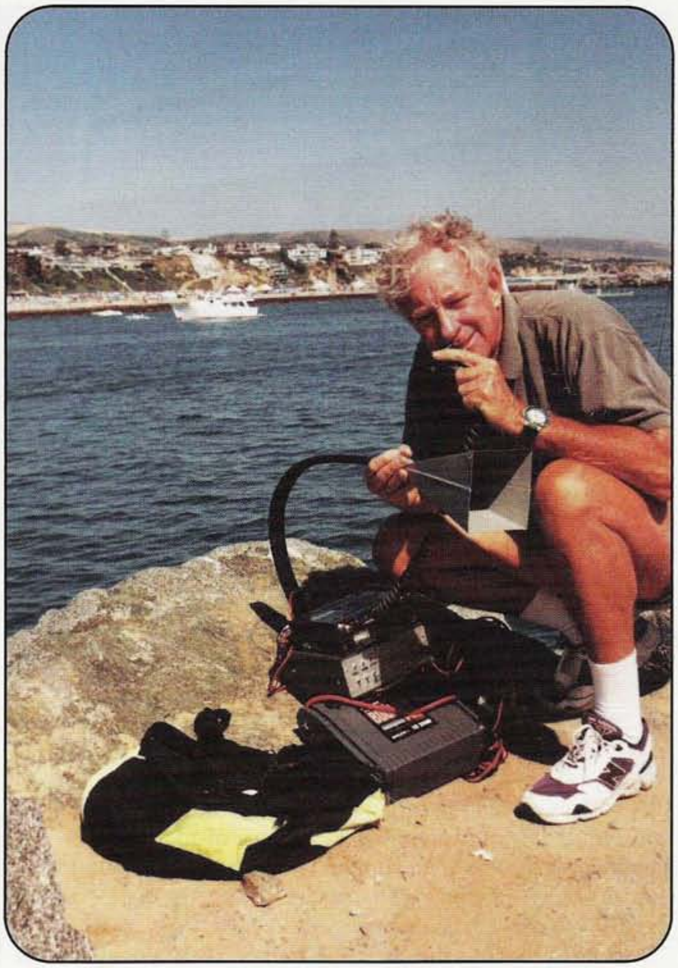
The 10 GHz and Up Contests, sponsored by the American Radio Relay League, are premier 10-GHz microwave events. They are held on two weekends each year, one in August and the other in September (for details go to: <www.arrl.org>).

If you ever wanted to buddy up with a ham group and check out your gear alongside theirs on a mountaintop or down at the beach, these are the two hot months! Contacts as far away as 400 miles are typical, and your 200 mW will probably work 80% of the same paths as other operators running 2 watts to 10 watts output with some very large dish antennas.

Microwave coordination on 2-meter FM or 440-MHz FM is strongly suggested. While a good mountaintop location during the contests in August and September will sometimes let you stumble across a microwave CQ, it's far easier to link up with a distant station on 2 meters or 440 FM, agree on a frequency, and then start the QSO "process."

Process? The more senior station will agree to transmit a steady carrier at a specific frequency for you to tune in and optimize dish or horn pointing. When the other station indicates his carrier is on the air, you first point your antenna in that general direction and then start tuning to find the microwave carrier. Once you have the carrier, you start precise aiming of your

A homebrew 10-GHz monster horn with the transverter (green box) attached directly to it.



Running 10,000 MHz microwave portable from a 12-aH gel cell. Flexible waveguide carries the signals to and from the 24-dB horn antenna.

dish or horn to peak up signals. Once you have made the adjustments, tell the other station over the 2-meter or 440-MHz band to drop carrier, and then peak up on your signal with a carrier or a long CQ. Once the other station has you locked in, he will announce "drop carrier" on the liaison frequency, and you then go ahead and complete your contact on 10 GHz. You will exchange signal reports, as well as your grid and sub-grid.

Pointing your antenna toward the distant station is not as critical as you might think. Two or three degrees either way to an 18-inch dish is fine. The experts at the other end of the circuit with their 6-foot dishes must be spot-on!

There are many more weekends of microwave activity throughout the year. If there is a 24-hour 10-GHz beacon on the air in your area, you now have a constant signal source to perfect your system. You may need to drive a few miles to get to the top of a building or a mountaintop to tune in the beacon. Beacons are worth the trip as a test of your receiver performance and for any antenna tweaking you may want to do. Both Down East Microwave and SSB Electronics also offer receiver pre-amps that will help boost RX capabilities.

A 10-GHz System

One of the most dramatic examples of a "hot" 10 GHz system was demonstrated last year at a regional ARRL convention. One operator set up his equipment early in the morning in the shadow of a nearby 20-story metal building. He told everyone to come over and listen, as the sun was ready to "light up" his dish, which was pointed directly at the sun. Just as the shadow from the building was disappearing from the dish, his receiver turned from a mild hiss to an exceptionally loud "frying eggs" crackling sound. The extraordinary sun static lasted for just 30 seconds and slightly decreased into microwave sun noise as the dish was now bathed in sunlight. Yes, you can hear the noise emitted from the sun with a good 10-GHz microwave system. What was most amazing was the big increase in sun noise caused by the edge of the building and a phenomenon known as knife-edge diffraction. We couldn't believe our ears!

Think about 10 GHz this summer. You will probably spend about a grand in addition to the IF rig with VHF/UHF SSB capabilities you may already own. While $1000 sounds like a lot for just a new single band on microwave, you will find the 10,000-MHz band fascinating in propagation and captivating when you meet some of the 10-GHz experts who absolutely delight in bringing hams up to the microwave region. It will be a rewarding experience that you will enjoy for years. I hope to hear you soon on 10 GHz! ■

QUARTERLY CALENDAR OF EVENTS

Current Contests

August: The **ARRL UHF and Above Contest** is August 7–8. The first weekend of the **ARRL 10 GHz** and above cumulative contest is August 21–22, 8 AM to 8 PM local time each day. The **Summer VHF/UHF QSO Party** is August 22, 1600–2200 UTC. For more information, go to the Colorado QRP Club URL: <http://www.cqc.org/contests/ summer04.htm>.

September: The **ARRL September VHF QSO Party** is September 11–12, 1800–0300 UTC. The **144 MHz Fall Sprint** is September 20, 7 PM to 11 PM local time. The second weekend of the **ARRL 10 GHz** is September 18–19. The **222 MHz Fall Sprint** is September 28, from 7 PM to 11 PM local time.

October: The **432 MHz Fall Sprint** is October 6, 7 PM to 11 PM local time. Regarding the **ARRL EME** contest, the VE7BQH survey results indicated a preference for October 9–10 as the first weekend. The **Microwave (902 MHz and above) Fall Sprint** is October 16, from 6 AM to 1 PM local time. Note: You are to operate no more than five hours, in one-hour blocks, during this contest time slot. The **50 MHz Fall Sprint** is October 23, 2300 UTC to October 24, 0300 UTC.

December: The VE7BQH survey results indicated a preference for the second weekend of the **ARRL EME** contest to be December 4–5.

For ARRL contest rules, see the issue of *QST* prior to the month of the contest, or go to: <http://www.arrl.org>. For Fall Sprint contest rules, see the Southeast VHF Society URL: <http://www.svhfs. org>.

Current Conventions and Conferences

August: 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, go to: <http://www.qsl.net/eme2004/>.

September: The 2004 **TAPR/ARRL Digital Communications Conference** will be held September 10–12 at the Airport Holiday Inn in Des Moines, Iowa. For more information, go to: <http://www.tapr.org/dcc/>.

October: The 2004 **AMSAT-NA Space Symposium and Annual Meeting** is to be held October 8–10 in Arlington, Virginia. This symposium will be held in conjunction with the ARISS International Meeting that is planned for October 10–13. For more information, please see the AMSAT URL pertaining to the symposium at: <http://www.amsat.org/amsat/news/ans.html#03>. The annual **Microwave Update** conference dates are October 14–16, and it is to be held in the Dallas-Ft. Worth area of Texas. For more information, please see the North Texas Microwave Society's URL: <http://www.ntms.org>.

Quarterly Calendar

Aug. 1	Moderate EME conditions
Aug. 7	Last Quarter Moon
Aug. 8	Poor EME conditions
Aug. 11	Moon Apogee
Aug. 12	*Perseids* meteor shower peak
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
Sept. 5	Poor EME conditions
Sept. 6	Last Quarter Moon
Sept. 8	Moon Apogee
Sept. 12	Good EME conditions
Sept. 14	New Moon
Sept. 19	Poor EME conditions
Sept. 21	First Quarter Moon
Sept. 22	Moon Perigee
Sept. 23	Autumnal Equinox
Sept. 26	Good EME conditions
Sept. 28	Full Moon
Oct. 3	Poor EME conditions
Oct. 5	Moon Apogee
Oct. 6	Last Quarter Moon
Oct. 8	*Draconids* meteor shower peak
Oct. 10	Good EME conditions
Oct. 14	New Moon
Oct. 17	Poor EME conditions
Oct. 18	Moon Perigee
Oct. 20	First Quarter Moon
Oct. 21	*Orionids* meteor shower peak
Oct. 24	Good EME conditions
Oct. 28	Full Moon
Oct. 31	Poor EME conditions
Nov. 2	Moon Apogee
Nov. 5	Last Quarter Moon
Nov. 7	Good EME conditions
Nov. 12	New Moon
Nov. 14	Moon Perigee; Poor EME conditions
Nov. 17	*Leonids* meteor shower peak
Nov. 19	First Quarter Moon
Nov. 21	Good EME conditions
Nov. 26	Full Moon
Nov. 28	Very Poor EME conditions
Nov. 30	Moon Apogee

—EME conditions courtesy W5LUU.

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:

Please submit camera-ready or electronic format papers for the 2004 **AMSAT Forum** by August 1 to: Daniel Schultz, N8FGV, 14612 Dowling Drive, Burtonsville, MD 20866, or by e-mail to: <n8fgv@amsat.org>. Papers for the 2004 **TAPR/ARRL Digital Communications Conference** are due by August 10 and go to: Maty Weinberg, ARRL, 225 Main St., Newington, CT 06111, or via e-mail to: <maty@arrl.org>. Submit papers for the 2004 **Microwave Update** by August 16 to: Kent Britain, WA5VJB, at <wa5vjb@cq-vhf.com>.

Meteor Showers

August: Beginning around July 17 and lasting until approximately August 14, you will see activity tied to the ***Perseids*** meteor shower. Its peak is predicted to be either August 11 or 12. For more information on this shower, see the NW7US's "VHF Propagation" column in this issue.

October: The ***Draconids*** is predicted to peak somewhere around 1000 UTC on October 8. The ***Orionids*** is predicted to peak on either October 21 or 22.

November: While another peak in activity for the ***Leonids*** is another year away, it is still important to pay attention to this shower, as it may produce a ZHR (zenith hourly rate) in excess of 100 at its peak. It is predicted to peak at around 0825 UTC on November 18.

For more information on the above meteor shower predictions visit the International Meteor Organization's URL: <http://www.imo.net>. ■

NTIA BPL Study Summary

In April 2004, the National Telecommunications and Information Administration released Study 04-413 on Broadband over Power Lines. Here K4NG provides a summary of the NTIA's findings.

By Anthony Good,* K3NG

On April 27, 2004 the National Telecommunications and Information Administration (NTIA) released a study on BPL (Broadband over Power Lines), Study 04-413. The NTIA is a government agency and its website describes it as:

> ...an agency of the U.S. Department of Commerce, is the Executive Branch's principal voice on domestic and international telecommunications and information technology issues. NTIA works to spur innovation, encourage competition, help create jobs and provide consumers with more choices and better quality telecommunications products and services at lower prices.[1]

The NTIA often works in conjunction with the FCC on matters relating to the radio spectrum, especially allocations for government and military entities. The NTIA is often on the cutting edge and was instrumental in the development of spectrum auctions.[2] For example, in 2003 the FCC was ready to grant a new band of frequencies to amateur radio operators, the 60-meter band, but the NTIA stepped in at the last moment and restructured the allocation to protect primary government users in the band.[3]

The intended impartiality of the NTIA can be noted in several places in the study, as evidenced by the following statement:

> [The] NTIA has oriented its study to find a solution that accommodates BPL systems while appropriately managing the risk of interference to radio systems.[4]

Study Introduction

The study is broken into Phase One and Phase Two. Report 04-413 is Phase One. Phase Two will be released at a future date and will address skywave (ionospheric) propagation of signals and issues concerning aggregation of signals from mature deployments of BPL.[5] On June 4, 2004 the NTIA filed comments with the FCC in response to FCC ET Docket 04-37 in which it included in a technical appendix the most significant issues considered in the comprehensive Phase Two study.[6]

Objectives and Scope of the Study

The study looked at BPL emissions from HF BPL from 1.7 MHz to 80 MHz,[7] the frequencies between the upper end of the AM broadcast band to the lower end of the FM broadcast band. This is where most BPL systems reside. Field measurements were taken at several BPL test sites.[8]

The study did not take into account regulatory frameworks and the suitability of FCC Part 15,[9] although it will be shown later the study does make some judgments. The potential of intermodulation, or the mixing of signals to produce new ones is not discussed. The possibility of signals outside the line interfering with BPL is also not addressed.[10]

Regulations

The study summarizes the regulations in several foreign countries that have already experienced BPL. Figure 1 is in-

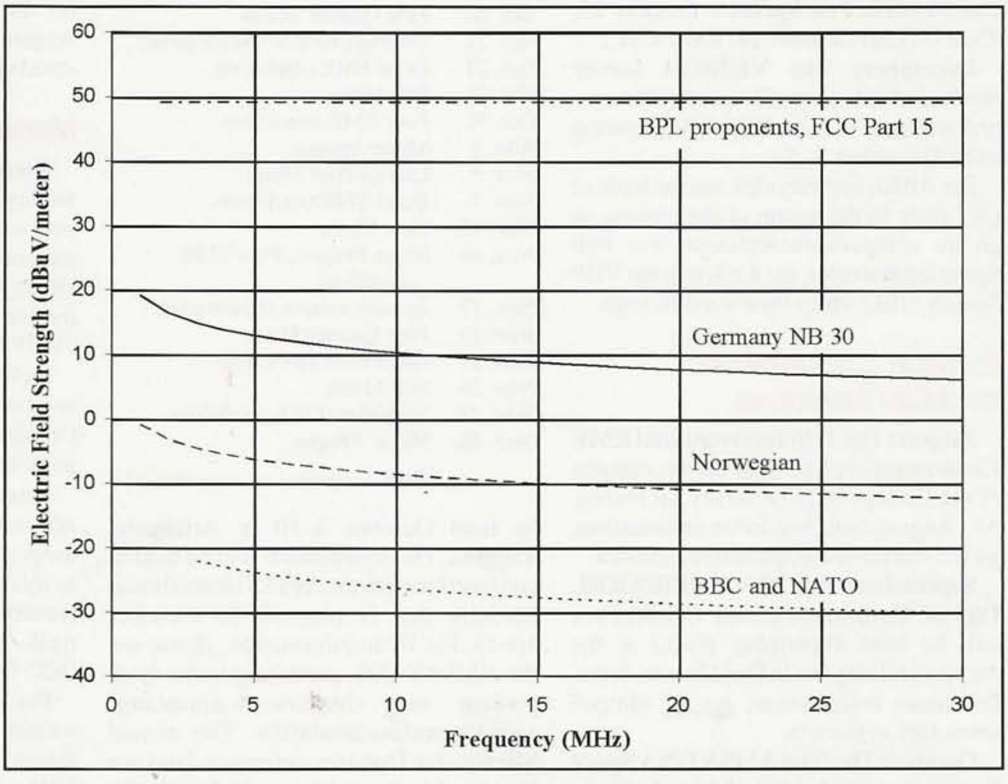


Figure 1. Comparison of proposals for regulating BPL emissions.[59]

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cluded to illustrate various limits in place.

FCC Part 15 limits currently are in place in the United States. Austria terminated tests due to unresolvable interference problems. Germany has NB30 limits, while Finland is considering NB30. Japan has limited further tests.[11]

Several BPL proponents had sought to lessen Part 15 emissions limits. However, the NTIA disagreed. The NTIA notes that with respect to measurements of BPL, Part 15 may be lacking:

Current Part 15 measurement techniques may significantly underestimate the peak field strength generated by BPL systems as a result of using a loop antenna in the near field; performing measurements with an antenna situated near ground level.[12]

Protection of Critical Allocations is Needed

The NTIA goes into excruciating detail on all the licensed services within the bands potentially affected by BPL. The summary below, though, sums up the critical nature of these allocations:

Frequencies between 1.7 MHz and 80 MHz are allocated to a total of 13 radio services, with the Federal Government using all but two, in varying degrees, to satisfy various mandated mission requirements. Federal agencies currently have over 59,000 frequency assignments in this frequency range. Allocations for the fixed and mobile services accommodate communications for homeland security, distress and safety, and other critical functions.[13]

The NTIA goes on to make a suggestion that would be potentially damaging to BPL:

Both NTIA and FCC have long recognized that certain frequencies or bands in the radio spectrum require special protection from interference because of the critical or sensitive functions they support, including distress and safety, radio astronomy, radionavigation, and others. NTIA identified forty-one (41) such frequency bands between 1.7 MHz and 80 MHz, totaling approximately 4.2 MHz (5.4% of the total spectrum under study), and proposes that they receive special protection from interference by licensed and/or unlicensed transmitters.[14]

On the surface, the amount of spectrum doesn't seem important, and it is not. The location of these protected bands, though, is of utmost importance. The suggested protected bands (in kHz, unless otherwise noted) are:[15] 2173.5–2190.5, 2495–2505, 2850–3025, 3023–3026, 3400–3500, 4125–4128, 4177.25–4177.75, 4207.25–4207.75, 4650–4700, 4995–5005, 5450–5480, 5480–5680, 5680–5683, 6215–6218, 6267.75–6268.25, 6311.75–6312.25, 6525–6685, 8291–8294, 8361–8367, 8376.25–8386.75, 8414.25–8414.75, 8815–8965, 9995–10005, 10005–10100, 11275–11400, 12290–12293, 12519.75–12520.25, 12576.75–12577.25, 13260–13360, 13360–13410, 14990–15010, 16420–16423, 16694.75–16695.25, 16804.25–16804.75, 17900–17970, 19990–20010, 21924–22000, 25500–25670, 37.5–38.25 MHz, 73.0–74.6 MHz, 74.8–75.2 MHz.

Most BPL signals are several megahertz wide. Protecting these bands would leave little to no room for BPL to squeeze in. Overlay amateur radio, shortwave, low-band VHF public-safety and business frequencies, and citizen-band allocations and it's a very crowded spectrum.

The NTIA study does not elaborate on the level of protection that would be sufficient. Any protection of these bands would likely be burdensome to BPL deployments. Zero emissions in these bands would spell the end of BPL, at least in the HF bands.

Power Lines Do Act Like Antennas

Contrary to the claims of several BPL proponents, power lines do act like antennas. They do not act strictly act like point sources as some have claimed. The NTIA performed computer modeling of power lines carrying BPL and took measurements at several BPL test sites.[16] There are several key points:

Any impedance discontinuity in a transmission line, which may arise from a BPL coupling device, a transformer, branch or a change in the direction of the line, may produce radiation directly or by reflections of signals forming standing waves that are radiated from the conductors.[17]

Even if the RF energy is injected into one of two or more conductors, the remaining wires generally act as parasitic radiators and, therefore, the lines can act as an array of antenna elements at certain frequencies. Radiation may come from one or more point radiators corresponding to the coupling devices as well as one or more power lines.[18]

Skywave Propagation of BPL is a Potential Concern

Skywave propagation was not in the scope of this study, but the NTIA notes:

...propagation mechanisms of concern for BPL emissions toward or below the power line horizon will be by ground waves. For emissions in directions above the power line horizon, the propagation may be either by space and ground waves for shorter distances or by sky waves for larger distances.[19]

In a dense deployment of BPL systems, there may be aggregation of co-frequency BPL emissions toward the ionosphere. Emissions in directions above the power lines may aggregate via sky wave or via ground wave and space wave, and emissions toward or below the power lines generally may aggregate via ground wave. Preliminary modeling of power lines (Appendix E) suggests that there is relatively strong radiation in directions above the power-line horizon (i.e., higher than radiation toward directions below the power lines), and so, aggregation of BPL signals at locations above power lines may be more significant than at lower heights where BPL signal propagation is less efficient.[20]

Therefore, the NTIA notes that in its models there is strong radiation at angles that could enable skywave propagation.

Field Measurements

The NTIA conducted field measurements at three active BPL test sites which showed that radiation doesn't drop off as quickly as claimed. The NTIA writes:

NTIA performed measurements at three different BPL deployment sites in order to characterize the BPL fundamental emissions. Measurements indicate that the BPL electric field does not generally decay monotonically with distance from the BPL source as the measurement antenna was positioned near to and moving along the length of the power line. As the measurement antenna was moved away from the BPL energized power line, the radiated power decreased with increasing distance, but the decrease was not always monotonic and a number of local peaks were observed at some locations. In some cases, the BPL signal was observed to decay with distance away from the power line at a rate slower than would be predicted by space wave loss from a point source.[21]

These observations support the claim that BPL is not a point-source type of radiator. It can be deduced from this that current Part 15 rules don't adequately address BPL, as Part 15 for the most part was created with part sources in mind.

The NTIA observed the importance of the antenna measurement height:

NTIA's measurements show that the radiated power from the BPL energized power lines was consistently higher when the measurement antenna was placed at a greater height (e.g., 10 meter vs. 2 meter). These results indicate a need to refine the Part 15 compliance measurement guidelines to ensure that the peak field strength of any unintentional BPL emissions is measured.[22]

Some BPL vendors and carriers and perhaps even HF band licensees may be taking measurements that are lower than the peak field strength which is ultimately the concern of Part 15.

Models that Do Not Account for the Neutral Wire

The NTIA found that a common practice in modeling power lines without the neutral wire in computer models might produce inaccuracies:

NTIA's modeling showed that inclusion of a neutral line with three-phase medium voltage wiring tended to increase the overall radiation. Thus, models omitting the neutral wire tend to predict lower field strength. The implications of these modeling results are that compliance measurements taken only around a BPL device and at heights below the power lines may significantly underestimate the peak electric field.[23]

Calculations of Interference Potential

The NTIA calculated interference potential to several types of stations:

Calculations of close-to-the-line interference potential for vehicular land-mobile receivers due to a BPL transmitter operating at FCC Part 15 limits show that there would be significant increases in the noise floor due to interference … there would be at least a ten-fold increase in total receiver noise power on the street adjacent to the BPL device and power lines.[24]

NEC interference calculations for an assumed fixed service or mobile base station receiving antenna found substantial (I+N)/N values at greater distances from the line than those found for land mobile receivers. This was especially true at 15 and 25 MHz… As can be seen, at 15 MHz the potential for a 3dB (I+N)/N level exists beyond 500 meters away, and at 25 MHz some locations more than 700 meters away could see this level of interference. Additionally, locations past 300 and 400 meters from the BPL-energized line on 15 MHz and 25 MHz, respectively, could experience (I+N)/N levels in excess of 10 dB.[25]

…an aircraft traveling above or near the modeled BPL deployment area could see substantial S/N degradation. These calculations include parts of the far-field radiation pattern (off the ends of the power lines, or on-axis) that exhibited potentially elevated power gain levels. Further study is needed of representative power line gain levels in skyward directions.[26]

Flawed Measurements

The NTIA had the privilege of reviewing several "proprietary" field measurement reports, presumably contracted by BPL vendors. These reports have never seen the light of day, as they are unavailable for public scrutiny.

NTIA has reviewed three proprietary reports of BPL measurements that were performed by contractors hired by BPL proponents to test compliance of trial BPL systems with Part 15 field strength limits. In all cases involving outdoor overhead power lines, measurements were performed using a one-meter high antenna on radials emanating from a power line pole to which a BPL access device was mounted. While consistent with §15.31(f)(5), this ad hoc measurement approach does not demonstrate compliance with the field strength limits because as shown by NTIA's measurements and models, peak field strength levels are not centered at the BPL device and do not occur at a height of one-meter above the ground. Other sources of potential BPL measurement inaccuracies include: the measurement distance and extrapolation factor; frequency-selective radiation effects; estimation of electric fields using a loop antenna; and selection of representative BPL installations for testing.[27]

This is one of the most interesting paragraphs in the study. Undoubtedly, the FCC made some crucial decisions about the viability of BPL based on these studies. The studies have obvious flaws, and if it were not for the NTIA, these errors probably would never have been made public. Did the FCC staff actually catch these problems? In addition, the "selection of representative BPL installations for testing" statement raises the possibility of rigged tests.

Aggregation of Signals

The NTIA recognized that as the systems ramp up, aggregation of emissions will be a concern and need to be accounted for in measurements:

Part 15 specifies that the aggregate emissions from a composite system must satisfy the field strength limits applicable for a single device. As BPL networks are substantially deployed in a community, the aggregated BPL emissions for the overall network are expected to increase above the levels generated by a single BPL device. This aggregation has already been observed by NTIA at one of the trial BPL systems where multiple simultaneous transmissions occur.[28]

Aggregation of emissions from BPL systems via ionospheric propagation and the associated BPL deployment models require further study. This is of concern in the long-term insofar as skyward emissions from many hundreds of BPL systems deployed over a large region might produce significant composite interfering signal levels at a very distant receiver.[29]

Part 15 Emissions Limits and Measurement Requirements

Contrary to the requests of many BPL vendors, the NTIA feels that Part 15 emissions limits should not be relaxed:

The Phase 1 analysis assumed that for outdoor overhead power lines, compliance measurements were performed using a one-meter high measurement antenna. This ad hoc measurement approach does not demonstrate compliance with the field strength limits.[30]

…potential sources of measurement underestimation of BPL field strength include: the measurement distance and extrapolation factor; frequency-selective radiation effects; estimation of electric fields using a loop antenna; and selection of representative BPL installations for testing.[31]

In light of the above considerations and the high perceived interference risks, NTIA recommends that field strength limits for BPL systems not be relaxed and that measurement procedures be refined and clarified as described in this section to better ensure compliance. These risk reductions should be effected as quickly as possible in order to better protect radio communications.[32]

Recommendations for Mitigation of Interference

The study recommends several interference mitigation techniques:

- Routine use of the minimum output power needed from each BPL device;
- Avoidance of locally used radio frequencies;
- Differential-mode signal injection oriented to minimize radiation;
- Use of filters and terminations to extinguish BPL signals on power lines where they are not needed;
- Use of one active device per frequency and area;
- Judicious choice of BPL signal frequencies to avoid efficient radiation;

• Maintenance of single points of contact and BPL network control;

• Use of web-based access to radio license information to avoid locally used radio frequencies.[33]

"Use of minimum power" should already be a practice by vendors desiring to avoid interference complaints. In reality, it's likely that many systems will use power levels at Part 15 emissions levels to enable increased repeater spacings and improved system economics.

"Avoidance of locally used radio frequencies" could be a rather arduous task, as it's difficult to determine what frequencies are in use in a given area by fixed stations. Adding mobile and aeronautical stations to the mix, frequency usage is ever changing.

"Use of one active device per frequency and area" is a bit ambiguous, as all BPL injection equipment uses wide bands of frequencies. Injection point and repeater spacing are driven by system design and customer density. Injection points "talk" asynchronously based on customer traffic patterns. It's conceivable that a station experiencing interference in a given area may be able to receive signals from multiple injection points.

NTIA Phase Two Study

The NTIA will not release its Phase Two study until later this year, but in its FCC Notice of Proposed Rulemaking comments filed on June 4, 2004, it has given the public a preview of the Phase Two findings.[34]

The Benefits of BPL

Surprisingly, the NTIA starts by praising BPL as reducing interference, namely power transmission noise, which has plagued amateurs for years, noting:

> ...existing power line noise and reliability problems that were cast as BPL detriments in the NOI phase of this proceeding likely will be remedied as a result of widespread Access BPL deployment...to the benefit of radio proponents, strong power line noise emissions likely will be reduced in the process of deploying BPL systems.[35]

Finding more silver linings in clouds, the NTIA extols the benefits of BPL to power companies, writing:

> With widespread deployment of Access BPL ... it will be possible to speed detection and diagnosis of electrical system failures and there likely will be increased demand and revenue subsidies for qualified electric system repair and maintenance personnel and equipment.[36]

Limited Frequency Bands and Geographic Areas

In sync with its recommendations in the Phase One study, the NTIA indicates that certain protections from interference are needed:

> ...additional emission restrictions are needed in certain frequency bands and geographic areas in order to protect radiocommunications consistent with current rules and practices. These restrictions would have the following forms: geographic "coordination areas," wherein BPL deployments at any frequency in those areas must be pre-coordinated by BPL operators; excluded bands, in which certain frequencies are not to be used by BPL in any geographic area; and small geographic "exclusion zones," wherein BPL emissions are forbidden at specified frequencies in accordance with protection requirements and electromagnetic compatibility studies.[37]

The NTIA does not go into detail on what it exactly recommends, but it indicates that a "minimal number of restrictions should be codified" and that it is continuing to study excluded bands and exclusion zones.[38]

Coordination Procedures and Other Recommendations

The NTIA supports the following interference mitigation procedures and techniques:

• Dynamic or commanded power reduction[39]

• A publicly accessible database of BPL systems with modulation and other technical details[40]

• Prior frequency coordination in known station locations or service areas[41]

• Frequency agility, suggesting 3 kHz of resolution at frequencies below 30 MHz[42]

• Not use the same frequency bands as mobile receivers[43]

• Notify the FCC 30 days in advance of a deployment to consider coordination data[44]

• Report total numbers of deployed devices on a quarterly basis[45]

• Each BPL operator should be required to provide a single, telephone point of contact for each deployment area and an email address for frequency coordination[46]

Measurement Guidelines

Regarding measurement guidelines, the NTIA wrote:

> ...refinements, clarifications and adaptations of Part 15 compliance measurement provisions are needed for Access BPL systems to reduce potential measurement inaccuracies and improve the validity of results for all deployed BPL systems.[47]

Its findings and recommendations include:

• Measurements should be taken at a standard 10 meter distance and using a modified extrapolation factor as: "BPL field strength with increasing distance from the BPL device and power lines is not well approximated by the existing Part 15 distance extrapolation factor."[48]

• "Specific field strength limits should be specified for the ten meter measurement distance at all permissible BPL operating frequencies."[49]

• "BPL compliance measurements should address both the BPL device and the power lines to which it is connected.... NTIA's BPL measurements discovered that the peak BPL field strength is not necessarily located at the BPL device."[50]

• "[R]elatively high emissions can occur at various distances from the BPL device along the power line, in some cases at regular distance intervals."[51]

• Recommends measuring emissions at a height of one meter and implementing an adjustment factor of 5 dB, and claims that 80% of all local field strength peaks will be within 5 dB of the one meter measurement. However, some peaks could be as high as 20 dB over the one meter measurements, but opposes using the 20 dB factor to avoid "undue constraint on BPL systems without significant impact on interference risks."[52]

• All BPL operating frequencies should be considered in measurements with maximum device power and duty cycle activated.[53]

• Measurements below 30 MHz should be made using a magnetic loop antenna with a magnetic-to-electric conversion factor.[54]

• Representative installations should be selected carefully to capture peak emissions.[55]

• Measurement bandwidth for BPL should be codified rather than use the usual guidelines in Part 15, specifically a 9 kHz bandwidth at frequencies below 30 MHz and 120 kHz bandwidth at frequencies above 30 MHz.[56]

• Spectral characteristics of BPL emissions should be included in compliance measurement reports.[57]

The NTIA writes that BPL may require its own rule Part (i.e., be separated from Part 15) or be covered by a new sub-part within Part 15, citing that incorporating needed changes for BPL may make Part 15 unclear and confusing.

Future Regulatory Action

The NTIA feels that the rules proposed in the BPL NPRM and those recommend ed by the NTIA "constitute an appropriate basis for rulemaking at this time," noting, "[it] is time to adopt rules that will enable development and implementation of [BPL] that are compatible with radio communications." The BPL operating frequency range should be limited to 1.75 MHz to 80 MHz minus excluded bands and areas. The NTIA intends to monitor BPL development in order to predict future ionospheric interference. However, this potential problem is deemed as being in the long term. Future regulatory action may be needed after additional studies are completed and more experience with BPL is acquired.[58]

Conclusion

Both the NTIA Phase One BPL Study and the NPRM Comment Filing, which contains a preview of its Phase Two findings, seem to have double personalities. The political side is one of optimism bordering on BPL advocacy similar to what we have seen from FCC Commissioners. The technical side, barring the aggregation of ionospheric signals modeling, for the most part confirms most, if not all, of the claims made by the amateur community and communications professionals.

The technological and regulatory fate of BPL could be determined by how closely the FCC follows the NTIA's recommendations. For example, if the requirements for critical frequency bands would be applied to the entire United States (no emissions in any of these bands), it is likely that most current BPL systems could not operate within the non-protected spectrum. Also, if the NTIA recommendation of no emissions in bands that support mobile operations is adopted and applied across all services, even more spectrum, including amateur radio bands, would be unavailable for BPL use. Unfortunately, the NTIA has left out several details or left ambiguity in place, citing future research. The NTIA mentions opposition to any delay of FCC rules to accommodate this research.

Many BPL vendors appear to have been relying on erroneous measurement techniques or measurement guidelines within Part 15 that don't sufficiently address the characteristics of BPL. Thus, some field tests that were considered to have demonstrated Part 15 compliance may be wrong. Depending on the magnitude of the errors, vendors may have to go back to the drawing board to adjust power levels and repeater spacings to come within Part 15 limits. The discovery by the NTIA of flawed field measurement studies that have been deemed "proprietary" by the FCC is disturbing and should cause the FCC to reevaluate past statements. The studies should be made public, or at the very least the magnitude of the errors in the studies should be made public. Undoubtedly, generic measurements from these reports could be released to the public without compromising proprietary vendor information.

Implementation of many of the NTIA's recommendations may raise the bar to a point where existing BPL systems cannot operate, or carriers will deem BPL to be too troublesome for deployment. The amount of material the NTIA has produced is staggering, and the information within the FCC NOI and NPRM pales in comparison. One has to question the extent to which the FCC has actually measured and modeled BPL and whether its understanding of the technology is in-depth enough to be making qualified decisions.

Thankfully for those in the amateur radio community, the NTIA was able to produce such a comprehensive technically focused report and corroborate the claims of numerous BPL interference opponents. Whether the FCC adopts the recommendations and protects licensed communications interests and the general public remains to be seen.

Notes

1. http://www.ntia.doc.gov/ntiahome/ntiafacts. htm
2. http://www.ntia.doc.gov/opadhome/history. html
3. http://www.arrl.org/news/stories/2003/06/ 03/1/?nc=1
4. NTIA Study 04-413, Section 3, p. 3-10
5. NTIA Study 04-413 Section 1.04, p. 1-3
6 "NTIA Files Comments with FCC on Broadband over Power Line Systems" Press Release, June 4, 2004, http://www.ntia.doc.gov/ntiahome /press/2004/bpl_06042004.htm
7. NTIA Study 04-413 Section 1.04, p. 1-2
8. NTIA Study 04-413 Section 5.3.1, p. 5-3
9. NTIA Study 04-413 Section 1.04, p. 1-2
10. NTIA Study 04-413 Section 1.04, p. 1-2
11. NTIA Study 04-413, Section 3, p. 3-3
12. NTIA Study 04-413, Section 3, p. 3-10
13. NTIA Study 04-413, Section 4, p. 4-11
14. NTIA Study 04-413, Section 4, p. 4-11
15. NTIA Study 04-413, Section 4, pp. 4-8 through 4-10
16. NTIA Study 04-413 Section 5.3.1, p. 5-3
17. NTIA Study 04-413 Section 5.2.1, p. 5-1
18. NTIA Study 04-413 Section 5.2.1, p. 5-1
19. NTIA Study 04-413 Section 5.2.2, p. 5-3
20. NTIA Study 04-413 Section 5.2.2, p. 5-3
21. NTIA Study 04-413 Section 5.5, p. 5-16
22. NTIA Study 04-413 Section 5.5, p. 5-16
23. NTIA Study 04-413 Section 5.5, p. 5-16
24. NTIA Study 04-413 Section 6.1, p. 6-11
25. NTIA Study 04-413 Section 6.2, p. 6-15
26. NTIA Study 04-413 Section 6.4, p. 6-20
27. NTIA Study 04-413 Section 7.1, p. 7-1
28. NTIA Study 04-413 Section 7.3, p. 7-2
29. NTIA Study 04-413 Section 9.4, p. 9-4
30. NTIA Study 04-413 Section 7.12, p. 7-8
31. NTIA Study 04-413 Section 7.12, p. 7-8
32. NTIA Study 04-413 Section 7.12, p. 7-8
33. NTIA Study 04-413 Section 8.11, P. 8-5
34. "NTIA Files Comments with FCC on Broadband over Power Line Systems" Press Release, June 4, 2004, http://www.ntia.doc.gov/ntiahome /press/2004/bpl_06042004.htm
35. Comments of the National Telecommunications and Information Administration on ET Docket 03-104 and ET Docket 04-37, p. 4
36. Comments NTIA p. 6
37. Comments NTIA p. 7
38. Comments NTIA p. 8
39. Comments NTIA p. 8
40. Comments NTIA p. 9
41. Comments NTIA p. 9
42. Comments NTIA p. 10
43. Comments NTIA p. 10
44. Comments NTIA p. 10
45. Comments NTIA p. 12
46. Comments NTIA pp. 12, 13
47. Comments NTIA p. 15
48. Comments NTIA p. 16
49. Comments NTIA p. 17
50. Comments NTIA p. 18
51. Comments NTIA p. 18
52. Comments NTIA pp. 20, 21
53. Comments NTIA p. 21
54. Comments NTIA p. 22
55. Comments NTIA pp. 22, 23
56. Comments NTIA p. 23
57. Comments NTIA p. 23
58. Comments NTIA p. 26
59. NTIA Study 04-413, Section 3, p. 3-5, Figure 3-1

Spectacular Sporadic-E Opening!

Here is a brief summary of some of the reports received after an early July unexpected, *spectacular* sporadic-*E* opening.

By Joe Lynch,* N6CL

Normally, because of the quarterly nature of this magazine, we do not cover current events per se. However, the timing of this issue coincided with the spectacular sporadic-*E* opening that occurred on July 6–7. This five-plus hour 2-meter opening, which occurred between approximately 2100 and 0200 UTC, also included approximately 20 minutes of propagation on 1.25 meters.

To date I have received more than 50 reports related to this opening, way too many to include in this space. This number is far in excess of any other single event in my more than a dozen years of reporting weak-signal activities in my "VHF Plus" column in *CQ* magazine. What follows is a very brief summary of these reports, with more details of the opening to appear in my September column in *CQ*.

Those who sent me reports of their activities include the following 53 hams in 48 grids: AA3ID, FM25; AF4HX, EM85; AF4OD, EM72; AK3E, FM19; KØAWU, EN37; K1TEO, FN31; K1TR, FN42; K2ERG, FN13; K2SMN, FN20; K3KEL, FN11; K4RTS, FM08; K5MQ, EM31; K5PJR, EM26; K5SW, EM25; K8MD, EN82; KE4YYD, EL79; KMØT, EN13; KT4JA, EL97; KY1K, FN54; NØGZ, EN31; N2SLN, FN22; NØLL, EM09; NØRQ, EM13; NØUK, EN34; N1BUG, FN55; N1RR, FN41; N4HN, EM95; N4ION, EM62; N4JQQ, EM55; N5TIF, EM12; N9LR, EN50; N9QQB, EN53; NW5E, EL98; VE3AX, FN02; N3LL (op. W3KWH) EN90; VE3TMG, EN82; WØFY, EM48; W1GHZ, FN42; W1LP, FN41; W2MPK, FN23; W4HP, EM75; W4VC, EM81; W5SNX, EM73; W8PAT, EN81; W8WN, EM77; W9FS, EN61; WA1ECF, FN41; WA3LTB, EN92; WA5IYX, EL09; WA5JCI, EM21; WA8RJF, EN91; WB2SIH, FN31; WB4WXE, EM74; WD4KPD, FM15; and WZ1V, FN31.

Additional reports came from WA5IYX, EL09, who advised me that he was too far south of the opening, and NØIT, EM48, who told me that in St. Louis he was one of 500,000 households with no electricity for two days. Also, noted for his absence was N1BUG, FN55, who was on the road between his QTH and New Hampshire, helping a family member who was moving. Your editor was in a similar predicament, on the road in Birmingham, Alabama, with XYL Carol, W6CL, at the American Council of the Blind national convention.

On 144 MHz the best DX reported was a contact between KY1K, FN54, and K5QE, EM31, which measures out to be 1604 miles. K5MQ, EM31, reported also working KY1K, FN54, for a distance of 1514 miles and his 46th state terrestrially. KY1K, in commenting on his station, stated that it is all the more remarkable that he was on the farthest DX end of so many QSOs considering that he is only running 200 watts into a single 12-element Yagi only 21 feet high and surrounded by trees. In addition, his new mast-mounted preamp is still in the box! During the opening his wife, NK1I, worked 20 stations.

Speaking of husband-and-wife teams, NØRQ, EM13, reported that he and his wife, KC5POV, worked W1AIM, FN34, for a distance of 1510 miles. KØAWU, EN37, reported his best DX to be NW5E, EL98, for a distance of 1440 miles. WA1ECF, FN41, reported making multiple QSOs in the 1000 to 1500 mile range. K1WHS, FN43, and K5SW, EM25, worked again (having worked the first time in last September's huge tropo opening), for a distance of just under 1400 miles. W8WN relayed a report that WA5LFD, EM12, worked WB2BYP, FN13, and K2AXX, FN12, for a distance of 1256 miles, and that W5FRG, EM35, reported that locals were working in excess of 1400 miles. Also, N4HN, EM95, reported working VO1TJM, GN85, the day before.

On 222 MHz AF4HX, EM85, reported working KMØT, EN13, and KØAWU, EN37. In turn, KMØT reported working NG4C, FM16, and also heard AA4H, EM86, and W4DEX, EM95. WD4KPD, FM15, reported working WØGHZ, EN34, NØKP, EN34, K3SIW, EN52, and K2DRH, EN41. K4RTS, FM08, reported his first sporadic-*E* QSO on 222 MHz with KBØPE, EM48. He also heard NØKQY, DM98, and NØLL, EM09. WA8RJF, EN91, reported working K5UGM, EM12, and K5SW, EM25. WZ1V, FN31, reported working WØJRP, EM27, AG4V, EM55, KØJXI, EM55, and K5SW, EM25, with the distance between K5SW and him measured to be 1274 miles. N9LR, EN50, reported that his first sporadic-*E* contact on 222 MHz was NG4C, FM16.

Also on 222 MHz, K1TEO, FN31, reported working WØJRP, and NØLIE, both in EM27, but WØJRP is in Missouri and NØLIE is in Kansas, which made for two new states in one grid. He also worked K5SW, EM25, for a total of three states during his first 222-MHz sporadic-*E* opening. KØAWU reported working W4VC, EM81, and AF4HX, EM85, for his first-ever QSOs on this band. VE3AX, FN02, reported working K5UGM, EM12, for his second sporadic-*E* contact on this band, the first one having taken place on July 8, 2001, with K5LLL, in EM10. He also reported hearing W2EV, FN03, work K5UGM, just before he did. N3LL, while at the club station of W3KWH, EN90, worked WØJRP, for their first 222-MHz QSO. NØLL, EM09, reported working W3OR, FM28, for his first 222-MHz sporadic-*E* QSO, in Delaware no less. Moments later he made his second QSO by working KO4YC, FM17. K5SW, EM25, reported working WZ1V, FN31, K1TEO, FN31, WA8RJF, EN91, W2EV, FN03, and NQ2O, FN13. He also reported hearing N3LL, EN90, VE3AX, FN02, and K2AXX, FN12. W4VC, EM81, reported that his first sporadic-*E* contact on 222 MHz was KØAWU, EN37.

On the extremes, it seems that Minnesota was the farthest northwest. The husband-and-wife team of KY1K and NK1I, FN54, seems to have been the farthest northeast station. In the southwest, central Texas was represented by several stations, but WA5IYX, EL09, stated that he was out of the propagation. In the southeast, Florida also was represented by many stations.

In commenting on what happened, Shelby Ennis, W8WN, stated to your editor that he still finds no evidence of double-hop *Es* and has not heard of any extra tropo in the northeast (even though he did not have a lot of comments from that area). He commented further that to him it appeared to be extra-long single hop or some cloud-to-cloud propagation. "Either one appears possible, as extensive as the coverage was and as strong as the ionization was!"

Finally, Shelby, who has been keeping track of these things, indicated that the July 6–7 opening was the fifth or sixth 2-meter sporadic-*E* opening for the month of July to that date. He went on to say that he had a short opening on July 11, lasting only ten minutes. By contrast, during the same timeframe the Europeans had already experienced 22 sporadic-*E* openings.

With the hugeness of the opening, it will be some time before all of the data will be analyzed. Perhaps by the fall issue of *CQ VHF* we will have some further information on this special day of propagation.

**Editor,* CQ VHF
e-mail: <n6cl@sbcglobal.net>

The Frontlines: HSMM

Developments in Amateur Radio – Part 3

What is this nationwide high-speed network via amateur radio? What do hams envision in the Hinternet? Read on to find out.

By John Champa,* K8OCL

In the Winter 2004 issue of *CQ VHF* we discussed High Speed Multi-Media (HSMM) applications (Part 1 of "The Frontlines") and in the Spring 2004 issue we covered operational considerations (Part 2). In this concluding part we will now look into our crystal ball and try to predict how the proposed HSMM Network Infrastructure (also affectionately know as the *Hinternet*), may emerge in the 21st century.

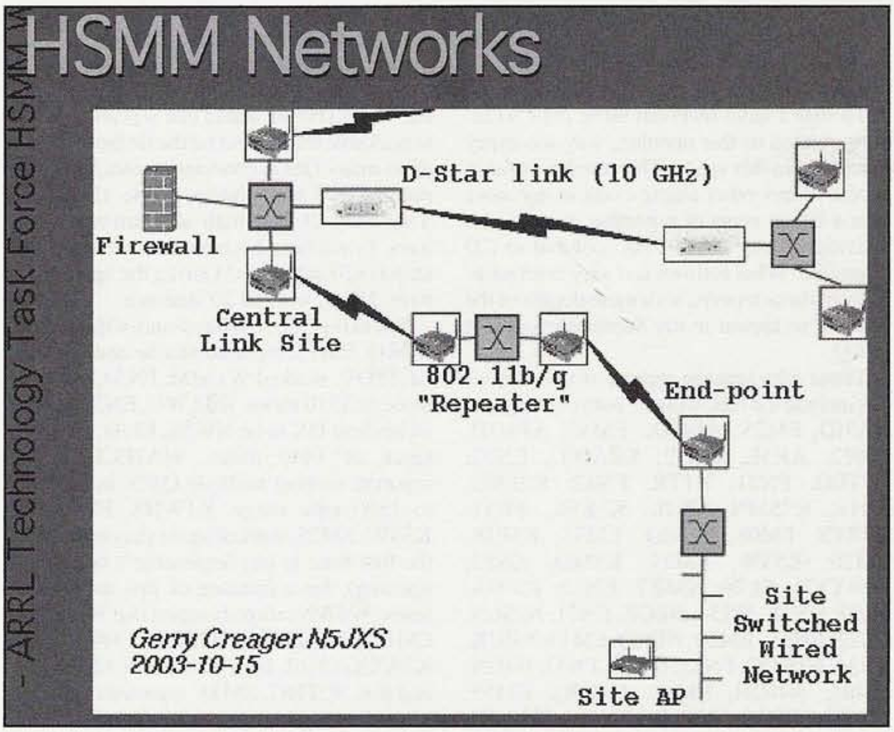
Proposed HSMM Network Infrastructure

The HSMM Working Group is following a systems engineering approach toward the development of a nationwide amateur radio HSMM digital network, as directed by its ARRL charter. Why?

The existing amateur radio data networks primarily consisting of 1200- and 9600-baud AX.25 packet radio are becoming totally inadequate to meet the growing requirements of modern mobile computing applications for the following reasons:

- Insufficient spectral efficiency—multiple users cannot simultaneously use the same frequency.
- Excessively slow data rates —far less than even the typical Internet dial-up speed of <56 kbps.
- Very limited linking capabilities—communication should be possible with any station on the air and on the network (or Hinternet, in this case) regardless of location.
- No combined, simultaneous data *and* voice *and* video capabilities.

Although the initial draft of the Hinternet has not yet been approved by the HSMM Working Group and subsequently opened for public comment, we can discuss some of its planned key provisions. Essentially, the Hinternet is intended to be similar to the Internet, but entirely (or at least primarily) for amateur radio.



A basic amateur radio HSMM network. It envisions multiple linked HSMM repeaters or access points joined via a smart mesh network to form what is called an HSMM Radio Metropolitan Area Network, or simply an RMAN. Various approaches are being investigated by radio amateurs to provide such links, including ICOM D-STAR, IEEE 802.16, and Virtual Private Networks (VPN) over the wired Internet.

One key element of the infrastructure specification and design is linking fixed EmComm sites in a metropolitan area which will be utilized in emergency settings by radio amateurs. This entails fixed path links, accessible solely by the target endpoints.

Another element of the infrastructure planning is creating an integrated network of these point-to-point links so that they are useful. Having a link between two sites is wonderful, but not too useful when there are 20 sites that need to communicate. To achieve this linking, the Working Group anticipates using conventional Ethernet switches (not hubs!) to interconnect the wireless devices at node points, and incorporate good RF practice in spatial and frequency diversity (different channels, changes in polarization, good horizontal and vertical separation) to achieve multiple links from a single site. One consideration in *all* of these links: The Working Group is rec-

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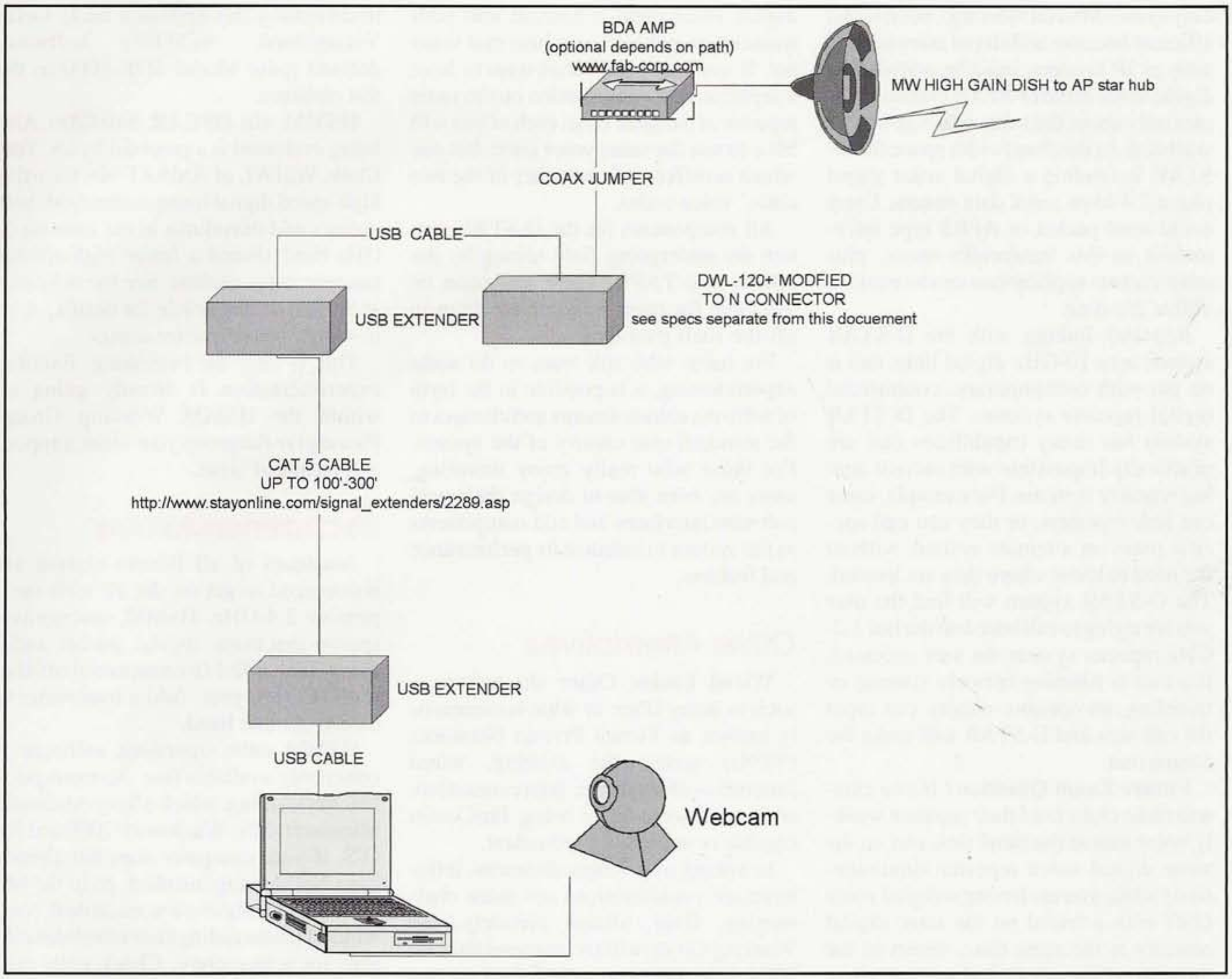

A typical Amateur Digital Video (ADV) station complete with cost estimates. We call this ADV to distinguish it from ATV. They both are excellent forms of amateur radio visual or image communications. However, depending on your base station, the HSMM approach is a less-expensive communications-grade video because of our use of software coders and decoders such as are found in Video-over-IP or streaming video technologies (H-323) coupled with inexpensive web cams. (Drawing by Jim Markstrom, KB9MMA, and courtesy of the Racine-HSMM Group)

ommending high-gain, dish-style grill antennas rather than omni-directional antennas at the node sites. These antennas are readily available for less than $100 including shipping and handling, with antenna gains in excess of 20 dBi (http://www.fab-corp.com/). Both horizontal and vertical polarizations are available from most manufacturers.

D-STAR®

Other alternatives for HSMM links, such as high-speed packet (56 kbps, or modem speeds) or the ICOM D-STAR® system on both the 1.2- and 10-GHz bands, might serve well.

D-STAR is a complete end-to-end, high-speed networked amateur radio data system that also provides digital voice over its backbone. The system uses 1.2-GHz transceivers and repeaters, and it has many advantages over analog systems. Hams familiar with computer systems and Internet-linked voice systems will be at ease with the D-STAR system, as it incorporates many of the existing features, as well as many new and advanced features not previously seen in amateur radio, but common on commercial digital repeater systems.

The high-speed data features in the D-STAR system were designed for mobile applications. While 802.11 can provide higher speed data, and it is frequently used from stationary mobile vehicles, it is not optimized for mobile applications when picket-fencing and multipath effects occur. The data rate of the D-STAR system is 128 kbps. This is still roughly three times faster than current dial-up technology. This is more than enough speed to allow hams to browse the Internet, send e-mail, and download files. Just as in other areas of the Hinternet, all of the applications that can be run on a home computer system can be run on D-STAR.

The D-STAR system also incorporates digital voice using the AMBE 2020 vocoder. This provides a very efficient occupied bandwidth of only 6.25 kHz. D-STAR digital voice is more efficient than compressed digital voice (G.711, G.722, or G.728) commonly used in 802.11 HSMM radio VoIP communications. VoIP is good for compatibility and it is easy to use (MS NetMeeting), but it is less efficient because additional information, such as IP headers, must be added. The digital voice in the D-STAR system occupies only about the same space as double sideband. In this bandwidth space the D-STAR is sending a digital voice signal plus a 2.4-kbps serial data stream. Users could send packet or APRS type information in this bandwidth space, plus other custom applications can be made to utilize this data.

Repeater linking with the D-STAR system uses 10-GHz digital links and is on par with contemporary, commercial digital repeater systems. The D-STAR system has many capabilities that are practically impossible with current analog repeater systems. For example, users can link repeaters, or they can call specific users on a remote system, without the need to know where they are located. The D-STAR system will find the user you are trying to call based on the last 1.2-GHz repeater system the user accessed. If a user is roaming between systems or traveling, an operator simply can input the call sign and D-STAR will make the connection.

Future Exam Question? If two amateur radio clubs hold their separate weekly voice nets at the same time and on the same digital voice repeater simultaneously while you are having a digital voice QSO with a friend on the same digital repeater at the same time, which of the three simultaneous digital voice conversations would a transceiver monitoring the digital repeater's output signal hear?

Answer: It all depends on which digital code was entered into the monitoring digital transceiver. If your radio club's digital voice code is entered into your transceiver, you will only hear that voice net. If you and your friend wish to have a separate side-conversation on the same repeater at the same time, each of you will have to use the same voice code, but one which is different from either of the two clubs' voice codes.

All components for the D-STAR system are undergoing field testing by the ARRL and TAPR. They will soon be available for users in complete form in off-the-shelf packages.

For hams who still want to do some experimenting, it is possible in the form of software enhancements and changes to the standard user control of the system. For those who really enjoy tinkering, users are even able to design their own software interfaces and add components to the system to enhance its performance and features.

Other Alternatives

Wired Links: Other alternatives—such as using IPsec or what is commonly known as Virtual Private Networks (VPNs) across the existing, wired Internet—offer routine interconnection, while not necessarily being EmComm capable or acceptably redundant.

In linking over longer distances, infrastructure considerations are more challenging. Here, almost certainly, the Working Group will recommend Internet VPN links between established metropolitan networks.

HF High-Speed Links: The Working Group is also investigating the use of the HF bands for links. The HSMM-HF Project, led by Neil Sablatzky, K8IT, is investigating this approach using Gerry Youngblood, AC5OG's software-defined radio Model SDR-1000 as the test platform.

HSMM via OSCAR Satellite: Also being evaluated is a proposal by Dr. Tom Clark, W3IWI, of AMSAT-NA for using high-speed digital transponders with both uplinks and downlinks in the amateur 5-GHz band aboard a future high-altitude amateur radio satellite. See the reference at the end of this article for details, or go to <http://www.gpstime.com/>.

This is only the beginning. Exciting experimentation is already going on within the HSMM Working Group. Please give the group your ideas, support, and technical input.

Recommendations

Amateurs of all license classes are encouraged to get on the air with inexpensive 2.4-GHz, HSMM, microwave, spread-spectrum, digital packet radio using IEEE 802.11b commercial off-the-shelf (COTS) gear. Add a transverter to try out another band.

HSMM radio operating software is commonly available free. An example is MS NetMeeting, which often comes with Microsoft (MS) Windows® 2000 and XP O/S. If your computer does not already have NetMeeting installed, go to the MS website (http://www.microsoft.com/windows/netmeeting/download/default.asp) for a free copy. Check with your local HSMM radio group. They may be using different free operating software such as OpenH323 using Linux.

A soundcard is already built-in with most PCs. Plug your headset into that soundcard using, for example, a $15 headset from RadioShack® (the typical laptop PCs have poor speakers and microphones, plus it is sometimes difficult to hear a laptop clearly if there is noise in the area). Then add an RIC ($85) and a suitable strain-relief cable or pig tail ($15), and any external outdoor 2.4-GHz antenna. Want to do ADV? Add a webcam ($20) to your PC, or interface your existing digital-camera video output port. It is an easy, extremely low-cost way to do microwave radio voice, video, and high-speed data (a.k.a. multimedia) experimenting.

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/>.

Recommended Further Reading on HSMM Microwave Radio Networks

Building Wireless Community Networks, by Rob Flickenger, a member of the ARRL HSMM Working Group. The 2003 Second Edition is recommended.

Proceedings of the AMSAT-NA 21st Space Symposium, November 2003, Toronto, Ontario, Canada, especially the paper by Tom Clark, W3IWI, "C-C RIDER, A New Concept for Amateur Satellites."

Both of the above excellent publications may be purchased from: ARRL Publication Sales Department, 225 Main Street, Newington, CT 06111-1494; toll-free U.S. 1-888-277-5289, outside the U.S. +1-860-594-0355; <http://www.arrl.org/catalog/cathelp.html>.

It has been suggested that many amateurs may need to enhance their networking skills. The following books will make upgrading networking knowledge easier than the average technical or engineering textx on the subject:

Ivens, Kathy and Larry Seltzer, *Linksys Networks: The Official Guide,* McGraw-Hill 2002.

Danda, Mathew and Heather T. Brown, *Step by Step: Home Networking with Microsoft Windows XP,* Microsoft Press 2001.

Gilster, Ron and Diane McMichael Gilster, *Build Your Own Home Network,* McGraw-Hill 2000.

As you can see, there are a lot of initiatives going on on several amateur radio bands. Experimenting with local connectivity at 2.4 GHz is only one of them. For more details and for the latest developments on all these initiatives, check out the link to the HSMM Working Group open reflector at the Texas A&M University website: <http://listserv.tamu.edu/archives/arrl-80211b.html>.

Acknowledgements

The author wishes to express his appreciation to two special members of the ARRL HSMM Working Group, Neil Sablatzky, K8IT (http://www.hsmm.us/), and Mark Williams, AB8LN (http://www.qsl.net/ab8ln), for the use of their HSMM frequencies and Hinternet infrastructure slides. These slides are a small part of an excellent full-range PowerPoint presentation on HSMM radio that Neil and Mark prepared. If you wish to do an HSMM demonstration for your club or repeater group, a full free copy of the most up-to-date version of the presentation is available for downloading at <http://www.hsmm.us>.

Also, thanks to Gerry Creager, N5JXS, a research network engineer at Texas A&M University, for his dedicated efforts to lead the design effort for the Hinternet. If you wish to comment or contribute to this network design effort, Gerry can be reached at 8610 Rosewood Dr., College Station, Texas 77845-5594; e-mail: <n5jxs@tamu.edu>.

Information on the ICOM D-STAR System was courtesy of Matthew F. Yellen, KB7TSE, Technical Sales Specialist, D-STAR, ICOM America, Inc., Bellevue, WA 98004; telephone 425-450-6045; fax 425-454-1509; <http://www.icomamerica.com>.

I would also like to thank the following outstanding individuals for their review, comments, suggestions, and other help with the draft of this article: Dr. Tom Clark, W3IWI; Joe Cupano; NE2Z; Walt DuBose, K5YFI; John Jaminet, W3HMS; Jeff King, WB8WKA; Howard M. Krawetz, N6HM; Barry Landson, K6IFX; Darwin "Dar" Thompson, K6USW; Kevin Wittmer, KB8VME; and Gene Zimmerman, W3ZZ.

Finally, I would like to express my warm appreciation to my beautiful and loving XYL, Karen Feder, art teacher extraordinaire, for all her patience during this writing and research. ■

By Gary Pearce,* KN4AQ

FM

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

Looking Good on Paper

"Guilty, your Honor," I said softly, my head hanging low. The charge? Hogging a 2-meter repeater frequency coordination for a repeater that had been off the air for well over a year. My lawyer reminds me that four years is *well* over a year. The venue? My imagination.

"But there were extenuating circumstances!" I pleaded.

"There always are," sighed the weary judge.

I'm also guilty of not writing about my indiscretion until the repeater was safely back on the air and the coordination was updated. What kind of fool do you think I am?

In case you haven't already figured it out, the subject of this column is "paper repeaters." Maybe you use a different term for them—repeaters that are coordinated and show up in the repeater directories, and that are not on the air and the prospects for getting on the air are dim in all but the mind of their owners. Hope springs eternal. If you are the owner of one of these maladroit machines, you can follow my example, or get serious about getting it on the air. (I would strongly recommend the latter.)

If you are a befuddled would-be user of a repeater that exists only on the pages of your repeater directory and in the filing cabinet of your local frequency coordinator (ergo a "paper repeater"), maybe I can explain what's going on. After all, I'm a reformed sinner myself.

The reasons for maintaining a paper repeater tend to be found in a few general categories. Among them are the following: You have the machines that were coordinated but never made it on the air, or the machines that broke or got zapped by lightning and collected dust on the bench waiting for repair or replacement. Tower sites are lost, and new ones are difficult to find. Behind each tale of woe is the repeater owner or club repeater tech who has the best intentions of getting the repeater back up, but he is busy and there's always something just a little more important to do. Weeks, months, years . . . the time just slips away.

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The Problems

What's the problem? There are a couple of them.

First, it's the users and their repeater directories. I have a foot in that camp. I use the heck out of my radios when I'm traveling. When I'm in a new town, I use the ARRL (or SERA [SouthEastern Repeater Association], or local website) repeater directory to see what repeaters I can hit. It isn't easy. General repeater directory usability (or lack thereof) is bad enough. Regional groupings may mean something to the locals, but travelers will be clueless. Repeaters listed for small towns (population 340) or obscure mountaintops are no help either without a lot of research. When a large percentage of the listed repeaters aren't even on the air, thumbing through the directory can be an even more frustrating exercise.

I've found the situation particularly bad on 6 meters, where I'd guess that more than half the repeaters listed in places I've visited don't respond. I'm careful about frequency, tone, and offset. Maybe the tone is listed incorrectly, or I'm just out of the coverage area. I'll bet a rubber-duck that most of them are just dark. The 1.25-meter allocation also has a poor track record. Repeaters on these bands see less use, and if there's a failure, there's less pressure to get them working quickly. Two meters has its share of black holes. What is it like in your area? Around here, six of the 45 repeaters I can hit from home are off today. Two of them are long-term. Actually, that's not bad.

The second problem is that missing machines tie up scarce spectrum. It's difficult to coordinate a new repeater in and around most cities. It's mostly a 2-meter problem, except in the biggest megalopoli, where it affects 70 cm too, and urban California, where there isn't an unspoken-for kilohertz above 29 MHz. A dark repeater is holding a spot that some other would-be repeater owner would like to have, and that scarcity of spectrum is just why the incumbent sits on the empty channel. If he (or she—there must be a female repeater owner out there somewhere, although I guess I've never met her) turns it in after failing to muster the enthusiasm to rebuild the machine and get it back up in a reasonable period of time, he (or she) won't get another channel for a long time, if ever.

Why don't frequency coordinators, those kilocycle kops of our FM bands, crack down? Most repeater councils have policies on paper repeaters, requiring that new machines be up in a given timeframe, and broken ones be fixed in the same or another given timeframe. In some places they enforce the policy, or at least they say they do. However, most states are much bigger than the local coverage of any one ham's home station, even with a nice, tall tower. The coordinator can't keep tabs on every repeater all the time. We're assuming that the coordinator even bothers to listen to 2 meters any more. Some are from the set that disdains the band and wouldn't be caught dead there.

How about a network of spies? The concept seems easy, but the execution is almost always flawed. Going after paper repeaters would be a great deal of work, especially if a state has built up a serious backlog of missing machines. It could take a coordinator one evening to initiate and complete the contacts as well as the paperwork, either to de-coordinate a dark repeater or to cajole the owner into getting it back up quickly. The state could have 30 of them, a reasonable estimate. That's every night for a month! Now I know frequency coordinators are well paid, but that's above and beyond, in addition to the regular coordinations still needing to be done.

Do you really think one evening per repeater will be enough? Have you ever talked to the owner of a dark repeater to see how defensive he can get about why his machine should be the exception, blah

blah blah? I wonder if one of those TV judge shows would be interested in helping? Judge Judy, I'm pretty sure the frequency coordinator just needs a new battery in his HT, and then my repeater will kerchunk just fine.

If coordinators were really the Gestapo that some make them out to be, it might not be all that difficult. In this case, they're not. They're too lenient, or sometimes their hands are tied. SERA just added language to its coordination guidelines that makes it easier to de-coordinate a dark machine. Repeater owners have always had six months to get a new machine on the air or fix a "busted" one, with a six-month extension if requested. Now the owner has to demonstrate that the machine is on when requested, and if the owner doesn't answer the mail or the phone, the owner can lose the coordination. Some of the SERA coordinators are vowing to get the vapor off the books. We'll see how well they do.

My story? I convinced the club whose repeaters I help maintain to return back to the pool one 6-meter and one 70-cm channel we were holding. We'd had machines on those channels in the past, but for the usual host of reasons they went silent. It was clear that nobody was going to get them going again. Another local club took the UHF frequency (nobody called to say thanks), and now and then I hear a "grrr" from one of my fellow club members because we gave it away. I didn't give our secondary 2-meter channel away when site changes and malfunctions took it off the air. Despairing of finding anyone in the club who wanted to take on the project and build a new machine, I bought an off-the-shelf repeater (works pretty well), but it still took forever to get it interfaced with the controller and get it programmed and installed. The total time working on it might have been 80 hours, but it was spread over three years. There always seemed to be something more important to do. When the frequency coordinator started dropping subtle hints about how the unused coordination looked bad (I was editor of the *SERA Repeater Journal*), I put in the effort to finish the repeater project. The magazine came out a week late.

If you're sitting on an unused coordination, get busy or let it go to someone who has the spare time to devote to the project. Don't make the coordinators come after you. I can say that with the smug satisfaction of someone who has finally made good, except for the club 1.25-meter machine, which I'm sure I'll have back on the air this year. I promise.

SERA to Require Tone

SERA said yes to tone at its board meeting in June. Tone, either CTCSS or DCS, will be a condition of coordination for all new repeaters, and it will apply to all current repeaters in two years. SERA will not officially de-coordinate repeaters that refuse to use tone, but it will not entertain any complaints from repeater owners who hear co-channel or adjacent channel neighbors or users until they tone-up. When repeater owners bypass SERA and complain to the FCC, one of the first steps the FCC's Enforcement Bureau's Special Council Riley Hollingsworth, K4ZDH, usually takes is to ask if they are coordinated, and confirm that with the coordinating body. SERA's answer will be "yes, but..."

The policy was passed unanimously, but not without dissent during the discussion. A few SERA staff members noted that tone is not a panacea for solving interference problems. Tone masks the problems, but it does not remove the interfering signal. They conceded that sometimes masking is the best that one can do. Tone, however, is "traveler hostile." That was my contribution, as I gently accused the board members of not using their radios when they are on the road. I was told to learn how to use tonescan. The real point is that tone repeaters can take steps to make things a little easier for travelers, such as "broadcasting" their tone via their voice ID, which I believe would be a message of interest to all hams. Does anyone out there have more creative solutions?

52 Revisited

We've talked about 146.52 in previous columns, and I've heard many complaints that nobody is there. Within a span of two weeks in June, I had two random 52 experiences on the road. First, a van passed me with a ham-looking antenna on the back, but no callsign plates. (I have callsign plates, and my car looks like a porcupine.) A hand stuck out the window and flashed five fingers, then two. We talked for 30 minutes until I reached my exit. The next week I was on I-40 again, talking to my wife on the cell phone (no, not allowed everywhere, and make sure to always make your driving the priority). Cyndi's a ham (KD4ACW), but the cell phone is just so easy. My radio volume was low, and in the background I thought I heard someone calling me. I was out of local repeater range, so who could that be? It was a fellow who had just passed me calling on 52. Yes, I drive slowly and everybody passes me. Gas is $2 a gallon! This time I had one of my radios on 52 just to see who would show up, and somebody did. A long talk occurred between us as we chased one another cross-country.

That's not exactly the flood of activity some hams would like to see on 52. I think some hams have an unrealistic view of our population density, unless you're in Dayton during the Hamvention®. The suggestion stands: Monitor 52 on the road, at least as your "nothing better to listen to" default while you're on the cell phone.

Speaking of Dayton . . .

Nothing extraordinary was on the FM scene at the Hamvention® this year. No NFCC (National Frequency Coordinators' Council) or coordinators' meetings (which is news). Last year there was a short meeting with a handful of people. A few years ago there was a bigger meeting. More on this in the fall column.

I did listen to two impressive speakers, ARRL President Jim Haynie, W5JBP, and the FCC's Riley Hollingsworth, K4ZDH. I've heard both speak several times before, and I always go again. Both are compelling. They speak plainly and honestly about our hobby/service, rarely mincing words. The news is always mixed, with no gloom and doom, although there are some problems that need to be solved.

Jim talked about a survey the ARRL commissioned that had a wealth of information, of course. One statistic stood out: 22% of new hams never get on the air!

How can that be? Someone takes the time and trouble to get a ham license and never uses it? These are people who don't have help. These are people who have no mentors. OK, I'll say it—Elmers. They go to a radio club meeting and no one greets them. The way things are today, with the Tech as the entry-level license, this is right up FM alley, since 2-meter FM is where these new hams would be headed first.

Who greased your entry into ham radio? I had a lot of help: K9ZGT, W9SCH, WA9BOX, and K9DKW are calls that come to mind among many. I hope some new hams remember my call 35 years from now.

Jim also talked about the hams who complain about the technical ineptitude of new hams. His comment: "You want to be an engineer? Go to MIT." Getting a ham license is the beginning of learning, not the end. I beamed with pride the day I passed my General, but I was one dumb kid when it came to engineering.

Also, he spoke of the "2-meter ghetto" to which new hams are relegated quite frequently. It would be easy for your FM columnist to take offense, but I won't. When the Tech became the de facto entry-level license, new hams were restricted to VHF, and effectively to FM. I love FM, and there's nothing wrong with making it your primary, or only, mode of operation, if that's what you like. However, new hams need variety. They need to be able to make informed choices by being able to sample HF and VHF/UHF—on phone, not just CW.

Riley also spoke about restructuring, saying that the Tech license was too difficult as an entry license. I like the idea of the new Novice, and saying "goodbye" to the Tech. VHF doesn't need an enforced constituency. We all need a unified ham radio.

BPL Update

The furious pace of BPL, Broadband over Power Lines, has slowed somewhat, at least down here. The FCC NPRM is out, and comments have been filed. Progress Energy, the company running a trial a few miles from my home in North Carolina, took aim at the hams who have been complaining about interference. As I expected, the term *harmful* will be in for a lot of attention, as Part 15 prohibits BPL from creating harmful interference. My favorite line from Progress Energy's comments comes when it seeks to define *harmful*: "The interference should have to be proven to so greatly interfere with operations such that communications are practically unintelligible." Progress Energy uses two-way radio to communicate between linemen who are working on, and turning on and off, some extremely high-voltage lines. I wonder if Progress Energy would accept interference that almost, but not quite, rendered its radio signals "practically unintelligible."

As I left you in the spring column, Progress Energy's BPL system was still covering the 10-meter band. We filed formal complaints with the FCC, and it moved, almost vacating the ham spectrum on the three overhead lines it is using in the trial. You'll recall that Progress Energy needs about 6 MHz of spectrum for each 2000 feet of power line. It identified three spots that fall between 40, 20, 15, and 10 meters, each of which yields enough space while covering only the small 30-, 17-, and 12-meter bands. Those bands would be "notched." That, plus some spectrum above 30 MHz, might meet Progress Energy's requirements of not re-using spectrum for several line segments.

The theory had a few problems in practice. After moving, Progress Energy is now covering the top 60 kHz of the 20-meter band at full strength. The notching technique it's using isn't deep enough, and audible signals remain across 12 and 17 meters (it isn't using the 7- to 14-MHz block at this time, so 30 meters isn't affected yet). Progress Energy's spectrum blocks don't end with a brick-wall stop; the signals trail off, and the trail crosses into the ham bands they abut. The "fringe" signals in the notches and at their band edges are weak (Progress Energy claimed that they are "not harmful"), but they are clearly audible.

Amperion, a contractor for the equipment vendor, told the ARRL that the notching, or "power masking," remains a "beta procedure" as well as "somewhat labor intensive."[1] Evidently, so is the procedure for moving around the spectrum—the frequency agility Amperion has promoted as the solution to interference complaints. Amperion has to send someone out with an HF receiver to see where things really ended up after it issued instructions to move the spectrum used on a line.

Amperion didn't mention the "beta procedure" in a reply sent to the FCC in response to our complaints. It just said everything had been fixed, and that the residual signals inside the notched bands and at their band edges were "not harmful."

We're glad Amperion is trying, but after the first move, it hasn't done much to fix the remaining problems, especially at the top end of 20 meters. In addition, Amperion has done nothing to get off the ham bands on its underground lines. That's because there are no hams living near the lines, and Amperion is discounting our mobile reports. Finally, it has ignored the SWL band issue, saying only that it will be able to resolve complaints as they occur. We did include several SWL interference issues in our complaints, but interference to that spectrum has not been "mitigated."

The ARRL is requesting that all hams get in on a grassroots campaign to have federal legislators put pressure on the FCC to respond to interference complaints, quit being cheerleaders, and become the impartial regulators they're supposed to be. See the ARRL website, <http://www.arrl.org>, for details.

That's it for this issue. See you in the fall! ■

Note

1. See *Iowa Ham is BPL Interference "Poster Child,"* from the ARRL website, <http://www.arrl.org/news/stories/2004/06/15/2/?nc=1>.

By Kent Britain,* WA5VJB

ANTENNAS

Connecting the Radio to the Sky

Circular Polarization with a Patch Antenna

What a week! As I start this column, power and telephones have been out for four days. The computer *did not* like getting power from my generator, so I'm typing on a Sharp palmtop and some lashed-together gel cells. Consequently, a lot of the planned construction projects have not had a chance to be tested, but we came up with something to talk about this time.

Circular Polarization

There are quite a few ways to generate circular polarization with a patch antenna. One way is to split the signal into two paths, delay one path 90 degrees of one-fourth wavelength, and then feed adjacent sides of a square patch. Use of a quadrature hybrid is highly recommended, but it isn't essential.

The second way is a slot through the patch at a 45-degree angle, which is certainly easy enough to do with a hobby knife and aluminum-coated styrofoam. However, my metal tabs for soldering coax kind of mess this up.

I first saw this third method used on a multi-band AMSAT dish feed at the Weinheim, Germany Hamfest. A circular patch was driven much like a square patch, but 45 degrees to one side of the feed. A variable capacitor to ground was used to generate a phase shift to change the patch from linear to circular polarization. This technique is very good, but to tune it up, you really need a network analyzer.

Okay, I go for cheap and easy. Just cutting the opposite tips off the square will create enough unbalance to generate circular polarization. Trim off the upper right corner (and lower left) and you'll get RHCP (right-hand circular polarization). Trim off the upper left corner (and lower right) and you'll get LHCP (left-hand circular polarization). There are many jokes floating around the antenna community that the opposite of right-hand circular polarization is really wrong-hand circular polarization, but I think I'll save that one for an April 1st article!

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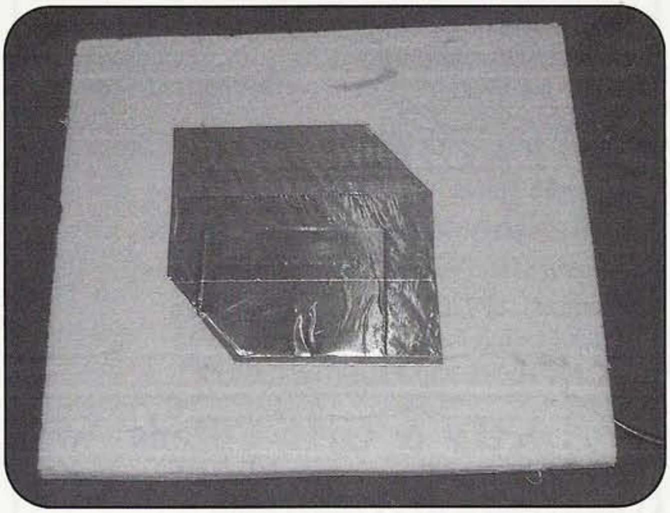


Photo A. A 915-MHz circularly polarized "Cheap Patch" antenna.

You also have to start with a square patch. The rectangular patches have a wider bandwidth, but this tip trick doesn't work with rectangular patch antennas. You want to trim off about 20% of the tip for circular polarization. Trim off too much, or too little, and we're back to that funny almost linear polarization again. Now if someone can come up with a good use for a patch antenna with 6 dB of ellipticity, we'll work something out. However, elliptical polarization is rarely used by hams.

Caveats with Circular Polarization

I apologize to Dr. Smith for my quick drawing of his chart (Figure 3), but I think you'll get the idea.

Richard Fogle, WA5TNY, once showed me how he tuned some critical circularly polarized patch antennas on his network analyzer. The start and stop points on the sweep are where the antenna is close enough to 50 ohms to be usable, but it's only

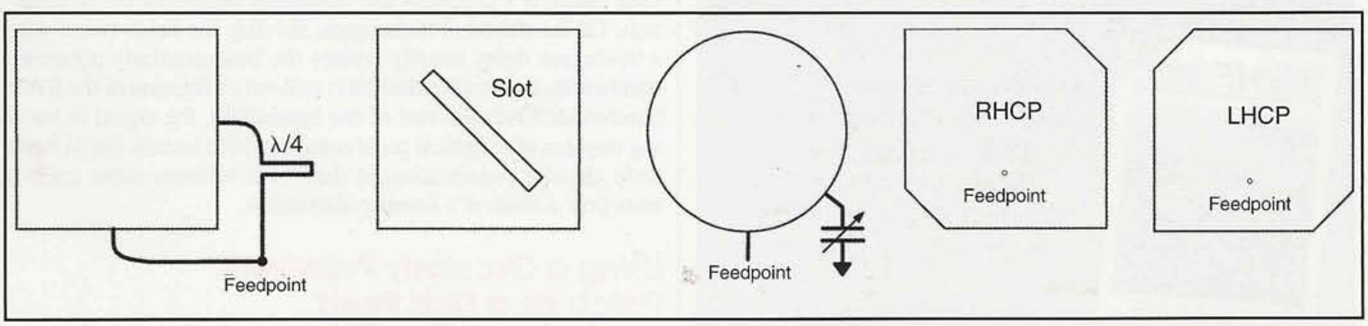


Figure 1. Different ways to generate circular polarization with a patch antenna.

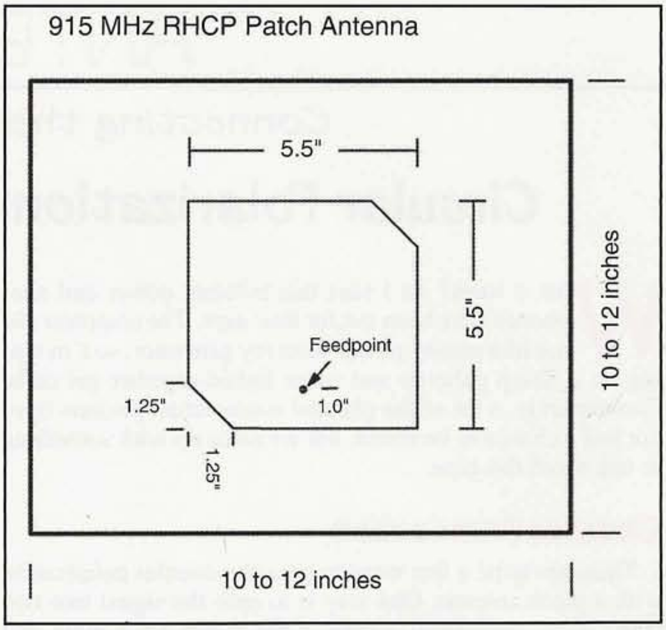


Figure 2. Looking at the patch.

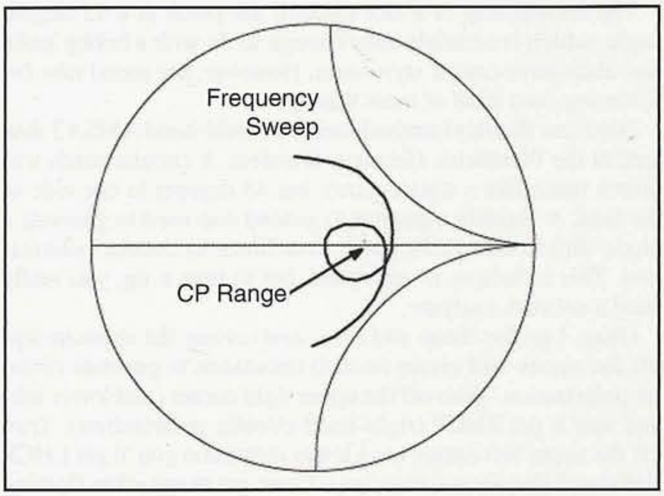


Figure 3. Smith Chart plot of a circularly polarized patch antenna.

in that circle where the antenna is actually circularly polarized. In most cases, a patch is only circularly polarized over 10 to 20% of its operating bandwidth. Therefore, if your wireless LAN or 2.4-GHz security camera is using a circularly polarized patch, it's probably not circularly polarized on all channels. Of the different techniques, feeding the patch twice with a 90-degree delay usually creates the best circularly polarized bandwidth, but this bandwidth is still only a fraction of the SWR bandwidth. Over the rest of the bandwidth, the signal is varying degrees of elliptical polarization, which means that it has a little circular polarization in there, but without some careful tests you'd think it's linear polarization.

Using a Circularly Polarized Patch as a Dish Feed

Just look in a mirror: Your right hand becomes your left hand, and vice versa. Much the same happens with your use of a circular polarized antenna as your dish feed. The world is really seeing a reflection of your feed. If you need a RHCP dish, use a LHCP feed.

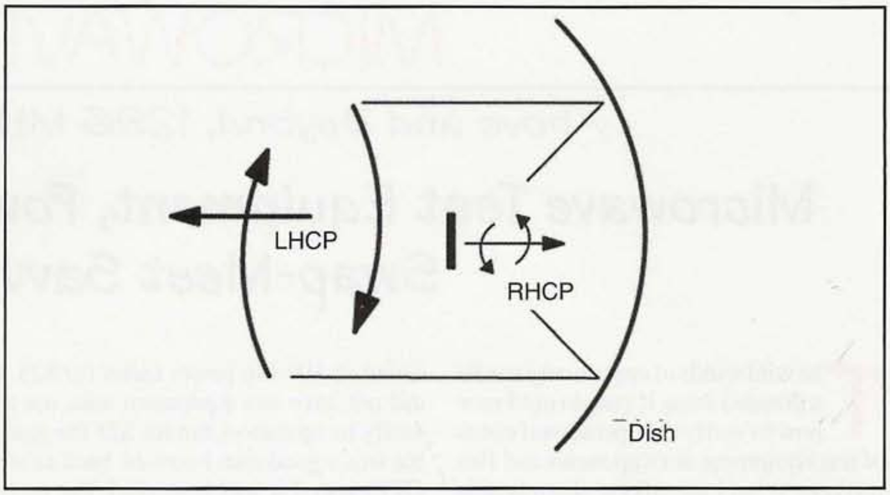


Figure 4. Polarization reversal when used as a dish feed.

Elliptical Polarization

A truly circularly polarized antenna is rare. To measure ellipticity, you put the antenna on an antenna range and then rotate the antenna slowly about its axis, always pointing at the source looking for a peak. Now rotate the antenna 90 degrees and measure the gain again. Do this with a Yagi, and you'll see 20 to 30 dB difference. If the gain varies less than 1 dB, pat yourself on the back. That's circular polarization with less than 1 dB ellipticity. If the gain varies less than 3 dB, I wouldn't brag, but that counts as circular polarization.

By the Way . . .

An e-mail from Tom, one of our readers, suggests using 3M™ 77 adhesive when gluing two layers of styrofoam together to make 435-MHz patches. It's not supposed to melt the styrofoam like most glues and probably sticks better than white glue.

Well, power is back on, but I don't have telephones as yet. Some of my best ideas for topics, or the best questions, come from you, our readers. If you have any VHF antenna questions, just drop me a line at <wa5vjb@cq-vhf.com>. Next time we'll cover some simple 1.2- and 2.4-GHz antennas. ■

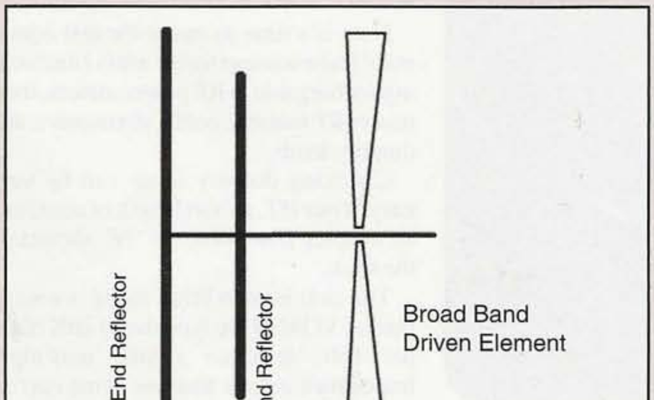
Yagi Reflectors

I had a question from a reader, Frank, about adding extra reflectors to a Yagi. Examples would be the F9FT 144-MHz Yagi with two reflectors or the NBS Yagi with its three reflectors. I've seen some European designs with up to six reflector elements.

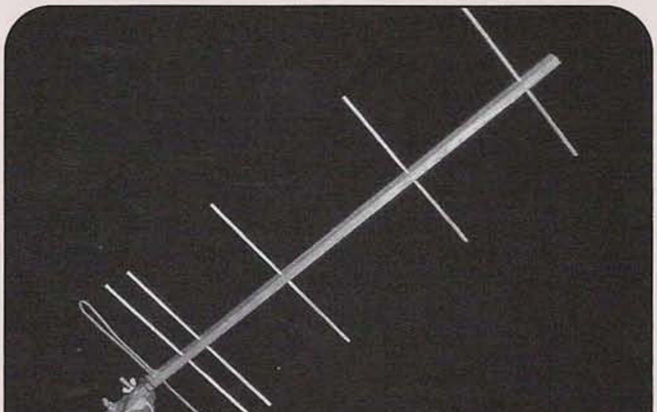
There has been a lot of theoretical work done in this area in recent years. With just a single reflector you can get a very good front-to-back ratio.Recent work has been centered around trying to use the extra reflectors to cut down other lobes. For the most part, this has been like poking a water balloon with your finger. You may push in the balloon at one point, but it pops out somewhere else. Most high-performance Yagis use only one reflector and don't need any more.

An East German antenna engineer told me, "With a tightly tuned Yagi, you can take the reflector off; it doesn't change anything." That certainly went against everything I had thought, but he was right. I even built a 432-MHz Yagi with no reflector. The computer predicted 40 dB front-to-back, and it demonstrated 27 dB front-to-back on the antenna range. You don't have to use any reflector, but it does help bandwidth a lot. The 43-MHz no-reflector design only worked for a 3-MHz or so bandwidth. With a reflector, a similar antenna would work over a 10-MHz or so bandwidth. Also note the close-in directors, but it showed better front-to-back than most commercial Yagis!

This brings us to the one time I do recommend multiple reflectors. I've worked with some very-wide-bandwidth Yagis, and I've worked with some Yagis designed to work on two bands. Putting on a reflector tuned for the lower end of, say, the UHF TV band, and a second reflector tuned for the high end works much better than a single reflector. In the case of the dual-band Yagis, the two reflectors were tuned for 902 and 1296 MHz, or 145 and 223 MHz.



Wide-bandwidth Yagi reflectors.



A 432-MHz "Cheap Yagi" with no reflector element.

By Chuck Houghton,* WB6IGP

MICROWAVE

Above and Beyond, 1296 MHz and Up

Microwave Test Equipment, Power Meters, and Swap-Meet Savvy

The wild winds of opportunity can be a dreaded thing if you do not know how to verify the operational status of test equipment at swap meets and flea markets. What I am talking about here is the method of making a good choice in picking up a bargain, rather than taking a chance and possibly selecting a great doorstop—an item that is not functioning and might prove too costly and/or take too much time to repair.

Such was the case with my USM-147 meter. All I could lose in this case, however, was time itself, as it was free. Normally I look for more exotic meters to upgrade my work bench. In one case I found an HP-436 power meter for $25. I did not have test equipment with me to verify its operation, but for $25 the gamble was a good one. I arrived back at my QTH, tested it, and it worked. For more expensive devices, read on for my recommendations on how to test them at swap meets and flea markets.

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General Guidelines

If you are told a piece of test equipment for sale is in working order and you know the seller is trustworthy, then you are in good shape. Another option is to purchase a unit with the explicit understanding that if you take it home and it doesn't work, you can return it and get your money back. Give it a shot if your best instinct tells you it's okay, and then barter the best you can to reach a price that is acceptable to you and the seller. I would limit this scenario, however, to items that are not very costly.

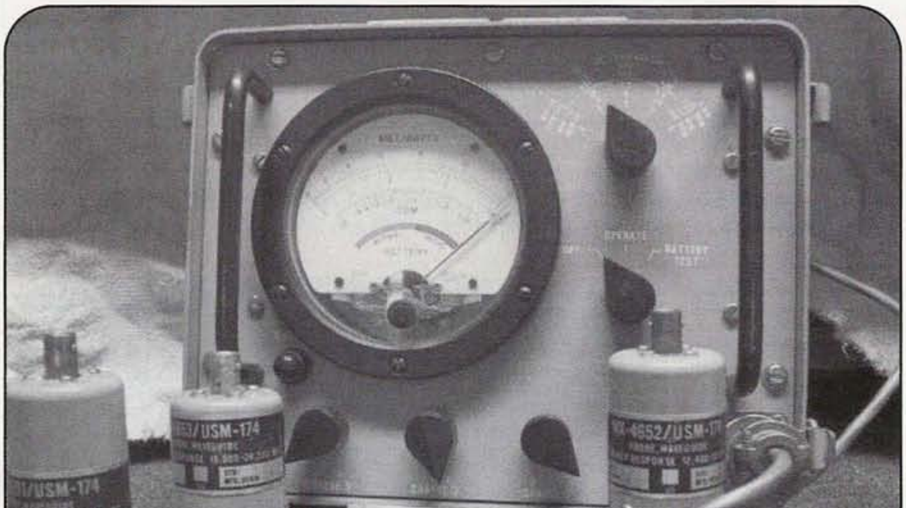

Photo A. The USM-174 military-surplus power meter and the attachments found in the top lid of the power-meter case: meter attachment cord to bolometers; and (left to right) the gray devices are 8–12 GHz, 12–18 GHz, and 18–25 GHz, and the black device is 100 MHz to 8 GHz.

Testing the equipment at a swap meet or flea market is the best of all possible options. Most swap meets do not have AC power available to do a simple check on a piece of equipment to determine whether it's working or not. For most small items (excluding transmitters) that you may want to check, bring along a 12-volt battery with a set of clip cords to power them up. Is the unit working on receive as a basic function? For those items requiring 110-volt AC power to test them, a simple 200-watt, 12-volt input AC inverter can be used. I would not carry these power units around, but rather keep them in your vehicle while looking for items of interest. Then take the power unit to the equipment or the equipment to the power, depending upon what can be worked out with the seller. A $10 or $20 deposit or even a QSL card given to the seller can be effective and a sign of good faith if you take the unit to your vehicle to test it.

Checking Out Microwave Test Equipment

Now it's time to cover the test equipment I take to swap meets when I am looking for bargains in RF power meters, thermistor RF mounts, cords, attenuators, and dummy loads.

Checking dummy loads can be very easy. Your HT, a short length of coax, and an adapter from BNC to "N" should do the trick.

The next item to bring along is a small pocket VOM of the type that is 20K ohms per volt, or other similar non-high-impedance meters that use some current to make a resistance measurement. High-impedance meters will not do the test that I am about to describe. However, my old, handy Triplet Model 310 does work admirably. The tests for non-indicating dummy loads check to see if 50 ohms is at the RF connector, and if so, it should be okay. Power tests performed later on will prove it.

Testing RF Power-Meter Heads

To guarantee with some assurance that the unit you want to purchase can be easily tested, locate RF power meter heads at swap meets and test them at the swap meet. First, the Hewlett Packard older model 478A heads, which operate from 10 MHz to 12.4 GHz, have two thermistors tied to ground from pins 1 and 3. With either a high-impedance meter or a 20K ohms per volt meter, this RF power head should read in the 2000- to 4000-ohm range, reading on each pin (pin 1 to ground and pin 3 to ground) and each value should be nearly the same, or balanced. It is important that both thermistors are nearly matched in resistance. Their being within 10% of one another should give you a good RF power-meter head regardless of HP frequency range or the model of HP head. Connecting the Triplet 430 from pin #1 to ground through the ohmmeter and supplying RF at 10 GHz with an HP 478A works just as well as the single mounts.

Some RF power heads of HP part series for the 431 and 432 power meters measure in the 500- to 1000-ohm resistance range. As long as they are matched in value they should work. This is not a formal, absolute test to ensure whether or not the thermistors are good by HP standards, but rather is a simple VOM basic check that should be good enough for a quick test to verify that the RF head is alive. Then you can judge what it's worth to you.

Another meter is the military USM-174 mentioned at the beginning of this column. When I picked it up and tried to test it, it did not function. I was in the process of putting the lid back on when I realized the lid was deeper than what I saw on top of the cover-cord storage area. Opening the snap retainer, the lid opened and oh my! In the recess of the cover-lid subcompartment were stored four thermistor power heads from 100 MHz to 26 GHz, along with waveguide attenuators for higher power testing. I was very surprised, as I had never seen such an array of older power-meter heads before. Occasionally there is one, but not a complete collection (see Photo A).

I tried the heads in the power meter (USM-174), but none of them worked when attached to the testing meter. Here again I applied the simple swap-meet test to see if anything was alive in the heads before I decided if I would go to extremes and repair the old power-meter assembly. I used the same trick with the high-Z ohmmeter (my workbench normal VOM) and all heads were open. Nothing was alive in any of the RF heads. The connectors were dirty. I replaced one to allow good contact connectivity, and the same thing occurred—open (meaning no connection) in either high-Z ohmmeter or diode test scale on the VOM. Pondering this overnight, I thought of trying the low-Z meter, the Triplet vane meter movement 20K ohms per volt. Ha, progress! This gave me the same value of resistance in either direction of the ohmmeter—connectivity with this VOM. This indicated a single thermistor, and it was alive. I borrowed an older 430 HP power meter, and it showed some measure of operation on the lowest frequency RF head. Because repair was needed at this stage, it was more trouble than it was worth. I needed to prove the RF heads were functional before going forward on anything else.

Not knowing what reading was good or bad, I connected the VOM to measure the thermistor (noting the static resistance value, 300 on × 10 scale = 3k ohms on the head being tested) and applied RF at about 0 dBm to the RF port on the RF head. Crude? Yes, but the ohmmeter responded and changed its resistance value, proving that it saw the RF. The power-meter head was working. The movement was not great—only a small percent, about 200 to 300 ohms on the power-meter scale of things.

Tests at the RF input connector showed open. It was blocked by an input capacitor. These single older thermistor heads were checked from the rear BNC connector for continuity. The simple RF test I performed was to see if they were alive. This was a learning experience, as both power meters (the USM-147 and the HP-430) were in need of repair, and I needed some guidance to prove what part of the system worked.

The tests I did on the bench are the same resistance tests used at swap meets to give an indication that an RF thermistor head is in reasonable condition and should work when attached to a proven good meter. Remember that HP-478 heads have two thermistors, one on pin 1 and the other on pin 3 in reference to ground, and measure in resistance close to one another by about 10%. The older RF heads with the single BNC cable connection as output should show continuity from BNC center connector to ground, and are suitable for use with the older 430 HP as well as similar RF power meters with BNC access to the RF power-meter circuitry. These older heads are not as reliable and a little drifty in meter movement, but they do work. I was especially glad to see the 25-GHz power-meter thermistor head, which filled a blank in my measurement systems for the work bench.

Then it was time to repair the USM-147, or at least see if it could be repaired, or determine whether it was worth the time involved.

The above tests are for the power-meter heads for the HP-430 (BNC connectivity) and the HP-431 and 432 power meters (6-pin cable connectivity). Note that these tests do not apply to the 435 and up power meters in the HP line or their differently constructed power meter heads. I have some bad heads for these meters, which I will open. I'll try to figure them out and see if any test information can be gleaned from them.

Power-meter cords can be tested for simple continuity on a pin-for-pin basis. Note that the power (RF cable) is unique to the 430-meter BNC; 431 meters and 432 meters use a 6-pin connector. The 435 and higher numbered models use a smaller multi-pin connector and look much like the Gigatronix power-meter cable. However, these cables are different and will not work in one another's power meter. Be sure about what you have, lest you pick up the wrong cable.

Attenuators

Attenuators are very similar to dummy loads and can be checked for simple resistances. First, measure from input to output. You should see a DC resistance. The lower the value of dB loss, the lower the resistance. Then check the shunt resistance from input to ground and output to ground. Both input and output to ground should be the same.

Diode Detectors

Diode detectors are best measured with a high-Z VOM meter in the diode test position on the selector switch of the high-Z meter. You can also use the Triplet low-Z meter, such as my model 430 Triplet, which is 20k ohms per volt. Either will work well. Note that some diodes are arranged for negative output and others for positive output. In essence, the diode is connected in a forward or reverse condition to satisfy the polarity required for a particular application. Test for forward and reverse conduction and whether the diode is okay. If the difference between forward and reverse is not great, the diode is blown and needs replacement.

In the local surplus store I found a Bird Termaline wattmeter good to over 1 GHz and calibrated from 5 watts to 150 watts in four settings—5, 15, 50, and 150 watts from 25 to 1000 MHz. However, the crystal diode, which was critical to the meter's operation, was missing. I made a new metallic mount out of brass rod and hobby brass tubing to resemble the missing detector mount. The diode looked like a standard 1N21 to 1N23 diode package, so I tried one. The 1N23 worked, but I could not calibrate the power meter. Trying the 1N21 diode, things were much better and calibration was getting very close. I changed the 1N21 diode to another one I had on hand, and calibration was not needed. It calibrated quite well as is. As a matter of fact, it was still quite good in calibration at 1296 MHz, 300 MHz above rated specs.

Currently I still use the 432 and up power meters for work-bench power measurements. I am lucky to have a full set of power attenuators. They range from 10 to 50 watts good to about 12 GHz, along with several Bird 43 power meters with a few low-power slugs to 2.4 GHz. My latest termination dummy-load acquisition is a Narda 369BMN 7- to 18-GHz 175-watt load. It tested just fine at our local swap meet using the old VOM test. It had been in the hands of another interested person who could not verify that it was good, so he put it back in the seller's box. I picked it up and tested it on the spot with the old Triplet 430 VOM. While it was not a necessary item for me, it has proven its worth as a loaner to others testing their high-power 10-GHz systems.

Don't be left out. To test your bargains, take your VOM and HT to a swap meet. It may save you lots of wasted dollars and extensive repair time. If you have any questions, drop me an e-mail at <clhough@pacbell.net>. ■

CQ's 6 Meter and Satellite WAZ Awards

(As of July 1, 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
65	JH7IFR	2,5,9,10,18,23,34,36,38,40
66	KØSQ	16,17,18,19,20,21,22,23,24,26,28,29,34

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>

50-MHz Long-Path Propagation

This article, excerpted from "50 MHz *F2* Propagation Mechanisms," which was originally published in the *Proceedings* of the 37th Central States VHF Society Conference (July 2003), is reprinted here with permission.

By Jim Kennedy,* KH6/K6MIO

Operation over long distances on 6 meters can be very challenging. The fact that *F*-layer ionospheric propagation is relatively rare provides interesting opportunities to observe some propagation modes in isolation that, while they may occur more often at lower frequencies, are often masked by other propagation modes occurring at the same time. Among the most interesting cases are Transequatorial Propagation (TEP) and two TEP-related beasts—Transpolar Long-Path Propagation (TPL) and Transequatorial Long-Path Propagation (TEL). Under suitable conditions these latter modes can produce spectacular 6-meter openings spanning well over halfway around the world, provided that one is lucky enough to be in the right place at the right time.

Transequatorial Propagation – A Review

TEP is a propagation mode that can allow VHF stations located in the magnetic tropics on one side of the Earth's geomagnetic equator to communicate more or less on a north-south line with similarly placed stations on the other side of the magnetic equator over distances of several thousand kilometers, generally in the afternoon or evening. The ionospheric skip points are located in the *F2* layer near the equator.[1] This effect is very well documented at 50 and 144 MHz, and has occurred less frequently at 222 and even 432 MHz.

The first recognition of this effect on 6 meters appears to have occurred in late August 1947, near the peak of solar Cycle 18.[2] On 25 August, KH6/W7ACS at Pearl Harbor worked VK5KL in Darwin, Australia to set a new 6-meter DX record. Two days later XE1KE in Mexico City worked a stunned LU6DO in Argentina.[3] At about the same time, stations in England and the Netherlands worked stations in Southern Rhodesia and South Africa.[4]

These patterns have been observed repeatedly since then, especially during solar maximum. While a total mystery at first, the basic mechanism began to come into focus as the result of amateur and professional studies, beginning with the International Geophysical Year (1957–58), and it continues to be the subject of study today.

During that time, it has become obvious that stations with the good fortune to be located within about ±40° of the magnetic equator can enjoy rather good propagation, often in the dead of night, with their neighbors on the opposite side of the equator. Notably, this effect occurs for a month or two in the Spring and Fall around the equinoxes, centered on March and October.

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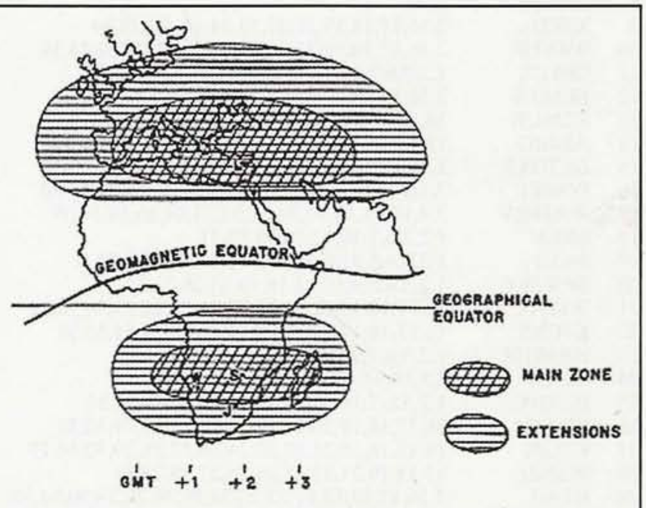

Figure 1. Path footprints for the southern Africa to Mediterranean TEP path, as seen by ZE2JV and 5B4WR in 1958.[4]

Moreover, the paths need not be strictly north-south. Stations in South America and Hawaii work each other frequently, and South American stations often also work into southern Europe. While these stations are indeed on opposite sides of the magnetic equator, there is a very significant east-west component to these paths, in addition to north-south.

Ions and Angles

To understand the causes of TEP (and TPL and TEL) most effectively, one should note that the Maximum Usable Frequency (MUF) on a given path vitally depends on two factors: the ion density (free electrons) in the reflecting layer, and the angle with which the radio wave encounters that layer.

Ionization. When an upward-moving radio wave reaches, say, the *F* layer, the electric field in the wave forces the electrons in that layer into a sympathetic oscillation at the same frequency as the passing wave. The oscillating electrons in the layer can reradiate the upcoming wave downward, like a static reflector. Thus, the wave appears to skip off the ionosphere and then come back to Earth at some distant point.

Since the ionospheric electron density gradually increases with height (up to a point), the skip actually occurs as a more or less gradual bending, or refraction, of the wave back around toward the ground, rather than a discontinuous reflection as from a mirror. For many purposes, however, this subtlety is not too important. We will come back to the refraction concept a little later.

Let's consider the effect of the electron density on a wave taken in isolation from other effects, such as the Earth's magnetic field. To do this, we look at a radio signal being sent straight up. One can calculate the so-called critical frequency, f_c, as the highest frequency at which the ionosphere can reflect the signal straight back down again. This critical frequency[5] is given by:

$$f_c = \sqrt{\frac{Ne^2}{4\pi^2 \varepsilon_0 m}} = \sqrt{N} \times (9 \times 10^{-6}) \quad \text{(in MHz)}$$

where N is the electron number density, e is the electron charge, ε_0 is the permitivity of free space, and m is the mass of the electron. Except for N, everything else has a known constant value.

The point is that the highest frequency that will skip vertically back down is the square root of the electron density times a fixed number. For example, in order to skip a signal at twice the current maximum frequency, the number of electrons must be increased by a factor of four.

What if the signal is sent at some angle other than straight up?

Angle of Attack. To answer the above question, we must add the concept of the angle of attack.[6] This is the angle that the direction of the moving wave makes with respect to the ionospheric layer. In the above example, the wave strikes the ionosphere with an angle of attack of 90° (i.e., going straight up vertically into the horizontal layer). In the more general case, the MUF is determined by both the maximum electron density that the wave encounters in the ionosphere and the angle at which the wave hits the reflecting/refracting layer.

If a signal is sent very near the horizon (e.g., with a zero angle of radiation), because of the curvature of the ionosphere around the Earth, the signal will normally hit the ionosphere at an angle of attack between 10° to 20°, depending on the layer in question. The MUF (represented by f_{max}) can be calculated from:

$$f_{max} = \text{cosec}(\alpha) \times f_c = M\sqrt{N} \times (9 \times 10^{-6}) \quad \text{(in MHz)}$$

where α is the angle of attack. Note the MUF depends on both the electrons and the angle α.

The cosecant of α is called the *M factor*. As the angle gets smaller, the cosecant gets larger. As a result, the smaller the angle of attack, the greater the MUF.

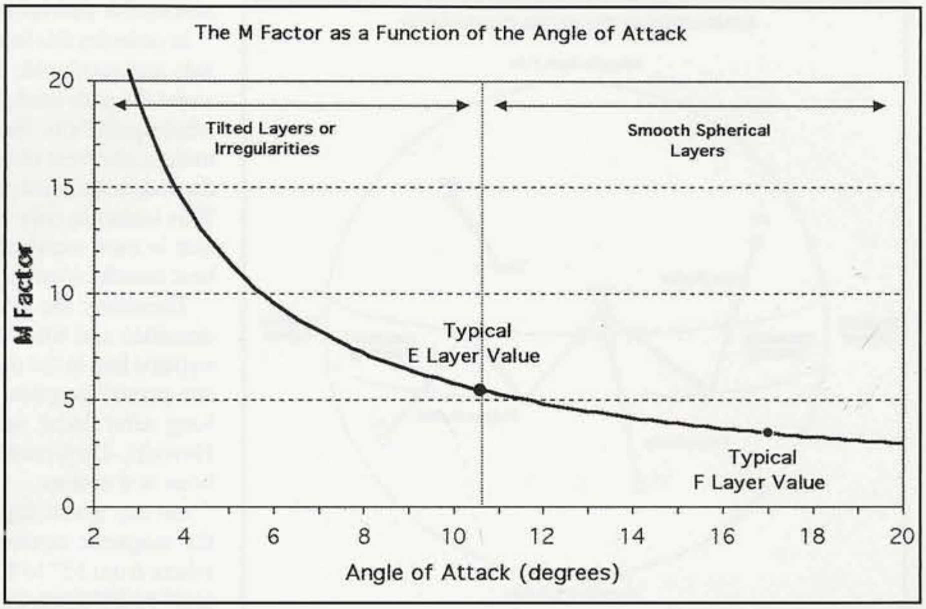

Figure 2. M (cosec α) varies with angle of attack. A smooth spherical ionosphere gives angles between 10° and 20°. Tilted layers can produce lower angles and very exciting results.

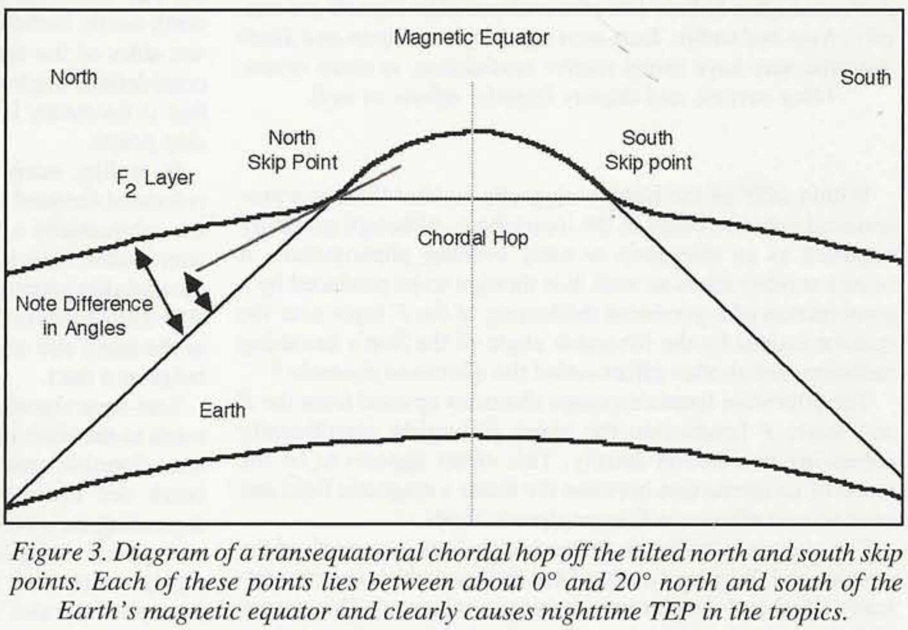

Figure 3. Diagram of a transequatorial chordal hop off the tilted north and south skip points. Each of these points lies between about 0° and 20° north and south of the Earth's magnetic equator and clearly causes nighttime TEP in the tropics.

This is the radio equivalent of skipping stones off the surface of a lake. If you toss a rock into a lake so that it hits the water at a high angle of attack, it will break the surface and sink. However, if it hits the surface at a very shallow angle of attack (grazing incidence), the rock will skip off the surface instead.

In principle, the MUF approaches infinity as the angle of attack approaches zero! However, such small attack angles are geometrically impossible to achieve from a ground-based station "illuminating" a smooth, spherical ionosphere. Under these circumstances, simple geometry would show that M ~ 3.4 at the *F* layer.[7] However, the operative key words here are "smooth" and "spherical"; there is a lot more to say about that.

How Does TEP Work?

It is not uncommon for north-south multi-hop *F*-layer (n*F2*) openings on 6 meters to have no evidence of stations at the end of the first hop. This is often due to an *F*-layer ionospheric bulge along the magnetic equator, known as the *equatorial anomaly*.

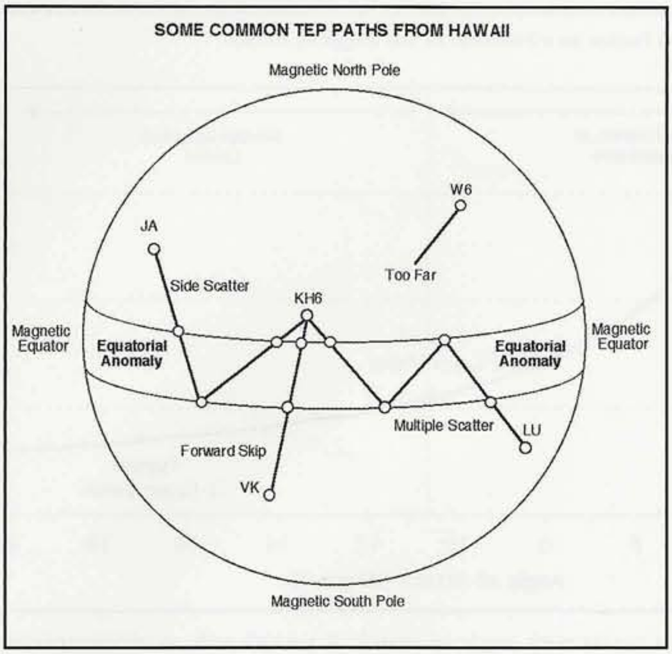

Figure 4. In geomagnetic coordinates, Hawaii is nearly due north of Australia, and these TEP paths transverse north-south paths and often behave like conventional skip. Signals are usually clean and stable. East-west signals from Japan and South America may have heavy scatter modulation, at times resembling aurora, and display Doppler effects as well.

Within ±20° of the Earth's magnetic equator there is a pronounced outward bulge in the ionosphere. Although generally regarded as an afternoon or early evening phenomenon, it occurs at other times as well. It is thought to be produced by a combination of a persistent thickening of the *F* layer near the equator caused by the favorable angle of the Sun's incoming radiation and another effect called the *afternoon fountain.*[8]

The afternoon fountain pumps electrons upward from the *E* and lower *F* layers into the upper *F2* region, significantly enhancing its electron density. This effect appears to be the result of an interaction between the Earth's magnetic field and west-to-east afternoon *E*-layer electric fields.

The equatorial bulge produces two regions, one north of the equator and the other south, where the ionosphere is systematically tilted and the electron density is enhanced. This occurs at the points where the normally spherical ionosphere is bent upward to form the bulge. An upcoming wave will hit the tilted near corner at a shallower angle of attack than it would have with the usual spherical layer. This means that it will have a higher MUF for the same value of electron density. The *M* factor is larger than the nominal 3.4, perhaps by quite a bit.

The wave need not be bent all the way back toward the ground. If it is bent enough to cross the equator and hit the tilted layer on the far side, without coming back to Earth, the second tilted surface may bring it down to Earth again. This skip from one corner of the bulge to another is referred to as a *chordal hop*. It will produce a much higher MUF than a traditional skip point.[9]

Since it really represents an *F2*-layer "hop and a half," the distance between endpoints can be a good deal greater than 5,000 km. It is also a low-loss path. Since the wave doesn't come down at the midpoint, it avoids two passes of *D*-layer absorption that normal double hop would have encountered.

In order for this form of propagation to function, both the north-side and south-side tilted regions need to be ionized enough to make the path work. If either one is insufficient to skip, then the whole path fails. Because there is little ionization margin at 6 meters, the best chance for this to occur is when both sides of the magnetic equator are illuminated equally by solar radiation. This situation only occurs around the two equinoxes when the Sun is most nearly directly over the equator. As observed, the best months seem to be March and October.

Therefore, the afternoon fountain causes enhanced electron densities and tilted layers to form within 20° of the magnetic equator late in the day or early in the evening. These conditions can persist long into the night, with some contacts taking place long after local midnight (common for South America to Hawaii). They readily provide near grazing-incidence chordal hops at 6 meters.

On any given day the bulge may not be exactly centered on the magnetic equator. Typically, the two corners will be anywhere from 15° to 40° apart, and each will be somewhere within 0° to 20° from the equator on its respective side. In order to access these skip points, the stations must be within one-half *F* hop of the nearest corner; this is the *TEP zone.*

As noted, for operators who have the good fortune to be in the TEP zone, the paths themselves do not have to be strictly north-south. In the simplest case, the two stations are on opposite sides of the magnetic equator, although they can be at a considerable angle to the north-south line, as noted earlier. All that is necessary is that the two corners be at usable chordal skip points.

In reality, many contacts made using TEP are a form of enhanced forward scatter, or even side scatter. If the stations are substantially east or west of one another (in geomagnetic coordinates) their signals will enter the region between the two chordal skip points at a considerable angle to a north-south line. When this happens, the signals may bounce back and forth within the north and south walls of the equatorial bulge, using the bulge as a duct.

East-west signals can be thought of as zigzagging north and south in the short term, but generally moving along in an east-west direction under the bulge until they find a weak point and break out. From there, they may go either north or south, depending on which side they find the "door" out.

A typical example of across-the-equator TEP is the nighttime pipeline that often exists between Hawaii and Australia (for example, Hilo and Townsville). Geomagnetically, this is nearly a north-south path. Usually signals are pretty clean and quite strong (50 watts; a long wire will do). On the other hand, it is not that uncommon for Hawaiians to hear Japan at the same time—and on the same beam headings as Australia—on what sounds like backscatter. Japan and Hawaii are on the same side of the equator and mostly east-west of one another.

Finally, propagation across the equator, but largely along the equatorial anomaly, can produce very strong signals, such as the link between Hawaii and South America. However, these signals can be strongly distorted, indicating significant scattering within the duct.

Cycle 23 Long-Path Observations

The peak years of solar Cycle 23 offered a number of opportunities to observe long-path propagation at 50 MHz. The mate-

Reporting	Working To:	Contacts
S79MXU	South Pacific	1
KH8/NØJL	Africa, Middle East	2
8R1/W7XU	Indonesia, Indian Ocean	3
FY/W7XU	Australia, Australian Maritimes	8
FO5RA	Africa, India, Middle East	10
CEØY/W7XU	India, Indonesia	11
9G/W7XU	Japan, Philippines	>30
KH6/K6MIO	Europe, Africa, Middle East	249

Table I. Sources of Data Used in the Study 1999–2002

rial that follows is the result of the analysis of more than 314 contacts and their accompanying temporal, geographic, geomagnetic, ionospheric, and solar circumstances. Table I shows the contributors to the data and the general areas into which they worked.

Initially, these reported contacts all were thought to be long-path contacts by the reporting stations. However, each report was carefully reviewed as to beam headings and endpoint separations in an effort to discern whether they were, in fact, long-path circuits. It became apparent that the contacts fell into one of three categories: long path via one of the Poles (TPL), long path via the magnetic equator (TEL), and short path via the magnetic equator (although over quite long distances). TPL was by far the most common of the three effects.

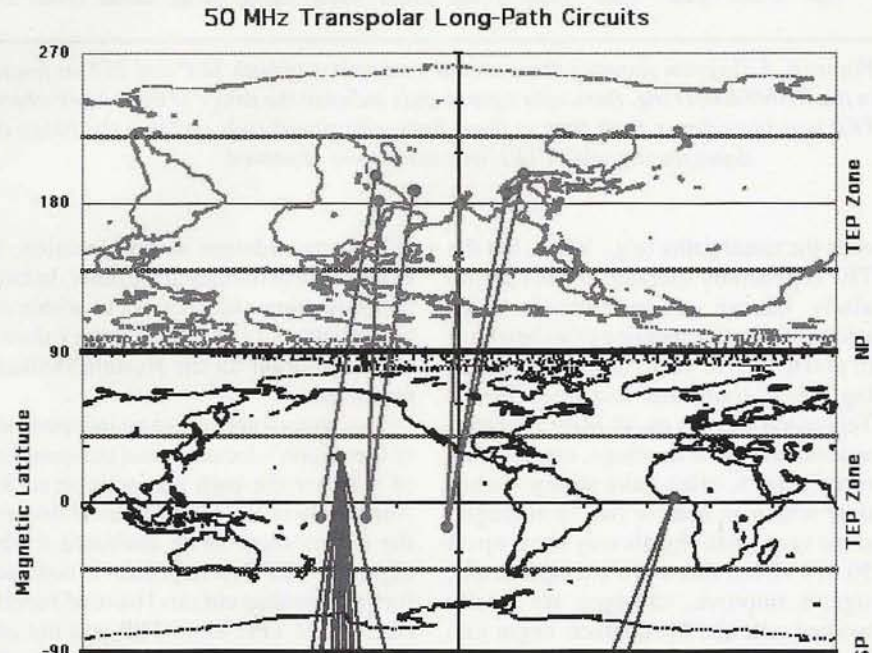

Figure 5. A world map in magnetic coordinates which shows 36 typical TPL contacts made in 2000–2002. The middle third shows the reporting stations; the upper third, the stations worked over the North Pole; and the bottom third, the stations worked over the South Pole. The curly lines in each third represent the approximate limits of the TEP zone. The map projection distorts the actual signal path between the respective stations, especially near the Poles. However, it accurately shows the endpoint relationships.

Sampling in Time

Before proceeding, some caveats are in order. The data about to be presented do not represent a controlled scientific experiment. For example, the stations at both ends of the various circuits were not all operational 24 hours a day, seven days a week. Events, or the lack of events, were not observed. Another factor is that the events all occurred during the peak years of the cycle, so one cannot logically infer conditions during other phases of the solar cycle.

Landmasses and Populations

The Earth is mostly covered with water. Given the long-path distances and what appear to be constraints on the propagation directions relative to a station, there may not be any stations available for some, otherwise technically possible, paths. Likewise, even on the world's actual landmasses, there is not a uniform distribution of amateur stations. Both of these facts will affect the sampling statistics, and the conclusions must be viewed in light of these limitations.

TPL—Really Stepping Out

Late in the evening on 9 October 1988, on the rapidly rising leading edge of Cycle 22, a 6-meter station in Greece (SV1DH, using the special 6-meter call, SZ2DH) worked a station in Japan, (JG2BRI). What was especially amazing was that it was nearly midnight in Greece and SV1DH was beaming southwest, away from Japan, toward the southern reaches of South America. The Japanese station was beaming southeast, at the other side of the south end of South America.

The two stations completed a nearly 31,000-km long-path contact from north of the magnetic equator southward, encroaching on the Antarctic near the South Pole, and then back north across the magnetic equator again and landing in Japan. The actual signal traveled about three-quarters of the way around the world![10, 11]

Now where did that come from? While perhaps not the first transpolar 6-meter long-path contact, this example demonstrates the profound propagation effects that can occur. One plausible answer points back to the power of grazing-incidence reflections.

Looking at 2000–2002

The peak years of Cycle 23 provided a number of TPL openings to the delight of operators in southern Europe, Africa, the Middle East, India, Hawaii, equatorial South Pacific, and elsewhere.

Perhaps the most widely known, if only because of the number of contacts made, were the series Spring and Fall openings in 2000, 2001, and 2002 between Hawaii and the Mediterranean and southern Europe—over the South Pole. However, during this same period of time there were many other contacts taking place in other parts of the world. These included contacts between Ghana and Japan/Philippines (South Pole), and Easter Island and India/Indonesia (North Pole), Tahiti and the Seychelles/Ethiopia (North Pole).

Figure 5 shows the relationship of the path endpoints for a sample of these contacts. The map is in geomagnetic coordinates rather than geographic coordinates. The map consists of three "Earths." The central one represents the location of the reporting station, while the upper one represents the corresponding station for contacts over the North Pole, and the lower one represents the corresponding stations for contacts over the South Pole.[12] Notice that all the stations, at both ends of each circuit, are in the TEP Zone.[13]

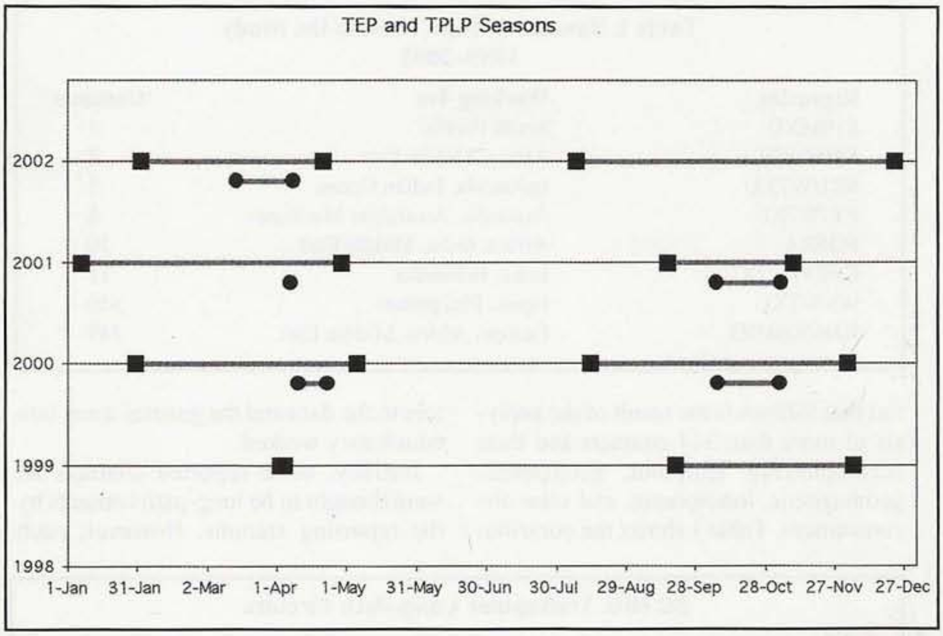

Figure 6. A diagram showing the seasonal occurrence of both TEP and TPL as found in the KH6/K6MIO log. Bars with square ends indicate the range of dates over which TEP was in evidence from time to time. Bars with round ends indicate the range of dates during which TPL was sometimes observed.

Time of Year

Figure 6 shows a comparison of the seasonal occurrences of both TEP and TPL. There well may be other instances that occurred but were not observed at that station.

The seasonal effects appear to be essentially the same for TEP and TPL, near the equinoxes, centered on March and October.

Time of Day and The Presence of TEP

A typical Hawaiian TPL opening occurs near solar cycle maximum on an evening when TEP is already in evidence over the usual paths (e.g., VK4), but the TEP is generally sporadic and not particularly intense or widespread. Quite strong backscatter coming from headings of about 195° is very common, suggesting lots of ionization and tilted layers. Television carriers on 48 MHz are heard at about the same headings, usually with many offsets, often quite strong. Sometime within an hour or two of midnight, some very weak signals may show up on 50.110 MHz. After a few attempted calls, signals improve, callsigns are finally worked out, and the contacts begin into southern Europe.

Usually signals are very weak, and high power is quite helpful. However, on a few occasions signals are enormous (e.g., 50 watts to an indoor wire dipole in Portugal working Hawaii), and even QRP is possible.

Examination of the Hawaii and other data shows that there is a clear correlation between the occurrence of the contacts and station's the Local Solar Time (LST). This is particularly in evidence when one calculates the actual solar time at the latitude and longitude of the stations involved, and not just the time held by clocks in the entire time zone.

On the nighttime side they occur within an hour or two of local midnight. Since the paths extend more than halfway around the world, one would expect that if it were midnight at one location, it would be near midday at the other. In fact, on the daytime side they occur within an hour or two of 11:00 LST. Figure 7 shows the distribution for the Hawaii-Mediterranean path.

This pattern appears to be independent of the station's location, and independent of whether the path has gone over the North Pole or the South Pole. However, the events seem to be anchored in the nighttime TEP. It is important to note that for the Hawaiian circuits I have no reported cases of TPL when TEP was not actively present around the time of the nighttime side opening.

While it was not uncommon to hear a few Australian stations coming into Hawaii before, after, and occasionally during TPL, the Australians were not hearing the Europeans at all, to their frustration. Interestingly, the same was true for stations in New Zealand and the South Pacific.

Except for normal TEP stations on the other side of the equator (who were not hearing the TPL), during the Hawaiian openings I did not observe a single instance of signals from any intermediate point, despite the fact that the signals traveled the equivalent of many F-layer hops. The TPL did not appear to have come down to Earth anywhere between the two endpoints.

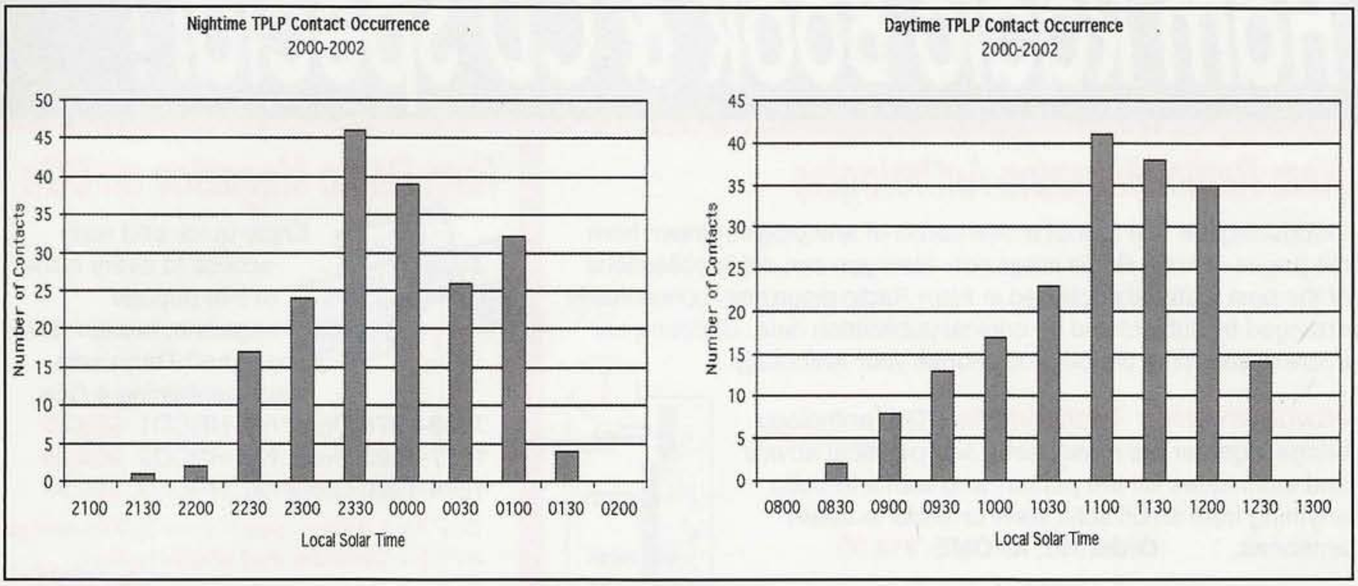

Figure 7. This frequency of occurrence histogram estimates the likelihood of TPL as a function of time of day. The average time on the nighttime side is 23:51 LST, and on the daytime side it is 11:01 LST. Local solar time is the actual solar time at the station, not the Time-Zone clock time.

It would be proper to ask whether the Hawaiian contacts were only made at night . . . well, not quite. All of the contacts except three were at night. During the daylight hours there were two contacts with Oman and one with Italy, all made at about 08:30 LST on various dates. These three were all on east-of-south headings, rather than on the nighttime west-of-south headings, but more on this in the next section.

On the nighttime side the propagation always occurred in the latter part of the typical period for evening TEP, and some TEP was in evidence.

Antenna Headings

While the expression "over the Poles" has been used frequently in this article, it is really shorthand for "near the Poles." The real poles of interest here are probably the geomagnetic poles, rather than the geographic ones. The geographic and magnetic poles are offset by about 11° of latitude.

In the Hawaiian openings, the nighttime openings were almost always close to the long-path Great Circle headings to Europe. These headings are about 15–20° west of south. Signals traveling on these Great Circles will reach about 70°S geographically before heading north. This takes the path very close to the South Magnetic Pole (65°S, 139°E geographic, in 1988).

The observed Hawaiian morning openings had headings of about 160°, again quite close to the expected Great Circle route for Oman[14], about 20° east of south. It was tempting to conclude that nighttime openings systematically went somewhat west of south, and daytime openings went somewhat east of south. Comparing these observations with the data from stations in other parts of the world, the indications are that the characteristics seen in Hawaii were typical.

All the TPL contacts reported occurred such that the daytime station was always beaming somewhat east of the Pole, and the nighttime station somewhat west of the Pole. Notwithstanding, the Hawaii log reveals that during a number of the nighttime openings strong 48-MHz TV carriers were heard from the 160° heading, but no stations appeared to be present (there are very few in that part of the world, and it was well into the work day). It is possible that this east versus west phenomenon was just a result of the landmass and population effect.

Although the observed headings seem to vary little, nevertheless, a few stations whose Great Circle bearings deviated from the above headings by as much as 30° were worked. It is not clear whether in the heat of rapid-fire DX exchanges the antenna heading could have improved the signal if adjusted, or if "steering" of the signal was occurring in the ionosphere, with modest Great Circle deviations. I suspect the answer is that a combination of both was happening. Certainly, when signals were "good enough," the tendency was to work what was there. On the other hand, there was at least one unusually intense opening where I found the "best" heading started at 200° but swung as far east as 170° and then back again. During this excursion there was no clear difference in the geographical location of the stations being heard. That is, it was not obvious that the footprint was changing significantly at the same time.

Generally, the paths involve offsets from north or south, but not more than about 20°.

The Path Footprint

The characteristics of the path footprint are shown by the latitude and longitude changes that occur between the location of one station and the other. Table II shows the average change in latitude and longitude with respect to the reporting station, along with some measures of variability. On the right there are 14 North Polar contacts based on several reporting stations and paths, and on the left there are 234 contacts (all the Hawaii-Europe path), where at least the grid squares of both stations—and hence the approximate endpoint latitudes and longitudes—could be known.

Both longitude tables are in good agreement with the average change being in the 193° to 197° range. They also agree very well regarding the longitude range about the average. Both show a standard deviation of 10° and quite similar values for the minimums and maximums. The

Table II. TPL Footprints Relative to the Reporting Station 2000–2002

	North-Polar Paths		South-Polar Paths	
	Contacts = 14		Contacts = 234	
	Lat (deg)	**Lon** (deg)	**Lat** (deg)	**Lon** (deg)
Average Change	196	194	242	193
Standard Deviation	6	11	4	10
Minimum	188	187	233	166
Maximum	214	216	250	222

center of the "other-end" footprint would be about 194° of longitude away, with a core footprint width of ±10°, with some endpoints as far as ±30° from the center.

The latitude changes between the two tables are a different story. Here we see a difference of almost 50° between the averages, although the standard deviations are very similar. One notes that compared to the South Pole there were very few North Polar contacts. Figure 5 suggests a possible explanation for both the number of contacts and the latitude differences—the landmass/population question. If the North Polar paths do have the same range of latitude changes as the South Polar paths, the footprints of the observed North Polar paths would fall mostly in the Indian Ocean, with few stations to work and badly skewed statistics.

Footprint Changes in Time. There was some question as to whether there was any systematic trend in the center of the footprint as a function of time, either during a given opening or during the season. The results were inconclusive. Although there are some weak indications of trends in the footprint center during a single night's operation, there was no consistent pattern from night to night, nor with the progression of the season.

Solar-Terrestrial Conditions

It is clear that solar activity and geomagnetic activity have an important effect on the occurrence of TPL. A careful examination of these conditions during all the reported TPL episodes confirmed the anecdotal information that a quiet geomagnetic field, in the presence of elevated solar activity, apparently is essential.

Comparisons were made to several geomagnetic parameters, and the conclusion was that TPL seems to be sensitive to all of them, as shown by the Figure 8 analysis of the KH6/K6MIO data, using the number of contacts in a given opening as a measure of propagation "quality." TPL appears to be most sensitive to the high-latitude (polar) *K* index, where $K_{hi} = 0$ was the dominant value for the South Polar path. The planetary *K* index, K_p, was also low, but the propagation was tolerant of somewhat higher values (averaging about 1). 94% of the Hawaii contacts were made while $K_{hi} = 0$. In every case, K_{hi} and K_p were 3 or less.

The daily 10-cm flux ranged from 141 to 229, with an average of 181. However, the smoothed flux was confined to the rather narrower range of 168 to 196. 37% of the contacts occurred with daily fluxes between 141 and 188. As with other forms of *F2* propagation, elevated smoothed values (168–196) seem more significant than the daily values.

Although not shown here, the same analysis of the Solar Polar contacts from Ghana to Japan and the Philippines looks almost identical to the Hawaii data.

As with the statistics for the path footprints, the 14 North Polar contacts in the data are anomalous. As with the South Polar paths, the K_{hi} indices were about one point less than the K_p indices. However, the median K_{hi} was 2, with a number of contacts made at 4. The mean solar flux value was 229. It must be taken into account that there really is very little data in this case (14 contacts, versus over 220 for the South Polar case), which may have skewed the statistics. In addition, the indications are that the 14 contacts correspond to the "edges" of the nominal footprint, rather than the center.

The TEP Connection

There is strong evidence to support the proposition that there is an essential connection between TEP and TPL:

1. TPL stations at both ends of the circuits are in the TEP zone.

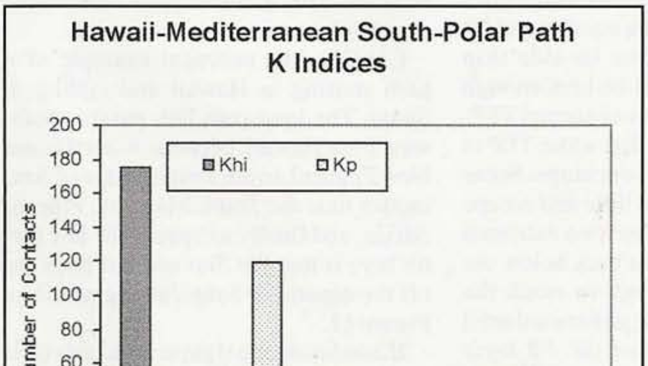

Figure 8a. The South-Polar TPL appears to require very quiet polar magnetic conditions and fairly quiet global conditions.

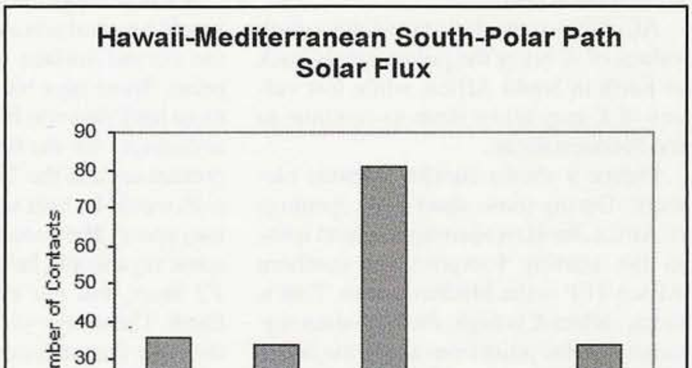

Figure 8b. Although favoring solar flux around 195, TPL appears to be fairly insensitive to the exact flux, occurring throughout the 150–250 range.

2. The TPL equinox seasonal effect is the same as TEP, principally March and October.

3. TPL normally seems to occur only when there is some evidence that TEP is present.

An additional piece of evidence is seen in Figure 9, which shows that the TPL Mediterranean footprint from Hawaii is also an excellent match to the TEP Mediterranean footprint from southern Africa. Note that the Great Circle path coming from Hawaii goes north from South Africa and slightly west.

The Hawaiian TPL signals came down in just the right spot to suggest that the last hop was actually TEP!

Table III. Summary of Conditions for TPL and TEL
Season: March ±1 mo. and October ±1 mo.

	Transpolar Long Path		Transequatorial Long Path	
***K* Index**	$K_{hi}, K_p \leq 2$		$K_{mid} \leq 3, K_p \leq 4$	
Solar Flux (10 cm)	Daily ≥ 150	Smooth ≥ 165	Daily ≥ 175	Smooth ≥ 165
Station Location (in the TEP Zone)	North of M. Eq.	South of M. Eq.	North of M. Eq.	South of M. Eq.
Daytime End	1100 LST ±2 hrs.		0730 LST ±1.5 hrs.	
Antenna Heading	SSE 160° ±20°	NNE 020° ±20°	ESE 120° ±20°	ENE 060° ±20°
Nighttime End	0000 LST ±2 hrs.		2030 LST ±1 hr.	
Antenna Heading	SSW 200°±20°	NNW 340°±20°	WSW 240°±20°	WNW 300°±20°

Close, But No Cigar

It is interesting to note that there were a few short openings between Hawaii and South Africa in 1999 and 2000. South Africa is almost exactly halfway around the world from Hawaii, and it is on the same Great Circle as the TPL path from Hawaii to Mediterranean Europe.

Like TPL, the openings occurred during the solar-cycle-peak years, with comparable solar-flux levels during the TEP season, when some TEP is present. However, unlike TPL, the *K* indices were systematically 4 or higher. This appears to be some form of propagation between TEP and TPL. It is much too far to be normal TEP. On the other hand, although the path crosses through the South Magnetic Polar region, it is not TPL. It is not long path of any kind, because it is a few hundred kilometers short of the halfway point around the world.

All of this suggests that medium to high values of *K* bring the polar signals back to Earth in South Africa, while low values of *K* may allow them to continue to the Mediterranean.

Figure 9 shows another curious element. During these short-path openings to Africa, the Hawaiian signals land within the starting footprint for southern Africa TEP to the Mediterranean. That is to say, when *K* is high, the Hawaiian signals end at the point from which the South African signals start, on their way to Mediterranean TEP. When *K* is low, however, these signals seem to pass by South Africa and land where the South African TEP lands—in the Mediterranean basin.

This latter point, together with the observation that TPL does not appear to come down to Earth anywhere between the two endpoints, suggests that the Hawaii-South Africa path and the Hawaiian TPL signals have crossed the South Magnetic Polar region at about the same point. In the first case, they were directed downward, and in the second case, they were directed to (another) chordal hop.

How Might TPL Work?

Consider the following scenario. Suppose that it is during the Spring or Fall equinox period, and that TEP is present. An upcoming wave from a transmitter within the TEP zone illuminates a range of the curved surface on the nearside TEP skip point. That wave is deflected, not at a single angle, but over a range of vertical angles as shown in Figure 10 (based on the technically more correct refraction model for skip).

A whole range of rays at various angles would proceed across the equator and hit the curved surface at the far-side skip point. Some rays would be bent enough to go back down to Earth as normal TEP, accounting for the fact that some TEP is present around the TPL openings. Some rays would be bent very little and escape into space. Between these two extremes some rays would be bent back below the *F2* layer, but not enough to reach the Earth. These rays would go forward until they hit the underside of the *F2* layer again, taking what is now a second, high-MUF chordal hop.

The significant point is that the chordal hop from the equatorial anomaly has injected a fraction of the signal energy into the ionosphere at such a shallow angle that even in the case of a smooth spherical ionosphere, the wave may now continue skipping around the Earth in a series of high-MUF chordal hops. In a smooth, spherical ionosphere this signal would be trapped forever in a series of grazing incidence hops, never returning to Earth. In reality, however, it eventually will encounter the equatorial anomaly on the other side of the Earth. There, the "injection" process could be reversed and a fraction of the arriving signal sent back down to Earth on the far side of the magnetic equator, as if it were TEP, but from very far away. This would mean that stations on the north side of the equator could communicate over the South-Polar region with stations north of the equator on the other side of the Earth. Stations south of the equator could communicate over the North-Polar region with other stations south of the equator on the other side.

Figure 10 also explains why the station on the right hears both TEP and TPL, and the TEP station on the left does not hear the TPL at all; it goes completely overhead.

Consider the practical example of a path starting in Hawaii and ending in Spain. The long-path link passes southwest from Hawaii, between Australia and New Zealand, to the western edge of Antarctica near the South Magnetic Pole, to Africa, and finally to Spain. The key factor here is that the first and last hops are off the equatorial bulge, as suggested by Figure 11.

If conditions are right at both ends (and in the middle), the chordal hop can be shallow enough such that when bouncing off the southern edge of the anomaly, it never comes down to Earth. Instead, it continues to bounce like a rock skipping across a lake as the curving ionosphere keeps coming back to meet it again.

If the same conditions seen south of Hawaii also exist at the magnetic equator over northern Africa, the shallow

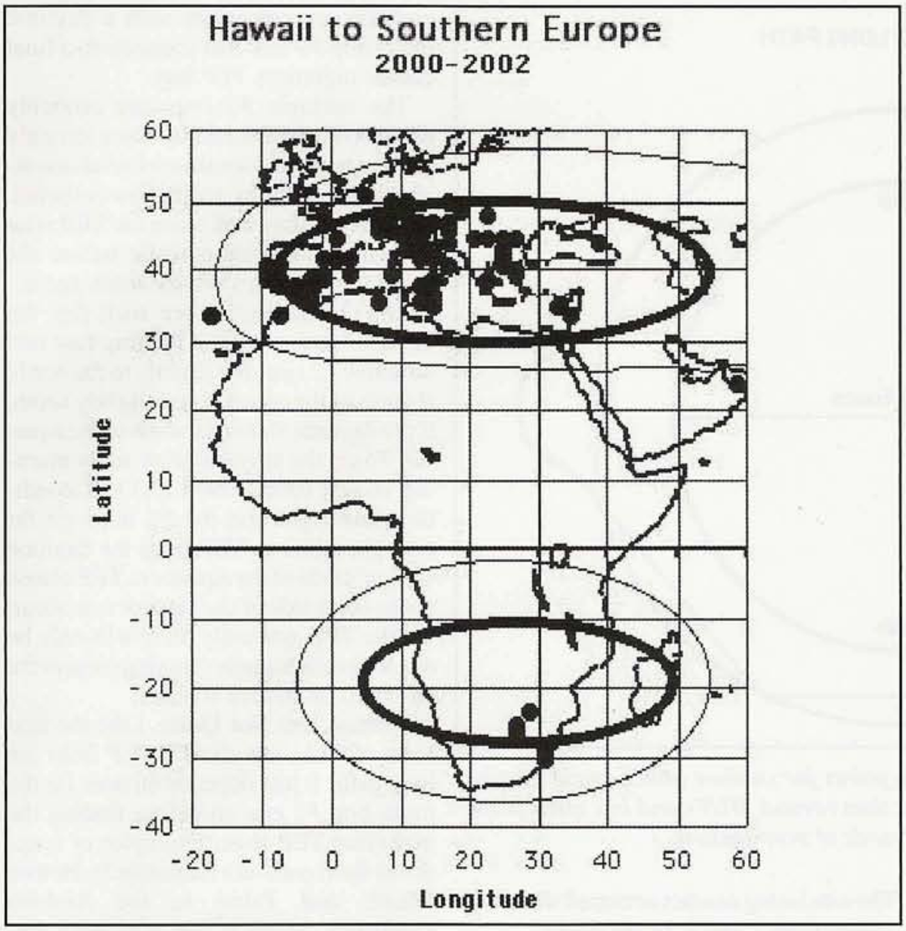

Figure 9. The footprints of the Hawaii TPL to the Mediterranean, and the non-long-path South Africa contacts. Dots show the Hawaii contacts. The ovals are the figure 1 TEP footprints for the south African-Mediterranean path. These strongly suggest that both Hawaii propagation forms are related to some kind of TEP insertion or launching effect.

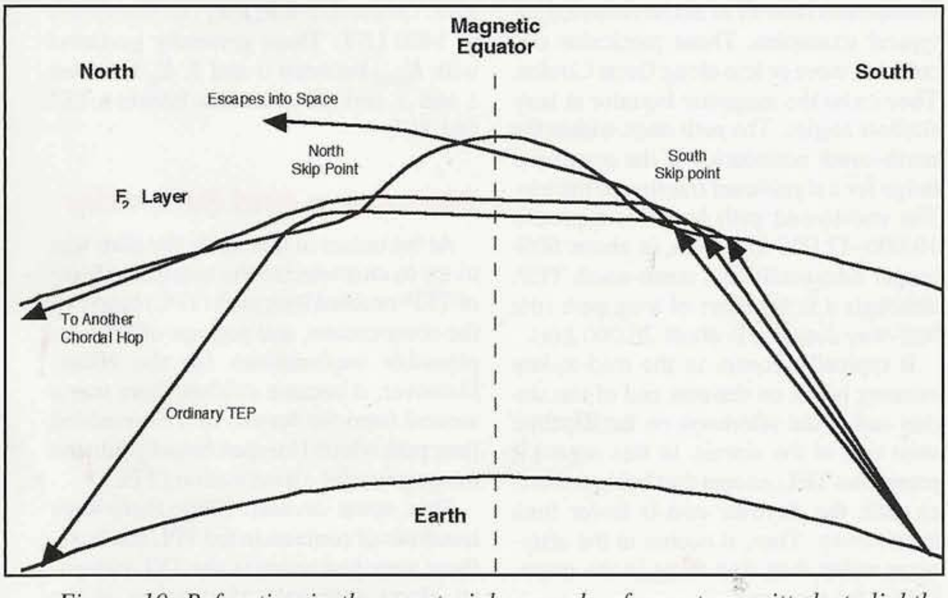

Figure 10. Refraction in the equatorial anomaly of rays transmitted at slightly different angles can lead to some parts of the signal escaping from the F2 *layer, or returning as TEP, or being injected at small angle of attack to produce further chordal hops.*

skipping wave finally will be bounced down out of the ionosphere by the northern edge of the bulge, landing in Spain. Since there is little *D*-layer absorption and the MUFs are very high because of the angle, the long path is actually possible, while the short path, with its entirely traditional earth-sky-earth hops, is completely out of the question.

Other Possibilities. This picture is probably over simplified and does not contain all of nature's subtleties. There well may be other things thrown in that could be puzzling. For example, there are known *F2*-layer tilts near the magnetic North and South Poles in the vicinity of geographic latitude 70°to 80° that may play a role in getting the signal across the Pole.[15] There may be bumps that look a lot like the TEP bulge, but on a smaller scale. These could pass a chordal hop through the Polar region.

It is also true that near the equinoxes the signals cross the day/night terminator (the grey line) near the South Pole at nearly right angles, where there are also tilts created by the day/night transition. Any or all of the above effects may play a role.

Another related possibility is that the trip over the Pole may be the result of ducting effects, such as a radio frequency "whispering gallery."[16]

Transequatorial Long Path, Another Way To Go Far

In addition to TPL, there is at least one other kind of long path. This phenomenon occurs more or less along the equator and is called Transequatorial Long Path (TEL).

In April 2000, a station in American Samoa (KH8/NØJL) beaming east contacted a station in Jordan at 0700 LST. A few months later in October 2000 between 0600–0800 LST, a station in French Guiana (W7XU), also beaming east, worked a number of Australian stations in Queensland and the Northern Territories. The later contacts happened during a time when there was a daytime *F2* opening from French Guiana to Europe and the Mediterranean. The beam headings were 045° toward southern Europe.

Samoa, Jordan, French Guiana, and Queensland/Northern Territories are all in the TEP zone, but the Great Circle routes were not transpolar at all. In both cases, the mostly eastbound signals from the west stayed in the TEP zone and crossed the magnetic equator once into darkness, landing at the other end of the

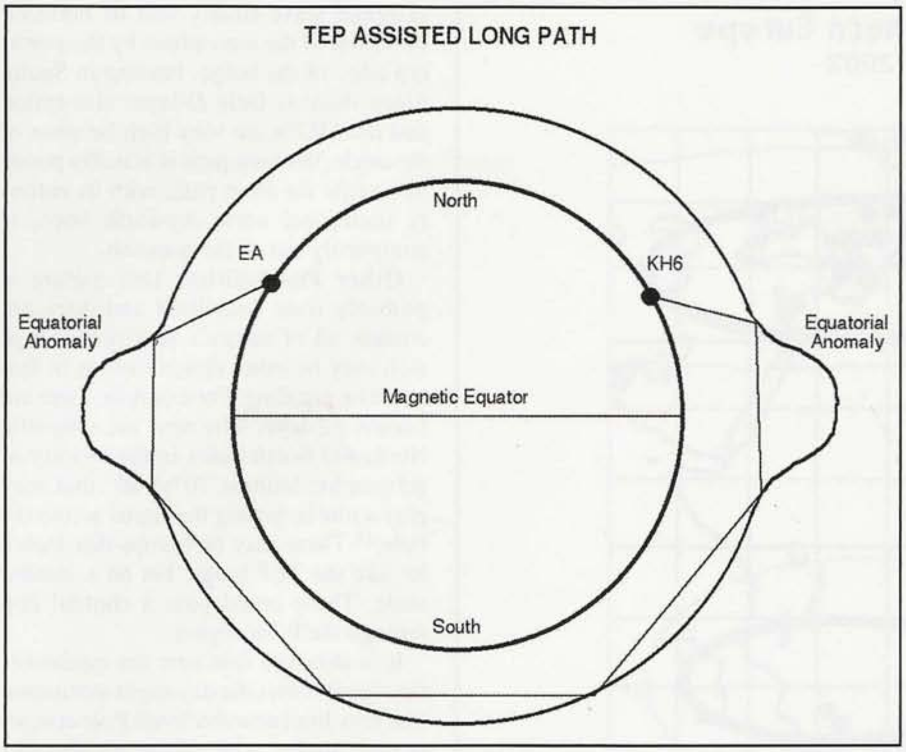

Figure 11. TEP can provide the launching points for shallow attack-angle grazing hops that cover long distances, with higher than normal MUFs and low absorption. At such times, long path can be a superior mode of propagation.

circuit between about 2000–2100 LST. All the contacts were definitely long path, traversing longitudinal distances of 190° to 206°.

Time of Day. Because the path was between a daytime station on the west working east to a nighttime station, where the nighttime path was apparently provided by normal TEP, one would expect to see a normal TEP time-of-day pattern for the nighttime station. Figure 13 shows that this is very much the case for the seven identified TEL contacts.

For the daytime side, the requirement is really that the station be far enough west that the contact actually stretches more than halfway around the world (or else it would not be classified as long path). Thus, one would need at least a 12-hour time change.

If the nighttime pattern is early evening, then the daytime pattern must be early in the daylight hours. Figure 13 shows that this is indeed the case, with most of the contact times clustering around 0700 LST.

Solar-Terrestrial Conditions. There were only seven instances of true TEL in the data. Generally, the K indices were much higher than for TPL. Six of these contacts occurred when the mid-latitude index, K_{mid}, equaled 3 and K_p equaled 4. The remaining contact occurred when the values were 1 and 2, respectively.

How Does TEL Work? Evidence suggests that there may actually be two different mechanisms at work here. In the first case, as in the discussion of Figure 4, fairly long east-west TEP is quite common. The paths from South America to Europe and Hawaii to South America are typical examples. These particular circuits are more or less along Great Circles. They cross the magnetic Equator at very shallow angles. The path stays within the north-south boundaries of the equatorial bulge for a significant fraction of the trip. The end-to-end path length is typically 10,000–12,000 km. This is about 60% longer than traditional north-south TEP, although it is far short of long path (the half-way distance is about 20,000 km).

It typically occurs in the mid-to-late evening hours on the east end of the circuit and in the afternoon on the daytime west end of the circuit. In this regard it resembles TEL, except that being a shorter path, the daytime end is fewer time zones away. Thus, it occurs in the afternoon rather than first thing in the morning on the west end.

It is entirely possible that some TEL is an extreme case, this same east-west TEP effect. On the other hand, some of the contacts are consistent with a daytime multi-hop *F2* link that connects to a final classic nighttime TEP hop.

The multiple *F2* hops are probably enhanced by the normally more strongly ionized north and south equatorial-anomaly ridges as the signal moves eastward. However, it may well leave the TEP zone altogether for a short while before the Great Circle brings it back south again.

The characteristics are such that the daytime station will be looking east into an active *F2* opening slightly to the north, if north of the equator, and slightly south, if the daytime station is south of the equator. To get the longest throw, early morning is best (0600–0900 LST). If conditions are right and the *F2* hops go far enough, a link to TEP from the daytime station's side of the equator to TEP across to the other side of the equator can occur. Unlike TPL, normally there will only be one magnetic equator crossing (nearer the eastward, nighttime station).

Almost, but Not Quite. Like the first form of TEL, not all n*F2*-TEP links are long path. It just depends on how far the multi-hop *F2* can go before finding the nighttime TEP zone. Examples of long-throw short paths are Hawaii to St. Helena Island, and Tahiti to the Arabian Peninsula, which is not long path, but probably the same propagation mode.

Altogether there were 18 cases of very-long short-path contacts linking to TEP one way or the other, very much like TEL, but not long enough. The contact times on the night side ran from 2000 to 0000 LST. On the day side, they ran from 0900 to 1400 LST. These generally occurred with K_{mid} between 0 and 3, K_p between 1 and 3, and the solar flux between 157 and 217.

Discussion and Summary

At the outset of this study the plan was to try to characterize the transpolar form of TEP-enabled long path (TPL) based on the observations, and perhaps offer some plausible explanations for the effect. However, it became evident there was a second form (or forms) of TEP-enabled long path which I lumped broadly into the transequatorial classification (TEL).

First, some caveats: While there were hundreds of contacts in the TPL database, there were just seven in the TEL category, along with only 18 contacts in the apparently related long-reach short-path mode. As a result of the small number of samples in the TEL data, one should be cautious about drawing very strong conclusions about its characteristics.

There were only 14 contacts for the North-Polar TPL case. As a consequence, there may be too few to describe the statistics of the effect. There are also significant landmass effects. North-Polar TPL connects stations in the magnetic Southern Hemisphere with stations on the other side of the Earth, but also in the magnetic Southern Hemisphere. The problem is that to a much higher degree than the Northern Hemisphere, the Southern Hemisphere is mostly water! Therefore, the spatial distributions of the expected footprints are not well sampled either.

TPL

The TPL contacts noted in 2000–2002 occurred between stations that were both in the TEP zone, essentially on the same side of the magnetic equator. It appeared as if they were working TEP across the equatorial anomaly, except that they were linked to one another on the far side of the equator by a very long-range propagation mechanism that involved a more or less Great-Circle path near one of the Poles.

The observational evidence is generally consistent with a model calling for the TEP mechanism to inject a portion of the upcoming signals into shallow angle-of-attack chordal hops on the far side of the equator. However, this really is not certain. For example, the day-night terminator for these paths was being crossed at nearly right angles in the vicinity of the respective Pole. It is possible that a greyline hop may have played a role there. Such a picture calls for enough ionization at the day side of the anomaly to allow some form of morning TEP.

Another issue is the conditions on the daytime side of the circuit. Morning TEP is not very common at all, but one should consider Figure 10, with the signals traveling in the opposite direction. In this picture, the incoming day-side wave is arriving from a chordal hop, not the Earth's surface. Thus, it needs a much shallower refraction angle to get back to Earth than a normal TEP signal. Thus, the day-side electron density would not have to be at the higher night-side levels in order to redirect the signal back to Earth. In any case, this requires the coincidence of favorable conditions over a very long path, and it is no surprise that it is relatively rare.

Where Can You Get TPL? This is a matter of looking at where paths start, where they end, and then asking whether there will be anyone there at the other end of the path. The experience is that both stations must be in the TEP zone. Generally, the paths involve offsets from true north or true south, but not more than about 20°. The center of the "other-end" footprint would be about 194° of longitude away (east or west), with a total width of ±30°. The latitude change can range from about 190° to 240° on centers with a range of ±15° or so.

If one takes a look at the world map in Figure 5 and picks a proposed starting location in the TEP zone in the central "Earth," then the possible TPL path options would be those areas in a wedge about ±30° from the same magnetic longitude in the upper or lower Earth, between the TEP-zone lines. One should be looking at paths that cross the magnetic equator near the starting station and again near the ending station.

North-Polar TPL Route. Recalling that this is a Southern Hemisphere to Southern Hemisphere path, a look at Figure 5 will show that the only significant landmasses in the southern TEP zone are Australia and the southern

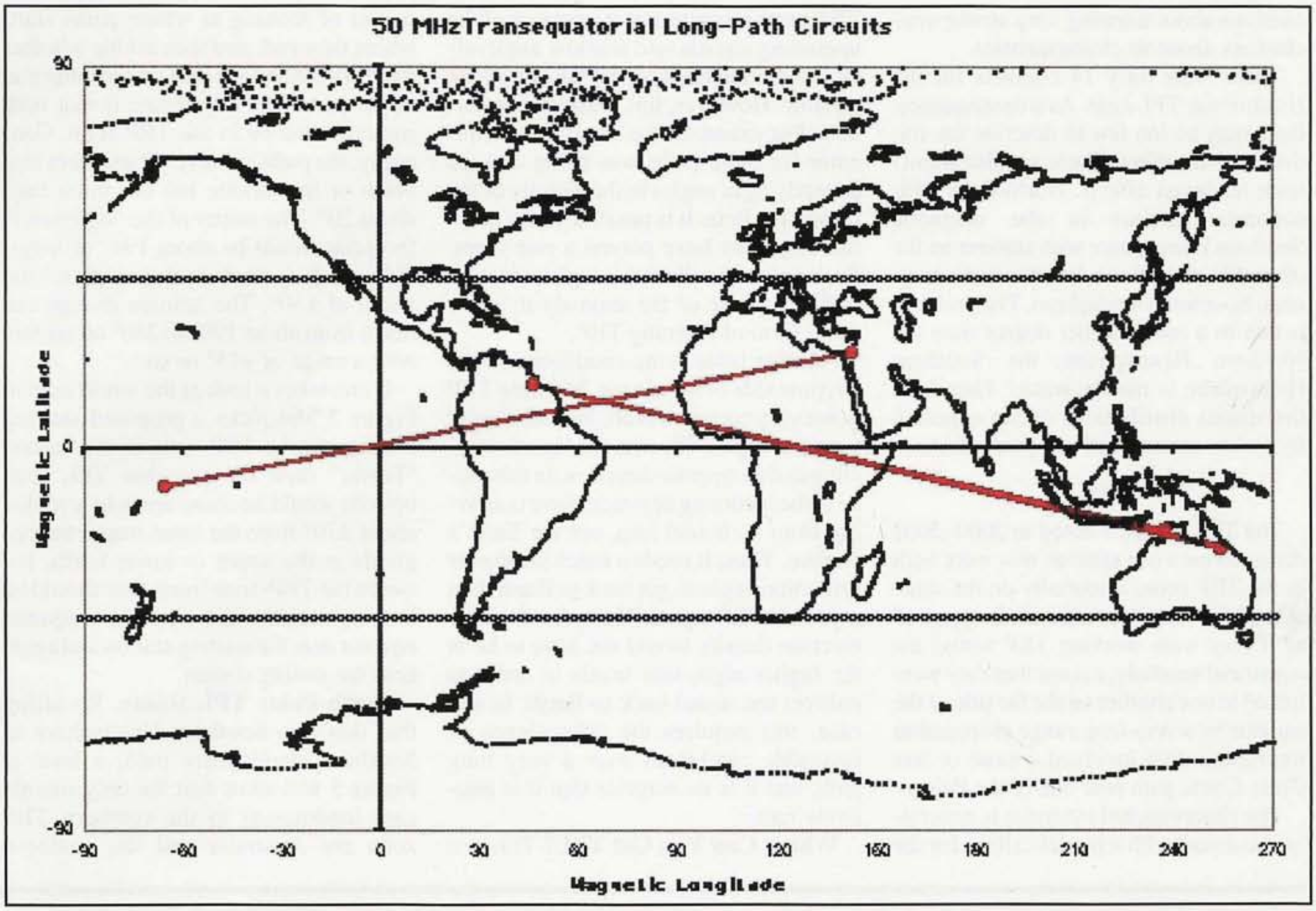

Figure 12. This map shows three examples of TEL (VK8 and VK4 overlap). The western-most station in each case is in daytime and the eastern most station is in nighttime. Note that only one crossing of the magnetic equator has happened in each case. The map projection distorts the actual Great Circle routes and headings.

halves of South America and Africa. Australia and Africa mostly match up with Atlantic and Pacific Oceans, respectively. Nevertheless, North-Polar TPL should be possible between the vicinity of the northern strip of Australia and southeastern South America (such as southern Brazil, Paraguay, Uruguay, and northeastern Argentina). If this were to occur, one would expect that the South-American end would be in local early morning and the Australian end would be near local midnight.

Referring back to Figure 5 will also reveal a number of South Pacific islands

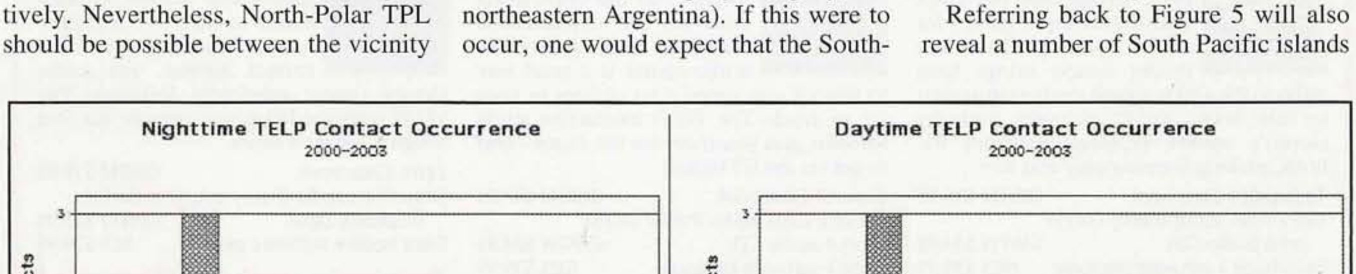

Figure 13. The frequency of occurrence of TEL as a function of Local Solar Time shows that the nighttime (east-end) station has the typical early-evening TEP pattern. The daytime (west-end) station must be up early in the morning in order to be far enough from the nighttime station to produce long path.

that have plausible paths to southern parts of Africa and South America.

South-Polar TPL Route. This approach connects the northern TEP zone to its northern counterpart on the other side of the Earth. Figure 5 suggests that circuits from Southeast Asia to Central America and northern South America should work, along with the well-known Hawaii to Mediterranean path.

TEL

Whether extreme east-west TEP or multi-hop *F2* to TEP links, TEL seems to be rarer because it appear to depend on the long-reach of *F2* mechanisms for much of the propagation distance. Consequently, the contacts not only require a geometrically usable connection to TEP on the eastward end of the circuit, but also good daytime *F2* conditions. Nevertheless, it can provide very long paths in a generally east-west direction.

A consequence of the day-to-night connection is that the daytime station is aiming generally east, and the nighttime station is aiming generally west. In all probability, the *F2* hops are aided by the enhanced ionization along the equatorial-anomaly ridges. If good *F2* conditions exist beyond the TEP zone, the path may leave the zone and reenter it as it approaches the other station.

Long-Throw Transequatorial Short Path

The east-west TEP and n*F2*-TEP modes are fairly common within the TEP zone. They appear to result from the same phenomena that cause TEL, except that the links are shorter. Like TEL, the daytime station is aiming generally east, and the nighttime station is beaming generally west.

At least one form is the "east-west" TEP described in Figure 4. Here again, the daytime station is beaming generally east toward the nighttime station. The difference is that the signal never leaves the TEP zone, but rather is converging with the magnetic equator as it moves eastward. It may well take an *F2* hop off the anomaly ridge before coupling to the night-side in a TEP chordal hop.

Acknowledgements

I would like to thank all the contributors to this work, without whom it would not have been possible: W7XU (from almost everywhere!), FO5RA, HB9MX (from S57MXU), and NØJL (from KH8). I especially appreciate 6-meter propagation pioneers Ray Cracknell, ZE2JV/G2AHU, and Dr. Costas Fimerelis, SZ2DH/SV1DH, for sharing their historical experiences for this paper. ■

Notes

1. J. R. Kennedy, 2000, "50 MHz F2 Propagation Mechanisms," *Proceedings* of the Central States VHF Society Conference, pp. 87–105. See also <www.uksmg.org/f2propagationmech.htm>.

2. This was the first solar maximum for the 6-meter band. Prior to World War II, the band was 5 meters.

3. E. P. Tilton in "The World Above 50 Mc.," *QST,* Oct. 1947, p. 56.

4. R. G. Cracknell, "Transequatorial Propagation of V.H.F. Signals," *QST,* Dec. 1959, p. 12. See also *Six News,* May 2001, p. 68, UKSMG, and <www.uksmg.org/equitorialpropagation.htm>.

5. Strictly speaking, the Earth's magnetic field leads to two critical frequencies, f_o and f_x, corresponding to the "ordinary" and "extraordinary" wave propagation modes. These differences are not important in this discussion.

6. This is a borrowed aeronautical term. I prefer looking at the angle between the layer and the wave direction, but physics texts normally use its cousin, the "angle of incidence," the angle between the vertical to the layer and the wave direction (90° minus the angle of attack). The equations change a little, but the answers are the same.

7. It is important to note that the angle of attack is also affected by the radiation angle of the antenna. Hence, a low angle of radiation actually increases the MUF for a given system.

8. Kenneth Davies, *Ionospheric Radio,* Peter Peregrinus Ltd., London, 1990, pp. 124, 129.

9. Ibid., p. 182.

10. Norman F. Joly, *The Dawn of Amateur Radio in the U.K. and Greece: a personal view,* Ch. 7, 1990. Project Gutenberg etext, <www.ofcn.org/cyber.serv/resource/bookshelf/radio10/>.

11. Costas Fimerelis, private communication, 2003.

12. Because of the map projection, the actual Great Circle ground tracks are not accurately shown, especially at the poles.

13. The TEP-zone boundaries are rough estimates. A few of the stations in the lower left of Figure 5 fall around the northern boundary, but these are actually in the observed TEP zone, as can be seen in Figure 1.

14. The Italian contact was certainly an anomaly. It was heavily modulated by multipath and was very weak. It occurred less than a minute before an Oman contact, which showed none of this. I am quite sure that Italy in the morning was a case of sidescatter as described earlier for TEP, except scattering was happening on the other side of the world!

15. Kenneth Davies, *Ionospheric Radio,* Peter Peregrinus Ltd., London, 1990, p. 271.

16. Ibid., p. 183.

By Joe Moell,* KØOV

ARDF Takes Hold

More Progress and Innovation

Seven years ago, only a few hams in the U.S. knew that on-foot hidden transmitter hunting is an international sport with many names, such as foxtailing, foxhunting, radio-orienteering, and ARDF (amateur radio direction finding). Most were unaware that eastern European countries began it decades ago, and the first World Championships took place in 1980. Stateside ARDF activity in 1997 was limited to small groups of hams in Portland, Oregon and southern California that were learning the ropes by holding on-foot foxhunting events using international rules.

With all the publicity for the fourth annual USA National ARDF Championships earlier this summer, many hams have become aware of the sport. However, few outside the ARDF hotbeds of Atlanta, Albuquerque, Cincinnati, and southern California have tried it for themselves. Perhaps they don't realize that one doesn't have to be a hardbody or a jock to take part. Competitors at our annual championships have ranged from age 11 to age 70. I don't think any of them have ever been marathoners. There's plenty of room for more participants.

I thoroughly covered last year's national championships just two columns ago,[1] so I won't make this year's championships the main topic this time. Instead, I will encourage you and your local club to hold some foxtailing events by answering some of the questions I have received about the sport and telling you about some new ideas that were tried this year. Innovation was an important part of this year's national championships, including a training camp, expanded medical services, and electronic scoring.

Putting on introductory hunts isn't difficult. One person can do it. You might discover a future world champion in your home town. Your club might even decide to bid for the 2005 USA ARDF Championships. That site has not been selected as I write this.

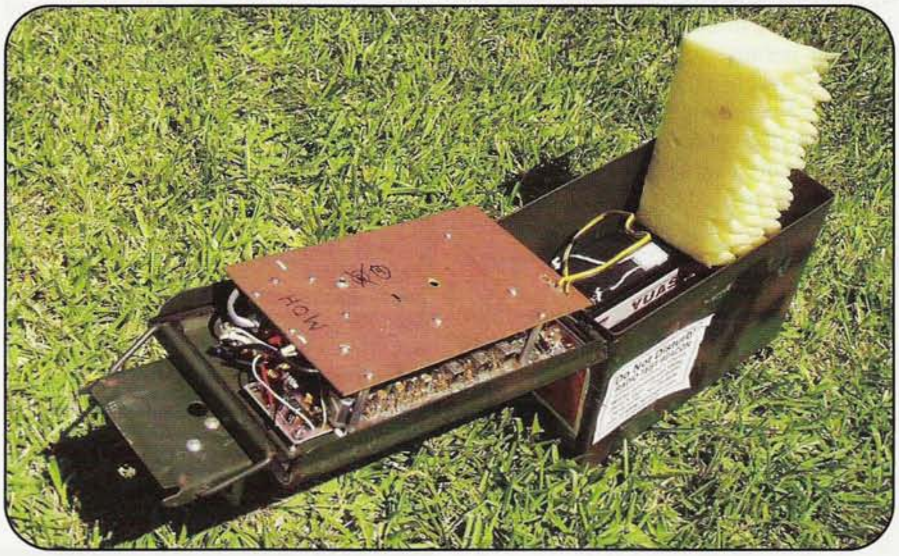

Photo A. Inside one of my well-worn foxboxes. The circuit-board plate protects the transmitters for 2 meters and 80 meters, both solidly mounted to the lid to minimize flexing cables. A PicCon controller is barely visible on the back of the protective plate. A foam wedge holds the battery in place. (All photos by Joe Moell, KØOV)

I often am asked, "Why follow a set of ARDF rules that seem archaic and arcane at first glance?" The simple answer is that we need to train under the same rules that Team USA members will be following when they go to ARDF contests everywhere else in the world. The rules have been developed and refined over the years by a special committee of the International Amateur Radio Union. The IARU is made up of over 160 national amateur radio societies, such as the Radio Society of Great Britain and the Wireless Institute of Australia. When the U.S. began to attend the ARDF World Championships in 1998, our national society (the ARRL) was welcomed into the rulemaking process.

The basic format (number of foxes, course size, transmit sequence) remains virtually unchanged, but recently the rules have been fine-tuned to add more age/gender categories and to streamline the starting process for large events. This has been well covered at my "Homing In" website, <www.homingin.com>, and in previous columns. In a nutshell, five transmitters are scattered in a large area. Competitors carry orienteering maps along with their foxhunting gear. They strive to find all of the transmitters and get to the finish line with the shortest elapsed time. Fox transmitters are on for 60 seconds at a time in perfect rotating sequence.

Our USA Championships follow the world's rules nearly 100 percent. (The main exception is that we use NBFM foxes on 2 meters instead of AM, as elsewhere.) There is no requirement that your club stick tightly to these rules for a local hunt. For instance, you might find that 30 seconds per transmission helps beginners to learn route planning more quickly.

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There are variations of ARDF worth trying. Fox-oring is a combination of RDF and orienteering wherein competitors receive a map marked with many small circles. Somewhere inside the area defined by each circle is a QRPp fox transmitter that can only be heard a few dozen feet away. Your mission as a foxtailer is to orienteer your way to the circles and then use RDF to find the foxes therein.

Foxboxes Made Easy

No matter what the rules, fox transmitters are almost always unattended and automatically timed. That leads to the most frequently asked question in my e-mail: "What can I use for the 2-meter foxes?"

The most popular fox controller is PicCon by Byon Garrabrant, N6BG, in Las Vegas (www.byonics.com), available wired and tested or as a kit. It provides timing, push-to-talk control, and MCW tones for IARU-rules hunts. You also can program it to generate just about any on-off cycle and tone sequence for mobile T-hunts. Sequences are held in non-volatile memory, programmed with DTMF tones from a control receiver or by wire from the earphone jack of your handie-talkie. For those who like to build from scratch, the Montreal Fox Controller[2] by VE2JX and VE2EMM is a simple PIC microcontroller project that outputs IARU-rules sequences only.

Power levels of 1/4 to 1/2 watt are adequate for small to medium parks, giving a new lease on life to your old HTs, such as IC-2ATs. For larger sites, 2 to 5 watts may be needed. Higher power handhelds are okay if they don't get too hot. Some clubs prefer to use kit or preassembled transmitter boards from companies such as Hamtronics Incorporated in Hilton, NY(www.hamtronics.com).

My own foxbox transmitters came from surplus 1980's-vintage, 151-MHz, business-band mobile transceivers. They were free, retuning into the ham band was easy, and the boards from these Yaesu FTC-1525A and FTC-2025 sets are of quality equal to or better than most of today's transmitter kits. They are crystal-controlled, but since almost all foxhunts in my area and many others take place on one frequency (146.565 MHz), this is no problem. I bypassed the 25-watt final stage and tied the driver output through the harmonic filter to the antenna jack.

PicCon is designed to work with handie-talkies that are keyed through the microphone jack, as most are. You will need to add a relay to key Hamtronics' or other transmitter boards. Typical coil current for small DC relays is 40 mA, which is more than the PicCon keying circuit can provide as supplied. Fortunately, the switching transistor can handle 40 mA and more base drive, for it is available from the PIC chip by changing R4 on the PicCon from 10K to 910 ohms.

Photo B. Orienteering punches such as this are available from orienteering supply stores such as Go Orienteering <www.866gaiters.com>. This competitor card is made of Tyvek® to withstand rain. Note the unique punch marks and the big X, marking a fox that competitors in this age category did not have to find.

For inexpensive, sturdy, waterproof enclosures, it's hard to beat surplus military ammunition boxes (Photo A). The size that I prefer ($5^1/2 \times 11 \times 7$ inches inside) is twice as big as necessary, but the large surface of the removable lid makes it easy to mount all parts except the battery. Add provisions for a bicycle chain and lock to prevent theft.

Flea markets and military-surplus outlets are good sources of ammo boxes. You shouldn't have to pay more than about $5 each. Look over the merchandise closely and pick boxes with good lid seals to keep your transmitter parts dry and prevent corrosion. Protect the equipment inside by mounting parts securely and using foam cushioning. My foxboxes have fallen out of trees more than once, with no damage so far.

Both PicCon and the Montreal controller include a delayed start-up feature so you can put out your foxes several hours before the hunt and have them automatically come on at start time. However, just a few milliseconds of power interruption in the interim will reset that timer. There's no way to tell if this has happened until it's too late, so take extra steps to prevent it. I use connectors instead of switches between battery and PicCon. Fuse holders can become intermittent, so I made my own battery fuses out of AWG 32 wire and soldered them into the circuit.

Rechargeable 12-volt batteries of 4 to 7 ampere-hours provide plenty of hunt time without being too heavy to carry into the woods. Check with the biomedical engineers at your local hospital. Regulations call for periodic replacement of backup batteries in some portable medical devices. You might be able to obtain some used, but fully functional sealed lead-acid packs just for the asking. Another possible source would be computer companies with SLA batteries in their uninterruptible power supplies.

A simple vertical antenna that's suitable for most hunts is a $19^1/2$ inch length of 3/32-inch bronze welding rod in a PL259 plug. The ammunition box can provide an adequate ground plane. For full compliance with IARU rules, horizontally polarized antennas must be used. Omnidirectional horizontal antennas will be covered in a future column, along with more of your questions.

E-Punch Debut

For decades, orienteering competitors have proven that they visited their required controls by carrying a card that they marked with special punches at each one. Each punch has a unique pattern of perforating pins (Photo B). Radio-orienteers adopted the same system because the punches are inexpensive and durable. For informal practice sessions, they sometimes substitute colored pens or crayons.

The pin-punch system has worked well over the years, although it seems that at least one runner loses the card on every hunt. In a local event, he or she will just punch the map and move on. However, the rules of national and international championships usually state that a lost card means disqualification. Another pin-punch problem is that occasionally a competitor will not squeeze the punch firmly, making it difficult or impossible to verify the correct pin pattern.

Classic orienteers are moving into the 21st century by adopting an electronic scoring method usually referred to as "E-punch." The most popular system is SPORTident (SI) <http://www.sportident.com/sportident-english/english.htm>. Here's how it works: Competitors wear a uniquely coded plastic tag. At the start line, finish line, and at each fox found, they insert this "e-stick" into a SI control station, which writes the location and exact time onto a chip in the tag using RFID technology (Photo C). After they "punch in" at the finish, they insert the e-stick into another control station at the scoring tent, where a laptop computer retrieves the time data from the tag. The computer operator immediately prints out and gives the competitor a slip of paper with overall elapsed time and splits (the elapsed time to find each fox).

Photo C. E-punch is replacing the old multi-pin punches at formal events. The e-stick (inset) is worn on a finger so that the competitor merely has to make a fist and briefly dip the stick into the control station next to the flag.

An early form of electronic scoring was used in the ARDF World Championships for the first time in 2000. SI scored the 2002 World Championships in Slovakia. Organizing Chair Marvin Johnston, KE6HTS, liked it so much that he arranged for the use of Los Angeles Orienteering Club's SI gear for this year's USA Championships.

It takes longer to set up an e-punch hunt, but almost every competitor prefers it. Missing competitor cards are a thing of the past. E-sticks don't get lost because they are snugly attached to a finger with Velcro™. They don't get in the way, and it's easy to punch in by making a fist and dipping it into the transponder. The results printout reveals everyone's fox-finding order and times, so it's easy to see which routes were best and which foxes were most difficult.

As I watched this year's championships, the only disadvantage I saw was the "pile-up" at the start point. Two competitors in different age/gender categories left the start at each 5-minute interval, just as fox #1 came on the air. They had to take turns punching out just after the starting beep. Gentlemen usually let ladies punch first. No one should have had to wait like that. The World Championship organizers solve this by having several control stations available at start and finish.

SI computer software is easily programmed for a variety of orienteering and ARDF events. A typical foxhunt is scored like a "Score-O" in orienteering, with each fox worth one point. The software verifies that competitors punch the correct foxes for their categories and that they do not punch extraneous foxes.

Timing information remains in transponder memory as well as tag memory. If a competitor gets lost or doesn't come to the finish for some reason, the organizers can get data from the transponders regarding which foxes the runner has already visited and when, as an aid in searching.

E-punch is another good reason for ARDF fans to get together with their local orienteering clubs. LAOC was very cooperative in providing the complete system for this year's USA ARDF Championships. Orienteering clubs usually charge $2 or so per event for e-stick rental. This helps cover the cost of the equipment. Regular competitors buy and keep their own stick for $40 or so and avoid the rental fees.

Medic!

How much medical support is needed at an ARDF event? It isn't an issue for a small hunt in a city park where it's hard to get lost and help is just a 9-1-1 call away. However, this year's USA Championship sites were miles from the nearest city in unfamiliar territory. The 2-meter hunt was in a relatively barren area of near-desert where the average high temperature is 92 degrees in mid-June. The 80-meter competition started at an 8300 ft. elevation in the forest.

With that in mind, April Moell, WA6OPS, agreed to make sure medical help was close at hand both days. She recruited Jon Schaffer, W6UFS, and Bruce Chappell, KE6TSM, two members of the Hospital Disaster Support Communications System (HDSCS), an ARES group in Orange County <www.hdscs.org>. Jon is a Registered Nurse and Bruce is an Emergency Medical Technician. Both do regular volunteer medical support at public events. They could bring the needed medical supplies and equipment.

Despite the wide range of ages, most participants were in good physical condition. A few were newcomers both to ARDF and potentially strenuous competition. Even a seasoned competitor can have problems in heat and altitude.

Competitors and spectators alike were encouraged to use lots of sunblock and insect repellent. Ticks can carry Lyme Disease, and some mosquitoes are transmitting West Nile Virus in California. Everyone was instructed what to do upon encountering a mountain lion, bear, or rattlesnake. Nobody did, fortunately.

Jon, Bruce, and April were prepared to take care of just about any misfortune, from a blister, to a bee sting, to more severe medical problems. "We paid careful attention to fluids," April said. "Hydration and replenishment are crucial. Lots and lots of water was available. For electrolyte replacement, we had Gatorade and bananas."

"When they're comfortable, people enjoy themselves more and can perform at their best," April continued. "So we had a lot of comfort items, such as special blister bandages and eye drops in individual packages. Competitors could take them along in case they needed them on the course. Baby wipes in individual packets were very popular for face and neck cool-down or for personal hygiene."

There were plenty of exhausted fox-hunters at the end, watched closely by the volunteer medics (Photo D). One medal winner sprinted so hard between his last fox and the finish line that he was offered a few minutes on oxygen to help him recover sooner than he otherwise would have at the altitude. "That's good stuff," he said.

Speed-learning for ARDF

"Immersion" is a buzzword in education nowadays. With Immersion Learning, students dive deeply into a subject, solving real-world problems under intense pressure. Proponents claim there's no better way to prepare for success in the 21st century.

No surprise there: It's just common sense that focusing attention and concentration on the subject at hand will speed up the learning process. ARDF is no different. The more hunts you go on, the faster you'll pick up the ability to look at a map and understand the terrain, take bearings and plot them without a protractor, plan an efficient route, and execute the plan.

Just before the World Championships in 2002, Gyuri Nagy, HA3PA/KF6YKN, immersed radio-orienteers at the first ARDF training camp for Team USA members near his home in Pecs, Hungary. Half of the Team USA members participated, along with the three members of Team Australia. Every one of them credited the camp for helping him or her do better in the World Championships that year.

Dick Arnett, WB4SUV, knew plenty about direction finding, but he needed to improve his orienteering skills. Afterwards, he said, "I think I got much better and it wasn't just from hunting lots of transmitters. Gyuri also would sit down with us and explain the types of courses—classic, non-classic, and so forth. When he looks at a competition map for the first time, he usually can tell approximately where the transmitters will be, and even which numbers will be where,

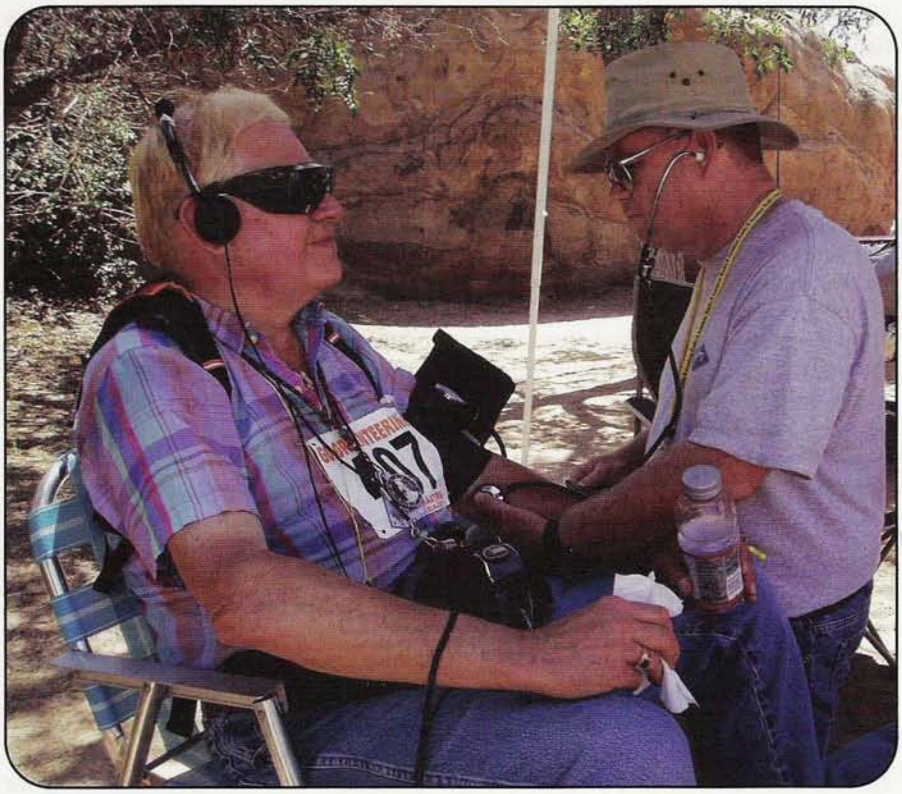


Photo D. Mike Cegelski, K8EHP, of Cleveland, Ohio gets a blood-pressure check from Jon Schaffer, W6UFS, after the 2-meter championship event at Vasquez Rocks.

because of the exclusion zones and the distances that must be traveled by the various category competitors. We benefited from his years of experience."

Conversely, Bob Cooley, KF6VSE, had won many orienteering meets over the years, but he needed to improve his transmitter tracking. "It's important to make a lot of mistakes while practicing and work so that you don't make them in the future," he explained. "I got the opportunity to get fooled in a variety of ways."

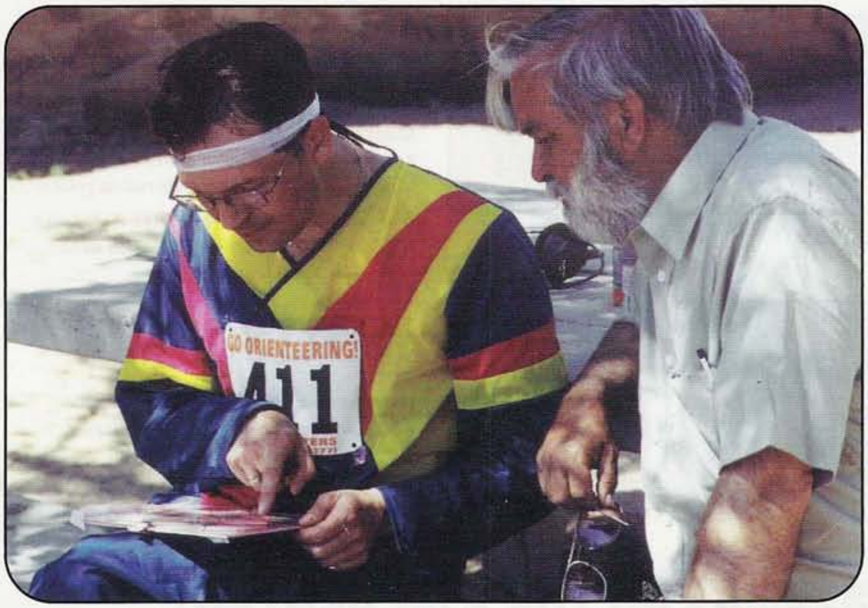


Photo E. Training camp organizer Marvin Johnston, KE6HTS (at right), discusses the fine points of ARDF course setting with Vadim Afonkin of Boston, who learned the sport as a youth in eastern Europe.

With that in mind, KE6HTS put on a training camp in the five days prior to the USA Championships this year (Photo E). It started with a LAOC event in the mountains, teaching basic orienteering skills such as map-reading, catching features, and pace counting. The remainder of the camp was at Griffith Park in Los Angeles, the largest municipal park and urban wilderness area in the USA. LAOC has two well-mapped venues in these 4100 acres of oak trees, wild sage, and manzanita. I suspect that by the end of this camp, the participants knew every trail by heart.

"We had two hunts a day, one in the morning and one in the afternoon," Marvin said. "One day it was all on 2 meters and the next day all on 80 meters. We also practiced rapid bearing-taking by the 'walk and drop.' I would walk up a trail and drop off the fox transmitters in numbered sequence in concealed spots alongside the trail every minute or two. Then the students would run up the trail and try to find each fox in the first 60 seconds that it was on."

Your club may not be ready to put on a full-fledged training camp, but you can use these ideas to immerse the newcomers in your area. Encourage them to participate in classic orienteering meets. Have day-long practice sessions in a big park, preferably one which has a good O-map available. Get one or two members to put out fox transmitters for the others to hunt in the morning. Then have someone else put them out in different locations in the afternoon. The more everyone hunts, the greater their confidence in their equipment and abilities.

Conclusion

In future "Homing In" columns, I'll have more about putting on events, including timing ideas and omnidirectional horizontally polarized antennas for 2 meters. In the meantime, please send your foxhunting news, photos, and questions to me. If you are interested in hosting a future national championship, I would especially like to hear from you.■

Notes

1. *CQ VHF* Winter 2004 edition, page 34.

2. "Homing In: Build the Montreal Fox Controller," *73 Magazine,* April 1998. Updates on the "Homing In" website.

New Product:

The JWM Engineering Model SEQ-1

Microprocessor-Controlled Transmit/Receive Sequencer

Recently, JWM Engineering Group introduced the Model SEQ-1 Microprocessor-Controlled Transmit/Receive Sequencer, which maximizes flexibility and safety with programmable time-delay values (http://jwmeng.com/seq1.html). The SEQ-1 is the first microprocessor-controlled sequencer on the market to provide one "heartbeat" and four visual outputs for confirmation of operation and the ability to program a variable time delay value for the control outputs.

The one-second heartbeat indicator verifies proper operation and provides an error status during the programming phase. The four status LEDs provide visual indication of the sequence and step operation.

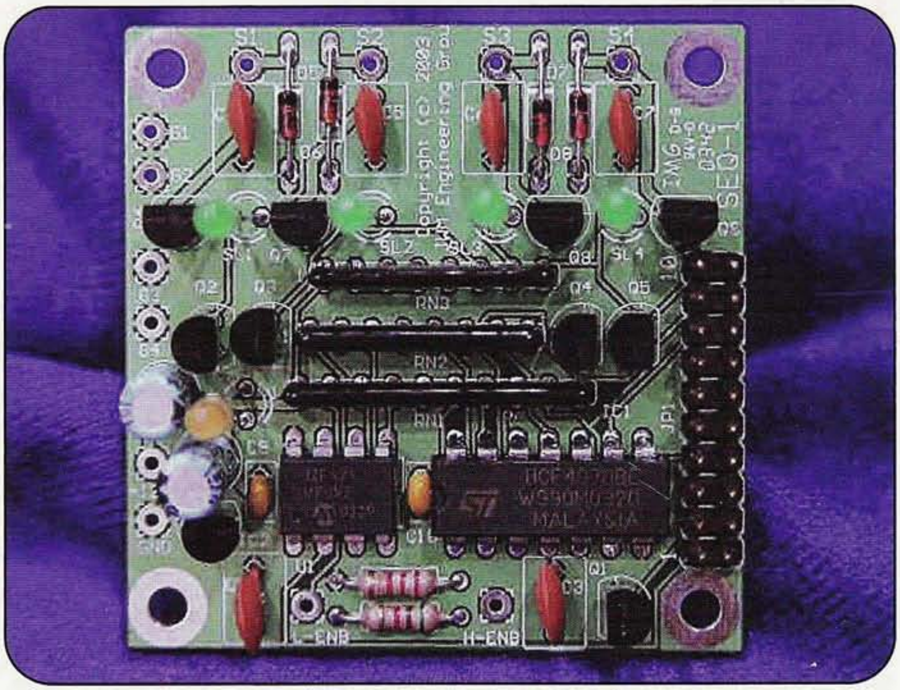
"Today's transverters use very low-noise front ends for the best possible signal-to-noise ratio, but low-noise front ends will not survive the high transmit power levels found in most competitive transverter systems," said Jerry Mulchin, N7EME, President of JWM Engineering Group. "The solution is sequencing. Controlling the power-on sequence and transmit-receive changeover time will minimize or eliminate damage to the receiver circuits," Mulchin concluded.

In addition, normal relay contact bounce found in every RF antenna changeover relay can induce unwanted transients that could damage sensitive devices in the receive chain.

The transmit-receive sequence can be initiated with either Low-Enable (ground to transmit) or High-Enable (positive voltage to transmit) input. The High-Enable input requires a positive input voltage from 2.0 volts to 14 volts.

The SEQ-1 provides four sequenced, open-collector outputs to control system switching. Open-collector outputs enable direct control of relay coils. Each output is capable of switching up to 35 volts at 600 mA continuously. Also provided is the ability to invert the active output state of any of the four outputs.

The SEQ-1 time-delay values default to 32 milliseconds for each step, but are programmable from 4 milliseconds to 128 milliseconds per step. This allows the user to fine-tune the delay time for the environment being controlled. For example, if RF switching is all solid-state using PIN diodes, then a small time-delay value would be appropriate. If circuits use electro-mechanical relays, a longer time delay would be required to allow contacts to settle.



The JWM Engineering SEQ-1.

Time-delay values can be user-programmed right in the circuit. There is no need to remove the SEQ-1 from your system to change the delay time. Other switching schemes are possible with additional analog circuitry.

Specifications:

- 13.8 VDC @ 50 mA typical (no switched output active)
- 35 VDC@ 600 mA open-collector switching capability, four outputs total
- Enable High or Enable Low input to activate sequencer
- Visual states displayed on four green LEDs
- 1-second yellow heartbeat indicator
- Programmable delay times from 4 msec to 128 msec (default is 32 msec)
- Operating temperature range 0° C to +70° C
- Full one-year limited warranty
- Price $39.95 assembled/tested (plus shipping). (*Note:* CA residents pay local sales tax)

For more details, contact JWM Engineering Group, 9 Westchester Ct., Trabuco Canyon, CA 92679-4955 (telephone: 949-713-6367; e-mail: <jmulchin @jwmeng.com>; <http://www.jwmeng.com>).

JWM Engineering Group is backed by over 37 years of electronics design experience in radio frequency, microwave RF, analog and digital design work. It is dedicated to delivering the highest level of quality at an affordable price for microwave experimenters, and will also perform consulting work for special needs, from amateur to commercial products. ■

By Tomas Hood,* NW7US/AAAØWA

PROPAGATION

The Science of Predicting VHF-and-Above Radio Conditions

The *Perseid* Shower Looks Promising

Lewis Swift and Horace Tuttle, Americans working independently, discovered a comet in August 1862. Three years later, Giovanni Schiaparelli (of Martian "canali" fame) realized it was the source of the August *Perseid* meteors. The comet, known now as Comet Swift-Tuttle, leaves a trail of dust that Earth passes through during August.

This year's *Perseid* shower promises to be more rewarding than before due to a relatively new filament ribbon trail of dust that drifted into the Earth's path. This trail boiled off the comet in 1862, during the Civil War. The main trail is older and more dispersed, and responsible for the month-long shower that peaks on August 12.

Perseids favor northern latitudes. Because of the way Comet Swift-Tuttle's orbit is tilted, its dust falls on Earth's Northern Hemisphere. Meteors stream out of the constellation Perseus, which is barely visible south of the equator.

The *Perseid* shower begins slowly in mid-July, featuring dust-size meteoroids hitting the atmosphere. As we get closer to August 12, the rate builds. Now, with this new ribbon, we can expect dozens, possibly even hundreds, of meteors per hour. For working VHF/UHF meteor scatter, this could prove to be an exciting event.

According to predictions, Earth will plow through the filament at 2100 UTC, Wednesday, August 11, 2004 (5 PM EDT). Most of the activity will be over Europe and Asia, with a possible visual rate of as many as 200 meteors per hour (see Figure 1). Later that night, North American observers and radio operators can expect most of the activity to be from the older dust from Swift-Tuttle, at a visual rate of about 40 to 60 meteors per hour, some of them intense.

The best time for working the *Perseid* VHF/UHF meteor scatter in North America is during the hours before dawn on Thursday, August 12. As early as midnight, but more likely at around 2 AM local time, you'll soon be working stations via the ionization caused by the heat of burning-up dust. (A good web resource on the *Perseid* meteor shower is <http://comets.amsmeteors.org/meteors/showers/perseids.html>).

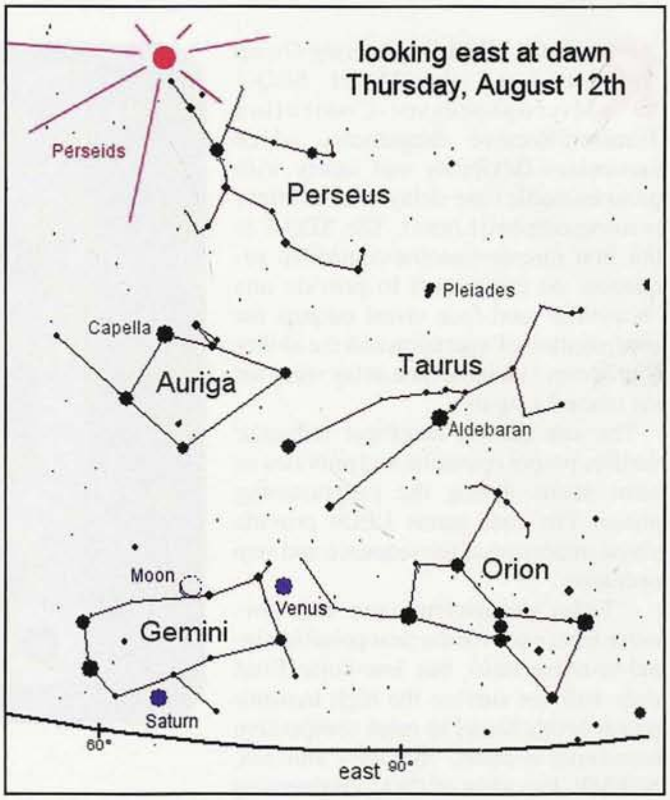


Figure 1. Location in the sky of the Perseid meteor shower. (Courtesy of NASA)

Other Meteor Showers

There are small meteor showers throughout this period, some of which might result in some easier to work events for the radio operator. The *Sextantids* is expected to peak on September 27, at 0300 UTC, but it may occur a day earlier. In 1999 a strong return was detected at sol 186°, though, equivalent to a peak on September 28, 2004 UTC.

Others showers include the weak *Northern delta-Aquarids,* July 15 to August 25, with a maximum on August 8; the weak *Northern iota-Aquarids,* August 11–31, with maximum on August 19; another weak shower, *kappa-Cygnids,* from August 3–25, with a peak on August 17; the weak *delta-Aurigids,* from September 5 to October 10, peaking September 9; and the *Piscids,* active September 1–30, with a maximum on September 19.

Then look for the *Draconids,* a primarily periodic shower which produced spectacular, brief meteor storms twice in last century, in 1933 and 1946. Most recently, in 1998, we saw a moderate peak of a ZHR (zenith hourly rate) reaching 700. This was due to the return of the stream's parent comet, 21P/Giacobini-Zinner, to perihelion. The next return of the comet will be in mid 2005. A repeat of the *Draconids* at this time would be between 1540 UTC and 1850 UTC, October 8, 2004. The *Draconid* meteors are exceptionally slow-moving, a characteristic that helps separate genuine shower meteors from sporadics accidentally lining up with the radiant. This is a good shower to work meteor-scatter mode.

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

Radio Meteor Observation

While many amateur radio operators find meteor scatter an exciting sport, many more might find great reward in trying

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their hand at radio meteor observation, which involves radios capable of reception of 30 to 300 MHz, and a good antenna system, and some software tools.

The receiving station is set up to "look" for signals from stations that are far away, such that those transmitting stations cannot be heard by the receiver during normal conditions. Then, when a meteor enters the atmosphere and creates an ionized trail, it makes possible the scattering of VHF/UHF radio waves, resulting in the receiver hearing that remote station. This is known as forward-scatter mode.

Another mode, of course, is back scatter, where the receiving and transmitting stations are located at the same position. It is possible to obtain detailed meteor information such as meteor geocentric velocity and beginning and ending height. This observation is also called "radar observation." This mode is much more expensive due to the equipment required. Check out <http://www.iap-kborn.de/radar/Radars/Skiymet/index_eng.htm>, which shows Radar Observations (see Figure 2, which shows meteors per hour observed).

Forward-scatter observation is easier and less costly to start off. There's a network of radio meteor-scatter observatories online at <http://radio.data.free.fr/main.php3> (see Figure 3 for the results of Jeff Brower during the beginning of July 2004). This page is a collection of observations from these various locations, with the graphs showing the level of meteor rate on a day (horizontal axis), one square per hour (vertical axis). The colors display the level of meteor counted per hour by the observer, the maximum level being red, while the minimum level is blue. Black represents no data. The level depends on the radio installation (antenna orientation, receiver, frequency, software, and so forth). It is not an absolute measure, but it is a statistic count, usable for calculating the time of the maximum of a meteor shower, length, profile of this peak, and visualization of the meteoritic background. Figure 4 shows another plot of radio meteor observation.

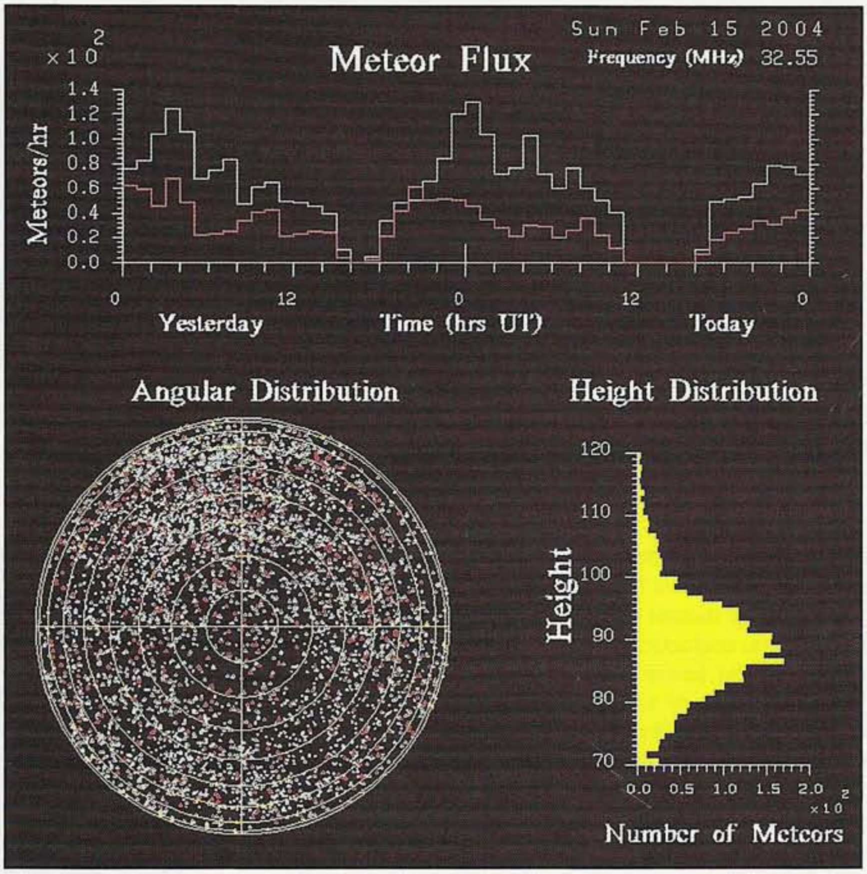


Figure 2. Radio observation of meteor activity, February 15, 2004. (Courtesy of SKiYMET All-Sky Meteor Radar)

Working Meteor-Scatter Propagation Mode

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

Meteor-scatter propagation is a mode where radio signals are refracted off these trains of ionized plasma. The ionized trail is produced by vaporization of the meteor. Meteors no larger than a pea can produce ionized trails up to 12 miles in length in the *E*-layer of the ionosphere. Because of the height of these plasma trains, the range of a meteor-scatter contact is between 500 and 1300 miles. The frequencies that are best refracted are between 30 and 100 MHz. However, with

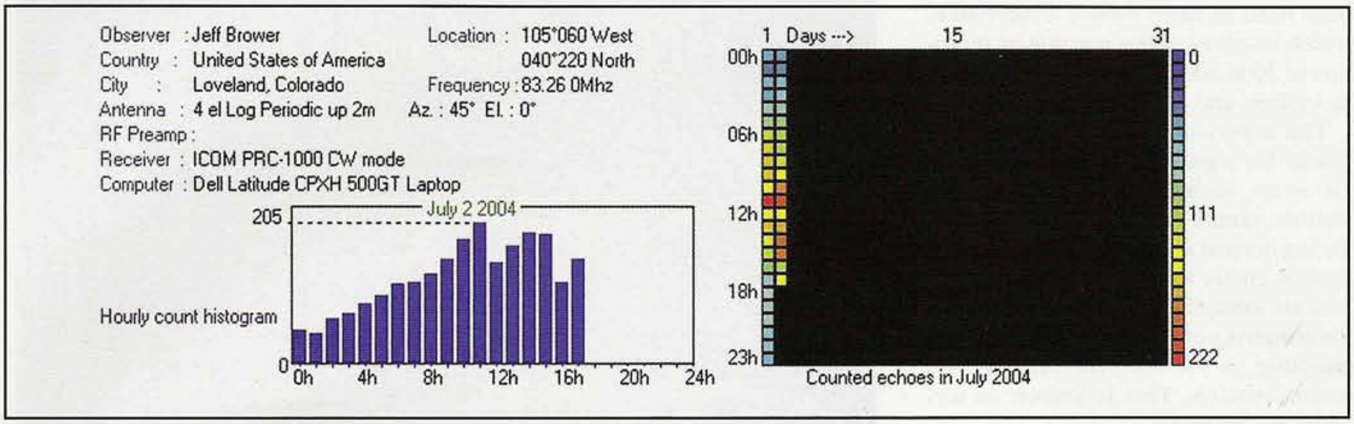


Figure 3. Data observed by Jeff Brower using an ICOM PCR-1000 and a 4-element log periodic antenna. (Courtesy of Radio Meteor Observatory)

the development of new software and techniques, frequencies up to 440 MHz have been used to make successful radio contacts off these meteor trains. On the lower frequencies, such as on 6 meters, contacts may last from mere seconds to well over a minute. The lower the frequency, the longer the specific "opening" made by a single meteor train. A meteor train that supports a 60-second refraction on 6 meters might only support a 1-second refraction for a 2-meter signal. Special high-speed methods are used on these higher frequencies to take advantage of the limited available time.

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

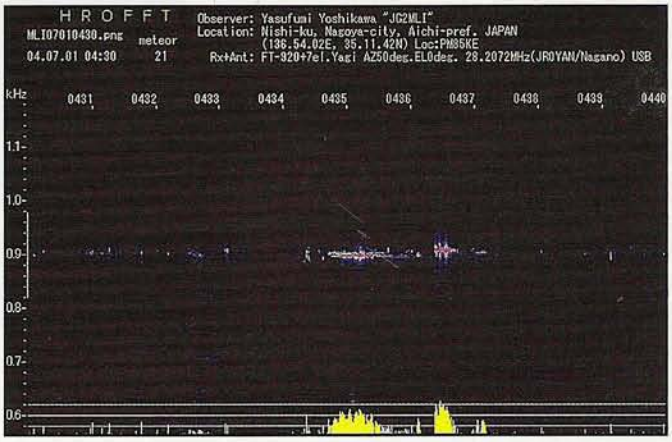


Figure 4. A plot of signals observed by radio meteor observation in Japan. (Courtesy of The International Project for Radio Meteor Observation)

Other Modes of VHF/UHF Propagation

August will show strong tropospheric-ducting propagation. However, as we move away from the hot summer months, expect the tropo-ducting to decrease in North America. Don't forget to check out Bill Hepburn's tropo-ducting forecast maps at <http://www.iprimus.ca/~hepburnw/tropo_xxx.html>, which include maps for the Pacific, Atlantic, and other regions.

Sporadic-*E* openings will also wane toward the end of the period, but strong *Es* openings are expected through the end of September. During Field Day 2004 sporadic-*E* played well, better than last year. This trend will continue all summer long.

Aurora activity has potential, especially after September 22, the Autumnal Equinox, when we see a seasonal increase in aurora. We are in the decline of the solar cycle (Cycle 23), so we

Sporadic-*E* Update!

In the Spring 2004 issue of *CQ VHF,* I wrote, "[b]ased on these [weather] predictions, I expect moderate to occasionally strong sporadic-*E* starting in May, and peaking in July and August 2004."

This prediction seems to be coming true. July 6 and 7, 2004 was an exciting period of sporadic-*E* propagation, providing propagation up into 220 MHz. Many have reported that this particular event was the strongest since the 1960s. Certainly, with Asia, Europe, and North America all reporting record-breaking *Es* activity during this opening, it goes into the history books as the best in decades.

Since there are so many more operators on the air for these openings, we have a great opportunity to discover more details about the mechanisms of sporadic-*E*. There are those who are now carefully watching the track of these *Es* openings to see if the Russian *Es* opening precedes the European's, and if those two precede the North American opening. If so, it might indicate that there is large movement of *Es* formations. Time will tell. I encourage more operators to become involved in spotting and reporting these *Es* events.

This is an exciting season for *Es*. Even during Field Day, *Es* played a more active role than in previous years. My prediction based upon trends in global weather might very well hold water.—*NW7US/AAAØWA*

are seeing many coronal holes, some of which have a great potential to cause long-duration geomagnetic disturbances, and possibly strong aurora.

Many years of auroral observations reveal that peak periods of radio aurora occur close to the equinoxes. Of the two yearly peaks, the greater peak, in terms of the number of contacts reported, occurs during October.

When the interplanetary magnetic-field lines are oriented opposite to the magnetosphere's orientation, the two fields connect and allow solar-wind particles to collide with oxygen and nitrogen molecules in the upper atmosphere of these ovals. This causes light photons to be emitted. When the molecules and atoms are struck by these solar-wind particles, the stripping of one or more of their electrons ionizes them to such an extent that the ionized area is capable of reflecting radio signals at very high frequencies. This ionization occurs at an altitude of about 70 miles, very near the *E*-layer of the ionosphere. The level of ionization depends on the energy and amount of solar-wind particles able to enter the atmosphere.

While correlations exist between visible and radio aurora, radio aurora could exist without visual aurora. Statistically, a diurnal variation of the frequency of radio-aurora QSOs that suggests two strong peaks, one near 6 PM and the second around midnight, local time, has been identified.

VHF auroral echoes, or reflections, are most effective when the angle of incidence of the signal from the transmitter, with the geomagnetic field line, equals the angle of reflection from the field line to the receiver. Radio aurora is observed almost exclusively in a sector centered on magnetic north. The strength of signals reflected from the aurora is dependent on the wavelength when equivalent power levels are employed. Six-meter reflections can be expected to be much stronger than 2-meter reflections for the same transmitter output power. The polarization of the reflected signals is nearly the same as that of the transmitted signal.

The *K*-index is a good indicator of the expansion of the auroral oval and the possible intensity of the aurora. When the *K*-index is higher than 5, most operators in the northern states and in Canada can expect favorable aurora conditions. If the *K*-index reaches 8 or 9, it is highly possible for radio aurora to be worked by stations as far south as California and Florida.

Expect an increase in geomagnetic storms, and auroral activity, as we move through March and into April 2005. For the daily conditions, you are welcome to check my propagation resource at <http://prop.hfradio.org>, where I have the current planetary *K*-index, links to various aurora resources, and more.

The Solar Cycle Pulse

The observed sunspot numbers from March through May 2004 are 48.9, 39.3, and 41.5, staying roughly at the same level as the last reporting period. The smoothed sunspot count for September, October, and November 2003 are 59.8, 58.4, and 57.0, all showing the steady decline of Cycle 23.

The monthly 10.7-cm (preliminary) numbers from March through May 2004 are 112.2, 101.3, and 99.7. The smoothed 10.7-cm radio flux numbers for September through November 2003 are 126.0, 124.1, and 121.8.

The smoothed monthly sunspot numbers forecast for August through October 2004 are 30.8, 28.5, and 26.3, while the smoothed monthly 10.7-cm is predicted to be 88.9, 86.2, and 83.8 for the same period.

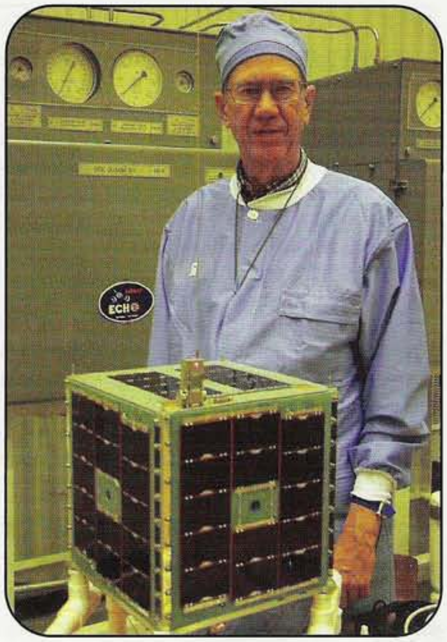
The smoothed planetary *A*-index (*Ap*) numbers from September to November 2003 are 21.9, 21.1, and 20.0. The monthly readings from March through May 2004 are 12, 10, and 9.

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! ■

All satellites for this launch are now positioned on the dispenser plate. ECHO *is in the foreground.*



Chuck Green, NØADI, with ECHO in Baikonur, Kazakhstan.

about 1/2 meter square and 2 to 3 cm thick. ECHO shared this plate with the Italian satellite. The carrying handles were removed for the last time, and then the dispenser plate was placed on the platform from which all the satellites would be deployed. We were ready to fly! Things would be very quiet from then until launch day.

June 29 was launch day. It started with a Kosmotras-supplied breakfast at 8 AM. Then there were formal readiness reports regarding the rocket, a Russian *Dnepr LV.* All the high-level people were there, including the director general and a general grade officer in charge of the military forces that would launch the rocket as a practice exercise. One person representing each satellite was asked to state the readiness of his or her satellite. Then the general declared that there was no reason not to proceed with the launch.

A little while later we all got on the buses and headed out to the viewing site. It wasn't very long before the launch. First there was a huge eruption of smoke as the rocket was pushed rapidly up out of the silo. After going almost straight up for a few second,s it began to head south and back over us. Soon we could hear the roar of the engines. Because it quickly went back over our viewing angle under our shelter, everyone ran out behind the shelter so they could continue to watch. We could see the first stage separate and the second stage take over.

I stood near the interpreter. Every ten seconds there was a report. It was a bit repetitive, but also reassuring that everything was going well. The second stage shut down and the third stage took over. After 900-and-something seconds the satellites began to be separated. One at a time in rapid succession the names were called out. All satellites were separated successfully.

There were a lot of cheers and hugs and about every other kind of emotion you could think of. I ran back inside the shelter before anyone else could think of it and called to report the successful separation of our satellite.

We then got on the buses and took the short ride over to the launch site. The huge defensive door over the silo was standing open and smoke was still coming up out of the silo. They had put up a protective rail around the pit so no one could fall in. Looking inside, it was dark and threatening. Everything was covered in black soot.

We all got back on the buses to return to our hotel. On the way back, the Italians received an SMS message saying that their satellite had been heard on the first orbit. The look at their satellite was only four degrees above the horizon, but that was enough to hear it. The bus erupted in celebration.

There was then a press conference, followed by a reception. After the reception we had about a half hour to pack and get back on the buses to be taken to the airport for the long trip home.

Post Launch

About ten hours after launch the command team in the U.S. commanded ECHO's transmitter on and began the process of checking out the satellite in orbit. Ground controllers made their first contact with ECHO at 1452 UTC and collected some telemetry to analyze before shutting down the digital downlink transmitter. The first downlink signals were 435.150 MHz FM at 9600 bps. With the preliminary checks complete, on July 7 Bill Tynan, W3XO, designated ECHO as AMSAT OSCAR 51 (AO-51)!

As of July 5, the first sets of Whole Orbit Data (WOD) from the satellite have been collected and analysis is continuing. In commenting on the data, Jim White, WDØE, stated, "We have looked at the WOD collected after we adjusted the solar-panel set point to what we determined would be close to the optimum point. It resulted in nearly double the peak power input from the panels on the following orbit."

Currently the solar panels are producing nearly 20 watts peak, 16 watts average in the sun. The WOD shows that ECHO's attitude motion is complex. The torque rod is clearly magnetized with the polarity that has the –Z down in the Northern Hemisphere.

The command team would like to thank everyone who has sent in ECHO telemetry to date. The data has already proven useful in the commissioning effort. A new web page is now available for submitting telemetry data. The web page also includes options for retrieving and graphing archived telemetry data. The new ECHO telemetry archive web page is <http://www.coloradosatellite.com/echo>.

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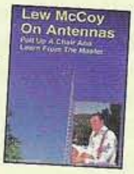

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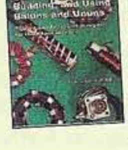

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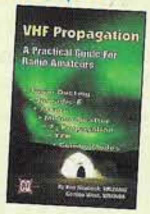

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Thanks to Mike Kingery, KE4AZN, the TlmEcho program has an updated coefficients file available, and version 1.03 was available for downloading on July 6 at <http://www.amsat.org/amsat-new/echo/tlm_decode.php>.

ECHO, now known as AO-51, is expected to be able to support multiple users and modes simultaneously. The two primary modes of operation will be FM analog and 9600 baud packet. The FM analog mode will operate in a manner similar to SO-50. The big difference will be in the received signal strength on the ground. While SO-50 operates at 250 mW, AO-51's transmitters have a variable power output and can operate at as high as 8 watts output on 70 cm. The exact transmitter output settings are still being determined and will be based on the amount of power available from the solar panels. This is expected to provide excellent reception for very modest stations. If you have a dual-band 2-meter/70-cm FM rig, you may find that you already have a satellite ground station just waiting to be used.

The second primary mode will be 9600-baud packet using the PACSAT protocol pioneered on AO-16 and still in use on UO-22 and GO-32. AO-51 essentially will be an orbiting file server available for uploading and downloading of messages and files. Many stations have already reported success copying the 9600-baud downlink data using radios such as the TM-D700, as well as hardware TNCs and sound-card packet software such as MixW[3] and AGWPE[4].

AO-51 also carries a tunable wide-band receiver and S-band transmitter. These will be used for experiments such as high-speed data links or perhaps even a PSK31 transponder where many station could chat keyboard-to-keyboard at the same time. AO-51 is truly a very flexible satellite. Receivers and transmitters can be switched around in almost any combination and mode. Table I lists the planned frequencies for initial operation. The current status of AO-51 and all the amateur radio satellites can be found on AMSAT's website. Also available from AMSAT is the AMSAT News Service, which provides e-mail bulletins about ongoing satellite activities. Instructions for subscribing can also be found on the website.

Many people contributed a great deal to help ECHO become AO-51. They include:

• Jim White, WDØE, for his technical contributions and leadership skills, and for the hundreds of hours he has invested.

• Mike Kingery, KE4AZN, for 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, especially Mark Kanawati, N4TPY, Dr. Dino Lorenzini, KC4YMG, and Lyle Johnson, KK7P, 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 integration support.

• 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 help and assistance, especially Rick Hambly, W2GPS, and Dick Daniels, W4PUJ.

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

• Chuck Green, NØADI, for his work at the launch site and for providing a great deal of material for this article.

You, too, can help support AO-51 as well as other existing and future amateur radio satellites by joining AMSAT. Applications are available on the web, or you simply can call the AMSAT office at 888-322-6728. ■

Notes

1. AMSAT, 850 Sligo Ave. Suite 600, Silver Spring, MD 20910; <http://www. amsat.org>.
2. SpaceQuest Ltd., 3554 Chain Bridge Road, Suite 103, Fairfax, VA 22030; <http://www.spacequest.com>.
3. MixW, <http://www.mixw.net>.
4. AGWPE, <http://www.raag.org/ sv2agw/agwpe.htm>.

Additional sources for this article include the AMSAT News Service (ANS) and the ARRL Letter.

Larry gave a condensed account of a typical launch and recovery for the EOSS group in Colorado. Marty followed up on that by expanding a little more on some of the group's procedures and the battle stations that the group uses to protect their perfect 80 for 80 recovery statistic.

Following a computer crash, a short field trip to drool over a well-stocked chase vehicle they had brought with them, and some group photos, Mike, W5VSI, finished out the trio by detailing their coordination with the friendly FAA folks who guard and protect Denver International Airport.

T-Minus 16 Hours (Friday Evening)

With all of the presentations out of the way, we got down to the real business of pre-flight details, such as a recap of the frequencies and who was flying what. Bill, WB8ELK, who had planned on flying a capsule but had to scrub due to work schedules, hooked up with Harry Mueller, KC5TRB, who had most of his equipment with him but hadn't planned on flying. They came together and became the group's fifth confirmed flight for Saturday morning.

Mark Conner, N9XTN, kicked off the state-of-the-art section by showing some very entertaining videos from a couple of his flights (okay, one flight and one attempt). On one flight he had a camcorder record the sound of a jet passing nearby his capsule at nearly 40,000 feet, as well as the contrail from the jet.

I demoed my own Balloon Finder software, which runs continuous predictions throughout a flight for the chase teams, as well as my tool box, which has a Yaesu FT-2600 and Kantronics KPC-3 mounted and ready to go at a moment's notice.

Teardown of the auditorium presentation setup soon commenced, and we were on our way out for dinner, where Don Pfister, KAØJLF, and his HABITAT (High Altitude Basic Investigation Testing And Tracking) group met us, which confirmed our sixth balloon for Saturday morning.

T-Minus 4 Hours (Saturday Morning)

I didn't get much sleep Friday night, which is typical before launches. I'm always afraid that I'm going to oversleep. I finally got up at about 6:00 AM, took a shower, and began running touchdown predictions for our payload. I then received a frantic call from Jon, AJØNR, asking if I had the parachute.

Soon 7:00 AM rolled around and I had to leave, since I was carrying most of the helium for the launch. I had already threatened the group with the loss of their knuckles if they were late to the launch site, so I figured I'd better get going.

I made the 25-minute drive to the McPherson airport, and we went ahead and let ourselves in. It didn't take long before trucks began driving all over the ramp, tanks of helium were rolling across

The Flight of ORB-11

By Harry Mueller, KC5TRB*

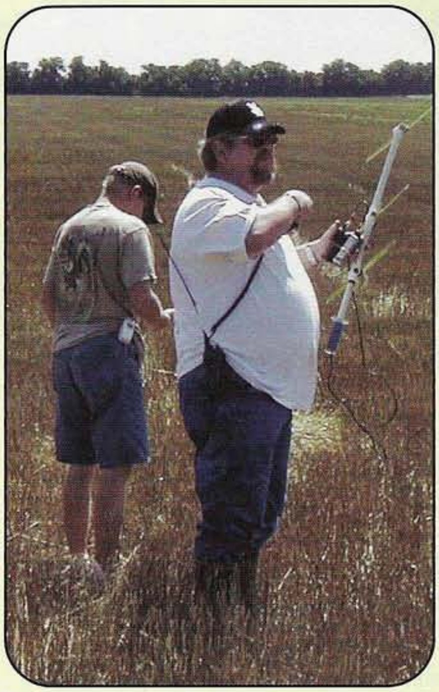
Oklahoma Research Balloon Flight number 11 (ORB-11) was flown from the McPherson, Kansas airport on the morning of Saturday, July 3. Our launch crew was Bill Brown,WB8ELK; soon-to-be amateur radio operator Bob Hill from Hutchinson, Kansas; and myself, KC5TRB.

As we completed the fill and weighed the lift we realized we had overfilled the balloon, and at about that same time Bill discovered a hole in the upper portion of the neck of the nozzle. We duct-taped the hole, and then the bottom one inch of the nozzle just broke off. We got the payload tied onto what was left of the nozzle, and then lots of duct tape was used all around the nozzle.

We launched with five other flights. We initially were expecting an altitude of 107,000 ft. until we overfilled the balloon, which gave us a 1200–1500 fpm lift instead of 910 fpm.

We positioned ourselves for the final chase, just south of Newton, Kansas. We had to backtrack about 10 miles when the balloon broke early at 81,559 feet. We were positioned right under the balloon as it reached 7,000 feet on descent, when we had a computer glitch and had to re-boot.

When we again got the computer operational, ORB was on the ground and we were receiving no APRS position reports. In about 15 minutes we heard Bill's voice beacon, and several minutes after that we heard my K-12 beacon as well. When we arrived at the landing site, two other teams were there; they had arrived 5–10 minutes before us. ORB was lying on its side, in the open, in a cattle pen. We were given the landowner's permission to enter the pen, and ORB was recovered at about 11 AM. Damage was evident on the K-12 beacon antenna, one of the two lines to Bill's beacon was cut, and the balloon remnants had fouled the chute.



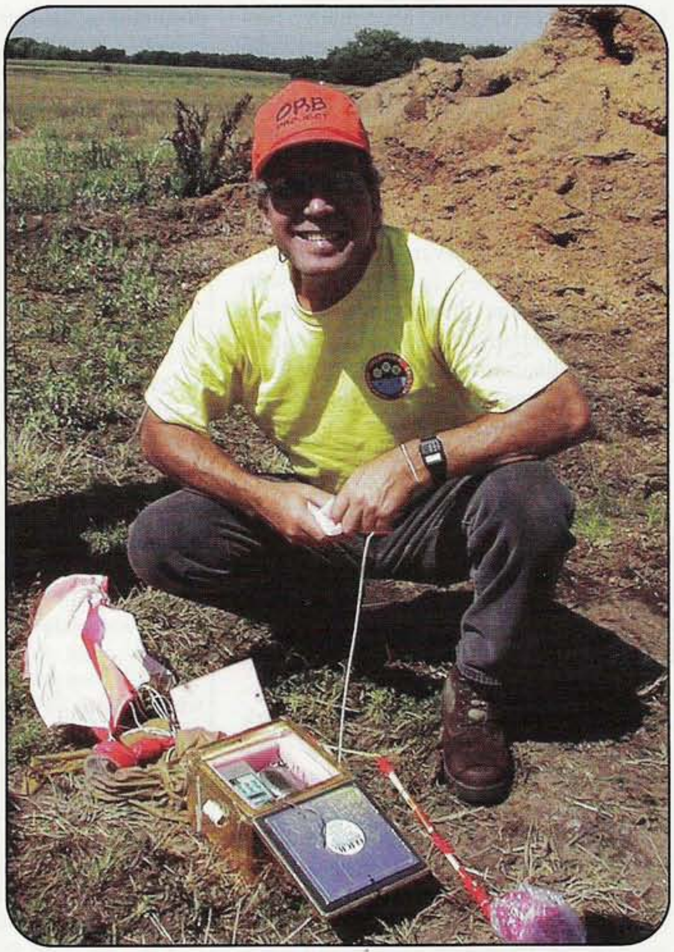
Bob Hill (soon to be a licensed amateur radio operator) and Chris Krengel, KBØYRZ, are shown DFing the downed EOSS payload through a wet Kansas field. (WB8ELK photo)

The EOSS payloads had landed about three miles from our landing site, so we all went to see if that group needed some help. When we got there, the payloads had not been found and it was determined through DFing that it was somewhere in a very large cornfield. Kansas has had a lot of rain and the fields are very muddy and the corn was 6–8 ft. tall. Three of us—Chris Krengel, KBØYRZ, Bob Hill, and myself—took on the challenge of finding and recovering the payloads. After an hour of trudging through the mud and corn, we found them.

At the end of the chase, many of the various members of the chase teams met at a truck stop near Newton, Kansas and had lunch. It was an opportunity to swap stories and show some hastily printed photos of the day's events.

**3307 E. Haskell Place, Tulsa, OK 74115*
e-mail: <hhm_74115@cox.net>

Jon Riley, AJØNR, retrieving Project: Traveler's payload from about 30 feet up in the tree. (WØZC photo)



Harry Mueller, KC5TRB, proudly displays what remains of his recovered payload. (WB8ELK photo)

the concrete, and general mass chaos began.

T-Minus 30 Minutes (Launch Site)

The chaos came to a climax at somewhere around 8:30 AM. It was quite a sight watching six teams intently working on getting their flying machines airworthy. Slowly but surely the latex envelopes began stretching out and that familiar hiss of gas rushing through a hose filled the air.

I spent my time running from one end of the group to the other checking each flight's status and estimated time of departure. At what seemed to be the last minute, Don, KAØJLF, announced that he needed a second tank of helium to fill his extra balloons, just as Paul, KD4STH, told me that he needed an extra two pounds of lift. The two of them agreed that they could split a tank, and off I ran to go find our spare T-size tank.

I had been monitoring the Common Traffic Advisory Frequency (CTAF) for the airport on my handie-talkie, and so far there had been only one aircraft in the area. As the launch time approached, I announced over the CTAF the group's intention to launch soon and then picked up my ham radio to tell the balloon groups to get into position. I continued to monitor CTAF while I waited for the last two groups to find their places.

In an instant, all of the groups had their conglomerations of latex, rope, nylon, Styrofoam®, and duct-tape raised into the air. I ran back to the aircraft-band radio and again announced that approximately "eight white targets will be departing the area to the southeast at 1000 feet per minute." That being said, I jumped back on the ham band and gave my group, Project: Traveler, the go ahead to launch.

Our payload on Project: Traveler included a downward-looking camcorder set to record the other group's lift-off. As my "baby" floated away above me, I gave the go ahead for all the other balloons to begin their countdown.

All of a sudden, the clear, blue skies were littered with white balls. Then they were almost gone, nothing more than specs about the size of a medium-size star.

T-Plus 5 Minutes (The Chase)

As if that wasn't enough for one morning, I then had eight 150-pound empty helium bottles scattered on the ground as the chase teams crammed their equipment back into their vehicles and went tearing out of the parking lot.

My uncle, as well as a few other kind souls, helped load the tanks back into our trucks so we, too, could go tearing out of town after our payload. With my wife in the co-pilot's seat and me behind the wheel, it wasn't long before we were on the Interstate dodging every "slow"-moving vehicle on the road.

As per the predictions that I had run that morning, the balloon tracked straight down the highway. As we neared Newton, everything was still looking very good and we decided to drive on past and get into position near the predicted landing spot a few miles south. Randy Berger, WAØD, and his crew met up with us on a little county road where we sat around and talked about ballooning, the nice weather that we'd been having, and the two intimidating army helicopters flying in formation that came buzzing by at about 500 feet.

After some idle chitchat and some searching of the sky trying to get a glimpse of our balloon at 80,000+ feet, the balloon finally burst at just over 94,000 feet, just a few hundred feet shy of my predicted burst altitude. My copilot noted that our predictions were now showing a touchdown a few miles back to the north of where we were, so I proceeded to mosey on up the road to check out the conditions and to see whether or not I could find a good grid of one-mile section roads.

The roads were good, but as the balloon settled down toward the 40,000-foot mark, it became obvious that we were still several miles too far south, and worst of all, our latest predictions were setting down the capsule right in the middle of the Interstate. This bothered us greatly, and we drove back to the highway and found an on-ramp just a few miles from our prediction.

As the capsule continued floating down, our landing predictions began bouncing back and forth between just east of the Interstate, just west of the Interstate, and right on the Interstate. By 15,000 feet things weren't getting any better, and we actually got on the highway and began crawling along on the shoulder closer and closer, knowing that if we went too far, we couldn't turn around.

Finally, at about 5,000 feet the prediction moved to about one mile east of the Interstate, so we took the first exit and began rushing to the landing site. As usual, Jon, AJØNR, and gang beat my wife and me to the landing site by just a few moments.

Recovery

We all leaped out of our vehicles because we knew from our GPS that the capsule was less than 100 feet off the side of the road. Unfortunately, the side of the road was a row of 50-foot hedge trees.

Now being a city-boy all my life, I didn't know the full implications of a "hedge tree" until I started crawling through them and examining those thorns that kept tearing at my shirt. The row wasn't very thick, and we soon made it through to the other side. Then I turned around and looked up. Ah ha! I actually was the first one to spot our capsule (which I think was a first after ten flights). Oh no! It was 30 feet up in a tree.

Thanks to "Monkey Man" Jon, we soon had our capsule back in hand without even a tear in the parachute.

Post-Flight

Fortunately, the other five groups all recovered their capsules safely, all with their own unique and often entertaining stories. Except for a couple of seemingly minor equipment failures, everything worked just as planned and is ready to see another day.

We gathered at a local truck stop in Newton, Kansas for lunch and sat back and told war stories about our past days', and past years', adventures.

Next Year

With the Great Plains Super Launch each year gets better and better. I've carried the torch long enough. Now it's time to pass it along to Mark, N9XTN, and the NSTAR group, near Omaha, Nebraska. Look for us at <http://groups.yahoo.com/group/gpsl> for up-to-the-minute information and the address for next year's official website.

Thanks to all of those who participated. This Super Launch would not have been possible without you: Bill Brown, WB8ELK, from Huntsville, AL; Edge Of Space Sciences from Denver, CO; High Altitude Basic Investigation Testing And Tracking from Kansas City, KS; Harry Mueller, KC5TRB, from Tulsa, OK; NSTAR from Omaha, NE; Paul Verhage, KD4STH, from Boise, ID; and Project: Traveler from Hutchinson, KS. ■

Correction

In the article "The Sporadic-*E* Files," by Ken Neubeck, WB2AMU, on page 32 of the Spring 2004 issue of *CQ VHF,* figure 1 was not printed in its entirety. We show it here, with its associated caption.

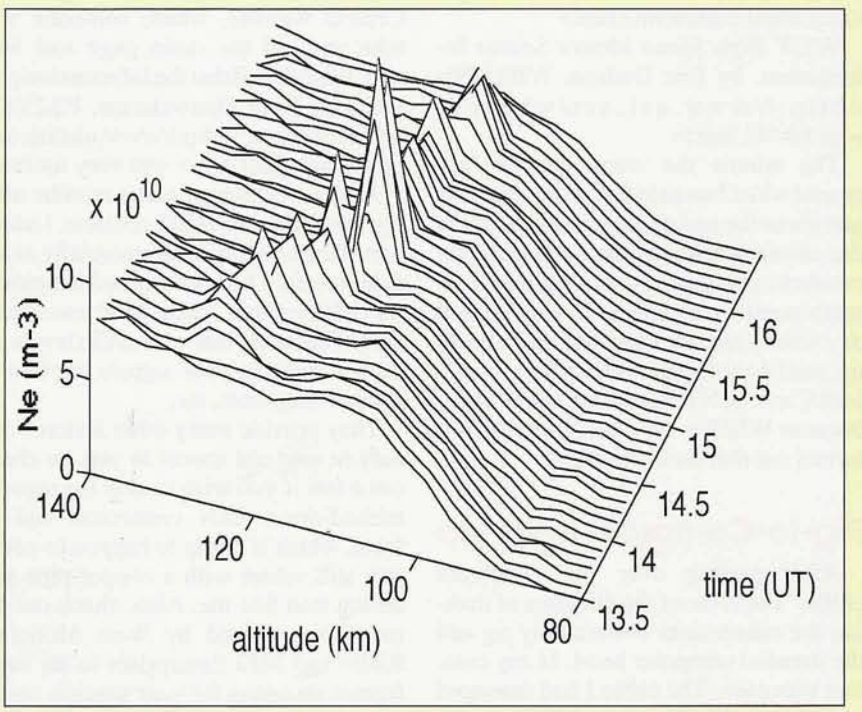


*Figure 1. This plot of a sporadic-*E *formation during July of 1992 was made in northern Europe using EISCAT radar. It can be seen that the thin sporadic-*E *layer is descending toward the 100-km mark due to tidal forces. (Plot courtesy of Dr. S. Kirkwood)*

VHF station should stop reading right here? No, absolutely not. Thanks to the genius of Joe Taylor, K1JT, the world of meteor-scatter fun and accomplishment has been opened to everyone. For more about how he has opened the door for the rest of us, please see the accompanying sidebar, A Typical WSJT Meteor Scatter Station.

A few short years ago, Joe developed software called WSJT. In Joe's own words, "WSJT is the name of a computer program. It stands for 'Weak Signal communication, by K1JT.'" The program is designed to facilitate meteor-scatter, moonbounce, and other difficult communication tasks on the amateur radio VHF/UHF bands. It is freely available to radio amateurs for non-commercial purposes.

To use the program, you will need a computer equipped with a sound card and running the Microsoft Windows© operating system. The software is free and can be downloaded from Joe's website: <http://pulsar.princeton.edu/~joe/K1JT/index.htm>. To learn more about the installation and use of WSJT Software, see these additional websites:

So You Want to Operate WSJT? by "Tip" Tipton, WA5UFH: <http://www.qsl.net/wa5ufh/>.

Also by Tip: Seven Necessary Steps: <http://6mt.com/wsm2.htm>

WSJT High Speed Meteor Scatter Information, by Eric Dodson, WB5APD: <http://www.qsl.net/wb5apd/wsjt-fsk441.html>.

The minute the word *software* appeared when I went to Joe's site, that was just about the end of my mission to get in the meteor-scatter game because I am computer challenged—in a big way. I always consider myself as having a good day when I turn the computer on, it boots up, and I do not hurt myself in the process. Jack Carlson, N3FZ, told me not to worry because WSJT is very user friendly. It it turned out that Jack was right.

A Typical WSJT Meteor-Scatter Station

I asked the majority of the stations I have worked on 6- and 2-meter WSJT meteor scatter to tell me about their stations. While a handful of them had a KW, receiver preamplifiers, and stacked antenna arrays, you will be delighted to know that the typical station is:

6 meters	50–150 watts	3- to 5-element horizontal Yagi
2 meters	100–150 watts	8- to 13-element horizontal Yagi

Most of the 6-meter ops told me that they were running a typical off-the-shelf rig without any sort of power or receive amplifier. The situation on 2 meters was essentially the same, except that many had added one of the easily obtained "brick" power amplifiers, most of which included a receiver preamp as well.

The antennas mentioned above are, in many cases, smaller than a high-gain RadioShack TV antenna. The ones not fitting that description are only slightly bigger and could easily be turned with a small rotor while being supported by a guyed push-up mast or chimney-mount mast.

It was exciting for me to discover that a number of stations I have worked repeatedly are using much less glamorous antennas than even these little, but effective, Yagis. I have worked stations out as far as 1000 miles that used only halos, wire antennas in trees, and even HF antennas. It appears that if the rig will load it, it can be used to make meteor-scatter WSJT contacts.

I have completed contacts with stations running as little as 10 watts. W9SE told me that he worked K5CM, who is about 500 miles away, while they were running 3 watts and 1 watt, respectively. Do not let low power keep you from getting in on the fun.

Rig-to-Computer Hook-up

After getting over the "software chills," I next faced the dilemma of making the connections between my rig and the dreaded computer beast. In my case, this was easy. The cable I had managed to lash together to get on RTTY on the HF bands using WriteLog and MMTTY was sufficient. For those not so fortunate, one of the terrific sites put together by experienced WSJT users listed above will walk you through this with ease. In all likelihood, you will need to get familiar with that auxiliary plug on the back of your radio or at least open the rig's operations manual. If you are like me, I am sure that this may be the first time that many of you take such dramatic action.

Of course, when all else fails, put out a quick plea for help on the Ping Jockey Central website, where someone will take you off the main page and help you. I also found that the information provided by Peter Gouweleeuw, PA2VST, on his website <http://www.uksmg.org/practicalwsjtinf.htm> was very useful.

A few weeks ago, many months after my first 200 or so WSJT contacts, I added one of the handful of commercially available interface boxes designed to connect rig and computer. These little jewels take care of ensuring that your audio levels are proper and that your signals are free of ground-loop hum, etc.

They provide many other features that may or may not appeal to you, so check out a few if you wish to skip the mess of melted-down DIN connector, and so forth, which is likely to happen to you if you still solder with a copper-pipe soldering iron like me. Also, check out the interfaces offered by West Mountain Radio and MFJ Enterprises to do some feature shopping for your specific needs.

Load and Go—Almost

I went to the WSJT website, started the download, and simply followed each step of the automatically generated instructions as the download unfolded. In no time at all I had the software fired up, a "short cut" safely placed on my computer desktop screen and the WSJT operating screen similar to Figure 1 looking at me.

Soon I discovered a problem. The software comes preprogrammed with two callsigns, neither of which is mine. I immediately recognized that my call is neither K1JT nor W8WN, so there was more work to do. The gang on Ping Jockey Central told me to read the instructions. It's not their fault that they did not know that I am one of those people with the anti-instruction-manual defect. My children still have scars from Christmas toys that did not quite play the way they were supposed to.

Nevertheless, I finally reasoned that I needed to get this software up and running, so a logical starting point was to click on "Setup." Sure enough, Setup menu tinkering got my software easily routed to the correct COM Port. In addition, my software knew my call, my grid, and the fact that I am located in the Eastern Time zone. If you don't know your grid, you can determine it by visiting <http://www.arrl.org/locate/gridinfo.html>. There you will find all sorts of helpful information, including links to purchasing ARRL products that you can use to locate and keep track of the grids that you have worked and need to work.

Jack, N3FZ, finally deduced that I was not an instruction-manual reader, so he took me off to a side chat page and patiently walked me through my first contact by telling me what buttons to click on the software screen and how to make sure my send and receive levels were set properly for my laptop computer sound card.

We started the sending and receiving sequences. At first I heard nothing. Then PING! There was a short but loud burst of data sounding signal from Jack. When his turn for sending was over and mine began, the software automatically went to work decoding the signal burst I heard with my ears. It was Jack calling me repeatedly just like the TX 1 message said. On a dead band I was hearing signals and communicating information over hundreds of miles!

In no time we sequenced through the messages. Well, actually it was clumsy, because remember, I did not read the instructions. There is a set protocol for "when" to send "what" message. If I had simply pressed the F5 key, a pop-up would have jumped out, clearly explaining this much-needed information. Blush!

At any rate, Jack was patient with me. The bad news was that he said I apparently needed additional software (cringe) because my computer clock was off, and I was off by several seconds in the sequence of transmitting and receiving.

The Time is…

As I learned from my first QSO with Jack, one important factor with this software is keeping track of the exact time. Jack sent me to Thinking Man Software —Dimension 4 (http://www.thinkman.com/dimension4/download.htm) so I could download the freeware. Dimension 4 software turned out to be a fast and easy way to synchronize my Windows®-based PC's clock. Once Dimension 4 was installed and I had made a few adjustments, I was able to forget it, and I have let it run automatically ever since. It is that automatic.

Dimension 4 monitors my Internet connection and automatically adjusts my PC's clock when I am online. This action in turn makes sure that my transmit and receive sequences are in step with the rest of the WSJT users. I am sure a visit to the Dimension 4 website will answer all those questions you technical types who are reading this have lingering just behind your forehead. Me? I was just glad I got it running easily without crashing my computer or breaking the Internet.

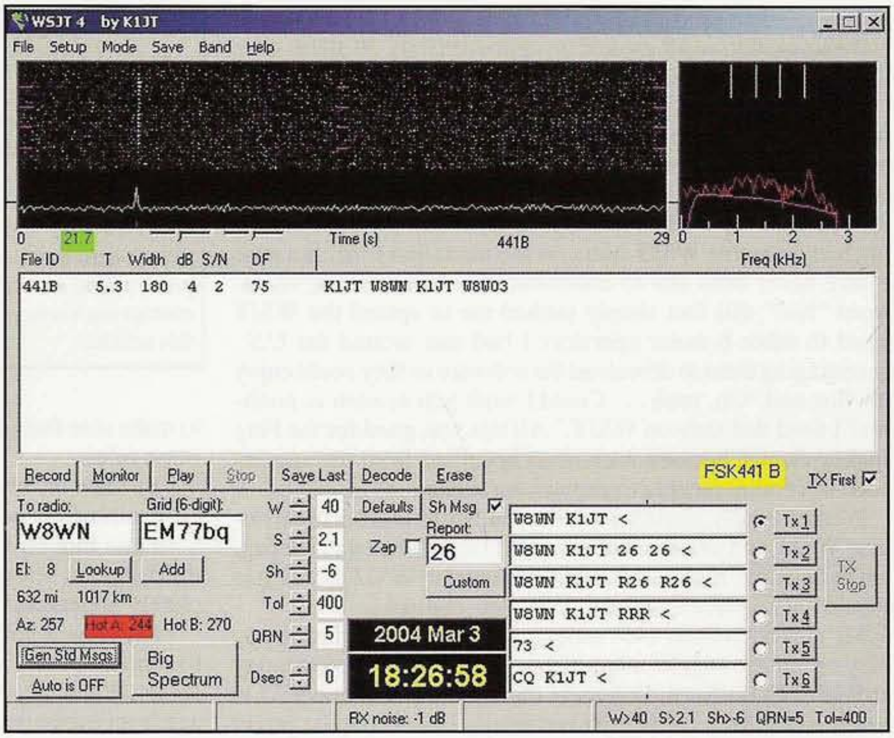


Figure 1. WSJT screen shot for meteor-scatter digital mode FSK441B.

Not being a computer whizzo, though, I did encounter some trouble getting my adjustments right. Thanks to the easily understood information that was readily available on the wonderful WSJT help website that Eric, WB5APD, has set up at <http://home.alltel.net/wb5apd/wsjt-fsk441.html>, I quickly was able to get my time tracking software doing its very important job so I could forget it and get on with enjoying WSJT meteor-scatter fun.

I presume that there is other terrific software out there to keep your computer clock set to the proper time if you choose to look for it.

Let the Pile-up Begin

As soon as the Ping Jockey Central users figured out that I was able to make contacts without flopping around too much, the rush was on to make a contact with me. I was like a new country showing up on the bands for these people! Later I observed that every newcomer is treated to the same enthusiastic reception.

It turns out that the WSJT crowd likes to measure their success by tracking the number of individual stations, states, grids, and even countries they work on "pure" meteor scatter. In a very friendly, non-cat-fighting way, they enjoy stacking their numbers up against other users. Bob Mobile, K1SIX, maintains the website <http://personalpages.mcttelecom.com/~b_mobile/6MFSK441.htm> to help the group keep an eye on what can be done, based on the accomplishments of others. I constantly see these WSJT users helping one another enrich their "numbers." This is an example of camaraderie that is most definitely a pleasure to witness.

The Race is On

All those offers of assistance and requests for contacts from these enthusiastic meteor-scatter people whet my appetite to see where my personal boundaries might be with this fun, new (to me) mode of operation.

I decided to hold my own personal contest. My rules were simple: Because meteor scatter is geometrically and scientifically limited to a range of approximately 1500 miles, I set a goal of working each of the 37 states inside that window, based on my Connecticut QTH.

The obsessive-compulsive devil once again raised its ugly head. I spiced up my personal challenge by setting a self-imposed limit of only 60 days to accomplish this feat. My new meteor-scatter friends chuckled quietly at this declaration, but not without encouraging me to go for it. The primary reason for their encouragement was because, at the time, none of the old timers had managed to work more than approximately 30 states over the entire few-year history of WSJT existence.

I had such a great time trying to work all the operators who were active during that period of time. They knew I was on the hunt, and many of them went beyond the call of duty to make late night as well as very early morning skeds with me to add their state to my worked list. However, some of the states simply had no active WSJT users on the air at that time. Because I have never been one to understand the true meaning of the word "No!" this fact simply pushed me to spread the WSJT word to other 6-meter operators I had met around the U.S., encouraging them to download the software so they could enjoy the fun, and "Oh, yeah . . . Could I work you as soon as possible? I need that state on WSJT." All this was good for the Ping Jockey crowd, because each of us benefited from the appearance of another newbie to expand our ranks.

When I finally recruited a fellow in North Dakota to download WSJT and join the fun, I thought I had the goal in the bag. Unfortunately, night after night of 6-meter WSJT skeds just would not produce a two-way complete contact.

My new friend was 1467 miles away, so I most certainly was playing on the ragged edge of my limitations. The 60th day arrived with no North Dakota in the log. In fact, number 37 is still missing from the log. Nevertheless, I am still quite proud of the other 36.

VUCC: Using Only WSJT Meteor Scatter

Months passed. One day I realized that I had worked about 80 grids on pure 6-meter WSJT meteor scatter. Up popped the Hyper Type, which is a personality defect, and the race was on to see how fast I could complete my personal goal of working 100 grids using only WSJT meteor scatter. Again, I ran into trouble finding enough people active on WSJT in a number of grids I still needed. E-mails flew through the Internet, new people were lured to Ping Jockey, and the fire of enthusiasm again fueled an increase in the number of WSJT users.

I completed the 100th grid contact just weeks before the April 23–24, 2004 Southeast VHF Society Conference in Atlanta, Georgia. More important is the fact that long-time WSJT Meteor Scatter King "Tip" Tipton, WA5UFH, accomplished the same thing some time before me, which was absolutely appropriate. Based on my results, I am now convinced that VUCC (VHF/UHF Century Club) is within reach of *anyone* who wants to work for it—with or without a microphone or Morse code key!

Some Important Lessons I Learned

Pursuing the goals mentioned above involved a fair amount of on-the-air time committed to learning how to use my new WSJT software and how to get the most out of my station, chasing burning rocks. Along the way I picked up a few tips worthy of mention here.

First, understand that the meteor-scatter gang takes the validity of a contact as a "good one" quite seriously. They want that contact to be made without any outside assistance once the sked has been established on Ping Jockey Central or by other means. The Ping Jockey site has an explanation of what constitutes a good contact. To demonstrate to the group that you are sincere in respecting the ethics of this mode of operating, you will want to make sure that you understand the following basic commonsense rules:

- Be clear on who transmits in the first and second halves of each minute; there is an easily understood protocol.
- Press that F5 key and keep the pop-up in front of you on the computer screen while making each contact until you completely understand the message sequencing.
- Pay close attention to the fact that your rig may not be able to run full power with WSJT. Many ops run 50% power-out levels. When they are in doubt, they do not want to cause damage from excessive heat with those 30-second key-down transmissions.
- Make sure your rig or rig/transverter is on frequency. WSJT is somewhat off-frequency tolerant, but we are talking Hz, not kilo-Hz.
- From the others, learn how to be sure that you do not make a sked on a frequency that is already being used.
- Have others point you to the various websites and freeware that will help you make the best advantage of meteor showers, operating times, and optimum sked times between two given grid squares.
- On the 2-meter and higher bands, you will want to have one of the more experienced operators explain Doppler and its effects on shifting frequencies.
- If you did not hear the ping, it probably did not happen, and the decode that you think you see is likely to be garble. "The ears are still the best judge" is the view that is held by most meteor-scatter enthusiasts.
- To increase the success of your meteor-scatter signal reception, learn to use a light touch on the RF gain control.
- Become aware of the various fun meteor-scatter competitions that occur each year to enrich your grid and state numbers. Competitions always liven up the group, often bringing some of the less active ops on the air for some action.

PowerPoint® Presentation Available

This past spring I prepared a Microsoft PowerPoint® presentation with the same title as this article for the 2004 SVHFS Conference. The presentation includes several .gif and .wav video and audio files that simply could not make the transition to printed matter for the conference proceedings.

This article was written to pique your interest in trying a new source of VHF fun and discovery—Digital Mode WSJT Meteor Scatter action. I would be delighted to make the full PowerPoint presentation available to you upon request. If interested, please contact me via my QTH information supplied on the first page of this article.

WSJT: A Team Sport

What an incredibly inspiring time I have had trying to accomplish my goals with all the help the many other Ping Jockey users gave me! I seriously doubt that there are many amateur radio activities that have such a close bond of mutual satisfaction in helping one another expand the horizons by "just" one more grid or by one state farther away.

I have found that operating WSJT meteor scatter is very much a team sport. I cannot think of a better place to send new Technician Class licensees or people who are new to the VHF bands.

With WSJT Meteor Scatter, *the band is never closed!* ■

radio contact involving) extra-terrestrial communications modes such as moonbounce, meteor scatter, auroral propagation, and amateur radio satellites. Either the physical cards required for each award or endorsement, in such quantity as may be required (that is, all 5, 10, 15, 25, 50, or 100 cards, as applicable), or legible photocopies thereof, must be submitted to The SETI League, Inc., along with the name and full postal address of the applicant. All cards will be returned to the applicant, provided that the administrative fee specified below accompanies the submission.

Detections from different, uniquely identifiable passive reflectors (i.e, a given moon, planet, specific asteroid, comet, or meteor shower) each qualify as a separate detection for the purposes of this award. Only one detection may be claimed for each source observed, except that repeat observations in different ham radio bands or radio astronomy bands will count as unique detections.

In the case of detections involving multiple examples of the same family of artificial source (e.g., multiple GPS satellites all received on the same frequency), each specific source must positively and uniquely be identified in order for it to count as a separate detection for the purpose of this award.

Mail all ETCC materials to: Operating Awards, The SETI League, Inc., P.O. Box 555, Little Ferry NJ 07643 USA.

The SETI League, Inc. will levy an administrative fee of $10 U.S. for U.S. applicants, and $15 U.S. for non-U.S. applicants, for each ETCC initial certificate and each ETCC endorsement awarded. Such fees are intended to cover the costs of administering this award and of returning all submitted QSL cards. The administrative fee is payable in U.S.-dollars checks (drawn on a U.S. bank or U.S. Correspondent bank) or postal money order only, and must be remitted at the time the QSL cards are submitted. Participants are, of course, welcome to make additional voluntary contributions to the nonprofit SETI League, Inc., which may be tax deductible to the extent allowed by law.

Our most active participants to date are already listed on the ETCC Honor Roll page of The SETI League's website, <http://www.setileague.org/awards/etcc.jpg>. I hope to be able to add your name or your callsign to that listing in the coming months . . . or years, or decades, or centuries. ■

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By Dr. H. Paul Shuch,* N6TX

DR. SETI'S STARSHIP

Searching For The Ultimate DX

Worked All Worlds

Are you getting bored yet? I sure am! We've been searching for extraterrestrial radio signals for nearly half a century now, and so far, no success. (Okay, well maybe not you and I personally, but for that long, as a civilization, Earth has pursued the science of SETI, the Search for Extra-Terrestrial Intelligence, and still no confirmed reception.) Hams have been engaged in the search since the inception of SETI, and hams are notoriously impatient. How do we hold their interest through what might well prove to be a multi-generational endeavor?

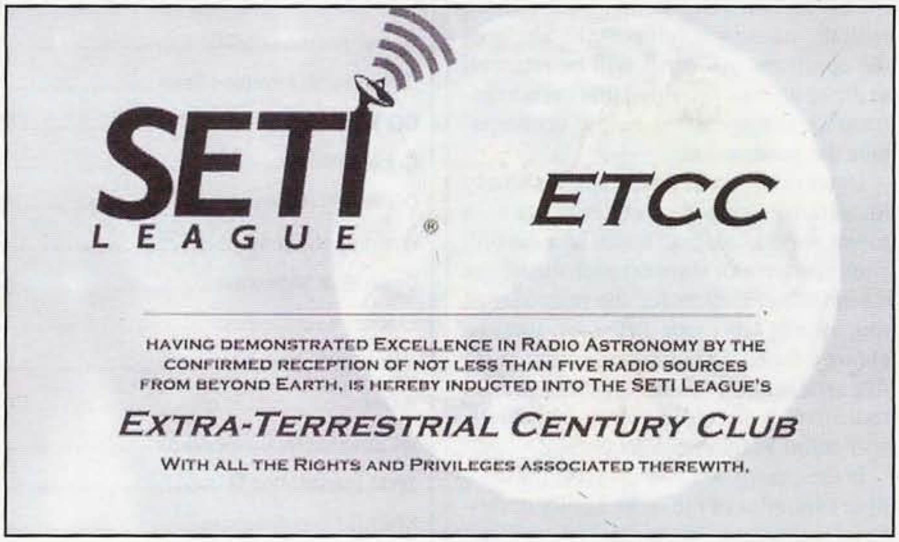
The problem is that SETI offers little to those who demand instant gratification. After all, it has been maybe 12 or 15 thousand million years since the Big Bang, the explosion that many of us believe formed the universe. Our Sun was formed perhaps 5 thousand million years ago, the Earth was formed shortly thereafter, microbial life emerged 3 billion years back, and humans came into being just yesterday on the cosmic clock.

What of our ability to communicate across the cosmos using photons, the fastest spaceships known to man? We have had the necessary technology for less than the blink of an eye. So how long *should* it take to detect our cosmic companions? No one can say for sure, but it's safe to guess it probably won't happen tomorrow.

We in The SETI League, however, are asking radio amateurs to build sensitive microwave receiving stations, point their antennas at the stars, and wait . . . and wait . . . and wait.

So far the bands are dead. No wonder we're getting bored. SETI's only hope of holding your interest (and mine) is to establish a program of on-the-air activities, competitions, and awards. When you're huffing and puffing and running toward the goal line, perhaps you'll be less likely to notice that it's light-years away. In my last installment I told you about The SETI League's extra-terrestrial QSL card program to acknowledge your reception of radio sources from "beyond." Today we take the next step.

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



Confirmed reception of a minimum of five radio sources from beyond the Earth's atmosphere can qualify you for membership in the Extra-Terrestrial Century Club. Endorsements are issued for additional detections, up to a maximum of 100.

The SETI League has an awards program to honor the efforts and accomplishments of the world's amateur radio astronomers. The Extra-Terrestrial Century Club (ETCC) award, patterned after the DX Century Club (DXCC) and VHF/UHF Century Club (VUCC) awards from the American Radio Relay League, rewards confirmed reception of a significant number of distinct extra-terrestrial radio emissions—manmade, natural, and even (dare we hope?) alien!

Amateur radio astronomers and SETI enthusiasts documenting radio reception from beyond Earth of a suitable number of artificial satellites, manned or unmanned space probes, natural astrophysical phenomena, Earth transmissions bounced off the Moon or another planet, or confirmed electromagnetic evidence of another civilization in space are eligible to apply for ETCC awards from The SETI League, Inc. The program is open to SETI League members and nonmembers alike, although interested radio amateurs are encouraged to join the nonprofit SETI League, Inc., this planet's most DX-oriented ham club.

The initial ETCC award is issued for the properly documented detection of five unique extra-terrestrial radio signals. Endorsements are issued for the documented detection of a total of 10, 15, 25, 50, and 100 such unique sources. Detection of extra-terrestrial radio sources in the categories of Natural, Human, Moonbounce, and Alien, in any combination thereof, as defined in our Extra-Terrestrial QSL rules (listed in last quarter's column), will be accepted as qualifying for ETCC initial certificates and endorsements. As is the case for most awards recognizing on-the-air activities, participants are asked to pay a modest fee to cover the costs of administering this program.

Here are some of the specifics:

For the purpose of this award, successful ET radio detections will be evidenced solely by the submission of valid QSL (confirmation of reception) cards. These may include Extra-Terrestrial QSL cards issued by The SETI League, Inc., or QSL cards issued by licensed radio amateurs documenting reception of (or two-way

(Continued on page 83)

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[1]Note that certain frequencies are unavailable. [2]5W output

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