ISSN 1085-0708

CQ VHF Ham Radio Above 50 MHz

www.cq-vhf.com

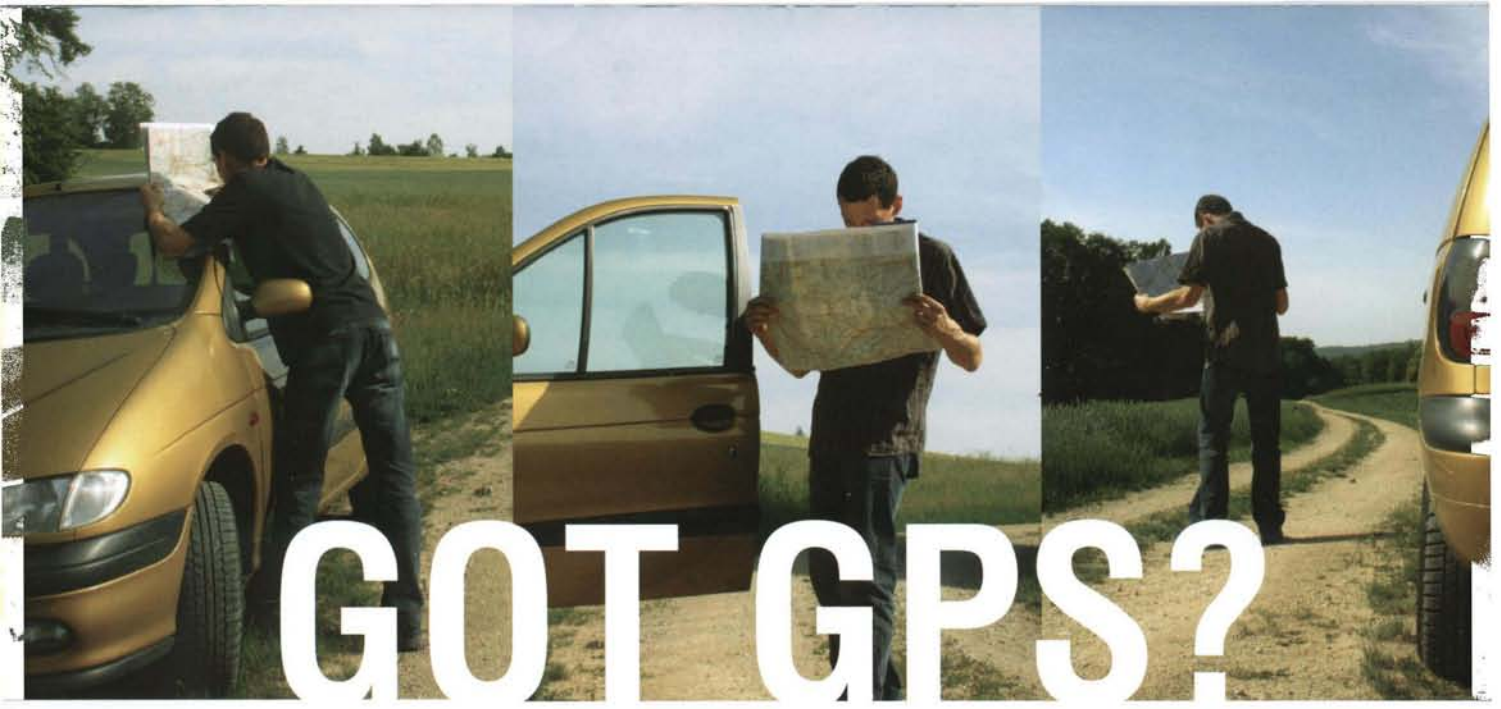
Summer 2007

$7.50

Creating Scientists and Engineers via Amateur Radio

- The Lost Letters of KH6UK and Remembering W2UK/KH6UK
- Building a Simple X-Band Transverter

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



NEW IC-2820H

D-STAR optional D-STAR DV + GPS

Add the latest in digital functionality to your 2820H by installing the optional UT-123 module. You'll get D-STAR DV and on-board GPS operation. Show lat/long data, a virtual compass and more, right on your 2820H's display. Connect your 2820H to a PC via RS-232C with an optional cable (OPC-1529R) and you can plot your or your sender's location on a map using third party software, too. Find yourself at an authorized Icom dealer today! For free literature call 425.450.6088 or go online: www.icomamerica.com

DIGITAL

ICOM

12 STORE BUYING POWER

HAM RADIO OUTLET®

WORLDWIDE DISTRIBUTION

Manufacturers Day in Salem NH–Aug 25th!
Special one day only pricing at ALL 12 HRO STORES
(Salem only) – *Hourly Prizes* – – *Meet Mfr. Reps* – – *See the latest gear* – – *Refreshments* –
10:00 - 5:30 pm (no purchase necessary)

DISCOVER THE POWER OF DSP WITH ICOM!

IC-706MKIIG All Mode Transceiver

• Proven Performance • 160-10M*/6M/2M/70CM • All mode w/DSP • HF/6M @ 100W, 2M @ 50W, 440 MHz @ 20W • CTCSS encode/decode w/tone scan • Auto repeater • 107 alphanumeric memories

IC-7800 All Mode Transceiver

• 160-6M @ 200W • Four 32 bit IF-DSPs+ 24 bit AD/DA converters • Two completely independent receivers • +40dBm 3rd order intercept point

IC-746PRO All Mode 160M-2M

• 160-2M* @ 100W • 32 bit IF-DSP+ 24 bit AD/DA converter • Selectable IF filter shapes for SSB & CW • Enhanced Rx performance

IC-7000

• 160-10M/6M/2M/70CM • 2x DSP • Digital IF filters • Digital voice recorder • 2.5" color TFT display

IC-756PROIII All Mode Transceiver

• 160-6M • 100W • Adjustable SSB TX bandwidth • Digital voice recorder • Auto antenna tuner • RX: 30 kHz to 60 MHz • Quiet, triple-conversion receiver • 32 bit IF-DSP • Low IMD roofing filter • 8 Channel RTTY TX memory • Digital twin passband tuning • Auto or manual-adjust notch with 70 dB attenuation

IC-718 HF Transceiver

• 160-10M* @ 100W • 12V Operation • Simple to Use • CW Keyer Built-in • One Touch Band Switching • Direct frequency input • VOX Built-in • Band stacking register • IF shift • 101 memories

IC-T90A Triple Band Transceiver

• 6M/2M/70CM @ 5W • Wide band RX 495kHz - 999.999MHz** • 500 alphanumeric memories • Dynamic Memory Scan (DMS) • Backlit keypad & display • CTCSS/DTCS encode/decode w/tone scan • Weather Alert

IC-2720H Dual Band Mobile

• 2M/70CM • VV/UU/VU • Wide band RX inc. air & weather bands • Dynamic Memory Scan (DMS) • CTCSS/DTCS encode/decode w/tone scan • Independent controls for each band • DTMF Encode • 212 memory channels • Remote Mount Kit Inc.

IC-V8000 2M Mobile Transceiver

• 75 watts • Dynamic Memory Scan (DMS) • CTCSS/DCS encode/decode w/tone scan • Weather alert • Weather channel scan • 200 alphanumeric memories

IC-91AD Digital Dual Band Transceiver

• 2M & 70CM @ 5W • 1304 Memory channels • Independent (dual watch) wide band RX 495kHz - 999.999MHz** • Full dot matrix LCD • New "duplex scan" • D-STAR digital voice • Compliments the ID-800H mobile

ID-800H Digital Dual Band Mobile

• 55 watt VHF/50 watt UHF • Wide RX: 118-173, 230-549, 810-999 MHz (cellular blocked on US versions) • Analog/Digital Voice & Data • Callsign Squelch • CTCSS & DTCS Encode/Decode w/tone scan

IC-2200H 2M Mobile Transceiver

• 65W Output • Optional D-STAR format digital operation & NEMA Compatible GPS interface • CTCSS/DTCS encode/decode w/tone scan • 207 Alphanumeric Memories • Weather Alert

IC-V82 2M Transceiver

2M @ 7W • Optional D-STAR format digital operation features include callsign calling, up to 20 character text message, & position exchange*3 • CTCSS/DTCS encode/decode w/tone scan • Also available in a sport version and a 70CM version (IC-U82)

ICOM

*Except 60M Band. **Frequency coverage may vary. Refer to owner's manual for exact specs. ✦Rebates and instant savings expire 9/30/07. Free offers are for a limited time only. Check with HRO for details or restrictions on any offers or promotions. ✦✦Rebates and instant savings expire 9/30/07. *1 AA Alkaline batteries not included, radio comes with a AA alkaline battery tray. *2 For shock and vibration. *3 When connected to an external GPS. © 2007 Icom America Inc. CQ Aug 07. The Icom logo is a registered trademark of Icom Inc. 9576

CALL TOLL FREE

Phone Hours: 9:30 AM – 5:30 PM
Store Hours: 10:00 AM – 5:30 PM Closed Sun.

Toll free, incl. Hawaii, Alaska, Canada; call routed to nearest store; all HRO 800-lines can assist you, if the first line you call is busy, you may call another.

West.....800-854-6046
Mountain.....800-444-9476
Southeast.....800-444-7927
Mid-Atlantic...800-444-4799
Northeast.....800-644-4476
New England..800-444-0047

Look for the HRO Home Page on the World Wide Web
http://www.hamradio.com

AZ, CA, CO, GA, VA residents add sales tax. Prices, specifications, descriptions, subject to change without notice.

ANAHEIM, CA
(Near Disneyland)
933 N. Euclid St., 92801
(714) 533-7373
(800) 854-6046
Janet, KL7MF, Mgr.
anaheim@hamradio.com

BURBANK, CA
1525 W. Magnolia Bl., 91506
(818) 842-1786
(800) 854-6046
Eric, K6EJC, Mgr.
Magnolia between S. Victory & Buena Vista
burbank@hamradio.com

OAKLAND, CA
2210 Livingston St., 94606
(510) 534-5757
(800) 854-6046
Mark, WI7YN, Mgr.
I-880 at 23rd Ave. ramp
oakland@hamradio.com

SAN DIEGO, CA
5375 Kearny Villa Rd., 92123
(858) 560-4900
(800) 854-6046
Tom, KM6K, Mgr.
Hwy. 163 & Claremont Mesa
sandiego@hamradio.com

SUNNYVALE, CA
510 Lawrence Exp. #102
94085
(408) 736-9496
(800) 854-6046
Howard, W6HOC, Mgr.
So. from Hwy. 101
sunnyvale@hamradio.com

NEW CASTLE, DE
(Near Philadelphia)
1509 N. Dupont Hwy., 19720
(302) 322-7092
(800) 644-4476
Rick, K3TL, Mgr.
RT.13 1/4 mi., So. I-295
delaware@hamradio.com

PORTLAND, OR
11705 S.W. Pacific Hwy.
97223
(503) 598-0555
(800) 854-6046
Leon, W7AD, Mgr.
Tigard-99W exit
from Hwy. 5 & 217
portland@hamradio.com

DENVER, CO
8400 E. Iliff Ave. #9, 80231
(303) 745-7373
(800) 444-9476
John N5EHP, Mgr.
denver@hamradio.com

PHOENIX, AZ
1939 W. Dunlap Ave., 85021
(602) 242-3515
(800) 444-9476
Gary, N7GJ, Mgr.
1 mi. east of I-17
phoenix@hamradio.com

ATLANTA, GA
6071 Buford Hwy., 30340
(770) 263-0700
(800) 444-7927
Mark, KJ4VO, Mgr.
Doraville, 1 mi. no. of I-285
atlanta@hamradio.com

WOODBRIDGE, VA
(Near Washington D.C.)
14803 Build America Dr.
22191
(703) 643-1063
(800) 444-4799
Steve, W4SHG, Mgr.
Exit 161, I-95, So. to US 1
virginia@hamradio.com

SALEM, NH
(Near Boston)
224 N. Broadway, 03079
(603) 898-3750
(800) 444-0047
Chuck, N1UC, Mgr.
Exit 1, I-93;
28 mi. No. of Boston
salem@hamradio.com

A publication of

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

Offices: 25 Newbridge Road, Hicksville, New York 11801. Telephone: (516) 681-2922. FAX: (516) 681-2926. E-mail: cq-vhf@cq-vhf.com. Website: http://www.cq-vhf.com. CQ VHF (ISSN 1085-0708) is published quarterly (4 times a year) by CQ Communications, Inc. Periodical postage paid at Hicksville, NY and additional offices. Subscription prices (all in U.S. dollars): Domestic—one year $25.00, two years $50.00, three years 75.00; Canada/Mexico—one year $37.00, two years $74.00, three years 111.00; Foreign—one year $48.00, two years $96.00, three years 144.00. Government Agencies: Subscriptions to CQ VHF are available to agencies of the United States government, including military services, only on a cash with order basis. Requests for quotations, bids, contracts, etc., will be refused and will not be returned or processed.

Printed in the United States of America.

Postmaster: Please send change of address to CQ VHF Magazine, 25 Newbridge Road, Hicksville, NY 11801.

contents

Summer 2007
Vol. 10 No. 2

FEATURES

COLUMNS

DEPARTMENTS

On The Cover: This year for Field Day the AO-51 Operations Team decided to run Mode V/U FM and Mode L/U FM simultaneously. The cover photo shows the W5IU satellite array. For details see the "Satellites" column by Keith Pugh, W5IU, on page 68. (Photo by W5IU) **Inset photo:** Columbus (Georgia) High School students with a rocket payload section after recovery from the Atlantic Ocean. For more of the story see "Creating a Few Scientists and Engineers with Amateur Radio," by Luther Richardson, KI4AOJ, on page 6. (Photo courtesy of KI4AOJ)

CQ VHF Ham Radio Above 50 MHz

LINE OF SIGHT

A Message from the Editor

History Made, Making History, and History in the Making

As the title of this editorial indicates, much of this issue of *CQ VHF* is about history. Regarding history made, it was 50 years ago this July that the International Geophysical Year (IGY) began. In actuality, it would last 18 months. It was a time of exciting worldwide propagation research that coincided with the peak of Sunspot Cycle 19, which is the highest recorded cycle to date.

Amateur radio involvement in the IGY was invited, encouraged, and recruited. Taking place almost as a sidebar to the IGY was an attempt by Tommy Thomas, KH6UK, and John Chambers, W6NLZ, to span the Pacific Ocean between Hawaii and the U.S. West Coast. They completed their initial contact on the evening of July 8, 1957. As it turned out, this QSO, which used tropospheric propagation, a mode in which IGY researchers were not initially interested, eventually earned the reputation as being perhaps the most important amateur radio contact to take place during the IGY. Along with the reputation the QSO earned Tommy and John, they also received the 1960 ARRL Merit Award and the 1961 Edison Award, for which they each were given a trophy and split a $500 cash award.

Tommy was no stranger to being in the limelight. Thanks to correspondence with his nephew Mark Shultise, WA3ZLB, the son of Tommy's sister, Freda Shultise, I have documented some of Tommy's fascinating history in an article entitled "Remembering W2UK/KH6UK," which begins on page 48. Even more important than Mark's recollections was Tommy's own documentation, which he did before and during his exploits in Hawaii. The repository of this documentation was his good friend Walter Morrison, W2CXY, who dutifully kept almost everything he received from Tommy in a file cabinet that eventually ended up in the basement of his son Mark Morrison, WA2VVY.

When Mark finally got around to rummaging through those files, he realized that he had a treasure trove of history that needed to be shared with today's amateur radio VHF-plus operators. Coincidentally, Mark chose to share what has become known as "The Lost Letters of KH6UK" with *CQ VHF* magazine at the beginning of the 50th anniversary of the IGY. Beginning on page 16 you can read the fascinating story of that history-making QSO between Tommy and John Chambers. We at *CQ VHF* are very grateful to Mark for choosing this magazine as a venue for sharing this historically significant material with the amateur radio VHF-plus community.

Thanks to Tommy and John's groundbreaking work on tropospheric ducting between Hawaii and the West Coast, numerous other QSOs have taken place over the past 50 years. Much of the successive pioneer work has been done by Paul Lieb, KH6HME, and Chip Angle, N6CA. However, eluding these two thus far is a QSO on the 10-GHz band. Regarding potential history in the making, Gordon West, WB6NOA, discusses their latest attempts beginning on page 27. Because of the increasing popularity of the 10-GHz band, another 10-GHz related article in this issue is by Wayne Yoshida, KH6WZ, beginning on page 22. This one is about an easy-to-build transverter.

Fifty years after the IGY began, amateur radio experimentation and research continues, now with a new generation of young people, which includes both college and high school students. Beginning on page 6 you can read of Luther Richardson, KI4AOJ's work with college students at Auburn University and high school students at Columbus (Georgia) High School. In particular, these students are learning about flying balloons and rockets and using amateur radio as an integral component of their experimentation.

Documenting and providing coverage of those things that involve amateur radio experimentation up in the air has been something that we at *CQ VHF* magazine have been striving to improve with each successive issue. With this issue our coverage has become significantly better thanks to veteran writer and editor Bill Brown, WB8ELK, who begins a new column entitled "Up in the Air: New Heights for Amateur Radio" (see page 54).

When we think about making history, as it was for Tommy Thomas and John Chambers, setting goals plays a significant role for so many of the rest of us who operate on the VHF-plus ham bands. The goal that Paul Kiesel, K7CW, set for himself was to improve upon the results that Bill Smith, KØCER, now WØWOI, achieved when he operated from Ketchikan, Alaska, during the 1970 ARRL June VHF QSO Party. This year Paul teamed up with Kevin O'Connell, KLØRG, to make the effort. You can read about their operation beginning on page 30.

Giving Paul and Kevin a big assist was Ed Cole, KL7UW, who is, as Paul writes, "making great efforts to popularize weak signal VHF in Alaska." I mention Ed here because in the Spring 2007 issue of *CQ VHF* magazine I let slip by a mistake in Paul Shuch, N6TX's "Orbital Classroom" column. Ed's callsign was incorrectly printed as KL7UB in the photo caption in the column. I regret the error and apologize to Ed for the mistake.

There is lots of other great reading in this issue, including the columns that you look for in each issue. One column that has been with us from the start is "Antennas," written by Kent Britain, WA5VJB. In this issue he takes a nostalgic look at antennas that were very popular in years past—and some of the models that continue to be popular today. You can read his column beginning on page 40.

In the middle of Kent's column is a new advertiser, Texas Towers. We welcome Gerald Williamson, K5GW, and his company to *CQ VHF* magazine and thank him for his advertising support. Concerning Texas Towers and all of our advertisers, it is very important that we support them by buying their products and services. One way that they get to know that the ads they place in *CQ VHF* magazine are working is by way of your feedback. Therefore, when you contact them, I ask you to please tell them that you saw their ad in *CQ VHF*. Thank you for doing so.

Following this idea of telling our advertisers that you saw their ads in the magazine, I also encourage you to tell others about the content of this magazine. Along with telling them, please also encourage them to subscribe to *CQ VHF*. It is this kind of word-of-mouth advertising that is a great method of promotion. When you tell a friend about a product or service, he or she is very likely to believe you and follow your lead because of the trust that friend has in your opinion.

Regarding feedback and opinions, we at *CQ VHF* magazine also value your feedback. What are we doing right? What else would you like to see covered in the pages of the magazine? Finally, what can we improve upon in order to make this, your magazine, the best that it can be? I look forward to hearing from you regarding your feedback and opinions.

Until the next issue…

73 de Joe, N6CL

ALINCO makes a SPLASH

with great audio and high grade waterproof design!

DJ-V17T 144 MHz HT
DJ-V47T 440 MHz HT

Actual Size

These powerful HTs make perfect companions for outdoor activities like fishing, camping or snow-sports.

The rugged polycarbonate materials are compatible to IPX7* so these HTs are submersible 1m/3ft. for 30 minutes! And unlike water-resistant radios you may have looked at before, the DJ-V17 and DJ-V47 both have a large 40mm internal speaker so the audio is clean and crisp, not muffled. You can enjoy 500mW max audio-output, new two-touch repeater access, and over 200 memories. A special battery-drain function helps avoid battery memory-effect. Other features include an ergonomic design, ultra-flexible antenna with SMA connector, 39 CTCSS settings, split function, two-level attenuator and more. Whatever your idea of outdoor fun, Alinco's DJ-V17 and DJ-V47 are ready to take on the challenges of rain, dirt and dust and come back for more.

- New, two-touch repeater access
- High grade waterproof materials compatible to IPX7* (submersible 1m/3ft. for 30 min.)
- Rugged polycarbonate body resists dirt, dust and moisture
- Large 40mm internal speaker for great audio!
- Highly visible backlit alphanumeric display
- Direct frequency input through illuminated keypad
- 200 Memories, plus one call channel and one repeater access parameter memory
- VFO, Memory and Scan modes
- Ultra-flexible antenna with SMA connector avoids breakage
- 39 CTCSS tone squelch (encode+decode) settings
- Tone burst function (1,000, 1450, 1750 and 2100Hz)
- Battery-drain function avoids memory-effect
- Cloning feature
- Ni-MH standard also uses optional Lithium-ion and NiMH battery packs or AA dry cell case
- SMA antenna port
- 2-level attenuator
- Waterproof single mic/speaker jack

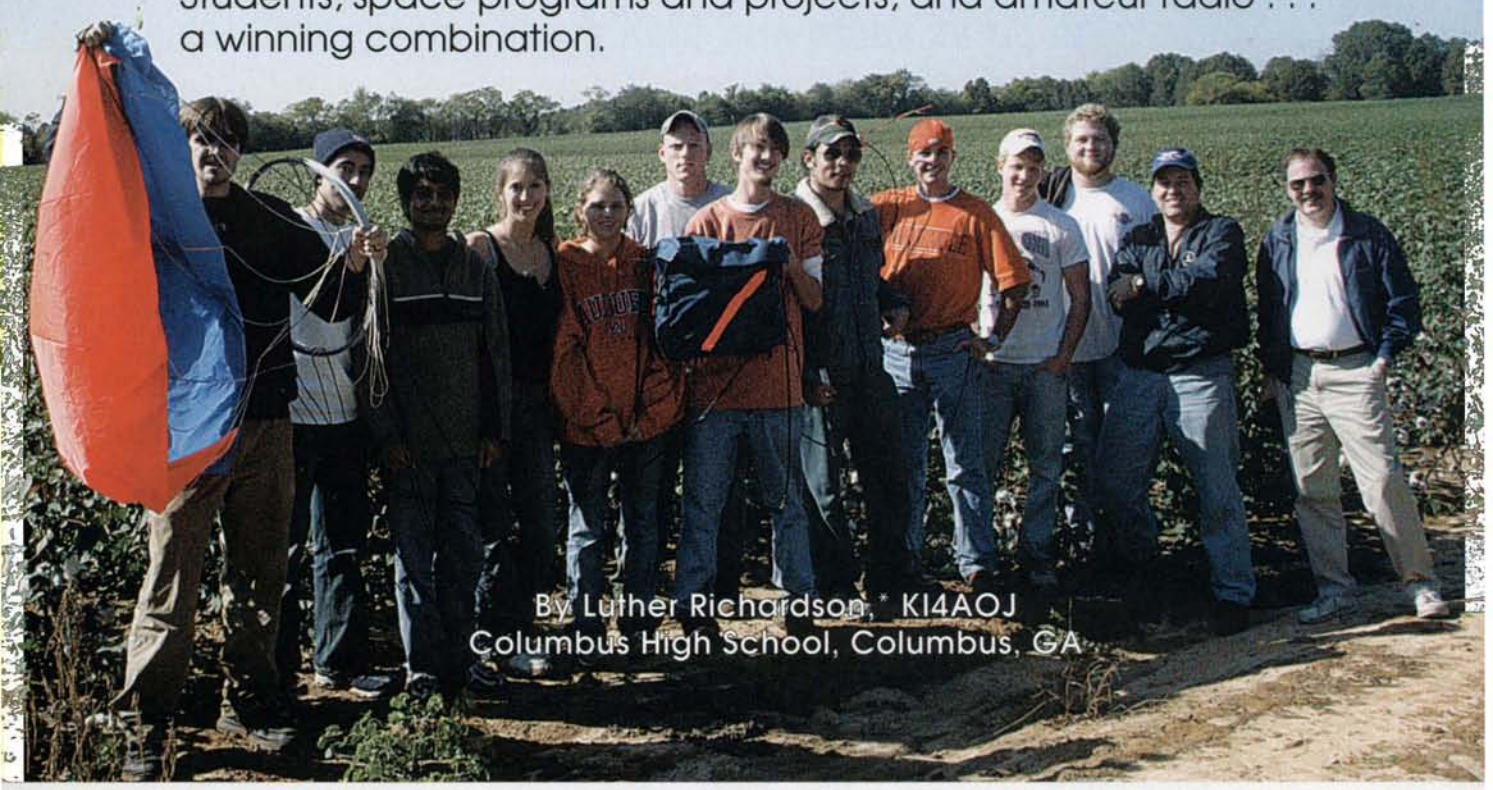
Alinco guarantees this feature for 1 year provided all jack covers are properly and securely closed.

www.ALINCO.com

Distributed in North America by Ham Distributors, 1775 North Loop 336 East, Ste. 8, Conroe, Texas 77301 • Phone: 936-649-1497 • Fax: 936-649-1303 • email: USrep@Hamdistributors.com

Creating a Few Scientists and Engineers with Amateur Radio

Students, space programs and projects, and amateur radio . . . a winning combination.



By Luther Richardson,* KI4AOJ
Columbus High School, Columbus, GA

The Auburn University balloon recovery team with the author and Keith Warren, AK4KO, on the far right. The launch site was selected to aim for the only flat terrain in the southeast, farm land and specifically a cotton field. (All images courtesy of the author)

If you visit an undergraduate physics or engineering lab at any college in the country, you will be alarmed to find out how many students have never built anything mechanical or electrical during their experiences in or outside of their classes in high school and college. Can the amateur radio community make a difference in the quality of educational opportunities available? Is it worth doing? These are the questions addressed in this article. Students at Auburn University and at Columbus High School (CHS) have completed some projects using amateur radio that do amazing things. For many science and engineering students, the lessons learned in these kinds of projects usually are transferable to an actual job setting.

Students who take on these kinds of projects often have to learn technical skills along the way, and just as important, they learn project management skills. The key element for both a mentor and organizer is to set up the students for success. The students may fail repeatedly through the various steps of a project and stop trying if they experience the fear of failure. Therefore, gentle nudges and words of encouragement are required, mixed with a few proverbial "kicks in the pants" to keep them going. Access to a knowledgeable amateur radio operator will prevent the students from constantly reinventing the wheel and give them a way out of those "technical dead-ends" that often stop the beginner in advanced projects.

This article describes a university student-built satellite project using amateur radio bands, a high school student antenna experiment that flew on a NASA rocket, and a high school high-altitude balloon program that will fly middle school experiments and use APRS to track the balloon. In the descriptions of these student projects, input by amateur radio operators will be highlighted. In the end, I hope I can convince you that teenagers and young adults really can do interesting things given the right atmosphere for learning, such as the one that exists in the applications of amateur radio.

*6239 Charing Drive, Columbus, GA 31909
e-mail: <lrich@physics.auburn.edu>

Some Background

In 2001, I started working with some of my high school physics students at Columbus (Georgia) High School on experiments proposed to NASA and others. The group calls itself the Columbus High School Space Program. In the last six years, this group of students has had over two-dozen proposals accepted by NASA, by the Lemelson-MIT Foundation, by Auburn University, and by others to design, build, and perform original experiments. Most of those experiments have been sent into space or to the very edge of it.

As a graduate student in physics, I have also been a part of the Auburn University Student Space Program *(also see the "VHF Plus" column in the August issue of CQ magazine)*. As you might imagine, the Columbus High School and Auburn University programs have frequently

crossed paths. Working with these students typically occurred after normal class hours and became my primary hobby. The reward has been seeing the students succeed. Also, it was kind of nice to see our work ride into space aboard NASA balloons, rockets, space shuttles, as well as spend many months aboard the International Space Station. While space is an exciting destination, it is equally rewarding to work with students and see their experiments dropped from NASA drop towers, and riding the NASA Weightless Wonder (or its more common name, the Vomit Comet).

Regrettably, all of the NASA-sponsored programs in which we have participated in the last few years have now been dropped because of budget cuts associated with NASA's "return to the Moon" effort and lack of funding from Congress to maintain the education component within NASA. However, the NASA Space Grant Consortium still supports a variety of student programs. Also, there are some great university programs and funding sources that can help support student amateur radio projects (see Table 1 for some examples). First, I'll give the background on the amateur radio satellite program called CubeSat; it was the Auburn University CubeSat program that led to the first student amateur radio experiment at CHS.

NASA Space Grant Consortium: <http://www.spacegrant.org/info/who.html>. Most states are represented. Contact the group with an idea to see if it could fit in with their goals.

Best Buy Teach Award & Community Grant: <http://communications.bestbuy.com/communityrelations/teach.asp>. At this website is an announcement about a series of gift-card or spending accounts awarded annually by Best Buy to support a "fun and exciting" education program. Submission for next year's awards must be between July 1 and September 30.

Lemelson-MIT InvenTeam Invention Grant: <http://web.mit.edu/inventeams/>. This is a great one. Students propose an idea for an invention, and selected schools receive up to $10,000 to build it and bring it to the campus of Massachusetts Institute of Technology. We built a vibration-sensitive robot that used amateur radio to send telemetry to a ground station.

One could spend hours searching online through available grants. Most want a teacher to be the primary contact, but good ideas make it hard for the grant providers to say no.

Table 1. Examples of grant sources for space education projects.

CubeSats: Satellites for Science & Engineering Education

It is rare to find a university educator who is driven to do all the work necessary to bring real experiences to students. Dr. J. M. Wersinger is one of those people. In 2002, Dr. Wersinger, a physicist at Auburn University, started a program for students called the Auburn University Student Space Program. One of the main initial goals was to build a student satellite using a predetermined form factor through an international program called CubeSat. The CubeSat program started at the California Polytechnic State University, San Luis Obispo and Stanford University's Space Systems Development Lab.

These satellites must have a mass below 1.0 kg and an external structure in the shape of a 10-cm cube. Several of these CubeSats are in space right now. The CubeSats use amateur radio frequencies to communicate with the ground stations as an agreed-upon rule to involve as many people as possible, thus making education outreach a real possibility for each mission.

The CubeSat effort has spread to over 40 schools in 26 states. A list of schools involved and information about the program can be found at the program website (http://cubesat.atl.calpoly.edu/). A typical CubeSat may cost between $5,000 and $10,000 using off-the-shelf components. The cost for final preparations and launch is another $50,000.

Until now, the only way to get a CubeSat into space has been to buy space on Russian rockets (converted ICBMs, or intercontinental ballistic missles) to ride up as a secondary payload. The launch cost may come down with new launch opportunities for secondary payloads through the private launch provider called Space-X (http://www.spacex.com/) and work to integrate the P-pod (the CubeSat launcher) on American Atlas rockets.

What about the possibility of starting additional programs? An interested and motivated amateur radio operator could contact a pre-existing program to get involved, or maybe even help get one started at the local high school or college.

The original Auburn mission was to be a picosatellite with no attitude control that was capable of maintaining consistent communication with the ground while tumbling. Maintaining ground contact was to be done using a series of antennas and algorithms monitoring and controlling an antenna switching mechanism to maximize communication with ground stations. To test this mission concept, antenna testing began.

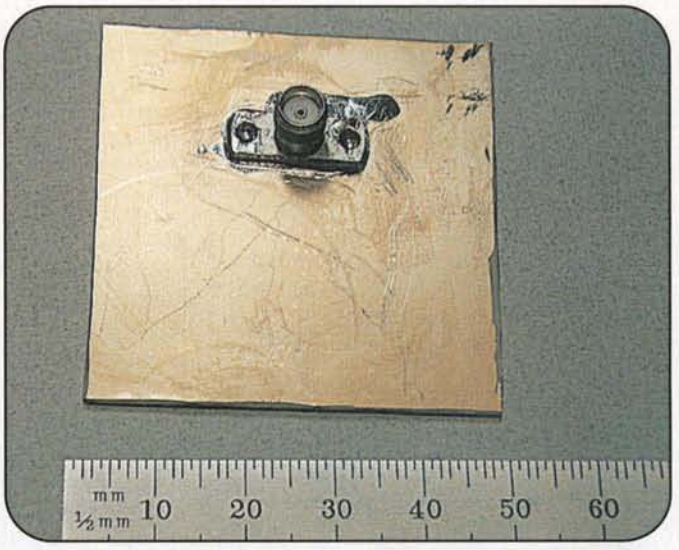
With the help of Auburn alumnus and electrical engineer Keith Warren, AK4KO, the student group designed a patch antenna tuned to 1270 MHz. This frequency was selected to be used as the uplink, because it would see less traffic than 2 meters or 70 cm. The plan was to embed a 70-cm twisted dipole for downlink underneath the patch antenna on each face of the cube.

CHS Program subSEM 2: Testing Communications with a Tumbling Satellite

Because I was involved in the CubeSat project while teaching full time at Columbus High School (CHS), I gave the Auburn University satellite-design review

This is a picture of the CalPoly CubeSat CP-4 being deployed in space. It was taken from the Aerospace Corp. Aero-Cube-2 CubeSat. The image was stored and sent down using 902– 928 MHz at 9600 bps, GFSK, 2 watts of power.

CHS students working in a cleanroom to create a patch antenna to be flown into space. From left to right: Gily Raz, Matt Lord, and Brianna Veenstra.



Final picture of the antenna, tuned to 1.265 GHz, with an SMA connector.

documents to the high school students to help them think of ideas for experiments to fly on a NASA rocket. NASA sponsored an annual competition called subSEM (suborbital Student Experiment Module), which used to be part of the Education Program at Wallops Flight Facility before budget cuts eliminated the program in 2006.

The students very quickly saw that the antennas were the experimental part of the Auburn effort, and they began writing the proposal. They were looking for a slot to ride to space on an Orion suborbital rocket that would climb up to 160,000 feet while spinning at four revolutions per second.

NASA selects only four high school experiments a year to fly into space on their sub-orbital rockets, with only one chosen from the southeast. In the years 2003, 2004, 2005, and 2006, the representative high school from the southeast was Columbus High School. This student proposal was the first CHS Space Program selected experiment to fly on a rocket, and it flew in the summer of 2004.

The students proposed to fly a patch antenna to measure its ability to capture packet radio transmissions from the ground. They ended up making the antenna in an Auburn University clean room. The antenna was to fly on board the spinning rocket with the antenna centered in a small 1.5-inch quartz window and monitor 1265 MHz using a Kenwood TH-59 radio. (This same type of antenna also flew on an Auburn University balloon to 93,000 feet and sent telemetry to a ground station 50 miles away.)

The TH-59, which is a single-band 1.2-GHz radio, had its speaker output connected to a signal conditioning circuit that was connected to an MP3 player. The MP3 player was to record audio of whatever the TH-59 was able to uplink from the student-run ground station.

On the ground, the students used a 1.2-GHz Yagi antenna connected to a Kenwood TM-541A and a Kantronics KPC3+ TNC connected to a laptop computer running TeraTerm. They manually tracked the rocket using timing marks on two protractors that were determined by doing a little physics using the known launch parameters of the rocket.

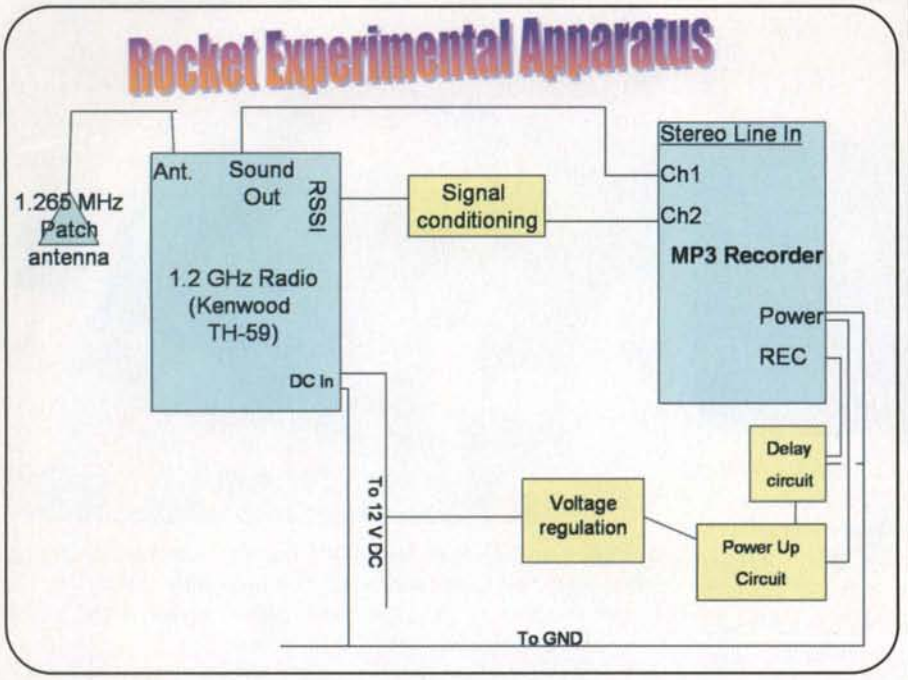
The original proposal also had a downlink experiment, but NASA was a little nervous about this because there was an outside possibility that our 70-cm downlink would resonate with the frequency they use to self-destruct the rocket.

The laptop ran the TeraTerm program and sent a sequence of letters. This sequence was comprised of three letters and symbols so that each three-letter combination represented a three-digit base94 number (using everything available on a standard keyboard). The experimental plan was to play back the MP3 recording of the packets to see which packets made it to the experimental antenna, and the three-digit base94 number meant they could tell when in time each packet was sent.

Four students and I went to Virginia to work for a week so we could integrate our satellite into the overall launch program and be part of the experiment at the actual launch in June 2004. The launch was scheduled for sunrise. Prior to the launch we had to set up. The team arrived at 3 AM and began setting up the laptop, TNC, radio, and antenna on its PVC pole.

Finally, at 6:30 AM the countdown began. We were only a few hundred yards from the rocket, so the incredible noise of the launch made it a challenge to track the rocket and follow the experiment procedure. The student team tracked the rocket for almost 30 minutes until we actually heard the lower stage impact the ocean 30 miles away. NASA had a boat crew in position to recover the payload section, which was floating gently back to Earth by parachute.

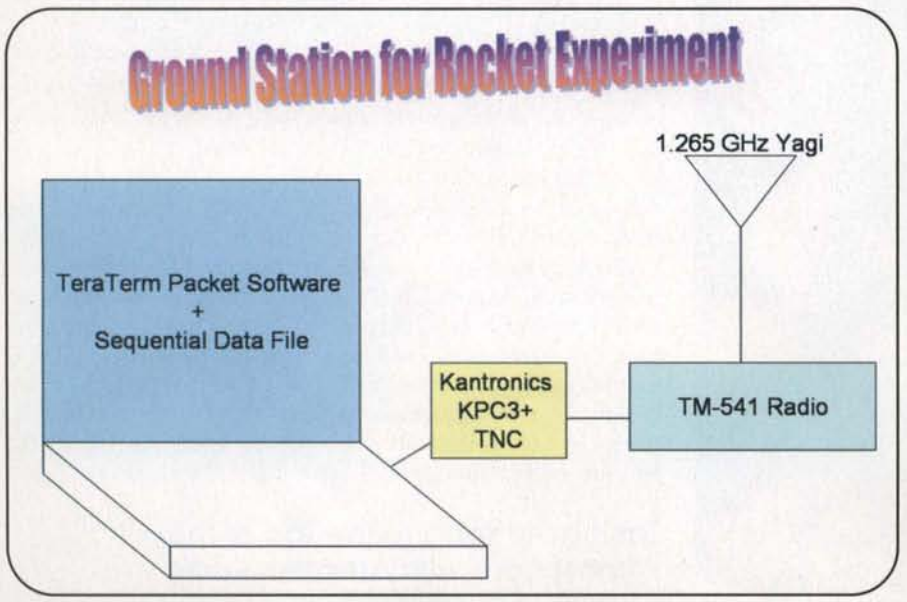
Later that afternoon, the students eagerly helped disassemble the rocket and took their experiment to their workstation. On the lab bench, the MP3 player was manually turned on and the students attempted to play back the data. No file was recorded. No data had been collected. It was heartbreaking for them, and tears were shed.



System block diagram for the student antenna experiment sent to space on the NASA Orion suborbital rocket.

By design the MP3 player had been stripped of its case so it could be turned on and its record buttons activated by an electronic timing circuit that engaged when power from the rocket was applied about ten minutes before launch. In shipping, the ground wire had come loose from the MP3 player. The wire was soldered back in place before integration to what appeared to be a solder remnant on the MP3. When the experiment was tested by the students on the lab bench while at NASA, it recorded fine. Apparently, the solder point was not a true ground, so when the experiment deck was mounted in the rocket, the ground changed, which caused the MP3 player never to turn on and record.

Even so, post analysis showed something interesting about the power consumption by our experiment deck. A very small periodic surge in current was pre-



System block diagram for the ground station that sent text packets to the student antenna experiment on the NASA Orion suborbital rocket.

Experiment in action. The Yagi is pointed at the rocket high in the sky 10 seconds after a thunderous launch. The students who were tracking it were so disciplined that they never looked up to see the rocket launch, even though they were only 300 yards away.

sent on top of the constant current draw used by the idle radio. The TH-59 had been modified so a voltage could be measured across its internal relative-signal-strength indicator (RSSI). It took many hours of help from Keith, AK4KO, and the help of the TH-59 service manual to get this to work correctly. In the middle of the rocket flight, the observed voltage surges appeared four times per second—the same as the rate of rotation of the rocket. It was possible that the antenna was working well enough to use a bit more current when it was seeing the signal from the ground station, causing a short spike in the RSSI meter.

Launch of the NASA Orion suborbital rocket carrying the student experiment.

Kelts Green, Gily Raz, Matt Lord, and Brianna Veenstra (from left to right) perform final testing on their antenna experiment before integrating the experiment plate into the NASA Orion suborbital rocket.

Matt Lord, the author, Kelts Green, and Gily Raz (all in the foreground) set up the ground station for testing in a NASA lab at Wallops Island Flight Facility.

The road to complete this experiment was a long one, with many trips to Auburn University to use its clean room and anechoic chamber to build and test the antenna. This experiment took over nine months for the students to complete, and they took away a hard but valuable lesson on the importance of attention to detail in science and engineering. From this particular group, two of the students went on to attend the Massachusetts Institute of Technology.

Taking Students to the Top of the Atmosphere with Amateur Radio

As the readers of *CQ VHF* magazine saw in the Spring 2007 issue *(see the article "Through the Back Door," by Kevin Carr, KE7KVT)*, it is possible to send amateur radio gear to the very

KENWOOD

Listen to the Future

AIRWAVE SUPERIORITY

Never before has a compact HT offered as many features, and such high powered performance as the TH-F6A. Arm yourself with one today and gain your own airwave superiority.

- Triband (144/220/440 MHz)
- Receives 2 frequencies simultaneously even on the same band
- 0.1~1300MHz high-frequency range RX (B band)[1]
- FM/FM-W/FM-N/AM plus SSB/CW receive
- Bar antenna for receiving AM broadcasts
- Special weather channel RX mode
- 435 memory channels, multiple scan functions
- 7.4V 1550mAh lithium-ion battery (std.) for high output[2] and extended operation
- 16-key pad plus multi-scroll key for easy operation
- Built-in charging circuitry for battery recharge while the unit operates from a DC supply
- Tough construction: meets MIL-STD 810 C/D/E standards for resistance to vibration, shock, humidity and light rain
- Large frequency display for single-band use
- Automatic simplex checker
- Wireless remote control function
- Battery indicator • Internal VOX • MCP software

[1]Note that certain frequencies are unavailable. [2]5W output

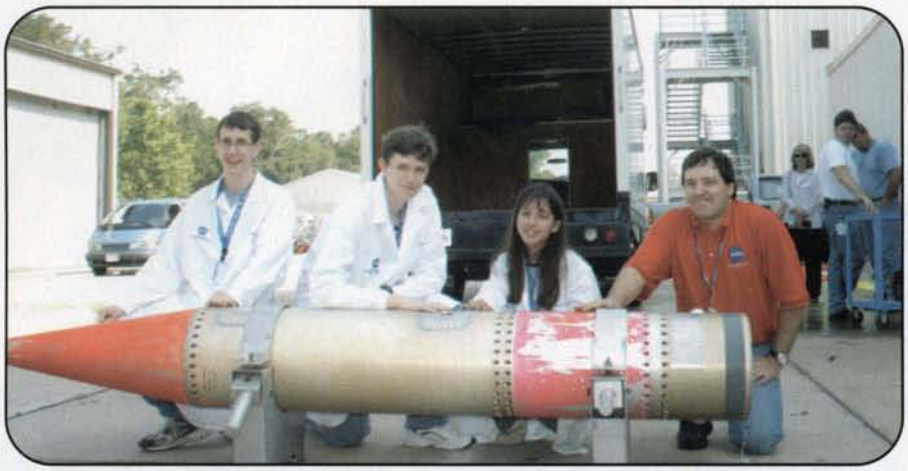
TH-F6A
TRIBANDER

KENWOOD U.S.A. CORPORATION
Communications Sector Headquarters
3975 Johns Creek Court, Suite 300, Suwanee, GA 30024-1265
Customer Support/Distribution
P.O. Box 22745, 2201 East Dominguez St., Long Beach, CA 90801-5745
Customer Support: (310) 639-4200 Fax: (310) 537-8235

INTERNET
Kenwood News & Products

ADS#25707

JQA-1205 091-A
ISO9001 Registered



A CHS student team with the rocket payload section after recovery from the Atlantic Ocean. Notice the stripped paint from air friction and heating during the rapid ascent through the atmosphere with acceleration up to 17g's.

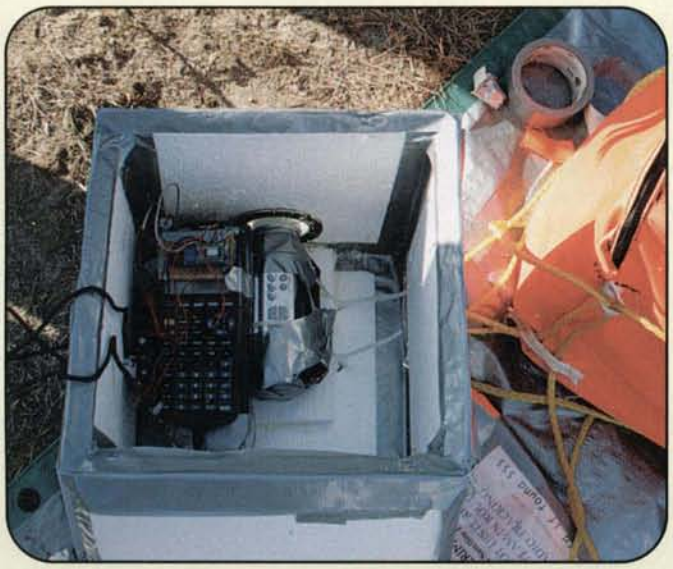
edge of space. In the summer of 2003 I traveled to the University of Colorado at Boulder to attend Chris Kohler's first "Starting Student Space Hardware Programs: A How To Workshop" (http://spacegrant.colorado.edu/studentsat/). This is the same workshop that KE7KVT wrote about in his article. Dozens and dozens of balloon programs have been started by those attending these workshops. We learned from the Edge of Space Science (http://www.eoss.org); the High Altitude Balloon Experiments in Technology (HABET) associated with Iowa State University (http://cosmos.ssol.iastate.edu/HABET/Home.html); and the Balloon Outreach, Research, Exploration and Landscape Imaging System (BOREALIS) from Montana State University (http://spacegrant.montana.edu/borealis/) how amateur radio can allow one to do science at the very edge of space.

These 8-foot diameter balloons, typically filled with helium, can provide upwards of 20 pounds of lift to carry about 12 pounds of payload to the top of the substantive atmosphere. Just like a boat floats on water, these balloons try to float on top of the atmosphere at around 90- to 100-thousand feet—that is, until they stretch to several dozens of feet across and then burst. Hopefully, a parachute will slow the fall. The trip typically takes about 90 minutes.

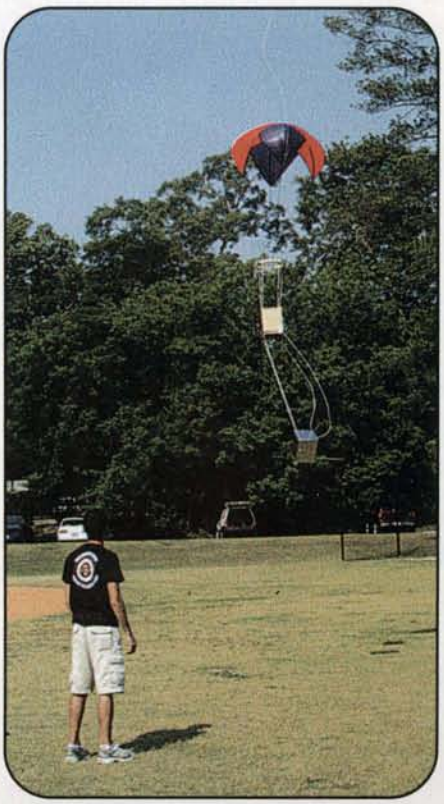
The FAA has regulations and guidelines for unmanned free balloons. However, those regulations are less intense if you stay under 12 pounds in at least two different structures. For more information on the regulations see <http://www.chem.hawaii.edu/uham/part101.html>.

When I returned from this summer workshop, I told my fellow members of the Auburn University Student Space Program what I had learned. With some motivation fueled by the excitement of sending our work to space, and with the help of the Auburn University Amateur Radio Club, we launched our first balloon four months later. This was not just a simple APRS beacon either. The first Auburn balloon carried with it solar-cell experiments for the satellite project, a patch-antenna experiment related to the rocket experiment previously discussed, an Alnico HT serving as a beacon and repeater, and a digital camera.

Since November of 2002, Auburn University has launched many balloons and has flown several Columbus High Space



Calculator (TI-83) collecting data from a Vernier Data Interface connected to an analog 3-axis Honeywell magnetometer (HMC2300).



Columbus High School student tests the parachute and cutdown system for the Columbus NASA Connections DREAM sky and payload systems.

Program experiments. Now the CHS Space Program has started its own balloon program.

DREAMS

I used some grant money to start a program called Columbus NASA Connections (http://connect.columbus2space.org), which is sponsoring the Doing Research at Extreme Altitudes by Muscogee County (Georgia) Students (DREAMS) program. The idea is that students from across a large school district will engage in a variety of activities related to NASA in the areas of science, technology, engineering, and mathematics. The activities will increase in intensity until they culminate with groups of students designing their own experiments to fly on the DREAMS high-altitude science platform. DREAMS 1, the first mission to fly, will be released later this summer. Some students have been working for almost a year on the DREAMS project, and as of this writing have nearly completed the design.

Help from two amateur radio operators in particular has made this education opportunity possible for over 33,000 students. They are Keith Warren, AK4KO, and John Klingelhoeffer, WB4LNM. Keith is an electrical engineering independent contractor specializing in Micro-Electro-Mechanical Systems (MEMS) technology and has over a dozen patents to his name. John is a retired president and general manager of the communication satellite company COMSAT. He has built satellite components on his own for Bob Bruninga, WB4APR, at the U.S. Naval Academy. Both Keith and John are Auburn University alumni, thus strengthening the connection between the high school and university programs.

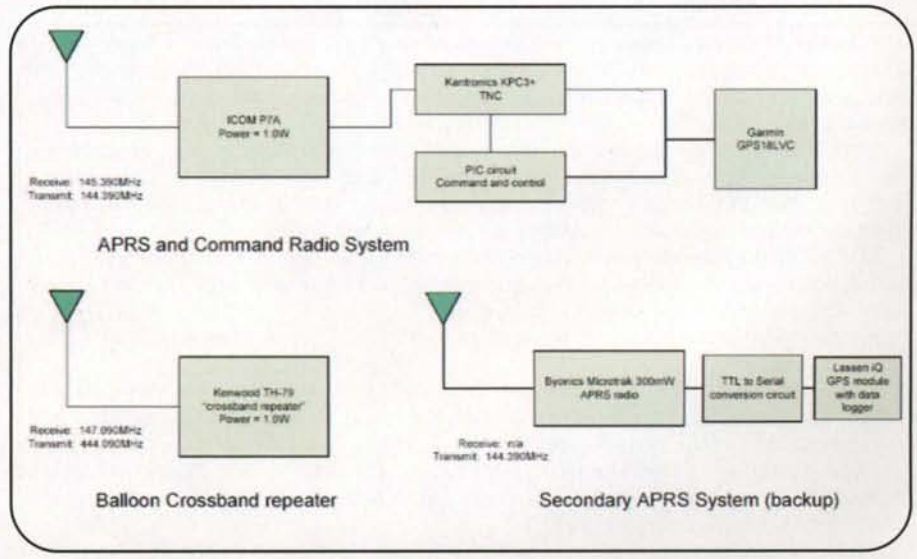
After many visits, e-mails, and hours on the radio and on the phone, the DREAMS design has been formed as shown in the system block diagrams. The balloon structure is comprised of two 9" ×9" ×11" tall boxes made of two carbon-carbon sheets sandwiched between a layer of 1/4-inch Nomex™. The boxes themselves are covered with a Mylar™ film to reflect thermal radiation in the near-space conditions.

Because the temperature is very low at high altitude, there are not many of those slow-moving cold-air molecules to carry away heat built up from absorbed infrared solar radiation. Inside the uppermost box is a very small HT made by ICOM—the P7A model with a mass under 150 grams.

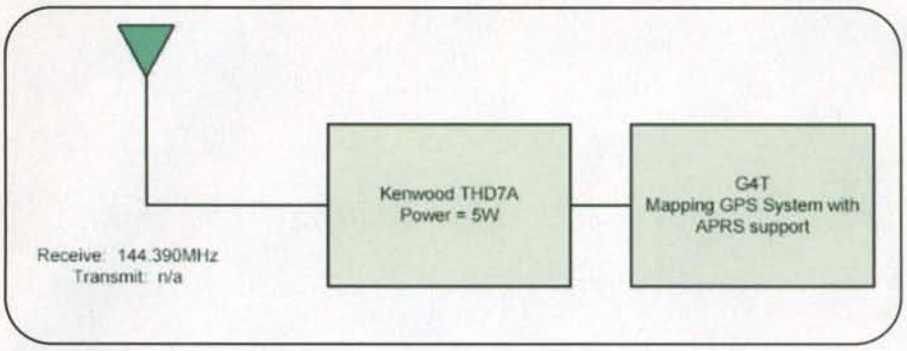
A group of teachers from the Muscogee County School District. These teachers trained to use a retired deep space networkradio dish to do radio astronomy with their classes over the internet (in a program called GAVRT, Golden Apple Valley Radio Telescope).

It is connected to a custom-built vertical dipole, which is integrated into the ring that separates the ropes going from the structure boxes to the parachute. A Kantronics KPC3+ TNC acts as the radio modem, and a programmed PIC circuit listens for one of up to four commands to activate relays if certain text commands are detected. Those commands include a cutdown to apply 12 volts and about 1 amp to a piece of Nichrome™ wire wrapped around the rope that connects the parachute to the balloon. The wire turns bright orange and will burn through the rope in about one second.

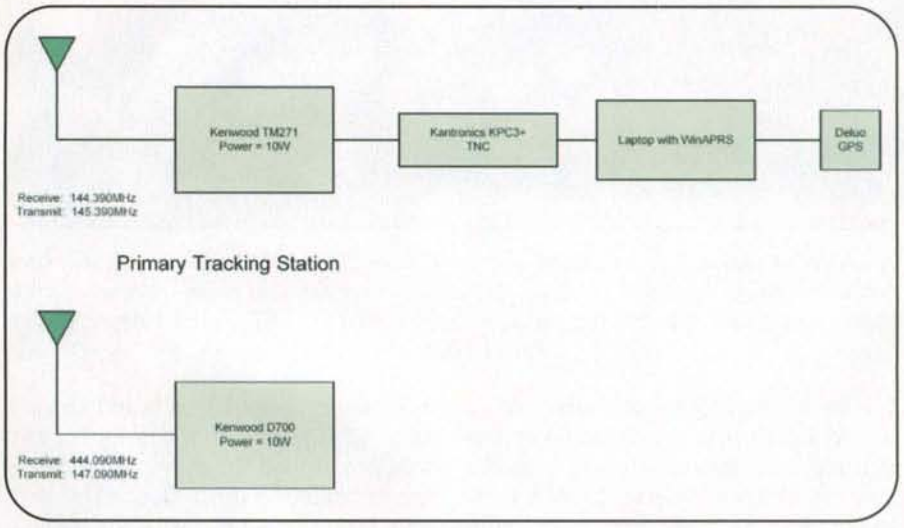
Another command activates a sound beacon (a car alarm) to help find the balloon once it lands on the ground. The PIC



Block diagram showing the Sky Station System that is completely housed in the DREAMS balloon. It facilitates APRS and communication with the ground.



Block diagram of the Secondary Tracking Station. This system is designed for simplicity so that an amateur radio operator could jump on a school bus full of participating students and track a balloon. The system includes a Kenwood handheld with built-in TNC and an APRS-compatible mapping GPS.



Block diagram of the Primary Ground Station System or the Primary Chase Vehicle. This system includes the capability to send command packets to the balloon Sky System to perform various functions and also to use the balloon as a repeater for the balloon chase teams.

Wireless Dynamics Sensor: Three-axis accelerometer, pressure sensors, force sensor. This sensor can be programmed to store data internally at various rates. Programming and data download are accomplished using Bluetooth® wireless technology. <http://www.vernier.com/>; $250

HMC-2300 Honeywell 3-axis magnetometer: This magnetometer is more sensitive than the magnetic compass sensors, and can measure decreases in the magnitude of the Earth's magnetic due to changing altitudes (moving away from the core of the Earth). <http://www.ssec.honeywell.com/magnetic/magnetometers.html>; $199

MMA7260Q Freescale 3-axis Accelerometer: This is a 3-axis accelerometer on an evaluation board ready for analog output. <http://www.SparkFun.com>; $40 (They have many other sensors and products as well.)

Surplus Motorola Pressure Sensor: Item #G15473. <http://www.goldmine-elec-products.com/>; $0.79

Hobo RH/Temp/2x External Logger: This small, self-contained unit is very simple to program and has built-in temperature and relative-humidity sensors and two channels to add more sensor data. <http://www.onsetcomp.com/>; $130

Onset TattleTale TT8v2 Data Logger: This unit allows up to eight channels of data to be recorded at decent rates with 12-bit resolution. Available from Onset Computer Corp. <http://www.onsetcomp.com/>; $500

Table 2. Sensors and data loggers. The sensor/logger is listed, followed by a description, availability information, and price.

circuit is also capable of activating the relays based on input from the GPS. For instance, if the balloon crosses a certain latitude, such as the one close to the airspace of Atlanta's Hartsfield International Airport, the cutdown would be activated automatically in case contact is somehow lost with the ground.

The second box is reserved for the scientific payload, which consists of various sensors and a data logger plus any biological samples. The data logger currently flying is a 19-channel 12-bit Tattletale data logger (http://www.onsetcomp.com/). Some of the sensors that can be flown are detailed in Table 2.

Middle school students in DREAMS must learn about the environmental conditions that occur at 100,000 feet. Then they must come up with a simple research question that can be answered with the kind of data we collect. The student groups do research and complete a report to explain their hypotheses prior to flight. With some training on analyzing data from the sensors using Microsoft® Excel (readily available on most computers), the students get their data after the flight and complete the report by trying to answer their research question.

Some advanced high schools or even middle schools can design their own experiment hardware. However, it is hard to find a high school with the right faculty in terms of both technical skill and motivation to support this kind of development. Nevertheless, the DREAMS model can be supported minimally by teachers at any level, with some specific training of those students over the summer and at some weekend meetings during the year. Results of the DREAMS program and more information can be found at <http://dreams.columbus2space.org>.

Summary

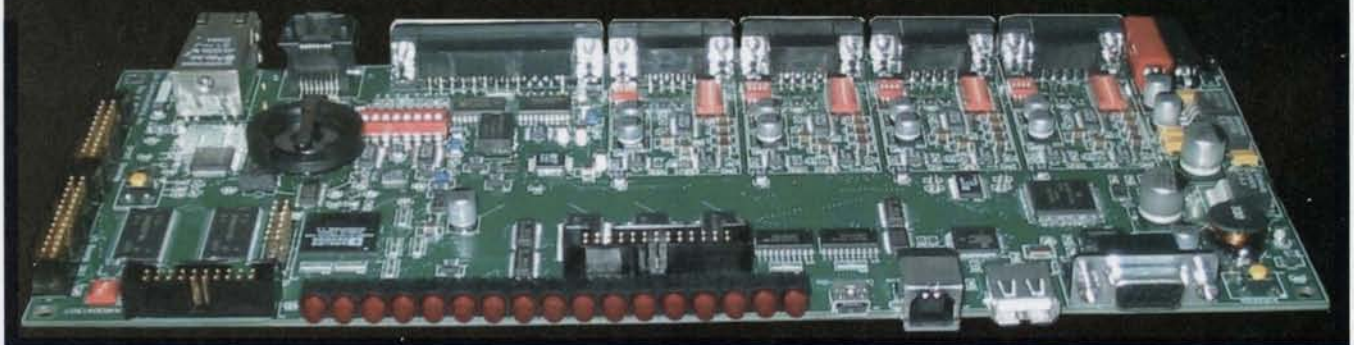
Amateur radio has impacted the lives of the students involved in the experiences described here. It clearly takes a lot of time by the amateur radio operators involved, but the payoff is seeing the new appreciation by these students in the application of science, technology, engineering, and mathematics. These are the kinds of things many readers, including this author, dreamed of doing when they were in high school—and this program reaches into middle schools and elementary schools. Amateur radio is making these dreams a reality for some of the next generation. ■

Redefining the Repeater Controller

Introducing the RLC-DSP404 Digital RLC Controller

Link Communications is once again redefining the Repeater Controller. Built upon the time-tested RLC core, this new controller is completely digital and has an unmatchable feature set.

Digital Audio Path
Built-in Ethernet
Streaming VoIP
Remote Control Functionality
Expandable Digital Voice Library
Supports up to 12 Radio Ports
Site Telemetry I/O Lines



Technical Specifications

Radio Ports	4 Radio Ports (expandable to 12) with DB-9 connectors. Individual front panel LED's per port
Radio Port Signals	COR, CTCSS, (1) Audio Input, (2) Audio Output, RS-232. Discriminator and Speaker audio
Telemetry Port	7 Analog Inputs, 0-15V, 12 bit with temperature sensor switch, 8 Input Lines, 8 Output Lines
Time of Day Clock Option	WWVB Receiver serial port supporting the WWVB-404 optional receiver allows off-air time RX
Network/Connectivity	RS-232, 10/100 Ethernet Control Ports, USB Host, USB Slave and USB On-The-Goto (OTG) port
LED Display Feature	COR, CTCSS, DTMF/Tone, PTT display for each radio port. LCD Display optional (Contact Link)
Switch Features	RX gain, TX gain, CTCSS/Tone control, Pre/De-emphasis controls, COR and CTCSS pull up/dn
Other Features	Integrated audio delay, electronic soft-pot adjusters, Digital voice and message recorder, etc...

Repeater and Linking has never experienced such an advanced product as the RLC-DSP404. With its total local and network management, streaming VoIP and powerful 600 MIPS Digital Signal Processor (DSP), the RLC-DSP404 will transform your repeater system into a more versatile and efficient digital system that will change and adapt as repeater systems evolve.

Windows GUI Included

Link Communications, Inc.
www.link-comm.com 800.610.4085

Building Repeater and Linking control systems since 1989

The Lost Letters of KH6UK

Part 1 – The International Geophysical Year and the Most Well-Known QSO

This two-part article presents the history of Tommy Thomas, KH6UK, as well as excerpts from Walt Morrison, W2CXY's files pertaining to Tommy's ground-breaking QSO with John Chambers, W6NLZ. Part 2, to be published in the next issue of *CQ VHF* magazine, will cover Tommy's pioneer EME work.

By Mark Morrison,* WA2VVA

Ralph "Tommy" Thomas was an accomplished radio operator whose "can do" attitude and excellent operating skills brought notable success on more than one occasion. We begin this two-part article with an introduction covering some of the history of Tommy's accomplishments.

Introduction

First in 1926 (as 2UK) Tommy exchanged messages with the George Miller Dyott expedition in the jungles of Brazil when commercial operators had failed to get through. *The New York Times* even reported on the event in its December 28, 1926 edition. Figure 1 is the front side of Tommy's QSL card.

In 1938, he was one of three radio amateurs to provide weather reports to aviator Howard Hughes on his record-setting flight around the world. In 1953, Tommy provided reports to George Rose, K2AH, during the first use of a transistor in amateur radio. In 1954, Tommy and Paul Wilson, W4HHK, were credited with the first meteor-scatter QSO ever made on 144 MHz. However, as impressive as these feats were, none won the acclaim that Tommy's 1957 QSO with John Chambers, W6NLZ, did, which is arguably the greatest amateur achievement of the International Geophysical Year (IGY). Some may think this accomplishment had nothing to do with the scientific purpose of the IGY, but in 1960 the General Electric company awarded both Tommy and John the prestigious Edison Award, the only time it was ever awarded for *scientific* achievement.[1] The judges of this award are said to have compared this accomplishment with the first radio transmissions across the Atlantic in the early 1900s. Even today this event remains a hallmark of amateur cooperation, skill, and determination.

Tommy lived in New Brunswick, New Jersey, where he worked for RCA Communications (RCAC), formerly Marconi America. In 1955, RCAC relocated Tommy to Hawaii to be engineer-in-charge of its Trans-Pacific radio station at Kahuku, Oahu. This historic station was one of the original Marconi stations spanning the globe in 1914, completing the link between Japan and California.

Once settled in Hawaii, Tommy received a new callsign, KH6UK, and put together his beautiful station (Photo A). Note the greetings on the right side of the photo. To keep in touch with his friends back home, Tommy wrote or typed letters, including many to my father, Walt Morrison, W2CXY. The typewriter used for many of those letters can be seen in the photo. When Walt passed away in 2002, these letters were discovered in a basement filing cabinet; they hadn't been seen in nearly 50 years!

Although much has been written about that historic QSO of the IGY, very little information has been added since. With the 50th anniversary of this event in July and Tommy's lost letters to guide us, what better way to celebrate than through the words of Tommy himself? Here, then, is the untold story of the most famous QSO of the IGY.

The Untold Story

By April of 1956, Tommy and Helyne Thomas had settled into their new home in Hawaii. It took about a year to get the

Some Background

It was in 2002 that Walter Morrison, W2CXY, became a Silent Key. Outside of his family, his passing was hardly noticed, except by a few close friends. One member of his family, his son Mark, followed in his father's footsteps in the hobby of amateur radio and became licensed as WA2VVA.

One day after his father's passing, Mark decided to go through his father's filing cabinet, which had been stored in the basement for lack of a better place to keep it. Tucked away in that basement filing cabinet Mark found some handwritten letters and other ham radio related memorabilia not seen for nearly 50 years.

The author's name on the letters was unfamiliar to Mark. However, Mark's brother Walter recognized the name as someone who once worked for RCA Communications. Written to W2CXY by VHF radio pioneer Ralph "Tommy" Thomas, W2UK/KH6UK, these letters provide a behind-the-scenes look at amateur VHF radio during the 1950s, not just from the perspective of those who lived it, but when they were actually living it! Those letters, in addition to numerous audio recordings, vintage QSL cards, and clippings from various ham radio magazines offer invaluable documentation to what was perhaps the most important QSO of the International Geophysical Year, as well as much more about the pioneer VHF plus operators of Walt's day.

What follows in this two-part article are excerpts from W2CXY's files pertaining to Tommy Thomas' ground-breaking QSO with John Chambers, W6NLZ. Part 2, to be published in the next issue of *CQ VHF* magazine will cover Tommy's pioneer EME work.

**5 Mount Airy Road, Basking Ridge, NJ 07920*
e-mail: <mark1home@aol.com>

Figure 1. Tommy's QSL card when he was W2UK in New Brunswick, NJ.

house in shape, including patching a leaky roof and replacing window panes etched by years of salt air, but once that was done, they were quite happy. Located on the north shore of Oahu, their house was close to the RCAC facility and it was a short walk to the beach.

Tommy had his own radio room, situated just off the lanai, with large glass doors that opened to fresh air and the sights of Hawaii. Although an operator's dream, its proximity to the high-power transmitters of the RCAC station made for terrible interference, especially on 6 meters and the lower frequency TV stations out of Honolulu. Nonetheless, the location had a relatively good shot to the West Coast, thanks to Marconi engineers who had surveyed the spot several years earlier.

Tommy's first project was to build a VHF array for 144 MHz. At the time, the greatest distance spanned on 2 meters was about 1100 miles, and since the nearest place with any significant 2-meter activity was California, some 2500 miles distant, Tommy was none too optimistic about the DX possibilities. In a letter to Walt, he said it this way:

> As far as 2 meter operation is concerned, out here on the island there's not a great deal of it. There's some CD work and attempts to work island to island but necessarily so I suppose, if you can't work anywhere else then why even try. Just about the closest place you could expect any activity is the West Coast and that's 2500 or 3000 miles away. So I suppose that has a damping effect on the long haul stuff out here.

Tommy's first real challenge was to work the local hams on the other side of the island, near Honolulu. A large mountain stood in the way, but Tommy convinced them that they could work each other, and they did. After that he set his sights on the West Coast.

As with most VHF enthusiasts of the era, Tommy thought a lot about moonbounce, which was only natural considering the lack of other stations within the range of a typical meteor-scatter or sporadic-*E* contact. His letters to Walt, W2CXY, mention the need for "25 dB minimum" and multiple "Long Johns," a name that describes the "long, long Yagis" popularized in *QST* magazine by John Kmosko, W2NLY, and Swan founder Herb Johnson, W6QKI. In one letter Tommy mentioned that Herb and Jim were "set for Moon deal tests around July" and commented to Walt that "they might beat us to the punch!"

By May 1956, Tommy had found someone interested in running 2-meter schedules with him. In his letters to W2CXY he mentioned for the first time that John Chambers, W6NLZ, "might be a good man to have on tests" and that "John wants to attempt 2 meters across the Pacific." Although the distance was about twice that of the best DX of the time, Tommy was ready for serious

weak-signal work. Tommy would later describe his new partner this way: "John is a very fine man to work with. He's always on the ball and I've certainly enjoyed my many contacts with him. He certainly is a VHF man of high caliber and high interest."

By this time Tommy was talking about "Big Bertha" antennas, such as those used by W6QKI and Ed Tilton, W1HDQ. At the time Ed was editor of *QST* magazine's popular VHF column "The World Above 50 Mc" and any recommendations from him would have carried significant weight.

Back on the East Coast, the growing number of high-power VHF stations was causing interference problems for weak-signal operations. A group of amateurs, including W2CXY, petitioned the ARRL to request the FCC to reserve the low end of the 2-meter band exclusively for CW work. Although Tommy didn't have to worry about such interference because of his remote location, his proximity to the RCAC station brought many of the same challenges that faced his friends on the East Coast. As such, he was quite interested in this matter. In a letter to W2CXY, Tommy mentioned that both he and his MARS director were interested in the exclusive CW segment. Tommy also mentioned that sideband splatter on 6 and 2 meters was particularly bad because of station interference. If Tommy were to do any serious DX work on 2 meters, he somehow would have to get around this interference.

By the summer of 1956, Tommy began construction of his VHF array. Work was slow due to the summer heat, but by October the beam was finally in position. Tommy sent Walt pictures to share with his friends back home. Upon seeing the pictures, John, W9WOK, commented that the antenna hardware, including the utility pole, looked quite similar to Tommy's setup in New Brunswick. Photo B shows Tommy on the left monitoring a crew of men ready to hoist the 56-element beam to the top of a 90-foot utility pole. The other men in the picture are "riggers" from RCAC.

Photo C shows the beam in final position. Note that it could be rotated but not elevated, thus ruling out any serious moonbounce work. Tommy later commented to W2CXY that he would replace this with a "first rate job" for moonbounce work, if he had the time. Tommy's stay on the island was supposed to last only three years, and because he was uncertain if RCAC would ask him to stay longer, he hesitated to build something bigger from the start.

In the fall of 1956, Tommy continued to exchange moonbounce ideas with Walt, W2CXY, and confirmed that Jim and Herb had not yet made moonbounce contact. They discussed plans for circularly polarized "monster antennas" and Tommy mentioned interest in contacting Dr. John Kraus, W8JK, regarding his work in this field.

In November 1956, Tommy began 2-meter tests with John. He also started to experiment with 6 meters. In an audiotape letter he mentioned to Carl Scheideler, W2AZL, his plans for 6 meters this way:

I had hoped, Carl, to make use of that very fine converter you sent me for 6 meters. I had hoped to do some work on 6 in conjunction with the 2 meter experiments, as I thought maybe if I could pick out the periods when 6 was open via sporadic-*E* we might be able to do something on 2 meters at that time. Just might. That, of course, was my intention but it didn't materialize mainly for the reason that the interference is so bad here on 50 Mc from

the station that it's practically impossible to do anything through it.

Tommy wondered what it was like back in New Jersey with all the big 2-meter stations. Still concerned about interference, he asked, "Has anyone figured a way to reduce crosstalk caused by overload in converters?"

The first half of 1957 was a busy one for Tommy. First there was a tidal wave that nearly swamped his shack. He described the ocean as slowly receding before rising slowly up to the level of the dunes, at which point it spilled over and into his yard. They had 18 inches of water all around the house, and if not for the fact that it was low tide, his radio room might have been flooded. Then there were serious manpower shortages at the station, and the lack of qualified workers to fill the openings. There was also a steady stream of visitors to the RCAC station, including several top brass from RCAC. On one occasion, the legendary David Sarnoff visited Tommy's shack and showed a great deal of interest in his meteor-scatter operations.

Tommy kept schedules with John practically every night from May into June of 1957 without success. They even tried daytime meteor-scatter work, but this was abandoned when John reported poor results with other stations with which he had schedules. In a tape sent to W2CXY just weeks prior to the record-breaking QSO, Tommy explained that since John lived in an exclusive neighborhood of Los Angeles (Palos Verdes Estates) and was only using a single Long John, he

Photo A. Tommy, KH6UK's station in Hawaii in 1955. The greeting on the right side of the photo reads: "Walt W2CXY, Aloha, Tommy KH6UK."

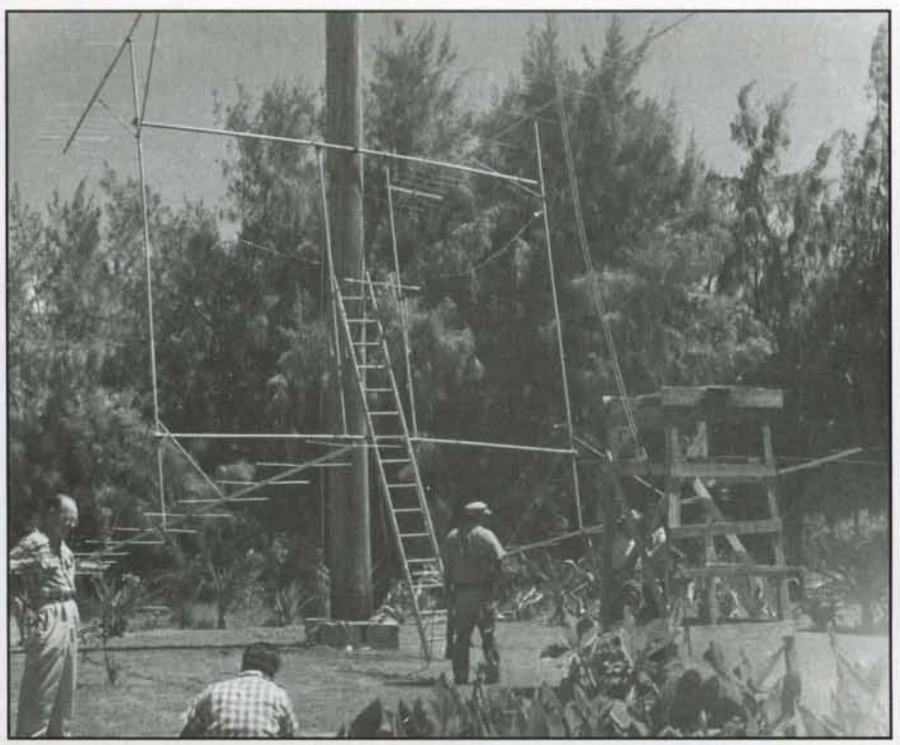


Photo B. Tommy (on the left) monitoring a crew of "riggers" from RCAC getting ready to hoist the 56-element beam to the top of a 90-foot untility pole at his location in Hawaii. (Photo circa 1956)

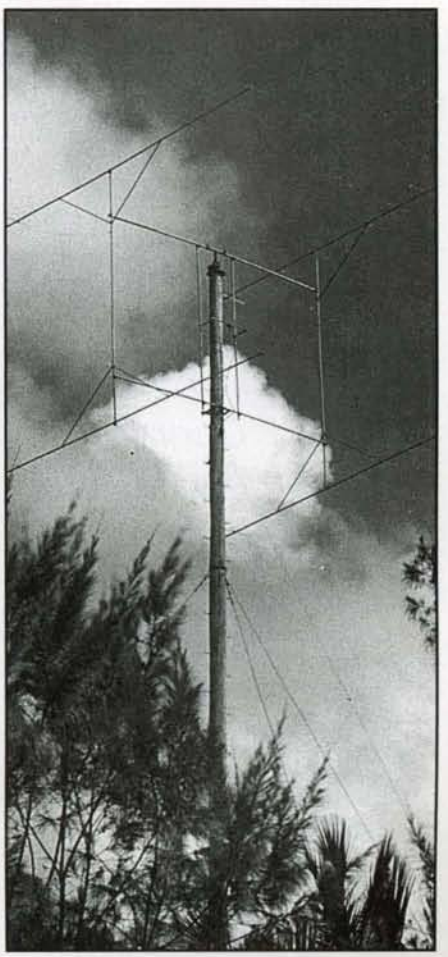


Photo C. The 56-element beam in final position.

On Into February

Hawaii-east coast contacts are ordinary events now judging by your reports. Quite a few of these QSOs took place on February 1st around 1500 EST. W1PHR worked KH6UK and KH6NS, and was hearing W6s at the same time. The Hawaii signals didn't extend much beyond Vermont, however, because W1QCC/VE1 in Pictou, N.S., heard only W6s and W7s at this time. Californians worked KH6s and W1s simultaneously on F2 on February 1st and their nearby neighbors and W7s were coming through on back scatter. Around 1530 PST (still on the 1st) K6RNQ worked ZL4GY in New Zealand. It's the first time that we have come across this particular path on any of your reports. K6RNQ repeated the performance on the 7th when he worked ZL2ABX at 1615 PST.

Figure 3. "The PRP News" article about Tommy's finding a way to get around station interference.

was not too hopeful that a contact would be possible. Tommy put it this way:

John unfortunately lives in a very exclusive neighborhood and cannot put up a big beam. He has one Long John, which as you well know is not sufficient. We're going to need everything we can get up in the air and also all the power and the best receivers and converters we can get if we're going to do anything at all. Starting out with the limitation of such a small antenna it's almost a forgone conclusion we're not going to get anywhere."

By June of 1957, Tommy must have been thinking the only DX possible from his QTH would be moonbounce, but even that was somewhat of a disappointment.

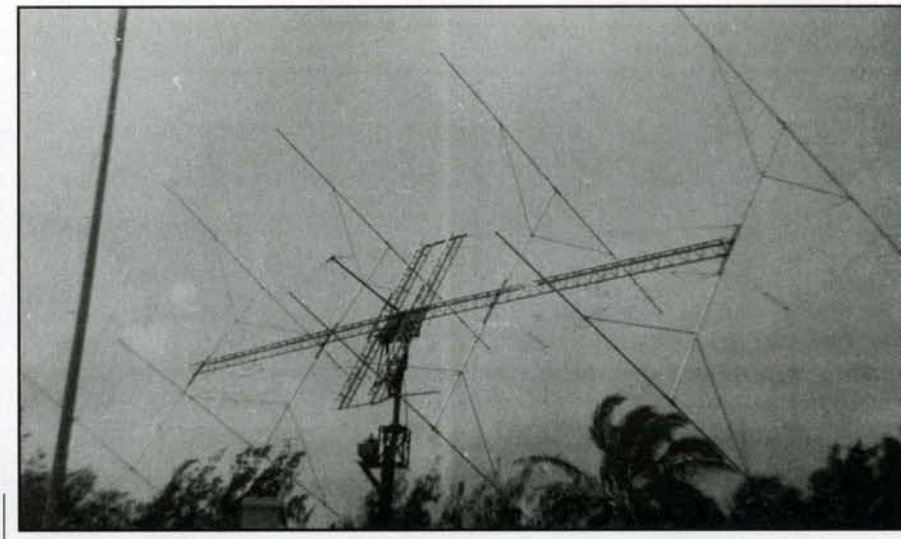


Photo D. KH6UK's "2×4" moonbounce array poised for testing.

In a tape letter to W2CXY he said:

I don't have too much time Walt, or too much energy either for that matter, when I do have the time, to build bigger and better antennas for moon reflection work. I'm a little disappointed along those lines but I don't know, weekends come along and when I m not working I'm trying to catch up on a little rest and preparing for the upcoming week. It's been rather rough over here. A lot more work than I had anticipated and a lot less leisure. Whether I will still find time before we return to put up a bigger beam or not I don't know. I'll have to get some energy and ambition from somewhere's if I'm going to do it. I don't seem to have it now. Over here on the islands you get so after a while you're contented to just sit and reflect. In the summer time it's rather warm and not conducive to a lot of occupations and activities that require expenditure of energy. Most people around here just sit!

In the following weeks, however, all that changed. Using techniques that Tommy and Paul, W4HHK, no doubt refined prior to their first 2-meter meteor-scatter QSO, Tommy and John used the HF band for liaison work. Once contact had been established on HF, they regularly switched to 2 meters to see if anything could be heard. They did this night after night until finally, on July 8, 1957 at 6:30 PM Hawaiian Standard Time (HST), Tommy's 2-meter signals were picked up by John Chambers in California. The signals lasted until 7:35 PM HST, at which point W6NLZ left the air. After John confirmed his QSO with Tommy, John's wife, W6NTC, took the controls and also had a QSO with Tommy. Tommy said he then called CQ for the next three hours to see if anyone else would reply, but no one did. He made three reel-to-reel copies of the QSO. One was sent to Ed Tilton, W1HDQ, another to John Chambers, W6NLZ, and the third to Walt Morrison, W2CXY. Here is an excerpt of what Tommy reported on his tape to Walt:

The recording was fairly good, in spite of the fact that I was so excited I didn't want to change any of the tuning controls and there was quite a bit of overloading at times. Also my signal sounded sad as you probably know by now. The signal sounds much better on a

pair of cans than it does on a loudspeaker. It always does.

We had been running this schedule, as you know, since last November, and I had never even heard a peep of any kind during that time. I had one report from 7, I think it was VVJ, that he copied the letter U out of my call but I could never get him to verify it. So I'm not sure that he actually heard it. Maybe he just thought he did.

This thing came as a complete surprise to us. I was listening on 20, and 144 at the time; it's a usual procedure for me to transmit on 14.095 and 144 Mc. And John would listen to 144 after working me on 14.095 and tell me how conditions were and how long he wanted the schedule. So this started the same as any other. When I said bye after a five minute transmission, John was calling me like mad and gave me a report of 559 I believe it was, on 2 meters. I thought he was suffering from the heat.

But he insisted such was the case so I dashed madly for the 2 meter converter and turned it on and hooked the antenna on it. And lo and behold there he was. The signal was in more or less the whole hour. He was very much excited. So was I! And I believe we would have stayed in much longer if John had wanted to stay on but he was anxious to get off and call up Ed and I was anxious to see how long it would stay in.

The call from W6NTC was a complete surprise also. I thought it was a second station calling. Well I guess it was in a way. And thought possibly it was someone in the same town. When they said Palos Verdes Estates I thought it was somebody with a 522, probably one mile farther than John! And I referred to him as "OM." I guess John's wife felt anything like an OM because she's eight months pregnant. It finally dawned on me what it was all about a little later, after the excitement had subsided. I really didn't know that John's wife was a ham. I don't believe she's active.

The tape is on its way to Tilton. I sent one to John and this is the next one to go off and I guess this will be the last one. It takes quite a while to make them up as you well know and I know that you will circulate it there in the East.

There's quite a bit of interest shown in the results over here in the newspapers and on radio. I just finished listening to a broadcast on ARRL and I see it's on there. So this will give you fellows something to shoot at. Maybe if you'll take time out from ping pong you can see if you can work some stuff. I guess you're doing OK though.

QST reports more and more states in the "states worked column" all the time. I look them over with envy and wonder how I'm ever going to catch up. I guess I never will. I have *one* now! I guess that's it.

Interest in this QSO was a highlight of the 7th U.R.S.I. (Union Radio-Scientifique Internationale) conference held in Colorado that year. Scientists from around the world, who had gathered to discuss radio propagation issues, showed considerable interest in this record achievement.

In the years that followed, Tommy and John continued their schedules, first on 220 Mc, where they found success in July of 1959, and later on 432 Mc, where John could hear Tommy but not the other way around. Tommy also found a way to get around the station interference as the excerpt (Figure 3) from "The PRP News" shows.

Tommy once commented to W2CXY that a new DX record could be established on 6 meters by working South Africa from his location. However, there just wasn't time to do everything, so this plan was abandoned in favor of serious moonbounce work on 144 MHz. Photo D is a picture of Tommy's "2×4" moonbounce array poised for testing. The story of Tommy's moonbounce activity will be the subject of Part 2 of this article.

Note

1. The *VHF Manual* 1972.

A Simplified Path to a High-Performance 10-GHz Transverter System

With the increase in popularity of the 10-GHz band, KH6WZ has risen to the challenge and created an X-band transverter that is quick to build.

By Wayne Yoshida,* KH6WZ

The challenge: Get another X-band transverter built quickly for a fellow club member who has been procrastinating for over a year about getting on the 10-GHz band. The solution: Get in there and help him build it!

We wanted to see how quickly a 10-GHz transverter could be built using readily-available components and surplus modules. All we needed were the "ingredients" for the system, some free time to build, some knowledge of how the modules connect together, and a good technical friend with test equipment for the microwave bands. This last ingredient was probably the most important, since the ability to test the unit (as well as surplus parts) requires some specialized gear. Fortunately, I have access to such a resource: my fellow San Bernardino Microwave Society (SBMS) club member, Dave Glawson, WA6CGR. Other microwave-specialty clubs have their cadre

*16428 Camino Canada Lane, Huntington Beach, CA 92649
e-mail: <kh6wz@cq-vhf.com>

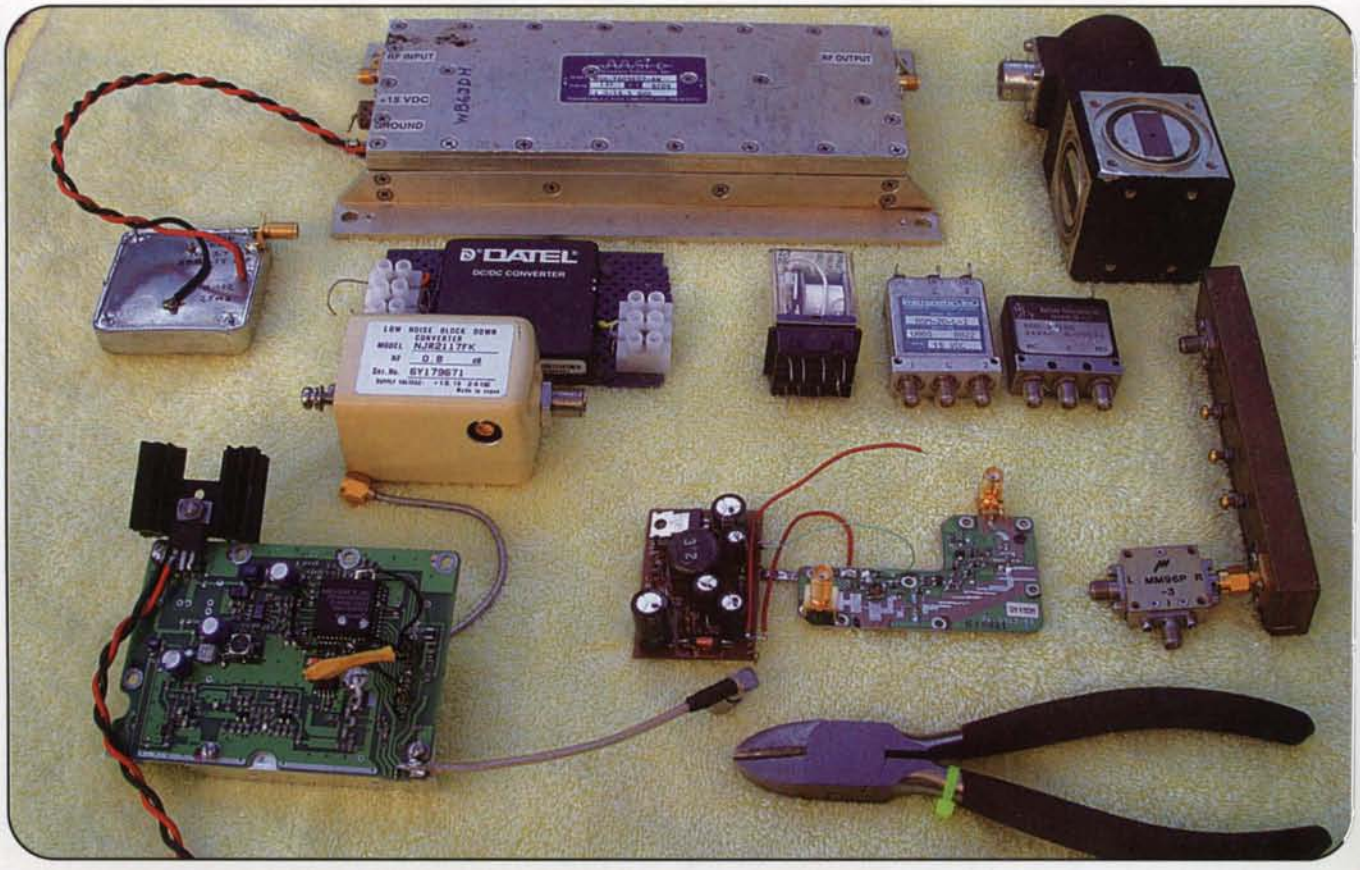


Photo A. Box of ingredients needed to form a complete 10-GHz transverter. Available surplus is changing, and the new challenge is moving from "where to get parts" to "where to find the time to build it." (All photos and artwork by the author)

of experts, and most of them are willing to help others.

The box of parts can be seen in Photo A. This box of ingredients includes a 1-watt, solid-state power amplifier (SSPA), all tuned up and tested for use at 10.368 GHz! The amateur radio X-band scene is changing rapidly, since parts are becoming easier to acquire. The challenge is moving from "where do we get parts?" to "where do we find the time to build a system?"

An enhanced, "competition class" 10-GHz rig would include a receiver pre-amplifier (low-noise amplifier, or LNA), a 2-foot (or larger) dish antenna, and a power amplifier putting out a full 1 watt (30 dBm) or more. The rig described in this article is just such a unit, with a receiver noise figure of less than 1 dB and about 23 dB conversion gain. Nine-hundred milliwatts at 10368 MHz appears at the antenna port (see Photo B).

Photo B. Surplus material and previously exotic parts such as microwave mixers are easier to obtain these days. This X-Band system has a receiver noise figure of 0.7 dB, with transmit power of 900 mW measured at the antenna port. An 18-inch reflector is attached to the front of the chassis box with machine screws.

It's a New X-Band World

In 1993 Zack Lau, KH6CP (now W1VT), ran a two-part article in *QST* magazine about building a 10-GHz transverter from "scratch."[1,2] Zack's project simplified parts procurement by eliminating surplus "brick" oscillators and exotic surplus, and the bill of materials called for off-the-shelf components.

As mentioned, today's surplus availability has changed radically with online auctions and other resources, including fellow club members with access to some fairly complex components such as waveguide relays and mixers. One of the biggest "boosters" on the 10-GHz ham radio front is the availability of QualComm modules, sub-assemblies, and modification instructions made available to hams. I have seen surplus QualComm units and systems for sale at local swap meets and on the online auctions for very good prices. For example, I recently saw a complete QualComm OmniTRACS® system on eBay with a starting bid of $10. Certain modules in this system are extremely useful for the microwave experimenter.[3] If you are lucky enough to find these useful QualComm units, please remember to heed the warning about not contacting QualComm with any inquiries. You must contact the ham community (San Diego Microwave Group in particular) for information on these units.

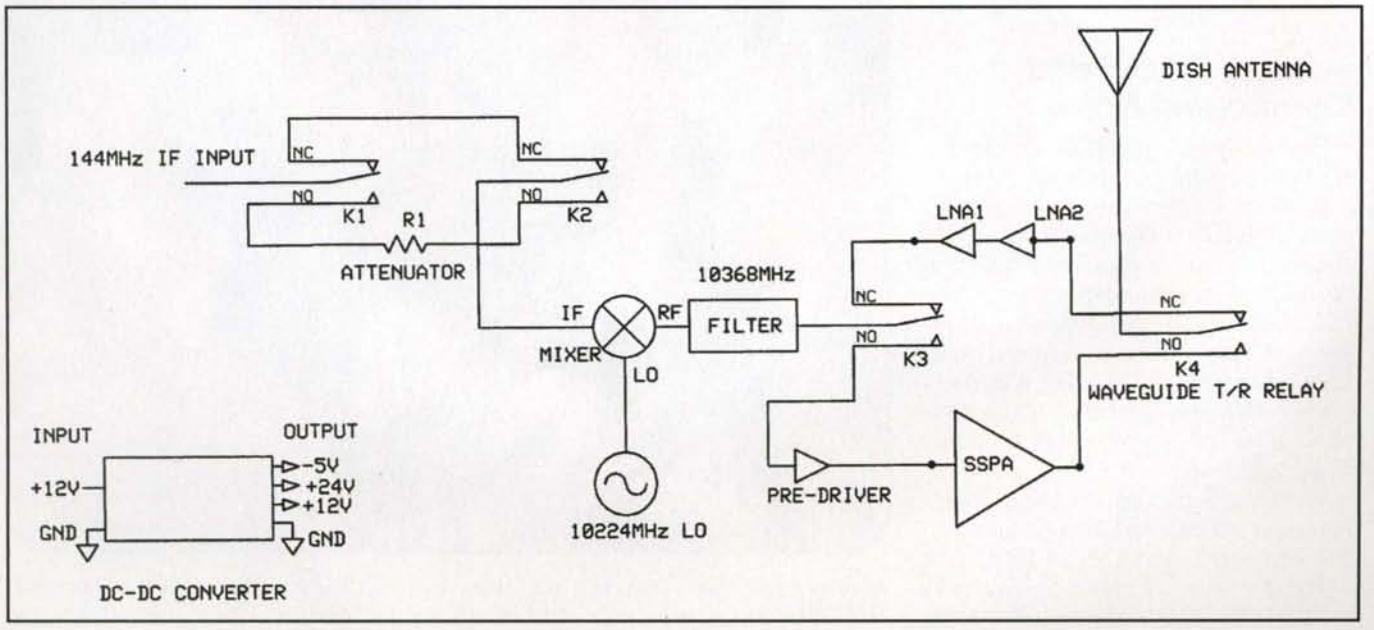


Figure 1. A simplified block diagram of an X-Band transverter using a 144-MHz IF.

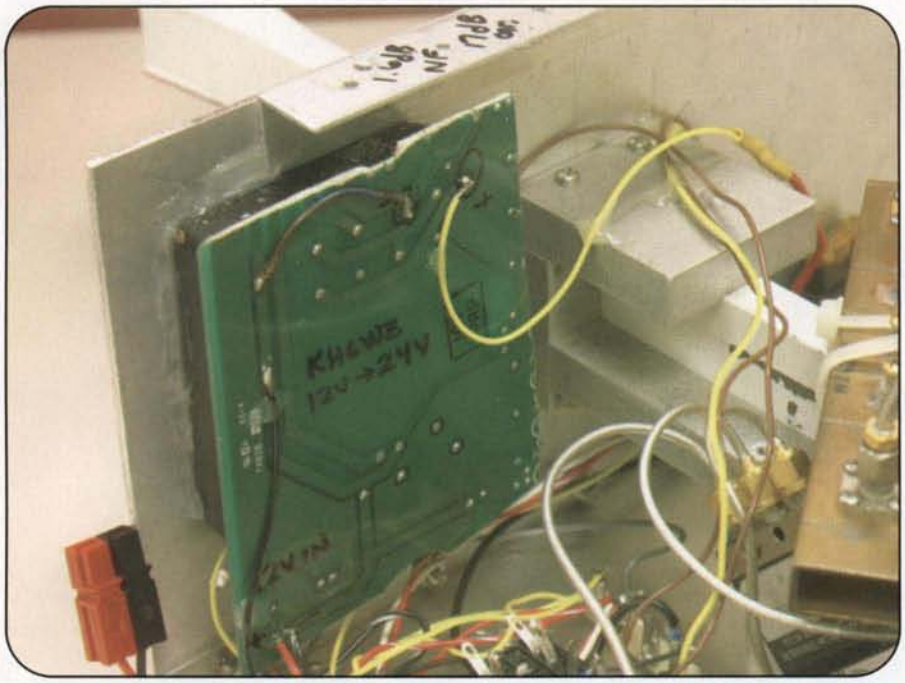


Photo C. A surplus DC-DC converter makes minus and plus 12 V as well as 5 V from a single 12 VDC input. The –12V and +12 V outputs are connected together to make 24 V, used to drive the SMA relays.

In addition, commercial microwave companies catering to hams—such as Down East Microwave (DEMI), and the DB6NT units available from Kuhne Electronic and SSB Electronic—provide kits, pre-built transverters, and other useful modules, such as local oscillators, for the microwave bands. These "store-bought" products can greatly simplify the path to successfully getting on the microwave bands with proven designs and technical support.

Building Blocks and Component Notes

Figure 1 is a simplified block diagram of the rig, based on the box of ingredients. Since we are dealing with surplus material, it is best to describe the needed circuits in terms of functional "building blocks," rather than referring to specific manufacturers or part numbers. In essence, this rig is made with a local oscillator running at 10,224 MHz, a mixer, a 10,368-MHz waveguide filter, a 144-MHz IF unit (2-meter all-mode transceiver), and relays.

The local oscillator is the main ingredient and can be created in several ways. For example, assuming an IF of 144 MHz, the local oscillator frequency is 10,224 MHz (10,224 MHz plus 144 MHz equals 10,368 MHz). The LO frequency can be generated using a modified surplus "brick oscillator" running at 10,224 MHz, or a 2556-MHz synthesizer and a quadrupler (times-four multiplier) working together to generate the 10,224 MHz signal.[4] Another LO option is the 10,224-MHz DEMI Microwave Transverter Local Oscillator (MICROLO), available in kit or assembled form. Other LO units are available from other suppliers; take a look at the "Sources of Supply" box for more information.

Power supplies for the various modules can be rather cumbersome, because of the various modules and sub-assemblies requiring different voltages. For example, the rig shown in this article requires +12 VDC, –5 VDC, and +24 VDC, and these voltages must be derived from the automotive 12-VDC (nominal 13.8 VDC) system. Scour the surplus suppliers mentioned in this article to find suitable power-supply components or assemblies. For example, the –5 V DC-DC converter can be found on the surplus market for less than a dollar. The relay voltage converter (12 V to 24 V) can be bought or built, and there are many circuits documented for this purpose.[5–9] In this rig, I used a surplus DC-DC converter module scrounged from a computer power supply. The unit takes 9 V to 15 V DC in, and puts out +12 V, –12 V, and +5 V. Since the voltages are isolated, you can take the two 12 V output voltages and connect the module so that the voltages are placed in series, making 24 VDC to drive the relay coils (see Photo C).

Of course, an AC-operated power supply can simplify the power requirements, but then you may be limited to non-roving operation, unless you have a source

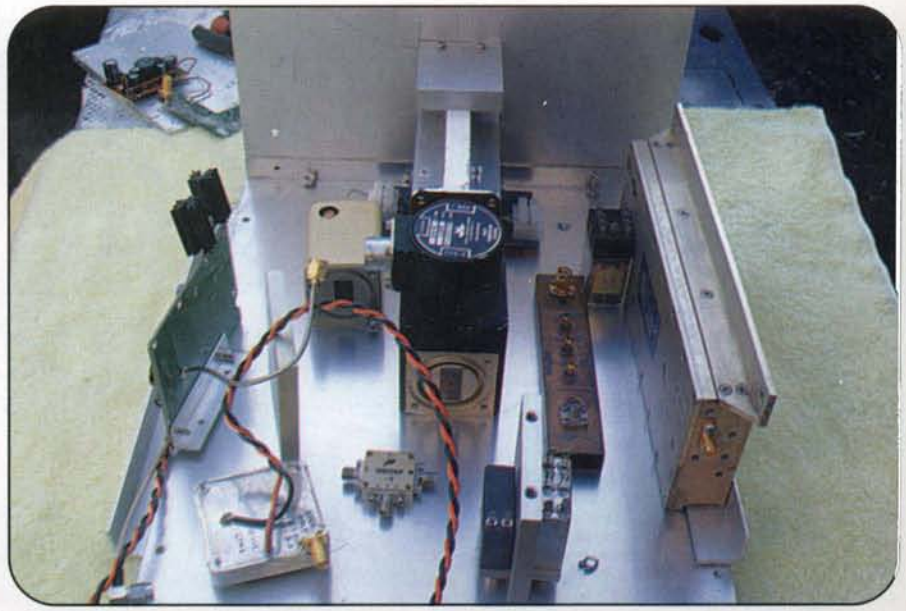


Photo D. The chassis layout is driven by keeping the RF paths as short as possible. DC and control circuits are not as critical, so those modules can be mounted wherever they fit.

of AC power from a generator or other 110-VAC mains electricity.

Always More Than One

When buying surplus material, my practice is to always purchase more than one, since the item may not be available later if (or when) it comes time to repair the unit. Generally my rule is "One to use, one to lose, and one for a spare." Another good reason to buy more than one of the item is its "barter potential." Trading surplus modules from your junk box for a desired item from another ham is a tradition that many microwave project builders rely on. It is also good practice to test your components as soon as possible, or at least before you install them in your project. Pre-testing parts and modules as you build increases your chance of success at first "power-up," and eliminates the need to guess whether or not the completed project will work.

Building Begins

Like almost any other electronic project, chassis layout and metal-working are the next steps (see Photo D). Place the various modules on the chassis so that the shortest RF paths are taken between modules. The DC components, such as the 12 V to 24 V converter, can be moved to the farthest areas on the chassis, because lead lengths will not have as much impact on system performance compared to the local oscillator or the frequency multiplier circuits.

After you have figured out where to put the various modules, it is time to work the chassis, drilling and tapping holes as needed. This "mechanical assembly" includes the routing of any waveguide pieces, since this "plumbing" will mostly be determined by the fittings you have on hand. This is similar to fixing a hot-water heater in your home, but you have only a limited supply of pipes and fittings to use and you have to work with what you have.

When the modules and sub-assemblies are securely mounted, DC power and control connections are done next. This allows DC and ohmmeter testing to verify that each individual module works before proceeding. When the DC checks are complete, continue with the RF wiring.

One of the features I like to include in my projects is a set of "status lights," or "reassurance indicators." These are various LEDs that light up (or do not light up) to verify the presence of voltage as a way to help diagnose a problem in the system (see Photo E). In addition, I have LED indicators on each relay when projects have more than one relay in the system. I first thought that it would be easy to tell if a specific relay has actually actuated by sound or by feel, but this is not the case. It makes more sense to use some other indicator for a better feeling of "reassurance."

The "Ups and Downs"

Be prepared for setbacks and delays while you are building any project using surplus (including "new-old stock") items. For example, the mixer I originally had in the box of parts turned out to not work on X-band. Fortunately, my good friend Dave, WA6CGR, had a selection of mixers to try. Although all of the mixers tested "good" and some of them are in pristine cosmetic condition, only three worked on 10 GHz, and all of them had

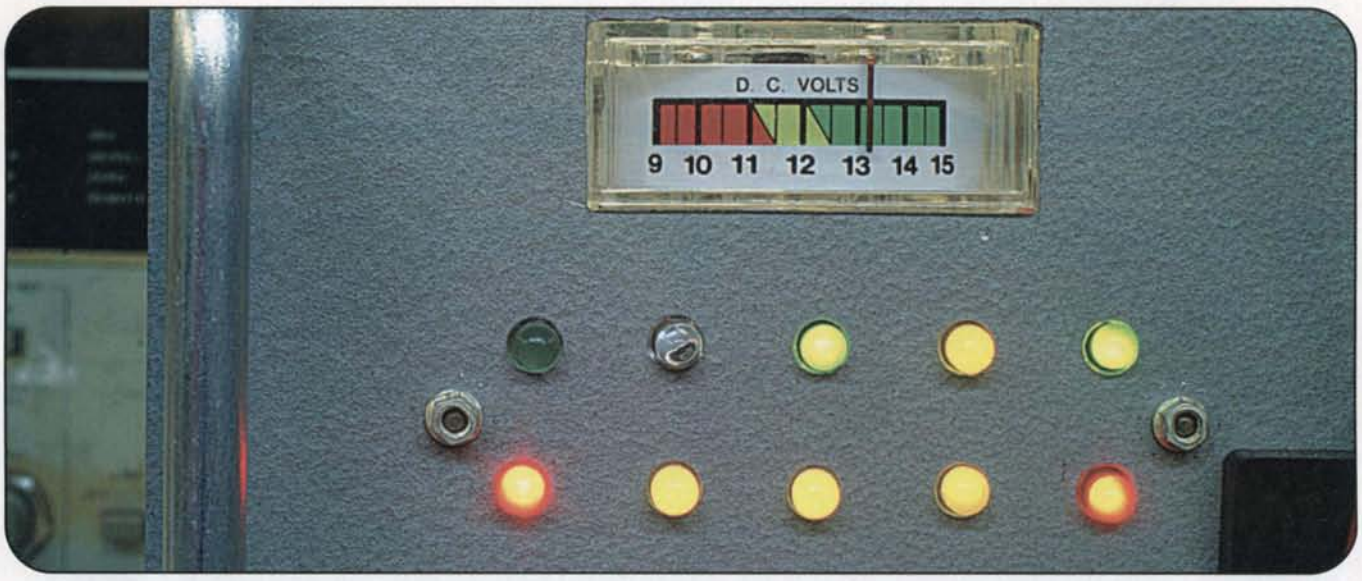


Photo E. The "status panel" helps diagnose simple failures, especially useful in the field. The LEDs indicate voltage is present at the various modules. The top row indicators are for receive and "always-on" functions, such as PLL Unlock (a high-brightness red LED, which turns on when the PLL is un-locked) and 5 V (used for bias power on the amplifier and receiver pre-amp). The bottom row is the transmit function indicators, such as relay actuation and SSPA on.

varying levels of performance. This is another reason to buy more than one item when surplus devices are available.

The Fun Part

Now that the project is complete, it is time to take it out and perform some field-testing. Notice the transverter system has lots of lights, but not many switches or controls. This is done to streamline set-up time and to minimize things to lose or break. For example, there is no main power switch, because the power cable can control the power, which eliminates a switch that can fail.

I hope these hints inspire more people to get on the microwave bands. A rig for 10 GHz is a good place to start due to the propagation characteristics; the two-part ARRL 10 GHz and Up contest; and the availability of microwave parts, kits, and assembled units available to today's experimenters. Experienced microwave hams generally are a helpful lot, since every new station on the air means more points in the next contest!

References

1. Lau, Zack, KH6CP, "Home-Brewing a 10-GHz SSB/CW Transverter, Part 1, *QST*, May 1993, pages 21–28.

2. Lau, Zack, KH6CP, "Home-Brewing a 10-GHz SSB/CW Transverter, Part 2, *QST*, June 1993, pages 29–31.

3. More information on QualComm surplus is posted on the San Diego Microwave Group projects page, on the San Bernardino Microwave Society (SBMS) website: <http://www.ham-radio.com/sbms>

4. Search eBay for surplus brick oscillators; there are many suppliers of this component. One excellent source is an eBay seller called "PyroJoseph" in Florida. A suitable 2556-MHz synthesizer and ×4 multiplier can also be found in surplus QualComm OmniTRACS units, as described on the SBMS/SDMG website, at the URL mentioned above.

5. Jim Klitzing, W6PQL, has a very good circuit for converting 12 V to 28 V for relays using an LM2585. His website is located at: <http://www.w6pql.com>.

6. In the UK publication for microwave enthusiasts, two circuits were described to get 24 V from 12 V. One circuit uses a transistor and a capacitor, and the other circuit uses a 7662 IC and a capacitor. See *Scatterpoint*, September 2004, page 10.

7. Vicor Corporation, in Andover, Massachusetts, makes a variety of 12 V in, 24 V out DC-DC converters that appear on the surplus market. Typical part numbers are VI-203-CX and VI-303-CY. There is also have a good library of application notes and other power supply data. Go to <http://www.vicr.com>.

8. Dave Glawson, WA6CGR, "A Complete X-Band SSB Portable Communications System," *Proceedings of Microwave Update 1991*, published by the ARRL, and online at <http://www.ham-radio.com/wa6cgr/X-Band.pdf>. In Dave's article, a DC-DC converter uses an LM383 audio amplifier chip and three-terminal regulators to convert 12 VDC to various other voltages. With suitable component adjustments, other voltages can be made from Dave's circuit.

9. Glawson has another DC-DC converter for powering microwave projects from 12 VDC. The circuit is based on an LTC1070 switching regulator and three-terminal regulators to make 28 V, –20 V, +15 V, and –5V. Go to: <http://www.ham-radio.com/wa6cgr/ps.html>

Sources of Supply

Down East Microwave. Kits and factory-assembled transverters and other accessories for the microwave ham: <http://www.downeastmicrowave.com>

JWM Engineering Group. Phase-locked oscillators and sequencers: <http://jwmeng.com>

Kuhne Electronic. Michael Kuhne, DB6NT, has a variety of kits and assembled units for the microwave experimenter: <http://www.kuhne-electronic.de>

MPJA Online. A source for general surplus items, including DC-DC converters: <http://www.mpja.com>

SSB Electronic. Supplies kits and assembled units as well as other accessories and items for the microwaver:<http://www.ssbusa.com>

The 10-GHz California to Hawaii Annual Attempt

This July, KH6HME in Hawaii and N6CA in southern California hope to be the first to complete a record-shattering 10-GHz contact via tropospheric ducting. Will they succeed?

By Gordon West,* WB6NOA

July is the magic microwave month for record-breaking tropospheric ducting between California and Hawaii. It was exactly 50 years ago when the late John Chambers, W6NLZ, in southern California completed the record-setting QSO with Tommy, KH6UK, in Hawaii over a path of 2500 miles via "tropo ducting." The contacts were completed with both CW as well as AM on both 144 MHz and 220 MHz.

During this same time, the military, conducting Operation Tradewinds, established near-daily mainland-to-Hawaii contacts on VHF and UHF, with the largest documented number of completed comms occurring in July.

It was 21 years later when Paul Lieb, KH6HME, a California transplant to the big island of Hawaii, completed the first 432-MHz contact with Louis Anciaux, WB6NMT, in July over the 2500-mile tropo-duct path.

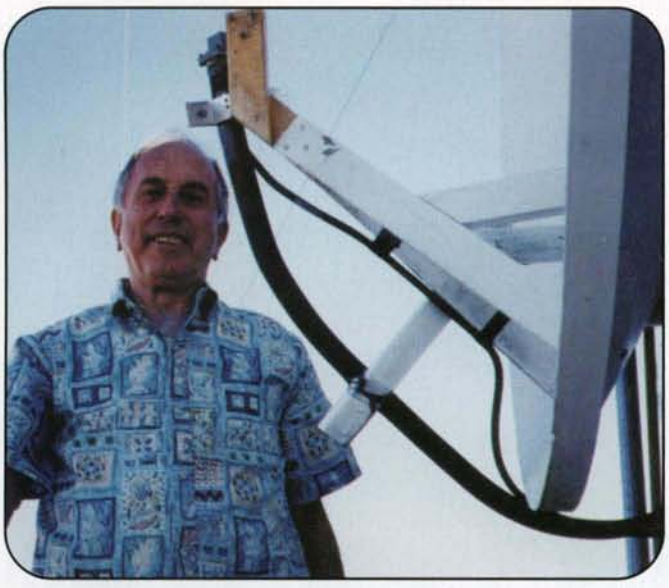
In 1980, Chip Angle, N6CA, completed the first-ever 1296-MHz contact with Paul, running 1 watt via a TRW-52601 transistor driven by a Motorola transistor to a rat-race mixer with a milliwatt at 28 MHz for injection. Chip went QRO with a water-cooled 7289 driver tube that delivered 30 watts output to drive a 7289 amplifier for hundreds of watts out.

The July path between southern California and Hawaii is so predictable that Chip and Paul continued to achieve microwave records, conquering 2.3 GHz, 3.3 GHz, and finally 5.6 GHz, where extraordinary path loss is overcome by Chip's homebrew equipment at both ends of the circuit—2500 miles, separated by

Chip Angle, N6CA (in the foreground), most likely will be the first from California to work Hawaii on 10 GHz. The author is in the background.

The author on 144.170 MHz talking to Hawaii over a 2500-mile path from the California shoreline using a KB6KQ loop antenna.

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



Hawaii on 10 GHz! Paul Lieb, KH6HME, makes adjustments to his 10-GHz island system aimed at the mainland 2500 miles away.

seawater—and hundreds of dB help from the July weather conditions between California and Hawaii.

As this is being written in mid-June, everyone is hoping that this July Paul in Hawaii and Chip in southern California will be the first to complete the record-shattering 10,000-MHz contact.

"The tropospheric duct improves as the frequency is *increased* until the walls of the duct become too irregular for propagation," commented J. B. Knorr ("Guide EM waves with atmospheric ducts," *Microwaves and RF,* May 1985, p. 67).

"Duct heights of 150 feet to 1500 feet are most common, and seem to be optimum for frequencies on VHF, UHF, and microwaves," commented Joe Reisert, W1JR. This over-water, low-level duct may only be 300 feet thick and routinely forms up high at Hawaii and low in southern California.

"All of my tropo ducting is conducted at the 8500-foot level of the Mauna Loa volcano," said Paul, KH6HME, Hawaii's only active tropo-ducting enthusiast. "Chip Angle, N6CA, has discovered an every-July 'hot spot' at around 300 feet for the best reception of my beacons." Paul's beacons are on: 144.170 MHz, 222 MHz, 432.070 MHz, 902 MHz (on site), 1296.303 MHz, and 10,368.1 MHz (when on site).

The Mauna Loa volcano beacon site is at a wind-swept corrugated-metal "shack" shared with television translator equipment, towers, and power source. The Hawaiian beacons run 24/7 into a variety of stacked Yagis, loops, and microwave to the 48-inch Ku and Prodelin .6f/d offset feed. On X-band, the KH6HME/N6CA-built system yields 10.3 watts at the feedhorn, with a 1.6-dB noise figure at the receiver. WR-90 waveguide and a W2IMU feed provide the hopefully adequate gain of 40 dBi. The entire 10 GHz is frequency-locked to a Ball rubidium frequency standard which has the local oscillator within 1 Hz.

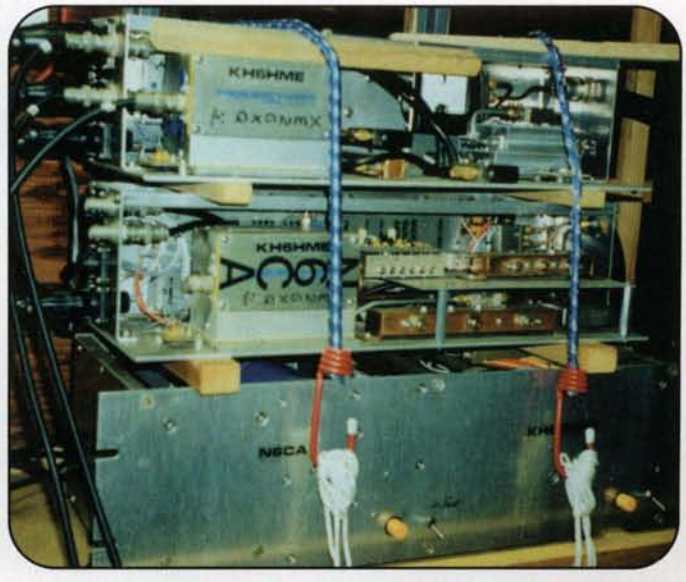
It takes Paul almost three hours to drive from his home QTH near Hilo to the beacon/operating site on the side of Mauna Loa volcano. Paul must navigate a treacherous lava road to get there and bring enough rations in case the band is open for several days.

"When the band opens between California and Hawaii, I am there!" said a beaming Paul, strategically placing food in warm equipment areas so his chow is always warm. During peak tropo times it's not uncommon to hear Paul operating from the remote volcano site for nearly a week!

The July "trigger" to a tropospheric opening is the classic "California High," which settles in between Hawaii and San Francisco. The clockwise motion of the high-pressure cell pulls in surface air and circulates this air *up.* Since there is a greater concentration of air *up high* within this high-pressure cell, the air begins to drop, creating a subsidence inversion.

As the air drops within the high, it begins to compress the air beneath it down to about 1500 feet. As the air gets compressed against the moist air below, it heats up and becomes dramatically dry. This creates both a temperature inversion as well as a vapor content inversion. Pressure also increases within this

Close-up of the KH6HME 10-GHz dish pointed toward California.



The N6CA microwave rack at the KH6HME station on the side of Mauna Loa volcano.

stratified layer, called a *tropospheric inversion.* This atmospheric stratification between Hawaii and the West Coast may become so pronounced that Hawaiians begin hear to southern Californians and FM music stations in Mexico!

"I can tell a lot about how tropo ducting conditions will be by listening to California and Mexico FM radio stations as I drive up the hill to the volcano," said Paul, adding that he always packs his car full of the two-way radio gear right after June Field Day.

This same tropo ducting "high" regularly occurs in July and August all over the United States, too: the Great Lakes to Texas path, Texas to Florida, Nova Scotia to Florida, East Coast to Europe (?), and California to Hawaii always in July!

"*CQ VHF* readers can see the latest equipment for the 10-GHz California to Hawaii tropo efforts at <www.hamradio.com/N6CA>," commented Chip. "To see construction pictures of the 10-GHz KH6HME station, go to <www.hamradio.com/KH6HME> and click on the "construction pictures."

Paul visited the prestigious San Bernardino Microwave Society (www.ham-radio.com/SBMS/) during its January 2007 meeting. There he met all of the members who were preparing for another potential shot at working Hawaii on 10 GHz, with plenty of interest in the higher bands locally, too.

"A large increase in the number of California stations that have 24-GHz capability suggests a possible new plan this year for the 10 GHz and Up contest, sponsored by the ARRL" commented Gary Lauterbach, AD6FP, of the San Bernardino Microwave Society. "For the last several years, most of the contest focus has been on 10 GHz, but now, having many stations on 24 GHz, maybe the time has come to explore and stretch the limits of the higher bands," added AD6FP.

Gary pointed out that by working both bands, 10 and 24 GHz, between a pair of stations doubles the km points that are accumulated, even though the 24-GHz distances are less. "My previous experience indicates that 200-km distances on 24 GHz are routine, and under good tropo conditions contacts out to 300 km are possible," added Gary. So far, the record on 24 GHz is 540 km, with San Bernardino Microwave Society members holding 375 km. "I think it would be a blast to push the envelope on 24 GHz and find out what the limits of that band really are," said Gary.

Tropo-ducting enthusiasts will tell you there is an untapped reservoir of potential microwave operators who are active on 2 meters SSB. Sidewinders on Two, the largest volunteer 2-meter weak-signal organization in the country, suggests joining the group to receive its bimonthly newsletter and continuous updates on all that is happening on 2 meters SSB. Twelve dollars a year is the membership fee for receiving the bulletin by mail, or $6.00 to receive it by e-mail as a registered member. Contact Howard Hallman, WD5DJT, 3230 Springfield, Lancaster, TX 75134-1214 (www.SWOTRC.org).

On our Sunday night net, West Coast SWOT net controllers give the latest on the Pacific high, and newsletter articles regularly focus on tropo paths all over the U.S., with photos and multiple web pages to browse.

Getting on 10 GHz is nearly as easy as getting on 2 meters SSB. In fact, you can turn your 2-meter SSB transceiver into the "business end" of a 10-GHz transverter. The following websites offer nearly "plug-and-play" 10-GHz SSB/CW transverters ready for 10-GHz microwave excitement: <www.downeastmicrowave.com>, <www.SSBUSA.com>, and <www.Prodelin.com>.

"Put up a 10-GHz horn at almost any hamfest gathering, and it is like a magnet, attracting hams to see what happens at 10,000 MHz," commented Kent Britain, WA5VJB, with the North Texas Microwave Society, <www.NTMS.org>, and also the "Antennas" editor of *CQ VHF.*

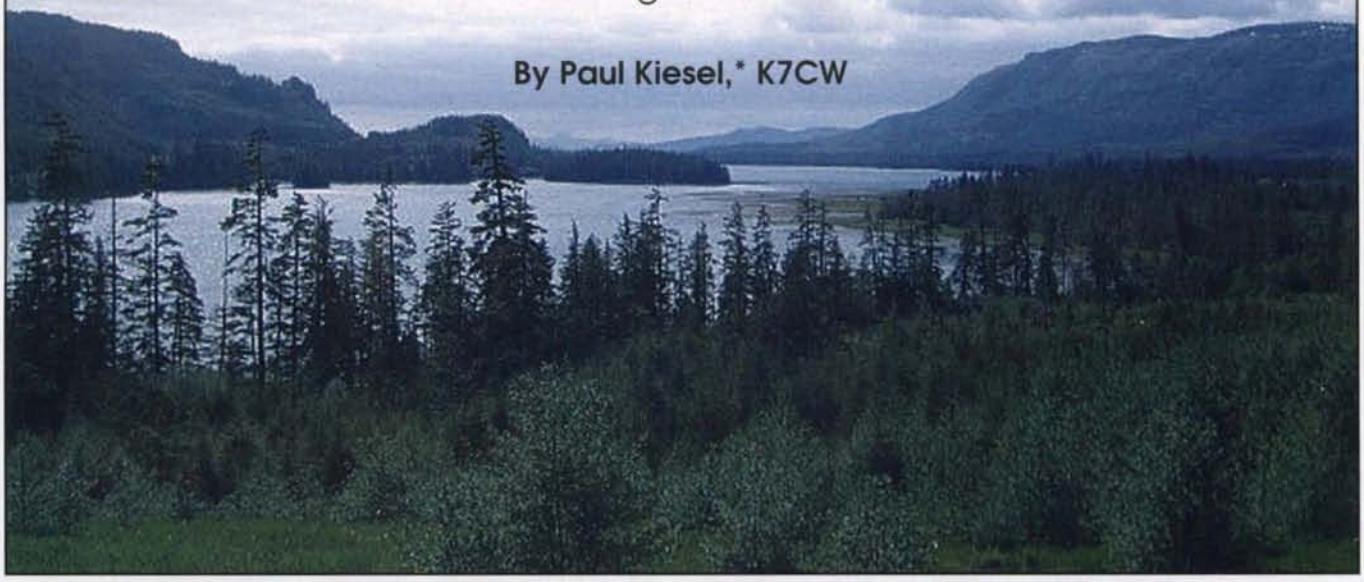
This same "show it off" technique was also a big hit at the recent Amateur Electronic Supply SUPERFEST, with 10-GHz demos put on by the local Badgers Contester microwave team (N8KWX@ARRL.net). The Northeast Weak Signal Group (www.NEWSvhf.com), the Southeastern VHF Society (www.SVHFS.org), and the Central States VHF Society (www.CSVHFS.org) also make it a point to regularly demonstrate 10-GHz equipment.

Explore the microwaves with 10-GHz ready-made 10- and 24-GHz modules. We're just waiting for new ham operators to discover this part of the hobby.

A VHF Contest Expedition to Prince of Wales Island, Alaska

Operating the ARRL June VHF QSO Party from Alaska and bettering a 1970 effort was the goal of K7CW and KLØRG this year. Here is the story of their efforts on 6 and 2 meters using the call KL7FF.

By Paul Kiesel,* K7CW



This is a view of Big Salt Lake on the west side of Prince of Wales Island, Alaska.

In 1970, the moderator of the "World Above 50 MHz" column for *QST* magazine at the time, Bill Smith, then KØCER (now WØWOI), drove his pickup with camper to Ketchikan, Alaska to take part in the ARRL June VHF QSO Party. Bill, using the call KL7ABR, operated the contest in Ketchikan because there were no roads anywhere else near there back then. However, Ketchikan is close to mountains that block any attempt to transmit to the east. Therefore, Bill was able to make contacts to West Coast states only via meteor scatter and sporadic-*E*. There probably was propagation in other directions, but the mountains kept Bill from making contacts in those directions.

Ever since that trip by Bill, I have wanted to do the same. I was hoping to better the effort made by KL7ABR in 1970. Over the last three years, I had strongly been considering the idea of doing the June VHF QSO Party in southeastern Alaska. I discussed this with Kevin O'Connell, KLØRG, and others, but made no decision to prepare for such a trip until 2006, when I retired. I called Kevin early in 2007 and told him that I had decided that this was the year for the contest effort. Kevin, an avid VHF weak-signal afficionado, immediately volunteered, and we became a two-man team for the competition. We would use the DX Scavengers Radio Club callsign, KL7FF.

In the meantime, I discussed the upcoming activity with Ed Cole, KL7UW, who is making great efforts to popularize weak-signal VHF in Alaska. Ed thought it was a great idea to submit a club entry from Alaska. In order to get things going, Ed took steps to make the Alaska VHF Up Group an official organization and obtain club affiliation with the ARRL. Ed published information on his web page, <http://www.kl7uw.com/>, which gave details of our contest plans. He also contacted many Alaskan amateurs and vigorously promoted the VHF contest effort and weak-signal VHFing in general. Unfortunately, the club affiliation didn't arrive in time for the contest, but interest in the activity was still piqued. Excellent job, Ed.

Kevin and I discussed possible locations in southeastern Alaska. Of primary importance was the necessity of having a clear shot with low take-off angle to Canada and the United States. I did a lot of Internet research, seeking possible accommodations. I made many phone calls to owners of vacation and hunting cabins. Some had electricity, but most had unacceptable radio horizons.

Finally, I located a cabin near the eastern shore of Prince of Wales Island, near the town of Thorne Bay, in grid locator CO35rq. From the published Internet photos and from discussions with the caretaker, Tim Lindseth, it appeared that all the necessary specifications would be met. We needed to know for sure, though, that we would have a clear shot to VE and W. A good horizon in the direction of south central Alaska would be a major plus.

At the beginning of May, I flew to Ketchikan to check out the cabin. I met Kevin, who unfortunately had work commitments. However, we were able to take the Inter-Island Ferry to Prince of Wales Island and visit the cabin. We immediately saw that the cabin suited all of our

*P.O. Box 112, Tahuya, WA 98588-0112
e-mail: <k7cw@qsl.net>

Paul, K7CW, on the deck of the M/V Malaspina *on the way to Ketchikan, Alaska.*

Kevin, KLØRG, at the U.S. Forest Service rest stop between Klawock and Thorne Bay, Alaska.

needs, and we made arrangements with Tim, the caretaker, to spend five nights there around the dates of the contest. I then flew back home.

Initially, I had planned to drive through British Columbia to Prince Rupert and then take the ferry to Ketchikan, then another ferry to Prince of Wales Island. The idea was to take my radio and pass out rare grid locators along the route. However, when I checked the ferry schedules, I found that I would have to spend a total of five extra days just waiting in Ketchikan if I went that route. Instead, I decided to take the Alaska Marine Highway System ferry from Bellingham, Washington to Ketchikan, and the mirror image route upon return. That way I would only have one extra day in Ketchikan.

The trip on the AMHS vessel is really a pleasant cruise that takes about a day and a half. The ferry route follows the Inside Passage and is very scenic, with mountains and fjords and virgin forests as far as the eye can see. There is an abundance of wildlife, too, including humpback and blue whales and orcas and bald eagles. I chose not to get a stateroom on the vessel. Brave folks can sleep under the solarium on the bridge deck. It's open to the outside, but has heating elements mounted above so you don't get cold at night.

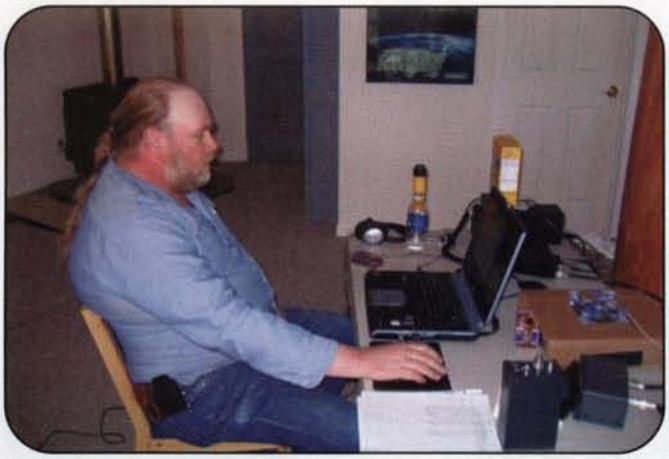
It's a good thing that I chose to take the ferry. As it turned out, there was a large mud slide, with fatalities involved, across the highway between Prince George and Prince Rupert, BC that caused the highway to be closed for several days. If I had taken the land route, I would not have gotten to the cabin in time to operate the contest.

Since I paid to take my pickup on the ferry, I was able to transport anything that I desired from home to Alaska. I took a large portable fan, all my non-perishable food, tower section, rotator, and mast. I took extra coax, coax connectors and adapters, extra power strips, extension cords, rope, radios, a 2-meter antenna, etc. I didn't have to decide what to leave behind, because there was plenty of room for everything I wanted to take. I had already shipped some things, such as the 6-meter amplifier and 6-meter antenna, to Alaska on the barge. When I returned to Washington, I brought everything back with me in the truck, with the exception of the amplifier, which stayed with Kevin.

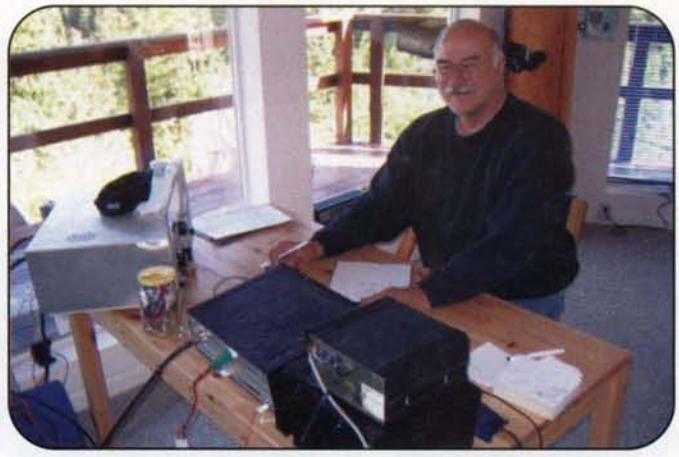
We got to the cabin on the afternoon of the June 7th. The weather was beautiful when we arrived, so there was no hurry to get everything inside. We had scheduled the afternoon and evening of the 7th, all day the 8th, and the morning of the 9th to get ready for the contest. However, no matter how much you prepare, some things don't go as smoothly as you want them to. In our case, I had forgotten to bring my climbing belt to use in mounting the 6-meter beam. I ended up using a few loops of rope around the tower to hold me to it as I lifted the beam over the top of the mast. This was not pleasant! We also had trouble with the T/R sequencer, which caused us some anxious moments just before the contest began.

We got going in the contest on 2 meters and 6 meters, the only bands we had. It didn't take long to start making contacts, but the only propagation mode that we had at the time was meteor scatter. In fact, this was the way it was to be for the entire contest, with the exception of two stations in eastern Washington and the stations in south central Alaska that we worked via sporadic-*E*. All of the stations we worked via sporadic-*E* had strong,

Here is the cabin as seen from the southeast. The 2-meter Yagi is on the porch to the left. The 6-meter Yagi is in the right foreground. The small dish is the satellite internet antenna. The other dishes are various satellite television antennas. All of this was 100% operational while we were there.



Kevin, KLØRG, at the 2-meter operating position of KL7FF.



Paul, K7CW, at the 6-meter KL7FF operating position.

consistent signals over long periods of time. When fading occurred, it was very slow. We did work one station via FM on 2 meters; it was located in Ketchikan in grid locator CO45. He was the only station we worked on a non-weak-signal mode.

The band that holds the most interest for me is 6 meters, so most of my planning was centered around that band. However, I remembered how exciting it was when I worked my first KL7 (yes, it was Kevin) on 2 meters during the *Leonids* meteor shower a few years ago. Kevin volunteered to bring his 2-meter gear, which included a 400-watt brick amplifier. I brought up the 12-element 2-meter Yagi that Kevin had recently purchased. We talked about the probability of making CW or SSB meteor-scatter QSOs on 2 meters during the contest. The *Arietids* meteor shower would be active, but probably could not be counted on to give long enough bursts to get information across in a limited amount of time.

We decided to try the WSJT mode FSK441, and in a few announcements that I made to reflectors before I left, I offered to run skeds during the contest on 2 meters. We received several requests for skeds using FSK441 and a couple for SSB and CW. We completed with everyone who attempted FSK441 contacts with us on 2 meters. We did complete one contact on SSB on 2. In all, we made a whopping 16 contacts in 9 grid locators on 2 meters. Stations in south central Alaska, southeastern Alaska,

British Columbia, western Washington, eastern Washington, Oregon, and Idaho were worked. This success far exceeded our dreams and has to represent a record-breaking performance.

Kevin found that it was easy to get contacts. We had encouraged folks without skeds to tailend after skeds. They did, and they also answered our CQs. We found that it was not hard at all to make contacts on 2 meters from southeastern Alaska! Folks realized that it paid off to go to the trouble of getting digital interfaces connected to their rigs and downloading WSJT. (Actually, we worked a total of 17 stations on 2 meters, having had a FSK441 QSO with a station on June 8th.)

Six meters was a little disappointing because of the scarcity of sporadic-*E*. We were sort of hoping that if there was no sporadic-*E*, then maybe we would have some aurora. A strong aurora would have made things very exciting. Alas, however, meteor scatter turned out to be the predominant propagation mode for us in the contest, and so it was on 6 meters. We had 74 QSOs in 27 grid locators on 6 meters. Not many contacts there, but it's not because we didn't try. There were quite a few partial QSOs that didn't get logged because we didn't get a "roger" from the other station. We did not work a single station beyond one-hop sporadic-*E* maximum range. On this band we ran 600 watts with an 8-element Yagi.

The day after the contest I spent several hours working as many stations as I could on 6 meters. There were some single-hop sporadic-*E* contacts made into Montana and south central Alaska, and a few double-hop sporadic-*E* contacts were made into the Kansas, Oklahoma, and Texas areas. I worked a few stations on meteor scatter, too.

For us, the contest was a success, because we found that it was possible to get on the air from southeastern Alaska and work into areas other than the narrow West Coast corridor to which one would be restricted by operating from Ketchikan. It is still difficult to find a suitable location because of the undeveloped, mountainous character of the entire region. Two-meter contacts between southeastern Alaska and the "Lower 48" have now proved to be an easy thing when using fast digital modes.

This is what sometimes happens when you have only two people to take down a tower with rotator, mast, antennas, and cables still attached!

I would like to thank Kevin, KLØRG; Ed, KL7UW; Bill, WØWOI; Tim and Teresa Lindseth; and all of the weak-signal VHF enthusiasts who offered help, suggestions, and encouragement for this trip. I think we all got a lot out of it. I hope it happens again soon! ■

VHF Propagation Hunter

Tips for Long-Range Terrestrial Contacts on 144 and 432 MHz

WB2AMU presents a brief overview of his chase for long-distance contacts in the weak-signal portion of 144 and 432 MHz while operating portable.

By Ken Neubeck,* WB2AMU

As many VHF operators know, it is a real challenge to make long-range contacts on 144 and 432 MHz via terrestrial means. This is not only because of the need to take advantage of propagation conditions when they happen—such as tropospheric ducting, sporadic-*E*, and aurora—but also because of the apparent lack of monitoring the calling frequencies on these bands on a daily basis by many VHF operators.

Indeed, for the most part these bands do come alive, to a degree, with increased activity during the major VHF contests throughout the year, particularly the ARRL's VHF contests in January, June, and September, when all VHF bands from 50 MHz up to the microwaves are utilized. The CQ WW VHF Contest in July utilizes 50 and 144 MHz, and often both of these bands enjoy significant activity during the contest period.

This brings up the real question: What about the rest of the year? Enhanced propagation conditions are present on 144 MHz and 432 MHz at certain times of the year and often are missed because of the lack of day-to-day monitoring by VHF operators. Both of these bands are included in a number of current HF-plus-VHF mode radios, so it becomes a matter of knowing when to monitor the bands.

The following is a brief overview of some of my limited successes chasing long-range contacts in the weak-signal portion (CW and SSB) of 144 MHz and 432 MHz using a portable station, as I do not have a permanent 2-meter station in my house. As I have found, you can have fun chasing contacts on these two bands.

Equipment That Can Be Used for the Chase

Later on in this article we will discuss the various propagation modes that can allow for long-range contacts on 144 and 432 MHz. However, the first question we need to ask is what type of equipment is needed to capitalize on some of these propagation modes and make contacts.

Because of the size of the wavelength for the VHF bands, it is not difficult to have a well-equipped station at home, where

This is a practical portable setup that involves a three-element 2-meter Yagi manufactured by MFJ. It is mounted on a telescope tripod that is resting on the roof of WB2AMU's Chevy Malibu. A short run of RG-8U coax connects the antenna to an FT-100 resting on the dashboard of the car. The antenna installation is very steady, as the weight of the tripod and beam is sufficient to stay in place during moderate wind conditions. This setup works well in the middle of a parking lot. (Photos by the author)

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

This is a close-up view of the mounting of the mast of the 2-meter Yagi to the platform of the tripod, where the telescope normally would be mounted. There were some pre-drilled holes that were in the mast portion of the beam, allowing for attachment screws and nuts to be added for securely mounting the antenna.

a multi-element Yagi is used up 50 to 100 feet on a tower. In addition to the multi-band radios that have 144 MHz and 432 MHz, there are plenty of linear amplifiers available for these frequencies. A home station with multi-element Yagis and amplifiers will do well with all of the propagation modes mentioned earlier in the article.

However, when working long-range contacts, it is possible to do quite well with portable and mobile setups for these bands. A major advantage of a portable setup is the ability to pick out a suitable site in terms of height and reduction in noise level. Indeed, VHF hill-topping has been a pastime of mine for close to 40 years. Major improvements in equipment and antennas have made my operations more feasible without a lot of effort.

All of the contacts listed in the tables in this article were completed using portable and mobile setups. For the most part, I used a Yaesu FT-100 with no amplifier (50 watts maximum on 144 MHz, 20 watts maximum on 432 MHz) and a simple three-element Yagi up as high as I could get it. During the big sporadic-*E* opening on 144 MHz last summer, I did not have a beam with me and I used a vertical with decent success! Would a better setup have made a difference? The answer is yes and no. I think with regard to aurora contacts, higher power and higher antennas would have helped. A portable setup seemed not to be an issue with regard to most tropo-enhanced conditions and with those rare sporadic-*E* openings on the 2-meter band.

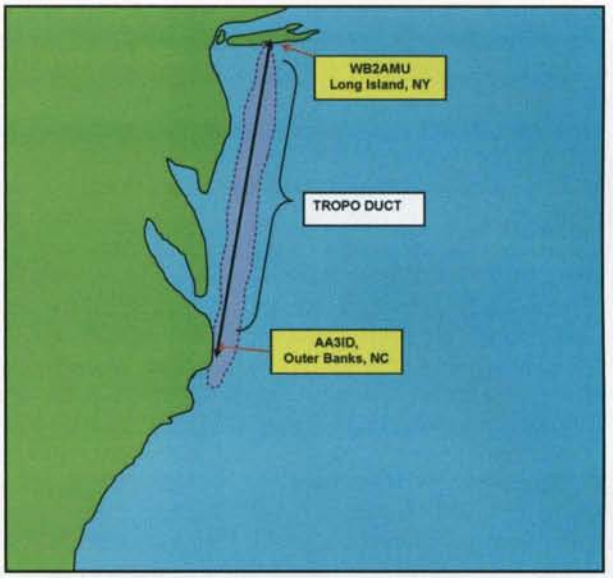


Figure 1. This image of the eastern coastline of the U.S. shows the tropo path between Long Island in New York and The Outer Banks of North Carolina. From this map it can be seen why the path ends at The Outer Banks area, since from that point, the coastline slants toward the west, making it harder for a duct to turn in that direction from The Outer Banks. On occasion, this path has been experienced during the summer months, and on rare occasions during the fall and mid-winter when conditions are just right.

I used to use an umbrella stand to support the masts holding my VHF beams. Recently, I obtained a telescope with tripod assembly as a gift for my years of service at my job. I have yet to use the telescope itself! However, the tripod assembly is very handy as a mount for my 2-meter beam on top of my car roof. The tripod can extend up to 5 feet, and on top of the car the overall height is 9 to 10 feet, which is generally sufficient for most 2-meter contacts, particularly in an enhanced location such as on a hill. I was able to find suitable hardware that would allow me to mount my three-element MFJ Yagi to the area where the telescope normally would be. See the photos with this article, which show the details of the assembly. I was able to use this setup successfully for 144 MHz as well as 432 MHz QSOs with the 2-meter beam during the ARRL's June VHF QSO Party.

Tropo Conditions

In recent years, I have experienced some amazing long-range contacts via tropo ducting on both 144 and 432 MHz. A close ham friend of mind, Van Fields, W2OQI, who is very active

Date	Time (UTC)	Callsign	Grid	Freq. (MHz)	Mode	Antenna	Power
June 9, 2002	1311	W4FSO	FM14	144.2	CW	3-el 2 meter Yagi	10 W
Nov. 23, 2003	2340	AA3ID	FM25	144.2	SSB	3-el 2 meter Yagi	35 W
June 13, 2004	1147	N4HB	FM17	144.2	SSB/CW	3-el 2 meter Yagi	10 W
Feb. 8, 2005	1720	AA3ID	FM25	144.2	SSB	3-el 2 meter Yagi	35 W
Feb. 8, 2005	1725	K4HHT	FM25	144.2	SSB	3-el 2 meter Yagi	35 W
Sept. 8, 2006	2151	AA3ID	FM25	432.1	SSB	3-el 2 meter Yagi	10 W

Table 1. Selected list of long-range VHF tropo contacts made by WB2AMU (FN30).

with the Coast Guard Auxiliary on Long Island, New York, alerted me to the fact that often on the Marine VHF Channel 9 calling frequency (at 156.450 MHz) or Channel 16 distress frequency (156.800 MHz) he hears the Coast Guard station on The Outer Banks, North Carolina coming into his area on eastern Long Island. However, at the same time, he does not hear all that much amateur radio activity on the 2-meter band; not many take advantage of this opening, except for a few out-of-town repeaters being heard in the FM portion of the band.

Tropo conditions seem to favor the warmer months of summer, particularly when there are a lot of cold and warm fronts passing through different areas. Some very well-known paths have been documented in various articles, such as the southern California to Hawaii path, where hams with HTs on the beach in California can work into Hawaii *(see "The 10-GHz California to Hawaii Yearly Attempt," by WB6NOA, elsewhere in this issue of* CQ VHF*—ed.)*. Here on the East Coast, the path from Long Island to The Outer Banks of North Carolina is an occasional one that shows up during the summer months and sometimes during the winter when certain weather conditions occur.

Based on my limited experience, I have found that enhanced tropo conditions seem to happen during the early morning and early evening hours. However, I have experienced enhanced conditions during the middle of the day and well into the late evening hours, as shown in the data presented in Table 1.

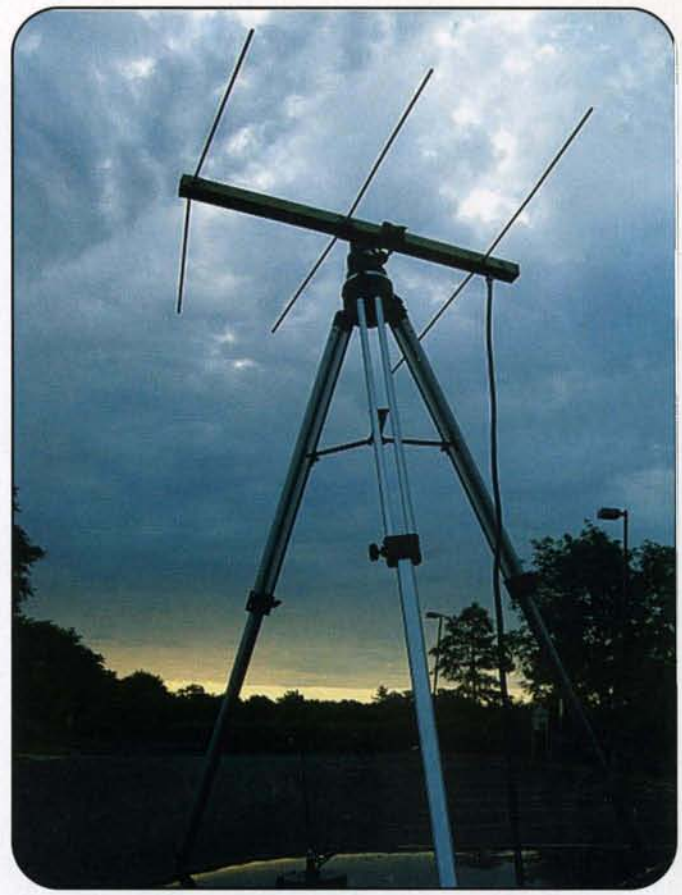
The VHF contests seem to bring stations out of the woodwork, as decent levels of activity can be heard in the weak-signal portion of 144 MHz with spotty activity on 432 MHz. For me it seems that usually during a VHF contest there is maybe one unusual contact on those two bands, either long distance or a rare grid.

One such highlight occurred during the September 2006 ARRL VHF QSO Party shortly before 6 PM local time on Saturday night. I was switching back and forth between 144 and 432 MHz while using the same antenna, an MFJ three-element 2-meter Yagi. Suddenly, on 432 MHz I heard a very loud SSB signal. I dropped in my callsign and AA3ID from FM25, located on The Outer Banks, came back to me! He apparently QSYed to 432 MHz from another band, looking for a station that had requested he go there. He was 59 with tropo distortion, and I was 57 for him using just 10 watts and the 2-meter antenna! The map shown in Figure 1 shows this path, one that has occasionally occurred between Long Island and The Outer Banks. Please note from Table 1 that I have made other contacts with AA3ID via tropo and at different times of the year!

An important website for predicting tropo conditions is provided by William R. Hepburn (http://www.dxinfocentre.com/tropo.html). This site predicts potential tropo openings for the upcoming five-day period for different areas of North America and uses color-coding to rate intensity of the tropo paths.

Another thing to remember regarding tropo conditions is that conditions can change during the course of a day or even a particular hour. For example, there are many times during a VHF contest when pointing towards a certain direction will yield little results in working stations. Then an hour later, a small tropo path may develop towards that direction and signals may be of significant signal strength so that they can be worked.

During the 2007 June VHF QSO Party, I saw how moderate tropo paths could be fickle on a band such as 144 MHz. During the Sunday morning of the event, 144 MHz had moderate activity toward the northern part of New England, but I heard nothing to the south. Then by 8 AM, I worked a pair of stations in the Maryland area on 144 in grids FM19 and FM18.



This is the 2-meter antenna/tripod assembly in action during the early morning hours on a hill on central Long Island (grid FN30) during the ARRL June 2007 VHF QSO Party. The setup performed satisfactorily, with grids as far north as FN43 and as far south as FM18 worked on the 2-meter band.

Tropo is the bread-and-butter mode for the 144- and 432-MHz bands, as paths capable of extending signals can occur several times a year. Thus, tropo becomes a more practical mode of propagation for these bands, compared to aurora and sporadic-*E*. More daily monitoring of the 2-meter calling frequency of 144.200 would be a good strategy to catch these paths, and then moving to 432 MHz could be an additional step to check conditions there.

Aurora Conditions

For the years preceding and especially for the year following a solar cycle peak, aurora conditions occur on an occasional basis on the VHF bands when geomagnetic activity increases. Most openings occur on 6 meters, and when density of the aurora formation increases, activity can occur on 144 MHz and on rare occasions 220 MHz, and even less frequently on 432 MHz.

Table 2 shows a list of selected contacts that were made by me during some intense aurora openings that reached the level of 144 MHz. All of the contacts that I made on 144 were during the years following the solar peak, and they all were made

Date	Time (UTC)	Callsign	Grid	Freq. (MHz)	Mode	Antenna	Power
Mar. 31, 2001	1835	VE3AX	FN02	144.1	CW	3-el 2 meter Yagi	40 W
Apr. 11, 2001	2314	K9MRI	EN70	144.2	CW	3-el 2 meter Yagi	40 W
May 29, 2003	2044	K4QI	FM06	144.1	CW	3-el 2 meter Yagi	40 W
Nov. 20, 2003	3257	K1GUP	FN54	144.1	CW	3-el 2 meter Yagi	40 W

Table 2. Selected list of long-range VHF aurora contacts made by WB2AMU (FN30).

Date	Time (UTC)	Callsign	Grid	Freq. (MHz)	Mode	Antenna	Power
July 6, 2004	2200	KX9X	EM59	144.2	SSB	1/4-wave vertical	40 W
July 6, 2004	2208	KC4PX	EL98	144.2	SSB	1/4-wave vertical	40 W
July 6, 2004	2212	KD4ESV	EL87	144.1	SSB	1/4-wave vertical	40 W
July 6, 2004	2218	W4HP	EM75	144.2	SSB	1/4-wave vertical	40 W
July 6, 2004	2220	N9LR	EN50	144.1	SSB	1/4-wave vertical	40 W
July 6, 2004	2223	NW5E	EL98	144.1	SSB	1/4-wave vertical	40 W
July 6, 2004	2256	KB4TCU	EM81	144.1	SSB	1/4-wave vertical	40 W

*Table 3. Selected list of long-range VHF sporadic-*E *contacts made by WB2AMU (FN30).*

on CW. It is almost impossible to make an SSB QSO via aurora on 144 MHz, as the signals are very wide because of the effects of aurora, and voice signals would be distorted even more than those heard on 6 meters!

One of the more amazing contacts from this list was with K9MRI from EN70 in Indiana. I clearly remember how strong his signal was during the opening. Also, after experiencing many aurora openings on 6 meters and not usually reaching out to the EN grid on that band, I was surprised to hear someone from that grid field on 144 MHz and was able to work him using a very modest portable setup in my driveway, where the antenna was only up 10 feet on mast sections!

While aurora events occur primarily during the equinoxes, some occasional events can occur at other times as well. Some intense openings have been observed during the months of May through August. In fact, the 2004 ARRL June VHF QSO Party saw a significant aurora opening on the Sunday afternoon of the contest, where signals were heard on both 50 and 144 MHz.

Even though we are in the valley of the sunspot cycle, 2-meter aurora is still potentially possible over the next few years when a major eruption occurs on the sun. However, this type of geomagnetic-storm activity is more likely to occur in the 2009 to 2011 timeframe. Again, a good indicator of potential events are the various solar websites, such as <http://www.dxlc.com/solar/indices.html>.

Also, it is important to note that aurora will first appear on 6 meters, before the density of the aurora formation makes it possible for aurora signals to be heard on 144 MHz. Usually when signals become very strong on 6 meters and many start appearing, it is prudent to check the 2-meter weak-signal calling frequency of 144.200 MHz.

Sporadic-*E* Conditions

Sporadic-*E* on 144 MHz is a fairly rare occurrence, with one or two openings being observed in the U.S. during the course of the summer season. During the winter sporadic-*E* season, it is very rare for the density of sporadic-*E* formations to reach the level of reflecting radio signals on 144 MHz and above. Thus, the focus for hunting 144-MHz sporadic-*E* should be during the summer season, beginning in May and ending in late August or early September.

The key to spotting a potential 144-MHz sporadic-*E* opening is to keep an ear on 6 meters. When the skip starts to shorten up on 50 MHz, where signals at distances of less than 800 miles or so are being heard at very loud signal strength, it is a good time to listen on 144 MHz, usually around 144.200 MHz.

When signals start to appear on 144 MHz, there may be instances of rapid increases in signal strength and rapid fading. The trick is to move quickly and exchange information during such an opening, as the opening may last for only 15 to 20 minutes.

One of the biggest openings that I have been fortunate to take advantage of in recent years on 144 MHz took place in July 2004. I was out doing some errands, and stopping at my father Ray, W2ZUN's house, I saw that many channels were severely impacted by interference on his TV hooked to an external antenna. Indeed, sporadic-*E* interference was reaching as high as Channel 7 (which is in the 175-MHz range)! Unfortunately, I only had a 1/4-wave whip antenna for 144 MHz in my car, but in spite of this shortcoming, after leaving my father's house I went to a parking lot and started working stations on 144 MHz. The skip lasted for over two hours, and my results with the vertical are shown in Table 3.

When it does occur, 2-meter sporadic-*E* propagation is a major event. As indicated before, when certain conditions start to occur on 6 meters, it may warrant listening on the 2-meter band. Also, making use of internet websites as well as other means, such as Broadcast TV or FM radio, may be a tip-off that an opening is in progress.

Summary

This article provides a little insight into some of my recent modest successes in chasing long-range 144- and 432-MHz contacts using terrestrial modes and mainly a portable setup. It can be seen that activity on the VHF bands remains a significant issue on a day-to-day basis outside of the VHF contest periods. In the future, I hope to provide some updates in on additional observations from 2007 and beyond. ■

By Kent Britain,* WA5VJB

ANTENNAS

Connecting the Radio to the Sky

Weak-Signal Mobile Antennas

Back in the late 1940s and the early 1950s, there was considerable discussion about the advantages of horizontally versus vertically polarized antennas for long-haul VHF/UHF QSOs. When considering propagation, it doesn't really matter if the signals are horizontally or vertically polarized, but there are mechanical advantages to each. As a result, SSB and CW generally are used from home stations and the antennas are horizontally polarized. Mobile stations usually find it much easier to put up a vertical whip antenna, so most mobile station antennas are vertically polarized.

Therefore, when it comes to mobile SSB/CW operation, you have the challenge of coming up with a mobile horizontally polarized antenna. However, 6 meters is rather an exception. When the 50-MHz SSB signal bounces off a few *E*-layer clouds during an opening, the sig-

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

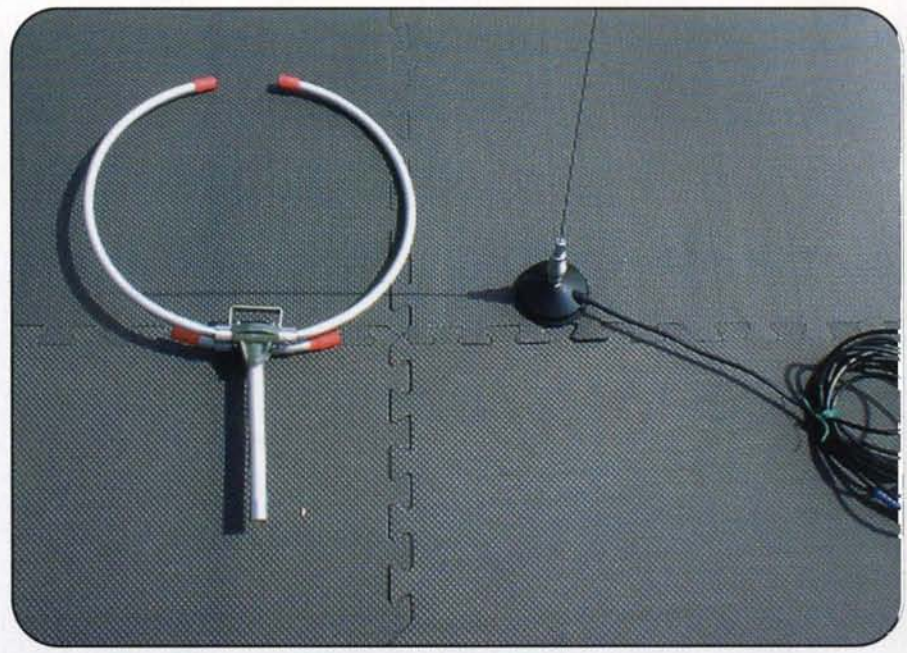


Photo 1. A 2-meter halo for horizontal polarization and a 2-meter vertical for vertical polarization. (Photos by the author)

Photo 2. My 2-meter squalo, which has had a long and hard life.

Photo 3. A 432-MHz magnet-mount halo.

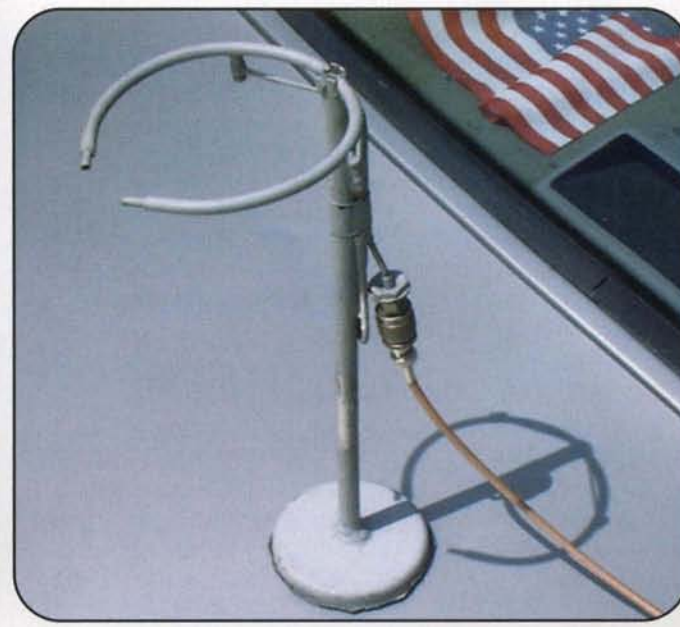


Photo 4. Close-up of the halo matching.

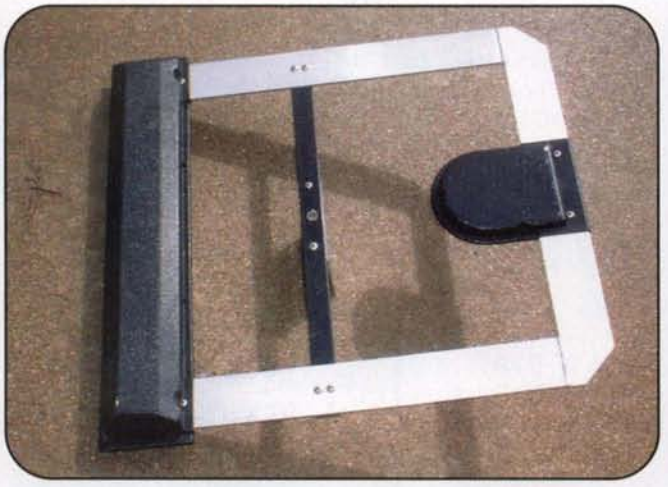


Photo 5. The M² 6-meter "halo" antenna.

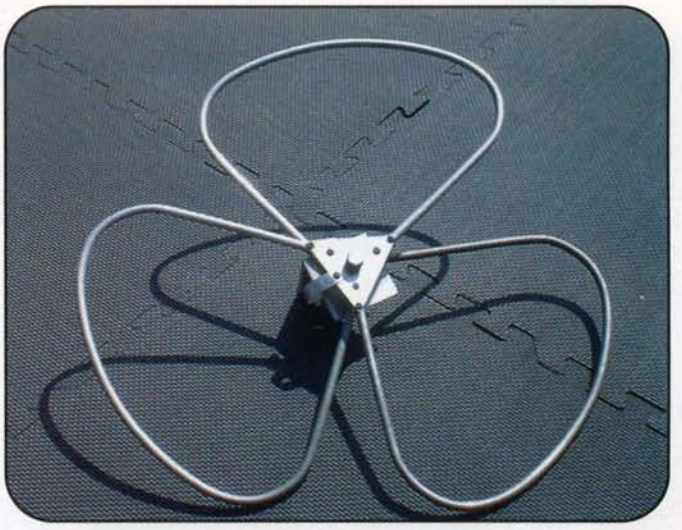


Photo 6. The 432-MHz "Big Wheel" antenna.

Photo 7. K5VH's 144-MHz "Super Wheel" antenna.

nal that bounces back has a confused polarization. Thus, a vertical antenna works almost as well as a horizontal antenna on 6-meter skip. I worked more than 30 states with an ICOM IC-502 (3 watts on a good day) and a 2-meter 5/8-wavelength mag-mount antenna on top of a 1977 Chevette. I'll bet, though, that I got something mixed up there. No, a 5/8-wavelength antenna is electrically 3/4 wavelength long, but is shortened to physically be 5/8-wavelength long. That's why there is a tuning loop in the base of a 5/8-wavelength antenna, to get that extra 1/8 wavelength. Therefore, the 2-meter 5/8-wavelength mag mount is also a 1/4-wavelength whip on 6 meters. It works great with some of the new multiband rigs as well.

The Halo and Squalo

In Photo 1 we have the most common VHF horizontal mobile antenna, the halo, and a 1/4-wavelength mag mount. In its simplest form, the halo is just a 1/2-wavelength dipole bent almost into a circle. Capacitance coupling between the tips can be used to shorten the antenna even more, but at the expense of a narrower bandwidth. This halo certainly has seen a rough life, and it uses a beta match, or a shortened stub, to get the feedpoint impedance back to 50 ohms.

In Photo 2 is my veteran 2-meter squalo. It was a used antenna when I got it 25 years ago. I added another 100,000 road miles, and forgetting to take the squalo off several times before pulling into the garage has created its share of wear and tear. However, it still works. This squalo uses a gamma match, which is an offset feed with some series capacitance. Personally, I am not fond of gamma matches, but they do work. The half of the dipole with the match on it has the most RF current, which makes the maximum radiation off the back corner of the squa-

YOUR NUMBER FOR SAVINGS (800) 272-3467

KENWOOD TM-D700A
Mobile 2m/70cm FM XCVR With Built-In TNC, Separate Front Control Panel, CTCSS Encode/Decode, 200 Memory Channels, and Much More!
CALL FOR YOUR LOW PRICE!

KENWOOD

KENWOOD TM-271A
Mobile 2m FM XCVR, 60 Watts, CTCSS Tone Encode/Decode, 200 Memories, More!
CALL FOR YOUR LOW PRICE!

ICOM IC-208H
Mobile 2m/70cm FM XCVR, Data Jack, Extended RX, CTCSS Tone Encode/Decode/Scan, DTCS Encode/Decode, 500 Memory Channels, More!
CALL FOR YOUR LOW PRICE!

ICOM

ICOM IC-V8000
Mobile 2m FM XCVR, 75 Watts, CTCSS Tone Encode/Decode/Scan, 200 Memories, More!
CALL FOR YOUR LOW PRICE!

TEXAS TOWERS
Savings As Big As Texas!

- **Great Gear**
- **Great Deals**
- **Great Service**
- **Free UPS S/H!***

*On all radio orders shipped within the contiguous USA.

Alfa-Spid • Alpha-Delta • Ameritron • ARRL • Astron • Bencher • Butternut • Cal-Av • Comet • Cushcraft • Daiwa • Diamond • Force 12 • Gap • Glen Martin • Hustler • Hygain • Icom • Kantronics • Kenwood • Lakeview • Larsen • LDG Electronics • M2 • MFJ • Mirage • Palstar • Polyphaser • Phillystran • Rohn • Tex-Com • Times Microwave • Unadilla • Universal Tower • US Tower • Van Gorden • Vectronics • Vibroplex • Yaesu

KENWOOD

KENWOOD TS-2000
Huge Band Coverage, All Mode HF/6m/2m/70cm, Auto Tuner, CW Memory Keyer, Dual RX, Dual DSP, Built-In 1200/9600 bps TNC, TCXO, and Much More!
CALL FOR YOUR BEST PRICE!

KENWOOD TS-480SAT
Mobile Performance, All Mode HF/6m, Auto Tuner, Separate Front Control Panel, 16-Bit DSP, CTCSS Encode/Decode, More!
CALL FOR YOUR BEST PRICE!

KENWOOD TS-570SG
Mobile Performance, All Mode HF/6m, Auto Tuner, CW Keyer, Built-In DSP, CTCSS Encode, Built-In PC Interface, and More!
CALL FOR YOUR BEST PRICE!

TH-D7AG
Hand Held 2m/70cm HT With Built-In TNC, Extended Receive, CTCSS Encode/Decode, 200 Memory Channels, Ni-Cad Battery, and More!
CALL FOR YOUR PRICE!

TH-F6A
Hand Held 2m/220/70cm Triband FM HT, Backlit DTMF Keypad, Extended Receive, CTCSS Tone Encode/Decode, 435 Memories, Li-Ion Battery Pack, and More!
GREAT LOW PRICE!

ICOM IC-91AD
Hand Held 2m/70cm D-Star XCVR, Backlit Keypad, Extended RX (500 kHz–999 MHz), CTCSS Tone Encode/Decode/Scan, Over 1300 Memories, Li-Ion Battery, and More!
GREAT LOW PRICE!

ICOM IC-T90A
Hand Held 6m/2m/70cm FM XCVR, Backlit Keypad, Extended RX (500 kHz–999 MHz), CTCSS Tone Encode/Decode/Scan, 555 Memories, Li-Ion Battery, and More!
GREAT LOW PRICE!

ICOM

ICOM IC-746PRO
HF/6m/2m All Mode Performance. Huge LCD Display with Bandscope Feature, 16-Bit Digital Signal Processing, Automatic Antenna Tuner, and More!
CALL FOR YOUR LOW PRICE!

ICOM IC-7000
Mobile HF/6m/2m/70cm XCVR, All Mode, 2.5" TFT-LCD Color Display, Twin Digital Signal Processing, Voice Synthesizer, and Much More!
CALL FOR YOUR LOW PRICE!

ICOM IC-706MKIIG
Mobile HF/6m/2m/70cm XCVR, All Mode HF/6m XCVR, Big Dot-Matrix LCD Display with Bandscope Function, 16-Bit Digital Signal Processing, and Much More!
CALL FOR YOUR LOW PRICE!

TEXAS TOWERS

1108 Summit Avenue, #4 • Plano, TX 75074
Hours: M-F 9 AM–5 PM Central Time
Email: sales@texastowers.com

MASTERCARD
VISA • DISCOVER

TOLL FREE **(800) 272-3467**

Proudly Serving Ham Operators Since 1978!
Visit Our Website for More Great Deals:
http://www.texastowers.com

MORE DEALS THAN YOU CAN SHAKE A STICK AT!

Call or email for our new Ham Radio Catalog!

TEXAS TOWERS

Savings As Big As Texas!

Alfa-Spid • Alpha-Delta • Ameritron • ARRL • Astron • Bencher • Butternut • Cal-Av • Comet • Cushcraft • Daiwa • Diamond • Force 12 • Gap • Glen Martin • Hustler • Hygain • Icom • Kantronics • Kenwood • Lakeview • Larsen • LDG Electronics • M2 • MFJ • Mirage • Palstar • Polyphaser • Phillystran • Rohn • Tex-Com • Times Microwave • Unadilla • Universal Tower • US Tower • Van Gorden • Vectronics • Vibroplex • Yaesu

YAESU

YAESU FT-450 .....$819*

Compact HF/6m Performance. All Mode HF/6m XCVR with IF-level Digital Signal Processing, Optional Internal Auto Tuner, Built-in TCXO, Built-in Personal Computer Interface, and More!

***AFTER $100 YAESU COUPON!**

YAESU FT-897D....$829*

Portable HF/6m/2m/70cm XCVR, All Mode, DSP, Optional Auto Tuner, Optional Internal Batteries or AC Power Supply.

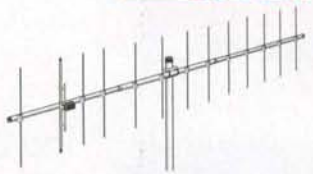
***AFTER $50 YAESU COUPON!**

YAESU FT-857D....$709*

Mobile HF/6m/2m/70cm XCVR, All Mode, Built-In DSP, Built-In CTCSS Encode/Decode, CW Memory Keyer, and Much More!

***AFTER $50 YAESU COUPON!**

cushcraft



CUSHCRAFT ANTENNAS

13B2, 13 Element 2m.....$199
A50-3S, 3 Element 6m.....$129
A50-5S, 5 Element 6m.....$199
A50-6S, 6 Element 6m.....$339
ARX-2B, 2m Vertical.....$79
AR-270, 2m/70cm Vertical....$109
AR-270B, 2m/70cm Vert.....$119

CALL FOR MORE CUSHCRAFT!

COMET

COMET ANTENNAS

GP-3, 2m/70cm Vertical.....$99
GP-6, 2m/70cm Vertical.....$159
GP-9, 2m/70cm Vertical.....$199
GP-15, 6m/2m/70cm Vert.....$159
CLP5130-1N, 50-1300 MHz.....$389
HVU-8, 80m-70cm Vertical....$299

MANY MORE COMET ANTENNAS IN STOCK, PLEASE CALL!

DIAMOND ANTENNA

DIAMOND ANTENNAS

X-50A, 2m/70cm Vertical....$109
X-200A, 2m/70cm Vertical..$149
X-510MA, 2m/70cm Vertical.....$196
X-500HNA, 2m/70cm Vertical...$259
X-6000A, 2m/70cm/23cm Vert...$209
X-7000HNA, 2m/70cm Vert.....$399

MANY MORE DIAMOND ANTENNAS IN STOCK, CALL!

M²

6M HO LOOP $119
6M3, 3 Element 6m $159
6M5X, 5 Element 6m.....$259
6M7JHV, 7 Element 6m $319
2MCP22, 22 Element 2m $299
2M HO LOOP $55
2M9SSBFM, 9 Element 2m $149
2M12, 12 Element 2m.....$209
2M5WL, 17 Element 2m.....$249
432-9WL, 28 Element 70cm.....$219
432-13WLA, 38 Element 70cm..$299
432-42UG, 42 Element 70cm....$349

WE CARRY MANY MORE M2 ANTENNAS, PLEASE CALL!

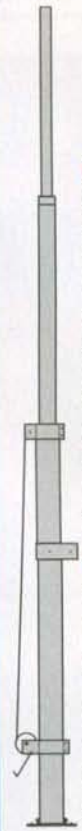
Yaesu G-1000DXA

ANTENNA ROTATORS

Hygain, Ham-IV $499
Hygain, T2X.....$569
M2, OR-2800PX $1379
Yaesu, G-450A.....$249
Yaesu G-550.....$299
Yaesu, G-800SA.....$329
Yaesu, G-800DXA $409
Yaesu, G-1000DXA.....$499
Yaesu, G-2800DXA.....$1089
Yaesu G-5500 .....$599

ROTOR CABLE IN STOCK, CALL!

US TOWER



MA SERIES

Neighbor Friendly Design offers a flag pole-like appearance while supporting an tenna loads up to 2. square feet. Model range from 40–85 fee in height and com with a hand winch an house bracket. Option al self supporting bas es are also available.

TOWER EXPERTS

We Ain't Braggin'... But we've helped s many Hams order U Towers over the year that we've becom the US Tower expert Please call for help se lecting the perfect U Tower for your QTH!

Universal

B-18 SERIES

Light Duty Aluminu Self Supporting Towers Five models range fror 30–50 feet in heigh and support up to 1 sq. ft. of antenna load.

CALL FOR MORE INFO

B-26 SERIES

Medium Duty Alum num Self Supportin Towers. Thirteen model range from 30–90 fee and support up to 34.5 s ft. of antenna wind load.

CALL FOR MORE INFO

B-30 SERIES

Heavy Duty Aluminu SelfSupportingTower Nineteen models rang from 40–100 feet, an support up to 34.5 sq. f of antenna wind load.

CALL FOR MORE INFO

TEXAS TOWERS

1108 Summit Avenue, #4 • Plano, TX 75074
Hours: M-F 9 AM–5 PM Central Time
Email: sales@texastowers.com

MASTERCARD
VISA • DISCOVER

TOLL FREE (800) 272-346

Proudly Serving Ham Operators Since 197
Visit Our Website for More Great Deals:
http://www.texastowers.com

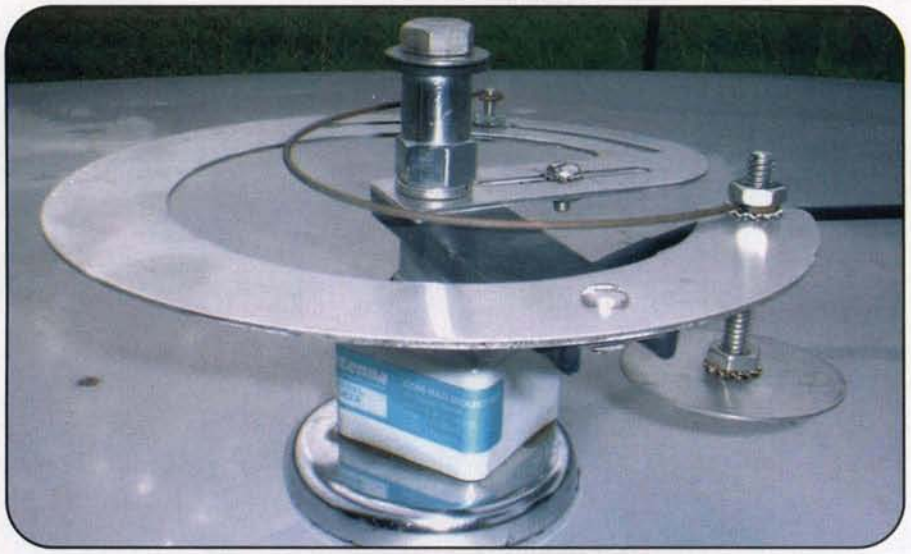


Photo 8. The 2-meter DDRR mobile antenna without its cover.

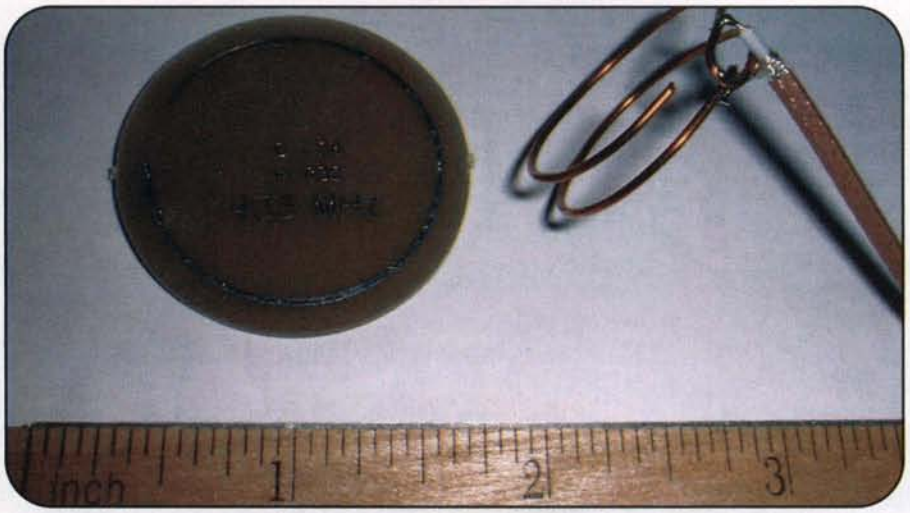


Photo 9. Shown here are 433-MHz and 915-MHz DDRR antennas

lo on the side with the match. Thus, gamma-match squalos are not exactly omnidirectional.

I dug out my 222-MHz halo antenna, but it seems that it didn't survive an avalanche in my garage last winter! Well, it was tuned to 220.1 MHz when I first used it mobile. However, I digress. Terry, W5ETG, has spent a lot of time tweaking mobile antennas, and he suggested I use a balanced feed on my 220-, 432-, and 1296-MHz halos. In Photos 3 and 4, I show my 432-MHz halo using the balanced feed. It has a 4:1 coax balun and equal-length matching arms on both sides. Tuning with Terry's match was smooth and broadband. It's certainly worth the extra effort.

In Photo 5 we have one of the M[2] mobile antennas. Mike Staal uses a halo-type antenna with lots of capacitive coupling on the ends to keep the size more practical. He also uses "magnetic coupling" between the coax and the halo. The coax drives a small loop inside the larger loop. This behaves much like a transformer, with the relative size and position of the loops controlling coupling and impedance. I have built several halos in this way. It's rather touchy to get it right, but once you have the combination dialed in, you have a very efficient and omnidirectional antenna.

The "Big Wheel"

Next is the 432-MHz "Big Wheel," sometimes called a "Clover Leaf" antenna (Photo 6). The wheels are much larger than the halos. In exchange you get about 2 dB more signal, better bandwidth, and they work nicely on their third harmonics. Therefore, a 144-MHz wheel can also be a 432-MHz mobile antenna, or the 432-MHz wheel can be used on 1296 MHz.

A 1/4-wavelength antenna must have a ground, and the bigger the ground the better. Halos and squalos do not need that. Halos, squalos, and wheels close to the ground form a sort of two-element Yagi with the beam (or main radiation lobe) of the antenna pointing straight up.

The "Super Wheel"

The next step up is the "Super Wheel" developed by K5VH (Photo 7). The Super Wheel has more gain than the normal wheel, and while it has a bit more wind loading, it is similar in size to the normal wheel antennas. For information, contact Tom at <K5VH@arrl.org>.

The DDRR

Here we have a very different species of antenna, the DDRR, or Directional Discontinuity Ring Radiator (Photo 8). While it looks like a horizontally polarized antenna, the loop is working with the ground plane to form a slot antenna, and the slot is vertically polarized. Thus, the DDRR is a very low-profile, vertically polarized antenna. For those of you who work in the low-power wireless field, I'm told that someone claims to have a patent that covers all "inverted-F" antennas. Inverted-Fs are very popular small antennas for cell phones, ZigBee[1], etc., applications. Actually, the DDRR is an inverted-F antenna, and the 40-meter version was written about in *QST* in the early 1970s, based on work done in the 1950s. I think some "prior art" on that patent can be shown. I have some 146-, 440-, and 915-MHz DDRR prototypes in the shack, and they have quite a few uses for those of you with only a few inches of clearance between your car and the garage door. In Photo 9 is shown a 915-MHz DDRR made of #22 copper wire, and a 433-MHz DDRR etched on PC board. I'll try to finish a DDRR for a future column.

For now it's summertime and a great opportunity to get more antennas in the air. As always, I welcome questions and suggestions for future topics.

73, Kent, WA5VJB

Note

1. ZigBee is a specification for a suite of high-level communication protocols using small, low-power digital radios based on the IEEE 802.15.4 standard for wireless personal area networks. *(Courtesy Wikipedia)*

CQ VHF books, cds, & dvds!

CQ HF Operator's Survival Guide*

NEW!

A practical, hands-on guide for newcomers to high-frequency (shortwave) Amateur Radio. Discusses the characteristics of each HF ham band and explains which is best and when, basic HF operating practices, choosing your first HF transceiver, antenna basics, HF modes and activities. Includes an HF band chart!

Order No. HFSurv $2.00

Ham Radio Magazine on CD

Brought to you by CQ & ARRL

Enjoy quick and easy access to every issue of this popular magazine, broken down by years!

Three sets, each containing 4 CDs -

1968-1976	Order No. HRCD1	$59.95
1977-1983	Order No. HRCD2	$59.95
1984-1990	Order No. HRCD3	$59.95

Buy All 3 Sets and Save $29.90!

Order No. HRCD Set $149.95

The Complete DXer

Third Edition

The joy of the chase, the agony of defeat, the thrill of victory are the stuff of The Complete DXer, a book that is almost as seductive as the DX chase it describes. It excites, it entertains, it teaches!

Order: COMPDXer $19.95

W6SAI HF Antenna Handbook

by Bill Orr, W6SAI

Inexpensive, practical antenna projects that work! Guides you through building wire, loop, Yagi and vertical antennas.

Order No. W6SAI $19.95

Contesting in Africa

Multi-Multi on the Equator

by Roger Western, G3SXW and the Voo Doo Contest Group

A compelling array of contesting and DXing experiences from one of the most unique operating venues on earth - the African continent. The personal stories told by the world-renowned and witty personality, Roger Western, G3SXW, make this book a must have.

Order No. Africa $19.95

Understanding, Building & Using Baluns & Ununs

by Jerry Sevick, W2FMI

Successor to the extremely popular and authoritative Baluns and Ununs. Great deal of new tutorial material, includes new designs, and explanations of how and why they work.

Order No. 2BU $19.95

Passport to World Band Radio

Edition 2007

The World's #1 selling shortwave guide! Have the world at your fingertips! Details on what to buy and where to tune.

Order No. PASS $22.95

The Short Vertical Antenna & Ground Radial

by Jerry Sevick, W2FMI

Small but solid guide on the design and installation of inexpensive, yet effective short HF vertical antennas. Antenna restrictions a problem? This book could keep you on the air!

Order No. SVERT $10.00

The NEW Shortwave Propagation Handbook

by W3ASK, N4XX & K6GKU

A comprehensive source of HF propagation principles, sunspots ionospheric predictions, with photos, charts and tables galore!

Order No. SWP $19.95

Heathkit - A Guide to the AR Products

by Chuck Penson, WA7ZZE

This greatly expanded Second Edition is a must for collectors and Ham history buffs! Pick up this 328-page volume and you won't be able to put it down!

Order No. HEATHKIT $29.95

2007 World Radio TV Handbook

The Directory of Global Broadcasting

The most up-to-date info on medium-wave, shortwave, and FM broadcasts and broadcasters. Includes articles on topics of great interest to both listeners and DXers, reviews of the latest equipment, updated maps showing SW transmitter sites and more.

Order No. WRTH $29.95

"Getting Started" DVD Paks

Our renowned Getting Started videos have been grouped together on DVDs!

1 - $24.95
2 - $45.95
3 - $65.95

CQ Ham Radio Welcome Pak

1 DVD contains 3 programs:
Ham Radio Horizons
Getting Started in Ham Radio
Getting Started in VHF

Order # HAMDVD $24.95

CQ HF Specialty Pak

1 DVD contains 2 programs:
Getting Started in DXing
Getting Started in Contesting

Order # HFDVD $24.95

CQ VHF Specialty Pak

1 DVD contains 3 programs:
Getting Started in Satellites
Getting Started in VHF
Getting Started in Packet

Order # VHFDVD $24.95

CQ DVD 3 Pak - one of each of the DVDs listed above.

Order # 3DVD $65.95

Buy any combination of DVDs and save!

1 Pak for $24.95; 2 Paks for $45.95; 3 Paks for $65.95

MIL SPEC Radio Gear

Korean War To Present Day
by Mark Francis, KIØPF

Detailed write-ups for many familia sets: PRC-25/-77, RT-68, PRC-10 GRC-106, GRR-5, R-392 and mor Over 230 pages of operation, modification, and maintenance tips and information, including 200+ illustrations.

Order No.MILSPEC $27.95

HR Anthologies

$19.95 ea.

Buy all 4 for only $

Now you can enjoy collections of the best material published in *Ham Radio magazine*, conveniently arr by subject and original publication date. Choose you interest, your time period and choose your anthology

Homebrewing Techniques .... *Order # AHOME*
Test Eqpt & Repair Techniques ...*Order # ATEST*
Antennas - 1968 - 1972 ... .*Order # ANTS1*
Antennas - 1973 - 1975 ....*Order # ANTS 2*

Get all 4 for $75 plus Free shipping . . . Order # A

***Shipping & Handling: U.S. & Possessions-add $5 for the first item, $2.50 for the second and $1 for each additional item. FREE shipping on orders over $75.**
***For a single *CQ HF Survival Guide* or *CQ Calendar* purchase - U.S. & Possessions add only $2 Shipping and Handling.**
All Foreign Shipping & Handling - calculated by order weight and destination and added to your credit card charge.

CQ Communications, Inc., 25 Newbridge Rd., Hicksville, NY 11801
Call 1-800-853-9797 - FAX your order to 516-681-2926 - www.cq-amateur-radio.com

Jamesburg Earth Station EME Update

In the last issue of *CQ VHF*, AA6EG wrote about efforts to use the Jamesburg dish on ham frequencies. Here is the latest on the project.

By Pat Barthelow,* AA6EG

This is a spectacular "over the shoulder" nighttime view of the Moon and Venus as "seen" by the Jamesburg dish. (Photo by Rex Allers, KK6MK)

I would really like to thank the *CQ VHF* magazine staff and editors for polishing and printing our Jamesburg Earth Station team's EME story. The Jamesburg story continues. Since the article in the Spring 2007 issue of *CQ VHF* was wrapped, we have achieved some very successful and fun EME contest operations and experimented with some sub-optimal 144- and 440-MHz near-prime focus feeds. Our intrepid volunteer team has gained complete precision control of the dish, both in azimuth and elevation.

Within the team, our software guys—led by Kevin Hague, N5XSA, and Rex Allers, KK6MK—have refined the dish-control software, so much so that Kevin demonstrated to us how the main program keeps the very tight beam created by the 30-meter dish actually centered on the moon's surface. Kevin created a great graphic of the moon that has a tiny dot representing the center of our beam. With

This photo was taken at the Jamesburg station during the 1296-MHz EME contest in May 2007. Left to right: John Hagerty, W6UQZ; Marc Goldman, WB6DCE; Goran Popovic, AD6IW; Rex Allers, KK6MK; Kevin Hague, N5XSA; Andre Barbe; Jim Moss, N9JIM; and Brian Yee, W6BY. (Photo by KK6MK)

*599 DX Drive, Marina, CA 93933
e-mail: <aa6eg@hotmail.com>

the laptop joystick, Kevin steered the beam around on the moon's surface while we listened to the return signals, and it was very cool! As expected, we could hear the return signal drop off rapidly in real time as we moved the beam off-center of the moon. This was a great reality check that told us that the beam is indeed tight and symmetrical at 1296 MHz and is correctly boresighted with the AZ/EL sensors of the VERTEX dish drive system. With this insight as to the accuracy of the program we can now lock in the beam center anywhere on the moon's surface with ease.

We have some preliminary results from our dish metrology expert, Mike Brenner, of <http://www.engr-metr.com>. We know from his laser measurements that the dish structure is extremely rigid, with an RMS surface change of only 10 to 14 mils between extremes of vertical angles. We hope the surface accuracy of the Italian-made Cospal panels are equally as good, but need more design dimensions of the two reflector surfaces to determine the current dish accuracy.

We are still looking for solutions to the long-term preservation of the Jamesburg station and hope that someone from the space, private, university, military, and/or philanthropic sectors comes forward to work with us to build a business model and give resource support to keep Jamesburg for the long term. We currently can accept tax-deductible donations to the effort through an interim partnership with a 501c(3) sponsoring organization. We have plans to create our own Jamesburg 501c(3) entity in due time.

Some photo credit corrections for our Spring 2007 *CQ VHF* magazine article need to be mentioned here, particularly for the cover picture, which was taken by Rex Allers, KK6MK. Congratulations, Rex (and Gerald Moseley, who is correctly credited with the inset cover shot). Thor Rasmussen, N6FNP, took the photo of our planning meeting on page 7, and also the shot of Bryan Yee, W6BY, about to unlatch the access hatch from the access ladder below the dish (page 10).

If you are interested in keeping apprised of our progress, then please check out our website: <http://www.jamesburgdish.org>, or contact me at: <aa6eg@hotmail.com>. ■

Remembering W2UK/KH6UK

Tommy Thomas, W2UK/KH6UK, was one of the most accomplished VHF-plus operators of the 1950s and '60s. Here, thanks to some assistance from his nephew Mark Shultise, WA3ZLB, is a brief history of this world-renowned amateur radio operator.

By Joe Lynch,* N6CL

The following are excerpts from my September 2005 and November 2005 "VHF Plus" columns in *CQ* magazine, along with a couple of minor updates since their publication.

As they do almost every year, over this summer Chip Angle, N6CA, and Paul Lieb, KH6HME, again have been working on setting a new 10-GHz record between California and Hawaii via the now well-known tropospheric duct between the West Coast and Hawaii. As of this writing, it is not known if their attempt has been successful. The attempt was made possible because of the pioneering work of John Chambers, W6NLZ, and Ralph E. "Tommy" Thomas, W2UK.

It was on July 8, 1957 that John and Tommy (using the call KH6UK) made contact on 2 meters. It would be about two years later, on June 22, 1959, when they again would set a record by making another contact, this time on 220 MHz.

Who was Tommy Thomas and how was it that he ended up in Hawaii to set these records? What follows are the results of some sleuthing and at least one fortunate coincidence of history that opened a major door, which is where I need to begin my story:

When I first looked up KH6UK in preparation for this piece, there was a note on the website that he was a Silent Key. I contacted Fred Lloyd, AA7QB, the owner of QRZ.com, who graciously supplied me with the information as to who inserted the note. It turned out to be Tommy's nephew, Mark Shultise, WA3ZLB, the son of Tommy's sister, Freda Shultise. Mark, like his uncle, had moved to Hawaii in 2003, approximately 48 years after Tommy's relocation. I am deeply indebted to Fred for assistance in contacting Mark.

Now to some history that I uncovered as a result of Mark's assistance and my on-again and off-again years of investigation of Tommy's accomplishments.

A Bit of History

Ralph E. "Tommy" Thomas was born on December 22, 1903 in New Brunswick, New Jersey, the son of Mr. and Mrs. Robert L. Thomas. Tommy's ham radio accomplishments were first on HF. According to Philip Peterson, W2DME, Tommy started his ham radio career in the spark-gap days. During the 1920s and 1930s Tommy "was constantly improving his equipment and was recognized for his special ability in radio communications."[1] According to *The Sunday Home News,* New Brunswick, NJ, Sunday August 4, 1957, these accomplishments included:

> Tommy's 1926 feat of communicating with the George Miller Dyott expedition at the River of Doubt in Brazil, when all commercial efforts to reach the party had failed; and the July 1938 effort when he was one of three amateurs to provide up-to-the-minute weather data for Howard Hughes in his historic globe-girdling flight.
>
> Of the River of Doubt contact, *The New York Times* termed it "an almost impossible feat."
>
> There are few better known amateur radio operators in the world than Thomas whose reputation has been enhanced by the years running in 1938 by virtue of making 329 contacts in 70 countries. Prior to that he had finished second and third and since then has been among the leaders many times.

After World War II, Tommy's interest in the hobby turned toward VHF. Again quoting Peterson, "Tommy said, 'I wanted to try something new after World War II. I started to explore the possibilities of increasing the communications distance range of the VHF and UHF spectrum.'" Tommy entered that spectrum with the same enthusiasm that he showed on HF before the war.

One of his early accomplishments was participating in the first amateur transmission using transistors, which was made in late 1952 when K2AH, using a one-transistor transmitter, worked Tommy on 2 meters some 25 miles away. The power output of that single-transistor transmitter was 50 microwatts.[2]

By December 1952 he was listed in *QST*'s "World Above 50 Mc." 2 Meter WAS standings as having worked 21 states in 7 call areas with the greatest distance being 1075 miles. Tommy would make history beginning the next year when he and Paul Wilson, W4HHK, began running schedules on 2 meters, leading up to the first 2-meter meteor-scatter contact—a feat that would earn both of them the ARRL's 1955 Award of Merit.

According to interviews I had with Paul and Tommy in 1994 in the run-up to the 40th anniversary of their QSO, their interest in the challenge of making a 2-meter meteor contact began in June 1953 when Paul and Ross, W4AO, were in contact via a tropo path. After the path fell apart, Paul continued to hear signal bursts. Ross advised Paul that these were meteor bursts. Within a few days of this contact, Paul got a letter from Tommy asking him to set up schedules for a possible 2-meter contact via any mode of propagation. Paul responded that he'd like to try to work him via meteor scatter.

Over the next several months, schedules were set without success. Then on the morning of October 22, 1954, it all

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

came together. Tommy copied more than two minutes of transmission from Paul, and he in turn was able to copy Tommy's confirmation and signal report. With that exchange they snagged the first complete 2-meter QSO via meteor scatter.

It is interesting to note that because this mode of propagation was experimental, there was no definition of what was considered a QSO. Therefore, Paul and Tommy looked to the ARRL—specifically to Ed Tilton, W1HDQ, then editor of *QST*'s "World Above 50 Mc." column—to define what was necessary for a completed contact. Ed determined that both operators had to acknowledge to one another that they had received both calls and the correct signal report; the latter had to be confirmed by repeating the signal report received back to the other operator.

Reliance on Ed's definition led to the rejection of Paul and Tommy's first claimed contact in August 1954. It wasn't until the second contact that both of them received enough information from one another for Ed to consider the QSO complete.

Their QSO was considered such a breakthrough in propagation that Paul's audio tapes of the meteor-scatter contacts were played at a meeting of propagation physicists of the International Scientific Union (URSI) in Washington, DC, in May 1954.

According to the October 1956 issue of *QST*,[3] as a result of this presentation, Ed, W1HDQ, was asked to prepare a summary of the work and supply some samples of the recorded signals for presentation at the General Assembly of the URSI to be held in The Hague in September 1954. The presentation also included a talk by Dr. J. T. de Bettencourt of MIT's Lincoln Laboratory. The audience was made up of the leading propagation physicists from most of the countries of the world, prompting the *QST* author to comment: "Thus scientific attention was focused on one of the worthwhile aspects of amateur radio that has had too little recognition—our ability to contribute to man's knowledge of wave propagation phenomena."

All told, it took Paul and Tommy two years of constant scheduling to finally make the contact. In their experimentation they tried high-speed keying and tape-recorded playback in their efforts to complete a QSO. Each station was running near-legal-limit power into high-gain antennas and preamps that had a noise-figure measurement of nearly 2 dB. During their experiments they were convinced by the regularity of the bursts that they were dealing with meteor-scatter propagation.

One needs to realize that in those days we did not have WSJT software, and the mode of communication was CW. Additionally, the sophistication of the radios was such that each operator had to tune the receiver with its analog dial in order to locate the signal. In spite of these restrictions, Paul and Tommy eventually were able to complete the QSO and make their entry into the history of VHF communications.

At the time of their QSO Tommy was working for RCA as the engineer-in-charge at the RCA transmitter station on outer Easton Avenue in New Brunswick, New Jersey. Operations ceased there in 1955, and Tommy was transferred to a similar post in Kahuku, Oahu, of the Territory of Hawaii. At that QTH he acquired the KH6UK callsign and relinquished the W2UK callsign for a few years. It seems that in the early 1960s, he did reacquire the W2UK callsign, because according to *QST*[4] he made his historical 1296-MHz EME QSO with W1BU as W2UK/KH6. Yet according to Al Ward, W5LUA, who reports in the May/June 2007 issue of the North Texas Microwave Society's newsletter "Feedpoint," Tommy made the QSO as KH6UK. More on his EME exploits follows below.

Tommy's transfer to Hawaii might have seemed a setback for others due to the limited opportunities to make contacts on the VHF-plus frequencies. For Tommy, it proved to be a new challenge.

Contacting VHF enthusiast John Chambers, W6NLZ, Tommy set about duplicating his feat with Paul, this time between Hawaii and California. Knowing little about the actual propagation mode of meteor scatter (that being the ionization of the *E*-layer and its characteristic limitations on distance to approximately 1300 miles), Tommy assumed that there was no reason why he could not complete a QSO with John.

It would be two years of 20-meter skeds before they made contact. Oddly enough, the QSO took place on July 8, 1957. Coincidentally, the contact took place "at virtually the same time a massive meteor flared in the Hawaiian skies."[5] This coincidence led Tommy and John to believe that their contact could have occurred as a result of meteor-scatter propagation. Even so, they also thought that it might have been a freak atmospheric effect.

Setting out to determine what might have been the cause of the successful contact, they started making skeds on 220 and 432 MHz. It would be nearly two more years, on June 22, 1959, before they completed a contact on 220 MHz. John reported that he did hear Tommy on 432 MHz; Tommy heard nothing. It was later determined that a receiver problem on the Hawaii end probably prevented a two-way QSO.[6] Incidentally, their 220-MHz QSO has never been bested, thereby making it the first tropospheric contact on that band, and the longest lasting VHF DX record to date.

For their accomplishments, they won 1960 ARRL Merit Award and the 1961 Edison Award. For the latter, each received a trophy and split a $500 cash award.[7]

Not much is known about Tommy subsequent to his EME accomplishments in the 1960s. He is in the record books for having made contact with W1BU via 1296 MHz on July 31, 1964.[8] It appears that after his retirement from RCA he moved back to New Jersey, settling in Farmingdale.

Concerning Tommy's VHF-plus accomplishments, Mark wrote: "As for the Hawaii to California contact, they made the attempt a number of times and just happened to get the call through.

"He also had performed some moonbounce in his experiments. When I asked why try to bounce a signal off the moon, his answer was pretty much 'because it was there.' It was not the best reflector, but its position in the sky was pretty easy to track."

Mark added:

I'm not sure where Ralph was at the time, but I believe it was Hawaii. Ralph answered the door and there was a truck driver with a big dish on it. "For me?" was his question. Yes, it appears RCA thought he might like a bigger antenna to play with. When he moved, the antenna stayed put! Some of his tubes came from the Varian brothers, who thought he might like some extra power to play with.

Tommy became a Silent Key on May 8, 1996. Commenting on Tommy's death, Mark stated:

I'm not sure why, but even members of his family learned of his death after the fact. His equipment may have been donated to friends or the local Ham Club. I don't even know where his logbooks ended up. To my knowledge, he only lived in two towns in NJ in the years before his death, Colts Neck and Farmingdale.

In my e-mail exchanges with Mark, he advised me, "Years before Ralph's death I visited him in New Jersey and surprised him with the information that I was now a Ham. We chatted about some of his accomplishments and so on. We talked about his providing weather reports for Howard Hughes's round the world flight. He was quite a good friend of Howard it seemed."

I am deeply indebted to Mark for supplying me with text of the two New Jersey newspaper articles. Making contact with Mark has been a wonderful window into Tommy's life.

Ironically, as I mentioned above, at the time I first started my investigation for this piece Mark had made a note on Tommy's listing on QRZ.com about Tommy being a Silent Key, which opened the door to contact him via Fred Lloyd's assistance. Unfortunately, that note has disappeared with the reassignment of Tommy's KH6UK callsign to Douglas M. MacDowell of Belleview, Washington this past March. Tommy's W2UK callsign was reassigned to Joseph Fernandez of Teaneck, New Jersey this past February. Such are the effects of the vanity callsign program.

Here is the story of how Mark ended up in Hawaii approximately 48 years after his uncle had relocated there.

Mark's initial e-mail intrigued me because he began it by writing, "Aloha Joe." Who else but someone living in Hawaii would greet someone with the word "aloha"?

It turns out that after an initial vacation trip to Hawaii in 2002, Mark decided to return there for good. He has become a Kona coffee farmer and lives on the big island of Hawaii. His QTH is Captain Cook, which is a two-hour drive from Pahoa, which is the QTH of Paul Lieb, KH6HME, who is the Hawaiian side contact for the potential 10-GHz QSO. What an incredibly small world we have! For more information on Mark, please see his website: <http://myhawaiiansite.com>.

I have forwarded Paul's phone numbers to Mark and will leave it up to them to make contact with one another. Hopefully, the nephew of the pioneer of the California to Hawaii duct might possibly be a witness to another pioneer set yet another record between California and Hawaii.

My September 2005 piece on Tommy Thomas, W2UK, resonated with three hams—Bud Weisberg, K2YOF, Dennis Kopecky, WJ2R, and Van Field, W2OQI—who had their personal recollections. While Bud gave me some insight into Tommy's switching between the calls KH6UK and W2UK, Dennis and Van wrote reflections from their having actually known Tommy. What follows are their comments.

Dennis, WJ2R, wrote:

I really enjoyed the Tommy Thomas article in September *CQ* magazine, and as requested I have a bit of a memory on Tommy that wasn't mentioned.

I had just gotten my ham license in March 1964 (effective the 17th, St. Paddy's Day), and begun my subscription to *QST*, after reading sporadic copies that came my way, either through the junior high school library (oh, thank God, for that nasty old lady) or from various ham friends.

Anyway, I had already gotten to work 2 meters AM with a Gonset II and was encouraged to go over to the ARRL National Convention at the New York Hilton, in August, by my "new" friends I was meeting on those frequencies.

I remember riding up the elevator to the ballroom with Tommy, and remember all the adulation he was graciously receiving as the very nice guy he was. I remember the badge showing the KH6UK call, and I'm not sure if he also had something on as W2UK. The ARRL Nationals, judging from what I saw there, had to be the "Dayton" of that day and age, the gathering of the many and the mighty!

The conversations by those riding on the elevator with me seemed to be welcoming him back to New Jersey and inquiring about whether he was here to stay. So, I could only assume, being the wide-eyed teenager for whom this was all new, that he was some sort of notabl, and well regarded. I remember him as a nice guy, shorter than me, and balding, upper middle-age, who for some reason I always wondered about all the years after, what became of him, and of course, learning later on, of his accomplishments.

I never worked him or heard him on the air, as this was easily possible from my Linden, NJ, QTH then and now. But at least now we can know that one of his activities during that rather sparsely known period was to go to that event. Whether he was a speaker at one of the various presentations or forums, I don't remember; I don't know whether I saved the program or not, or if it would still be around here. Maybe some more research in *QST* would have included program highlights in the issues preceding the convention.

About the only other speculation I have of Tommy was that living in the Colts Neck area, he had to be acquainted with Carl Scheidler, W2AZL—another one of our VHF pioneers with his widely built and known AZL converter for 2 meters—if the two of them were ever to discuss 2 meters and VHF in general! I think Carl worked for the Bell Labs facili-

ty over there in Holmdel, and when I did finally meet him at his QTH, I was surprised that his station was just a modest, average looking one with an average amount of equipment, and compared to some of the stations now on the covers of *CQ* would have paled by comparison.

I was privileged to meet W2AZL through Ron Todd, K3FR (then WA2JAM), who also designed and built his own converter, which later appeared in *73 Magazine*. I would think Ron's mentor was W2AZL, which is why I think Ronnie made it a point to meet up with and be friendly with Carl.

Ron and I, and his cousins, who were not hams, met at Drexel University (Institute of Technology back then; I was in the last graduating class of DIT; next year, it was DU!). Ron's father, W2UM, (SK, mid '70s) worked at RCA in Somerville, and I can't help thinking, with a call as close to Tommy's, that they too had been acquainted, maybe even having taken the tests together. Perhaps Ron would have some memories of things his father, Paul, might have said along the way that referred to Tommy. Or you could maybe pick Ronnie's brain for a future article on Carl. I know Ron and I had also talked about VK3ATN's work, with moonbounce from Australia, and we were both members of W3MGF, Drexel's ham radio club. At that time, I was WB2MXZ, and I haven't talked to Ron since maybe the time when his father passed on.

The sad part about it today is that with all the FM and repeater work, sure there are plenty of stations on those frequencies, but so few of us are around who would consider or are working with experimenting with the other modes and propagation. It's going to be left to the commercial interests soon, and there's so much fun to be had if people would realize that there is life after the repeater!

There are a number of us here in NJ who are actively refurbishing any of the old Gonsets and Cleggs we can find, and some schedules are being set up once they are up and running. I can count 13 of us in various stages of keeping these antiques active, and more are in the thinking about it process. Whether any of us ever gets to build some of the old circuits anymore, with all these all-mode rigs available, remains to be seen, but at least some of us remember how it once was.

That ARRL convention was a real eye opener, as I probably brushed elbows with Ed Tilton, W1HDQ, a tall, thin, bespeckled gentleman, and didn't even know why I should be happy to get to meet him. And then there was Leo Meyerson, WØGFQ, cigar in mouth, in person, hawking his World Radio gear from all the catalogs I had read, for the days when I'd set up my own station. Of course Heathkit was there, and what a brilliant idea the Heath Monitor Scope was; you could see where there was a station on the band and you could pounce on if you liked! Gus Browning, W4BPD, might have even been there, as I remember Collins pushing his exploits with its equipment.

Ah, those were such "Good Old Days," "Golden Years" in ham radio. Hope you enjoyed this walk down memory lane.

Van, W2OQI, wrote:

Your piece on W2UK sort of rang a bell when I saw it. His VHF-UHF operation from Hawaii was sort of a second career in the spotlight. I knew Tommy when I was a teenager. I also used to meet him for an RCA get-together in Riverhead a few years before he went SK.

He lived in Quogue on Montauk Highway. The wooded lot west of his house was used to hold the rhombics he used to keep in contact with Howard Hughes on his round-the-globe flight. They had a commercial license for that.

He won the DX contest in 1937 and 1938, the only person to win two years in a row back then. Eimac or maybe Taylor used his feat as an ad with his rig in *QST*.

Also in Quogue were resort hotels. One was run by my father (later W2PDU). He knew Tommy because Tommy married his head waitress. By the way, Tommy arranged for my first job interview!

I guess all this goes under the heading of trivia. Tommy liked to do things that others didn't bother to try I guess. I imagine his VHF operations were inspired by Gil Wickizer, W2DOG, another engineer at RCA in Riverhead. He wrote several papers on VHF-UHF propagation for RCAC.

While this piece has not covered all of Tommy's life, it does address some of the highlights of this important pioneer of the VHF-plus ham bands. *(Also see the article "The Lost Letters of KH6UK, Part 1, by WA2VVA, on page 16 of this issue.)* Compiling and writing this article was a labor of love—love for the hobby and love for the preservation of its history. I am deeply indebted to those who assisted me in my efforts. Thank you for playing a part in bringing to print our wonderful history so that future pioneers in our hobby can emulate and make contributions to its ongoing success.

Notes

1. <http://www.infoage.org/p-43W2uk.html>)
2. *QST*, February 1953, p. 65.
3. *QST*, October 1956, p. 62.
4. *QST*, September 1964, p.e 96.
5. *The Sunday Home News*, New Brunswick, NJ, Sunday August 4, 1957.
6. *QST*, September 1960, p. 78.
7. *The Home News*, January 21, 1961.
8. *QST*, September 1964, p. 96.

By Bill Brown,* WB8ELK

UP IN THE AIR

New Heights for Amateur Radio

The View from the Edge of Space

Twenty years ago, I watched a video of Joe Kittinger parachuting out of a Project Man-High research balloon from 103,000 feet above the Earth. The view was incredible. You could see the curvature of the Earth and the blackness of space. The ride he took back to the ground was just plain amazing, and he was falling so fast he nearly broke the sound barrier.

This inspired in me the strong desire to visit the edge of space (also called Near Space), and it dawned on me that there had to be a lower cost and much safer way of experiencing this. At the time I was very active with Amateur Television, so I figured I could send a live TV camera to the very edge of space and back again using a weather balloon. From 100,000-plus feet, I could see what Joe Kittinger had seen, but I could do this by watching the view on my TV set in the comfort of my ham shack.

My first flight was on August 15, 1987 from Findlay, Ohio and carried a 1-watt ATV transmitter and a 50-milliwatt 2-meter FM transmitter. At peak altitude the low-power ATV and 2-meter signals were copied beautifully in Chicago, some 250 miles away. As those who have ever tried mountaintopping can attest, antenna height is everything!

You can see 400 miles in all directions from a balloon at 100,000 feet. The first time I sent a film camera up on a balloon, I anxiously took the film to be developed. When I went to get my processed film from the photo shop, the fellow who worked there asked me, "How'd you take these photos; are you an astronaut?" With a view like this, just imagine what kind of coverage you can get with a balloon-borne VHF or UHF repeater. Contacts between hams over 700 miles apart have been made this way, often using nothing more than HTs on the ground. How's that for a wide-coverage repeater? Just think of the emergency communications possibilities; one balloon payload can cover an entire Katrina-size disaster area.

ARHAB

Since 1987 I've flown over 200 balloons from 19 states. In addition, quite a number of balloon groups from across the country have popped up over the years. Called ARHAB (Amateur Radio High Altitude Ballooning), this is a great way to put some new excitement into amateur radio and combine the best elements of specialized digital and video modes (APRS, CW, PSK31, RTTY, and ATV), homebrewing (build your very own satellite), ground and mobile tracking station design, and of course, the ultimate in foxhunting challenges. It's an exciting way to attract newcomers into ham radio, particularly among the young people, where the Internet, webcams, and cell-phone text messaging compete with amateur radio. Let them know that they can build, track, and recover their very own satellite and this definitely captures their interest. Many of the young engineering students who participated in the local university's BalloonSat course got their amateur radio licenses strictly for the balloon flights.

*12536 T 77, Findlay, OH 45840
e-mail: <wb8elk@aol.com>

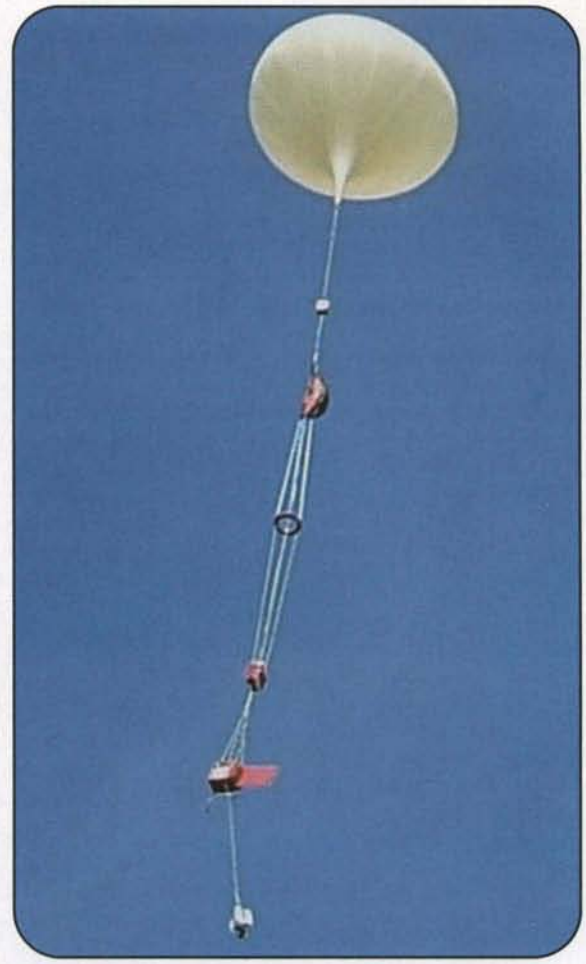


Photo A. A typical BalloonSat flight system. (Photos courtesy of the author)

Once they saw how exciting ham radio can be, they went on to become active members of our local radio club.

The BalloonSat

A typical balloon flight consists of a latex weather balloon and a parachute with the experiments dangling below (see Photo A). Dubbed a BalloonSat, they quite literally are very low-cost satellites that you can fly right to the very edge of space for hundreds, instead of millions, of dollars.

Up to 12 pounds can be flown under FAA rules (no more than 6 pounds in any payload). Most groups adhere to this rule, but some of the larger groups, universities, and government agencies do fly much larger experiments, which require a waiver from the FAA.

The typical ARHAB mission takes about 90 minutes to reach 100,000 feet. At that point the balloon has expanded to its max-

imum size due to the near vacuum environment and bursts. The parachute inflates and brings down the experiment to a gentle landing place some distance away from the launch site, usually taking about 40 minutes. Fortunately, we now have prediction software that allows us to use FAA winds aloft data and forecast the landing zone fairly precisely.

The Chase

Part of the fun is chasing the balloon and recovering the payload. There are a number of amateur radio operators who will jump at the chance to tromp through the woods, climb mountains, or hike across fields to find these experiments once they've landed. A balloon chase basically is a foxhunt on steroids, with the added challenge that no one quite knows exactly where the transmitter will land. Most balloon trackers have APRS and a laptop with a mapping program that plots the balloon's position in real-time, and some just rely on good, old-fashioned direction-finding techniques, which often are needed if the primary APRS transmitter fails (see Photos B and C).

Live on the Internet

You can actually participate in a BalloonSat flight from your home computer. Those flights that carry APRS on board will link up directly to <www.findu.com> and also <www.aprsworld.net> in near real-time on a moving map display thanks to a network of APRS Internet gateway stations. You can see the altitude, course, and speed during the mission.

For those interested in participating in a flight, there a number of websites to help get you started:

http://www.arhab.org: There are now so many balloon groups that fly each weekend that you likely can find a flight nearby. The ARHAB website is a wealth of information that includes launch announcements and details of flights worldwide. Web links to many balloon groups are also listed, in addition to a Balloon Records page. There is even an annual contest for a variety of categories relating to amateur radio ballooning. This year's categories are: Highest Altitude, Longest Flight Time, Longest Downrange travel, Greatest Telemetry Reception Range of a balloon's signal (VHF/UHF and HF), and the Greatest Distance Two-Way radio contact using a balloon as a repeater relay.

http://www.eoss.org: The website of one of the largest balloon groups based in Colorado, this site is a wealth of information on getting started in high-altitude ballooning. Check out the links for FAA regulations concerning balloon payloads and download Balloon Track from the software section to help plan your very own flight.

http://www.nearspaceventures.com: This website has a link called "Web Based Balloon Track," which is a very useful tool to help predict your balloon's flight path plotted on a Google map. The Near Space Ventures group is based near the Kansas City area and does a number of flights involving the Civil Air Patrol and Boy Scouts.

http://www.superlaunch.org: This is the website for our annual high-altitude ballooning conference, called the Great Plains Super Launch. Typically held in Nebraska, Iowa, or Kansas, each summer balloon groups from across the nation attend this event for a day-long conference to share payload ideas as well as launch and recovery techniques. The next morning they hold the Super Launch, where ten or more balloons are launched at once. It's an amazing sight to behold, and chasing

Photo B. The KBØYRZ balloon chase mobile. Left to right: Joe Lynch, N6CL; Jim Harper, KCØSHZ; Mark Garrett, KA9SZX; and Chris Krengel, KBØYRZ.

ten balloons is an experience that is not soon forgotten. This year's event will be held on July 6–8 in Grand Island, Nebraska.

http://www.wb8elk.com: This site has launch announcements for my flights, which typically are flown from the southeastern states. In addition, details on the upcoming 20th anniversary of ARHAB celebration in Findlay, Ohio can be found. This event will be a Super Launch to commemorate the 20th anniversary of my first flight and will be held on the morning of August 11th.

In addition, there are a number of Yahoo discussion groups pertaining to ARHAB flights. Check on the ARHAB links section of <www.arhab.org> for a list of these. One great place to start that will get you in touch with some very experienced high-altitude balloon folks is <GPSL@yahoogroups.com>.

In future columns, I plan to feature balloon groups from around the world and cover ways to take amateur radio to new heights using weather balloons, hot-air balloons, radio-control airplanes, kites, and even rockets. 73, Bill, WB8ELK

Photo C. Recovering the WB8ELK ATV payload from a field of Iowa corn. Left to right: Mark Garrett, KA9SZX; Paul Verhage, KD4STH; and Jim Harper, KCØSHZ.

By Del Schier,* K1UHF

AIRBORNE RADIO

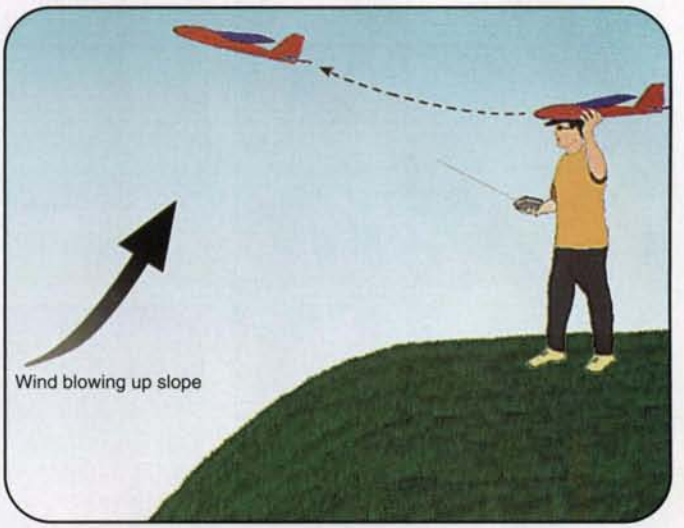
Using Amateur Radio to Control Model Aircraft

Motorless Flight

Perhaps the most enjoyable way to fly is without a motor, whether it is a full-size glider that you can fly in or a model that you fly from the ground. This month's column is a quick overview of RC (radio-control) soaring—how it is done and the necessary equipment.

Gliders are the simplest form of aircraft. They also have many advantages over more complicated types. They are less expensive, easier to build, and more reliable. In general, they also are easier to fly. However, the skill it takes to keep an aircraft such as this in the air without a motor is an endless challenge.

Personally, I find soaring fascinating, a challenge similar to using unusual radio propagation for working DX on VHF and above. You will never be bored with our infinitely changing atmosphere! Both flying and radio propagation are highly dependent on the atmosphere.



The basic slope launch. (Photos courtesy of the author)

Two Forms of Soaring

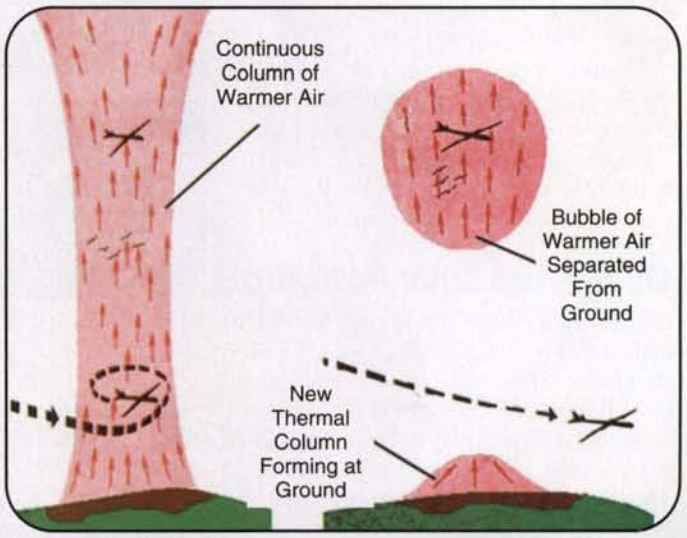
There are two basic forms of soaring— slope soaring and thermal soaring. The term *soaring* refers to keeping a glider aloft longer than it would remain in still air, which is the whole point of flying a glider. Wikipedia® defines soaring as a mode of flight in which height is gained slowly by using air that is moving upwards.

Slope soaring is simply flying in air that is being displaced upwards by some obstacle to the air flow, such as a hill or cliff. When horizontal air flow (wind) hits the side of a hill, it has no way to go but up. If the vertical component of this upward flow exceeds the rate at which the glider descends, you can stay aloft.

It sounds simple, but finding a good place to slope soar requires a variety of factors, such as the wind speed and direction, the shape of the hill and also the amount of turbulence in the air. The ideal hill would have a wide expanse of steep, but not vertical, slope with wind hitting it directly at a perfect 90 degrees. You will never find this perfect slope. Therefore, making do with what you can find is what makes it interesting. It is important that the wind hits the hill without being disturbed by some obstruction in front of the hill. Cliffs along lakes and oceans are ideal, especially if they face the prevailing wind. Depending on where you live, there may or may not be a good place for this type of soaring. I drive to Cape Cod, Massachusetts and have flown at the Marconi site and also at Mt. Greylock, both of which are excellent VHF operating locations.

To fly in slope lift, also known as slope soaring or ridge soaring, you simply fly back and forth in front of the ridge where the lift is best. This sounds simple, but it requires some finesse and an understanding of how the lift is formed by the wind hitting the slope.

The other type of soaring, which is much different and more challenging, is thermal soaring. Thermals are convective updrafts—air that is warmer than the surrounding air and therefore less dense, lighter, and more buoyant than what naturally rises. Thermals can occur anywhere. Any time the surface of the land is heated by the sun, it causes the air to heat unevenly and produce thermal updrafts when it becomes buoyant enough to lift.



Pictorial of a column thermal and a bubble.

Weather conditions play a major factor in the formation of thermals and are best when the air is convective—that is, colder in temperature and higher in altitude. The worst condition for thermal activity (meaning *no* thermal activity) is when there is a temperature inversion. If you are a VHF DXer and RC glider pilot, there is no conflict of hobbies. You can work VHF openings with temperature inversions and go soaring with the

*e-mail: <k1uhf@westmountainradio.com>

A discus hand launch.

Two-man tow for a competition event.

Launching a big glider on a tow.

opposite weather conditions. I am kind of kidding, but it is true!

Finding thermals can be like searching for the Holy Grail; they are invisible and it almost requires a sixth sense to find them. Actually, a pilot skilled in thermal conditions will have no trouble if the air is unstable and the sun is shining.

Gliders are Solar Powered

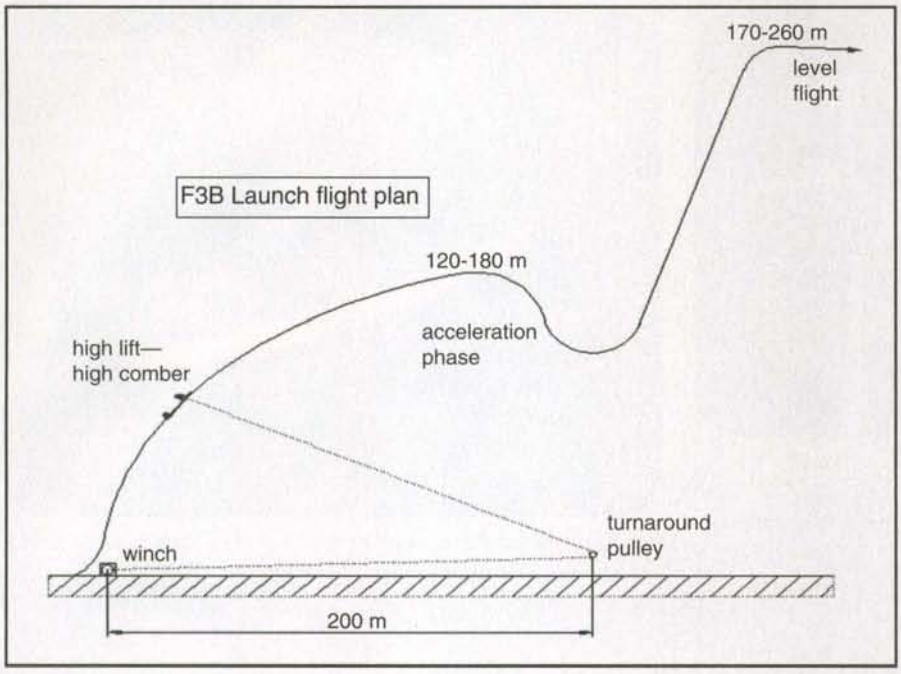
The sun's energy causes air to move and causes convection; therefore, a glider is solar powered. Periodic wind gusts indicate thermal activity, as the air surrounding a lifting body of air moves in to fill the void left by the thermal updraft. The closest thing to visualizing a thermal is to watch a pot of boiling water. Bubbles form on the bottom of the pot and then rise when enough buoyancy is achieved. Thermals on a very convective day are like a rolling boil; the air is lifting vigorously everywhere.

To fly in a thermal you must use all of your senses and carefully monitor the glider. The turbulent boundary layer around the lifting bubble of air will cause the glider to move and shake as it passes through that layer. When the glider hits the thermal, it will pitch up or lift a wing. If the left wing lifts, you turn left into the lift and start circling. You fly in careful circles, adjusting the turn to center on the strongest part of the lift while flying the speed and circle diameter that gives the maximum rate of climb. Any wind causes a thermal to tilt and drift with the wind. Therefore, your glider's circles must also follow the tilt and the thermal's bubble or rising column of air.

Launching the Glider

Okay, how do we launch the glider into the air if we are going fly on the rising air currents? The simplest way is to throw the glider into the lift. For slope soaring it's easy: Just stand on the edge of the hill and throw the glider into the wind. Hand-launching works with thermals, but you have to be lucky and skilled to find a thermal before the glider is back on the ground.

For years model gliders have been launched by throwing them like a javelin. However, more recently hand-launched gliders are thrown like a discus. Special gliders are built to be thrown or launched like a discus. Discus- launch gliders have a throwing peg on one wing tip that allows holding the wing tip and spinning around to impart much more kinetic energy to the glider than a javelin throw. A good javelin launch might put the glider 30 feet in the air, but a discus launch can achieve over 100 feet in altitude. Either way, it is a challenge to throw to the maximum altitude and a bigger challenge to find a thermal before the glider is back on the ground.



FAI F3B competition-class electric winch system using a car starter motor.

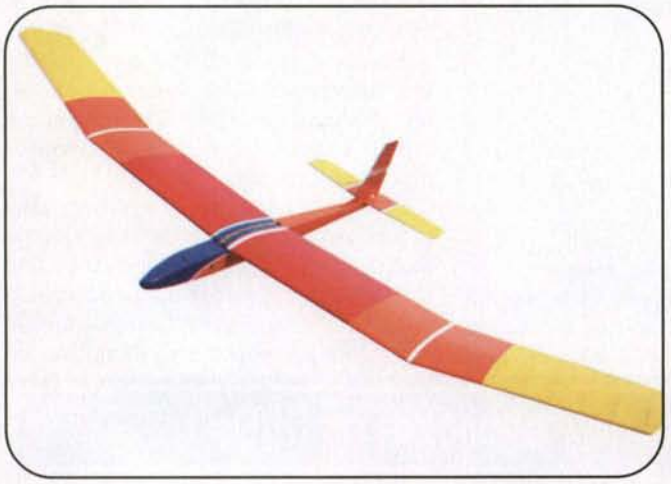
There are many other ways to launch a glider. A bungee launch uses surgical tubing or a bungee cord staked into the ground with a long cord attached to the glider end. The bungee-launch cord is stretched out to the appropriate tension by walking downwind. A ring is attached to the end of the cord and then hooked on a tow hook on the underside of the glider. The glider is released and catapults almost vertically into the air, eventually leveling out at the maximum height possible. This launch has to be done correctly or it can easily end in disaster, as you can well imagine.

Another way similar to the bungee launch is using an electric winch. This is usually a car starter motor with a drum of strong cord that goes several hundred feet to a pulley and back to the pilot and glider. The pilot steps on a switch and takes the tension out of the cord and with just the right timing releases the glider and modulates the power, thereby lofting the glider to several hundred feet in the air. Another way to launch a glider is two men run, pulling the glider into the air with a pulley system. Both the men pulling launch method and the electric winch system are used for FAI[1] (The Fédération Aéronautique Internationale) world-class competitions.

The purists may not like it, but today most sport fliers fly gliders with electric motors. The motor is used only for a few seconds to get to winch altitude and then it is shut off. An electric-launch sailplane has a folding propeller to minimize the

A homebrew winch.

A hollow molded 2-meter fiberglass and carbon Gabby-E, the newest addition to my fleet and another folding prop.



A simple rudder and elevator 2-meter glider, the "Gentle Lady."

A foam electric-launch training glider. Notice the folding prop.

drag. With the incredible efficiency and low weight of a brushless motor and lithium battery, there is very little penalty in performance flying an electric glider. Setting up any kind of bungee or other launch is a project and requires a lot of walking back and forth. Electric launches are simply a matter of having a charged battery and opening the throttle.

There is one more way to launch a sailplane—an aero tow. Just like full-size sailplanes, larger scale RC gliders are towed into the air by a scale tow plane. Of course, the simplest and most challenging way to fly is to just throw your glider into the air.

Varieties of RC Gliders

RC gliders, like all RC airplanes, come in a wide variety of styles. The simplest are rudder and elevator control only. A full-house sailplane has ailerons, flaps, spoilers, elevator and rudder, and perhaps even retractable landing gear and a tow hook. They come in all sizes up to 5-meter wingspans or more.

Model gliders perform better if they are bigger because of aerodynamic effects defined by something called *Reynolds numbers*. Wings are more efficient, and there is less drag and more lift if they are long and skinny (high aspect ratio). The construction of an RC glider might be balsa wood and covering, or foam, with the best construction being hollow molded fiberglass Kevlar™ and carbon fiber.

Finally . . .

Here is a bit of advice for the VHF operator who is also an RC glider enthusiast: Remember to stay home and operate your VHF-and-above station on those days with temperature inversions and fly your plane when there are cumulus clouds.

73, Del, K1UHF

Note

1. Founded in 1905, the FAI is a standard-setting and record-keeping body for aeronautics and astronautics. This includes man-carrying vehicles from ballons to spacecraft and unmanned vehicles such as model aircraft. It is also the international governing body for air sports. *(Courtesy Wikipedia)*

By Joe Moell,* KØOV

HOMING IN

Radio Direction Finding for Fun and Public Service

Computerized T-Hunting with Doppler RDF

Technology in the spy movies of the 1960s and 1970s has always given me a chuckle. The hero often had a sophisticated-looking screen on the dashboard of his sports car. It received transmissions from a "bumper beeper" transmitter on the bad guy's car and displayed his exact location on a moving map as the obligatory chase proceeded through the streets. The real radio-direction-finding (RDF) methods of the time didn't have nearly enough accuracy to pinpoint cars that way, but it made good fiction.

Twenty years ago, Bob Bruninga WB4APR, took the first step toward making this kind of spy tracking a reality when he wrote the Automatic Position Reporting System (APRS). It was an adaptation of a program he had previously written to map the growing network of packet BBS nodes. APRS displays the position and movement of stations that report their latitude and longitude. When inexpensive Global Positioning System (GPS) receivers with serial data output became available, APRS made instantaneous vehicle location practical for almost every ham.

Early GPS sets were insensitive battery hogs with quadrifilar helix antennas pointed toward the sky and single-channel receivers that took many minutes to acquire the Navstar satellites. Position errors with government-imposed "Selective Availability" often approached 300 feet. Today's multi-channel GPS receivers are far more sensitive and lock in much more quickly. With SA turned off and with aid from the new Wide Area Augmentation System, typical accuracy is now 25 feet or better.

In this decade, remote tracking using GPS has become so commonplace that young people can't remember when it didn't exist. GPS controls the movement of fleets of company vehicles and locates cellular callers to 911.[1] Parents can surreptitiously keep track of their teenage drivers almost as easily as the fictional spies of 40 years ago did of the bad guy.[2]

APRS RDF Networking

During the 1990s, WB4APR constantly devised novel applications for APRS, such as tracking high-altitude balloons, marathoners, emergency vehicles, Olympic torch runners, and even the ceremonial 128-mile game ball relay for the annual Army/Navy football game. Besides their coordinates, APRS stations can beacon their own weather data, DX reports, and RDF bearings for display on the screens of all other users within radio range.

Some transmitter hunters envisioned a time in the future when networked APRS triangulation would provide nearly instantaneous location of any signal of interest, including malicious interference, stuck transmitters, and spurious emissions.

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

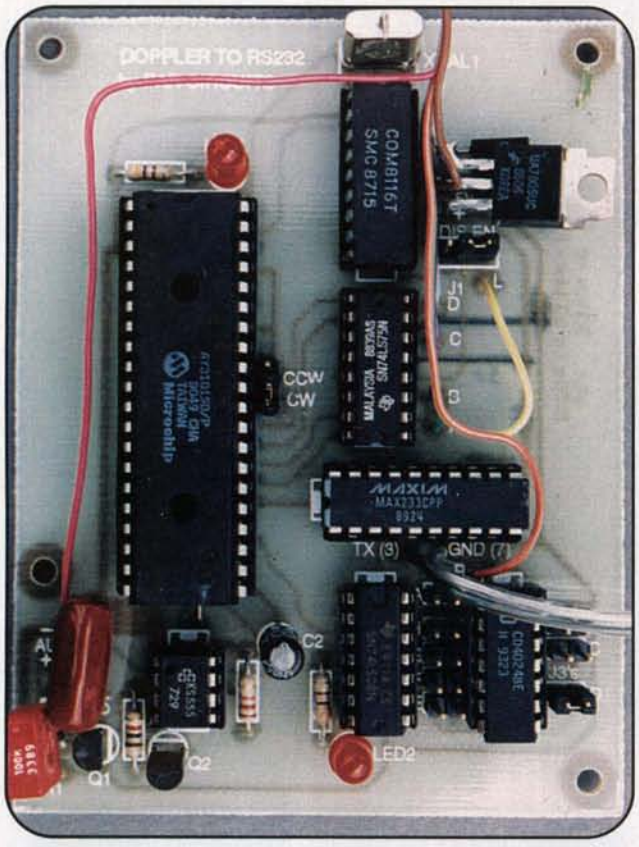
If there were "Thinking Outside the Box" awards, Bob Bruninga, WB4APR, would clearly be a winner. Bob pioneered remote-location technology in the 1980s and developed many novel uses for it. Here he gives an overview of APRS at the Tampa Bay Hamfest in Florida. (All photos and screen captures by Joe Moell, KØOV)

At first, all RDF entry was from the keyboard. Stations in strategic locations took accurate bearings relative to true north and typed them in. APRS automatically deleted them after two hours to prevent clutter on the network.

The next goal was to automate the process. The idea was that APRS terminals with Doppler RDF sets[3] would beacon their position and bearings with no manual entry. Unattended and attended base stations would assist mobiles driving to the target on cooperative searches.

At that time, only the relatively expensive Doppler Systems[4] RDF sets had serial bearing data output. Bob modified APRS to accept this format, which provided one-degree resolution. Next came a 3" × 4" interface board designed by Robert Swain, N7LUE (now KA4JSR).[5] It tapped into the 16-LED displays of affordable Doppler sets of the day, such as the Roanoke Doppler[6] and the Dick Smith Doppler[7]. APRS was upgraded to support this data format, but with only 22.5-degree resolution, it left a lot to be desired.

In 1995, the first commercial microprocessor-based Doppler RDF set appeared on the market, manufactured by Agrelo



Robert Swain designed this interface to connect classic 16-LED Doppler sets to computers running APRS. This one-of-16 data format is not supported by GPSS.

My original APRS-DOS mobile setup used this laptop to display the rudimentary maps of the time. The packet-relayed bearings from several base and mobile stations (represented by triangles) are converging in an area that is not well-mapped. The solid-line bearings indicate highest quality, while dashed or dotted lines indicate lower quality bearings.

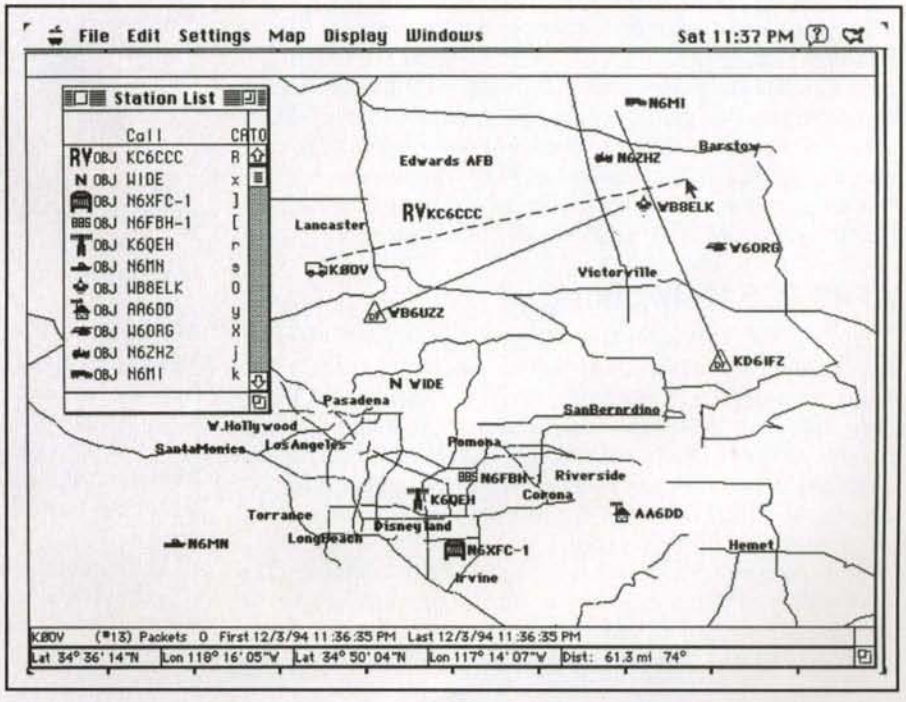
Engineering. Designed with APRS and other tracking networks in mind, the DFjr boasted an improved data-stream format that would support 0.1-degree bearing resolution, although the DFjr's stream was only capable of 1.4-degree resolution. Output bearings were averaged from 96 directional samples and were assigned quality numbers from 0 to 9, based on consistency of the samples.

At about $350 for the plug-and-play display unit and antenna set, the DFjr quickly attracted a large backlog of orders. Unable to fulfill them, Agrelo Engineering went out of business in 1998. Nevertheless, "Agrelo format" became the standard for serial Doppler bearing interfaces.

When WB4APR wrote APRS-DOS in QuickBasic, his biggest problem was the mapping. Commercial digitized map suppliers were insisting on royalties for every copy of every map. Therefore, Bob developed his own system. Anyone with patience could create his or her own maps for APRS, and many did. That was good, because APRS-DOS maps were small files that didn't clog the tiny hard drives of the day.

These simple maps were okay for rudimentary triangulation, but inadequate for street-level mobile navigation. The next step came in 1994, when Keith Sproul, WU2Z, wrote a Think-C version of APRS for 680x0 series Macintosh computers with help from his twin brother Mark, KB2ICI. Including the serial RDF bearing input feature was important to Keith, because he was Senior Technical Advisor to a college amateur radio club that was launching high-altitude balloon packages. He wanted an RDF backup to the onboard GPS telemetry.

MacAPRS took advantage of the mouse, multiple windows, and pull-



MacAPRS graphics were an improvement over those of APRS-DOS. The maps could be zoomed in to show individual streets, but the streets were not named.

down menus of the Macintosh. With an accompanying utility, MacAPRS users could create their own unlabeled street-level maps based on public USGS data. A version of APRS for Windows® by the Sprouls soon followed, with the same maps and automatic RDF features.

Fast Forward to 2007

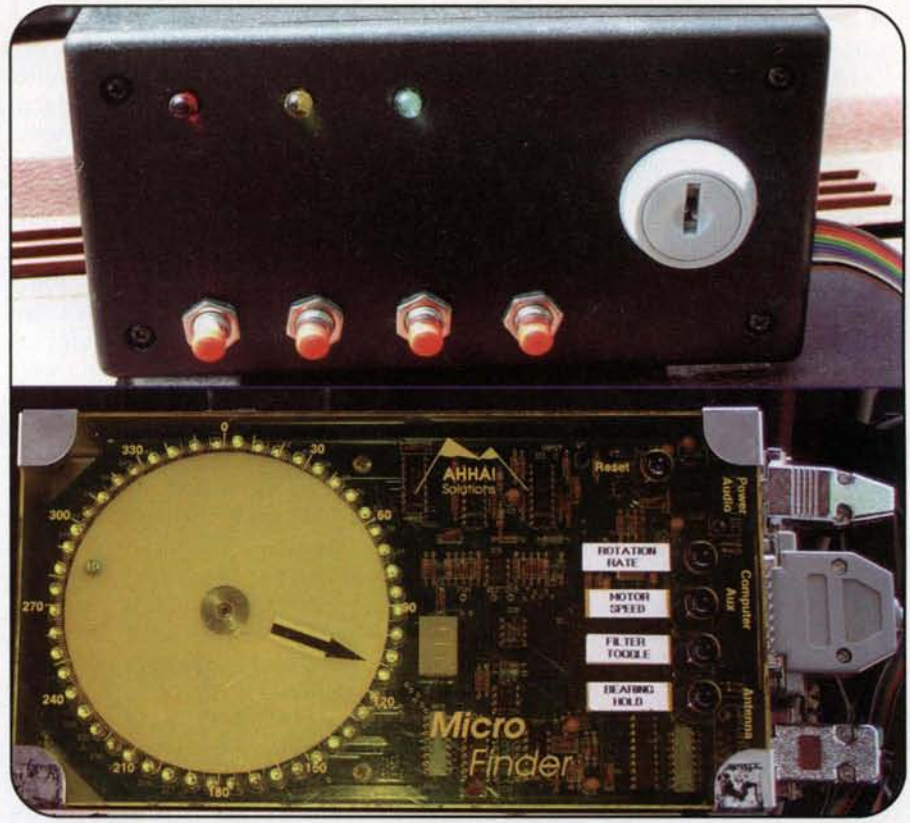
Detailed street-level map data and hard-disk space to store it now are readily available. New versions of APRS such as APRS-SA and Xastir have come along to take the place of APRS-DOS and MacAPRS. They don't include RDF interfaces, probably because there were very few hams who made use of them in the earlier programs.

There were technical problems with hands-off APRS RDF. Many hams couldn't get the Hardware Single Port system working to connect together the GPS, RDF, and packet Terminal Node Controller (TNC). The packet beaconing transmitter often caused QRM to the signal being tracked. It wasn't easy to automatically beacon RDF data only of the signal of interest without also beaconing false bearings of noise or other signals on the RDF frequency.

There were non-technical issues, too. Most mobile T-hunters don't want to divulge their positions and bearings when they are in competition. The APRS on-air network isn't secure, which makes it unsuitable for covert tracking of malicious interference. For balloon tracking, jammer-stalking, and search/rescue missions, when cooperation is important, most users have concluded that it is just as efficient and much more secure to exchange bearings via cell phone.

For almost all the mobile transmitter hunting that I do, precise navigation is more important than bearing networking. Thus, I have turned from APRS to GPSS[8], a navigation program by Robin Lovelock of Sunninghill, UK. Although GPSS was available back when Agrelo Engineering was in business, it was e-mail from two "Homing In" readers that got me thinking about it again.

GPSS is modular and easily adaptable to new features and technologies. Users can draw their own street-level maps or adapt aerial/satellite photos from the Internet, but it's usually easiest to just download the maps at Robin's site. He has them for dozens of countries. I found files of fully labeled street-level maps for 1×1-degree latitude/longitude rectangles throughout the states. Four of them cover all the territory where I do 90 percent of my mobile T-hunting.



There are 50 LEDs in the display ring of the MicroFinder Doppler set by AHHA! Solutions. I built the black box to house additional features that are supported by the firmware, including a heads-up left-right-center indicator and four additional soft-buttons for quick calibration and control of bearing output flow. The keyswitch prevents accidental changing of the calibration.

Like the APRS programs, GPSS must communicate with both the GPS receiver and the RDF set so that bearings are automatically displayed as vectors from vehicle positions along the roads. GPSS is easier to implement than APRS, because there is no TNC interface.

RDF sets with Agrelo-format serial output have features to combine the GPS and RDF data strings onto one RS-232 port at 4800 bps, but models are significantly different from one another. If you are picking a GPS set for use with Doppler RDF, make sure that it outputs NMEA-formatted GPS data over RS-232, not USB. I use the Magellan Gold. Of course the computer must have a RS-232 port, which is getting hard to find in new PCs.

GPSS supports separate computer ports for GPS and RDF, but this may introduce timing problems. Joe Bizzaro, WJ2B, and I recently corresponded about his attempt to use a USB-output GPS set with the DFjr and its RS-232 bearing stream. The differences in port rates led to bearing vectors being displayed from the wrong road positions. GPSS has provisions to delay RDF bearing data to accommodate delays within GPS sets, but not the other way around. WJ2B solved the problem by changing to a RS-232 output GPS set and using the data combining feature within the DFjr.

The DFjr has a GPS data input and intersperses GPS data with bearing data on its serial output. Unfortunately, the firmware is fixed such that bearings come out more than once per second and GPS data comes out every five seconds at the fastest. That's too much RDF data and not enough GPS data, so the PC screen gets cluttered with bearings. A partial solution is to set the GPSS-DF configuration file to require several tenths of a mile travel between accepted bearings. A hardware workaround would be to put a switch in the cable from DFjr to computer, to control the bearing flow. A SPDT switch is necessary, because when bearings are off, the

computer input must be switched directly to the GPS receiver for navigation.

Although I own a DFjr, I prefer the MicroFinder Doppler set from AHHA! Solutions, which has better GPS-DF combining. It passes almost all of the NMEA data for the most accurate vehicle tracking. Bearings in Agrelo format are interspersed at a rate programmed by the user, from every second to every 50 minutes. You can set a panel pushbutton to toggle the bearing stream on and off so that it's only on when a signal of interest is being tracked. You can program another button to send just one bearing when the stream is off, which is perfect for that moment when you crest a hill and the bearing is most free of multipath.

GPSS speaks periodically to tell where you are and the direction you're traveling. This voice output is handy when you are alone—just like having a navigator talking to you. If you already have a navigator or don't want the distraction, you can command the voice to stop the updates and only give critical messages. Conversely, you can give commands to GPSS by voice instead of keyboard if your computer supports voice recognition.

Too Many Destinations

If you allow it, GPSS will triangulate all your RDF bearings and display the most recent bearing intersection as a destination. Robin's voice will tell how far away you are from this destination and the relative direction to it, such as "Destination 3.5 miles at your 4 o'clock." With the configuration file, you can instruct GPSS not to triangulate bearings less than a given number of degrees apart and to suppress triangulated destinations more than a given distance away.

The automatic triangulation feature sounds great in theory, but it's practical only when you present GPSS a few carefully chosen bearings. If you just feed in the constant bearing stream from your Doppler, the normal variations in bearings due to vehicle motion and nearby signal reflections will result in close-in triangulations from successive bearings about 50 percent of the time. You will constantly hear a voice telling you that you're less than a mile away from the target, even if you're not. The screen maps will keep changing to display these bogus destinations.

I am now discussing ideas for improvements to the triangulation feature with Robin and some other GPSS RDF users. Perhaps a keyboard command to perform triangulation only when it is wanted would be a good fix. Watch for any changes on the RDF page of Robin's site. Meanwhile, I use an undocumented feature in the configuration file[9] to suppress all automatic triangulation when I'm not closing in.

In the close-up screen shot is a demonstration of how GPSS helps me circle in on the target. Proceeding east on Dorothy Lane, the bearing is to the left, so a turn north onto State College Boulevard seems appropriate. However, that isn't the shortest way to the transmitter. GPSS draws bearings as I correct by turning east onto Yorba Linda Boulevard, go under the 57 freeway, turn south on Placentia Avenue, and west on Nutwood Avenue. From all the bearing crosses, it's clear at that point that the target is in the parking lot just west of Campus Drive, which is where I go. The most recent bearing is white. Previous bearings are shades of yellow, the darkest are oldest.

GPSS has additional navigation features, such as an "instrument panel." It is capable of auto-routing and turn-by-turn directions to destinations, but this requires much more detailed mapping than supplied on Robin's site. I already have a Garmin StreetPilot® on the dashboard to give directions, so I use that for vehicle navigation and let GPSS concentrate on RDF tasks.

GPSS may be used for non-commercial purposes at no charge. It is fully functional once downloaded and installed, but an annoying "This software is unregistered!" banner appears regularly. Robin will provide a free banner-killing one-computer key code, good for six months and probably renewable, if you answer his online questionnaire. You have the option of buying a permanent key code, linked to your name and good on any PC, for 20 GBP (about US$40).

After more than a decade of support, Robin remains very responsive to his GPSS users. I discovered that GPSS wouldn't respond to tenth-degree resolution bearing data from the MicroFinder, which apparently had not been a problem on slower computers in the past. Robin found the bug, fixed it, and posted an updated GPSS version within 24 hours.

MicroFinder detects second-harmonic level in the induced Doppler audio tone to determine quality of bearings, which is more effective than the DFjr's statistical method. Low-quality bearings are suppressed from showing on the LED ring by two levels of optional digital filtering. You can also program in a minimum-quality threshold for bearings to be sent out to GPSS (e.g., only 7 or higher). MicroFinder was supplied as a kit without antennas and antenna switcher, but it supports a wide variety of antenna systems from three to eight elements, including my wide-range Roanoke switcher.[10] If you want one today, you will have to scour the flea markets and auction sites.

Last Call for USA's 2007 ARDF Championships

As this issue arrives in your mailbox, it's not too late to register for the Seventh USA Championships of Amateur Radio Direction Finding (ARDF), which are scheduled for September 14 through 16 at South Lake Tahoe, in the Sierra Mountains near the border between California and Nevada. Beginners and experts at on-foot radio-orienteering will test their skills and learn from one another. Some may win positions on ARDF Team USA for the next World Championships in 2008.

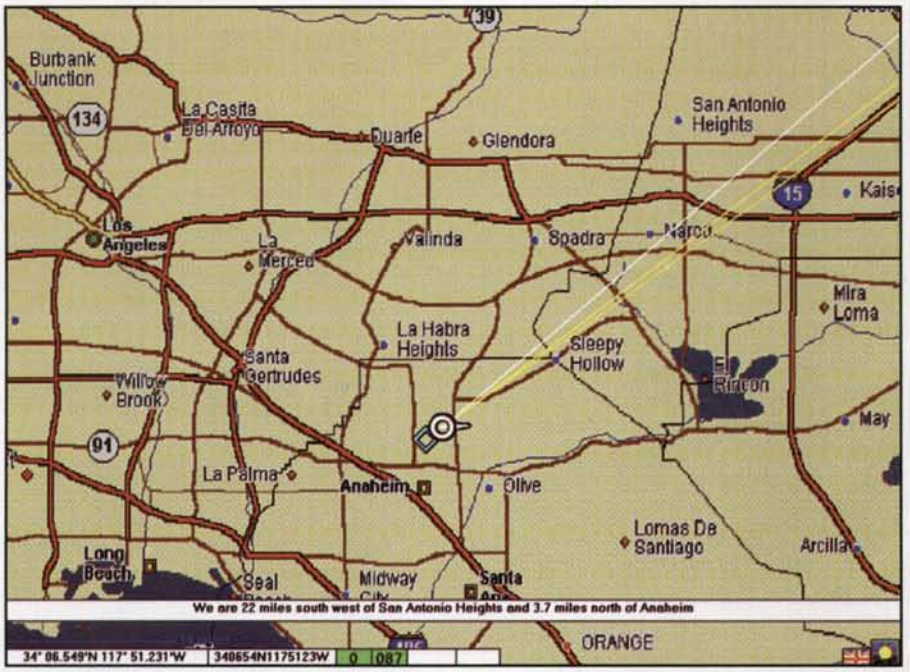
Santa Barbara Amateur Radio Club and Los Angeles Orienteering Club are joining together to present the 2007 USA Championships. As in recent odd-numbered years, our national championships are being combined with the ARDF championships for International Amateur Radio Union (IARU) Region 2, encompassing North and South America.

The 2-meter and 80-meter ARDF courses will be open to all, beginner and expert alike. Event headquarters will be at Camp Concord in the El Dorado National Forest. An inexpensive package including two nights of lodging in the rustic cabins and five meals is being offered to event registrants. There are other lodging and dining options nearby.

National ARDF Championships are for individuals only. No teaming or assistance on the course is permitted. Participants are divided into five age categories for males and four age categories for females in accordance with standard IARU rules. Medals for first, second, and third place will be awarded in each category.

As this issue goes to press, plans for the championships are going ahead, despite the June wildfires in the South Lake Tahoe area. The latest information and registration forms, plus photos of accommodations at Camp Concord, can be found at <www.homingin.com>. There you will also find lots more about the international sport of ARDF.

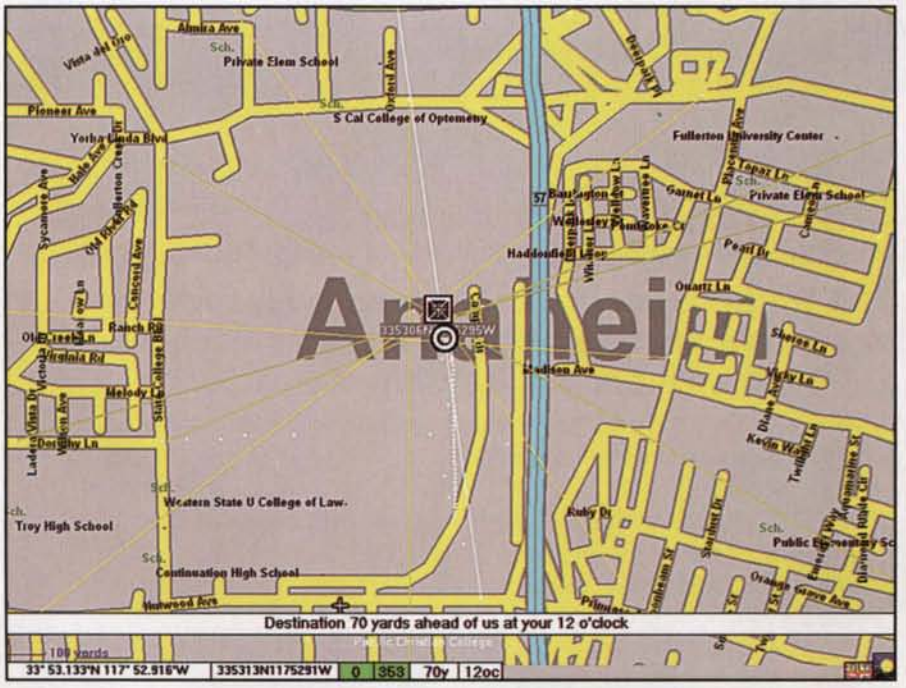
Joe Moell, KØOV
ARRL ARDF Coordinator



As I drive away from the hilltop starting point on a transmitter hunt, this wide-area GPSS map helps me determine where I might be headed. Because there are normal variations in successive Doppler bearings, I have turned off automatic triangulation to keep bogus destinations from being displayed.

They are no longer sold new in kit form, but a working used one would be a worthwhile purchase.

Three currently available Doppler set designs provide bearing data in Agrelo format: PicoDopp by Bob Simmons, WB6EYV[11], DSP-RDF by Dan Welch, W6DFW[12], and the Montreal Doppler 3v2 by Jacques Brodeur, VE2EMM[13]. Each of them has provisions to combine



Close-in GPSS triangulation to a hidden transmitter in a university parking lot. The trail of closely spaced white-dot "breadcrumbs" shows the most recent vehicle movement. The large circle is the current vehicle position. The "Anaheim" label is a USGS mapping error, because this institution is actually in Fullerton, just north of Anaheim.

RDF and GPS data onto one 4800-bps RS-232 port for GPSS, but there are differences in how the GPS data is handled within the RDF sets. Watch for more on these sets in future "Homing In" columns.

GPSS automatically adds the relative RDF bearing to the vehicle heading to display bearings relative to true north. If your RDF set outputs a true-north-referenced bearing already, you can tweak GPSS to accept that.

Safety First

When you experiment with mobile computer mapping and tracking, keep safety in mind at all times. Have solid mounts for your computer, GPS, and RDF gear so they can't fly about. Minimize distractions and pay full attention to the road while driving. Get a helper to handle the computer and RDF gear when you drive, or get someone else to drive so you can concentrate on the RDF task. Carefully check your cable wiring to prevent expensive damage to RS-232 hardware.

GPSS can be operated in a simulation mode without serial GPS and RDF data input. RDF station locations are entered by mouse right-click and true bearings are entered by keyboard. In this mode, a network of base stations could gather bearings from one another and triangulate them to estimate the location of an unknown signal. Bear in mind, however, that mapping programs such as GPSS and APRS assume a flat Earth. This won't cause significant triangulation errors on local VHF T-Hunts, but it won't do for pinpointing signal sources on the HF bands from locations that are hundreds of miles apart. That would require an advanced program that performs spherical triangulation.

If you are using a computer to automatically display bearings when mobile, whether with a Doppler or another type of RDF setup, I would like to hear from you. Let me know how well your system works, what you like, and what improvements you would like. Also, if you have not already done so, be sure to send me a report of your activities during the CQ Worldwide Foxhunting Weekend last May. Happy hunting! 73, Joe, KØOV

Notes

1. Verizon and Sprint mobile networks use GPS receivers in users' phones to report location when they call 911. More on enhanced 911 locating systems for wireless networks is in "Homing In" in the Winter 2007 issue of *CQ VHF*.

2. <http://www.gpsglobalstar.com/sub_main.php?selection=whatdt>

3. See "Homing In" in the Spring 2004 issue of *CQ VHF* for tips on optimizing performance of the DFjr and other Doppler RDF sets.

4. <http://www.dopsys.com/>

5. Moell, Joe, "HOMING IN: APRS Puts Doppler Bearings on the Map," *73 Magazine*, August 1995.

6. Complete plans in "Transmitter Hunting—Radio Direction Finding Simplified" by Moell and Curlee. Information on this book and Roanoke Doppler antenna system improvements are at <www.homingin.com>.

7. Information on the Dick Smith RDF set and improvements are at <http://members.aol.com/homingin/DSEfix.html>

8. <http://www.gpss.tripoduk.com/>

9. Set the first line of GPSSDF.CFG file to -9999.0.

10. <http://members.aol.com/homingin/newdopant2.html>

11. <http://www.silcom.com/~pelican2/PicoDopp/PICODOPP.htm>

12. <http://www.byonics.com/dsp-rdf/>

13. <http://www.qsl.net/ve2emm/pic-projects/doppler3/doppler3-e.html>

QUARTERLY CALENDAR OF EVENTS

Current Contests

August: There are two important contests this month. The **ARRL UHF and Above Contest** is scheduled for August 4–5. The first weekend of the **ARRL 10 GHz and Above Cumulative Contest** is August 18–19.

September: The **ARRL September VHF QSO Party** is September 8–10. The second weekend of the **ARRL 10 GHz and Above Cumulative Contest** is September 15–16. The **ARRL 2304 MHz and Above EME Contest** is September 29–30. The **144 MHz Fall Sprint** is September 17, 7 PM to 11 PM local time. The **222 MHz Fall Sprint** is September 25, 7 PM to 11 PM local time.

October: The **432 MHz Fall Sprint** is October 3, 7 PM to 11 PM local time. The **Microwave (902 MHz and above) Fall Sprint** is October 13, 6 AM to 12 PM local time. Please note the time change from last year. The **ARRL 50 MHz to 1296 MHz EME Contest** is October 27–28. The Delaware Valley VHF FM Simplex Sprint Contest is October 21, 10 AM to 2 PM local time. For more information see the following URL: <http://www.harcnet.org/contest.htm>. The **50 MHz Fall Sprint** is October 20, 2300 UTC to October 21, 0300 UTC.

November: The second weekend of the **ARRL 50 MHz to 1296 MHz EME Contest** is November 24–25.

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

Current Conferences & Conventions

September: The 2007 **TAPR/ARRL Digital Communications Conference** will be held September 28–30 in Hartford, Connecticut, at the DoubleTree Hotel in Windsor Locks. For more information, go to: <http://www.tapr.org/>.

October: The 2007 **Microwave Update** conference is to be hosted by the Packrats and will be held October 18–20, in Philadelphia, Pennsylvania at the Inn at Valley Forge. For further information, please check the Microwave Update website: <http://www.microwaveupdate.org>.

The 2007 **AMSAT-NA Space Symposium and Annual Meeting** is to be held October 25–28 in Pittsburgh, Pennsylvania at the Pittsburgh Airport Marriott Hotel. For more information, see the AMSAT URL pertaining to the symposium at: <http://www.amsat.org/amsat-new/symposium/2007/index.php>.

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, e-mail, etc., please contact the person listed with the announcement. The following organizations or conference organizers have announced a call for papers for forthcoming events:

ARRL and TAPR Digital Communications Conference: Technical papers are solicited for presentation at the 26th Annual ARRL and TAPR Digital Communications Conference to be held September 28–30, 2007 in Hartford, Connecticut. These papers will also be published in the conference *Proceedings* (you do *not* need to attend the conference to have your paper included in the *Proceedings*). The submission deadline is July 31, 2007. Please send papers to: Maty Weinberg, ARRL, 225 Main St., Newington, CT 06111, or you can make your submission via e-mail to: <maty@arrl.org>. Papers will be published exactly as submitted and authors will retain all rights.

AMSAT-NA 2007 Space Symposium: Technical papers are solicited for the 2007 AMSAT Space Symposium and Annual Meeting to be held October 25–28 in Pittsburgh, Pennsylvania. Proposals for papers, symposium presentations, and poster presentations are invited on any topic of interest to the amateur satellite program. An emphasis for this year is educational outreach to middle and high school students. In particular, papers on the following topics are solicited: Students & Education, ARISS, AO-51, P3E, Eagle, and other satellite-related topics,

Camera-ready copy on paper or in electronic form is due by September 1 for inclusion in the printed symposium *Proceedings*. Papers received after this date will not be included in the printed *Proceedings*.

Abstracts and papers should be sent to: Daniel Schultz, N8FGV, via e-mail: <n8fgv@amsat.org>.

Microwave Update: A call for papers has been issue for the 2007 Microwave Update. If you are interested in submitting a paper for publication in the *Proceedings*, then please submit your papers, articles, and abstracts to W2PED at <pdrexler@hotmail.com> or to N2UO at <lu6dw@yahoo.com> in MSWord or as a PDF by August 15, 2007. Diagrams, photographs, and illustrations should be in black and white. Hard copies may be mailed to Paul E. Drexler, 28 West Squan Road, Clarksburg, NJ 08510.

Quarterly Calendar

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

Aug. 3	Moon Perigee
Aug. 5	Last Quarter Moon; Moderate EME conditions
Aug. 12	New Moon and *Perseids* Meteor Shower Peak; Good EME conditions
Aug. 19	Moon Apogee; Poor EME conditions.
Aug. 20	First Quarter Moon
Aug. 26	Moderate EME conditions
Aug. 28	Full Moon and Total Lunar Eclipse visible throughout most of eastern Asia, Australia, the Pacific Ocean, and the Americas
Aug. 31	Moon Perigee
Sept. 4	Last Quarter Moon
Sept. 11	New Moon and Partial Solar Eclipse visible throughout most of central and southern South America
Sept. 15	Moon Apogee
Sept. 19	First Quarter Moon
Sept. 23	Fall Equinox
Sept. 26	Full Moon
Sept. 28	Moon Perigee
Oct. 3	Last Quarter Moon
Oct. 11	New Moon
Oct. 13	Moon Apogee
Oct. 19	First Quarter Moon
Oct. 20	*Orionids* Meteor Shower Peak
Oct. 26	Full Moon and Moon Perigee
Nov. 1	Last Quarter Moon
Nov. 9	New Moon and Moon Apogee
Nov. 17	First Quarter Moon and *Leonids* Meteor Shower Peak
Nov. 24	Full Moon and Moon Perigee

—EME conditions courtesy W5LUU.

Current Meteor Showers

August: Beginning around July 17 and lasting until approximately August 24, you will see activity tied to the *Perseids* meteor shower. Its predicted peak is around 0500–0730 UTC on August 13. A possible tertiary peak may occur around 1500 UTC. Amateur radio communications data could confirm or detect otherwise unobserved maxima. The *κ-Cygnids* meteor shower is expected to peak on August 18.

October: The *Draconids* is predicted to peak somewhere around 2030 UTC on October 8, then again around 0910 UTC on October 9. The *Orionids* is predicted to peak on October 21.

November: The *Leonids* is predicted to peak around 0250 UTC on November 18. However, unlike recent showers, this year's peak may go largely unnoticed.

For more information on the above meteor shower predictions see Tomas Hood, NW7US's propagation column beginning on page 78. Also visit the International Meteor Organization's website: <http://www.imo.net/calendar/2007/>.

By Keith Pugh,* W5IU

SATELLITES

Artificially Propagating Signals Through Space

Satellite Station Alternatives

Since my last column, I have participated in three major amateur radio events: the Dayton Hamvention®, Ham-Com, and Field Day. This year at the Hamvention® and Ham-Com I had the opportunity to be in charge of real-time demonstrations on the amateur radio satellites. In the past I have usually done these demonstrations utilizing only the FM satellites or given a "receive only" demo on the SSB/CW birds. Working with Drew Glasbrenner, KO4MA, last year inspired me to include full demonstrations of the SSB/CW birds.

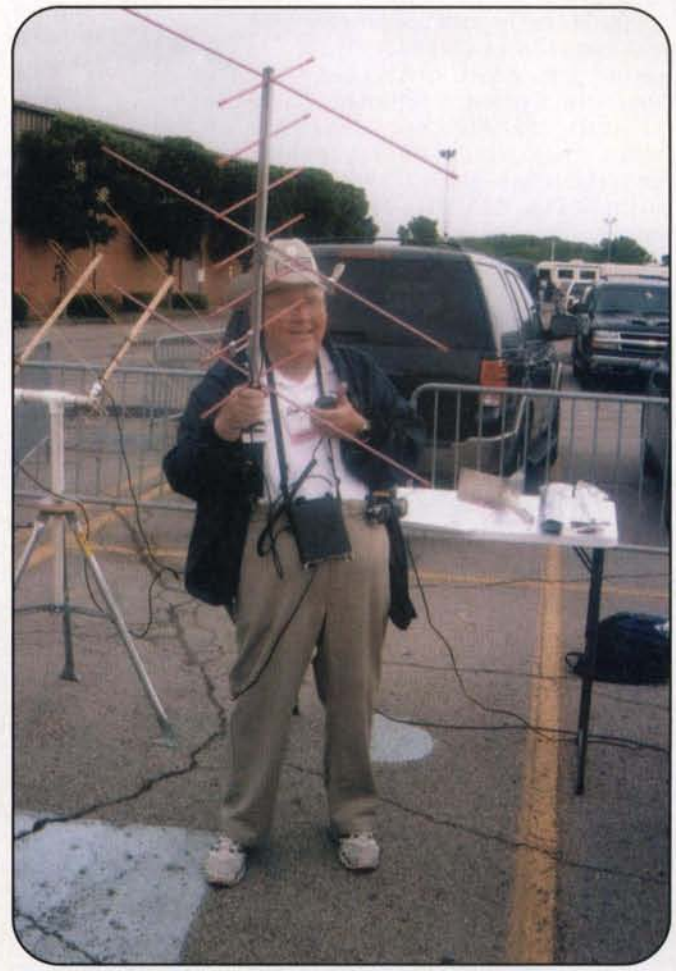
This year I was determined to find a way to do full demos on all of the birds. In addition to requiring multi-mode transceiver capability, SSB/CW demos require more "hands-on" operation to do the precise tuning required to compensate for Doppler and match up your uplink and downlink while still keeping the antenna pointed, etc. The RF environment at hamfests and major conventions represents a challenge as well. In this column I will address some solutions to these demo problems and expand into Field Day with a special mode this year.

Multi-mode Satellite Demonstrations

Demos on the FM birds are usually done with little more than a dual-band HT and an Arrow antenna or its equivalent. Only one uplink-downlink pair is used per transponder, and Doppler tuning in 5 -kHz steps of the higher frequency is adequate for the mode V/U and U/V birds. A full-duplex capability is highly desirable so that you know for sure when you are "making the bird," but it is not absolutely necessary. One hand can be used to control the antenna and the other hand the channelized FM radio.

On the SSB/CW birds, full-duplex operation is absolutely essential, and precise tuning of both the uplink and downlink is necessary to locate the station you wish to talk to, match up the uplink to the downlink, and continue to correct for Doppler. This normally requires two independent radios, since most full-capability satellite radios are usually a bit cumbersome for a portable environment. All of this must be done while keeping the antenna(s) pointed at the bird. Most people come up at least "one hand short" to do all of this without some extra help.

Handheld multi-mode receivers such as the ICOM IC-R20, Yaesu VR-500, and Kenwood TH-F6A are available; however, these radios suffer, to varying degrees, from poor sensitivity, wide-open front ends, and marginal detectors. Some of these problems can be tolerated in a benign RF environment, but not at Dayton. None of the current handheld equipment has a SSB/CW transmit capability. The best compromise I have found is the Yaesu FT-817 Back-Pack Radio. At least one of these is necessary for the transmit capability. The FT-817 can be paired with one of the other receivers mentioned above, or better yet, with another FT-817. Many other combinations are also possible with larger, more powerful radios, but for the purpose of this discussion I have chosen two FT-817s as the smallest combination of radios that will provide acceptable uplink and downlink performance to do the job.



W5IU at the Dayton Hamvention® demo area working AO-51 FM. The WA5VJB Cheap LEO Antennas and W5IU Cheap AZ-EL Positioner are in the background. (Photo courtesy of Bill Reischl, KBØAZB)

Two possibilities have been explored for the antenna control problem. First, assign the task to another person. Second, place the antenna(s) on an AZ-EL positioner so that the antenna(s) do not have to be held constantly—only updated periodically. Both methods work, and the second method works better if a second person is assigned that task as well.

At both Dayton and Ham-Com the second method was used most of the time on the SSB/CW birds and was implemented with two WA5VJB "Cheap LEO Antennas" mounted on a W5IU "Cheap AZ-EL Positioner." These are described in the

*3525 Winifred Drive, Fort Worth, TX 76133
e-mail: <w5iu@swbell.net>

The Cheap LEO Antennas and Cheap AZ-EL Positioner.

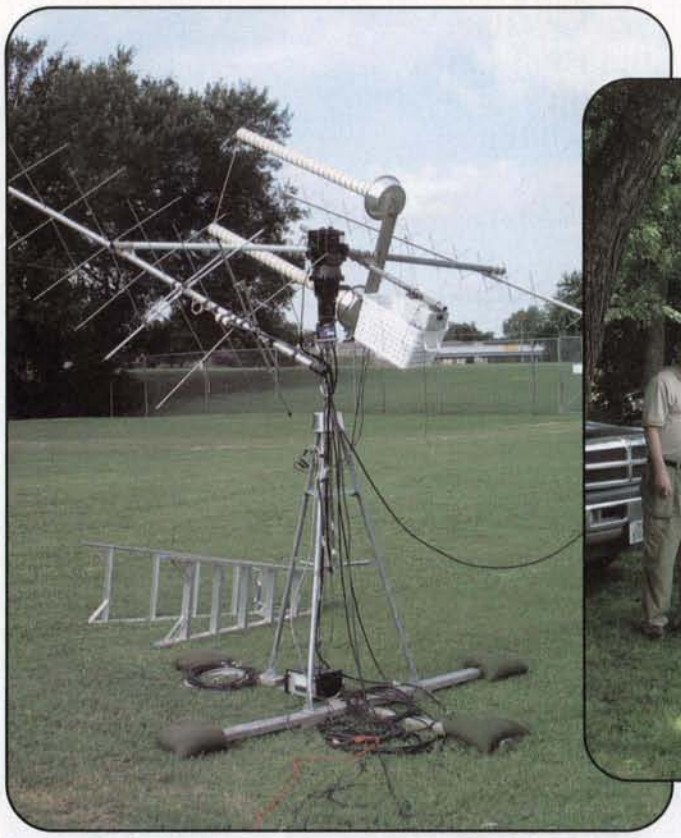
Summer 2006 and Winter 2005 issues of *CQ VHF* magazine, respectively.

FM demos were planned for AO-51, SO-50, and AO-27. However, only the AO-51 demos were actually done due to time constraints. Successful SSB/CW demos were done on VO-52 and AO-07. At one point we actually had a "roundtable" going on VO-52. All of this was done with the FT-817s "barefoot" at 5 watts maximum.

Field Day and AO-51 Mode L/U

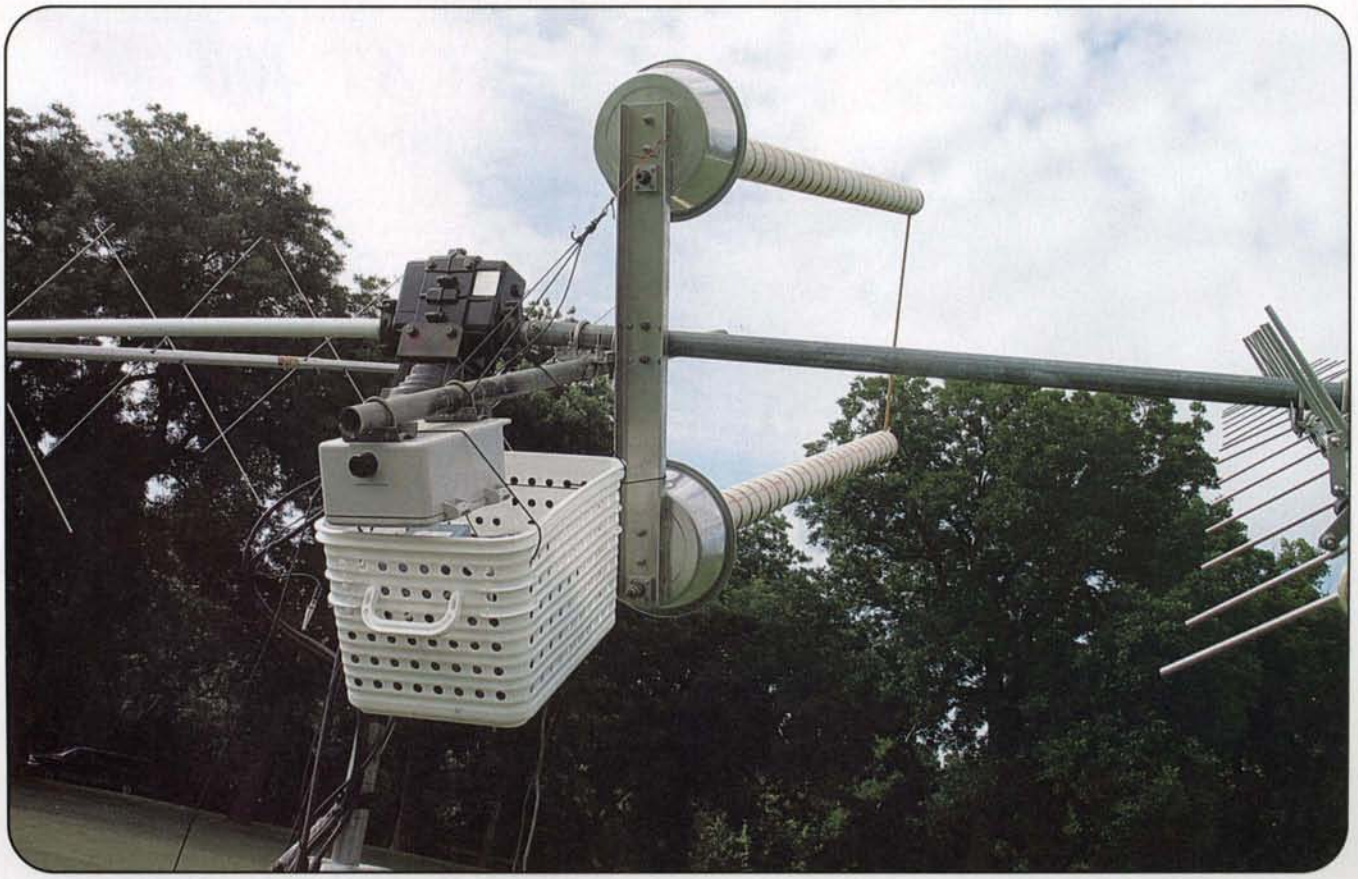
This year the AO-51 Operations Team decided to run both transponders simultaneously on AO-51 for Field Day. One ran

The L-Band transverter and power-amplifier chain.



The W5IU Field Day satellite array.

The Lockheed Martin Recreation Association Radio Club members present at Field Day teardown. (Photo courtesy of Bill Penny, WM5U)



Looking up the satellite array.

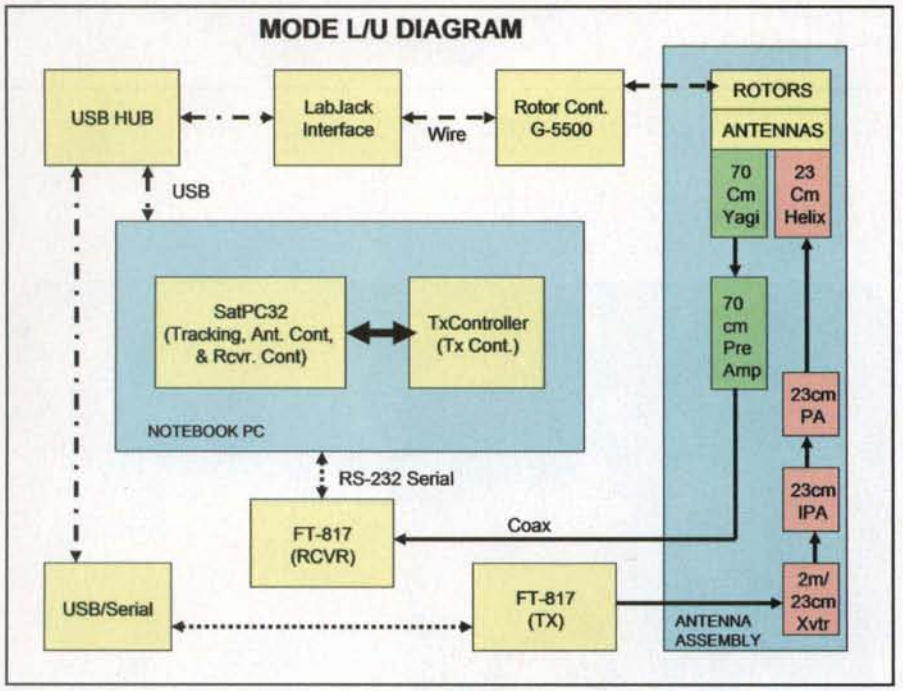


Figure 1. The Mode L/U diagram.

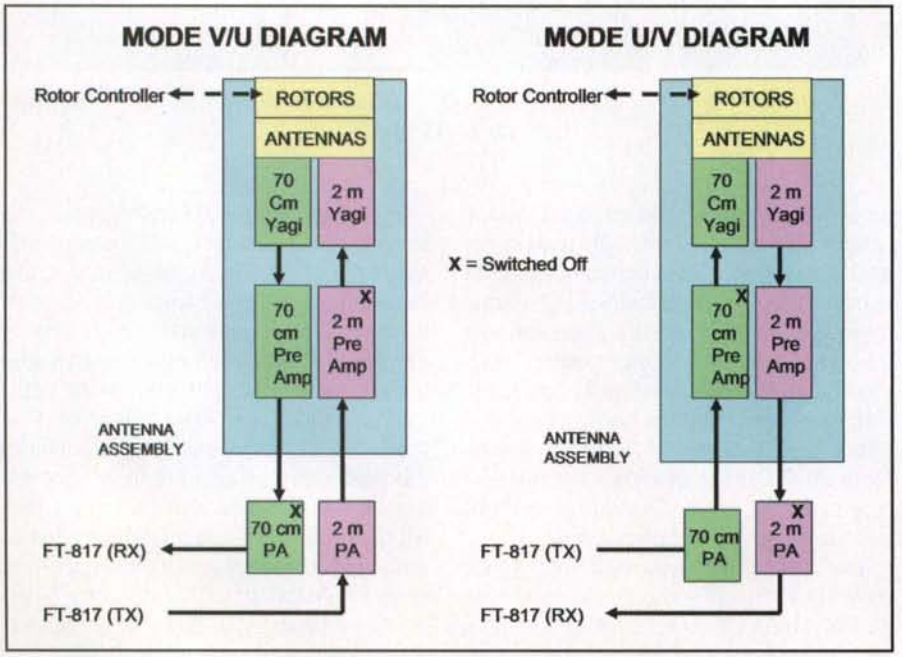


Figure 2. Alternate hookups for Modes V/U and U/V.

in the normal Mode V/U FM configuration and the other one was configured for Mode L/U FM. Mode L/U was the "spark" I needed to get going and try something new.

I decided to combine technology from the old AO-10 and AO-13 Mode L days with newer software and radio technology of today.The old technology consisted of the usual Hy-Gain Satellite Pack antennas for 2 meters and 70 cm supplemented by a WD4FAB 28-turn helix from the 1992 (and later) *ARRL Handbook*. One year I built a set of these for use on AO-13 at W1AW/5 in Arlington, Texas during the ARRL National Convention. Only one of these helix antennas was driven, although two of the original four were mounted on the positioner. RF equipment from the AO-10 Mode L days consisted of an SSB Electronics LSM-24 satellite-transmitter-mixer, an SSB Electronics PA-2310 linear power amplifier, and a Down East Microwave power amplifier. This mixer–power-amplifier chain (mounted in the basket on the back of the helix) provided approximately 20 watts of power to the helix when driven by 1 watt from one of the FT-817s. This combination provided an excellent signal into AO-51.

The newer technology consisted of the two FT-817s (idea borrowed from the demos) and an old Dell notebook running SatPC32 and TxController software. TxController is a program included with SatPC32 that permits control of a separate transmitter while SatPC32 controls a separate receiver, antenna rotors, full Doppler correction, and all of the usual graphical support expected these days. Due to port limitations on the Dell notebook, it was supplemented by a four-port USB hub and one USB to RS-232 serial adapter. Antenna control was provided through a LabJack and LabJack piggyback interface combination from one of the USB ports to the Yaesu G-5500 rotors. Diagrams of this entire hookup are provided. Figure 1 is the Mode L/U diagram; Figure 2 is the alternate hookups for Modes V/U and U/V.

Getting this set up and working required some attention to detail, but the results were worth it. Full Doppler-correction radio control along with automatic antenna control was great. In addition to both modes of AO-51, we also worked VO-52 and AO-27. We heard, but did not work, SO-50 and AO-07 due to cockpit problems. We also missed the first good AO-51 pass for the same reasons. The setup was new to everyone and changed for each bird. Next year these problems will be solved by training, check lists, and a more reliable power source.

Summary

Hamfests and Field Day are great fun, but they also can be very challenging. The FM birds are quite controversial on Field Day due to single-channel operation and the FM capture effect. We desperately need a new HEO (High Earth Orbit) bird. To this end, don't forget to support the AMSATs of the world in their efforts to build and launch new and challenging HEO satellites. Look for P3-E in late 2008 and Eagle after that. Good progress is being made with both of these programs, but they really do need your support.

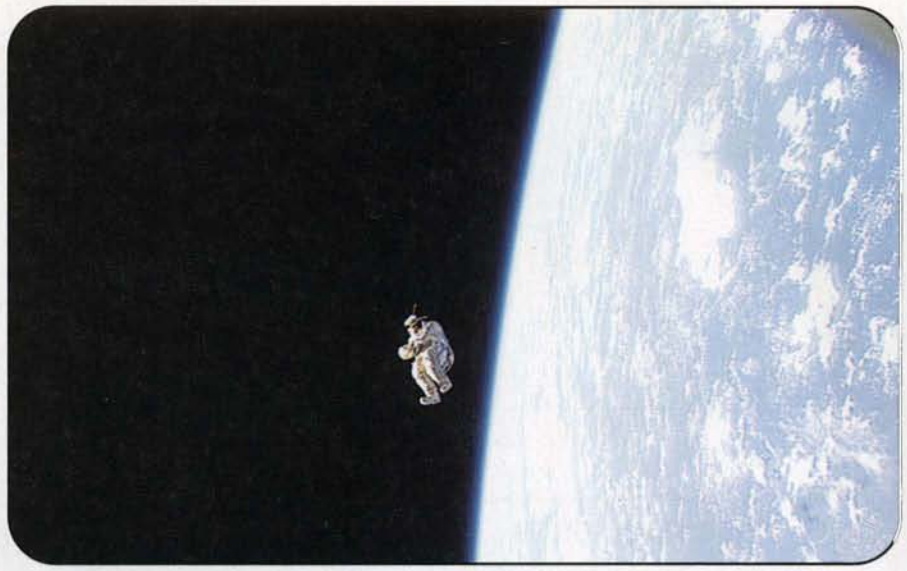
73 de Keith, W5IU

By Dr. H. Paul Shuch,* N6TX

THE ORBITAL CLASSROOM

Furthering AMSAT's Mission Through Education

Following Suit



On September 8, 2005, SuitSat (AMSAT OSCAR 54) started its long, desolate journey. (NASA photo)

No amateur satellite has captured the public imagination quite like SuitSat, the discarded Russian space suit that was tossed overboard from the ISS (International Space Station) on September 8, 2005, stuffed full of ham radio equipment and dirty laundry. Proposed by Sergey Samburov, RV3DR, at the 2004 AMSAT Space Symposium near Washington, DC, this innovative project came together in a record 11 months and stands out as one of AMSAT's greatest educational successes despite technical malfunctions that made the suit's 2-meter beacon almost impossible to copy, except by the best equipped high-end ham stations. Nevertheless, students around the world were galvanized by an image evocative of a stranded cosmonaut (see Photo 1), giving amateur radio in general, and the ham satellite community in particular, an unprecedented foot in the classroom door.

Not ones to sit on their laurels, Sergey, Lou McFaddin, W5DID, Frank Bauer, KA3HDO, and their ARISS (Amateur Radio on the International Space Station) team started right in planning a sequel. As this column is being written, SuitSat2 is rapidly taking shape in a handful of laboratories and classrooms scattered around the U.S. However, unlike his predecessor, when this cosmonaut gets the boot, he should not whisper, but roar.

No one knows exactly why the original SuitSat's signals on Earth were several S-units weaker than planned. Speculation centers on malfunctions in the transmitter itself, the antenna, and the coax that connected the two. Nevertheless, significant upgrades are planned this time around, involving more transmitter power, better coax, a new antenna design, a completely different power system (more about that later), and the use of SDR (Software Defined Radio) technology for the first time in an amateur radio satellite. In short, this ain't your father's spacesuit.

The first SuitSat carried into space messages from students around the world. Some of these were the spoken words of greeting, stored in digital memory and transmitted from orbit. Others were essays and pictures contributed by students to a CD-ROM attached to the suit's chest. Unlike the golden records carried into space aboard the NASA Voyager interplanetary spacecraft three decades earlier, this disk was never intended to be recovered and studied by intelligent extraterrestrials. Rather, it was our own terrestrial students who were given the opportunity to contemplate the kinds of messages they would most like to send off into space.

Looking beyond the first SuitSat, the successor spacecraft will carry into space not just student messages, but also student hardware and software. Much of the circuit fabrication and testing is being carried out in an Software Defined Radio course by a group of electronic engineering students at The College of New Jersey in Trenton (see Photo 2). Under the leadership of adjunct faculty members Frank Brickle, AB2KT, and Bob McGwier, N4HY, these undergraduates are gaining experience in producing real spaceflight-qualified hardware. What better motivator can there be for tomorrow's leaders of technology? When the suit gets the boot, I'm sure they will be among the proudest youngsters on planet Earth.

"Working with these kids has been one of the most enjoyable things I've done in quite awhile," writes instructor Frank Brickle, AB2KT, of his students. "They seem genuinely turned on by walking the tightrope without a net as far as SuitSat is concerned. We all will be doing a very good thing if we can continue to involve these kids, and more like them, in future AMSAT projects."

*Director of Education, AMSAT
e-mail: <n6tx@amsat.org>
<www.AMSAT.org>

At The College of New Jersey in Trenton, undergraduate Electronics Engineering students work on the hardware and software for SuitSat2. AMSAT members and faculty mentors Frank Brickle, AB2KT, and Bob McGwier, N4HY, stand at the back. (N4HY photo)

Frank emphasizes that the complexity of his students' project is not to be underestimated. "Since they're working with what is essentially the orbital design, there is nothing in the way of diagnostic hardware or software, which is why I described them as walking a tightrope without a net. Furthermore, given the complexity of what the SDR/SDX in SuitSat2 will be required to provide, the applications will need to run in an unprecedented software environment—preemptive multitasking under freeRTOS (an open-source real-time operating system). What the course comes down to, then, is giving them a little verbal swimming instruction and then tossing them straight into the ocean. Rather than being intimidated, they all seem to be relishing the challenge and meeting it with obvious enthusiasm, just the sort of attitude I have learned to expect during my association with AMSAT. Couldn't be a better match."

The first SuitSat burned up in the Earth's atmosphere just six months after orbital insertion, successfully completing its brief mission to boldly go where no suit had gone before. (As a teacher, I can't help but add, "to boldly split where no infinitive has split before.") SuitSat2 will follow in its footsteps, which means its mission too will be brief. However, because it carries panels of photovoltaic solar cells, and a sophisticated battery charge regulator, this latest suit should transmit for the majority of its orbital lifetime, unlike its predecessor, whose (non-rechargeable) batteries expired after just a couple of weeks.

The power system is one area of focus for The College of New Jersey engineering students. Frank Brickle says, "In talking outside of class, a number of them have expressed real interest in power. It's not a subject covered anywhere in their curriculum. The biggest surprise about them as a group is how interested they are in taking a new approach to very basic, fundamental kinds of engineering issues, and not necessarily the trendy, flashy topics. This is an unexpected source of optimism, for me anyway."

Given the second suit's improved power system, we hope numerous students, in classrooms widely scattered across our globe, will have the opportunity for multiple receptions and ongoing experiments. The more youngsters who can hear SuitSat2's digitally synthesized voice, the more future space technologists we can claim credit for cranking out. Isn't that what AMSAT education is all about?

However, whether they hear a peep from SuitSat2's transmitter or not, I expect thousands of students will be captivated forever by the image of the lonely astronaut, spinning away into the black void of space. If that isn't an educational message, what is? 73, Paul, N6TX

By Bob Witte,* KØNR

FM

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

FM VHF at Dayton 2007

After several years of not being able to attend the Dayton Hamvention®, this year my personal and work schedules aligned to allow my attendance at the world's largest ham radio convention. I was really looking forward to getting back to Dayton, and I wasn't disappointed. In this column, we'll take a look at Dayton activities with a FM VHF emphasis.

New Radios

Dayton is a great place for radio equipment manufacturers to show off their latest products. In particular, there were a number of new dual-band FM 146-MHz/440-MHz transceivers, a popular type of rig for *utility-mode* ham radio. The ham equipment manufacturers are always looking for ways to differentiate their latest equipment and offer us that new rig.

Yaesu presented its new FTM-10R transceiver, shown in Photo 1 mounted on the handlebars of a motorcycle. Yaesu says this rig's detachable front panel is waterproof and dustproof, ideal for installations exposed to the weather. The rig has an optional Bluetooth® wireless headset for hands-free operation. The radio supports FM broadcast receive in stereo along with an input for an external CD player or MP3 player. Clearly, Yaesu has put features into this rig with the aim of being the entertainment center for your ride.

At the ICOM booth, we found the IC-2820H, the latest dual-band transceiver with optional D-STAR and GPS capability (Photo 2). The rig includes a *diversity receive* mode that is intended to improve reception while mobile in the face of varying signal strength. Diversity reception uses two separate antennas spaced a small distance apart, each grabbing the signal at a different physical location, increasing the odds that one of them will hear the signal well. Although this approach is well known in the communications world, it is the first time I've seen it used in a VHF amateur radio. It will be interesting to see how much better diversity receive works in typical mobile situations.

Photo 1. The Yaesu FTM-10R remote head mounted on a motorcycle.

Photo 2. The ICOM IC-2820H dual-band FM transceiver with optional D-STAR capability.

Most dual-band FM rigs have a lower power output on the 70-cm band (compared to the 2-meter band), but the IC-2820H has a full 50 watts output power *on both bands*. The UT-123 option adds D-STAR capability and a GPS receiver to the IC-2820H. This is not just a GPS interface; this is a full-GPS receiver built into the rig, including an external GPS antenna. The GPS positional data is

*21060 Capella Drive, Monument, CO 80132
e-mail: <bob@k0nr.com>

Photo 3. The Kenwood TM-V71A dual-band FM transceiver.

Photo 4. The Kenwood TM-V710, kept under glass at Dayton.

shown on the large transceiver display, and the transceiver can be configured to transmit position information at preset intervals. This is basically a D-STAR version of APRS, but not compatible for traditional AX.25 packet-based APRS.

Kenwood introduced the TM-V71A dual-band transceiver, also with a full 50 watts of transmit power on both bands (Photo 3). This rig includes features aimed at making Echolink operation more convenient. For the Echolink user, ten DTMF memories are there to store your favorite Echolink nodes. Just as important, Kenwood made it easy to set up this rig as an Echolink node, with the right computer interfaces built into the rig (optional PG-5H interface cable required).

Like many dual-band FM rigs, this radio has a cross-band repeat feature that retransmits the signal from one band to the other. Kenwood added an important improvement to cross-band repeat—an automatic identifier (CW or optional voice recording). Automatic identification is a key feature that has been missing for years. Unfortunately, TM-V71A IDer transmits every 10 minutes, even if the cross-band repeater has been idle. This makes it act more like a "beacon" than a well-behaved repeater identifier. (Usually, a repeater identifier remains silent until there is activity on the repeater.)

Kenwood also displayed the new TM-D710, the replacement for the popular APRS/packet rig, the TM-D700A (Photo 4). However, we are going to have to wait a while longer until this rig is available. There were no data sheets available at Dayton, and the rig is expected to go on sale this fall.

D-STAR Happenings

For the FM VHF crowd, the biggest buzz at Dayton centered on D-STAR. Of course, you would expect ICOM to be displaying their D-STAR line of equipment (Photo 5), but the topic of D-STAR showed up in several other places at the convention as well.

The D-STAR Forum was very well attended, even though it was held on Sunday morning—not exactly prime time for convention attendees! Greg Sarratt, W4OZK, ARRL Alabama Section Manager, and Jim McClelland, N5MIJ, of the Texas Interconnect Team, talked about how the deployment of D-STAR equipment was going in their respective locations (Photo 6).

Photo 5. The display of ICOM D-STAR radios at the D-STAR booth.

Previously, I had bumped into the work that the Texas team is doing, but I was not aware of how the Alabama section has embraced D-STAR with an emphasis on emergency communications. The Alabama section website indicates there are 14 D-STAR systems on the air in the state, with many of these repeater sites having repeaters on more than one band.

You may recall that I wrote an article on D-STAR technology for the Winter 2006 issue of *CQ VHF* ("D-STAR Digital Voice for VHF/UHF"). I received a few e-mail messages that basically said, "I don't see any reason for this new digital stuff; my analog FM rig is just fine." This is not a big surprise, as there are people out there who think single sideband is just too radical a technology to be used on the ham bands. The attitude I found at the D-STAR forum was just the opposite: Hams hungered for information on how this new-fangled mode works and how they can get involved with it. It reminds me of when AX.25 packet arrived on the scene years ago, with people interested in playing with the technology and figuring out how to use it.

Photo 6. Jim McClelland, N5MIJ (left), and Greg Sarratt, W4OZK (right), discuss D-STAR repeater deployment at the D-STAR Forum.

Photo 7. An operational D-STAR repeater on display.

Whether you think D-STAR is the future or not, it is refreshing to see the ham radio community excited about something new. After all, many of us have a strong interest in experimenting with radios and new technology.

At the Frequency Coordinators Forum, D-STAR was a hot topic. It seems that most of the frequency-coordination organizations are receiving requests for the coordination of D-STAR repeaters (Photo 7). This led to a lively discussion of "where to put them," since in many regions the available 2-meter repeater pairs are all coordinated. In some areas of the country, D-STAR repeaters are being dropped into the existing band plan, having either 20-kHz or 15-kHz channel spacing. This approach certainly works, but it does not take advantage of the narrower bandwidth of the D-STAR signals (more like 10-kHz channel spacing).

Robert Shepard, KA9FLX, Technical Committee Chair for the Illinois Repeater Association, put together a proposal for migrating existing analog FM channels to digital ones. Basically, the Illinois proposal provides for 10-kHz channel spacing on 2 meters, while 70-cm repeaters split existing 25-kHz channels to create 12.5-kHz digital channels. While the frequency coordinators tended to agree that there was a serious band-plan issue to be solved, there was no clear agreement on the best method for moving ahead.

Mark Thompson, WB9QZB, invited everyone to participate in the Yahoo group (illinoisdigitalham) that he started to discuss digital ham radio. Despite the "Illinois" name, this lively group has participants from all over the U.S.

Homebrew D-STAR

One of the issues with D-STAR is that ICOM is the only manufacturer selling equipment in the U.S. (Kenwood has marketed D-STAR gear in Japan but has not chosen to bring these products to North America.) Whether the perception is reality or not, outside of Japan D-STAR *looks like* an ICOM proprietary technology: If you are going to have D-STAR, you are going to have to buy ICOM.

Well, Robin Cutshaw, AA4RC, decided to change all that. Robin constructed and demonstrated a *homebrew* D-STAR 2-meter transceiver at his booth at the Hamvention®. Although the D-STAR standard is touted as "open," it still requires significant reverse engineering to make this radio work. Robin says he is committed to making his work available to everyone, so keep an eye on this website: <http://www.opendstar.org/>.

While it is still not clear where this will lead, it does prove that there is enough information, technology, and parts available out there for hams to construct D-STAR-compatible transceivers.

Is a D-STAR System a Repeater?

Another controversy winding its way through the aisles was this question of whether D-STAR systems are really repeaters. This apparently was initiated when a ham e-mailed Bill Cross, W3TN, of the FCC Wireless Telecommunications Bureau asking for clarification on whether D-STAR systems are repeaters or some kind of digital station. The argument goes like this: Since a D-STAR repeater takes in received digital data, processes it, and forwards it on to the transmitter, it operates as a store-and-forward digital station. Said another way, the repeater output is not really simultaneous with the repeater input; it is processed and delayed. Why is this important? Well, if a D-STAR system is not a repeater, then it doesn't need to be coordinated like a repeater, and it can be deployed on frequencies that are not specified for repeater operation.

Bill Cross spoke at the FCC Forum and was asked about this specific issue. He gave a very long answer (available for download as an audio file, see below), which I'll summarize this way:

- The amateur radio licensee is solely responsible for operating his station consistent with FCC rules and regulations.
- Don't believe everything you read on the internet, especially an e-mail that answers a question without including the context of the original question.

Okay, both of those statements are true, but they don't really answer the question of whether D-STAR systems are considered repeaters under the FCC rules. My opinion that it is an interesting armchair lawyer debate, but like most such debates it doesn't really accomplish much. I see D-STAR systems as being fixed in frequency, occupying a pair of duplex frequencies, and requiring frequency coordination to prevent interference. It sure

sounds like a repeater to me. (If it looks like a duck, quacks like a duck . . . it probably is a duck.)

Where's Project 25?

As I said earlier, the buzz at Dayton was around D-STAR, but occasionally we heard some comments about APCO Project 25. There are hams with P25 systems on the air, but there is no manufacturer pushing ham radio adoption of P25. It seems that the typical scenario is for hams who are involved in land-mobile communications to redeploy their favorite P25 repeater equipment onto the ham bands. Commercial P25 radios generally are more expensive than equivalent D-STAR gear, but the cost will come down as the commercial gear becomes available on the used market. Commercial radios usually are very channel oriented and don't have the flexible features of your typical ham rig. This will limit the adoption of P25 by the ham radio community, unless, of course, some innovative amateur radio manufacturer decides to offer a P25 rig tuned specifically for the ham market. Now *that* could get interesting.

Classic FM Gear

A visit to Dayton is not complete without a trip or two through the flea market. The flea market is usually a great spot to pick up well-used land-mobile FM gear from GE, Motorola, etc. I spotted a pile of handheld rigs starting at the bargain price of $5 each (Photo 8). There is always an extensive collection of repeater parts and repeater systems, everything from used duplexers to complete repeater systems (Photo 9). There is always so much stuff from which to choose that I have to be careful not to take home that "treasure" that ends up being on my table at the next local swapmeet.

Summary

Attending the Dayton Hamvention® was a great experience, one that I highly recommend. Thanks to the members of the Dayton Amateur Radio Association (DARA) for putting on an outstanding ham radio event.

If you have thoughts about this column or FM VHF in general, please drop me a note at <bob@k0nr.com> or stop by my blog at <http://www.k0nr.com/blog>.

73, Bob, KØNR

Photo 8. Who says ham radio has to be expensive?

Photo 9. A UHF repeater for sale in the flea market.

Resources

Open D-STAR: <http://www.opendstar.org/>
Texas Interconnect Team: <www.k5tit.org>
Alabama Section D-STAR: <http://www.arrl-al.org/Alabama_link.htm>
KA9FLX Digital Migration Plan (Illinois Repeater Association): <http://www.ilra.net/The%20Digital%20Migration-IRA_R0428071.pdf>
Illinois Digital Ham group: <http://groups.yahoo.com/group/illinoisdigitalham/>
The Rain Report (June 21, 2007), audio recording of comments by Bill Cross, W3TN, concerning D-STAR repeaters: <http://www.therainreport.com/rainreport_archive/rainreport-6-21-2007.mp3>

By Tomas Hood,* NW7US

PROPAGATION

The Science of Predicting VHF-and-Above Radio Conditions

Calling All North American VHF Amateur Radio Operators!

What is the most exotic propagation mode you personally have experienced while operating on VHF? Pinging your signal off of a meteor trail? Catching aurora-mode DX? Making contacts by way of back-scatter propagation? Or have you worked stations in nearby states by way of sporadic-*E* propagation?

While there are a fair number of VHF operators manning the weak-signal and non-FM-mode segments of the VHF ham bands, there seems to be a significant lack of serious, systematic observations on a grand scale in North America. There are those involved with PropNET <http:// propnet.org/>, and there are many who post individual spots on DX clusters. However, is there a concerted effort by the VHF community in North America to collect and study the vast operational data in a way that uncovers the rich VHF radio signal propagation phenomena that occur each season?

Such a systematic activity is alive and well in Europe. For instance, you can find a great amount of material presented at the "Amateur Radio Propagation Studies" website (http://www.df5ai.net/) by Volker Grassmann, DF5AI. He postulates, and I concur, that the absence of systematic studies of operational data is an obstacle in the discovery and deeper understanding of VHF radio propagation in North America. The majority of the studies Volker presents on his website are Eurocentric.

There are unanswered questions about VHF propagation in North America. For instance, Volker points to the different propagation characteristics of Europe and North America during the sporadic-*E* season between May and September. Does sporadic-*E* activity in North America track with the level of activity in Europe, or are there vastly different systems at work in the sporadic-*E* season in each area of the world?

Because there does not seem to exist any systematic collection of daily and seasonal VHF DX information on a grand scale (more than a handful of die-hard VHF stations posting on DX reflectors), it is difficult to analyze the real VHF propagation phenomena across the vast geographical area of North America. Scientific background data such as ionosonde, sferics, and upper-air sounding data is easily obtained. However, there's very little information from the VHF community about daily continent-wide propagation on a grand scale (hundreds of operators representing all of the geographical regions).

What is FAI?

An example of what needs to be studied by the VHF community is the Field-Aligned Irregularities (FAI) related propagation modes. A field-aligned irregularity is a dense "cloud," or bubble, that becomes aligned with the powerful geomagnetic field lines that run from each of the Earth's poles. A great deal of scientific research has been and is being performed to understand the FAI phenomenon. However, the ham radio VHF community knows only the most obvious occurrence of FAI propagation, such as when the dense ionized patches form during aurora and cause VHF signals to refract in the *E* region of the ionosphere, where the dense patches ride the turbulent geomagnetic field lines, causing broad Doppler shifts in frequency.

However, there is a lot more FAI activity occurring all the time, according to the research coming out of many universities and scientific communities. A study by scientists in India revealed that a total eclipse of the sun causes cooling within the dark, supersonic disc created by the moon's shadow as it races across the Earth. In turn, that cooling causes gravity waves that form plasma disturbances. These plasma waves align with the magnetic field lines and can refract radio waves at some range of frequencies.

It follows, then, that other forms of plasma disturbance in the ionosphere can cause the same formation of dense patches of ionized gas, which in turn can become field-aligned and could then possibly refract radio signals. Could perhaps lightning jets, or temperature inversions, or other gravity-wave events cause FAI? Non-amateur-radio researchers say yes. Their research even hints at possible meteor-trail plasma clouds contributing to FAI propagation. Have we as a community uncovered any of these occurrences? Do we know what to look for?

We need a very large increase in the number of radio operators attempting long-distance communications on the low VHF spectrum, using many different modes and techniques. Also, with that increase in the number of researchers, we need to have a centralized place to collect all of the data, and then a way to begin analyzing the patterns and events to see what really is possible on VHF. I am convinced that we have only begun to scratch the surface of understanding VHF propagation.

That's just on VHF. What about UHF research on a grand scale? Remember, "you can't work 'em if you can't hear 'em," and you can't hear them if you are not working the band. Not enough research is being done on a continent-wide basis, and a large number of operators is needed on a daily basis to really uncover any unique—rare or not—phenomena that might exist on VHF and UHF by way of the ionosphere.

If you are new to the world of VHF radio, I challenge you to explore how you might be a part of the movement to research the "wild frontier" of North American VHF propagation on a large scale. This is a call for operators, data handlers, researchers

*P.O. Box 213, Brinnon, WA 98320-0213
e-mail: <nw7us@hfradio.org>

and analyzers, and promoters of VHF propagation exploration. If you are a veteran VHF DXer, contribute your knowledge and passion to this new initiative. Can you write software to help analyze such vast data? Perhaps you are great at organizing data on such a scale. Most of all, if you have any interest in the science behind getting your signal from here to there, any interest in VHF operation beyond chatting on a local repeater, then join up with as many other VHF explorers on the air and let's see what we can discover.

The *Perseids*

We are entering a period of the year in which we can work VHF DX off meteor trails. One of the most reliable yearly meteor showers is the *Perseids.* The *Perseids,* like other meteor showers, is named after the constellation from which it first appeared to have come. This shower's constellation is Perseus, which is located near Cassiopeia. The *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.

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

This year, the *Perseids* will be active from July 17 through August 24, and should peak between 0500 UTC and 0730 UTC, August 13. The number of visual meteors is expected to be about 100 per hour. It is possible, using high-speed CW, to realize a much higher hourly rate, since many meteors that are not visible might contribute to the ionization necessary for long-distance contact.

The *Perseids* shower begins slowly in mid-July, featuring dust-size meteoroids hitting the atmosphere. As we get closer to August 12, the rate builds. For working VHF/UHF meteor scatter, this could prove to be an exciting event.

The best time for working the *Perseids* VHF/UHF via meteor scatter in North America is during the hours before midnight, until about 5:00 AM local time.

The characteristic *Perseids* burn is bright white or yellow and typically lasts less than half a second. The brighter meteors usually leave a persistent train, or "smoke trail," that lasts a second or two after the meteors have vanished. This is not really smoke at all, but rather ionized gas created by the meteors passing through the atmosphere at tremendous velocities. It is this trail that potentially reflects the VHF radio signal.

Other Meteor Showers of the Summer

There is very little anticipation of significant *Draconids* activity this year. The *Draconids* is primarily a periodic shower which produced spectacular, brief meteor storms twice during the last century, in 1933 and 1946. Most recently, in 1998, we saw a moderate peak of the Zenith Hourly Rate (ZHR) reaching 700. This was due to the stream's parent comet, 21P/Giacobini-Zinner, returning to perihelion. There was a small outburst of activity in 2006. There is discussion that this year the activity could be a strong minor storm.

The *Draconids* 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, since we might see storm-level activity this year.

Meteor activity improves somewhat with the *Orionids* later in October. The *Orionids* shower is active from October 2 through November 7, peaking on October 21. This year the hourly rate could reach about 30 meteors per hour. This is expected to increase in the next year, as well.

For more information, take a look at <http://www.imo.net/calendar/2007>. Check out <http://www.meteorscatter.net/metshw.htm> for a very useful resource covering meteor scatter and up-coming showers.

The Solar Cycle Pulse

The observed sunspot numbers for April and May 2007 are 3.7 and 11.7. The smoothed sunspot counts for October and November 2006 are 14.2 and 12.7.

The monthly 10.7-cm (preliminary) numbers for April and May 2007 are 72.4 and 74.5. The smoothed 10.7-cm radio flux for October and November 2006 is 79.4 and 78.5, respectively.

The smoothed planetary *A*-index (*Ap*) for October and November 2006 is 8.6 and 8.5. The monthly readings for April and May 2007 are 9 and 8.

The monthly smoothed sunspot numbers forecast for August through October 2007 are 13.5, 15.5, and 18.1, while the monthly smoothed 10.7-cm radio flux is predicted to be 75.5, 76.4, and 77.8 for the same period. Give or take about 12 points for all predictions. (Note that these are preliminary figures. Solar scientists make minor adjustments by careful review after publishing.)

What do these numbers indicate? It looks very possible that this is the start of solar Cycle 24. While many expert forecasters predicted a delayed ending and prolonged start to a new cycle, the current numbers indicate that the sun may be ramping back up. Could Cycle 24 be the big cycle that some have predicted? More recent predictions by some, notably at NASA, forecast a moderate-to-weak solar cycle. However, those same forecasters predict that perhaps Cycle 24 won't start until late 2008. I'm predicting that the earlier forecast, which indicates that Cycle 24 will be one of the strongest since the 1950s, is more accurate, and that the end of Cycle 23 has just occurred.

Feedback, Comments, Observations Solicited!

I am looking forward to hearing from you about your observations of VHF and UHF propagation. Please send your reports to me via e-mail, or drop me a letter about your VHF/UHF experiences (sporadic-*E*, meteor scatter, etc.). I'll create summaries and share them with the readership. You also are welcome to share your reports at my public forums at <http://hfradio.org/forums/>. Up-to-date propagation information can be found at my propagation center at <http://prop.hfradio.org/> and via cell phone at <http://wap.hfradio.org/>.

Until the next issue, happy weak-signal DXing.

73 de Tomas, NW7US

CQ's 6 Meter and Satellite WAZ Awards

(As of July 1, 2007)

By Floyd Gerald,* N5FG, CQ WAZ Award Manager

6 Meter Worked All Zones

No.	Callsign	Zones needed to have all 40 confirmed
1	N4CH	16,17,18,19,20,21,22,23,24,25,26,28,29,34,39
2	N4MM	17,18,19,21,22,23,24,26.28.29,34
3	JI1CQA	2,18,34,40
4	K5UR	2,16,17,18,19,21,22,23,24,26,27,28,29,34,39
5	EH7KW	1,2,6,18,19,23
6	K6EID	17,18,19,21,22,23,24,26,28,29,34,39
7	KØFF	16,17,18,19,20,21,22,23,24,26,27,28,29,34
8	JF1IRW	2,40
9	K2ZD	2,16,17,18,19,21,22,23,24,26, 28,29,34
10	W4VHF	2,16,17,18,19,21,22,23,24,25,26,28,29,34,39
11	GØLCS	1,2,3,6,7,12,18,19,22,23,25,28,30,31,32
12	JR2AUE	2,18,34,40
13	K2MUB	16,17,18,19,21,22,23,24,26,28,29,34
14	AE4RO	16,17,18,19,21,22,23,24,26,28,29,34,37
15	DL3DXX	18,19,23,31,32
16	W5OZI	2,16,17,18,19,20,21,22,23,24,26,28,34,39,40
17	WA6PEV	3,4,16,17,18,19,20,21,22,23,24,26,29,34,39
18	9A8A	1,2,3,6,7,10,12,18,19,23,31
19	9A3JI	1,2,3,4,6,7,10,12,18,19,23,26,29,31,32
20	SP5EWY	1,2,3,4,6,9,10,12,18,19,23,26,31,32
21	W8PAT	16,17,18,19,20,21,22,23,24,26,28,29,30,34,39
22	K4CKS	16,17,18,19,21,22,23,24,26,28,29,34,36,39
23	HB9RUZ	1,2,3,6,7,9,10,18,19,23,31,32
24	JA3IW	2,5,18,34,40
25	IK1GPG	1,2,3,6,10,12,18,19,23,32
26	W1AIM	16,17,18,19,20,21,22,23,24,26,28,29,30,34
27	K1LPS	16,17,18,19,21,22,23,24,26,27,28,29,30,34,37
28	W3NZL	17,18,19,21,22,23,24,26,27,28,29,34
29	K1AE	2,16,17,18,19,21,22,23,24,25,26,28,29,30,34,36
30	IW9CER	1,2,6,18,19,23,26,29,32
31	IT9IPQ	1,2,3,6,18,19,23,26,29,32
32	G4BWP	1,2,3,6,12,18,19,22,23,24,30,31,32
33	LZ2CC	1
34	K6MIO/KH6	16,17,18,19,23,26,34,35,37,40
35	K3KYR	17,18,19,21,22,23,24,25,26,28,29,30,34
36	YV1DIG	1,2,17,18,19,21,23,24,26,27,29,34,40
37	KØAZ	16,17,18,19,21,22,23,24,26,28,29,34,39
38	WB8XX	17,18,19,21,22,23,24,26,28,29,34,37,39
39	K1MS	2,17,18,19,21,22,23,24,25,26,28,29,30,34
40	ES2RJ	1,2,3,10,12,13,19,23,32,39
41	NW5E	17,18,19,21,22,23,24,26,27,28,29,30,34,37,39
42	ON4AOI	1,18,19,23,32
43	N3DB	17,18,19,21,22,23,24,25,26,27,28,29,30,34,36
44	K4ZOO	2,16,17,18,19,21,22,23,24,25,26,27,28,29,34
45	G3VOF	1,3,12,18,19,23,28,29,31,32
46	ES2WX	1,2,3,10,12,13,19,31,32,39
47	IW2CAM	1,2,3,6,9,10,12,18,19,22,23,27,28,29,32
48	OE4WHG	1,2,3,6,7,10,12,13,18,19,23,28,32,40
49	TI5KD	2,17,18,19,21,22,23,26,27,34,35,37,38,39
50	W9RPM	2,17,18,19,21,22,23,24,26,29,34,37
51	N8KOL	17,18,19,21,22,23,24,26,28,29,30,34,35,39
52	K2YOF	17,18,19,21,22,23,24,25,26,28,29,30,32,34
53	WA1ECF	17,18,19,21,23,24,25,26,27,28,29,30,34,36
54	W4TJ	17,18,19,21,22,23,24,25,26,27,28,29,34,39
55	JM1SZY	2,18,34,40
56	SM6FHZ	1,2,3,6,12,18,19,23,31,32
57	N6KK	15,16,17,18,19,20,21,22,23,24,34,35,37,38,40
58	NH7RO	1,2,17,18,19,21,22,23,28,34,35,37,38,39,40
59	OK1MP	1,2,3,10,13,18,19,23,28,32
60	W9JUV	2,17,18,19,21,22,23,24,26,28,29,30,34
61	K9AB	2,16,17,18,19,21,22,23,24,26,28,29,30,34
62	W2MPK	2,12,17,18,19,21,22,23,24,26,28,29,30,34,36
63	K3XA	17,18,19,21,22,23,24,25,26,27,28,29,30,34,36
64	KB4CRT	2,17,18,19,21,22,23,24,26,28,29,34,36,37,39
65	JH7IFR	2,5,9,10,18,23,34,36,38,40
66	K0SQ	16,17,18,19,20,21,22,23,24,26,28,29,34
67	W3TC	17,18,19,21,22,23,24,26,28,29,30,34
68	IKØPEA	1,2,3,6,7,10,18,19,22,23,26,28,29,31,32
69	W4UDH	16,17,18,19,21,22,23,24,26,27,28,29,30,34,39
70	VR2XMT	2,5,6,9,18,23,40
71	EH9IB	1,2,3,6,10,17,18,19,23,27,28
72	K4MQG	17,18,19,21,22,23,24,25,26,28,29,30,34,39
73	JF6EZY	2,4,5,6,9,19,34,35,36,40
74	VE1YX	17,18,19,23,24,26,28,29,30,34
75	OK1VBN	1,2,3,6,7,10,12,18,19,22,23,24,32,34
76	UT7QF	1,2,3,6,10,12,13,19,24,26,30,31
77	K5NA	16,17,18,19,21,22,23,24,26,28,29,33,37,39
78	I4EAT	1,2,6,10,18,19,23,32
79	W3BTX	17,18,19,22,23,26,34,37,38
80	JH1HHC	2,5,7,9,18,34,35,37,40,
81	PY2RO	1,2,17,18,19,21,22,23,26,28,29,30,38,39,40

Satellite Worked All Zones

No.	Callsign	Issue date	Zones Needed to have all 40 confirmed
1	KL7GRF	8 Mar. 93	None
2	VE6LQ	31 Mar. 93	None
3	KD6PY	1 June 93	None
4	OH5LK	23 June 93	None
5	AA6PJ	21 July 93	None
6	K7HDK	9 Sept. 93	None
7	W1NU	13 Oct. 93	None
8	DC8TS	29 Oct. 93	None
9	DG2SBW	12 Jan. 94	None
10	N4SU	20 Jan. 94	None
11	PAØAND	17 Feb. 94	None
12	VE3NPC	16 Mar. 94	None
13	WB4MLE	31 Mar. 94	None
14	OE3JIS	28 Feb. 95	None
15	JA1BLC	10 Apr. 97	None
16	F5ETM	30 Oct. 97	None
17	KE4SCY	15 Apr. 01	10,18,19,22,23, 24,26,27,28, 29,34,35,37,39
18	N6KK	15 Dec. 02	None
19	DL2AYK	7 May 03	2,10,19,29,34
20	N1HOQ	31 Jan. 04	10,13,18,19,23, 24,26,27,28,29, 33,34,36,37,39
21	AA6NP	12 Feb. 04	None
22	9V1XE	14 Aug. 04	2,5,7,8,9,10,12,13, 23,34,35,36,37,40
23	VR2XMT	01 May 06	2,5,8,9,10,11,12,13,23,34,40

CQ offers the Satellite Work All Zones award for stations who confirm a minimum of 25 zones worked via amateur radio satellite. In 2001 we "lowered the bar" from the original 40 zone requirement to encourage participation in this very difficult award. A Satellite WAZ certificate will indicate the number of zones that are confirmed when the applicant first applies for the award.

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

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

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

By Dr. H. Paul Shuch,* N6TX

DR. SETI'S STARSHIP

Searching For The Ultimate DX

Light Speed

Tuning the bands in search of an interstellar CQ, we become aware that the universe is immense. When contemplating its magnitude, we need a whole new yardstick. For astronomers, that yardstick is the light year (LY), the distance light travels in one year.

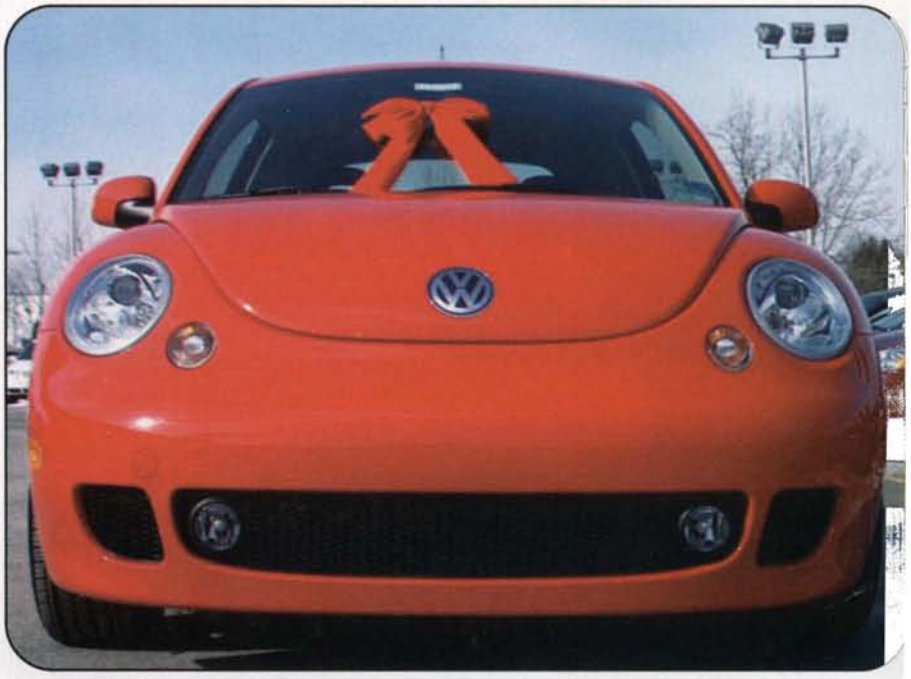
However, that doesn't tell us very much, does it? I mean, how many of us can close our eyes and visualize the speed of light? I can't. I can board an airliner and know that I am traveling at, say, 78 percent the speed of sound, but even that velocity challenges my comprehension.

Just how fast does light travel, how far does it go in a year, and how can we use that knowledge to assess our place in the universe? I could tell you that a light year is a quarter of the distance to the nearest star. However, from my vantage point under this ocean of air, one star looks pretty much as remote as the next, so that doesn't clarify things at all.

Still, Mach 1, the speed of sound, is a familiar concept to most of us. We know that if we see a lightning flash and then 5 seconds later we hear the thunder roar, the storm must be about a mile away. We know this because sound travels at about one fifth of a mile per second, and light (at least over such limited distances) seems to arrive instantaneously.

Well, in fact, light travels about a million times faster than sound, so we can quantify the speed of light, very approximately, as Mach 1 million. Thus, a light year is about how far we'd go in a million years, traveling at Mach 1, or how far the Concorde (which flew at Mach 2) would have gone in 500,000 years—if it didn't have to stop for gas.

Of course, we all have to stop for gas, sooner or later. My little Volkswagen Beetle gets about 30 miles to the gallon on a good day. Just how many gallons of fuel would I need to drive a light year, and how many times would I have to stop to fill up?



Dr. SETI's spacecraft orbits the sun at about one 10-thousandth the speed of light. Its fuel economy is 200-billion gallons per light year (see text).

The textbooks tell us that one LY is about 6-trillion miles. Let's see if we can sink our teeth into that one. Well, 6 trillion is 6,000 billion, so at 30 miles per gallon, we merely need to divide 6,000 by 30 (that equals 200) and then tack a billion on the end.

Okay, 200-billion gallons of fuel. A 20-gallon gas tank means we need to fill up (let's see, 200 billion divided by 20 equals…) 10-billion times. How long do you suppose that will take us?

Each gas stop consists of pumping the petrol, paying for it, visiting the rest-room, grabbing a cup of coffee, and maybe making a phone call to home to keep the spouse apprised of our progress. Let's say 12 minutes per pit stop. That's 5 to the hour, which means we spend—let's see now, 10 billion divided by 5 equals—2-billion hours spent at interstellar service plazas. I wonder what that is in years?

Now there are 24 hours in a day and 365 days in a year. Multiplying the two together, we see that a year consists of just under 10-thousand hours. (I told you this would be approximate.) Dividing 2 billion by 10,000, we find we're spending 20,000 years just fueling up. That's for a hypothetical one light-year trip, and we haven't even begun to calculate the driving time!

Were this space ship on which we reside traveling at the speed of light, it would, of course, travel one LY in exactly one Earth year. In fact, however, Earth is a slow boat to nowhere. Is it possible that during its brief history our planet has traveled light years?

Actually, it has, if you count its curved path around our sun. Let's calculate the Earth's annual orbit in light years:

We start with the known fact that it takes 8 minutes for sunlight to reach us. (We know this because when we flip the switch to turn off the sun, it takes 8 minutes for the sky to go dark.) Well that places the Earth 8 minutes from

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

its source of power, so we'll use 8 light minutes for our orbital radius.

One trip around the sun takes us just a year. Not counting the sun's own motion around the galactic center, the distance we travel in a year is (pi times diameter equals ... two pi times radius, equals ...) 50 light minutes. Rounding up, we'll call it a light hour.

Since Earth travels about a light hour per year, and a year is almost 10,000 hours long (remember?), we can wee that we're orbiting the sun at one 10-thousandth the speed of light, or Mach 100. Did you realize that you live on a supersonic spacecraft? Furthermore, we see that in about the last 10,000 years our planet has traveled about one light year.

Ten thousand years ... let's see. That's about how long it's taken us humans to advance from primitive hunter-gatherers to ... primitive hunter-DXers.

What does all of this have to do with interstellar communications and the search for radio signals in space? Actually, more than a bit. Let's imagine our planet as a starship. We somehow manage to snap the gravitational rubber-band that binds us to our sun, and we shoot off in a straight line, toward the stars. Here we go, at one 10-thousandth the speed of light. It takes us 10,000 years to travel one LY. If we're lucky enough to be shooting off in the right direction, it takes us about 40,000 years to reach the next nearest star. And if we visit about a thousand stars, we're likely to find one being circled by a habitable planet. This means that shopping for a new home could take us 40-million years, give or take.

Is it any wonder that some of us choose to embrace electromagnetic communications, rather than merely going there?

73, Paul, N6TX

Advertisers' Index

It's easy to advertise in CQ VHF. Let me know what I can do to help.
Don Allen, W9CW, (217) 344-4570 or FAX (217) 344-4575
e-mail:ads@cq-amateur-radio.com

ANAHEIM, CA
(Near Disneyland)
933 N. Euclid St., 92801
(714) 533-7373
(800) 854-6046
Janet, KL7MF, Mgr.
anaheim@hamradio.com

BURBANK, CA
1525 W. Magnolia Blvd, 91506
(818) 842-1786
(800) 854-6046
Eric, K6EJC, Mgr.
Magnolia between
S. Victory & Buena Vista
burbank@hamradio.com

OAKLAND, CA
2210 Livingston St., 94606
(510) 534-5757
(800) 854-6046
Mark, WI7YN, Mgr.
I-880 at 23rd Ave. ramp
oakland@hamradio.com

SAN DIEGO, CA
5375 Kearny Villa Rd., 92123
(858) 560-4900
(800) 854-6046
Tom, KM6K, Mgr.
Hwy. 163 & Claremont Mesa
sandiego@hamradio.com

SUNNYVALE, CA
510 Lawrence Exp. #102, 94085
(408) 736-9496
(800) 854-6046
Howard, W6HOC, Mgr.
So. from Hwy. 101
sunnyvale@hamradio.com

NEW CASTLE, DE
(Near Philadelphia)
1509 N. Dupont Hwy., 19720
(302) 322-7092
(800) 644-4476
Rick, K3TL, Mgr.
RT.13 1/4 mi., So. I-295
newcastle@hamradio.com

PORTLAND, OR
11705 S.W. Pacific Hwy.
97223
(503) 598-0555
(800) 854-6046
Leon, W7AD, Mgr.
Tigard-99W exit
from Hwy. 5 & 217
portland@hamradio.com

DENVER, CO
8400 E. Iliff Ave. #9, 80231
(303) 745-7373
(800) 444-9476
John, N5EHP, Mgr.
denver@hamradio.com

PHOENIX, AZ
1939 W. Dunlap Ave., 85021
(602) 242-3515
(800) 444-9476
Gary, N7GJ, Mgr.
1 mi. east of I-17
phoenix@hamradio.com

ATLANTA, GA
6071 Buford Hwy., 30340
(770) 263-0700
(800) 444-7927
Mark, KJ4VO, Mgr.
Doraville, 1 mi. no. of I-285
atlanta@hamradio.com

WOODBRIDGE, VA
(Near Washington D.C.)
14803 Build America Dr. 22191
(703) 643-1063
(800) 444-4799
Steve, W4SHG, Mgr.
Exit 161, I-95, So. to US 1
woodbridge@hamradio.com

SALEM, NH
(Near Boston)
224 N. Broadway, 03079
(603) 898-3750
(800) 444-0047
Chuck, N1UC, Mgr.
sales@hamradio.com
Exit 1, I-93;
28 mi. No. of Boston
salem@hamradio.com

12 STORE BUYING POWER

Manufacturers Day in Salem NH–Aug 2
Special one day only pricing
ALL 12 HRO STORES
(Salem only) – Hourly Prize
– Meet Mfr. Reps
– See the latest gear
– Refreshments
10:00 - 5:30 p
(no purch necessa

HAM RADIO OUTLET®

WORLDWIDE DISTRIBUTION

Hot Summer Deals From Yaesu thru 7-31

YAESU

FT-897D VHF/UHF/HF Transceiver

- HF/6M/2M/70CM • DSP Built-in
- HF 100W (20W battery)
- Optional P.S. + Tuner • TCXO Built-in

Call Now For Our Low Pricing!

FT-817ND HF/VHF/UHF TCVR

- 5W @13.8V ext DC • USB, LSB, CW, AM, FM
- Packet (1200/9600 Baud FM) • 200 mems
- built in CTCSS/DCS • TX 160-10M, 6M, 2M, 440
- Compact 5.3" x 1.5" x 6.5", 2.6 lbs
- FNB-85 NiMH battery + NC-72B included

Call Now For Low Pricing!

FT-8800R 2M/440 Mobile

- V+U/V+V/U+U operation
- V+U full duplex • Cross Band repeater function
- 50W 2M 35W UHF
- 1000+ Memory channels
- WIRES ready

Call Now For Low Pricing!

VX-2R 2M/440 HT

- World's smallest Dual-band HT w/ wide RX
- 1.5 W RF output
- WiRES compatible
- 1300 Memory channels

Call For Low Price!

FT-60R

- 2m/440 HT
- 5W Wide-band receive
- CTCSS/DCS Built-in
- Emergency Auto ID

Low Price!

VX-7R/VX-7R Black

50/2M/220/440 HT

- Wideband RX - 900 Memories
- 5W TX (300mw 220Mhz)
- Li-Ion Battery
- Fully Submersible to 3 ft.
- Built-in CTCSS/DCS
- Internet WIRES compatible

Now available in Black!

VX-6R

2M/220/440HT

- wideband RX – 900 memories
- 5W 2/440 , 1.5W 220 MHz TX
- Li-ION Battery - EAI system
- Fully submersible to 3 ft.
- CW trainer built-in

NEW Low Price!

VX-150

2M Handheld

- Direct Keypad Entry
- 5w output
- 209 memories
- Ultra Rugged

$10. + FREE extra FNB-64 battery

Call Now For Special Pricing!

FT-857D

Ultra compact HF, VHF, UHF

- 100w HF/6M, 50w 2M, 20w UHF
- DSP included • 32 color display
- 200 mems • Detachable front panel (YSK-857 req

Call for Low Price!

FT-7800R 2M/440 Mobile

- 50w 2m, 40w on 440mHz
- Weather Alert
- 1000+ Mems
- WIRES Capability
- Wideband Receiver (Cell Blocked)

$15.

Call Now For Your Low Price!

FT-2000 HF + 6M tcvr

- 100 W w/ auto tuner • built-in Power supply
- DSP filters / Voice memory recorder
- 3 Band Parametric Mic EQ • 3 IF roofing filters

Call Now For Low Pricing!

FT-8900R Quadband Transceiver

- 10M/6M/2M/70CM • Wires capable
- 800+ memories • Built-in CTCSS/DCS
- Remotable w/optional YSK-8900

Call Now For Special Pricing

AZ, CA, CO, GA, VA residents add sales tax. Prices, specifications, descriptions, subject to change without notice.

Look for the HRO Home Page on the World Wide Web
http://www.hamradio.com

COAST TO COAST FREE SHIPPING
UPS - Most Items Over $100
Rapid Deliveries From The Store Nearest To You!

YAESU NOW PRESENTS THE THIRD GENERATION ULTRA-COMPACT HAND-HELD FM TRANSCEIVER

The Third Generation Ultra-compact Handheld, VX-3R, is loaded with more new convenient and enjoyable features — "AA" Battery Operation*, FM Stereo Broadcast Reception, Internal Bar Antenna for the AM Broadcast Band. Yaesu again leads the world of Compact Hand Held Transceivers!! The supplied High-Capacity Lithium-ion Battery (FNB-82LI) is compatible with the VX-2R. Handy to upgrade!

* Optional 3 x "AA" Cell Battery Case FBA-37 (Batteries not supplied)

ULTRA COMPACT 2 m/70 cm
DUAL BAND FM HANDHELD

VX-3R

- Ultra-Compact (1.9" x 3.2" x 0.9") and Light Weight! (4.6 oz)
- Rugged Aluminum Die-cast Chassis
- 1.5 W Output w/Internal Battery (70 cm : 1 W)
  3W Output w/External DC (70 cm : 2 W)
- High-Capacity Super-thin Tiny Lithium-ion Battery with Charger (supplied)
- The Optional FBA-37 Permits Convenient Operation with AA Batteries ("AA" x 3)
- Special Memory Banks :
  WX Broadcast, VHF Marine, Short-wave Broadcast Stations
- Huge 1286-channel Memory Capacity
  24 Memory Banks x 100 ch
- Wide-band Receiver Coverage (Cellular-band Blocked)
- Internal Bar Antenna for AM Broadcast Band
- Separate Broadcast Band Earphone Jack for a Stereo Headset or Earphone
- AF Dual (Sub RX) Function : Listen to Your Favorite AM or FM Stereo Broadcast Station and Monitor the Amateur Band at the Same Time
- New Mechanical Dial Lock Function
- CW Learning and Training Feature
- EAI (Emergency Automatic ID) Function
- WiRES-II® Internet Key
- Short Text Messaging Function

Actual Size

5 W Ultra-Rugged, Submersible 6 m/2 m/70 cm Tri-Band FM Hand held
VX-7R/VX-7RB
(220 MHz: 300 mW)

5 W Heavy Duty Submersible 2 m/70 cm Dual Band FM Hand held (220 MHz: 1.5 W)
VX-6R

5 W Heavy Duty 2 m/70 cm Dual Band FM Hand held
FT-60R

5 W Heavy Duty Submersible 2 m FM Mono Band Hand Helds
VX-120 VX-127
70 cm FM Mono Band Hand Helds
VX-170 VX-177
2 m Mono Band
70 cm Mono Band

Ultra-Rugged 5 W Full Featured 2 m FM Hand helds
VX-150/VX-110

YAESU
Choice of the World's top DX'ers

Vertex Standard
US Headquarters
10900 Walker Street
Cypress, CA 90630 (714)827-7600

For the latest Yaesu news, visit us on the Internet:
http://www.vertexstandard.com

Specifications subject to change without notice. Some accessories and/or options may not be available in all areas. Frequency coverage may differ in some countries. Check with your local Yaesu dealer for specific details.

Imagine the Future of the Mobile Radio ...
It's Now All Yours ! ... YAESU FTM-10SR

2 m/70 cm Band
FM Dual Band Transceiv
(2 m 10 W/ 70 cm 7 W)
FTM-10SR

IP57
Submersible
3 feet for 30 min
Body/Front panel

Great New Features to Support Outdoor Motor Sports Activities
Mobile Transceiver... Great Appearance ...Easy to Operate

2 m/70 cm Band
FM Dual Band Transceiver
(2 m 50 W/ 70 cm 40 W)
FTM-10R

IP57
Submersible
3 feet for 30 min
Front panel

2 m Band

50 W 2 m Ultra Rugged
VHF FM Mobile
FT-1802M

2 m Band

65 W 2 m Rugged FM Mobile
FT-2800M

QUAD BAND
DUAL RECEIVE

50 W 10 m/6 m/2 m/70 cm*
Quad Band FM Mobile
FT-8900R
*70 cm 35 W

DUAL BAND
DUAL RECEIVE

50 W 2 m/70 cm*
Dual Band FM Mobile
FT-8800R
*70 cm 35 W

DUAL BAND

50 W 2 m/70 cm*
Dual Band FM Mobile
FT-7800R
*70 cm 35 W

YAESU
Choice of the World's top DX'e

Vertex Standard
US Headquarters
10900 Walker Street
Cypress, CA 90630 (714)827-7

For the latest Yaesu news, visit us on the Internet:
http://www.vertexstandard.com

Specifications subject to change without notice. Some accessories and/or options may not be available in all areas. Frequency coverage may differ in some countries. Check with your local Yaesu dealer for specific details.