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# CQ VHF
## Ham Radio Above 50 MHz

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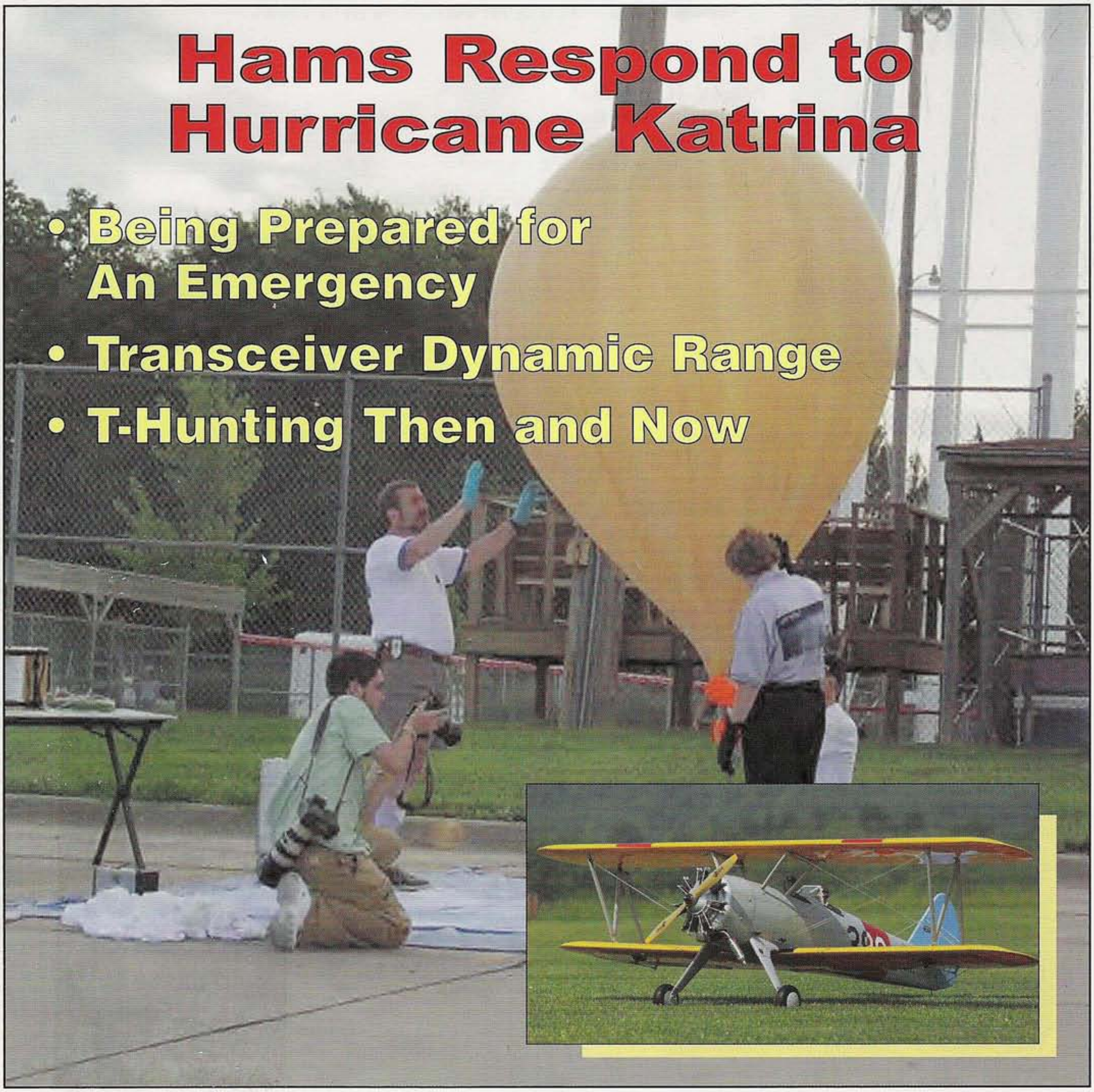
Fall 2005

$6.50

# Hams Respond to Hurricane Katrina

- Being Prepared for An Emergency
- Transceiver Dynamic Range
- T-Hunting Then and Now



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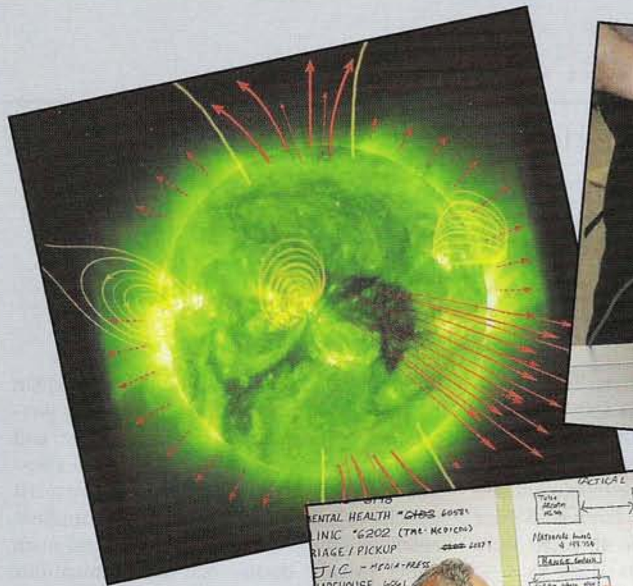
## *FEATURES*





## COLUMNS



## DEPARTMENTS



**On The Cover:** At the Great Plains Super Launch 2005, a team fills its 1500-gram weather balloon in preparation for flight. Left to right: Reporter from the *Omaha World-Herald*; Keith Kaiser, WAØTJT; Cindy Campbell, KCØRRW; and Mike Hackley, KCØSGD. For details see page 10. Inset: Premiering this month is "Airborne Radio," a column by K1UHF that covers controlling model aircraft via amateur radio; see page 21.

CQ VHF Ham Radio Above 50 MHz

# LINE OF SIGHT

## A Message from the Editor

# Emergency Communications: Amateur Radio's Evolving Involvement

During these past few months we have witnessed the use of our hobby as backbone communications in the aftermath of disastrous hurricanes. Amateur radio operators from all over the country have been pressed into duty in a variety of communications services.

Two such examples are described starting on page 6, where Mark Conklin, N7XYO, reports on Oklahoma amateur radio operators' involvement, both in rescue operations and in being the backbone communications for the Camp Gruber evacuation site. For the latter, amateur radio operations became critical at the Camp Gruber site, as the following quote illustrates:

> Shortly before 10 AM Sunday, Steve Palladino, an Emergency Management Officer for the Oklahoma Department of Emergency Management, arrived in the incident command. Oklahoma has spent millions of dollars on equipment that would allow interoperability of communications. When I asked Palladino if the interoperability communications trailer (known as ECHO 1) was coming, Steve told me that it was "out of pocket," which is what happened to many of the "first in" resources from some agencies in our area. "Out of pocket" means that they were deployed to the major disaster in the Gulf region. Palladino and I spent a few minutes covering where we had or would have operators. He said, "You guys are great. Thanks for jumping in to help." I asked him how long he would expect to need amateur radio. Palladino replied, "for the duration."

As Mark illustrates, a specific number of hams strategically placed within the evacuation center replaced a multimillion-dollar communications van. Plus, no doubt they provided more flexibility in handling the interoperability needs at the site.

## The Baseline

In many respects, amateur radio emergency communications can look to the Oklahoma City Murrah building bombing as a baseline for measuring the assistance we can and have rendered over the years. Before the bombing, many times our involvement with various government and non-government organizations (NGOs) was by happenstance. Lack of experience in working with hams led to reluctance to use us, and in some cases outright mistrust of us and our intentions. These reactions were not unfounded, as sometimes we hams invited ourselves into the disaster communications situation without prior approval from or awareness of those government and NGO operators on the scene. Even with prior approval, sometimes those on the scene were reluctant to cooperate with us or use us.

Considering the latter, but for some serendipity such might have been the case in my emergency operations from the Oklahoma City Police Department mobile EOC van in the aftermath of the Murrah building bombing. When I arrived downtown, I was instructed by the emergency net control operator to report to the van and join the amateur radio operator already on board. While walking over to the van, I wondered how I was to explain to the police officers my being assigned to their van. My concerns were eliminated when Stan Van Nort, N5JFQ, greeted me at the door and invited me inside. Stan was one of the police officers operating the police radios, and his approval of my entrance set the other police officers at ease with my presence. After finding the location of the ham station, I immediately went to work with the other amateur radio operator, supplying information to the police as to the locations of the various NGOs inside the disaster perimeter.

## The Aftermath

In the aftermath of the Murrah building bombing, we amateur radio operators who worked that disaster held a debriefing meeting a few weeks later at the Green Country Hamfest. One of the issues we discussed was what it was like to be so intricately involved with several government and NGO agencies at the same time. The problems of interoperability and even the various organizations' lack of knowledge of who was doing what inside the perimeter were among the topics we covered. Another issue discussed was the uselessness of cell phones in the immediate aftermath of the bombing. For us, it was very productive, and several of us later found out that many of the lessons we learned were implemented by the amateurs who responded to the September 11, 2001 terrorist attacks.

In the ensuing weeks and months following the disaster one item we noticed was that while the Salvation Army championed our involvement (both during and in the aftermath debriefings), there was still much skepticism by other NGOs, as well as the various government agencies involved in the disaster and its aftermath. Sadly, it was during the aftermath of the September 11, 2001 terrorist attacks when more and more government agencies and NGOs recognized—and even come to rely upon—our communications skills. Even so, widespread recognition was slow in coming.

Thanks to the huge education and lobbying efforts by the ARRL, we received the well-earned recognition and backing from the Department of Homeland Security. Now, Hurricanes Katrina and Rita have become our proving grounds. As Mark illustrates in his article, for the most part hams were and are responding very well. Even so, there continue to be a few instances of Lone-Ranger-type responses by hams who are not trained or prepared for emergencies. Such responses continue to hamper our increasingly positive image, which we should never stop presenting to the rest of the world.

We will have lots to learn from the many debriefings that will occur in the aftermath of these disasters. One item already being discussed is the problem of lack of interoperable communications between various responders to the disasters. What Mark tells us by way of his article is that interoperability of communications continues to be a major problem for emergency responders—and no doubt will continue to be problematic for quite some time to come.

The question for us hams is: Will we continue to be equipped to fill the void? I believe we can be. Furthermore, articles such as Mark's in *CQ VHF* can and will play a role in our emergency communications education. Therefore, I will be looking for these types of stories, as well as how-to articles related to emergency communications, for future issues of this magazine. I am especially interested in articles that describe the various creative ways in which the VHF-plus frequencies have been and can be utilized for emergency communications. Therefore, if you have a unique story to tell that will be of benefit to your fellow emergency-response amateur radio operators, please contact me with your story idea and we will give consideration to publishing it.

Until the next issue...

73 de Joe, N6CL

# Oklahoma Amateurs Respond to Hurricane Katrina

In response to the devastation caused by Hurricane Katrina, hams all over the country were pressed into service to provide necessary communications. Here N7XYO describes the roles that Oklahoma amateur radio operators played, both in a rooftop rescue and in providing backbone communications at the Camp Gruber emergency shelter for persons displaced by the hurricane.

**By Mark Conklin,* N7XYO**

There were 15 people trapped on the roof of their home in New Orleans as the flood waters from Hurricane Katrina raged by on August 29. They clung to the roof and watched as others floated by in the rushing flood waters. They had a cell phone, but none of the local emergency numbers worked. They called a relative in Baton Rouge. Because the local emergency numbers in Baton Rouge also were not working, that relative called Sybil Hayes, a relative living in Broken Arrow, Oklahoma.

Hayes had been worried about her 81-year-old aunt and her cousins in New Orleans all day as she watched the coverage of the storm. She tried and tried to call her aunt, but all circuits were busy. Then her phone rang; it was the call from the relative in Baton Rouge giving her the news of her elderly aunt.

Sybil knew that the Red Cross could help, because the Red Cross had helped her family during a flood in 1995. She immediately contacted the Tulsa Oklahoma Chapter of the Red Cross.

The Tulsa Chapter of the Red Cross Emergency Services, which has a partnership with the Tulsa Repeater Organization (TRO is a Tulsa-area amateur radio group dedicated to public service), had a plan. Red Cross emergency services put the plan into action and contacted response team member Paul Papke, WB5MPU.

Papke is a Red Cross volunteer and an amateur radio operator. Papke then rounded up Ben Joplin, WB5VST, to help get the message through. Joplin immediately went to the Tulsa Red Cross Emergency Operations Center, which has a fantastic HF station ready for action.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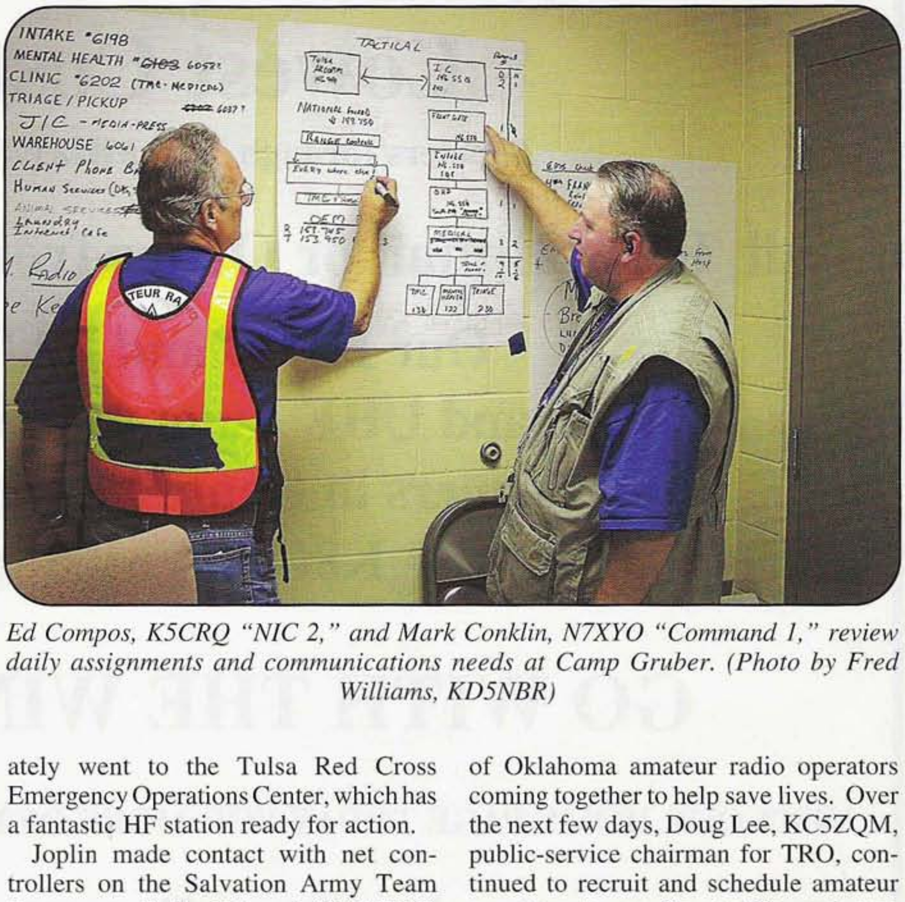


*Ed Compos, K5CRQ "NIC 2," and Mark Conklin, N7XYO "Command 1," review daily assignments and communications needs at Camp Gruber. (Photo by Fred Williams, KD5NBR)*

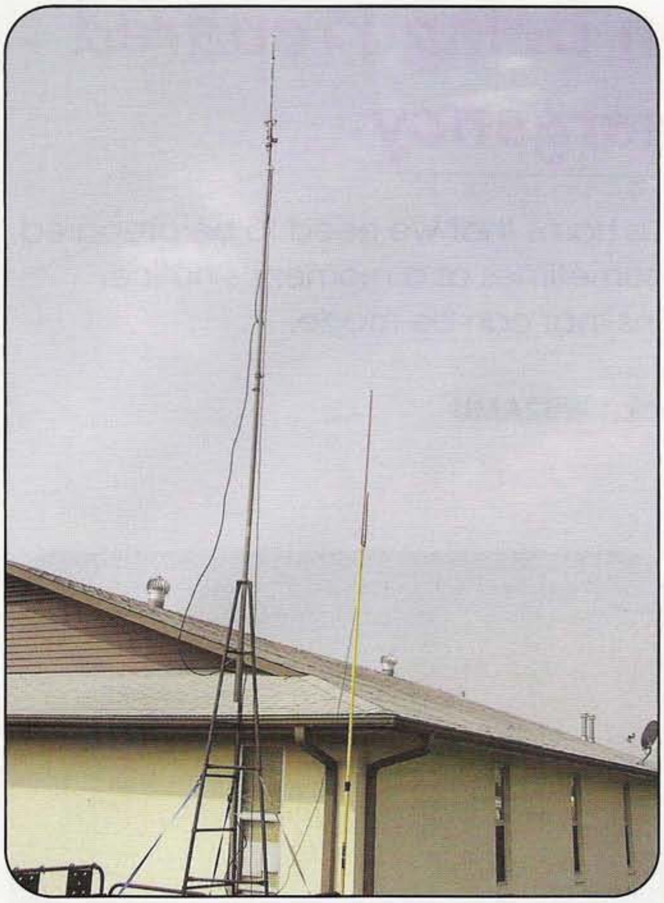
Joplin made contact with net controllers on the Salvation Army Team Emergency Radio Network (SATERN) on 14.265 MHz. The emergency traffic went from Tulsa to Oregon to operators in Idaho to Amateur Radio Emergency Service stations in New Orleans, who alerted the Louisiana rescuers.

"When all else fails, amateur radio works" is more than a catchy tag line. It's a lifeline. At about 10 PM the Red Cross reported that Sybil Hayes's 81-year-old aunt and everyone on that roof were safe and at a Red Cross shelter.

This is only one of many such stories of Oklahoma amateur radio operators coming together to help save lives. Over the next few days, Doug Lee, KC5ZQM, public-service chairman for TRO, continued to recruit and schedule amateur operators to monitor traffic and pass emergency messages from the Tulsa Red Cross communications center to rescuers in the disaster area. Then the Tulsa Red Cross received word that Texas was full.

## Texas is Full?

On Friday September 2, Oklahoma was notified that approximately 6000 evacuees were being sent from the Houston, Texas area to Oklahoma City and Tulsa. The Oklahoma Department of Emer-



*A portable mast system from Paul Papke, WB5MPU, made quick work of setting up at Camp Gruber. Notice the "fold-up" J-pole and push-up mast provided by Robert Coughlin, KE5BGX, which went up in a snap. (All photos by the author unless otherwise noted)*

gency Management (ODEM) started working with emergency managers and the mayors of both cities to form an emergency-reaction plan.

Rather than house the evacuees inside convention centers or other large buildings that had not been designed for that purpose, the plan was that evacuees would first be sent to Camp Gruber in Braggs, Oklahoma and to Falls Creek church camp in Davis, Oklahoma, located in the southern part of the state. Camp Gruber is an Oklahoma National Guard Training campus in the eastern part of the state.

The Red Cross would run shelter operations at Camp Gruber; Baptist Men's Disaster Relief Ministers would operate the shelter at Falls Creek. Because many of the displaced victims did not want to take another bus ride to anywhere else (after traveling from New Orleans to Baton Rouge and then to Houston), the Falls Creek camp was prepared to accept evacuees, but they never received any. Camp Gruber did.

Amateur radio's initial mission was to maintain a back-up communications link from Camp Gruber to the communications center at Red Cross in Tulsa, some 65 miles northwest of the camp. Late in the evening on Friday and into the wee hours of Saturday, we sent amateurs to Camp Gruber to set up that link. Ed Compos, K5CRQ, made contact with Red Cross Shelter Manager Janell Mullinax and then set up communications inside the incident command center in building #240 of the camp. Using a dual-band VHF/UHF radio, we were able to maintain contact with the Red Cross in Tulsa via the 146.940 TRO repeater in Tulsa. As a back-up to that, the 443.100 Muskogee repeater linked via the Tulsa Amateur Radio Club (TARC) super-link to the 443.850 repeater in Tulsa. To make sure we could contact the state EOC in Oklahoma City, we set up an HF system with an FT-920 and a G5RV antenna. Things seemed to be covered. In any emergency communications operations, events tend to be fluid. It was about to pour at Camp Gruber.

## The Guests Arrive

Shortly after 10:45 PM on Saturday, September 3, 39 bus loads of tired and hungry evacuees began to arrive at Camp Gruber. Many of these people needed medical attention. More than 40 ambulance runs from the camp to area hospitals were required. It quickly was discovered that this was going to be more than a shelter operation. This was going to require a full disaster response. It also was discovered that many of the agencies responding could not communicate with one another.

Many phone and communications systems are designed for some of the people to talk some of the time. In an emergency or disaster, everyone wants to communicate at the same time. Camp Gruber was designed as a National Guard training campus, and some of the buildings have telephones and some do not. The phones that were there operated on a Voice over IP (VoIP) phone network, and when overloaded they crashed.

Because I am the club president of TRO, I ended up as the amateur radio emergency communications leader for this response. During the night (now Sunday morning of September 4) my home phone and cell phone rang all night long with status updates or requests for additional communications support. As daylight began to shine on Camp Gruber, I and a number of additional amateur radio operators were on the road and en route to help at the camp. I contacted our team at Red Cross HQ. I instructed them to round up more volunteers and ask a few more to stand by to respond.

As I drove through the main gate at Camp Gruber, things seemed odd. The camp had the look of many other disasters I had responded to: ambulances with lights flashing, Oklahoma Highway Patrol cars everywhere, Red Cross vans, National Guard troops, and all sorts of responding agencies. What was odd was that all the buildings were neatly numbered and painted, the grass was mowed, and street signs were all clearly visible. It was a strange mix of order and chaos.

I walked into the Incident Command center in building #240 and got fewer than ten steps across the floor when I made contact with a Tulsa Police Officer, Rick Bondie. Bondie, a member of the Tulsa disaster response team and the Oklahoma Department of Emergency Management (ODEM), had dispatched the Tulsa disaster response team to Camp Gruber to take over operations. I had worked with him on other disasters and in training. Bondie and I stepped into a conference room and he gave me a quick briefing. He requested amateur radio support to ensure that all the responding agencies could communicate with one another and all the critical points at the camp had communications.

We were about to grow from three volunteer amateur radio operators to nine, 24/7, for who knew how long. This response was going to take more structure and effort than most public-

*(Continued on page 76)*

# Some Thoughts on Being Prepared for an Emergency

The recent natural disasters have taught us hams that we need to be prepared to render emergency communications—sometimes at a moment's notice. Here WB2AMU discusses some preparations that can be made.

By Ken Neubeck,* WB2AMU

Having lived on Long Island, New York all of my life, on occasion we have had severe hurricanes that have caused extensive damage to the area with winds causing power loss as the result of blown-down power lines. One thing that I cannot stress enough is being thoroughly prepared for a natural disaster such as a hurricane, when typically one has at least two days to prepare.

One experience that I vividly remember occurred on the evening prior to Hurricane Belle's arrival in August of 1976. As a young ham I helped another local ham set up an 80-meter amateur radio station at the local Red Cross headquarters in my town. Although Belle was only a Category 1 hurricane, at that point it was the most damaging hurricane to hit Long Island since Hurricane Carol in 1954.

It took about 30 minutes to set up the 80-meter antenna outside of the headquarters building in the rain and then set up the station inside the headquarters building. The 80-meter station was to be used to interface with other amateur radio groups in the Northeast region. In the meantime, I had a 2-meter setup in my car and I checked into the local 2-meter emergency group with a quick call. The ham I was helping was not particularly interested in 2 meters being another source of communication, as he was concentrating on the 80-meter station. However, as much as he thought that he had the situation under control, he made a number of rookie mistakes that eventually made the 80-meter station useless during the hurricane that came into the area later that night. These mistakes were:

1. He had not formally introduced himself to the local Red Cross group ahead of time to explain how ham radio would be of help during an emergency. The ham operation seemed like an intrusion to the group.

2. He had neglected to bring headphones, and thus the audio from the 80-meter station was causing interference to the Red Cross people, preventing them from listening to their radio and further adding to their annoyance.

3. Most important of all, the 80-meter station was running on commercial AC power, and he had neglected to bring a portable power source such as a generator or battery bank and thus . . . When power went out at midnight, both the 80-meter station and the Red Cross station were rendered useless for a few days until a generator was finally brought to the headquarters.

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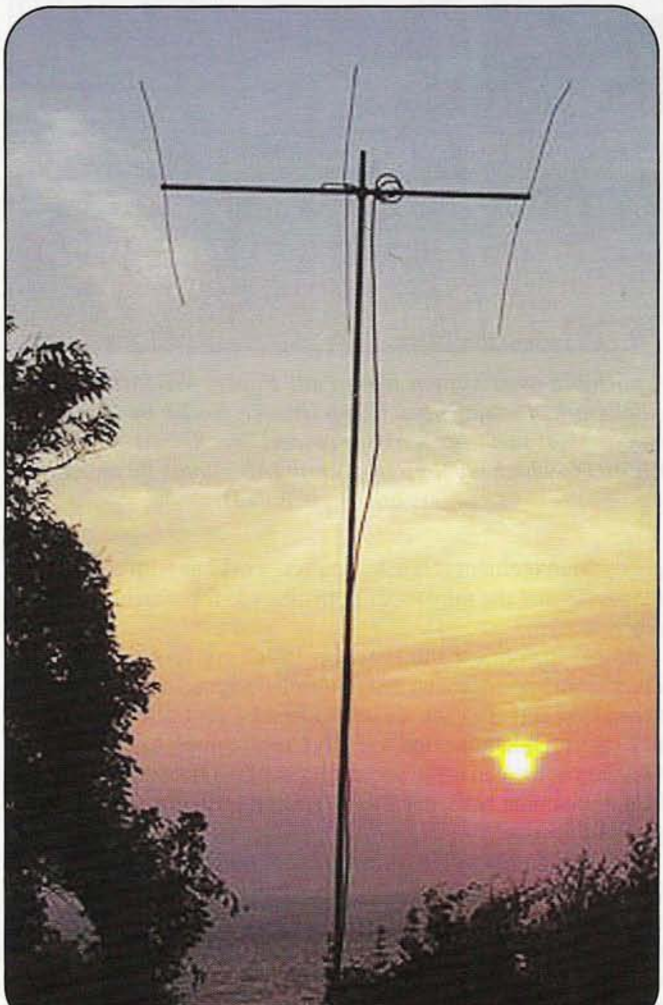


*Field Day is an ideal time for learning how to set up a radio station during emergency conditions. This photo shows the 6-meter antenna as one of the several VHF stations that were set up for the 2005 Field Day effort of the Peconic ARC on the north fork of eastern Long Island. In addition to Field Day, the club participates regularly in simulated emergency exercises such as the ARRL SET events to keep up the level of preparedness. (Photo by WB2AMU)*

The ham radio operator in charge had no Field Day experience, nor did he do much in the way of VHF operation, such as 2-meter FM. Looking back at this particular incident many years later, I can see that as a minimum, any ham who has plans to help out in an emergency should have some practical experience in setting up an emergency station (either for Field Day or VHF portable operation). While HF is one important aspect of communication, it is just as important to have either an all-mode VHF station or a properly operating FM HT.

Each disaster is different. Sometimes there will be a shelter for the ham radio station and sometimes there will not be one. I would like to think that the ham who has had experience with portable operation in the field can either set up from his or her car or in shelter running battery power.

It is most likely that 2 meters will be the logical band for carrying on local coordination, with FM being the mode that most hams will have access to. I think that alternative VHF bands such as 6 meters and 432 MHz could also be used for non-essential communications. In addition, VHF SSB should not be ruled out. HF in the area of 80, 40, or 20 meters will serve a purpose for long-range communications to other states or regions for obtaining any needed medical and logistical supplies.

In my opinion, participation in Field Day is one of the best ways hams can prepare for emergency operations. You learn many things from participating in a number of Field Day events. For example, one thing most hams do is bring headphones for a multi-transmitter operation to lessen the impact of audio noise from stations adjacent to one another. I also feel that those hams who do both rover and portable operations during VHF contests, as well as SET (simulated emergency tests), are doing well in improving their skills!

With a storm such as a hurricane, there is usually a warning at least two days in advance. All batteries for your HTs should be charged, and your vehicle's gas tank, as well as additional tanks (but be careful where you place them), should be filled. The VHF or HF station that you plan to use should be up to operating snuff and easy to remove for portable operation. If you have not already joined up with an emergency group, find out right away which group is in charge. If there is none, form a group with local hams and work out the procedures ahead of time.

This year Hurricane Katrina caused a great amount of damage and tragedy for so many. I am certain that ham radio will continue to distinguish itself as a vital resource during the months of rebuilding ahead. Perhaps, too, as people continue to see the good that amateur radio can do in times of emergency, there will be an increase in the number of those who want to join our ranks. It is important that the public see a well-prepared amateur radio response, and this is gained from practical experience. All hams would do well to think outside of their base stations and be capable of setting up a VHF station in a portable manner. ■

# CAPNSPACE (Civil Air Patrol Near Space program)

This past July via the Great Plains Super Launch, GPSL-2005, ten groups launched balloons from Traynor, Iowa. Here KCØMIC tells his story.

By Troy Campbell,* KCØMIC

We had three "firsts" this year. (1) This flight marked the first flight made at a GPSL (Great Plains Super Launch). Last year we only observed at GPSL-2004 in the hopes of starting a program. (2) It marked the first flight CAPNSPACE made as a member of the Near Space Ventures group. In conjunction with that, we worked with a Boy Scouts of America venture group. (3) It was the first flight that we recovered without any "outside assistance" (i.e., the farmer didn't find it before we did and call us).

## Launch

At 7:00 AM we arrived at Traynor High School and began setting up. The winds were still light and it was about 70°F. After another group had began to fill their launcher (balloon), we noticed that the wind was just starting to pick up. We decided that we would fill our balloon and be ready for launch should the wind start to pick up any more. It also was decided that we'd put in more lift than we normally would to get the package out of the ground winds and past 40,000 feet faster than normal.

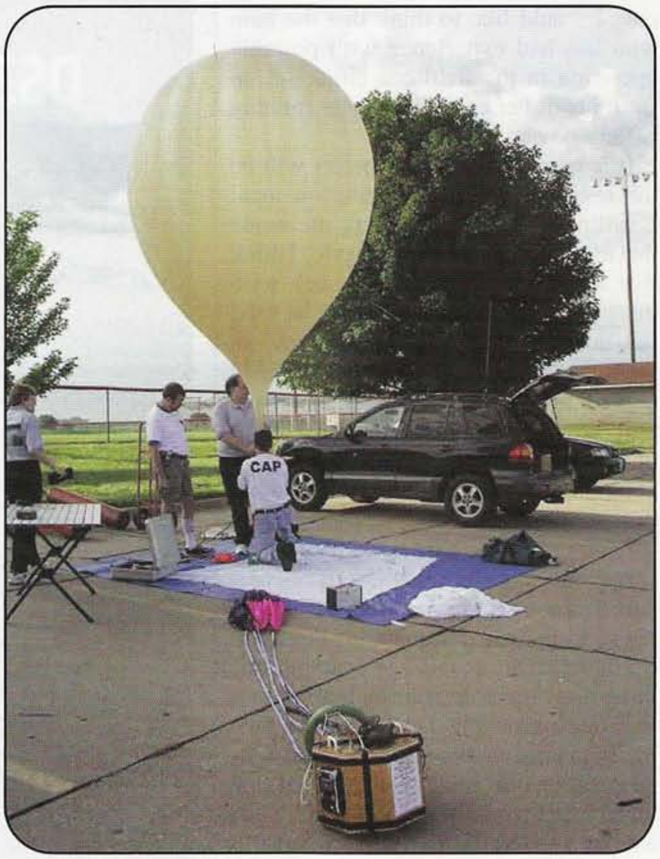
We launched at 8:10 AM CDT, about five minutes after the first launch. The climb rate was about 1100 fpm (that's an estimate until the data from the flight recorder can be analyzed). We packed up and split into three teams, leaving the launch area right after five more teams launched their balloons.

## Tracking

The APRS (automatic position reporting system) telemetry showed that the flight path was following the flight projection fairly closely. Almost immediately after takeoff, the tracking system froze up for chase Team 1. Team 3's tracking equipment never did work. Team 1 rebooted and got some limited functionality for maps and vehicle location, but the KPC 3+ TNC (terminal node controller) stopped working altogether. Chase Team 2's equipment was working perfectly.

At this point, Teams 1 and 2 departed east on highway 92 to highway 71 to stay ahead of the balloon. Team 3 remained to try to get the tracking system working. The 2-meter simplex repeater on board the spacecraft worked great, so all the teams stayed in contact . . . up to a point.

The spacecraft is equipped with an ELT (emergency locator transmitter) on a practice frequency of 121.775 MHz. Every five minutes the flight-control computer would turn on the ELT for one minute. When the spacecraft neared apogee, the flight controller latched on the ELT so that it could be tracked on the way down.

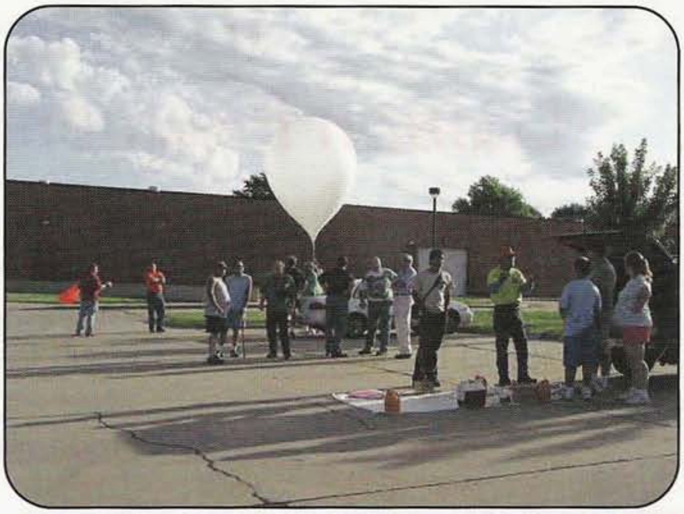


*The launch crew attaches the payload to the launch vehicle (balloon). Left to right: Cindy, KCØRRW (Captain, CAP); Keith, WAØTJT; Troy, KCØMIC (Major, CAP); and kneeling, Mike, KCØSGD (Major, CAP). (Photos by Deb Kaiser)*

The problem was that the ELT modulated the 2-meter simplex repeater. We still don't know if the issue was the proximity of the antennas, or if the ELT or 2-meter transmitter needed to be shielded, or both, or all three. In any case, when the ELT latched "on," the simplex repeater became pretty much useless. It would still key up, but whatever voice traffic was on it was drowned out by the ELT. Because of that, Teams 1 and 2 lost contact with Team 3 about an hour into the flight.

*6933 N. Mercier, Kansas City, MO 64118


*Troy, KCØMIC, readies the payload—near-spacecraft—for flight.*



*Another GPSL teams prepares for launch.*

The tracking equipment of Team 2 (Keith Kaiser, WAØTJT, and Deb Kaiser) was still working fine, so Team 1 (Troy Campbell, KCØMIC, and Cindy Campbell, KCØRRW) stayed within simplex range and both teams stopped just outside Grant. The balloon had pretty much stopped its forward motion over Elliot, and it climbed to 95,082 feet and burst just a little west of Elliot. What was interesting was that if we kept the meter on the ELPER (an emergency locator receiver that is used to determine the position of the ELT) "centered," we could get a fair sense of the elevation as well as the direction. The DFing fixes agreed with the APRS data, which was gratifying. I was worried that we wouldn't be able to track it with only one set of APRS equipment. The ground teams departed for a position between Elliot and Grant.

## Recovery

Keith on Team 2 had binoculars and spotted the balloon at about 3000 feet after it had passed over us, but lost it over a hill. The last APRS position was from 2400 feet at a little past 10:00 AM CDT. We left for that spot. Team 2 was already there and searching a corn field (Iowa = corn, and we probably should have guessed the landing obstacles). Joe Lynch, N6CL, editor of *CQ VHF,* was also on the scene to help with the search.

After a while I broke out the ELPER and took a couple of fixes on the ELT. It was still strong, showing the signal coming from farther north, but basically straight up the road. If you look at the track from the APRS data, you'll see that the package flew up the road and landed within 20 feet of the balloon (for more information on the APRS date, see <http:// www.capnspace.org>). Unfortunately, the corn was taller than I was and the fence propagated the signal in many wonderful ways.

Even though the ELPER was pointing to the package correctly, the terrain was very hilly with intermittently space tree lines, creeks, and terrace ridges. The owner of the farm arrived about midway through the search and attempted to help from the top of his almost two-story harvester, but it was on the ground in the tall corn and just couldn't be seen.

After about $2^1/2$ hours we'd narrowed down the location of the package to a 50-foot patch of corn using an aircraft radio and "body nulling." When I couldn't get a null any longer, I took the antenna off the radio, held it away from me and par-

*(Continued on page 58)*

*Photo of near space taken by the camera on board the payload of the CAPNSPACE balloon. (Photo by KCØMIC)*

# 10 GHz and Up
# Liaison Frequency Observations

As witnessed by this past summer's ARRL 10 GHz and Up Contest, the 10-GHz amateur radio band is enjoying increasing popularity. In this article, WB6NOA describes how members of the San Bernardino Microwave Society, and others, are handling the increased activity in their area of the country.

**By Gordon West,* WB6NOA**

The recent ARRL-sponsored 10 GHz and Up Contest saw more coast-to-coast microwave activity than ever before. In anticipation of wall-to-wall signals on 10 GHz in southern California, fixed and rover stations staked out frequency claims ahead of time! Here is just a small list of how the San Bernardino Microwave Society (SBMS@hamradio.com) spread out its coordinated operations:

| | |
|---|---|
| Baja Mexico | 10,368.450 MHz |
| Signal Hill, near L.A. | 10,368.380 MHz |
| Frasier Mountain, north of L.A. valley | 10,368.525 MHz |
| San Diego mountaintops | 10,368.200 MHz |
| An island off southern California | 10,368.475 MHz |
| San Bernardino mountains east of L.A. | 10,368.400 MHz |

Mountaintop rovers also pre-announced their favorite X-band frequencies.

Throughout the country, 10-GHz teams met at elevated hot spots and consecutively operated their own individual equipment to increase activity, scores, and the personal satisfaction of maximizing the total count of stations each person's little milliwatt rig had worked. The big signals and big dishes went first, allowing the distant station to lock frequency as well as bearings. The team stations then came on individually, usually going from higher power stations down to the pipsqueak stations that ultimately would be heard because all of the team members helped set the direction of the path.

"Multiple team stations helped out one another by letting the lowest power station come into rotation as a long path was beginning to peak," comments Bill Alber, WA6CAX, operating out of the Bay Area.

BadgerContesters (badgercontests-request@mailman.qth.net) echoed the same technique with big-dish, high-power, 10-GHz stations becoming the *moderator* and assisting their hillside team members in establishing a contact when conditions got rough.

## The Liaison Frequency Connection

Until this year, the likelihood of establishing a 10-GHz QSO "in the blind" by calling CQ on 10,368.100 MHz would have been pretty slim. Unlike 144.200 or 432.100 on VHF/UHF SSB, your chances of hooking up with another station that just happened to be on the same frequency and pointing in your direction as you pointed in their direction are hit or miss—more than likely, more miss than hits! Hence, the liaison frequency.

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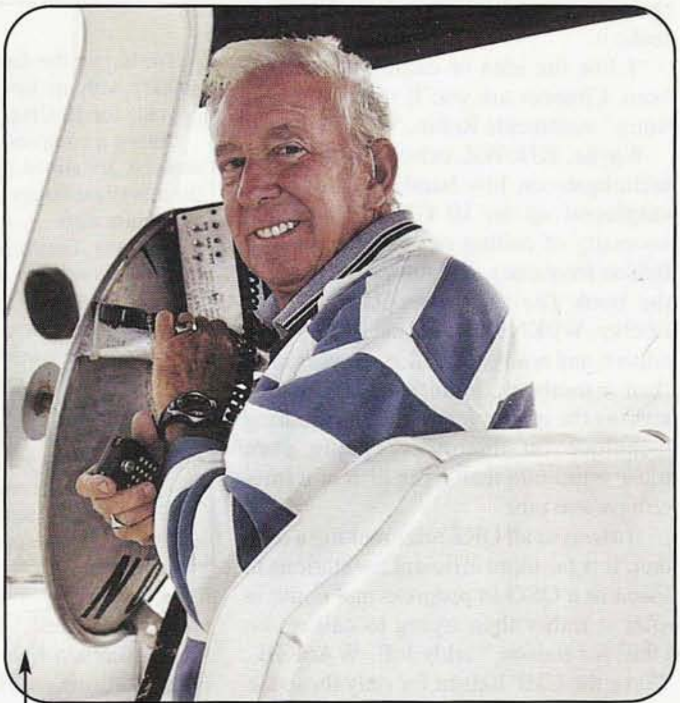
*The author's new 10-GHz antenna for dune-buggy mobile.*

Liaison frequencies likely are 2 meters or 70 cm with your handheld hanging on the dish. Everyone in the area must agree on the liaison frequency, whether it is simplex or duplex through a series of linked repeaters or a single repeater. In southern California linked repeaters were a necessity for some of the nearly 1000-km paths that were being worked on 10 GHz. (Twenty years ago, liaison was on 144.330 MHz simplex for the coordination of our wide-band FM 10-GHz contacts, which rarely exceeded 300 miles!) Even so, there are problems.

While the linked UHF repeater systems worked well for the range extension necessary for distant-station coordination, the combined repeater links, skillfully mixed to eliminate unintelligible doubling, were a test of each operator's skill in listening simultaneously to three or four conversations!

"Everyone was stepping on one another over the coordination channel," comments Bill Alber, WA6CAX, listening in on one of the California links. "Mexico was coordinating with Kettleman, Frasier was talking to Gordo maritime mobile, Site 51 was coordinating with San Diego, and La Canada was looking for any contacts aimed west. This was all going on simultaneously," adds Alber, pleasantly surprised that the liaison instructions indeed got through after a couple of times, and everyone took the QRM as being the way liaison communications take place on linked repeaters.



WB6NOA's 10-GHz maritime mobile setup. One watt and 300-plus miles to Mexico makes him smile!

*Tom, N6DCL, uses a horn antenna with 1 watt over a 100-mile path.*

"Maybe we need an NCS (net control station) who is an experienced microwave operator and is also experienced in coordination and control operator duties," adds Art, KC6UQH, a seasoned 10-GHz homebrewer. "This net controller would not be out operating, but rather paying attention to all the traffic on the band and expertly keeping liaison comms flowing," adds Art. Art feels that each station should check in and out with NCS; the NCS will need to be microwave-knowledgeable so a station checking *in* can be advised on an appropriate contact to try next and then send him off to a particular X-band frequency and approximate bearing.

"Yes, the liaison system is in need of improvements. The net control will solve most of the current problems by knowing who is looking for contacts, who is enroute to another site, who had a dish fall over and is now QRT, and who has a carrier on the air and on what frequency," adds Art. "A net control will reduce continuous chatter. The good net controller can also cut the idle chatter on the liaison frequency, such as a discussion on 3 dB of noise coming out of a local palm tree."

Art further reports that once he starts making contacts on 10 GHz he shuts off the liaison radio. "If I know at 10-minute intervals the net control station will give the status of contacts in progress, and operators looking for contacts, I do not need to continuously monitor the liaison frequency and have that chatter disrupt my train of thought in making a long-range, 10-GHz QSO," adds Art.

"I lost many contacts last year because I was unable to raise anybody at a known group location on the liaison channel—frustrating when I know that a few hundred points worth of contacts are right there if only they would answer the liaison radio," adds Mel, WA6JBD. "It takes considerable effort to repeatedly pack up and move. The liaison contacts must get through with a minimum of repeats and an absolute minimum of unanswered calls by other stations that could likely be easily worked over a long path."

"Maybe it's time we consider the 10-GHz contest operations the way we would consider operating during a 20-meter SSB DX contest. There is so much great activity on the 10-GHz band that we can tail-end stations, work pile-ups, and wait on frequency to see if there are other stations to work," comments Doug, K6JEY. "I think we need to expand our 10-GHz operating procedures to a dual mode where we use both the liaison and low-band techniques, such as tail-ending, calling QRZ or CQ, and listening after a QSO for other stations that might be calling," adds Doug. Several 10-GHz East Coast microwave groups regularly call CQ on 10,368.100. They also say it's common to stand by on "your" assigned frequency and let someone else tail-end on a contact you've just made, and let them make it.

"I like the idea of calling CQ with a horn. Chances are you'll snag more stations," comments Robin, WB6TZA.

Wayne, KH6WZ, echoes some of the techniques on low band that might be employed up on 10 GHz without the necessity of calling out on the crowded liaison frequency. Wayne says to look at the book *The Complete DXer* by Bob Locher, W9KNI. "This book is in its third edition and reads more like a novel rather than a textbook," adds Wayne, underscoring the importance of good operating technique on microwave being even more important than a big dish or a traveling wave tube.

"I always call QRZ after making a contact. It is far more efficient for stations to listen to a QSO in progress and come in after it rather than trying to call up on UHF for liaison," adds Jeff, WA6KBL. "Save the UHF liaison for only those situations when you can't possibly hear the other station without putting up a carrier and aligning both ends. *There are far too many S-9 contacts that take too long because each end sits on X-band with a carrier for a minute at each end, making a total of 2 minutes before the QSO is even made,*" adds Jeff.

"The liaison link gets very busy with many stations overlapping one another. If your audio is low, you might not be heard amidst all the chaos. Have someone check your audio level compared to others on the link," comments W6BY. "Another trick—get to know the people in the club you are working on 10 GHz. If people can associate a face with a call, they respond better," adds W6BY.

"*Most important,* when operating through a repeater or linked repeater system, you need a pair of radios to run full duplex so you can hear yourself over the link to make sure you are not taken out, or doubled, or captured by another station," adds Mel, WA6JBT, indicating his link radio is a mobile in the front of the rig, another mobile near the X-band rig, and even an HT. As a double check he hears himself through the link when activity is high, which is usually all the time!

Finally, the link issue touches some sensitive areas, such as "secret" repeater and link frequencies so just chosen stations can coordinate over long paths, putting newcomer local stations out of the loop. Or worse yet, coordination via cell phone, which indeed negates the friendly ham radio party-line exchanges so everyone else knows what's going on.

Maybe a net control station would assign liaison non-linked repeaters that would cover a specific path with an announcement on the 'main' channel that X and Y will spend the next 15 minutes on a certain repeater attempting to establish a link, and any and all stations are invited to join in after the initial contact is made.

Finally, part one of the contest found me maritime mobile, and while working the link was certainly important, I found that operating the little horn and aiming it at a distant island with an initial callout on the link frequency that I would be calling CQ on .100 was a great way to attract attention and give out additional water grids.

What ideas does your group have for establishing liaison links for 10 GHz and up contacts? ■

### Swinging the Dish

The bigger the dish, the more precisely you must aim it over long paths. I found this out quickly with my new Prodelin .84-meter Ku-band antenna. The feed horn was a precision upgrade for 10 GHz, thanks to Art, KC6UQH.

"Bring a compass and use it! When I am careful in lining up the dish, 99 percent of my contacts are aimed right where they are supposed to be," comments Art, advising me that the new dune-buggy-mounted dish will be much more precise than my traditional Casagrain aluminum dish.

However, beside proper azimuth aiming of a dish, the 10-GHz operator needs to always monitor his relative dish elevation.

"On aiming, don't forget to look *up* a little. Long paths are often enhanced by the Boeing effect, and that effect can peak above the horizon by a couple of degrees," comments Robin, WB6TZA, speaking of the common occurrence of aircraft 10-GHz scatter signals.

"I have worked dozens of contacts and can enhance some of the other long hauls by an enormous amount by slight azimuth realignment and a 2-degree uptilt to maximize signals," adds Robin. "This does not mean that an oblique angle cannot be used. It is just much more difficult, as both stations have to track a moving target that is probably much closer than those used in a 'forward' direction."

Thus, on your next 10-GHz outing do some air-traffic chart calculations, and give your system a 2-degree uptilt to see whether or not you can take advantage of the Boeing effect!

# QUARTERLY CALENDAR OF EVENTS

## Current Contests

**November:** The second weekend of the **ARRL 50 MHz to 1296 MHz EME Contest** is November 12–13.

**January:** The **ARRL VHF Sweepstakes** is scheduled for the weekend of January, the 21–23.

For ARRL contest rules, see the issue of *QST* prior to the month of the contest or the League's URL: <http://www.arrl.org>.

## Calls for Papers

Calls for papers are issued in advance of forthcoming conferences either for presenters to be speakers, or for papers to be published in the conferences' *Proceedings,* or both. For more information, questions about format, media, hardcopy, email, etc., please contact the person listed with the announcement. The following organization conference organizer has announced a call for papers for its forthcoming conference:

**EME Conference 2006:** The EME Conference 2006 will be held in Wuerzburg, Germany on August 25–27. Interested authors are invited to present a paper(s) for the conference. Electronic submissions in Word97, Word2000, Acrobat5 (PDF), or text format will be accepted by e-mail or on CD. Please ask if you are using another format.

If you are interested in writing and/or presenting a paper for the EME Conference 2006, send an e-mail to Rainer Allraun, DF6NA, at: <df6na@df6na.de>. Please contact him as soon as possible with an abstract or even a general idea. This will help the conference team with its planning activities. For more information about the EME Conference 2006 see: <http://www.eme2006.com>.

## Meteor Showers

**November:** The *Leonids* is predicted to peak around 1430 UTC on November 17.

**December:** Two showers occur this month. The first, the *Geminids,* is predicted to peak around 0224 UTC on 14 December. The actual peak can occur 2.5 hours before or after the predicted peak. It has a broad peak and is a good north-south shower, producing an average of 100–110 meteors per hour at its peak.

The second, the *Ursids,* is predicted to peak around 1053 UTC on 22 December. It is an east-west shower, producing an average of greater than 12 meteors per hour, with the possibility of upwards of 90 at its peak.

**January:** The *Quandrantids,* or *Quads,* is a brief, but very active meteor shower. The expected peak is around 1620 UTC on January 3. The actual peak can occur three hours before or after the predicted peak. The best paths are north-south. Long-duration meteors can be expected about one hour after the predicted peak.

For more information on the above meteor shower predictions, see Tomas Hood, NW7US's propagation column on page 69 in this issue of *CQ VHF.* Also visit the International Meteor Organization's website: <http://www.imo.net>.

## Quarterly Calendar

| | |
|---|---|
| Nov. 2 | New Moon |
| Nov. 6 | Very poor EME conditions |
| Nov. 9 | First Quarter Moon and Moon Perigee |
| Nov. 13 | Good EME conditions |
| Nov. 16 | Full Moon |
| Nov. 17 | *Leonids* Meteor Shower Peak |
| Nov. 20 | Poor EME conditions |
| Nov. 23 | Last Quarter Moon and Moon Apogee |
| Nov. 27 | Moderate EME conditions |
| Dec. 1 | New Moon |
| Dec. 4 | Very Poor EME conditions |
| Dec. 5 | Moon Perigee |
| Dec. 8 | First Quarter Moon |
| Dec. 11 | Moderate EME conditions |
| Dec. 14 | *Geminids* Meteor Shower Peak |
| Dec. 15 | Full Moon |
| Dec. 18 | Moderate EME conditions |
| Dec. 21 | Winter Equinox and Moon Apogee |
| Dec. 22 | *Ursids* Meteor Shower Peak |
| Dec. 23 | Last Quarter Moon |
| Dec. 25 | Moderate EME conditions |
| Dec. 31 | New Moon |
| Jan. 1 | Moon Perigee. Poor EME conditions |
| Jan. 3 | *Quadrantids* Meteor Shower Peak |
| Jan. 6 | First Quarter Moon |
| Jan. 8 | Moderate EME conditions |
| Jan. 14 | Full Moon |
| Jan. 15 | Moderate EME conditions |
| Jan. 17 | Moon Apogee |
| Jan. 22 | Last Quarter Moon. Poor EME conditions |
| Jan. 29 | New Moon. Moderate EME conditions |
| Jan. 30 | Moon Perigee |
| Feb. 5 | First Quarter Moon; Moderate EME conditions |
| Feb. 12 | Good EME conditions |
| Feb. 13 | Full Moon |
| Feb. 14 | Moon Apogee |
| Feb. 19 | Poor EME conditions |
| Feb. 21 | Last Quarter Moon |
| Feb. 26 | Good EME conditions |
| Feb. 27 | Moon Perigee |
| Feb. 28 | New Moon |

*—EME conditions courtesy W5LUU.*

# VHF+ Roving
# Part 2 – Roving in General and Station Configuration


In this second part of their two-part article (see the Summer 2005 issue of *CQ VHF* for part one), ND2X and N4FLM give an overview of roving and discuss the proper and efficient configuration of the rover station.


**By Paul S. Goble,* ND2X, and Wayne Gardener,† N4FLM**

The four main functions involved in roving are driving, navigating, operating, and logging. For the "shoot 'n' scoot" rover, operating includes functions similar to those used for Field Day, such as raising/lowering antennas, operating generators, etc.

## Roving in General

**Driving:** Note that the first function on the list of roving functions is driving. Do this properly or risk your life! This is not a threat; it's a statement of what could very easily happen if a rover doesn't do it right! Whether traveling between stops or on a full-effort mobile-in-motion rove, keeping the rubber between the lines and the shiny side of the vehicle up is paramount! Piquing the ire of local gendarmes is also to be avoided; nothing ruins a roving budget more needlessly than a stiff traffic fine. Perhaps more important, stopping to talk to law-enforcement personnel can ruin a schedule—hi!

All the standard "going on a trip" preparations apply to roving. The vehicle must be mechanically sound and all fluids should have been checked and where applicable changed or topped off. Tires must be in good condition with good tread and proper air pressure. The success of the rove depends more on the vehicle than any other single factor. To illustrate, on the ND2X 35 grid effort in September 2000, 43 miles west of Grand Forks, North Dakota the ND2X "run 'n' gun" rover ceased to rove. The engine temperature was rising to unacceptable levels. This is bad enough for a gasoline engine, but it can be the death knell for a diesel engine! Only nine grids had been activated up to that point, and it was still relatively early on Saturday. KD5ABM was driving for us as a "non-operator," and his background as a diesel mechanic proved to be invaluable. He was able to determine the cause—a thermostat stuck shut, and thankfully that was a "roadside fixable" problem. It did cost over three hours for diagnosis and to let the engine cool sufficiently. The top cooling-system hose was then removed from the thermostat housing and a long screwdriver was used to jam the thermostat open permanently. There were no further cooling problems for the rest of the trip!

This problem didn't stop the rove, but it did cost the time required to activate as many as three additional grids! Had it been the fan clutch or water pump, ND2X would have had to drop out of the contest instead of merely missing out on three grids at the end of the contest because the contest time had expired. What a disappointment dropping out would have been!

**Navigating:** Knowing where one is going is imperative. This begins with a serious map study. All aspects of road and infrastructure parameters must be considered. There are differences in routing for the two roving modes (shoot 'n' scoot and run 'n' gun).

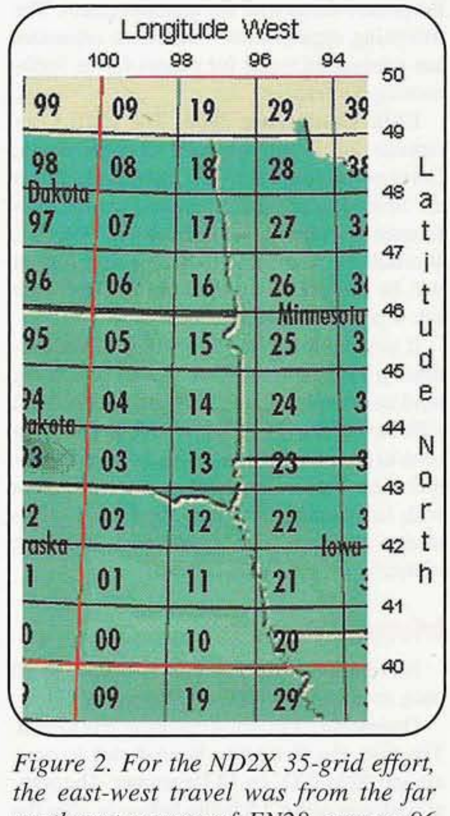



*Figure 2. For the ND2X 35-grid effort, the east-west travel was from the far southwest corner of EN28, across 96 degrees longitude and EN18 to 98 degrees longitude and EN08. The route north to EN28 was along 96 degrees longitude.*

For shoot 'n' scoot rovers it is necessary to identify locations at which five to six hours of parking and operating would be possible without stirring up any park personnel or park rangers who might happen on the scene. Most often "site sur-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veys"—i.e., short day trips to investigate potential contest operating locations—are required. Any point of terrain advantage, from actual mountaintops to the high bridges and interstate overpasses, qualifies. Each location is rated according to the coverage it provides. It must be determined what directions to what grids are possible from a given location. One location might be great on certain bands but not very good on others. Another location might be excellent in certain directions but blocked by heavy, RF-absorbing vegetation in others. Sides of mountains can provide superlative coverage, except, of course, for the directions blocked by the mountain itself. Some locations preclude parking within 50 feet of the roadway. Each has good points and bad points, and each must be evaluated considering what is required of that particular spot during a given contest.

Routing between operating locations must be determined carefully. The shortest route in terms of time, if not distance, between two points must be selected to minimize the amount of time lost to travel. Here again, if possible, running the course once or twice before doing it during the contest can be a major help in avoiding the unexpected during a rove. Closed roads, bridges out, construction delays, and the like all contribute to ruining otherwise beautiful plans!

For run 'n' gun rovers, running the course beforehand may be impossible, as it was for the ND2X 35-grid run 'n' gun effort. In this case, hams living along or near the chosen route are consulted for "on the scene" reports. When planning a multiple-grid effort, selection of north-south roads close to even longitude lines is important. This, in terms of distance driven, effectively gives "two for the price of one," as the route provides access to grids on both sides of the even-longitude line as north-south travel is accomplished. If the number of grids activated is large enough, *some* east-west travel is unavoidable; there are only 23 grids from Brownsville, Texas north to the Canadian border. For a rover to activate more than 23 grids, then, travel from one even-longitude line to another is unavoidable.

As in north-south travel, and an east-west route should be chosen as close as possible to a "whole number" latitude line to be as close as possible to the demarcation (latitude) line between grids. Grids are just short of 70 miles north-south, but vary from over 124 miles wide at Brownsville to about 91 miles wide at the Canadian border. This shows that east-west travel between even-longitude lines should occur as close as practical to the northernmost point of the chosen roving route (see figure 2).

For the ND2X 35-grid effort, the east-west travel was from the far southwest corner of EN28, across 96 degrees longitude and EN18 to 98 degrees longitude and EN08. The route north to EN28 was along 96 degrees longitude, allowing activation of EN25, EN15, EN16, EN26, EN27, and EN17, in turn. It was necessary to dash east from the EN17-EN18 crossover into EN28, where a 20-minute stop was made before turning around and proceeding westward.

**Map Studies:** While the old standby, the Rand-McNally road atlas (or equivalent), is indispensable to both preparatory map studies and the travel itself, software aids exist to help in both aspects of navigating. ND2X likes the DeLorme (http://www.delorme.com/) products "Topo" and "Street Atlas." A tremendous amount of detail is available for a given route or site, and the ability to zoom in for closer inspection with the option to have lat-lon grid lines present on any map makes the DeLorme products particularly attractive. These programs also work well with GPS data if a GPS receiver is interfaced with the computer in use. When in motion, it is sim-

*Photo G. Some shoot 'n' scoot rovers operate between portable operating locations, but generally only on 6 meters, 2 meters, and 135 cm due to the foliage-limited propagation at higher frequencies.*

ple to determine vehicle location and the relationship at any given time to the next planned turn or stop by watching the progress on a laptop computer. In addition, the exact location of maidenhead grid boundaries can be seen at a glance. DeLorme also has an inexpensive GPS receiver designed specifically for its mapping applications and laptops; the latest version interfaces via a USB port. These are not the only products available, but this is what is used and, therefore, what is discussed here. It is a certainty that other sources can provide this capability, depending on personal preference.

**Operating:** This aspect of roving is primarily driven by personal preference. Equipment is configured to best support individual likes and dislikes, as well as the roving mode employed. In a like manner, division of responsibility is a matter of personal preference. ND2X likes to drive and operate the radios while someone else logs and navigates. Even so, on the ND2X 35-grid effort driving and navigating were paired, as were operating and logging. N4FLM, on the other hand, does not operate at all between his selected operating locations. It's not that he couldn't, but he chooses not to for safety's sake. Some shoot 'n' scoot rovers *do* operate between portable operating locations, but generally only on 6 meters, 2 meters, and 135 cm due to the foliage-limited propagation at higher frequencies (photo G).

There is one "fly in the ointment" regarding rover operations: Current ARRL contest management is adamant that drivers, even if they never touch anything having to do with communication equipment or logging, count as operators for a roving station. This becomes a safety issue, since only two operators are allowed for a roving station. In 2000 the ARRL told us drivers did *not* count as operators. Even so, with only three people in the vehicle for the weekend, with one primary driver who never touched a radio, in hindsight we were very fortunate to have completed on the order of 1600 miles without incident! Over-the-road truckers are allowed only so many driving hours before they must take a break for a mandatory number of consecutive hours. These rules are in place to mitigate the number of accidents caused by driver fatigue. Rovering hams are no less at risk due to fatigue during or after a 33-hour contest. Just ask W3HMS after *his* VHF contest roving related accident in 2004. This rule and its current interpretation virtually eliminate the possibility of another high grid count run 'n' gun effort simply because suicide is not a good way to end a contest! This is a shame, because ND2X believes a 40-grid effort is possible.

**Logging:** Record-keeping during a contest, or *any* operation, basically is limited to two approaches. Either one uses pencil and paper, or one employs a computer-based logging program. ND2X lost a few thousand points in September 2000 because the logging program in use "blew up" after 31 grids activated, and some QSO records were lost. This shortfall has been corrected for the program used at that time, and there are myriad programs from which to choose; do an internet search ("VHF logging software," "ham radio logging software," "amateur radio logging software," etc.) and see! "You pays yer money and takes yer choice!"

Run 'n' gun rovers must find a means of logging while driving, navigating, operating, or whatever. This means either having two folks engaged at all times, or finding some means to record all pertinent data for after-action transcription. Shoot 'n' scoot rovers do not have this restriction when operating at a portable location. In either case, logging can be computer-based or paper and pencil. Much of the modern logging software keeps track of duplicates; automatically records time, date, and grid for each contact (GPS connection); and even produces after-action logs in Cabrillo format. Some also "automatically" e-mail results to the ARRL once reconnected to the internet after a contest! What a deal!

## Station Configuration

Of prime concern is keeping any roving station installation as simple as possible. The "KISS" (Keep It Simple Stupid) principle cannot be overstated here! Complexity is merely an open invitation to Mr. Murphy. Ground loops, RF feedback, overdriving transverter inputs to the point where the smoke escapes, telescoping antenna masts not telescoping or not collapsing, rotators not rotating, and any number of other cataclysmic maladies *will* occur unless KISS is applied across the board. Integrating equipment, even such as using a simple switchbox to switch one headset among all radios, can rapidly become *over* integration because of the problems caused—in this example, ground loops and RF feedback. Backup or replacement parts and gear should also be considered. Extra microphones, headphones, AA batteries for the GPS, fuses, automotive light bulbs, coaxial cables cut to length with connectors installed, spare antennas and antenna parts, etc., can make a tremendous difference. Having spare equipment is a very effective Murphy preventative!

**Equipment:** The equipment suite chosen is another area driven by personal preference, although there are certain constants that apply to all stations. A GPS is invaluable for positioning information. Radio gear should be chosen to minimize the use of transverters, realizing transverters cannot be avoided for most bands above 2300 MHz, plus 902/3 MHz. A single "IF radio" used for all transverters is the best of all transverter worlds, but not always possible. Power amplifiers can be the difference between a successful rove and a frustrating effort filled with stations heard but not worked. Nothing will work, of course, without an adequate power source. Top off whatever approach chosen with a detailed checklist to be completed prior to departure, and the probability of success can be quite high!

**GPS:** A GPS receiver is a must if one is operating while on the move. Once one is committed to a specific route, a GPS receiver is the simplest, most accurate means of keeping track

*Photo H. Some shoot 'n' scoot rovers use an antenna base that is secured to the ground by driving a vehicle's front tire onto it. The tower is bolted quickly to the pre-existing hinges and then tilted up from the base. The example shown is from KL7JR.*

of one's location. Shoot 'n' scoot stations if operating while traveling between stops, and run 'n' gun stations, are always watching for that next grid. While it is possible to mark latitude and longitude on a paper map, it is clumsy and often inaccurate by as much as 400 yards. GPS is often accurate to less than 21 feet. ND2X uses Garmin GPS equipment because it can be set to read out location in six-digit maidenhead grid notation, but here again, "You pays yer money and you takes yer choice!"

**Radio Gear:** As with most aspects of ham radio, radio equipment selection is a budget-driven situation. ND2X sold an IC-706 mk II, an FT-847, and a pristine Drake TR-7 to gather the cash to buy a TS-2000X for the mobile—one radio, four VHF/UHF bands, plus a transverter mode with band-specific frequency readout to run 902 MHz. An IC-375A rounds out the 6-meter/23-cm installation. N4FLM uses an IC-746 modified for low-level output on 28 MHz to run 222- and 1296-MHz transverters, so one radio handles four of the five bands implemented. An FT-100D is used to cover 70 cm as well as to provide some backup. ND2X plans to add 2304-MHz through 10-GHz transverters using an FT-817 IF rig. The transverters will be placed remotely, as close to their antennas as possible; control and switching issues are sure to present a challenge. "KISS"?

There are a couple of mode-driven differences for equipment installation. For the run 'n' gun rover, or for any "mobile-in-motion" operation, equipment must be readily accessible with operators strapped into normal vehicle driver/passenger positions. If the driver is to operate at any time, radio, amplifier, and power controls applicable to operating while in motion must be within arm's reach and generally as high off the floor as possible to preclude the driver having to look down. Looking off a little to the right or left of straight ahead allows one to remain "road vigilant" with peripheral vision.

Shoot 'n' scoot rovers can have most or all equipment mounted at an operating position that is other than driver/passenger accessible—for example, an operating table in the back of a van, or the covered bed of a pickup truck, etc. *No matter what mode used, all equipment must be mounted securely.* Under certain undesirable conditions, a loose piece of equipment can turn into a lethal(!) projectile. Some years ago, a car that had a box of facial tissues sitting loose on the flat area behind the back seat was involved in a frontal collision. The car and driver stopped, but the box of tissues didn't until it hit the driver in the back of the head, killing him instantly. It's easy to imagine how much more dangerous a flying radio would be to vehicle occupants.

**Power Amplifiers:** Since run 'n' gun rovers generally use omni-directional antennas with relatively low gain over a dipole, they need all the power available, at least up to 500 watts. Experience indicates that 500 watts is about the maximum level at which a mobile station using 4–5-dBd gain omni antennas can hear as well as be heard. More than 500 watts and the "average" fixed station will hear and call, but the rover may not hear him; fixed stations running full legal limit would be the exception.

Shoot 'n' scoot rovers make up for brute-force power, at least while stopped on a mountaintop, by using high-gain directional antennas. This doesn't mean shoot 'n' scoot folks should use QRP, by any stretch of the imagination! In fact, with directional antennas to provide several dB of gain on receive, the shoot 'n' scoot station could probably use at least 800 watts before becoming an "alligator" (all mouth, no ears).

**Antenna Configuration:** Antennas are the main difference between shoot 'n' scoot and run 'n' gun rovers. Whereas shoot 'n' scoot folks raise directional antennas at each stop, the run 'n' gun rover *never* touches an antenna unless a repair or replacement becomes necessary due to mechanical breakage. Mechanical breakage can come from unintentional interaction with low-hanging tree limbs, cable TV, and even power-line cables strung across roads below minimum height; bird strikes; and metal fatigue from the vibration caused by unloaded one-ton pickup truck suspensions. The run 'n' gun antenna configuration never changes.

Shoot 'n' scoot rovers use various methods to erect antennas. N4FLM has a nice mechanical crank-up tower mounted in the bed of his pickup truck which puts his top antenna at 30 feet or so. He avoids non-mechanical means to raise antennas–for example, pneumatic towers—to stay away from anything with seals; bad seals are almost sure to keep one from successfully raising the antennas at the most inconvenient time! KISS! Some use an antenna base that is secured to the ground by driving a vehicle's front tire onto it; the tower is bolted quickly to the pre-existing hinges and then tilted up from the base. The example shown in photo H is from KL7JR. These towers can also be telescoping, as in crankup. In extreme situations, such as the aforementioned winds atop Mt. Washington, these towers can be guyed or, more properly, roped off, by tying ropes from the tower top to nearby fence posts, trees, boulders, barrier or safety rails which prevent pedestrians from straying off the sidewalk, or whatever solid, immovable object is present.

**Powering the Station:** While run 'n' gun rovers never have to worry about running down batteries (since the engine is always running), shoot 'n' scoot folks are in a different situation, as they operate primarily while stationary. Shoot 'n' scoot rovers have the luxury of being able to turn their vehicle's engine off and use a generator to power their station at each operating location. Run 'n' gun rovers could run a trailer with a generator and power cable running to the prime mover with the station installation in it, but this level of complexity would definitely *not* be following KISS principles, and it has additional safety concerns which further complicate matters. Note that the common situation for any rover is that only one transmitter will be operating at any given time, limiting power requirements to a relatively reasonable level.

There are myriad practical means of powering a rover station. Some rovers power stations using completely stock, unmodified automotive electrical systems. Some rovers modify their electrical systems by installing an extra battery or batteries in their vehicle. This group most often uses standard off-the-shelf recreational-vehicle battery isolators to separate automotive and communication-system batteries, preventing radios from drawing off the automotive batteries. Some use inverters (there *are* some electrically quiet inverters out there) in conjunction with whatever 13.8-VDC automotive system is in use, and some use separate gas or diesel generators that are part of their rover equipment. At the risk of more redundancy (a little humor here), "You pays yer money and you takes yer choice!"

ND2X has operated without problems at 400 watts output on 2 meters from platforms as small as a 1992 Plymouth Acclaim, sporting its whopping 90-amp stock alternator and single battery. The next platform, a '95 Ford F-350 diesel, used the stock 130-amp alternator and the dual batteries present; no problem. The current platform sports two 130-amp alternators, one of which was completely removed from the automotive electrical system and rewired to charge a separate battery installed in the bed of the pickup truck. This is dedicated to powering the antenna hydraulic system and the power amplifiers. It may, one day (it's good to dream, right?), power a 1.8-KVA sinusoidal inverter dedicated to tube amplifiers for that magical 500 watts output on all bands through 23 cm! (Note: The second alternator and battery system was not created because it was required; it was done because it was possible!)

N4FLM uses a 3-KW Honda generator to power all of his equipment. He never has to worry that he might run his automotive battery down and become stranded because he cannot start his vehicle. He must, instead, track the amount of fuel available for the generator.

## Summary

In planning for your rover operation, keep in mind the following eight important points:

1. Safety First!
2. "KISS" (Keep It Simple Stupid)!
3. "You pays yer money and you takes yer choice!"
4. Ultimately, everything is driven by personal preference and budget.
5. There are two primary modes of roving. Using military parlance, one is labeled "shoot 'n' scoot" and the other is termed "run 'n' gun."
6. The mode of roving employed is determined by terrain, vegetation, existing roads, infrastructure and traffic, population density and distribution, climate and weather, and area-specific propagation.
7. The four main functions involved in roving are driving, navigating, operating, and logging. Note which is most important (see #1, above).
8. Have fun! ■

By Del Schier,* K1UHF

# AIRBORNE RADIO

## Using Amateur Radio to Control Model Aircraft

## An Introduction to Using Amateur Radio to Control Model Aircraft

Amateur radio has many facets, possibly too many to explore in a lifetime. This column will discuss one aspect—radio control, or RC. This new "Airborne Radio" column will give a general overview of radio control, for which hams are licensed to operate on 6 meters. I will be sharing with you this interesting and enjoyable segment of amateur radio, and I hope that this new *CQ VHF* column will be of interest to all radio hobbyists.

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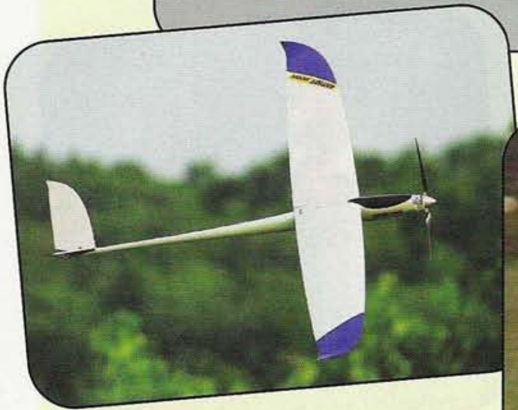
Many amateur radio operators have similar interests within and outside our hobby. I have met many hams on the air who are "full-scale" or RC pilots. I also meet a good number of hams at RC model events. RC modeling by itself has perhaps as many facets as amateur radio and shares many similar aspects.

RC modelers who are licensed hams use 50 MHz to control their model airplanes. Amateur television and telemetry experimenting takes place on the 432-MHz amateur band. The two hobbies are not only similar, they are also intertwined.

Identical twin brothers, Walt Good, W3NPS, and Bill Good, W8IFD (later W2CVI), made the first RC flights in 1936. Historians credit them with being the first hobbyists and radio amateurs to

*Some examples of the variety of model aircraft: balsa, foam, carbon fiber, scale, indoor, 200 mph—you name it! (All photos courtesy of Walter Sidas,* FlyRC Magazine *<www.flyrc.com>)*



*More examples of the variety of model aircraft.*

fly RC in the United States, and perhaps the entire world.

The Winter 2004 issue of *CQ VHF* had an article on the historic RC model flight ("A 6-meter Rig Flies the Atlantic," by Maynard Hill, W3FQF), where on August 11, 2003 an RC model flew non-stop, unrefueled, across the Atlantic Ocean! It was controlled on 6 meters with a 432-MHz beacon and was built by a team of volunteers led by W3FQF.

Analogies may be made between both hobbies. Airfoil design and antenna design, both with highly evolved engineering disciplines, both require almost a sixth sense and a great deal of experience to come up with effective designs. Piloting an RC glider that is dependent on Mother Nature's thermal updrafts is as fascinating as observing the variations in radio propagation.

In this column I primarily will discuss electric-powered RC aircraft. Wet-fuel-powered aircraft are still popular, but the trend is toward quiet and clean electric power. Electric flight, involving more electronics, is what I suspect most hams would be interested in. Recent technology, including Lithium Polymer batteries and three-phase brushless motors, have made electric-powered model aircraft match or exceed the performance of fuel-powered models, and in my opinion this is the "way to fly." Personally, I also enjoy flying pure gliders powered only by the sun's energy.

Like ham radio, there are no longer many dedicated home brewers. There are few kits and not as many kit or scratch builders as there used to be. Today the majority of model aircraft are supplied Almost-Ready-to-Fly ("ARF" for short). ARFs come almost completely built, usually to the extent that the airplane can still be packed in a shipping carton. Getting an ARF model ready to fly most often involves only attaching the wing and the tail to the fuselage and installing the radio, servos, and motor system. Today it is much easier to get a model airplane flying than it used to be, but perhaps not as satisfying.

For starters let me give you some basic information about RC model aircraft.

An airplane can be very simple, with only two servos, one for elevator and one for rudder. Of course, it could have a complete set of controls, including flaps, ailerons, spoilers, retractable landing gear, and more.

Model aircraft come in almost every conceivable size and shape and type. There are micro-flight RC models that weight only a few grams can fly around in a living room. With special authorization, you can actually fly a 400-pound, 25-foot-wingspan electric-powered Spruce Goose, as was built for the movie *Aviator*. The Spruce Goose used eight outer rotor brushless motors with 20 3.3-Ah NiMh batteries for each motor!

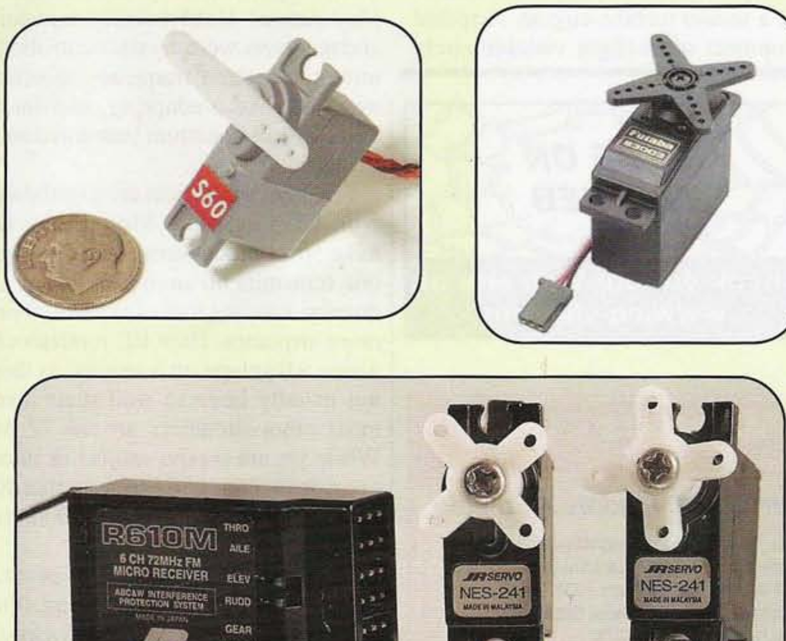
There are scale models of almost every type of airplane, with varying degrees of scale accuracy. Many models are designed only for a specific realm of flight and may have been designed without any concern for realistic scale appearance. For example, a sailplane may be totally optimized for maximum aerodynamic efficiency and not include landing gear or a cockpit for a scale pilot. So-called "3D" aerobatic airplanes are made for one purpose: outrageous aerobatic flight that a real stunt plane could not perform. You will find all types of aircraft: flying wings, biplanes, triplanes, canards, gyrocopters, parasails, helicopters, ornothopters … you name it.

Some model aircraft are still made from balsa wood, but many are not. There is a trend toward great flying and inexpensive cut- or molded-foam construction. The more exotic aircraft use fiberglass, carbon fiber, Kevlar®, and other composite materials.

A model may be powered by one or more motors or may be a pure glider without anything but Mother Nature's updrafts. Electric motors range from tiny


*Transmitters for 6 meters are avialable from several manufacturers.*


*Receivers for 6 meters, even synthesized, are available in many sizes.*

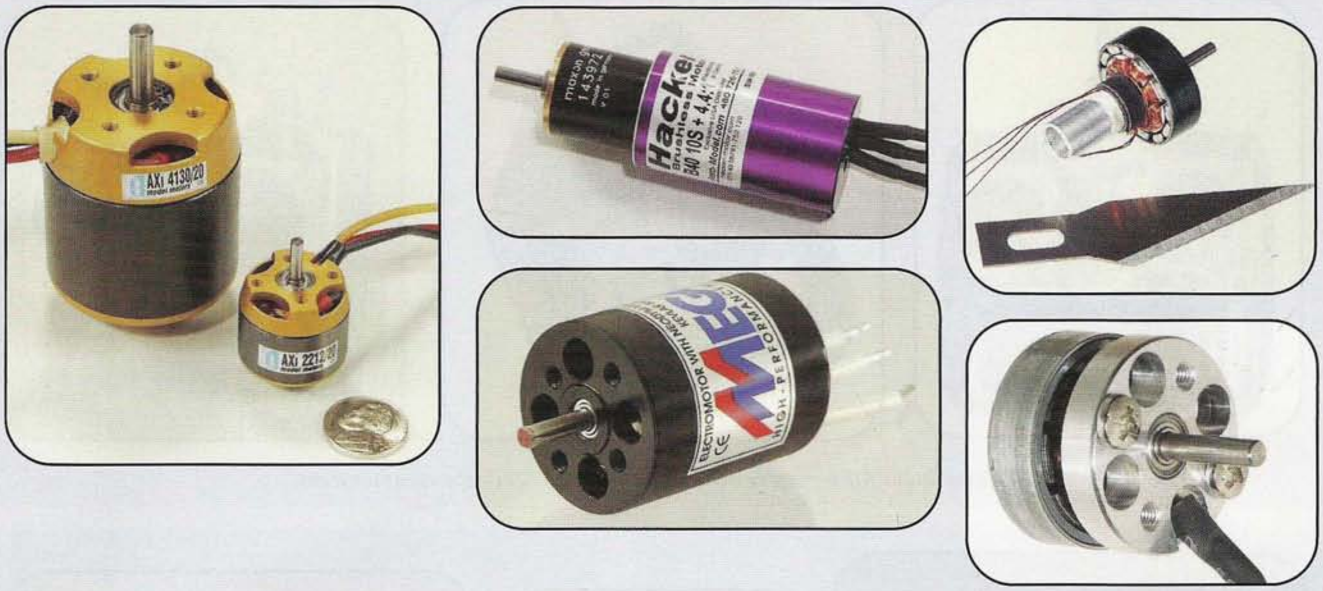



*Servos range from incredibly small to large, powerful ones.*

cell-phone/pager vibrator motors and $5 DC cordless drill motors, all the way to super-efficient three-phase AC brushless motors developed especially for RC aircraft. Fuel-powered airplanes may use gasoline spark engines, glow-plug or diesel-ignited methanol/nitro methane power, or even kerosene-burning model turbine engines.

Electric motors are "fueled" by NiCad, NiMh or Lithium Polymer (LiPo) batteries. LiPo batteries are a recent development that represents a tremendous improvement in flight performance with one third the weight of the same capacity NiCad pack. A medium-size electric model may draw 60 amps from an 11-volt 4-Ah LiPo battery pack. Electric-power systems range from a fraction of a watt to over 2500 watts. Brushless motors have efficiencies of well over 90% with a one-horsepower motor weighing a few ounces and only a bit bigger than a 35-mm film canister.

Electric motors are controlled via the throttle channel of the receiver using sophisticated electronic speed controls (ESC). An ESC uses switching FETs to




*Three-phase brushless motors are now the most popular and come in all sizes, up to 3 horsepower.*

govern the motor's speed either by varying the pulse width for a DC motor or by generating a three-phase AC signal for a brushless motor. An ESC usually will include a regulator circuit to bring the motor battery down to 5 volts to run the airborne receiver and servos without the need for a second flight battery. These regulated outputs are called BECs, or Battery Eliminator Circuits.

The motor's power is fed to a propeller either directly or with gear reduction. Small motors may run at more than 40,000 RPM, so the use of a gearbox allows for a larger diameter, more aerodynamically efficient propeller. A propeller must be chosen to load the motor system in a safe power range, and the entire package must be suited to the airplane's weight and flying speeds. Model jets will sometimes be propelled with an internally mounted ducted fan or actually use a model turbine engine. A recent development of in-flight variable pitch, reversible propellers makes for some very interesting aerobatic capabilities.

Radio systems are usually purchased as a package of transmitter, receiver, and servos and can range from two channels to fourteen. Good-quality radio systems provide proportional control of each channel and use various modulation schemes. The most common are FM transmission with PPM (Pulse Position Modulation). Until recently, transmitters and receivers were crystal controlled, but now synthesized frequency selection is available. Auto-adapting, non-interference, spread-spectrum transmission is on the horizon.

Frequency conflicts are a real concern with RC modeling. Most flying fields have strict procedures to ensure that no one transmits on another modeler's frequency, causing loss of control of one or more airplanes. Ham RC modelers have a nice advantage on 6 meters, as they do not usually have to wait their turn, as most other modelers are on 72 MHz. While we are on the subject of interference, it is interesting to note that RC is also threatened by BPL (Broadband over Power Lines).

In my next column I plan to cover how to get started in RC modeling. Future columns will touch on various aspects of the hobby, such as aircraft, motors, radios, control systems, batteries, video, and the like.

73 and happy flying!

Del, K1UHF

# Real-life Dynamic Range of Modern Amateur Transceivers

Reprinted from *DUBUS** magazine, this article deals with the correct way to measure transceiver quality.

**By Leif Åsbrink,† SM5BSZ**

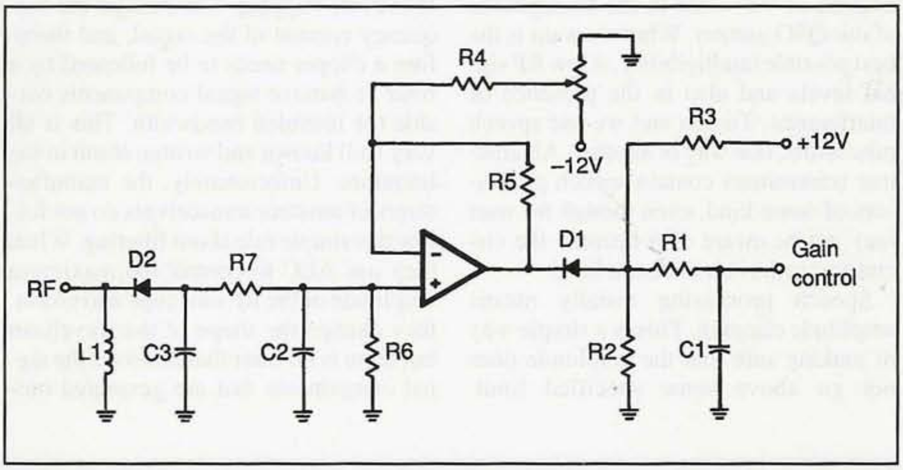



*Figure 1. Simplified ALC schematic.*

Following the recent general advances in receiver design, the receiver part of a typical amateur transceiver now has quite good ability to handle strong, unwanted signals—but only if those signals are free from unwanted spurious sidebands (notably keyclicks, splatter, and other transients). In contrast, the transmitters have been almost completely neglected. This article gives measured data for several different transceivers from different manufacturers, and it shows that the transmitters are becoming the most important source of inter-station interference. A major contribution to unwanted sidebands comes from ill-designed ALC circuits. The article also discusses what we can do to avoid generating interference to one another, by controlling the output power by means other than the internal ALC.

## Introduction

Inter-station interference can occur when a receiver is trying to listen on a clear frequency, but there is a very strong transmitter using a frequency close by. All transmitters have unwanted sideband emissions (keyclicks, splatter, and other transients—the type depends on the transmission mode). If the suppression of these sidebands is worse than the dynamic range of the receiver, then the transmitter will be mostly responsible for the interference experienced by the receiver. Modern amateur receivers have quite good dynamic range, on the order of 90 to 100 dB with the usual definitions (500-Hz bandwidth, and at frequency separations beyond a few kHz). To avoid causing interference to such receivers, the unwanted sidebands from our transmitters must be suppressed to better than −120 dBc/Hz on the frequency to which the receiver is attempting to listen.

Previous articles have dealt with unwanted sidebands due to keyclicks on CW, and splatter on SSB, and have shown that major improvements are needed.[1, 2, 3] The measurements uncovered a significant source of unwanted sidebands that are added by ill-designed ALC circuits. This article explores further, focusing mainly on the effects of poor ALC on the bandwidths of SSB and CW transmissions, and gives actual measured data for several different transceivers from different manufacturers.

## Speech Processing and ALC

All voice-modulation methods have an amplitude limit, a level that must not be exceeded. This is valid for FM and SSB as well as for AM. It is, of course, possible to set the microphone gain low enough to make the largest amplitude peaks that occur when speaking into the microphone so low that they will never exceed the limit. Doing so will provide the best sound quality, but only when the RF signal is strong. The average amplitude from the microphone would be far below the limit nearly all the time, and the transmission channel would be poorly used.

As amateurs, we usually are not very interested in high fidelity in the repro-

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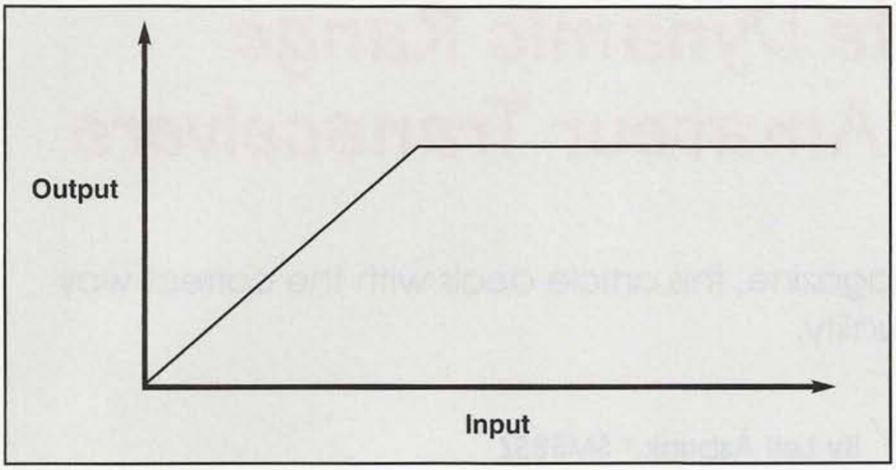


*Figure 2. ALC is a form of amplitude limiting.*

duction of our voice in the loudspeaker of our QSO partner. What we want is the best possible intelligibility, at low RF signal levels and also in the presence of interference. To this end we use speech processors, one way or another. All amateur transmitters contain speech processors of some kind, even though the user may not be aware of it because the circuitry may have a different label.

Speech processing usually means amplitude clipping. This is a simple way of making sure that the amplitude does not go above some specified limit. However, clipping will change the frequency content of the signal, and therefore a clipper needs to be followed by a filter to remove signal components outside the intended bandwidth. This is all very well known and written about in the literature. Unfortunately, the manufacturers of amateur transceivers do not follow this simple rule about filtering. When they use ALC to control the maximum amplitude of the RF envelope waveform, they change the shape of the waveform but there is no filter that removes the signal components that are generated out-of-channel. Modern ALC systems have high gain and large bandwidths, and they flatten the envelope waveform abruptly, which leads to wideband interference. This means that even the emissions from transceivers used at reduced power are far from acceptable. For example, on 144 MHz the FT-817 even has problems complying with the FCC emission rules §97.307(e), which generously allow spurious emissions with a mean power up to –43 dB with respect to the mean power of the fundamental emission at a power level of 0.5 watt. The problem is common, and by no means limited to the FT-817 or to Yaesu as a manufacturer. Also, the problem is by no means new, but it has worsened over the years.

Fortunately, it often is possible to use a properly designed speech processor, limiting the amplitude of the RF drive signal so that the ALC is not activated. Many transmitters already contain a separate speech processor, so in the IC-7800 and FT-1000D, for example, it is possible to set the controls so that the peak envelope power reaches the desired level without activating the ALC at all. The desired level then is only a few tenths of a dB below the level that would have been set by the ALC, but the transmission is a lot cleaner. Other transceivers such as the Orion cause a lot of needless interference

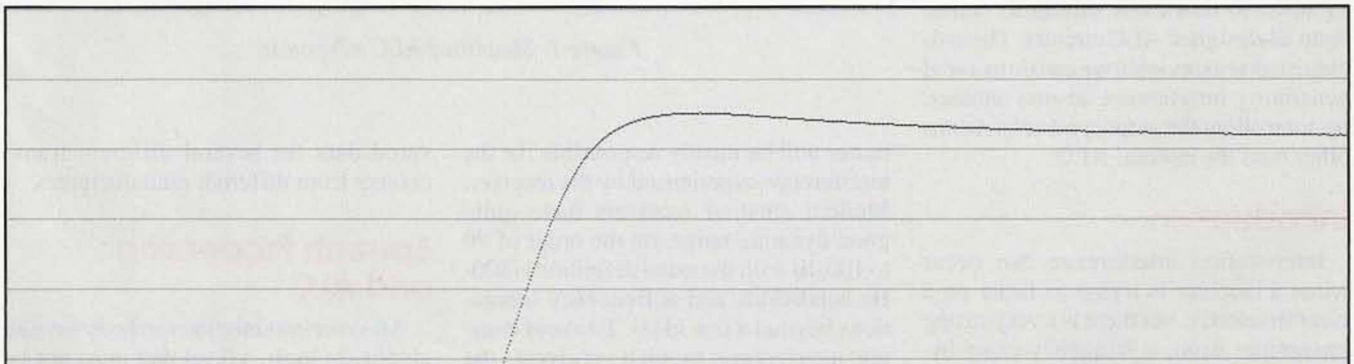

*Figure 3. First key-down transition of a TS-2000 on 144 MHz. A rare example of a transceiver in which the ALC does not cause spectral broadening.*

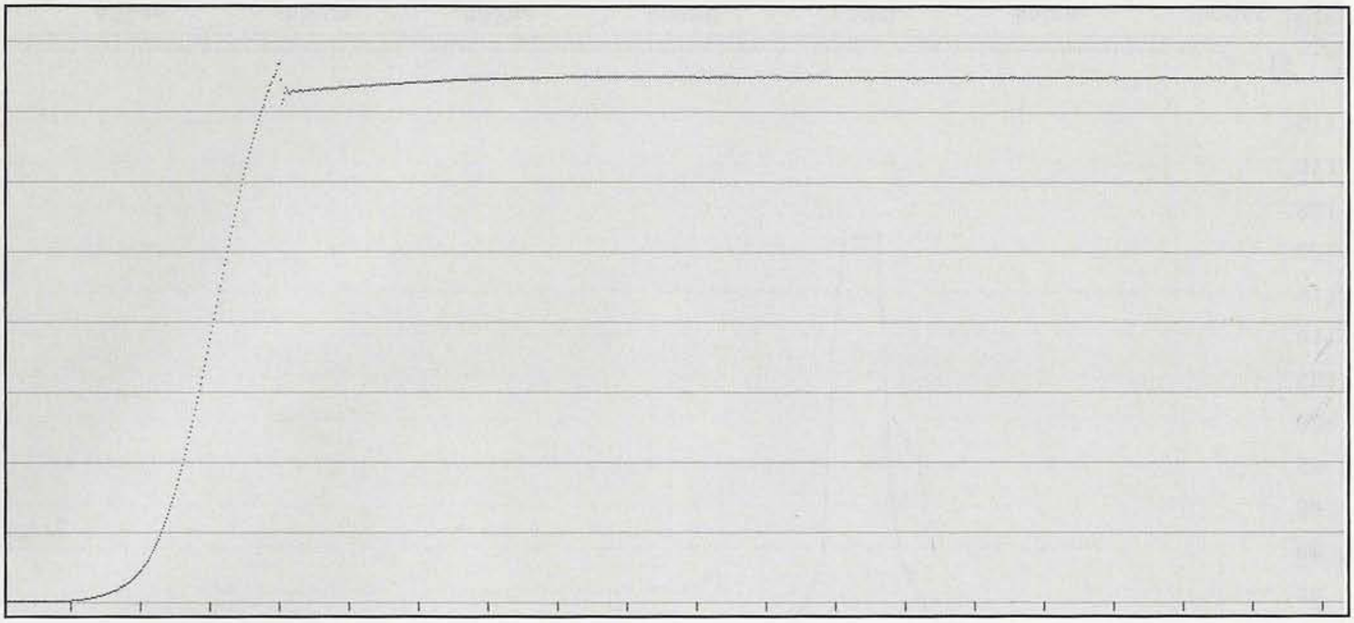

*Figure 4. First key-down transition of a Ten-Tec Orion on 14 MHz. Note the ALC transient at the top corner.*

that could easily be removed by a software update; the computer inside has full control of everything, but the transmitter RF gain does not have a front-panel control. Another possibility is to control the transmitter RF gain by feeding a variable negative voltage into the transceiver's "External ALC" input, which overrides the internal ALC. Often it is easy to make a modification to use the FM speech processor in SSB mode[2]; this was published over 20 years ago.

Besides generating out-of-channel interference, the ALC systems of modern transceivers make them generate occasional pulses of very high power—far above the maximum rated output of the transceiver. These pulses may cause damage to equipment, may cause protection circuits to operate, or at the very least may cause key-clicks and splatter. The problem is not limited to SSB mode. A wideband pulse is generated in any mode every time the ALC has to turn down the gain quickly, and that happens each time the power has been low for a time that is longer than the ALC decay time. For some transmitters it happens after each word space in CW, while for others even after every space in a string of dots at high speed. There is a particular danger for transverters and other equipment that can only accept a low RF power input; if the power output of the transceiver is reduced simply by turning down the RF PWR control, the transceiver's ALC may still allow pulses of very high RF power. These may either destroy semiconductor devices or cause a gradual worsening in performance.

## The ALC System

The ALC system is a simple servo system, and the theory should be well understood by every electronics engineer. The reason for the poor performance is that product testing in amateur journals does not look for the out-of-channel emissions of modulated transmitters, except for the two-tone test, which is a static test as far as ALC is concerned. The maximum power level repeats at typically 1-ms intervals in a two-tone test, and therefore even a very short ALC decay time is long enough to keep the ALC voltage nearly constant.

The principle of an ALC system is illustrated in figure 1. The output signal is coupled through a directional coupler to the RF input at the left side of figure 1. Diode D2 rectifies the RF signal and charges C3 to the peak value of the RF voltage in the negative direction (minus the diode forward voltage). The low-pass link R7-C2 removes remaining RF components and feeds the negative peak RF voltage to the positive input of the op-amp. If the RF power is well below the power limit, which is set by the potentiometer, the op-amp will saturate in the positive direction and the gain-control output will have the voltage defined by the voltage divider R2 and R3.

As the RF power increases, the rectified voltage will go further in the negative direction until the output voltage of the op-amp goes below the gain control voltage by the forward voltage drop of D1. Then D1 will start to conduct and reduce the RF gain so the RF power will no longer increase, but will stay at the level set by the potentiometer. The transmitter gain can be reduced rapidly (fast attack), but with a large value for R6 it will increase slowly (slow decay).

It is pretty obvious that an ALC system such as this will behave nicely if the response time for gain reduction is much faster than the envelope rise time of the RF signal sent into the transmitter. A less obvious second condition for good behavior is that the phase shift in the servo loop formed by the RF circuits and the ALC system must remain below 90 degrees at all frequencies where the loop gain is above 1. With a slowly rising signal level, the output power will be proportional to the input power (the power that comes out from the bandwidth-defining filter) up to the limit level, where there is a knee, after which the input power may be increased but the output power increases very little. Thus, the transfer curve is essentially two straight lines (figure 2), and for practical purposes the upper line can be taken as horizontal. For slowly varying signals, the ALC behaves exactly like an amplitude limiter in the way it affects the envelope shape, and for such signals it therefore generates inter-

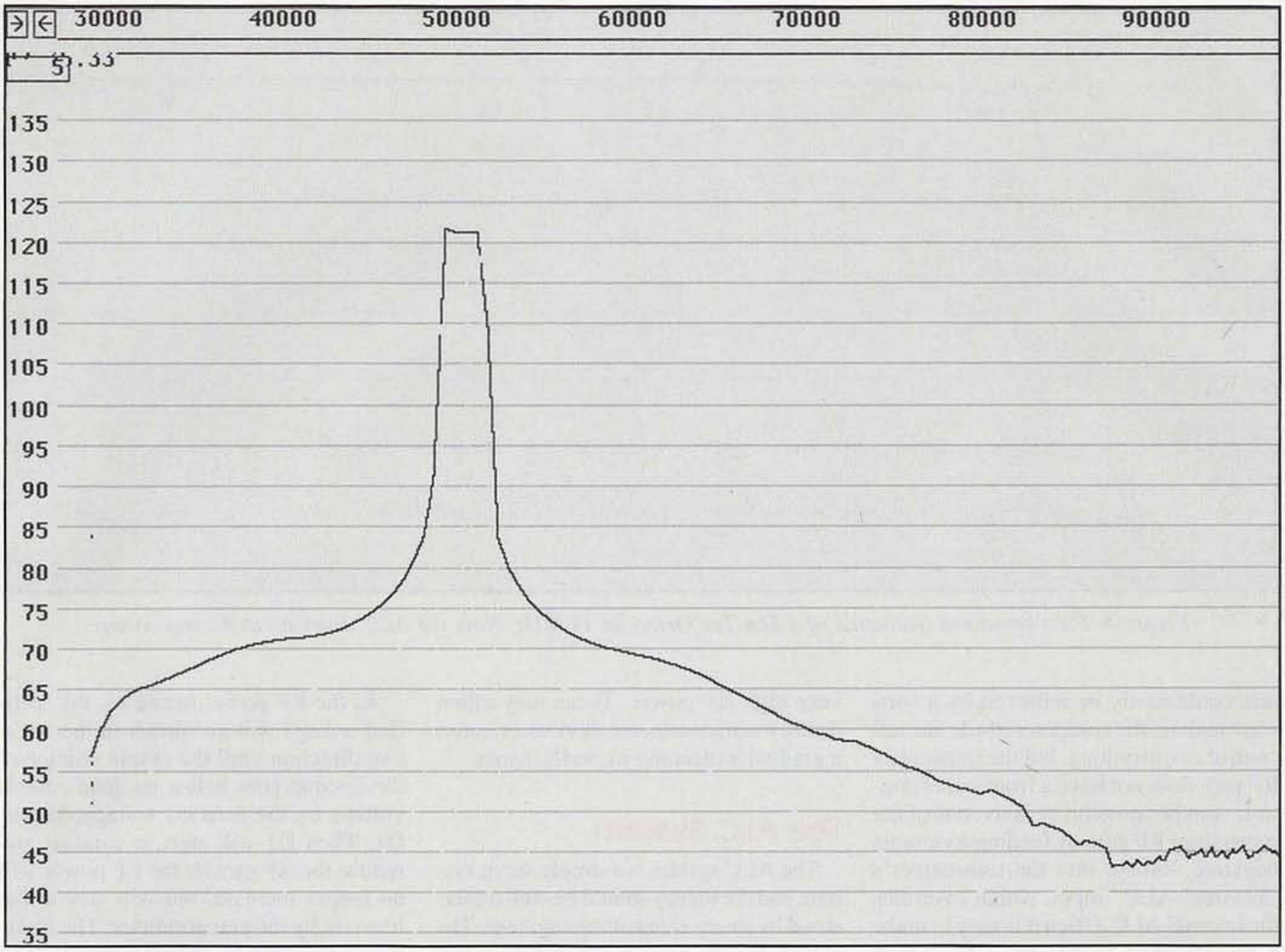


*Figure 5. First key-down transition of a Ten-Tec Orion on 14 MHz. This is the peak-hold spectrum in 2-kHz bandwidth from the same Orion producing the waveform of figure 4. Because of the ALC transient, the keying clicks are only about 20 dB below those of a transmitter with totally unfiltered cathode keying!*

modulation exactly like an amplitude clipper does.

If the attack time constant is made very short in relation to the rise time of the SSB or CW envelope waveform, there will be a transient at the knee point where the ALC system starts to reduce the gain. Such a transient is a splatter pulse or a keying click, and its magnitude depends on how much the gain has to be reduced. By having a very long release time constant one can ensure that the amount by which the gain needs to be lowered next time is very small. This way there will only be one interference pulse at the onset of each transmission.

If the attack time is made a little longer, for example by increasing R7, there will be an overshoot at the onset each time the ALC becomes active. If gain levels are set so that the ALC only ever needs to reduce the transmitter gain by a small amount, one can select a rather long attack time, which will generate a nicely rounded overshoot that does not increase the bandwidth. Such an overshoot is completely harmless if the transmitter is connected to an antenna, but if it is used with a power amplifier it could drive the power amplifier into saturation, with a very strong interference pulse as a consequence. It could also be harmful to the amplifier, or activate a protection circuit which takes the amplifier off-line. Figure 3 shows the first key-down transition of a TS-2000 on 144 MHz at full power (100 watts). This is one (rare) example of a correctly working ALC circuit.

If the loop gain is too high, the amplifiers within the servo loop saturate and the servo system becomes non-linear. Then transients of large bandwidth may be emitted, and also the loop will over-react, bringing the gain down too much. The

| CW Setting | Carrier peak (W) | SSB continuous (W) | PTT-off peak (W) | peak (W) |
|---|---|---|---|---|
| H | 75 | 49 | 108 | 120 |
| 5 | 55 | 33.8 | 78 | 116 |
| 2 | 16.4 | 9.5 | 32.4 | 97 |
| 1 | 10.0 | 5.0 | 11.3 | 79 |
| L | 5.2 | 2.5 | 9.0 | 46 |

*Table 1. Power output transient levels at the antenna connector for an IC-706MKIIG.*

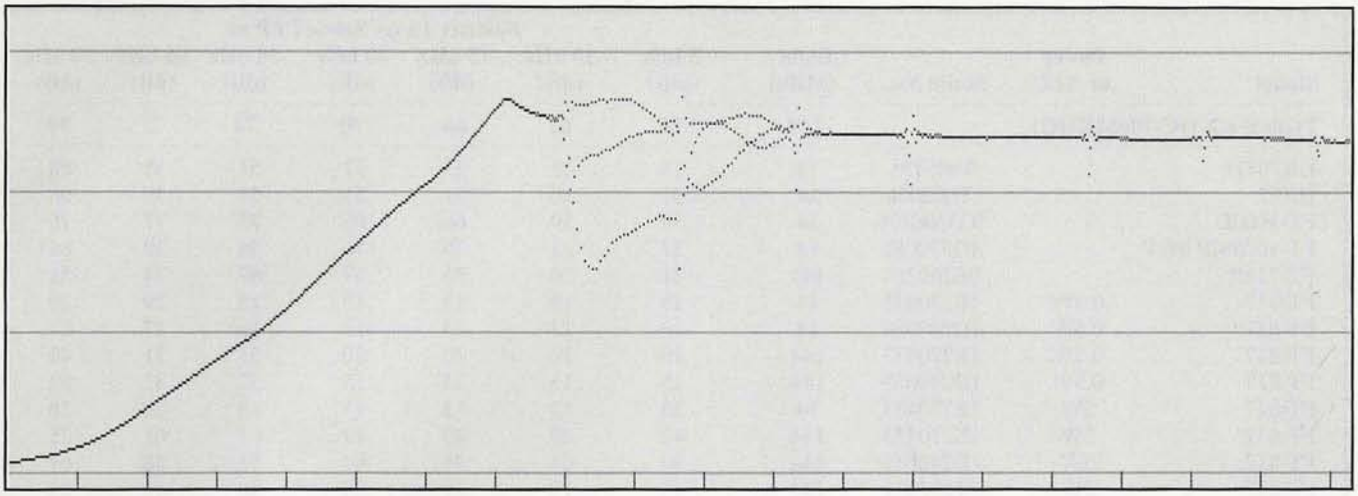

*Figure 6. First key-down transition of an FT-817, 14 MHz. Note the self-oscillation in the ALC circuit.*

slow ALC release time constant (R6*C2 in figure 1) will then slowly allow the power to reach the desired level again. Figure 4 shows the first key-down transition on a Ten-Tec Orion, which is an example of this phenomenon. The designer clearly intended to give a nice "raised-cosine" or S-shape to the rising edge to minimize key-clicks, but the top corner is severely distorted by the ALC transient and the resulting spectrum in figure 5 is far from what one would have hoped.

Unfortunately, most amateur transceivers are no better designed. The gain in the servo loop is often very high and the phase shift large, with stability problems as a consequence. It is a general rule in the design of servo loops that one should not have more than one RC link to set the gain vs. frequency function for the loop. If R7*C2 and R1*C1 are made with similar time constants, the servo loop is close to an oscillator, and more delay through more RC links makes it even worse. It is a good idea to make all RC links except one with time constants that are at least 100 times shorter than the single large one that sets the loop gain roll-off with frequency.

Manufacturers of amateur transceivers seem to be unaware of this well-known rule about having a single "dominant pole." For example, figure 6 shows the waveform of the first key-down transition of an FT-817 on 14 MHz. The ALC is self-oscillating at a frequency of about 35 kHz, which produces the wideband transients measured in figure 7.

In better transceivers the front-panel "RF Power" control is simply a manual gain control which makes a fixed change in the RF drive level. However, many transceivers use the ALC system to implement the gain reduction dynamically, which means that the gain reduction that the ALC has to provide is larger at low power levels. This in turn means that the gain of the ALC servo loop becomes higher at reduced power, so oscillations may occur. Figures 6 and 7 show typical test results for the FT-817. The IC-706MKIIG behaves in a similar way, although oscillation is lower in frequency (about 5 kHz) amplitude and duration compared to the FT-817. The FT-817 is not even stable in the steady state when the key is held down, as can be seen in both figure 6 and figure 7.

As mentioned above, the use of ALC for regulating the output power may have other side effects. Table 1 shows measured power levels from an IC-706MKIIG at various power settings. The pulse emitted when the PTT button is released in SSB mode may be fatal for a solid-state power amplifier. [4]

## Effect on Inter-Station Interference

There are two possible causes of inter-station interference on the air—receiver overload or transients from transmitters—and it is sometimes difficult to tell which is responsible. Receiver overload has been extensively reviewed, but transmitted transients have not.

State of the art in amateur transmitters is illustrated in Table 2, which shows the results of many measurements of peak hold spectra in a bandwidth of 2.4 kHz. The first entry of Table 2 shows the dynamic range of a typical receiver, an IC-706MKIIG, on 144 MHz. If any of the transmitter performance figures in the rest of the table is *smaller* than the receiver dynamic-range figure at the head of each column, it means that the transmitter, rather than receiver overload, would be the dominant cause of inter-station interference. Any transmitter performance figures that are equal to or better than this criterion are shown in bold, and you can see there are very few of them! Note the dramatic improvement in the IC-718 and IC-7800 that was achieved by disabling the ALC as discussed above.

The receiver dynamic range of the IC-706MKIIG is not especially good (for example, the TM-255E is about 20 dB better in dynamic range), so it is not a very demanding standard for comparison. Even so, most transmitters in Table 2 failed to meet that standard, which shows how poor is the typical performance of today's transmitters. There is no good reason for this, because it should be much easier to make a good transmitter than to make a good receiver.

The problem, of course, is that they all use the ALC to limit the RF envelope waveform. At narrow frequency separations the linearity of the final amplifier may affect the transmitter bandwidth, but above 15 kHz the interference mainly originates in the transmitter's ALC loop. To use ALC to limit the envelope waveform of a signal that has already gone through a speech processor is ridiculous, as discussed earlier, but very common in amateur equipment. ALC might perhaps have been a clever way of controlling the power level in the vacuum-tube era, but

| Model | Power or ALC | Serial No. | Band (MHz) | Splatter Level Below PEP at 5 kHz (dB) | 10 kHz (dB) | 15 kHz (dB) | 20 kHz (dB) | 30 kHz (dB) | 40 kHz (dB) | 50 kHz (dB) |
|---|---|---|---|---|---|---|---|---|---|---|
| **Typical RX (IC-706MKIIG)** | | | **144** | **56** | **61** | **66** | **70** | **74** | **77** | **79** |
| DX70TH | | T005735 | 14 | 15 | 15 | 32 | 32 | 51 | 55 | 68 |
| DX77 | | T002056 | 14 | 31 | 50 | 51 | 51 | 51 | 59 | 68 |
| FT-1000D | | 3G3300126 | 14 | 39 | 59 | **66** | 66 | **75** | **77** | **79** |
| FT-1000MP MkV | | 4D570081 | 14 | 33 | 35 | 35 | 46 | 46 | 59 | 66 |
| FT-736R | | 9E260294 | 144 | 31 | 50 | 55 | 59 | 67 | 74 | **81** |
| FT-817 | 0.5W | 1E270433 | 14 | 15 | 15 | 15 | 15 | 15 | 29 | 29 |
| FT-817 | 0.5W | 1D240059 | 14 | 13 | 13 | 13 | 13 | 13 | 27 | 27 |
| FT-817 | 0.5W | 1E270433 | 144 | 20 | 20 | 20 | 20 | 31 | 31 | 40 |
| FT-817 | 0.5W | 1D240059 | 144 | 15 | 15 | 15 | 15 | 32 | 32 | 32 |
| FT-817 | 5W | 1E270433 | 14 | 13 | 13 | 13 | 13 | 13 | 26 | 26 |
| FT-817 | 5W | 1E270433 | 144 | 40 | 49 | 49 | 49 | 61 | 61 | 75 |
| FT-817 | 5W | 1D240059 | 144 | 36 | 44 | 44 | 44 | 56 | 56 | 67 |
| FT-847 | 2W | 81100231 | 144 | 19 | 19 | 19 | 38 | 38 | 41 | 41 |
| FT-847 | low | 81100231 | 14 | 18 | 18 | 18 | 18 | 35 | 40 | 40 |
| FT-847 | | 81100231 | 14 | 27 | 27 | 27 | 34 | 42 | 50 | 54 |
| FT-857 | | 3J130041 | 144 | 30 | 50 | 54 | 60 | 69 | 75 | **79** |
| FT-857D | | 4D200054 | 144 | 33 | 52 | 60 | 66 | 71 | **79** | **84** |
| FT-897 | | | 14 | 34 | 52 | **68** | **74** | **80** | **80** | **82** |
| IC-706MKIIG | | 06230 | 144 | 28 | 48 | 58 | 62 | **75** | **81** | **84** |
| IC-718 | alc ON | 03011151 | 14 | 41 | 52 | 56 | 58 | 61 | 62 | 63 |
| IC-718 | alc OFF | 03011151 | 14 | 49 | 58 | **69** | **75** | **84** | **84** | **85** |
| IC-765 40W | | 02576 | 14 | 36 | 52 | 59 | 64 | 64 | 64 | 64 |
| IC-765 | | 02576 | 14 | 34 | 37 | 37 | 37 | 37 | 37 | 37 |
| IC-7800 | alc ON | 0301012 | 14 | 38 | 46 | 54 | 61 | 71 | **81** | **88** |
| IC-7800 | alc OFF | 0301012 | 14 | 43 | **68** | **88** | **88** | **89** | **89** | **89** |
| IC-910H | | 01533 | 144 | 32 | 53 | 64 | 68 | 69 | 69 | 69 |
| Orion | | 03C10433 | 14 | 37 | 41 | 46 | 47 | 53 | 58 | 64 |
| TR-9130 | | 3040284 | 144 | 33 | 42 | 50 | 56 | 67 | 75 | **82** |
| TS-2000 | | 30400028 | 144 | 44 | 53 | 63 | **76** | **85** | **88** | **89** |
| TS-2000 | | 50600050 | 144 | 32 | 48 | 55 | 61 | 71 | **86** | **89** |
| TS-2000 | 25W | 50600050 | 144 | 35 | 48 | 64 | **79** | **84** | **86** | **89** |
| TS-2000 | | 30400028 | 14 | 31 | 45 | 57 | 66 | **74** | **75** | **75** |
| TS-2000 | | 50600050 | 14 | 32 | 53 | 59 | 68 | **77** | **78** | **78** |
| TS-2000 | 25W | 50600050 | 14 | 32 | 49 | 61 | 69 | **79** | **79** | **79** |
| TS-50 | | 41000988 | 14 | 50 | **67** | **77** | **82** | **85** | **85** | **85** |
| TS-711E | | 8070268 | 144 | 17 | 27 | 32 | 42 | 53 | 58 | 67 |

*Table 2. Peak-hold spectra of some amateur transceivers in SSB mode. With the exception of the cases shown in bold, the transmitted signal quality is likely to be the dominant cause of inter-station interference.*

this aspect of transmitter design has stood still for 30 years. With appropriate knowledge about what the service menu functions do, or with a software update, most modern rigs can probably be run without the ALC as a speech processor. The computer inside a modern rig should be able to set the gain correctly for the constant amplitude signal that comes out from the SSB filter when a speech processor is used.

## Speech Processing

Although best readability in SSB mode is obtained without speech processing, the peak power may then go as high as 100 times the average power, and practical transmitters cannot deliver such extreme power levels. In reality, there always is some engineering or legal limit on the peak power, and therefore, as pointed out in the introduction to this article, speech processing is necessary for optimum intelligibility in voice communication. (Saving energy when operating from a battery is a very special case. With cleverly managed bias currents, a battery-operated SSB station would be best used *without* speech processing for maximum battery life, but for the rest of this article it is assumed that transmitters are limited by peak power and that the total energy consumption is of no concern.)

It is well known from amateur literature that an RF clipper is much better than an audio clipper. This is not quite true, however: The RF clipper is better, but the difference is small as long as the clipping is not harder than necessary for optimum intelligibility. The drawback of audio clipping is often illustrated something like this:

Let us assume that the passband is 0.2 to 2.4 kHz, and that the signal from the microphone is 300 Hz at a given moment. An audio clipper will convert the waveform towards a square-wave that contains odd harmonics. The frequencies 900 Hz, 1.5 kHz, and 2.1 kHz will fall within the audio passband and make the sound very different from the original sine-wave. An RF clipper will, of course, also convert the sine-wave which is present at, e.g., 10.7 MHz to a square-wave. However, the

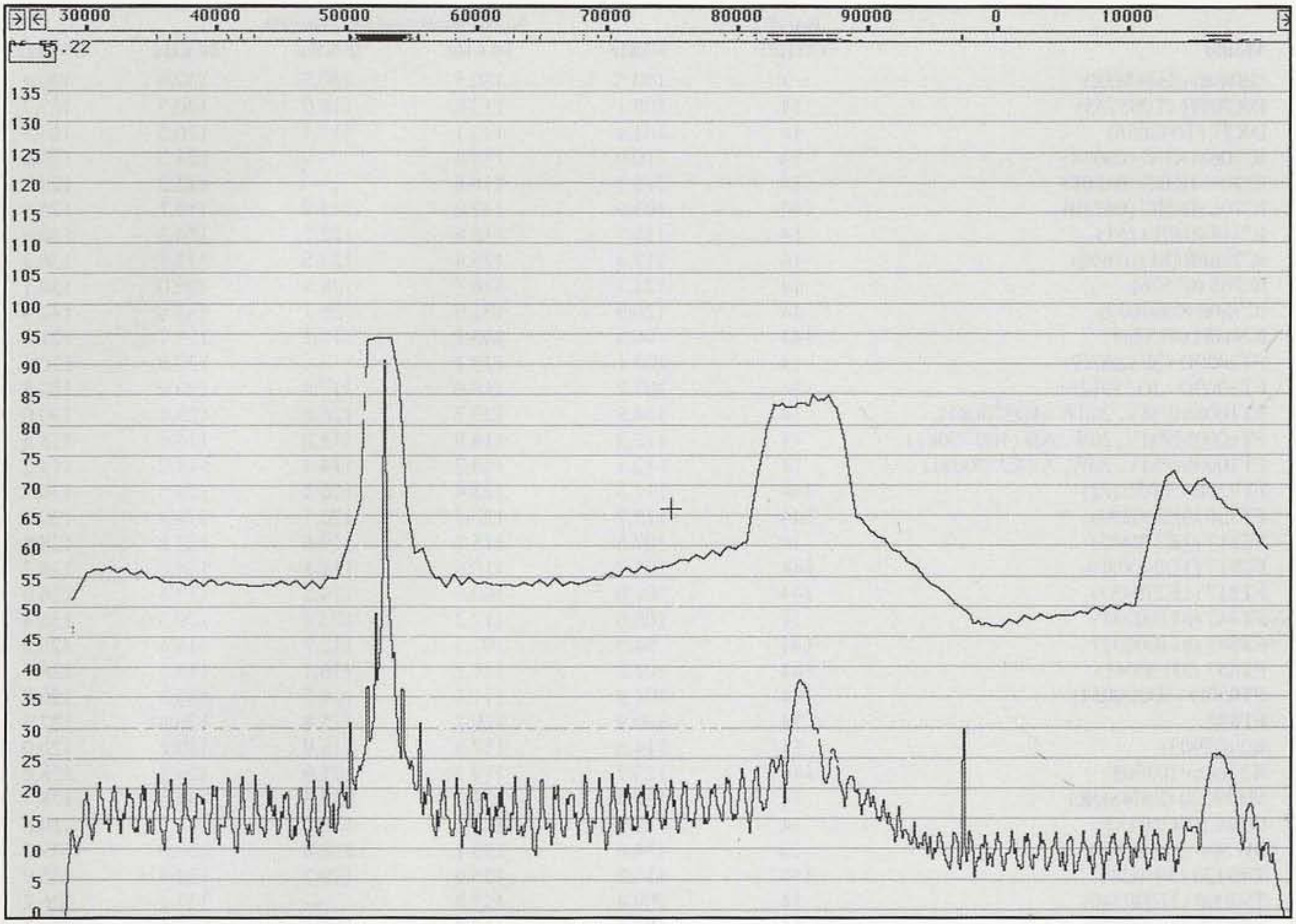


*Figure 7. Spectrum corresponding to figure 6. This is typical of FT-817 when run at reduced power on 14 MHz. The upper curve is peak-hold in a bandwidth of 2.4 kHz and the lower curve is the average power spectrum at narrow bandwidth.*

overtones at 32.1 MHz and higher will not pass through the filters, so only the original sine-wave will remain and be transmitted, and thus the output from the loudspeaker at the receive side will be exactly the original sine-wave (assuming a correct BFO setting). The only effect of RF clipping to a sine-wave is to reduce the amplitude to make it fit the power limitations of the power amplifier.

That line of argument that a sine-wave will not be distorted by an RF clipper may sound convincing, but it is not really valid. The very purpose of the speech processor is to change—to distort—the voice waveform. Indeed, if it fails to distort the waveform, the speech processor is not doing anything! The relevant question is whether the distortion to a voice signal that an RF clipper introduces is more favorable for intelligibility than the distortion produced by an audio clipper.

The human voice is not a sine-wave. If it were, an audio AGC would be the perfect speech processing, fully equivalent to RF clipping. With short pulses sent into the microphone it does not make much difference whether clipping is made at AF or RF. Likewise, if two signals at, say, 800 and 900 Hz were sent into the microphone input, the third-order intermodulation at 700 and 1000 Hz would be the same for RF and audio clipping.

One could argue that the human voice is much more like a series of pulses than a sine-wave, and that the difference between AF and RF clipping is small. The only way to really know is to make tests with a real voice signal. I did such tests some 30 years ago and no one was able to say whether I was using RF or AF clip-

| Model | 5 kHz RX (dBHz) | 5 kHz TX (–dBc/Hz) | 20 kHz RX (dBHz) | 20 kHz TX (–dBc/Hz) | 100 kHz RX (dBHz) | 100 kHz TX (–dBc/Hz) |
|---|---|---|---|---|---|---|
| IC706 (02803) | 92.6 | 91.0 | 107.7 | 108.3 | 125.8 | 125.4 |
| IC706MKIIG (04668) | 106.8 | 103.8 | 118.7 | 117.2 | 132.3 | 125.0 |
| IC821H (01942) | 97.8 | 95.8 | 113.7 | 113.1 | 129.0 | 127.7 |
| IC970H (LA3FV) | 102.7 | 100.1 | 123.7 | 121.6 | 140.7 | 132.0 |
| FT100 (9E032006) | 108.6 | 107.6 | 118.9 | 119.0 | 130.6 | 129.4 |
| FT817 (0N110101) | 103.3 | 101.3 | 118.2 | 117.2 | 132.6 | 130.4 |
| FT847 (LA9CM) | 99.9 | 96.0 | 116.9 | 115.0 | 131.9 | 130.4 |
| TM255E (51100675) | 128.8 | 116.2 | 136.9 | 122.3 | 144.5 | 125.5 |
| TS850S+conv (LA6MV) | 112.6 | 113.9 | 125.6 | 129.2 | 138.8 | 133.8 |

*Table 3. Comparison of receiver reciprocal mixing and transmitter composite noise. Data from the Scandinavian VHF/UHF meeting in Gavelstad Norway, June 2003.*

| Model | Band (MHz) | Noise Sideband in –dBc/Hz 5 kHz | 10 kHz | 15 kHz | 20 kHz | 50 kHz |
|---|---|---|---|---|---|---|
| DSW40 (SM4MJR) | 7 | 130.5 | 130.5 | 130.5 | 130.5 | 130.5 |
| DX70TH (T005735) | 14 | 105.1 | 113.8 | 118.0 | 120.5 | 127.7 |
| DX77 (T002056) | 14 | 101.4 | 112.1 | 117.4 | 120.5 | 128.9 |
| IC706MKIIG (06034) | 14 | 110.9 | 118.4 | — | 124.3 | 129.3 |
| IC706MKIIG (04668) | 14 | 112.3 | 118.8 | — | 122.2 | 123.7 |
| IC706MKIIG (06230) | 144 | 103.6 | 112.0 | 115.9 | 118.1 | 125.6 |
| IC718 (03011151) | 14 | 111.7 | 118.6 | 122.2 | 124.3 | 130.6 |
| IC756PROII (01690) | 14 | 117.4 | 125.4 | 129.8 | 131.7 | 136.3 |
| IC765 (02576) | 14 | 121.3 | 126.7 | 128.4 | 129.0 | 130.1 |
| IC7800 (0301012) | 14 | 120.9 | 131.9 | 136.1 | 137.8 | 142.4 |
| IC910H (01533) | 144 | 96.9 | 106.2 | 111.1 | 113.7 | 121.3 |
| FT1000D (3F320079) | 14 | 108.1 | 116.1 | — | 127.9 | 130.4 |
| FT1000D (3G330126) | 14 | 107.7 | 115.0 | 117.8 | 120.0 | 124.7 |
| FT1000MPMV, 200W (4D570081) | 14 | 114.8 | 123.7 | 126.8 | 128.4 | 130.0 |
| FT1000MPMV, 20W, AB (4D570081) | 14 | 112.3 | 114.8 | 115.0 | 115.0 | 115.5 |
| FT1000MPMV, 20W, A (4D570081) | 14 | 112.1 | 114.2 | 114.4 | 114.2 | 114.2 |
| FT726R (3I050222) | 144 | 111.3 | 123.6 | 128.2 | 129.5 | 130.7 |
| FT736 (9E260294) | 144 | 115.7 | 123.7 | 126.7 | 128.4 | 130.8 |
| FT817 (1E270433) | 14 | 107.3 | 115.2 | 119.6 | 122.8 | 128.8 |
| FT817 (1D240059) | 144 | 101.7 | 110.6 | 114.8 | 118.0 | 126.7 |
| FT817 (1E270433) | 144 | 101.0 | 109.6 | 114.2 | 117.4 | 126.0 |
| FT847 (81100231) | 14 | 105.6 | 117.2 | 124.9 | 129.3 | 136.4 |
| FT847 (81100231) | 144 | 94.3 | 107.3 | 112.7 | 116.1 | 125.2 |
| FT857 (3J130041) | 144 | 101.2 | 111.2 | 116.1 | 119.6 | 126.7 |
| FT857D (4D200054) | 144 | 101.2 | 111.4 | 116.5 | 119.8 | 126.9 |
| FT897 | 14 | 109.9 | 120.2 | 125.8 | 128.4 | 127.3 |
| K2 (03903) | 14 | 114.6 | 117.8 | 118.9 | 119.1 | 120.0 |
| K2+conv (03903) | 144 | 113.7 | 119.3 | 121.9 | 123.9 | 128.0 |
| MFJ9020 (SM4MJR) | 14 | 127.3 | 133.1 | 135.3 | 136.6 | 138.7 |
| Orion (03C10433) | 14 | 128.2 | 127.1 | 126.2 | 125.2 | 119.8 |
| SW30+ (SM4EPR) | 10 | 134.6 | 136.1 | 136.8 | 137.0 | 137.0 |
| TR9130 (3040284) | 144 | 116.3 | 125.6 | 129.7 | 132.3 | 135.9 |
| TS2000 (21000340) | 14 | 109.4 | 117.8 | — | 123.1 | 126.2 |
| TS2000 (30400028) | 14 | 108.6 | 117.8 | 119.6 | 121.1 | 124.1 |
| TS2000 (50600050) | 14 | 110.3 | 118.3 | 121.5 | 123.0 | 125.4 |
| TS2000 (30400028 | 144 | 105.3 | 115.3 | 119.8 | 122.6 | 131.0 |
| TS2000 (50600050) | 144 | 104.7 | 112.9 | 117.2 | 120.6 | 129.7 |
| TS450S (60700160) | 14 | 110.6 | 120.0 | — | 125.6 | 128.4 |
| TS50 (41000988) | 14 | 109.6 | 114.2 | 115.2 | 115.9 | 116.7 |
| TS711E (8070268) | 144 | 114.0 | 121.1 | 124.3 | 126.0 | 130.8 |

*Table 4. Transmitter sideband noise levels. The values given are the largest values measured at or above the corresponding frequency separation, so this table gives the frequency offset beyond which there is no wideband interference (splatter) above the level given in the table.*

ping. I did these tests at marginal signal levels only. For strong signals it is easy to hear the difference, but you have to remember that intelligibility is not the same thing as a pleasant "hi-fi" sound. Recently, I verified these findings with computer simulations. There is a difference, but it is not large. The speech-processing simulation is included in Linrad-01.25 (and later versions) as part of the setup for transmit routines. You can download it from <http://www.sm5bsz.com/linuxdsp/linroot.htm>[5] and make your own tests to find out how clipping and filtering affect intelligibility with your own voice.

The reason for bringing up the merits of audio clipping is that modern transceivers actually use RF clipping without filtering after the clipper by means of a fast ALC system. It has been used for decades, in transceivers such as the FT-225 for example ,[2] but it is and it always has been a bad idea because of all the off-channel interference generated. All rigs designed like this should be modified to make the speech clipping occur on the correct side of the bandwidth-defining filter. For the FT-225 this is particularly easy,[2] but it is pretty easy in other rigs also. Basically, one can reduce the gain of the amplifier immediately after the filter until the ALC becomes inactive. There will still be something ahead of the filter that limits the signal level and serves as a clipper, but it does not matter if it is an audio amplifier, the SSB generator, an RF amplifier, or mixer. Anything that limits the peak power at the right side of the filter—before the input—is fine. It is extremely easy to reduce the gain after the SSB filter. Just send some DC into the ALC input to make the ALC meter permanently show its normal peak voltage.

## Carrier Sideband Noise

The wideband noise surrounding a strong carrier is often the limitation on VHF bands. Such sidebands are usually referred to as phase-noise sidebands because it is assumed that they originate in the phase noise of a local oscillator. Transmitters are typically not even as good as the quality of the LO would allow, because inadequate noise figure of the transmit amplifiers plays an important part, and such noise modulates the amplitude as much as the phase.

As was pointed out in the article "Receiver Dynamic Range,"[6] the first article of this series, in order to make sure that no part of the transceiver unnecessarily limits the overall performance, the two-signal receiver dynamic range (in dB for 1-Hz bandwidth) should be equal to the LO phase-noise suppression (in dBc/Hz).

The transmitter sideband noise should also have the same value, if it is correctly designed and does not add needless noise from poorly designed amplifiers. Remember also that each of these performance figures is valid only at a given frequency offset from the signal frequency. Table 3 shows the two-signal dynamic range and the transmitter sideband noise levels of some typical 144-MHz transceivers, at three different frequency offsets.

I think it is because this kind of performance information is not made public in transceiver testing that the manufacturers see no reason to design the transmitter carefully. I am sure it would be very easy to cure problems of this kind at the design stage and that it would not lead to higher production costs.

At the 2003 Scandinavian VHF/UHF meeting I only made systematic measurements on receivers. At subsequent meetings I have mainly made measurements on transmitters, because transmitter spectral purity is becoming the limiting factor for dynamic range on VHF bands. Table 4 shows the sideband noise of various transceivers collected at several amateur meetings.[7]

HF transmitters typically have lower noise at close separation than VHF transmitters. This is a natural consequence of a lower LO frequency. At large frequency separations, on the other hand, VHF transmitters are typically better than HF transmitters. Maybe it is because engineers designing at VHF frequencies are more aware of amplifier noise performance, but HF engineers simply assume it will be okay.

## State of the Art: What is Good and What Needs Attention

It seems to me there is a general consensus that HF receivers have adequate dynamic range.[8] HF receivers also are not often limited by the two-signal dynamic range, and therefore some degradation may be harmless. On crowded HF bands the challenge is in the summed power from a large number of strong signals (including broadcast signals on 40 meters). The performance at very close frequency separation may need some attention—e.g., CW operators on the extremely crowded low-frequency bands may need a good intermodulation dynamic range at strong-signal separations as close as 0.5 kHz, and I have been told that many modern rigs fail badly at such close separations.

However, HF transmitters are very unsatisfactory. The bad habit of using the ALC as a wideband modulator distorts both CW and SSB waveforms, and generates emissions that often degrade the transmitter dynamic range by 40 dB and even more. This is not quite as bad as the number indicates, because the ALC-generated sidebands have a high peak to average power ratio, and it is possible to hear signals that are much weaker than the splatter peaks or keying clicks—unless, of course, these peaks are strong enough and long enough to capture the AGC of the receiver.

On VHF it is different. Neither transmitters nor receivers have the dynamic range required for several operators in the same city area to operate simultaneously without mutual interference. Even at large frequency separations, they are far from achieving this goal. However, there is no good reason why any VHF LO synthesizers should be notably worse than the best ones (for example, the synthesizer used in the TM-255). It typically is easy to modify the oscillator of any 144-MHz transceiver to this performance level. As an example, LA6LCA has modified the VCO in his TR-9130, and the two-signal dynamic range of the modified unit is 147.8 $dB_{Hz}$ at a frequency separation of 100 kHz and above.

I think the weak-signal VHF community would benefit greatly if the manufacturers would receive this message from the market: "We will only buy transceivers that have a transmitter and receiver dynamic range better than 140 dB/Hz at a separation of 100 kHz as soon as at least one such unit becomes available." Compared to the current state of the art, the improvement needs to be 15 to 30 dB—especially on the transmitter side—and it would make a significant difference to many of us.

Finally, there is no reason why such improvements should make the rigs significantly more expensive. At the present, what is missing is not costly hardware, but rather some thought and attention from the designers. ■



### References


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7. <http://www.sm5bsz.com/dynrange/rig_compare.htm>

8. Peter Chadwick, G3RZP, "HF Receiver Dynamic Range: How Much Do We Need?" *QEX,* May/June 2002, pp. 36–41.

# Moondata Update 2006 and Related Comments

One of the most important factors in EME communications is knowing when it is best to communicate via moonbounce. W5LUU presents a summary and table of the best and worst conditions for EME in 2006.

By Derwin King,* W5LUU

The earth-moon distance and the cosmic (sky) noise temperatures in the direction of the Moon are predictable cyclical variables that set basic day-to-day quality of the Earth-to-Moon path for communications at frequencies below 1.0 GHz. Best conditions occur when: (1) the Earth-Moon distance is at an absolute minimum, and (2) the Moon, as viewed from Earth, is in the coldest part of the sky. This rarely occurs. The EME signal-to-noise ratio, in dB, is usually degraded by a factor, DGRD (see below), which varies slowly with time. The 144 and 432 DGRD factors (in dB) and other pertinent EME data are tabulated in W5LUU Weekend Moondata at 0000 UT on each Sunday of the upcoming year. These are useful as a general guide to the basic EME weekend conditions. Ionospheric disturbances, local noise, polarization mismatch, and scattering properties of the Moon may make DGRD higher. The Range Factor is equal for all frequencies. Sky temperature is greater at 50 MHz than on 144 and lower on 1296 and higher than on 432.

In early 2006 the average DGRD remains high as Moon apogee occurs in the cold sky region, but by the end of the year this will reverse. In September Moon perigee occurs at a northern declination for the first time in many years. This continues for the remainder of 2006—and for the next several years. Five *good* weekend days occur in the first half of 2006 and eight in the second half. No weekend days are rated any better. However, these will be coming next year and for a few years thereafter. Contest dates for 2006 need to be carefully coordinated if all interest groups are to be fairly accommodated within the few feasible weekends.

## Definitions

**DEC (deg):** Moon declination in degrees north and south (–) of the equator. This is cyclical with an average period of 27.212221 days. The maximum declination during a monthly cycle is also cyclic, with a range of 18.15 to 28.72 degrees and a period of about 19 years. *Next maximum is on 09/15/2006.*

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

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

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

**DGRD (dB):** The degradation in EME signal-to-noise (in dB) due to: (1) the excess sky noise temperature (in dB) at the listed position of the Moon compared to the lowest cold sky temperature and the system noise temperature (all at the frequency of interest); plus (2) the Earth–Moon range factor (dBr) for the listed time and date. The tabulated DGRD is referenced to the lowest possible sky noise temperature along the Moon path, to a system noise temperature of 80K at 144 MHz and 60K at 432 MHz, an antenna beam width of ~15°, and to the absolute minimum Earth-Moon (surface-to-surface) distance.

The dBr affects DGRD equally at 144 and 432 MHz, but at 432 MHz and higher sky noise effects are lower. During a monthly lunar cycle DGRD can vary up to13 dB on 144 MHz and 8 dB on 432 MHz. DGRD varies less with small antennas than with large ones.

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

**Conditions:** Summary of EME conditions as controlled by DGRD at 144 MHz and NM. Conditions may be worse, due to ionospheric disturbances, but not better than indicated. In general, 144 MHz DGRD <1.0 dB is considered Excellent, 1.0 to 1.5 is Very Good, 1.5 to 2.5 is Good, 2.5 to 4.0 is Moderate, 4.0 to 5.5 is Poor, and over 5.5 is Very poor. Within a day of New Moon (NM), high sun noise can make conditions Very Poor regardless of the DGRD.

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# W5LUU Weekend Moondata for 2006
## For Sundays at 0000 UTC

| 2006 | DEC (deg) | RA (hrs) | 144 MHz Temp. (°K) | Range Factor (dBr) | DGRD (dB) 144 MHz | DGRD (dB) 432 MHz | Moon Phase | Conditions |
|---|---|---|---|---|---|---|---|---|
| **Jan 01** | −26.4 | 19.6 | 528 | 0.32 | 4.3 | 1.6 | NM + 21h | Poor |
| **08** | 14.4 | 2.0 | 322 | 1.17 | 3.3 | 1.7 | | Moderate |
| **15** | 24.4 | 8.3 | 202 | 2.19 | 2.8 | 2.3 | FM + 14h | Moderate |
| **22** | −10.9 | 13.5 | 322 | 1.92 | 4.1 | 2.3 | | Poor |
| **29** | −24.1 | 20.3 | 360 | 0.17 | 2.7 | 0.9 | NM – 14h | Moderate |
| **Feb 05** | 18.6 | 2.6 | 359 | 1.14 | 3.7 | 1.8 | | Moderate |
| **12** | 21.8 | 8.9 | 170 | 2.29 | 2.4 | 2.3 | FM – 1.2d | **Good** |
| **19** | −14.9 | 14.0 | 349 | 1.94 | 4.4 | 2.5 | | Poor |
| **26** | −22.2 | 20.8 | 334 | 0.20 | 2.5 | 0.8 | NM – 2d | **Good** |
| **Mar 05** | 22.0 | 3.2 | 362 | 1.04 | 3.6 | 1.7 | | Moderate |
| **12** | 18.7 | 9.5 | 183 | 2.32 | 2.6 | 2.3 | FM – 3d | Moderate |
| **19** | −18.8 | 14.6 | 391 | 1.87 | 4.7 | 2.6 | | Poor |
| **26** | −19.3 | 21.4 | 345 | 0.36 | 2.7 | 0.9 | NM – 3.5d | Moderate |
| **Apr 02** | 24.4 | 3.8 | 362 | 0.97 | 3.5 | 1.6 | | Moderate |
| **09** | 15.3 | 10.1 | 188 | 2.30 | 2.7 | 2.3 | | Moderate |
| **16** | −22.2 | 15.3 | 436 | 1.71 | 4.9 | 2.6 | FM + 2.5d | Poor |
| **23** | −15.4 | 22.0 | 276 | 0.55 | 2.2 | 1.0 | | **Good** |
| **30** | 26.3 | 4.4 | 398 | 1.02 | 3.9 | 1.8 | NM + 2.2d | Moderate |
| **May 07** | 11.7 | 10.6 | 201 | 2.26 | 2.8 | 2.4 | | Moderate |
| **14** | −24.8 | 15.9 | 506 | 1.47 | 5.3 | 2.5 | FM + 0.7d | Poor |
| **21** | −10.7 | 22.7 | 244 | 0.66 | 1.9 | 1.0 | | **Good** |
| **28** | 27.6 | 5.0 | 467 | 1.19 | 4.7 | 2.2 | NM + 0.8d | Poor |
| **June 04** | 7.9 | 11.0 | 211 | 2.24 | 3.0 | 2.4 | | Moderate |
| **11** | −26.7 | 16.5 | 708 | 1.23 | 6.3 | 2.5 | FM - 0.75d | Very Poor |
| **18** | −5.3 | 23.4 | 244 | 0.65 | 1.9 | 1.0 | | **Good** |
| **25** | 28.3 | 5.6 | 512 | 1.43 | 5.2 | 2.7 | NM – 0.7d | Poor |
| **July 02** | 3.9 | 11.5 | 235 | 2.26 | 3.3 | 2.4 | | Moderate |
| **09** | −27.9 | 17.2 | 1199 | 1.06 | 8.2 | 3.2 | FM – 2d | Very Poor |
| **16** | 0.0 | 0.0 | 252 | 0.54 | 1.9 | 1.0 | | **Good** |
| **23** | 28.4 | 6.3 | 440 | 1.67 | 4.9 | 2.8 | NM – 2d | Poor |
| **30** | −0.2 | 12.0 | 260 | 2.30 | 3.7 | 2.6 | | Moderate |
| **Aug 06** | −28.5 | 17.8 | 2619 | 0.99 | 11.4 | 5.0 | FM – 3.5d | Very Poor |
| **13** | 4.9 | 0.5 | 271 | 0.57 | 1.9 | 0.8 | | **Good** |
| **20** | 27.6 | 7.1 | 358 | 1.84 | 4.4 | 2.5 | | Poor |
| **27** | −4.4 | 12.5 | 312 | 2.33 | 4.4 | 2.9 | NM + 3.2d | Poor |
| **Sept 03** | −28.5 | 18.4 | 2247 | 1.04 | 10.8 | 5.4 | | Very Poor |
| **10** | 9.1 | 1.1 | 285 | 0.21 | 1.9 | 0.6 | FM + 2.2d | **Good** |
| **17** | 25.9 | 7.8 | 257 | 1.92 | 3.3 | 2.2 | | Moderate |
| **24** | −8.6 | 13.0 | 314 | 2.31 | 4.4 | 2.8 | NM + 1.5d | Poor |
| **Oct 01** | −27.6 | 19.1 | 828 | 1.13 | 6.8 | 3.4 | | Very Poor |
| **08** | 12.8 | 1.6 | 300 | 0.16 | 2.1 | 0.6 | FM + 21h | **Good** |
| **15** | 23.5 | 8.4 | 196 | 1.91 | 2.4 | 2.0 | | **Good** |
| **22** | −12.6 | 13.5 | 325 | 2.22 | 4.4 | 2.7 | NM – 5h | Poor |
| **29** | −25.7 | 19.8 | 470 | 1.18 | 4.7 | 2.3 | | Poor |
| **Nov 05** | 16.3 | 2.1 | 329 | 0.27 | 2.5 | 0.8 | FM – 6h | **Good** |
| **12** | 20.7 | 9.0 | 166 | 1.87 | 1.9 | 1.8 | | **Good** |
| **19** | −16.2 | 14.1 | 354 | 2.10 | 4.6 | 2.6 | NM – 1.9d | Very Poor |
| **26** | −22.7 | 20.5 | 339 | 1.11 | 3.4 | 1.7 | | Moderate |
| **Dec 03** | 19.7 | 2.7 | 360 | 0.52 | 3.1 | 1.2 | FM – 2d | Moderate |
| **10** | 17.6 | 9.5 | 182 | 1.85 | 2.1 | 1.8 | | **Good** |
| **17** | −19.5 | 14.6 | 390 | 1.99 | 4.8 | 2.7 | | Poor |
| **24** | −19.0 | 21.2 | 339 | 0.89 | 3.2 | 1.4 | NM – 3.4d | Moderate |
| **31** | 23.1 | 3.3 | 360 | 0.81 | 3.3 | 1.4 | | Moderate |

# A Telemetry Beacon, Digital Camera, and Controller System for Experimental High-Altitude Balloon Flights

Here WC5Z describes a simple and inexpensive flight payload system for experimental high-altitude balloon flights.

**By Michael Helm,* WC5Z**

*The payload described in this article includes a simple 2-meter FM/CW telemetry beacon transmitter, an automated IDer/controller which can provide up to 16 different CW telemetry status messages and also control an inexpensive digital camera for collecting still images at predetermined intervals during a balloon flight. This total system design has successfully flown in two recent flights. The total payload weight without batteries is about 8 ounces.* —*WC5Z*

High-altitude experimental balloon flights have been described elsewhere in the literature. This article covers the design of a small multi-purpose payload, which is useful to fly as a standalone payload or in conjunction with other experimental payloads. This payload includes a low-power 2-meter beacon transmitter for tracking purposes and some limited status telemetry, along with an inexpensive digital camera which will take pictures at timed intervals (photo A).

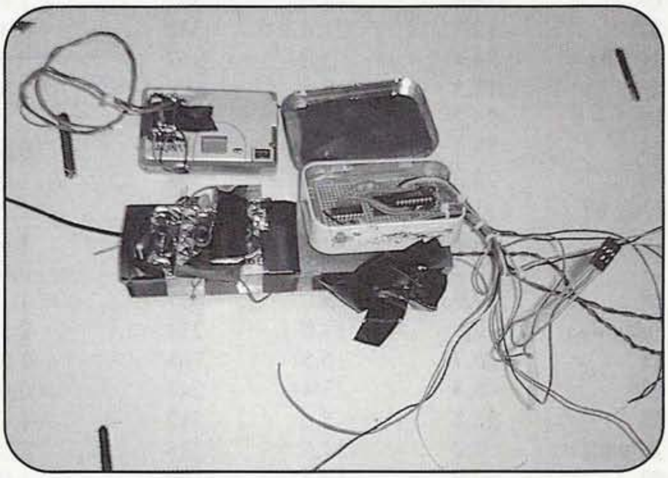

*Photo A. Controller, two separate beacon transmitters, and the modified digital camera prior to final packaging before flight.*

The total cost of duplicating this payload including camera and even the batteries should be less than $100. The entire system is designed to operate from a 6-volt DC power source in the interest of keeping battery weight low.

## The 2-meter Beacon Transmitter

The low-power 2-meter beacon transmitter is designed around a conventional oscillator-multiplier chain[1] with the circuit as shown in figure 1. The design is based around proven technology rather than a leading-edge approach, since reliability is the most significant performance requirement. This beacon transmitter provides an FM-tone modulated signal that is on/off keyed with the CW ID/telemetry message. A simpler transmitter design has been flown that does not include the FM audio tone, but many of the casual balloon trackers only have FM equipment and the signal is more pleasant for those trackers if the FM tone modulation is included. The FM tone modulation does not significantly hinder those who are using SSB/CW receivers for tracking.

The transmitter starts with a 12.288-MHz surplus crystal that can be obtained for very low cost. The first stage is an oscillator-tripler; the next stage doubles to the 72-MHz region. Following is a doubler stage to 147.456 MHz which feeds a single amplifier stage. Double-tuned circuits are used in most stages to provide for good signal purity. Although it is possible to eliminate some of the double-tuned circuits, I have found this often results in close-in spurious signals plus or minus the fundamental crystal frequency from the desired final carrier frequency. Double-tuned circuits add little to the total cost and weight and are very desirable from a clean-signal standpoint. Even though this transmitter only produces about 25 mW when operated from a 6-volt DC power source, since it will be flown at up to 20 miles of altitude it is very important for its output to be spurious free. The spurious-emissions requirements of FCC Part 97 are tighter than you might think, even for a low-power transmitter such as this in this frequency range. Even at this low power, harmonics and spurious emissions must be down about 38 dB and have to be down 40 dB if the power is as high as 100 mW.[2] I use a spectrum analyzer for final tuning of these transmitters and would recommend that you do the same if you choose to duplicate this design for your own flights. I have built several transmitters similar to this one and all have met the FCC Part 97 spurious-emissions requirements when properly tuned, but just tuning for maximum power out may not achieve a clean output.

At the output, a low-pass filter is included. I feed the signal from the output into either a standard half-wave dipole or an

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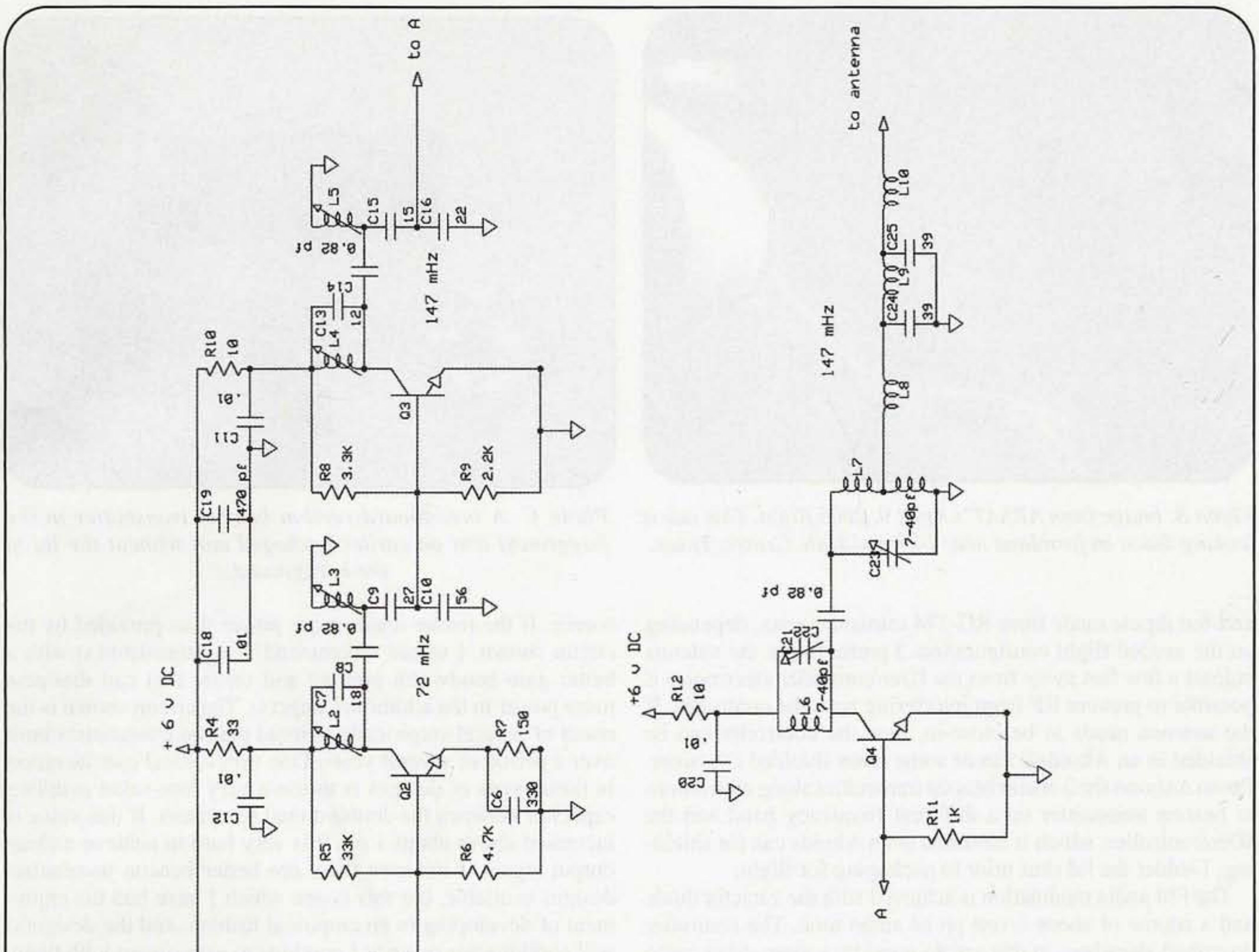


*Figure 1. One version of the simple FM/CW beacon transmitter. This version will produce about 25 mW of output power. One more amp stage can easily bring this up to more than 100 mW.*

*Photo B. Image from ARSAT's April 9, 2005 flight. This one is looking down on farmland near I-27 and Hale Center, Texas.*

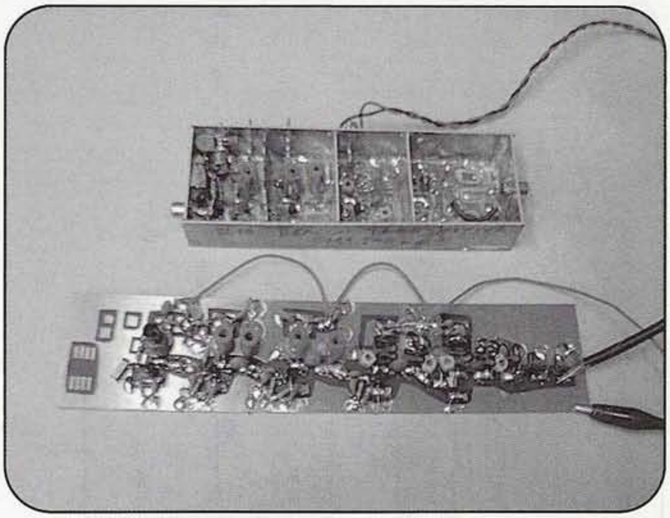

*Photo C. A breadboard-version beacon transmitter in the foreground and an earlier packaged unit without the lid in the background.*

end-fed dipole made from RG-174 miniature coax, depending on the needed flight configuration. I prefer to put the antenna at least a few feet away from the IDer/controller electronics if possible to prevent RF from interfering with the controller. If the antenna needs to be close-in, then the controller can be shielded in an Altoids® can or some other shielded container. Photo A shows the 2-meter beacon transmitter along with another beacon transmitter on a different frequency band and the IDer/controller, which is mounted in an Altoids can for shielding. I solder the lid shut prior to packaging for flight.

The FM audio modulation is achieved with the varactor diode and a source of about 1-volt pp of audio tone. The controller described elsewhere in this article provides square-wave audio tone, or a 555 timer or other audio tone source can be used. If a square-wave audio tone source is used, it should be filtered with a low-pass RC network to provide something close to a sine wave.

The transmitter power is deliberately kept low for multiple reasons. Very little power is needed to track the beacon while it is flying. K5IS, who has much more experience with tracking than I do, has explained to me that too much power in the beacon transmitter makes it more difficult to get good beam headings while tracking the balloon in the air. The 25 mW is plenty sufficient for tracking the payload in the air and is useful when the payload is on the ground with a good mobile tracking setup if the beacon antenna is off the ground. A member of our local ARSAT (Amateur Radio Society At Tech [Texas Tech]) group, KD5UXO, developed a payload concept to keep the antenna off the ground. In this payload arrangement the antenna is attached across a large disk attached about one third from one end of a cylindrical payload mounted in the center of the disk, so regardless of how the payload lands, the antenna should never be flat on the ground. Experiments have shown this to very useful in improving the on-the-ground tracking range.

Another advantage of lower power is much longer battery life. The estimated battery life on our most recent ARSAT flight was eight days with this payload, and could have been of great benefit had the payload been lost.

I have built several variations on this design. Some have included additional power gain stages and have achieved up to about 200 mW of output power when using a 12-volt DC power source. If the reader wants more power than provided by the circuit shown, I would recommend using transistor(s) with a better gain bandwidth product and one(s) that can dissipate more power in the additional stage(s). The circuit shown is the result of several empirically derived beacon transmitters built over a period of several years. One very critical consideration in these types of designs is to use a very low-value coupling capacitor between the double-tuned resonators. If this value is increased above about 1 pF, it is very hard to achieve a clean output signal. I am sure there are better beacon transmitter designs available, but this is one which I have had the enjoyment of developing in an empirical fashion, and the design(s) will continue to evolve as I continue to experiment with them.

## Multipurpose IDer/Controller

A single micro-controller chip, the PIC16F84[3], is the core of the IDer and the camera controller. This less than $5 component provides the automated beacon ID, provides for up to 16 different pre-amble messages to indicate the status of four digital input bits, provides the control signals to control the power and shutter for an inexpensive digital camera, provides for security lockout, and provides the potential for timed payload release or other timed event during flight. The keying for the beacon transmitter is provided in two forms, either on/off keying or audio tone.

The PIC16F84 can use either a crystal-controlled clock or an RC-controlled clock. I use an RC clock since it is less expensive and also provides the ability to provide relative temperature telemetry by including a thermistor in parallel with the clock resistor as shown in figure 5. This causes the CW ID message to become slower at lower temperatures, and when it speeds up, it alerts trackers that the payload is descending. An alternative way to telemeter this information is to use the thermistor on the audio tone source for the FM modulation.

The PIC16F84 has a total of 13 I/O pins. These can be assigned individually as inputs or outputs. Outputs include beacon transmitter on/off keying, camera power control, camera shutter control, and an optional payload-release timed signal. Inputs include a security power-up feature, and four digital on/off status bits which select one of 16 preamble messages.

This allows a limited amount of status information to be sent on every ID cycle.

The security power-up feature provides some security for the callsign owner in case this payload is not recovered. A certain sequence has to occur during power-up of the unit in order for the beacon to transmit or the camera to start taking pictures. Basically, if the unit is powered up without a special signal jumper in place, the unit simply will halt and never key the beacon transmitter nor take any pictures. If the jumper is in place at power-up, the beacon will begin to send the letter V in Morse Code, but will not take any pictures. When beacon signals are confirmed after power-up and flight is imminent, the special jumper is removed and the controller will start the normal ID sequence, including the preamble message indicating the status of the four digital input bits. After the jumper is removed, the camera sequence will start and will take a picture once each ID sequence. Because the camera has automatic power-down after about 30 seconds, it is necessary to turn on the power to the camera for every picture and then toggle the shutter. The ID sequence includes one very long key-down time to assist the trackers in getting good bearings. The total ID cycle takes about one minute at nominal temperature and yields one picture for each ID sequence.

## The Camera and Interface

The camera is a very inexpensive (approximately $20) unit obtained from a local Walmart store. This unit will store about 75 pictures of 640 × 480 pixels and is very sufficient to obtain interesting photos from the payload. The camera uses two internal AAA batteries, and apparently they have worked okay even at the cold temperatures during two recent flights. To provide the interface, the power and shutter switch connections are determined after disassembling the camera. I used small reed relays to control those signals. This provides a very clean interface to the PIC16F84, which will directly drive the relays. I got the idea about the camera from a couple of articles by Paul Verhage in *Nuts & Volts*.[4,5]

## Conclusion

This design provides a simple, lightweight, and inexpensive payload for experimental high-altitude balloon flights. It is suitable as a standalone payload or a supplemental payload. Because it runs on 6 volts DC and averages less than 60 mA of current consumption, it can run for several days on a good set of lithium batteries. The long battery life may be beneficial in the event of initially lost payload.

Experiments have been run to determine the range of the beacon transmitter once the payload is on the ground. With the antenna lying on the ground, it can be received about 1 mile with a simple FM mobile setup. With the payload configured so that the antenna will always be off the ground, a good mobile tracking setup with SSB/CW receiver and multi-element Yagi can track it 5 or 6 miles, depending on actual beacon power. A recent flight by the ARSAT group in Lubbock, Texas includ-

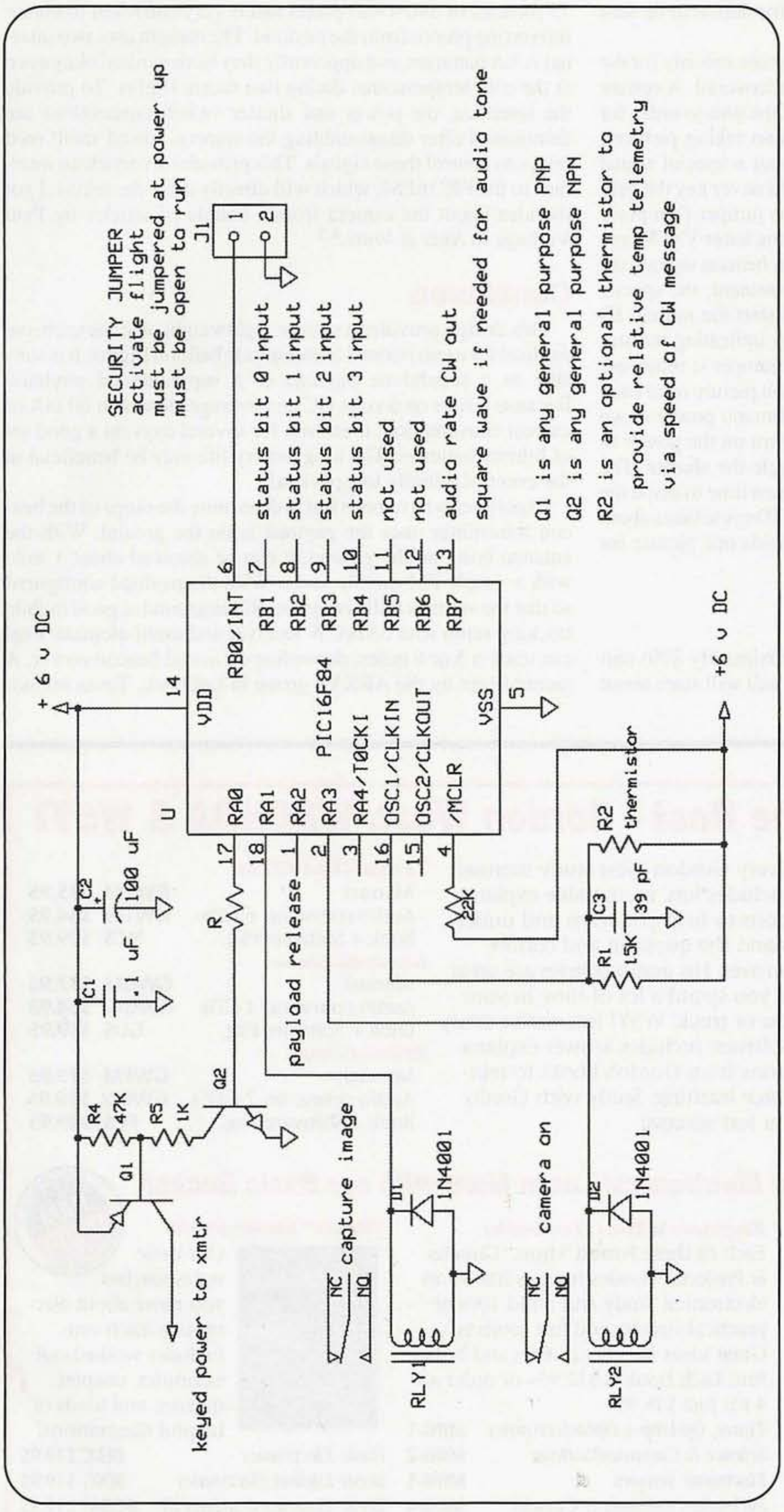


*Figure 2. The beacon and camera controller.*

ed only this payload and was successfully recovered within 30 minutes of payload down. Without the beacon transmitter, recovery would likely not have occurred. This payload is also suitable as a backup to GPS/APRS payloads.

In another recent flight with the K5IS group near Booker, Texas, a payload similar to this one was flown as a supplemental payload, and yet proved to be useful during a brief time when the APRS payloads had failed temporarily (due to cold temperatures?). This payload at least gave us a reasonable indication of where the balloon was and that at least some things were still functional. The beacon transmitter/ IDer did briefly enter a continuous key-down mode at the top of the flight, but recovered. Since the transmitter and controller were not insulated, cold temperatures are suspected as the source of that brief problem.

Other beacon transmitters have been designed and flown, including 12-volt DC versions of the same general design and a simpler CW-only beacon that used a 49-MHz-region crystal and that required fewer multiplier stages, hence a smaller, simpler, lighter weight beacon. I am currently working on a 440-MHz design and a 915-MHz design, but those are still in the development phase and have not flown—yet. This general beacon transmitter design has now flown a total of four flights, and the IDer/controller has now flown three flights. In all cases the systems performed well with the one brief failure mentioned above.

The assembly language source code for the PIC16F84 will be available on my website at: <http://www.cs.ttu.edu/~mhelm/balloonBeacon2005.asm>. The code is reasonably well documented and should be self-explanatory.

## References

1. Helm, Michael, "Some Experiments with Multiplier Chains," *Proceedings of Microwave Update '91*, ARRL, Newington, CT 1991.

2. *ARRL Handbook,* Emission Standards, pp. 1.13, 1.14, ARRL, Newington CT, 2005.

3. MicroChip, PIC16F84 Data Sheet, <www.microchip.com>.

4. L. Paul Verhage, "Modifying a PenCam for Use in Near Space Applications," Near Space column in *Nuts & Volts* magazine, T&L Publications Corona, CA, November 2004

[5] L. Paul Verhage, "Updates on Modifying Cameras for Digital Control" Near Space column in *Nuts & Volts* magazine, T&L Publications Corona, CA, March 2005. ■

# CQ's 6 Meter and Satellite WAZ Awards

**(As of September 31, 2005)**

**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 | 1,10,18,19,23,31,32 |
| 16 | W5OZI | 2,16,17,18,19,20,21,22,23,24,26,28,34,39,40 |
| 17 | WA6PEV | 3,4,16,17,18,19,20,21,22,23,24,26,29,34,39 |
| 18 | 9A8A | 1,2,3,6,7,10,12,18,19,23,31 |
| 19 | 9A3JI | 1,2,3,4,6,7,10,12,18,19,23,26,29,31,32 |
| 20 | SP5EWY | 1,2,3,4,6,9,10,12,18,19,23,26,31,32 |
| 21 | W8PAT | 16,17,18,19,20,21,22,23,24,26,28,29,30,34,39 |
| 22 | K4CKS | 16,17,18,19,21,22,23,24,26,28,29,34,36,39 |
| 23 | HB9RUZ | 1,2,3,6,7,9,10,18,19,23,31,32 |
| 24 | JA3IW | 2,5,18,34,40 |
| 25 | IK1GPG | 1,2,3,6,10,12,18,19,23,32 |
| 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 | KØSQ | 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 |

## 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 |

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>

# T-Hunting Then and Now
## From Gooney Birds to GPS

For over 40 years, hidden transmitter hunters have prowled the streets in search of the elusive sources of unusual signals. Equipment has evolved, but the adventure and intrigue remain the same.

### By Joe Moell,* KØOV

To me, the best thing about ham radio is that it's not just one thing. Our hobby offers a myriad of bands, modes, and activities, each with its own group of dedicated followers and proponents. I've tried most of them and they all are a blast. However, to me, nothing can compare with the excitement of hidden-transmitter hunting.

When you set out on a mobile transmitter hunt (which southern California hams call a "T-hunt"), you never know where you'll end up and you never know what you'll find there. What surprise awaits today? On-foot hunts are an equal challenge, where you can improve your physical conditioning and perhaps win medals in international competitions.

Transmitter hunting is far from new in amateur radio. *QST* magazines of the 1930s tell of on-foot hunts at ARRL conventions, where hams used rudimentary equipment—just a galena crystal across the terminals of an earphone—to "sniff" out a signal source.

The heyday of T-hunting began a half-century ago, when gasoline was cheap and the open road beckoned. A ham would take a portable transmitter to an unlikely location and put it on the air. The hunters, usually all starting from the same location, would try to see who was best at radio direction finding (RDF). Each hunt was a test of construction skills as well as tracking abilities, for no commercial RDF gear was available.

I went on my first T-hunt as a 12-year-old Novice. On the rolling plains of Nebraska where I lived, the not sensitive 2-meter rigs of the day could hardly talk from one town to the next. Therefore, our Novice 2-meter voice privileges went unused. Local hams kept track of one another on the 75-meter phone band. Some of them had upgraded to the latest in ham technology—single sideband. The natural place for a transmitter hunt was right there on 75.

I was working toward my General Class license, learning to draw RF oscillator and amplifier schematics from memory, as was required back then. My pride-and-joy Hallicrafters SX-100 receiver was all I had for 75 meters, so I built a vibrator power supply for it out of junk car radio parts. It sat on the seat of the family convertible, with the wicker-weave antenna from an old AM radio up on a pole that I held high. Dad had to drive, of course. The antenna directivity was not good and we didn't find the transmitter, but I was hooked. Unfortunately, the local club never had another hunt until after I graduated from high school.

### Follow the Winking Green Eye

At the same time in southern California, hams had discovered the delights of T-hunting on VHF. David Pepper, WA6TWA, was also age 12 when he first took a Saturday night ride to experience it. He had heard about it from Hal Rattray, WA6SZY, who lived across the street. For David's first hunt, he was relegated to the back seat of Hal's car, where he kept track of the flashlight and maps.

*Getting back into the game, David Pepper, WA6TWA, sniffs out a hidden transmitter using a state-of-the-art 2-meter RDF set from Australia. (All photos by Joe Moell, KØOV)*

"All of the cars were equipped with receivers, signal-strength meters, and other electronic gadgets," says David. "They also had strange-looking antenna rotating devices and handheld aircraft landing lights to show the way. The antennas ranged from beams, which looked like housetop TV antennas, to helicals with futuristic-looking spiral copper tubing protruding from dish-like structures."

T-hunting had become a popular sport in the City of Angels, attracting 10 to 20 cars for each hunt. Inside were two or three people. The driver concentrated on the road while the others handled all the gear and maps. Some attached their antennas to a window mount, while others had to stop and get out of the car to get bearings.

Before the hunt, an organizer would record every vehicle's odometer reading. The most popular hunts were scored by mileage from start to finish, to encourage safe driving and careful map reading. Occasionally there were hunts in which the first-to-find was declared winner and mileage didn't count, but

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these "road races" weren't as popular. Afterwards, everyone headed to the famous Bob's Big Boy restaurant for treats, war stories, and mileage calculations.

According to WA6TWA, "Bulky and heavy vacuum-tube AM gear was the order of the day. Commercial transceivers included Heathkit Pawnees and Gonset Communicators, or 'Gooney Birds' as they were called. The Gonsets had a weird fluorescent-green 'eye' tube. Its glowing pattern would open and close depending on the signal strength. This winking eye added intrigue to the strange chirping tones that assaulted my ears that night.

"We started at Darby Park near Hollywood Race Track," David continues. "Bearings were in the northerly direction. Some teams shot for the moon and headed toward Mount Wilson by freeway, hoping that the transmitter was in the mountains and they could minimize mileage through the city. We took a more conservative route along the side roads, taking antenna bearings every mile or so and ending up in the Verdugo Hills above Glendale, 20 miles from the starting point.

"As we got closer to the transmitter, the warbling, chirping sounds from our rig became more and more intense and the meters began to peg. Occasionally, the hidden operator would break the tension by getting on his microphone and exclaiming, 'This is the hidden transmitter, located on Mount Suribachi!'[1] Driving up the dark canyon roads on this moonless night was very exciting, but even with our aircraft landing light in hand, we were unable to find the fire road that would have led us to the pot of gold at the end of the radio-wave rainbow. Nevertheless, I had a great time."

Today's stamp-size transmitter boards make it possible to really "hide" a transmitter. Back then it was better to be in plain sight, using camouflage if necessary. Resourceful hiders had many tricks up their sleeves, as David discovered on his second outing.

"The T was cleverly placed in full view of the traffic flow along La Cienega Boulevard, brightly illuminated by streetlights above. The electronics were in a metal box with a cable emerging and neatly stretched across the street on the pavement. The antenna was attached to the other end of the cable and hidden from view in bushes.

"This contraption looked just like an official traffic counter," WA6TWA explains. "Most of the T-hunters, along with the rest of the traffic flow, drove over the cable. It was not until several miles down the road that we caught on, once we got bearings pointing behind us!"

Young David sought hunt rides wherever he could get them. By accompanying many different hunters he learned what worked well and not so well. He was especially excited to get a seat with Neil McKie, WA6KLA, a top-tier hunter of the time. However, his mother was understandably concerned when the doorbell rang on that drizzly night. He says, "A 6-foot 5-inch burly man told her that he was here to pick up her precious pimple-faced, nerdy-looking 12-year-old boy whose voice had yet to change.

"In his deep, yet gentle voice Neil tried to convince my mom that all was safe and that I would be in good hands. She then asked him about the transportation. Neil proudly pointed out his T-hunt car in front of the house—a dilapidated 1940s tan-painted clunker with a strange-looking set of antenna wires out the window.

"Neil was a wonderful guy, and the T-hunt that night was a real surprise. The transmitter was right there at the Darby Park starting point in the brush. Output power was very weak to bluff everyone into thinking that it was miles away. However, Neil had a sixth sense as he drove about three blocks away from the starting point and patiently waited until the other hunters drove past. When I asked him why the delay, he told me that he had a hunch that the transmitter was closer to us than we first thought, in spite of the very weak signal.

*Unusual rotating VHF RDF beams are a common sight in southern California. JaMi Smith, KK6CU, built this motorized version in the 1990s. It turns at constant 6 rpm and displays bearings in polar form on a storage oscilloscope.*

"After taking a few more bearings, he said that it was back to the starting point for us. Once there, he took out his war-surplus portable direction finder along with his flashlight and walked around the park with me closely behind. Ten minutes later, he found the transmitter hidden in the brush and the T-hunt for us was over almost before it started. In spite of this impressive display of talent, Neil and I were humbled because the winning car turned back after only two blocks and beat us by a fifth of a mile!"

## They've Landed!

Was it a coincidence that the hunters' vehicles looked like something from the popular science-fiction movies at local drive-ins?

"We would be routinely queried by onlookers as to what was going on," WA6TWA reports. "One of our more outrageous responses occurred on a T-hunt that took us along Hollywood Boulevard. When asked about our intent, we responded that a

*Huntmasters often use exotic antennas to help their signals bounce in the southern California hills. Gary Holoubek, WB6GCT, set up this 30-foot circularly polarized 2-meter helix for a Saturday night hunt.*

secret Russian Sputnik had landed in the area and we were tracking it down for the government."

That sort of flip answer may have brought trouble to some other hunters. Ken Walsh, K6ZRL, recalled, "One night several of us found ourselves under arrest, albeit briefly. We weren't doing anything illegal, but a homeowner had complained about strange people with radio gear tramping through the countryside. One hot-shot officer crashed his patrol car in the fog during that caper."

Even though it was the midst of the Cold War and many homes had fallout shelters, hams of the 1960s could hide radio gear in places that would be unthinkable today. WA6TWA says his most memorable transmitter find was in the TWA terminal at Los Angeles International Airport. He explains, "This predated the double-deck arrival/departure streets by decades. Back then, security was nonexistent by today's standards. No loudspeakers in front of the terminal urged cars and pedestrians to move on, no baggage searches were made, no security guards were on patrol, and no metal detectors or x-ray machines were to be seen.

"That Saturday night, our antenna bearings from Darby Park all pointed toward the beach. As we drove westward, we realized that LAX was to be our destination. More and more unusual cars began to pull up in front of the TWA terminal. When we couldn't find anything outside, we unmounted our antennas and equipment, then proceeded inside.

"There were three on my team, with interconnected equipment. One guy carried the buzzing vacuum-tube receiver, another carried a heavy car battery to power the mobile unit, and I held a 5-foot-long beam antenna to get directional readings. We strolled upstairs to the departure gates and eventually found the transmitter. It was in a briefcase plugged into the wall, left unattended next to a chair in the gate area just a few feet from the departure tunnel. A 19-inch coat hanger sticking out of the briefcase served as the antenna."

When David moved up to Fairfax High School, he found an active amateur radio club. Of course, he was eager to share his love of T-hunting with its members. He found a sympathetic ear in the boys vice-principal, who happened to be a ham. Mr. Alm agreed to let the club hold lunchtime on-foot hunts.

WA6TWA continues the story: "When it was my turn to hide, I decided to use the room where we met for the weekly chess club tournament. I placed my ham radio set under a desk and turned it on. Only a barely perceptible buzz came from the rig, which was transmitting the strong beacon signal. The tournament chess games continued as the hunters approached. In they came with their antennas, meters, and loudspeakers blasting away with Martian-sounding chirps."

School authorities put a quick end to that hunt, but David was undaunted. Later he found a way to go mobile without a gas-guzzling car by raiding his savings and purchasing a Honda touring motorbike. He says, "On a drizzly night I tried to T-hunt on the cycle with my old Heathkit Pawnee strapped on the rack. I stopped the bike every few miles, and using my body as if it were a reflector dish, I twisted around with a spike antenna in front of me in a futile attempt to take bearings.

"I was the joke of my competitors in cars that night. A few miles from the starting point my headlights began to dim and my engine began to sputter. I drained my motorcycle battery to a record-low charge level, but almost won the hunt. That night's transmitter was in a parking structure adjacent to the world famous Grauman's Chinese Theater in downtown Hollywood with a spike antenna dangling from the wall, a sure antenna-buster for anyone in a car."

## The More Things Change...

Fast-forward to a few months ago, when WA6TWA and his wife Denise rode in my van for David's first T-hunt in three decades, and Denise's first ever. What a difference! Sensitive receivers have made high-power transmitters unnecessary most of the time. A half watt usually does it, and such a transmitter is a snap to conceal or disguise.

Hunt boundaries are much larger, encompassing over 2300 square miles on one of the Saturday night hunts. Rules of the "All-Day Hunts," which can last an entire weekend, merely require the transmitter to be within the continental USA and be copyable at the top of Rancho Palos Verdes.

A complete on-foot RDF setup with three-element beam and receiver with tone-pitch S-meter weighs around two pounds and can be carried in one hand, even by a pre-teen. Doppler RDF sets can capture and display bearings on transmissions of only a few milliseconds, but their relative insensitivity and less-than-ideal performance with horizontally polarized signals make them a secondary system for most of the hunters who use them here.

The favorite hunt vehicle is now a van or SUV. Equipment often includes laptop-based mapping software with GPS positioning. However, that doesn't mean that T-hunting doesn't require skill anymore. Hiders have learned how the local mountains can make signals bounce like billiard balls, giving false directional readings over a wide area. Instead of being continuous, typical transmissions last only a few seconds.

Much of the time there are three, four, five, or more transmitters all on one frequency, each squawking for a few seconds at a time in random sequence. On the occasional "Free For All" hunt, each participant pre-hides one or more unattended "T-boxes," as they are called. Then for a set period everyone tries to find each others' boxes. The winner is the team that finds the most.

## ...The More They Stay the Same

Despite all the technical improvements, former southern California T-hunters of the 1960s still feel right at home in 2005.

*Jason McLaughlin, KD6ICZ, started riding along and sniffing out transmitters as he entered his teens. A decade later, he is still a fan of this ham radio sport.*

Lowest-mileage scoring is still preferred, with Crenshaw Factor[2] normalization to accommodate differences in odometers. There are fewer Bob's Big Boy restaurants out there, but everyone swaps stories after the hunt at Denny's, Coco's, or Norm's.

Subterfuge, camouflage, and deceit are still prized characteristics of hiders and their transmitters. Tiny "micro-T's" have been concealed in fenceposts, soda cans, sprinkler pipes, and cell-phone cases. Once in a while, one will be a few yards from the hunters at the start point, just as WA6TWA experienced on his first hunt with WA6KLA.

Even David's derided body-reflection maneuver from his motorcycle hunt has gotten its proper respect in this decade. Hunters routinely use the "body fade" technique to get approximate heading with just a VHF handie-talkie. If you hold the HT tight against your chest and turn around, there will be a null in strength when the signal source is behind you. It's not because your body is a reflector, but because it attenuates signals passing through it. As one hunter says, "The bigger the body, the better the bearing!"

Nowadays, hunters and hiders are more conscious about security. They check on (and heckle) one another during the hunt, but they do it with their cell phones so as not to give RDF hints of their locations. "No clues!" is still the foremost rule.

Despite today's homeland security consciousness, T-hunters are rarely hassled by police. Experienced officers are used to our strange antenna arrays and slightly erratic driving. They give friendly waves as they pass by the hilltop starting points lined with hunters' vehicles, and they usually ignore the fact that a couple of them protrude into the traffic lanes.

I'm sure that as we approached the hidden T that night, David got the same thrill he had on his first hunt. I think every ham should experience this thrill at least once. T-hunting skills have many benefits for amateur radio and the public, especially in volunteer enforcement and search/rescue. For David and me, experiencing it as a pre-teen was incentive to learn more about electronics and science, leading both of us to lifelong careers. I think that's still the best part of it, so I make it a point to take young persons on hunts, mobile or on foot, whenever possible.

WA6TWA's interest in the strange properties of invisible electromagnetic waves jump-started him toward a Ph.D. in Applied Physics from Caltech and employment as a researcher in physics and optics. He sums it up this way: "Hopefully, 40 years hence there will be many middle-aged persons who will reflect back on those innocent times at the turn of the 21st century when they first tried T-hunting as a youngster."

For the latest news of T-hunting in southern California, point your web browser to <www.thunter.org>, provided by Steve Heinemann, N6XFC, and Deryl Crawford, N6AIN. For more about amateur radio RDF in general, and on-foot hunts for all ages in particular, please visit my site at <www.homingin.com>. ■

## Notes

1. The famous flag-raising on the island of Iwo Jima was atop Mount Suribachi on February 23, 1945.

2. Prior to the hunt, each vehicle is driven on a standard course of approximately nine miles along Crenshaw Boulevard from the city of Torrance to a hilltop in Rancho Palos Verdes. The indicated mileage (Crenshaw Factor) is divided into elapsed mileage at the end of the hunt. The resulting Crenshaw Units for each team are compared to determine the winner. Current Crenshaw Factors for active T-hunters are posted at <http://www.thunter.org/crenshaws/newcrenshaw.htm>. ■

By Rich Arland,* K7SZ

# BEGINNER'S GUIDE

## All you need to know but were afraid to ask . . .

# Mods for the IC-202 Receiver

Hi again and welcome back to VHF+ on a shoestring budget. If you have read the first two installments of this column, you'll undoubtedly have formed an opinion about yours truly—either I am crazier than an outhouse rat or I have a special affinity for older VHF gear that can be pressed into service at a fraction of the cost of buying new gear, or I am cheap and don't like to spend money and I enjoy doing more with less. Well, you are undoubtedly right on at least two of the three counts. I'll leave it to your imagination as to which two!

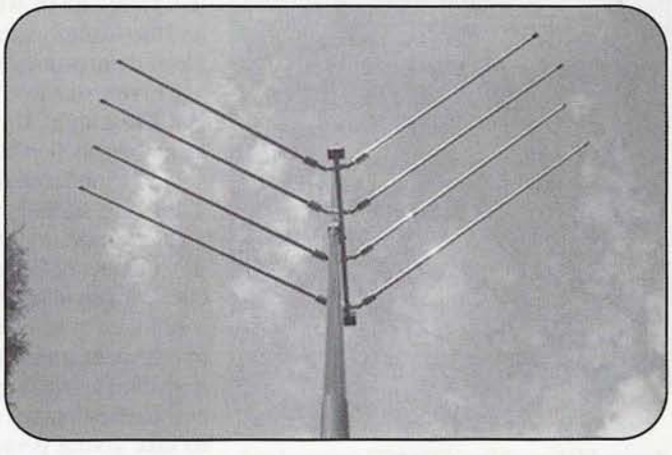
So far we have taken a critical look at what we want to do at VHF+ and have constructed a plan to bring our thinking into focus and procure some gear. Now if you are like me, you'll have been scouring e-Bay, local ham radio flea markets, and the various lists on the internet in search of gear. Just because I chose to use the 25-year-old ICOM "bookcase" radios doesn't mean you have to go that route. Yaesu, ICOM, and Kenwood all had economy-class as well as high-end VHF+ rigs aplenty in the mid 1970s through the late 1980s. Many of these radios will work quite well in your quest to get some RF gear on the high bands that can be procured at reasonable cost. Several of my non-ICOM favorites are the Kenwood TS-700A and the Yaesu FT-221R (both 2-meter multi-mode rigs) and prices are very reasonable. While they don't have all the bells and whistles of the newer multi-mode VHF+ radios, these two units are still good prime movers.

A quick look through older issues of *CQ, QST, Ham Radio Magazine,* and *73 Magazine* should yield ads and product reviews on most of this older gear. As a matter of fact, a few years back the ARRL published a set of books (*The ARRL Radio Buyer's Source Book,* Vols. 1 & 2) that were a compilation of *QST* product reviews that took in everything from HF radios to VHF/UHF rigs, accessories, and antenna rotors. Therefore, if you are really into doing some research, hit the ham radio fleamarkets and locate copies of these out-of-print books and use them for reference. Look around, do your homework, and spend your hard-earned money wisely. After all, that's the point of this entire series on VHF+ on a shoestring.

## Meanwhile, Back at the Ranch...

Time to go back to the IC-202 we were working on in the last installment. The addition of the Ten-Tec speech processor module greatly increases the average RF output, so you definitely "sound" louder than with an unprocessed radio. Likewise, the simple receiver mods discussed in the last issue definitely had a positive effect on how well the IC-202 receiver played on the bands.

There is always a temptation to add a MMIC or GAsFET receiver preamplifier ahead of the radio in an attempt to make the receiver "hear better." This might be worth doing provided you don't have the technical expertise to do a couple of simple mods as outlined previously. However, you must remember that any time you add 18–20 dB of raw gain ahead of the receiver, you may end up destroying the intermodulation distortion (IMD) characteristics of the receiver.



*A new DK9SQ 4-element, dual-band (2 meters and 70 cm) log periodic array designed for portable/rover use. This neat antenna collapses into a very small package for transport.*

Basically, the IMD figures show how well a receiver can handle large and small signals in close proximity to one another. The added noise factor (NF) of the preamp may also degrade receiver performance by injecting significant amounts of noise into the system. While your S-meter will show a definite upswing, you may not be able to hear the target station any better due to the increase in noise levels!

## Gain vs. Noise...Life at VHF

Ask those who have been in the VHF+ business for a while and they will tell you that you need all the receiver gain you can handle and then some. They are right, within reason. The old adage "you can't work 'em if you can't hear 'em" is oh, so true. However, misapplied receiver gain can be a bad thing. To fully understand where we are going with this we need to lay some ground work regarding noise, gain, and noise figure (NF), and define some terms.

All receiving systems (starting at the antenna and ending at the speaker or headphones) generate noise. This noise is a product of electrons moving within a solid-state device (transistor, FET, etc.), mixing products within the IF, synthesizer phase noise, atmospheric noise, and a host of other factors, including poor solder connections on your coaxial cables, just to name a few. This noise is cumulative and needs to be kept to an absolute minimum to be sure you can work the weak ones on the bands.

Your system noise is initially set at the antenna and increases as you progress toward the receiver. That is why experienced

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VHF+ operators insist on placing any receiver preamps as close to the antenna as possible. That way the noise factor (that little number in dB specified by the manufacturer which indicates how much noise the preamp will inject into your system) of the preamp is factored in prior to any additional noise generated by the rest of the system. If your preamp is capable of 20 dB of gain and is placed close to the radio as opposed to at the antenna, any noise generated throughout the system also will be amplified by the gain of the preamp!

The reason is relatively simple to understand if you look at the situation from a noise point of view rather than a signal (S-meter) standpoint. Let's say your super-hot preamp has a gain factor of 20 dB. *That* is a *lot* of gain! The noise figure is the amount of noise generated internally inside the preamp, and must be factored into the entire equation. Normally, in today's world, the NF of a preamp is around .8 to 3.0 dB, depending upon manufacturer, circuit layout, and the solid-state devices employed. What this means is that along with 20 dB of gain, the preamp will inject between .8 and 3.0 dB of noise into the system. A normal set of ears can hear a 1-dB change. While it might be hard to distinguish a noise increase of .8 dB, most people can hear a 3.0-dB change. Therefore, you may be able to actually hear a change in background noise when you switch in the preamp.

By placing the preamp at or near the antenna feed point (these are called "mast head preamps"), you can keep the overall system noise in check *and* provide gain at the same time. The gain of the preamp is secondary to the NF. If you are going to sacrifice anything, sacrifice the gain in favor of noise. In other words, drop a few dB of signal gain in favor of a decreased NF. This will allow you to hear the weaker stations and not cover them up with the system noise of your station.

Having said all of this, I did some research into the IC-202. Looking over many internet sites, it became apparent that the actual NF of the IC-202 receiver varied considerably among units, being measured anywhere from 4 to 8 dB! What this means is that the receiver itself injects between 4 and 8 dB of noise in on top of any signal that is being heard! Why the huge disparity? Darned if I know, but a good guess might be traced to the variations in manufacturing techniques used in the solid-state RF devices of that period (late '70s through mid-80s).

In talking with Zack Lau, W1VT, from the ARRL Lab, I was enlightened. Zack had a different take on the IC-202 and any associated modifications I was planning on implementing to improve the NF of the receiver. Zack's comment was "Why? The radio is a 25+-year-old rig, with associated technology of the day. Things have changed over the years, including unbelievable crowding of the VHF+ bands, which would basically negate any efforts to improve the IC-202 receiver." Good point, Zack.

However, being a long-time QRPer, ardent homebrewer, and zealous tinkerer, I just couldn't resist the idea of performing a couple of the more simple mods to improve the IC-202 receiver. As detailed last month, the mods involved rewiring the input to the receiver to exclude the transmitter pi-network output filter, which resulted in approximately 2 dB improvement in NF, and replacing the existing 3SK40 MOSFET in the first mixer with an updated quieter GAsFET device (Philips BF-981). According to published information, I gained about another 2 dB of NF improvement using the BF-981 device. I am well pleased with the receiver mods on the IC-202, and overall I noticed a significant improvement in receiver sensitivity by doing them.

Since I also have an unmodified IC-202, I can do "A-B" comparisons between the two receivers. There is a definite increase in receiver performance on the modified IC-202. Quite frankly, I preferred this tack rather than placing a wideband RF preamp (with its associated increase in NF) into the receive antenna line. Besides, I didn't really think I needed an additional 20 dB of raw gain. Sometimes you have to know when to leave things well enough alone.

## Thick as a Brick

Among the many things one can acquire (at moderate cost) at hamfest fleamarkets is a "brick" amplifier. They get the "brick" pseudonym since these power amps are normally a compact solid-state amp with an extremely large heat sink attached. The shape and weight equate to a "brick." Now you know!

Normally these amps take 2 to 15 watts input and yield somewhere between 10 and 85 watts output on your favorite VHF+ band. Recently, I procured an old Tokyo Hy-Power 85-watt linear (CW/SSB) power amp that featured a 15-dB receiver preamp. Total cost $20! I really didn't expect the amp to work, especially at that price. However, after firing it up on the bench I was rewarded with about 10 watts output on 2 meters while driving the amp with the IC-202 in the CW mode running about 1.5 to 2 watts key-down output. Hmmm . . . that was about right! The receiver preamp worked, too, so I was really ahead of the power curve on this particular purchase! Twenty bucks for an 8-watt increase in RF output (about 7 dB of gain)—not bad! Of course, if I ever find the 10-watt, 2-meter amp that matches the IC-202, I can then daisy chain the two amps and get about 75 to 80 watts output on 2 meters! Then we'd be cookin'!

This amp came in quite handy during Field Day 2005 with the Eastern Pennsylvania QRP club at French Creek State Park, near Reading, Pennsylvania. On a couple of occasions it actually made the difference between working the target station and a missed QSO. Since this was a QRP effort, the addition of the amplifier and the associated 10 watts of output power (on SSB) still qualified this station for the QRP category.

During Field Day 2005 my wife, The Beautiful and Talented Patricia, KB3MCT, made her first contacts on 2 meters! Trooper that she is, she stood her watch at the VHF+ station at French Creek State Park and added a few Qs to the total contacts. Life at VHF+ during Field Day is not all that exciting due to the majority of emphasis being placed on HF operation. However, it does have its moments!

Thanks to the efforts of a very helpful local ham, Phil Theis, K3TUF, we were able to check out and verify the operation of a new 4-element, dual-band (2 meters and 70 cm) log periodic array (LPA) designed for portable/rover use. The neat thing about this antenna is that it collapses down into a very small package for transport. This is great for VHF+ ops who want to do some serious hilltopping or portable work. The Radio Web Store (http://www.k1cra.com) sells the DK9SQ portable log periodic 2-meter/70-cm beam (model #KANG0002).

While four elements don't sound all that impressive on VHF/UHF, the portability aspect of this antenna far outweighs the shortage of elements. Pat and I used this antenna exclusively on 70 cm. Pointing the antenna directly at K3TUF's QTH yielded an S-9 + 20 dB incoming signal on the IC-402's receiver.

It should be clarified at this point that the IC-402 was a completely stock receiver with no internal modifications or external receiver preamplification. Turning the small LPA around 180 degrees dropped the S-meter down to an S-9, indicating an approximate 20-dB loss of signal strength. Okay, so we crudely measured the front-to-back ratio of this antenna at 20 dB. As we turned the LPA broadside to K3TUF's QTH, the S-meter dropped off to around S-5; roughly a 32-dB loss of signal. Not bad for a front-to-side ratio.

Indications are that this tiny transportable dual-band LPA performs quite nicely for a price of around $85 and is well worth exploring for anyone needing a small antenna for hiking, camping, hilltopping, and/or roving. My most humble thanks to Phil Theis, K3TUF, who took the extra time during Field Day to help sort out the dual-band LPA. This is what ham radio is all about.

In the next column we will be taking a critical look at antennas for VHF+. Keeping with our overall theme of "doing more with less," cost will, of course, play a major factor in what we erect. Until next time, stay focused, look for bargains, and spend some time in front of the radio! ■

By Bob Witte,* KØNR

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

# FM Simplex on the Road

This summer I did two road trips, over 1200 miles long, across the Midwest from Colorado to Indiana either via Interstate 70 or 80. I like road trips and always make sure I have something interesting to do with the ham gear while traveling. I've tried different types of radio activity during similar trips, including working a VHF contest as a rover, working HF mobile, and working the FM repeaters along the way.

Repeaters are useful on a road trip, but I have to admit that sometimes I get tired of dialing around trying to find the right frequency and CTCSS while mobiling down the highway. I've noticed that simplex contacts can be especially enjoyable, since you tend to work other hams out doing their own road trips. It is almost like DX in reverse. Normally we think of DX stations as people from far away brought to us via the magic of radio. Two-meter FM mobile simplex is just the opposite—people close by who may have come a long way via their automobile travels. It is fun to make random contacts and find out where people are from, where they are heading, and their interests in ham radio.

With that as background, I want to encourage everyone to try 2-meter FM simplex when out on the road. Here are a few tips for making this work better:

## Tip 1. Monitor 146.52 MHz

Okay, so maybe this is an obvious one. However, did I hear someone suggest that we need an official 2-meter FM Road Frequency? Well, we have it. It is 146.52 MHz, the National Simplex Calling Frequency, per the ARRL 2-meter band plan. This frequency is commonly referred to as "Five Two." It is the frequency to use when you are cruising the Interstate. (I am going to intentionally sidestep the issue of ragchewing on .52 for now—maybe later, maybe never.)

I am *not* proposing that you stop using repeaters, just that you make it a point to monitor .52 in addition to listening to the local repeaters. This leads to our next tip.


*A VHF/UHF transceiver set up for dual receive on the 2-meter band, with one 2 receiver set to 146.52 MHz.*

## Tip 2. Use a Dualband/Dual-Receive Transceiver

It is really helpful to have a dualband transceiver that can receive two frequencies simultaneously. These rigs have two separate receive systems that usually default to having one on the VHF band and the other on the UHF band. Most (but not all) of these rigs allow you to program the receivers independently for either band. To enable efficient 146.52 monitoring, just keep one receiver on 146.52 and set the other one to any other frequency of interest (e.g., the nearest repeater). This is sometimes referred to as "V/V" or "VHF/VHF" operation. Examples of current ham transceivers of this type are the ICOM IC-2720H, Kenwood TM-D700A, and Yaesu FT-8800R. I've assumed that you'll want to have both receivers on 2 meters, which is probably the case when you are in less-populated areas. However, you might choose to listen to a UHF frequency, either a repeater frequency or the UHF FM calling frequency, 446.0 MHz. On many rigs you can even scan a set of frequencies stored in memory on one receiver while monitoring .52 on the other receiver.

Single-band 2-meter FM rigs and many of the lower cost dualband rigs can only receive one frequency at a time, so check out the data sheet carefully. If you don't have dual-receive capability, you may be able to use some other radio features to monitor .52. You can put 146.52 in memory and scan it along with the other stored frequencies, or use the "Dual Watch" or "Priority Channel" feature to scan two frequencies (with one of them being 52). Any way you can, keep an ear on "Five Two."

## Tip 3. Call CQ Frequently

Now that we have everyone listening on .52, we need to make sure that someone is calling! It is easy to run many miles down the road without hearing anything.

Let's do some math on two mobiles approaching one another out on the highway. Let's assume that the mobile-to-mobile range on 2-meter FM is 20 miles and that the speed of both mobiles is 60 miles per hour. Sure, you might be going faster than this, but 60 miles per hour makes the math easy, as that speed equals one mile per minute. The two mobiles will just be able to make contact when they are 20 miles apart. Since they both will travel 10 miles in 10 minutes, 10 minutes later they will pass one another on the highway. Another 10 minutes later and they will have traveled another 10 miles and be just out of range. The net result is that they have a 20-minute window to make a contact.

I made some assumptions that might be optimistic. If the maximum range of the mobiles is only 10 or 15 miles, or if they

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## Hurricane Katrina

Just before press time, Hurricane Katrina had hit the Gulf states and the emergency response was underway. I am sure more complete coverage will become available over time, but here are some early observations, with an FM VHF emphasis.

### Be Prepared

Hurricane Katrina, like most major disasters, reminds us that it pays to be prepared. Fixing that antenna cable you've been neglecting, replacing that dead battery pack, or finishing that half-done mobile installation as an emergency unfolds is not the best approach. Get it done now.

We also need to prepare ourselves in terms of training. The communications from the ARRL concerning Katrina emphasize the value of having completed at least Level I of the Amateur Radio Emergency Communications (AREC) course training. This is an important credential to have if you volunteer to help in a geographic area away from your home. The Section Emergency Coordinators in affected states are likely to have many hams with a range of experience and skill volunteer. The AREC training does not guarantee proficiency, but it indicates you've spent time and energy on training for emergencies. If you haven't passed this course, it is time to get it done.

Keep in mind that a disaster situation is inherently chaotic. (If they were completely planned, we wouldn't call them disasters.) It is vitally important that hams responding to the need for radio communications coordinate with the appropriate ARES or RACES officials to ensure that they are part of the solution and not aggravating the problem. Of course, you should already be involved with your local ARES or RACES team.

### Media Coverage

We always need to look for ways for the general public to know about and appreciate the role that ham radio plays during emergencies. Sometimes we are involved with important public-service work that gets no attention. Sure, the served agency may know that we are there making a difference, but the general public may not see it.

With Hurricane Katrina, I am jazzed that the mainstream media has picked up and is telling the story of the ham radio response. I did a search on the web and found dozens of stories in the media about ham radio activity, including handling health and welfare traffic as well as handling life-saving communications.

Of particular note is an interview with Ben Joplin, WB5VST, on the NPR program *All Things Considered.* Ben did a great job of describing the role of ham radio in a particular rescue effort after Katrina hit, in a way that was understandable by the general public. Sometimes hams get wrapped up in talking about their station, the frequencies used, the propagation effects, etc., and lose the main story. Ben's message was concise and on target for the general audience. This interview is online at: <http://www.npr.org/templates/story/story.php?storyId=4824598>.

### The Role of VHF FM

The fundamental communications challenge in a disaster situation results from the breakdown of infrastructure: the telephone system, mobile/cell-phone systems, police/ fire communication systems, electric utilities, water systems, etc. These systems often are either damaged in the disaster or they are overloaded by the increased load resulting from the disaster.

Unlike many communications systems, ham radio is amazingly resilient. A large number of hams will be back on the air in short order, even in the face of antenna damage and loss of electric power. In addition, ham radio is very *agile*, in a number of ways. We are *frequency agile,* in that we can use any of the ham bands and any of the repeaters within the VHF/UHF bands to establish communications. Ham radio is *location agile,* in that our stations can be moved to operate almost anywhere, with or without AC power available. Finally, a well-trained ham operator is *personally agile,* able to adapt to changing conditions. All of these things play together to enable the ham radio community to respond effectively in the case of emergency.

The early reports of Katrina were mostly about HF operations. This is typical of large-scale disasters where the outside world is trying to get in touch with the disaster area. The high-frequency bands are an incredible resource for this kind of work. Later reports included the use of the VHF/UHF bands, near the disaster and points distant.

*ARES members operate from the Colorado State Emergency Operations Center (EOC) in support of Operation Safe Haven. Left to right: George Riedmuller, NØNJM; Ben Baker, KBØUBZ; and Dan Meyer, NØPUF.*

VHF FM is the *utility mode* and is always a key part of emergency and disaster communications. The ham infrastructure, in the form of VHF and UHF repeaters, often comes into play. Of course, these repeaters can be knocked off the air by storms or other events, but in most cases there are machines still on the air after a storm. Many ARES groups maintain a portable repeater that can be called into service if repeater coverage is lacking (location agile). Depending on terrain, simplex communications are very useful, eliminating the need for repeater coverage.

A key advantage of VHF/UHF FM transceivers is that they are very compact and portable (location agile), especially handheld radios. Antennas are small, enabling VHF/ UHF operations to be set up quickly in a variety of situations. If you are a reader of *CQ VHF,* you probably have a rig that operates VHF FM. These radios are very affordable these days, with 2-meter FM mobile rig prices starting at around $150. UHF (440 MHz) capability is becoming more important as ARES/RACES groups make use of that band. (Check with your local emergency communications group to find out what they recommend.) Fortunately, dual-band radios are also affordable, starting at around $250 for a radio that covers 2 meters and 70 cm.

### Operation Safe Haven

As I write this, people from New Orleans are being evacuated to the Denver area. Dormitories at the Colorado Community College, Lowry Campus (former Lowry Air Force Base) are being used to house the evacuees. According to the *Denver Post,* Operation Safe Haven will transport up to one-thousand refugees to Buckley Air Force Base and then by bus to Lowry, where they will be housed in 500 dorm rooms.

Communications support for this effort is being provided by multiple ARES groups, with Arapaho County ARES taking the lead. This is a classic VHF FM utility-mode communications operation, making use of several VHF/UHF repeaters, including the Rocky Mountain Radio League 449.450-MHz machine, the 146.88-MHz Denver Radio League repeater, and the 146.805-MHz WA2YZT repeater. While not in the heart of the disaster area, this is an important support operation to provide housing for people evacuated from the disaster area.

### Disaster Response Team

The Colorado ARES/RACES Disaster Response Team has been called into service at the request of the ARRL Section Manager in Louisiana. As of September 9th, they are heading to the city of Covington, LA to support EOC and Red Cross operations. This team was created with this kind of response to another geography in mind. Team members are Mike Allen, NØMIK; Tom Dawson, KCØNRZ; Dean Haskins, KAØPII; Paul Garvey, KCØMIR; and Wes Wilson, KØHBZ. Good luck, guys.

I've used examples from my own state, but I know that many other hams across the country are doing similar work. It is a good day for volunteerism and ham radio.

are traveling faster than 60 miles per hour, the time window will be correspondingly shorter. At 75 miles per hour and a range of 10 miles, the window decreases to 8 minutes. (This is shorter than a good LEO satellite pass!) It is no wonder that we often miss contacts on 146.52 MHz.

Yes, it *is* okay to call CQ on 2-meter FM. The really long CQs heard on HF are not usually welcome, but something like "CQ Five Two, this is Kilo Zero November Romeo, westbound on Interstate 70" should work fine.

## Tip 4. Make your Callsign Visible

Sometimes another ham will pass you on the road and notice your mobile antenna. He or she may be left wondering whether that was really a ham antenna or just some other wireless device. Remove any doubt by making sure your call letters are visible on the vehicle. Call-letter license plates are one obvious way of doing that, but there are other ways to display your call. Magnetic stick-on signs are available online from various ham radio vendors or can be obtained from your local office-supply store. I have a small magnetic sign that just says "146.52" that I put on my bumper near my call-letter plates. It generates calls.

## Tip 5. Use APRS on Voice Alert

APRS is one of my favorite road-trip modes, using a separate 2-meter rig and antenna so that it does not conflict with my VHF FM voice operation. My status message is usually configured to say, "Listening on 146.52 MHz" to encourage any APRS operators to call me there. APRS stations are configured to "ping" digital packets on 144.390 MHz, at a time interval determined by the operator.

When mobile, I usually configure APRS to ping every 5 minutes.

Bob Bruninga, WB4APR, suggests an enhancement to mobile APRS called "Voice Alert." The basic idea is that mobile APRS stations looking for simplex contacts configure their APRS transmitter with 100-Hz CTCSS enabled. Any other operators (whether they have APRS or not) listen on 144.390 MHz with 100-Hz CTCSS squelch enabled. That way they hear the "I want a simplex contact" packets that have 100-Hz tone but not all of the other APRS packets. Of course, it is important that digipeaters and unattended APRS stations *don't* transmit 100 Hz.

With this system you cruise down the highway until you hear a packet burping through on 144.390 MHz (on your CTCSS squelched receiver). Then you give a quick call on FM voice on 144.390 MHz (with 100 Hz) asking who is there on "Voice Alert." After you make contact on 144.390 MHz, you must change frequencies to a vacant simplex channel to avoid lots of interference with APRS packets. It is a clever, back-door method to use the "pinging" nature of APRS to have mobiles find one another on simplex. Pretty cool, huh?

## Other Ideas

A recent e-mail from Mike Urich, KA5CVH, presented an interesting idea on how to generate activity on 146.52 MHz while mobile. His e-mail was actually to Gary Pearce, KN4AQ (former FM VHF columnist), who forwarded it on to me with comments.

*From Mike Urich <mike@ka5cvh.com>:*

I just made a business trip to MX last week and grabbed my Winter 2005 *CQ VHF* to reread. Based upon your comments about APRS mobile, I have something to throw to you to consider throwing to the readers. First a little history.

I have a FT-8900 in the car, which is 15 months and 72,000 miles old, so yeah, I get a lot of windshield time. I have every possible standard 2-meter pair programmed starting with 145.11 and going in order through 147.39 for both the 15-kHz and 20-kHz splits.

Obviously, I don't program the common ones twice. In the next group I have all the 442-MHz splits (442.000–442.975) then the 443- and 444-MHz splits. I have a lot of 6-meter repeaters and 52.525 programmed as well. What I do is put the right receiver on 146.52 and scan the memories with the left receiver.

Like you, I seldom make many .52 contacts, mainly because I'm not CQing, nor is anyone else when I know there are a lot of people who monitor .52 on the highway at least here in Texas. Your article triggered my thought process to look into building/buying a MCW [modulated CW] IDer to put onto my rig so that, say, every 3 minutes or so it will send out an MCW ID with my callsign. Not everyone can copy the CW, but they will hear the ID and possibly call QRZ. *—Mike, KA5CVH*

*Gary's reply:*

It's an interesting idea. A variation that comes to mind is you could use a "voice keyer" instead of Morse to catch everyone,

*This mobile ham station, spotted in a hamfest parking lot, obviously is set up for monitoring lots of frequencies on road trips.*

not just those who know CW (and not be confused with a repeater ID). Then maybe manufacturers could be convinced to include the recorder as a feature (we need more features!). Finally, we convince hams to leave it on .52 when they're on the road.

This might discourage home stations from monitoring .52 though, with a lot of IDing going on all day. Might be some brief interference to ongoing communication unless a "hold-off" feature were incorporated.

However, impromptu on-the-road contacts on .52 have always been interesting, especially if I hook up with someone going my way for a while.
—*73, Gary, KN4AQ*

My thoughts are that Mike's IDer idea is interesting, especially if it were implemented to not "ping" until the frequency had gone quiet for some period of time (probably a few minutes). A CW ID would clearly have its limits of who could copy it these days and might easily be confused with a repeater output. This would argue for a voice-keyer approach. Surely this approach could be abused if people just indiscriminately banged away with voice or CW beacons on 146.52. However, for the long road trip scenario it could really be useful.

Its pinging nature is similar to Voice Alert on APRS, which apparently got Mike thinking about this in the first place. I wonder about an even better merging of these two approaches. Why can't we have a system that merges voice and data, automatically pings with digital content, and instantly enables voice communication as well? Let me know what *you* think.

73, Bob, KØNR

## References

Bob Bruninga, WB4APR, APRS web page: <http://web.usna.navy.mil/~bruninga/aprs.html>.

Ham Stuff by W7NN (source for magnetic signs): <http://www.hamstuff.com/>

The Sign Man of Baton Rouge (source for magnetic signs): <http://www.thesignman.com/>

By Keith Pugh,* W5IU

# SATELLITES

## Artificially Propagating Signals Through Space

# PCSAT2, SSETI Express, SuitSat & SSTV for the ISS

Since the last column, PCSAT2 has been carried up to the ISS (International Space Station) by mission STS-114 of the Space Shuttle and installed during a space walk (EVA); the launch of SSETI (the Student Space Exploration and Technology Initiative) had been delayed at least six months; and the 2005 Space Symposium due to be held in Lafayette, Louisiana was canceled because of Hurricane Katrina. Also, get ready for SuitSat and ISS SSTV!

## PCSAT2

**Launch:** PCSAT2 was carried into orbit by the Space Shuttle on its return to service mission, STS-114. A few days later, 3 August 2005, it was installed on the external structure of the ISS during EVA (Extra Vehicular Activity). It has been operational since that time. Since it is physically attached to the ISS, tracking data is the same as for the ISS, and operation must be carefully coordinated with other ISS activities to avoid interference. It is part of another experiment, and as such will be retrieved after approximately one year of use. Like the original PCSAT, this one was designed and built by Bob Bruninga, WB4APR, and his team of engineers from the US Naval Academy. Full details are available at: <http://web.usna.navy.mil/~bruninga/pcsat2.html>.

**Capabilities:** PCSAT2 is part of MISSE (the Materials International Space Station Experiment) and provides the following capabilities:

- A *UI-Digipeater* to help ease congestion on the currently shared ARISS PMS (packet mail system).
- A *PSK-31 Transponder* for multi-user comms to improve accessibility for schools and ARISS (Amateur Radio aboard the International Space Station) outreach programs.
- An *FM Voice Repeater* for full-duplex special ARISS or crew communications to facilitate school outreach.
- Routine *Telemetry* on the spacecraft systems.

The following frequencies are used in the various modes:

UI Digipeater: 145.825 MHz FM 1200 Baud AFS
TLM and PSK Downlink: 435.275 MHz FM 1200 AFSK or PSK-31
PSK-31 Uplink: 29.4 MHz PSK-31
Aux Downlink: 437.975 MHz FM 1200 and 9600 Baud AFSK
Voice Repeater Downlink: 437.975 MHz FM
Deployed: 3 August 2005

**Operation:** All modes have been checked out, and the "bird" has been operated in the PSK-31 mode for several weeks as of this writing. At press time, it is available for digipeating. Telemetry has been gathered throughout the operation and is being accumulated for study.

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### Use of Satellites in Disasters

Amateur radio satellites are unique, but seldom used, communications assets in times of emergency and disaster. Their wide-area coverage and predictability make them useful for traffic similar to that handled via HF. A minimal amount of equipment is needed for the LEO "birds," but the hardware needed and the techniques for deployment and use are not well understood by the general amateur radio population.

The "store and forward" digital birds are particularly well suited for health-and-welfare traffic. Again, these digital birds are even less understood than the analog birds. For example, AO-51 was configured as a "store-and-forward" bird during the Indonesia tsunami, but little, if any, traffic was passed.

VO-52 was developed in India with emergency communications as one of its primary goals; however, little use has been made of it for that purpose. It was not launched in time for the tsunami disaster. Its use would be for "point to point" contact within a disaster area on a scheduled basis.

PCSAT2 and the other ARISS UI digipeating capabilities can be extremely useful in emergency situations. Again, the capabilities are not well understood by the general amateur radio community and disaster-preparedness people.

Emergency communications tests were conducted with some success on AO-10 and AO-13 while they were still usable. More equipment is required for these high-altitude birds, but the benefit is long-term availably of the bird. With Phase 3E and Eagle coming along, we need to once again think through how to best utilize these valuable assets in an emergency.

The amateur radio satellite community needs to put on its thinking cap and come up with how to best utilize each satellite in an emergency and "start the ball rolling."

## SSETI Express

The Student Space Exploration and Technology Initiative, or SSETI, project was discussed in some detail in the last column (*CQ VHF* Summer 2005) and details will not be repeated here. At last press time, it was scheduled for launch in August 2005. Until this writing, it was scheduled for 30 September 2005 with a backup date of 1 October 2005. Today, an indefinite slip due to one of the other payloads was announced. It is anticipated that this will mean at least another month. At press time, the hardware and launch team is in Russia preparing for launch, but they now will be securing the equipment and going back home to wait.

## SuitSat and SSTV for the ISS

The Suit Sat hardware to be installed in the old Russian Orlon space suit has now been transported to the ISS along with the long-awaited SSTV hardware and the school project CDs. This equipment will be installed by the new Mission 12 ISS crew, which will deploy to the ISS in early October. SuitSat will be deployed in December via an EVA. Watch the AMSAT News Service and the AMSAT and ARRL web pages for updates on allel to the ground, and started walking the rows until the signal indicated I was within a few feet of it. I literally tripped over the package.

It was 12:30 CDT now and everyone was hot, tired, and hungry. Team 3 (Mike Hackley, KCØSGD) arrived while I was searching around the corn field. After we had recovered the near-spacecraft, Mike and I shut down everything, retrieved the flight recorder and the RAM card from the digital camera and the film from the film camera.

The digital camera looked as if it had impacted something pointy and we had to pry the RAM card out of it. The camera will have to be replaced. We then drove back toward Omaha, stopping at The Rose family restaurant in Traynor.

Things we learned and that need improvement follow:

**Recovery Operations:** The ground tracking equipment in the chase vehicles needs to be "hardened" and tested.

We need to practice more as a team. When the teams become separated, common frequencies and contact procedures need to be used.

Standard DFing procedures need to be documented and practiced.

Several other "standards" need to be discussed, simple things such as what notation should everyone use for latitude/longitude?"

**Flight Operations:** An additional crew is needed for coordination of the flight phase, from launch to just after burst.

When we launch a package for a group or specific science or instrument package (e.g., the 2-meter simplex repeater), a person dedicated to controlling the package needs to be on the team. For example, the 2-meter simplex repeater was enabling contacts in Champaign, Illinois and Independence, Missouri, but there was no one to log the traffic.

**Launch Operations:** This went pretty smoothly except that while we had decided to use more lift that we normally would, we used too much. We had wanted 2.5 lbs and ended up with 3.8 lbs. We need to add a checklist for the launch vehicle (balloon) similar to the payload power-up and attachment checklist.

While we want to encourage visitors and participants, there is a time when it would be very useful to have a "sterile" launch area (this is also a safety issue). Stanchions and tape or orange rope might work.

**Engineering:** The CAPSTAR-1A near-space frame is nearing its end of life. It's getting pretty beat up. Another one or two frames need to be built and readied to fly.

The RF crosstalk between the ELT and the 2-meter FM RF sections needs to be addressed.

A commanded cut-down device needs to be installed so that we can fly larger payloads.

## GPSL Suggestion

GPSL-2005 was *great!* Mark Conner, N9XTN, did a super job pulling it all together. The conference topics and speakers were *very* interesting and informative. There were ten balloons launched and over 65 people attended. It was great to work with everyone I'd met last year and to meet new groups.

I did hear a good suggestion that at the next GPSL there be a "net control station and operator." The controller's job wouldn't necessarily be to coordinate a net (there was very little congestion on the local repeater). However, the controller "could" facilitate communication between different groups when, for example, a group needs help with recovery operations or they want to cross-check their own tracking with another group. ■

both of these items. The SuitSat project will be of great interest to school kids (and older kids as well).

## AMSAT Space Symposium Cancelled

The 2005 AMSAT Space Symposium and Annual Meeting scheduled for 7–9 October in Lafayette, Lousiana, reluctantly has been cancelled by the AMSAT Board of Directors. The action was taken after a careful review of the damage caused by Hurricane Katrina (and later Hurricane Rita) indicated that there was too much uncertainty in the hotel situation in Lafayette. Even though several offers were made, there was insufficient time to coordinate and move the entire meeting to a new location, and a change in date was not practical due to vacation scheduling of the attendees. The 2006 AMSAT Space Symposium and Annual Meeting will be held in the San Francisco Bay area in October. Planning has now started for that conference.

The AMSAT Board of Directors Meeting, the AMSAT Annual Meeting, and the Project Eagle Meeting were scheduled to be held in conjunction with the Space Symposium. They will instead be held on 6–9 October in Pittsburgh, Pennsylvania.

I will be attending the meetings in Pittsburgh and will report on them in the next column. The meetings should be very good with a lot of topics to discuss and some new and some renewed AMSAT BoD members attending. Incumbents re-elected are Rick Hambly, W2GPS; Barry Baines, WD4ASW; and Gunther Meisse, W8GSM. New to the board is Emily Clarke, WØEEC. First Alternate is Bob McGwier, N4HY, and Second Alternate is Lee McLamb, KU4OS. Returning BoD members for their second year are Tom Clark, W3IWI; Paul Shuch, N6TX; and Lou McFadin, W5DID.

## Summary

As of this writing, we now have another new satellite, PCSAT2, with a second one, SSETI Express, on the way before this fall. Sharpen up your disaster communication skills and plan to use the unique capabilities offered by the amateur radio satellites. Get ready to fully utilize SuitSat and ARISS SSTV from the ISS. Finally, start planning now to attend the 2006 AMSAT Space Symposium in the San Francisco Bay area.

73, Keith, W5IU

By Chuck Houghton,* WB6IGP

# MICROWAVE

## Above and Beyond, 1296 MHz and Up

# Transmit-Receive Relay Control Switching Circuit

This time we will discuss a simple sequencing relay-control switching circuit that I have used for some time. Although the circuit is simple, it controls two 12-volt relays that are the heart of the device. Activation of the switching is done by PTT (push to talk) RF detection from a 2-meter multimode low-power (modified) IF driver. In this case, RF output power is reduced from the normal low-power setting by modification of the 2-meter multimode radio to obtain RF power in the 100- to 200-mw range. An additional relay can be installed to further reduce the power to the desired level by insertion of a relay to add a pad of 3 to 10 dBm in the coax path before it is injected into the mixer circuit of the microwave converter. The idea here is to keep power low to protect the 10-GHz mixer, as it is a precious device and difficult to obtain. All efforts are made to keep RF transmit power low in the IF converter stages of the microwave converter to protect the mixer.

Additional protection is provided by the circuit's two relays, which are sequence driven by the N-channel FETs and the switching time constant that controls each one of them. Contacts on these two relays are used to control the coaxial relays and associated receive and transmit amplifier components of the microwave converter. When the PTT switch is depressed, it causes the receiving pre-amplifier circuits to be switched out before the transmit amp control circuitry is switched on. The opposite is done by releasing the relay circuitry. When the IF transmit PTT is released, the transmit relay circuitry is fast to release and the receive preamp control switching is slow to release. This is accomplished by using two different time constants in this circuit. They are 1 mFd charged by a 1K-ohm resistor and 1 mFd charged by a 47K-ohm resistor. Charging or discharging a 1-mFd capacitor through a 1K-ohm resistor is fast compared with charging through a 47K-ohm resistor.

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Capacitor values can be changed to add or remove capacitance to suit your specific timing requirements. I set up a couple of LEDs tied to the drains of each FET with a series 1.3K-ohm resistor to +12 VDC for the LEDs' DC power. In this way I could watch the timing of the "A" and "B" relay drivers by observing the LEDs for visual circuit timing of the "A" and "B" relay controls. Relays could have been used here just as well, watching the time each relay operates and releases.

These two relays are controlled by a simple diode control circuit switching two different time constants. The use of DC relays provides isolated contacts that can be wired to switch your coaxial relays and associated amplifier circuitry for receive and transmit control. This simple diode steering circuit protects the receiver preamp by switching the coaxial relays on the receiving side of the circuit, taking the preamp out of the circuit before the transmitter amplifier coaxial relays are switched in. Just the opposite is done when the transmit relays are switched out (released) first, and then the receiver relays are switched back in the circuit.

It uses a simple diode switching circuit that controls the DC distribution to several time-constant circuits via diode steering, producing a fast-to-operate and slow-to-release receive time constant for the (A) sequencing relay, receiver-controlled switching. The sequencing for transmit RF amplifier relays is controlled by the (B) relay circuitry, and the time constant is just the opposite. The time constant is slow to operate and fast to release.

Operation is as follows: When the IF transceiver (100-mw driver) PTT microphone switch is operated in transmit, the 741 op-amp detects RF input and the 741 goes high with +12 VDC output and charges the 1-mFd capacitor (discharged by a 1-meg resistor), controlling hang-time operation of the circuit. Increase the 1-mFd capacitor and the circuit will stay operational longer after the PTT is released. The first gate of the 4049 IC (plus in pin #3; low out pin #2) causes the "A" relay FET to operate by charging a 1-mFd capacitor through a 1K-ohm resistor. Fast to operate and slow to release (PTT released) occur by discharging the "A" relay 1-mFd capacitor control through a 47K-ohm resistor.

The diodes used in this control circuit are 1N4148 because they were in the junk box. They also are easy to obtain surplus. Anything similar can be used; it's just a low-power signal diode. The 741 op-amp and 4049 hex inverter are also easy to obtain. The Buz-72 is an N-channel FET and can be replaced with a NTE66 high-speed switch TO-220 package. I used the Buz-72 because it was in my junk box.

Due to the fact that we reduced the RF power output to 100 mw, a sensitive detection circuit was needed to start off the circuit operation and then remain reliable. Standard RF detection circuits using Darlington transistors to detect the RF transmitter power (100 mw) just did not work well at this low power level.

The RF drive, now in the 100- to 200-mw range, from a modified 2-meter rig used for converter operation needed an RF detection circuit that would detect the IF-system PTT in transmit SSB mode. I wanted the circuit to activate with background noise when the PTT switch was activated on the IF-driver multimode 2-meter transceiver.

I found a promising circuit to modify, dropped the output circuit, and kept only the detector rectifier and amplifier parts of the circuit. What was used was a double-diode RF detection rectifier coupled to a 741 op-amp that produced sufficient gain for low-level PTT operation for SSB before modulation was applied. The finished circuit was very sensitive in detecting operation of the transmitter low-level PTT operation. I used a coax line passing through the transceiver switch and coupled a 5-pF capacitor to tap off some of the RF between the coax center conductor and the switch detect rectifier. With 100 to 200 mw passing through, this amount of coupling has proven to be adequate. I assembled the unit and constructed the circuit dead-bug style on a small piece of copper circuit board. Kerry, N6IZW, designed the diode-switching second half of the switch timing control circuit. It is

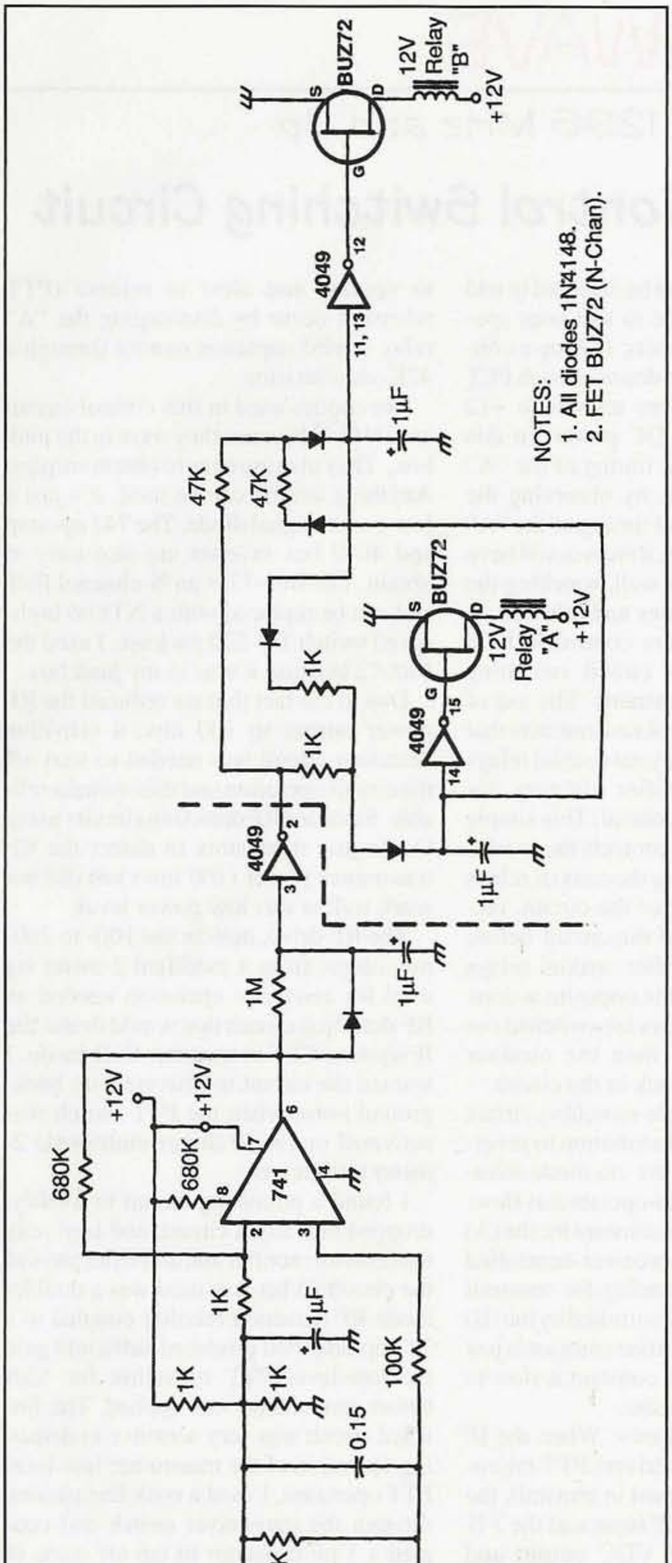


*Figure 1. Schematic diagram of the sequenced switching relay control circuit.*

quite innovative. Without Kerry's circuit design and his help, this project would not have been completed.

## Reliability

This circuit is still in service on my 10-GHz main transceiver. What has helped over the years is that I potted the dead-bug parts in a layer of RTV, which has held up well. By having lots of relay contacts available, many different configurations can be used to suit your switching requirements. For instance, I switch in an extra drive amp for the TWT (traveling wave tube) and remove connectivity to the low-noise pre amp with this circuit. On transmit I also switch on and off a 10-watt TWT with the setup of four SMA coaxial relays to control all the switched functions. This setup has been in operation since the early 1990s.

I should reconstruct the circuitry and clean up the many experiments and changes that were made to my 10-watt black box rig for 10 GHz over the years of operation. I call it my "black box" rig, as it is housed in an old BC221 WW II military surplus frequency-meter case. Yes, I might have been just lucky, as the circuit and the 10-GHz rig it controls have performed well over many years of operation. However, I feel that taking these additional protection methods has contributed substantially to the success of the rig's operation over the many years of use. It has survived the grandchildren and their nearby sand box, and many nights in the rain.

There are many different types of controllers that are more complex than the device described here. However, as I stated in the beginning, this was to be a simple device—easy to troubleshoot and use, easy to construct using standard parts, and easy to put together with a low parts count for the entire circuit. I might point out that this switch controller can be used on other converters for PTT switch operation. It's not band specific on 10 GHz. By detection of RF external to a modified low-power IF driver, many different rigs can be adapted to one standard PTT RF switching circuit.

With low-power operation from the IF rig, using its internal microphone controller, a variety of IF driver rigs for this switch-controlled transceiver circuit are possiible. I have used this board in 1296-MHz converters and for 3456 MHz and 5760 MHz—plus 10 GHz, where this project started. Switching of the PTT operation has proven to be a great asset in communications.

I have a few PC boards of the home-constructed type that are available on a limited basis. I am looking at trying to get better artwork done and boards produced later. However, the circuit is not that complex, and a dead-bug wiring job like I originally did can be just as effective as fabricating a PC board. I just retired from 43 years of service working for the Bell System and later SBC Communications, so time to play with projects is not a factor for me. If there are any questions regarding this project, just drop me an e-mail at <clhough@pacbell.net> and I will reply as quickly as I can.

New projects on the work bench include a 1152-MHz synthesizer used for a marker generator, along with a second 2-GHz synthesizer. The second synthesizer on the PC board can be programmed for 2556 MHz, which is an LO (local oscillator) injection frequency for 10368 MHz (2556 MHz × 4 + 144 MHz = 10368 MHz). The board is up and running. However, documentation on the modifications is needed to make the board useful as a marker for most of the microwave band bottom edge, which is a multiple of 1152 MHz. For instance, 5 × 1152 MHz is 5760 MHz, and 1152 MHz × 9 is 10368 MHz, making the board and its harmonics quite useful and improving accuracy as a band-edge marker or LO for 10368 MHz.

73, Chuck, WB6IGP

By Joe Moell,* KØOV

# HOMING IN

## Radio Direction Finding for Fun and Public Service

# Practice Makes Proficiency: Learn RDF and Have Fun

You have probably heard the old joke about the musician standing in front of a New York hotel with his instrument case. A passer-by asks, "How do you get to Carnegie Hall?" The musician answers, "Practice!"

As I write this, hams from around the country, including some from here in southern California, are helping victims and agencies in the wake of hurricanes Katrina and Rita. No doubt each of them is thankful for the preparedness that prior drills and training have provided.

Are radio direction finding (RDF) skills being used by hams after the hurricane? My guess is they are, and I'm eager to get any such reports. I know that transmitter hunters have served the public in disasters near me, as the following example shows.

## De-jamming the Sheriff

In 1994, JaMi Smith, KK6CU, was a District Communications Officer for the Los Angeles Disaster Communications Service (DCS). Right after the Northridge earthquake that devastated parts of Los Angeles and vicinity in January of that year, he took charge of the RACES room at the Sheriff's Communications Center (SCC) and the county's Emergency Operations Center (EOC) in East Los Angeles. Thirteen hours after arriving, JaMi was taking a short break from his volunteer DCS duties when a county employee, also on break, mentioned that a steady carrier had appeared on a county-wide law-enforcement frequency.

At the time, KK6CU was a regular participant in mobile T-hunts. He used a unique motorized VHF/UHF quad and storage oscilloscope display unit on three ham bands. However, he had traveled by motorcycle to the EOC, leaving his gear at home in Pasadena. Besides, the stuck transmitter was near 482 MHz, out of range for his UHF RDF quad. Figuring that he could hunt the carrier with a beam and his extended-range hand-held, he asked if a Yagi for 482 MHz was available. The answer was negative.

Minutes later, JaMi was approached by Larry Bryant, N6YLA, Officer in Charge at County Incident Command, along with a sergeant from the Communications Section. They told him that the interference was blocking a sheriff's administrative repeater that was vital for radio-assignment requests and quake-related mutual-aid communications. Of 37 receiver sites in the county, eight were picking up the signal. Vehicles and RDF gear were available. Could he help?

JaMi and the sergeant surveyed the SCC equipment pool, finding a commercial Watson-Watt type RDF set and antenna system by OAR Corporation (now Cubic Corporation).[1] Further search yielded a multi-mode scanner, necessary because Watson-Watt RDF processing requires an AM-mode receiver.


McKenzi Garlitz, KE7DRD, of West Jordan, Utah is excited after finding her first hidden transmitter at the beginner's hunt of the Utah Hamfest. (All photos by Joe Moell KØOV)

The RDF unit had two connectors for receiver IF input plus an audio connector. The scanner had no IF output connector and no equipment manuals were handy, so JaMi decided to try hooking just the scanner audio to the RDF set. For this he needed a cable with an RCA plug on one end and a miniature phone plug on the other. He quickly made one by cannibalizing a set of headphones and soldering its cable to a spare cable with an RCA plug.

The sergeant offered a choice of vehicles and an officer to drive. He and the radio technician strapped the RDF antenna to the car top and put the rest of the gear inside. After a quick check of the setup using a hand-held transceiver, they took off. JaMi rode with the driver in front and the technician sat in the back. The offending carrier was not copyable at the SCC, but signal levels into the receiver "voting" system led the county's technician to conclude that it was coming from the north end of the San Fernando Valley, perhaps from Sylmar.

## Radio Waves and Ping-Pong Balls

UHF signals reflect from nearly any hard surface or object that's bigger than a breadbox. They carom off mountains, hills, buildings, billboards, and cars. The bearing on an RDF display tells the arrival direction of a signal, but in urban or hilly ter-

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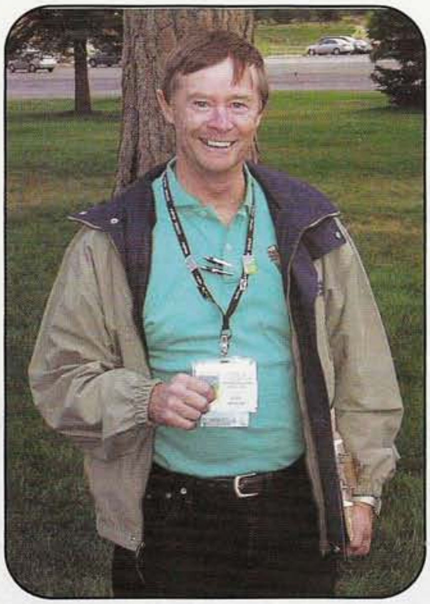


*Larry Benson, N7GY, of West Valley City, Utah put on three transmitter hunts at the Utah Hamfest.*

rain this may not be the direction from which the signal originates.

When signals arrive at a receiver by both direct and reflected paths simultaneously, the effect is called "multipath." In severe multipath, an RDF bearing may change constantly, or be consistently wrong. From his T-hunting experiences, KK6CU knew that the best way to maximize the signal level and get an accurate bearing, with minimum multipath effect, is to be as high and in the clear as possible. He decided to immediately go to the top of the hills above Hollywood.

"On Mulholland Drive," he says, "there's a great spot that overlooks the San Fernando Valley. I've used it on T-hunts before. We headed up Interstate 5, then west on Highway 134 to Highway 101. All we could get was an occasional blip of signal on the RDF set. We had just gotten off 101, going south on Laurel Canyon Boulevard, when I got a strong bearing to the west as we waited at the light.

"I suspected a reflection," JaMi went on to say, "and it went away as we went south. But as we gained elevation, the signal came up again, mostly bearing to the north because it's a box canyon. The hills were to the east and west. Once we were up on Mulholland, there was a steady bearing and virtually full-quieting signal. Before, we had gotten a lot of broadband noise. I could tell that because I have learned from experience to check by tuning off frequency to see if I am hearing noise or signal.

"We had no maps and no compass, but I knew that streets in the valley run north and south, so I looked down toward them for reference. The strong bearing was about 290 degrees true, pointing toward the extreme northwestern end of the valley. The tech said he didn't believe it. He still thought it was to the north."

Back at Highway 101, the trio headed west at well above the speed limit. "A couple of miles west, we started getting signal again," JaMi explained. "Then the bearing started to change. I got a couple of strong due-north blips at the Van Nuys exit, but we still guessed we would have to go to the far end of the valley. By the time we got to Interstate 405, we were not getting good signal strength because we were below ground level. We decided to go north on the 405, and as we came up, I got good bearings east of us, swinging again. I told the driver to take the next exit. He locked up the brakes, swerved over, and we went east on Victory Boulevard."

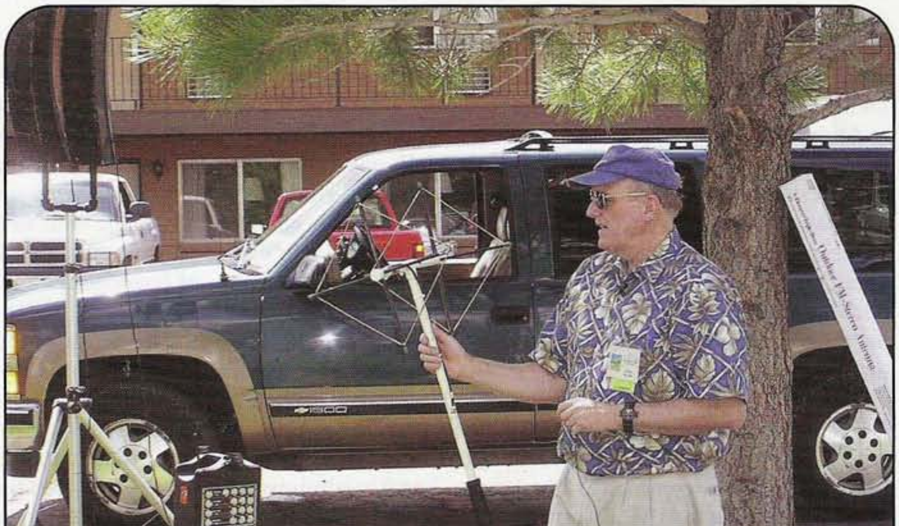
JaMi and his companions were now only six miles from the earthquake epicenter. Power was out in most places and a curfew was in effect. Fortunately, the driver was an officer in uniform.

Multipath makes UHF RDF in urban areas tricky. Rows of buildings tend to funnel signals down the streets. The bearing may appear to be constantly in front (or behind), and then suddenly change at an intersection. "As we approached Van Nuys Boulevard, the bearing tended toward south," KK6CU continued. "Now the signal was full quieting and I could hear the DF tone plainly in the AM receiver audio.

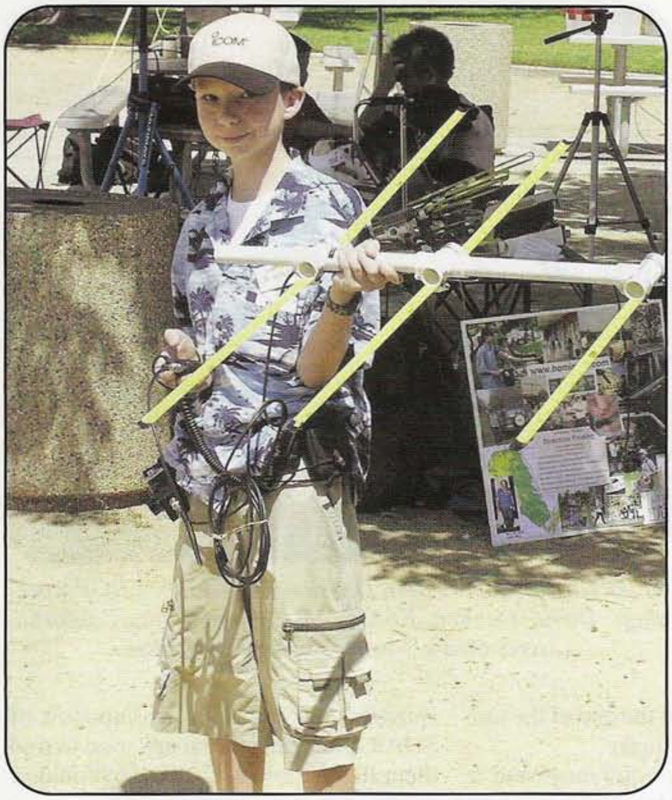
"I had the driver pull out into the intersection very slowly. There was a lot of multipath and the display swung around quite a bit. I told him to continue east, and at the next street we went out in the middle again. It looked to be toward the south, so we turned that way for three blocks and found ourselves inside a large complex of government buildings, including two courthouses and the Los Angeles Police headquarters for the San Fernando Valley."

They headed for the police mobile command center, where JaMi got out and checked by the vehicles with his dual-band hand-held. No stuck mics there. Back in the sheriff's car, they drove around the complex. Signal was weak everywhere except on the south side of the Northwest District Superior Court building. They parked again and walked all around, seeing no one but noting boarded-up doors and other signs of damage.

After going next door to the police sta-



*Even when moved out to the lawn, the Utah Hamfest forums were well attended. Mike Collett, K7DOU, of Layton, Utah is showing his 2-meter "shrunken quad" antenna for RDF.*



← *At the Catalina Amateur Repeater Association picnic, Eric Rice, KG6SIH, of Northridge, California found all of my hidden transmitters after instruction from his Dad, WB6BXP.*

*Matt Mendenhall, KE6ALM, of Norwalk, California was first to find the SOARA transmitter at the CARA picnic. Then he and Kareem Rashad, KG6USK (not pictured), set off to find the mini-T's in the park.* ↓

tion, they introduced themselves and KK6CU checked for signal inside the building. Meanwhile, the technician found out that a sheriff's radio set had been installed in the Superior Court building a year ago. Back they went to that courthouse to peer into the windows again.

"Finally, we saw somebody inside," says KK6CU. "It was a plainclothes deputy assigned to guard the building. He let us in and we asked directions to the communications room. There we found wet ceilings and water all over the floor from leaking pipes. There was an old desk with stacks of paper around the edges of the desktop, which was sagging in middle. Water was a half inch deep in the center. An old desk mic sat in the middle of the pool with its pushbutton switch submerged. I carefully pulled it out, shook it dry, and the carrier disappeared!

"We were still in a period of strong aftershocks," JaMi continued. "So we decided to get out of there right away. To be safe, we unplugged it and a few other pieces of equipment that were saturated. I disassembled the RDF gear and we headed back to the SCC."

The submerged microphone was connected to a 100-watt transmitter. So why was the signal so weak until the T-hunters were within a mile of the courthouse? It turned out that this radio is used mainly for communications within the building on simplex frequencies. The transmitter drives a long run of special "leaky" coax, such as Radiax® by Andrew Corporation.[2] It goes up the south side of the

*Trey Barton, KG6ZOE, of Rancho Palos Verdes, California won the 2005 ARRL Southwestern Division Convention on-foot transmitter hunt.*

*Jay Thompson, W6JAY, showed simple on-foot RDF gear to attendees of the 2005 ARRL Southwestern Division Convention and told of his travels to the ARDF World Championships. Besides his own hour-long talk, he was a speaker at the Youth Forum.*

*At the ARRL Southwestern Division Convention's RDF workshop, David Danner, K6AIX, of Canoga Park, California assembled a 2-meter tape-measure Yagi.*

building to a dummy load. Enough signal escapes from the coax to reach the officers' transceivers inside for simplex work. The signal can also be heard by the sheriff's sensitive repeater network when the transceiver is switched to the administrative frequency, which the marshall had apparently done at the end of the last work shift before the quake.

Despite unfamiliar equipment and a weak signal, KK6CU found the problem and fixed it in less than an hour. Without JaMi's understanding of RDF principles and his practical foxhunting experience, the interference to emergency communications would have lasted much longer.

## Learn and Have Fun

When an emergency is at hand, it might be too late to build RDF gear and learn to use it. Fortunately, the building and learning process can provide a great deal of enjoyment in itself. Fun, education, and emergency preparedness—what a great combination!

More and more ham groups around the country are giving amateur RDF a try. Not only are they setting aside days and evenings for mobile and on-foot transmitter hunts, but they are incorporating it into other membership activities. For instance, for several years there have been transmitters to find at the annual Catalina Amateur Repeater Association (CARA) picnic. At first, only the bravest hams tried it. Now people of all ages are joining in.

At this year's CARA picnic there were five of my foxboxes in Heritage Park. In addition, there was the hidden T for the mobile hunt of the South Orange Amateur Radio Association (SOARA), courtesy of that day's huntmaster, Dave Seroski, KG6QCI. CARA picnickers watched and joined in as cars full of SOARA hunters arrived and tried to find them all. (We told them that they couldn't get free burgers until they did!)

Along with transformer tosses and left-foot CW sending (QLF) contests, many hamfests and conventions are staging on-foot transmitter hunts. Most of them are on 2 meters, where RDF equipment can be very simple. A Yagi made from steel measuring tape, a simple RF attenuator, and a handie-talkie are usually all that it takes.[3]

In late July I had a great time at the Utah Hamfest near Bryce Canyon. An unexpected hazmat incident[4] moved my forum talk and several others out onto the lawn, but everyone stayed in good sprits. I told them about hams around the country who are traveling the world in search of ARDF medals. Mike Collett, K7DOU, and I showed them some easy-to-build RDF gear.

The Utah Hamfest Huntmaster, Larry Benson, N7GY, staged three on-foot hunts of varying difficulty on the spacious grounds of Ruby's Inn. The first had only one fox and was only a few dozen yards away, just to give everyone the idea and to help them check gear. The next day there was a two-transmitter hunt, followed later by a five-fox hunt with timing that was intended to simulate international ARDF rules.[5] With that great introduction, I hope to see Utah hams at the next USA ARDF Championships (see sidebar).

RDF was high-profile at the ARRL Southwestern Division convention in

## North Carolina Hosts Next USA ARDF Championships

If you missed the chance to meet and test your skills against the USA's best on-foot transmitter hunters in Albuquerque this summer, another opportunity is coming in just a few months. The sixth annual USA Championships of Radio-Orienteering will be April 7 through 9, 2006 in Raleigh, North Carolina.

The competition gets under way on Friday afternoon with an information and safety briefing, followed on Saturday by the 2-meter hunt and on Sunday by the 80-meter hunt in William B. Umstead State Park. In addition to the ARDF competitions, there will be a picnic get-together on Saturday night and an award ceremony following the 80-meter hunt.

As always, the USA ARDF Championships are open to anyone, from beginner to expert, with or without a ham radio license. Competitors are divided into standard age/gender categories, with awards for first three places in each category.

The 2006 USA championships organizers are Charles (NZØI) and Nadia Scharlau of Chapel Hill, NC. Both have been consistent medal winners at previous USA Championships. Latest event information, rules, and registration forms are in the 2006 USA ARDF Championships website: <www.ardf.us>.

ARDF is a worldwide radiosport, regulated by committees of the International Amateur Radio Union (IARU). There are competitions in over 30 countries around the globe. Every two years one country hosts the ARDF World Championships (WCs). In 2004 they were in Brno, Czech Republic, with a 21-member group from the USA on hand. The next WCs will be on the Black Sea Coast south of Bourgas, Bulgaria from September 12 through 17, 2006.

ARDF Team USA is now forming and training for the 2006 WCs. Final team member selection takes place in summer 2006, based on performances at the 2005 USA Championships in New Mexico and the 2006 events in North Carolina. If you wish to compete in Bulgaria next year, register now for the North Carolina Championships and watch my "Homing In" website: <www.homingin.com> for the latest information on ARDF Team USA membership and travel arrangements. My site also has details of the IARU's international ARDF rules and links to local groups providing ARDF training and practice.

*Joe Moell, KØOV*
*USA ARDF Coordinator*

Riverside, California this September. In addition to separate talks on competitive ARDF by Jay Thompson, W6JAY, and myself, there were two hands-on equipment workshops organized by Marvin Johnston, KE6HTS. He brought plenty of kits for the aforementioned measuring-tape Yagis and offset attenuators. Soldering irons, sandpaper, and tools were at the ready so that attendees could complete their gear and be all set to hunt radio foxes right away. Most of them built beams for the 2-meter band, but Bob Miller, N6ZHZ, and I already had them. Thus, we scaled the dimensions and built beams for the 120-MHz aircraft communications band. Now we're ready to quickly track 121.5-MHz aircraft Emergency Locator Transmitters (ELTs) when the need occurs.

Orange Section Technical Coordinator Jim Eason, AD6IJ, put on the official transmitter hunt at the Riverside convention. A 2-meter rig in an ammunition box was concealed in bushes on the convention center grounds. Several hunters headed for it and were close within a few minutes. It was Trey Barton, KG6ZOE, who saw it, snatched the ticket, got back to the start point first, and claimed the prize. Trey is one of the Palos Verdes High School students who learned about ham radio and RDF from volunteer instructor Dan Welch, W6DFW, as I detailed in the Spring 2005 issue of *CQ VHF.*

Has your local club held a hidden transmitter hunt lately? Did you include RDF in your October Scout JOTA activities? If so, please send me a note and some photos. If not, give it a try. Besides having lots of fun and perhaps enticing some new folks into ham radio, you will be developing a skill that could be very important when intentional or unintentional interference affects communications in your town, in a disaster or not.

73, Joe, KØOV

### Notes

1. <http://www.cubic.com/cda1/Prod_&_Serv/C4ISR_Prod_&_Sys/DF_Products/index.html>
2. <http://www.andrew.com/products/trans_line/radiax/default.aspx>
3. <http://members.aol.com/homingin/equipment.html>
4. <http://www.arrl.org/news/stories/2005/08/03/7/?nc=1>
5. <http://members.aol.com/homingin/intlfox.html>

By Kent Britain,* WA5VJB

# ANTENNAS

## Connecting the Radio to the Sky

# Painting Antennas

Painting antennas was first recommended to me by WB6NMT. Louie ran Lunar Electronics and sold a fine line of antennas. He also lived near the Pacific coast, and thus his antennas were subjected to a lot of salt spray. If paint helps antennas last a few more years in salt spray on the coast, then it will help them last decades longer here in inland Texas. My 432-MHz and 222-MHz Yagis were painted in 1979 and they are still up in the air (with a few touch-ups over the years).

Painting antennas has several advantages (photo A). First, the paint tends to "glue" the hardware together. Not as many screws and nuts seem to work their way loose with some paint in the threads. Next, the paint protects plastic parts from ultraviolet light exposure and air pollution. Therefore, the antenna holds together longer and fewer bits fall off if it is painted.

I had several reservations about how the paint might detune the antenna. I built a 3.45-GHz loop Yagi and measured its gain. Then I gave it several coats of spray Zynolite, epoxy paint. I let the paint set and then measured the gain again. There was no measurable difference. If I can't measure any loss at 3.45 GHz, I'm not going to worry about paint losses with my 2-meter beam.

Next I used a light-gray -paint. It used to be called "Battleship Gray," but Machinery Gray is a common color among the better spray paints, and when the sky is just a little overcast, the antennas virtually disappear. Louie painted his antenna white, but I like to keep mine somewhat lower profile.

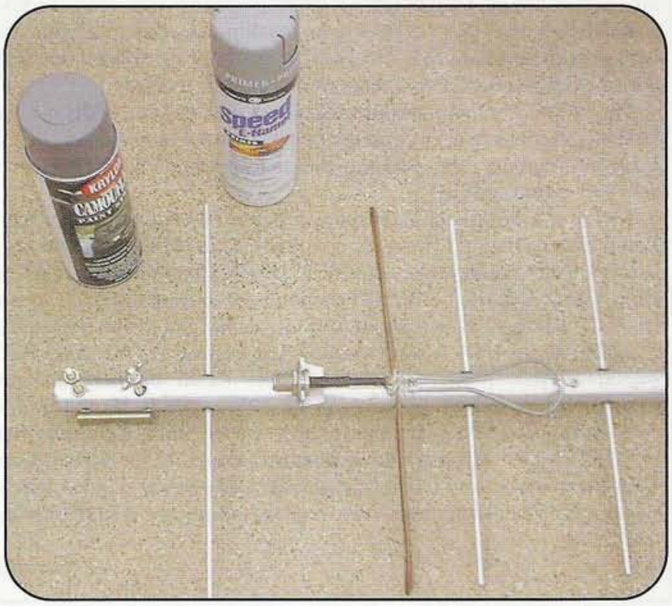



*Photo A. Painting an antenna protects the plastic parts from ultraviolet light and pollution and also tends to "glue" the hardware together.*

## Cheap RAM

RAM, or radar-absorbing material in this case, has many UHF and microwave applications. Coating an aircraft or pickup truck with it is just one possible use.

I have to give credit here to Bob, W5EMC, for this tip. Military RAM is selected blends of ferrite dust in a silicon rubber matrix. Often a wire mesh is added for strength and to improve the RAM's characteristics at a spot frequency. Well, those magnetic signs often seen on a pickup saying, for example, ACME Lawn Care, or the little signs that hold a business card to the refrigerator, are made of a very similar material (photo B). In EMI/EMC work, a strip of this magnetic silicon rubber is placed over particularly noisy chips to help the board pass FCC emissions standards. For ham use we can think of this stuff as sheet ferrite beads.

In a future column we will be covering some projects using magnetic-particle-loaded material. It makes great microwave dummy loads, can be used with dish feeds to reduce sidelobes, and can be placed in the lids of microwave project boxes to kill resonances. I personally find a few drops of Goo-Gone® work great for separating the magnet itself from the advertisement. Keep an eye out for those sheet magnets. Start collecting old magnetic signs!

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e-mail: <wa5vjb@cq-vhf.com>*

## Reader Question

Paul B. asks, "How close to the tower can I side-mount a Ringo Ranger without messing up the pattern or the SWR?"

This question covers just about any ground-plane or Ringo-style antenna. You just can't always put your antenna at the top of the tower mast.

There are two issues here. The first is how close can the antenna be to the tower before the tower changes the SWR of the antenna (figure 1).

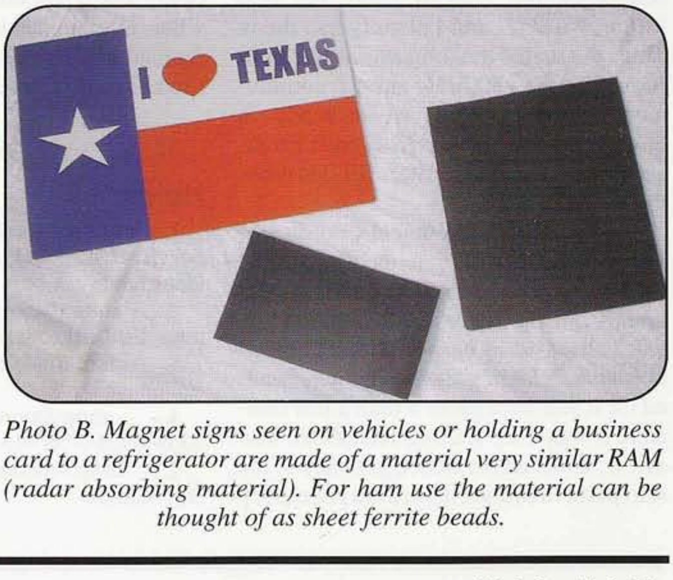


*Photo B. Magnet signs seen on vehicles or holding a business card to a refrigerator are made of a material very similar RAM (radar absorbing material). For ham use the material can be thought of as sheet ferrite beads.*

| Distance | 146 MHz SWR | New Frequency and SWR at that Frequency |
|---|---|---|
| 12 inches | 1.5 | 144 MHz, 1.35 SWR |
| 18 inches | 1.5 | 144 MHz, 1.3 SWR |
| 24 inches | 1.17 | 145 MHz, 1.12 SWR |

*Table I. How close to the tower can you place an antenna before the tower changes the SWR of the antenna? Here are my results at different distances, including the new resonate frequency.*

I started with a 2-meter vertical and measured the SWR at different distances. All by itself the antenna had an SWR of 1.25 at 146 MHz. Moving the 2-meter vertical near the tower lowered the vertical's resonant frequency due to the loading effects of the tower. Table I shows my results at different distances, including the new resonant frequency. At 24 inches from the tower the antenna had a better SWR at 146 MHz than it did when it was on a pole all by itself. However, I'm pretty sure that can be attributed to a less than optimum SWR match when I started. It does show, though, that you can place a 2-meter vertical within 12 inches of a mast or tower and all you need to do is shorten it less than an inch or so to get the antenna back on the starting frequency.

The pattern was a very different story. Even when I mounted the antenna 10 feet from the tower, the tower still distorted the vertical's pattern. This may not be all that bad. The vertical and the tower tended to form a two-element Yagi. Also, from a mounting offset distance of 12 inches to an offset of 48 inches the pattern didn't change very much. The signal behind the tower was a consistent –4 dB. In the direction where the reflected signal adds, the gain was running between +4 and +5 dB.

For a better pattern I broke down and built an NEC model using the EZNEC 4.0 modeling software. As you can see in figure 2, the nulls are not on the opposite sides of the tower, but rather at ±120 degrees. That 120-degree angle varied a bit with distance but was pretty consistent for all distances at which the antenna was mounted from the tower.

Therefore, the tower offset can be used to shade a repeater, etc., about 4 dB. That's not all that much, which can be good news or bad news. You can get better shading/blockage at ±120 degrees, but the position may need a little tweaking for your tower. Off the other side you're picking up almost an S-unit more signal. In short, mount the vertical on the side of the tower where you need a bit more signal.

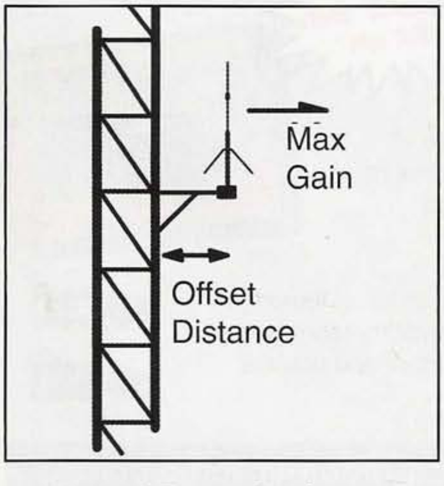


*Figure 1. Tower offset distance.*

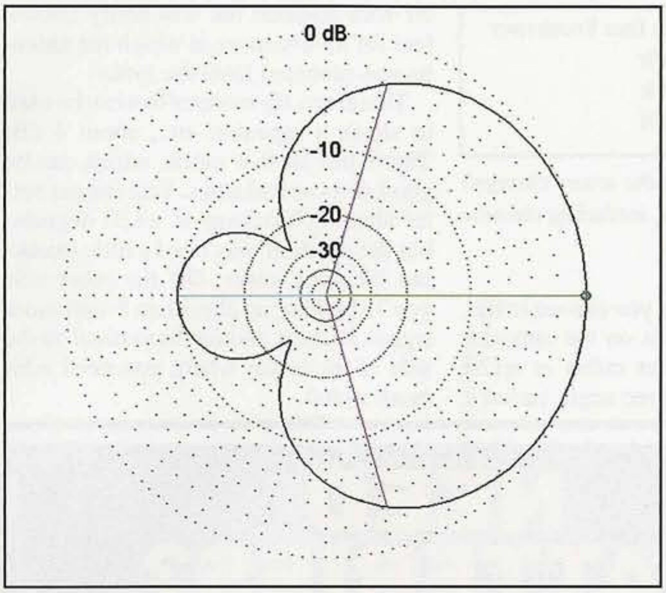


*Figure 2. Tower and pattern with a 2-foot offset.*

For a nearly omni pattern, the antenna needs to be more than 6 feet from the tower. For a 440-MHz vertical, just divide all of my distances by 3. About a foot of offset is all you need.

## Neat Ideas

I have always gotten some of my best ideas for articles from you, our readers. How about going to the next level? Do you have any neat ideas you would like to share with other readers? A trick for grounding a mobile vertical? A simple way of attaching a coax connector? Using something unusual to build your antenna? Let me know, and we'll make a short topic out of it for a future column.

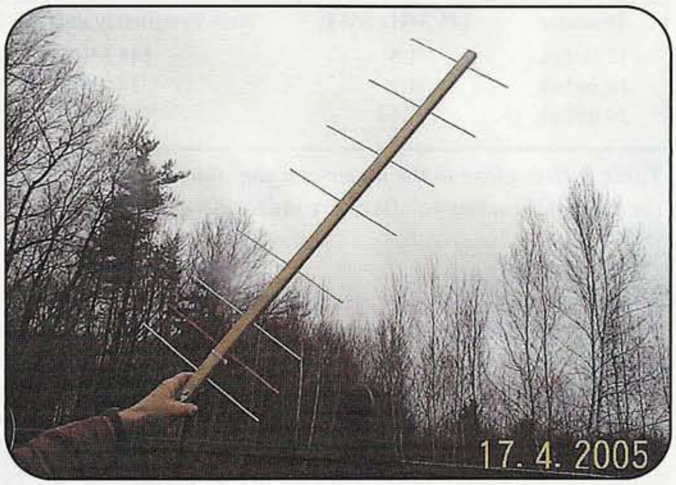


*Photo C. Building Yagi antennas on hockey sticks. (Tnx to Denis in Quebec)*

From Denis in Quebec we have a suggestion for building Cheap Yagis out of broken hockey sticks (photo C). I'll have to take his word on it, as we don't see very many used hockey sticks in Texas, but that hard wood should make a pretty good boom.

## Next Time

Keep a look out for those magnetic sheets, and we'll cover some ways you can use them in a future issue of *CQ VHF*. Also, I plan to cover several cases where a 1/4-wave antenna is a terrible choice. Yes, there are times when a 1/4-wave antenna isn't doing what you think it is.

And remember . . . Anything in the air works better than the perfect antenna still on the drawing board!

73, Kent, WA5VJB




By Tomas Hood,* NW7US/AAA0WA

# PROPAGATION

## The Science of Predicting VHF-and-Above Radio Conditions

# Is the End of Cycle 23 Near?

Does solar Cycle 23 have enough life left to spark some excitement for those of us hunting for exotic VHF propagation? Also, what is the outlook for Cycle 24?

The current cycle has not been too exciting for VHF enthusiasts, with Cycle 23 peaking at a smoothed sunspot number of 120.8. That's a bit dismal compared to previous cycles. Cycle 21 peaked at 164, and Cycle 22 peaked at 158. Compare these last three 11-year solar activity cycles to Cycle 19 from the late 1950s, which had a smoothed peak of 201.3. That's a cycle remembered fondly among VHF veterans, with frequent worldwide *F*-layer openings on 6 meters and plenty of aurora-mode propagation.

The official prediction for the ending of the current solar cycle is around the end of 2006. This prediction has not been changed for several years and is thought to still be valid. However, a panel of scientists is planning to meet in early 2006 and hopes to provide an update in April 2006. I don't expect the outlook to change too much, and I continue to postulate the end of Cycle 23 to occur in the fall of 2006.

Despite the impending death of Cycle 23 in about a year's time, there have been recent moments of rather energetic bursts of solar activity. An example occurred during September, when a huge sunspot rounded the sun's eastern limb. As soon as it appeared it exploded, producing one of the brightest x-ray solar flares so far recorded (see Table 1). As it traversed the visible solar disc, the complex and ever-growing spot exploded at least nine more times. Each X-class flare caused a radiation storm and provided conditions for modest aurora-mode propagation. On September 10th and 11th, ruby-red auroras were seen as far south as Arizona.

It is typical during the decline of recent solar cycles to see moments of strong activity, although they are less frequent than in the years centered on a cycle's maximum. What makes 2005 unique, though, is the strength of these occasional solar flare-ups. The year started immediately on New Year's Day with the first of many X-class flares! Since then we've experienced four severe geomagnetic storms and 14 more X-flares.

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e-mail: <cq-prop-man@hfradio.org>

| Ranking | Day/Mo./Yr. | X-Ray Class |
|---|---|---|
| 1 | 04/11/03 | X28 |
| 2 | 02/04/01 | X20.0 |
| 2 | 16/08/89 | X20.0 |
| 3 | 28/10/03 | X17.2 |
| *4 | *07/09/05 | X17 |
| 5 | 06/03/89 | X15.0 |
| 5 | 11/07/78 | X15.0 |
| 6 | 15/04/01 | X14.4 |
| 7 | 24/04/84 | X13.0 |
| 7 | 19/10/89 | X13.0 |
| 8 | 15/12/82 | X12.9 |
| 9 | 06/06/82 | X12.0 |
| 9 | 01/06/91 | X12.0 |
| 9 | 04/06/91 | X12.0 |
| 9 | 06/06/91 | X12.0 |
| 9 | 11/06/91 | X12.0 |
| 9 | 15/06/91 | X12.0 |
| 10 | 17/12/82 | X10.1 |
| 10 | 20/05/84 | X10.1 |
| 11 | 29/10/03 | X10 |
| 11 | 25/01/91 | X10.0 |
| 11 | 09/06/91 | X10.0 |
| 12 | 09/07/82 | X9.8 |
| 12 | 29/09/89 | X9.8 |
| 13 | 22/03/91 | X 9.4 |
| 13 | 06/11/97 | X9.4 |
| 14 | 24/05/90 | X9.3 |
| 15 | 06/11/80 | X9.0 |
| 15 | 02/11/92 | X9.0 |

*Table 1. Top X-flares so far recorded by scientists. The X17 flare of September 7, 2005 is marked by an asterisk (*). This list is based in part on "Large Solar Flares Since 1976," compiled by IPS Radio & Space Services.*

"That's a lot of activity," says solar physicist David Hathaway of the National Space Science and Technology Center in Huntsville, Alabama. "In the year 2000," he recalls, "there were three severe geomagnetic storms and 17 X-flares." 2005 registers about the same in both categories!

September's activity was caused by sunspot 808. All by itself, this sunspot has made September 2005 the most active month on the sun since March 1991. All of this activity came out of a sunspot that had already made it around the sun once before as active region 798. When it returned a second time, it rotated into view with a bang. On September 7, 2005 this sunspot unleashed the fourth largest flare of Cycle 23 and was the fifth largest ever recorded. The flare measured in at X17! From that point onward, it continued to stir up space weather and influence radio propagation with at least nine more X-class flares. During some of these solar flares, coronal mass ejections (CMEs) were hurled toward the Earth, triggering geomagnetic storms and aurora. As I write this, this same sunspot group is just making its way around again for a third time and it shows continued, although much weaker, life (see images A, B, C, D).

Hathaway cautions against predicting the exact end of the current cycle. Before 2005, the last solar minimum was due in 1996, and at the time the sun seemed to be behaving perfectly: From late-1992 until mid-1996, sunspots began to disappear and there were precisely zero X-flares during those long years. It was a time of quiet. Then in 1996 when sunspot counts finally reached their lowest value, bang! An X-flare erupted.

"The sun can be very unpredictable," says Hathaway. When asked when we should expect the end of this cycle, he points out, "We need to observe more solar cycles to answer that question. And because each cycle lasts 11 years, observing takes time." (See image E.)

The prediction for the next cycle indicates that it will be a modest cycle, with no more than a maximum smoothed sunspot peak of 150. Regardless, I bet we'll have moments that will surprise us with explosive activity much like we've seen during this cycle. Its peak should be around 2009 through 2012, with a relatively fast rise from the cycle's start in 2007. A rapid rise has been typical during a number of recent solar cycles. Such a rise and subsequent peak period is great news for the VHFer, since it brings the

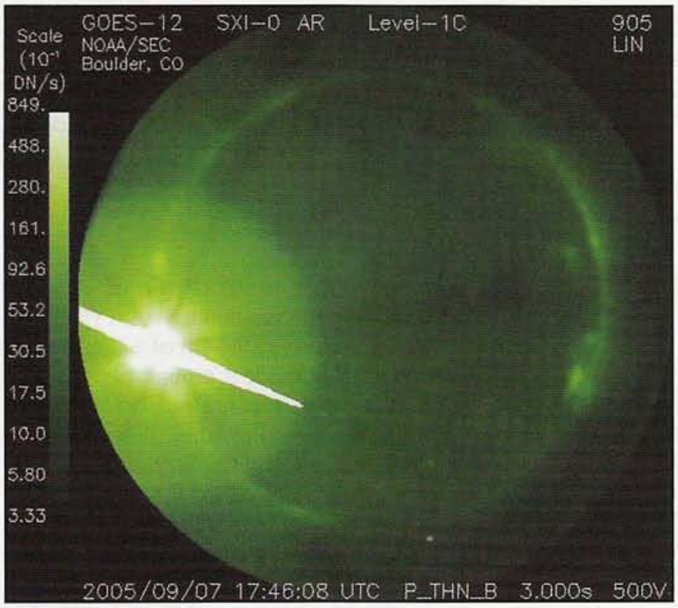



*Image A. At 1:40 PM EDT on September 7, 2005 forecasters at the NOAA Space Environment Center in Boulder, Colorado observed one of the largest solar flares on record. (Source: NOAA/SEC)*

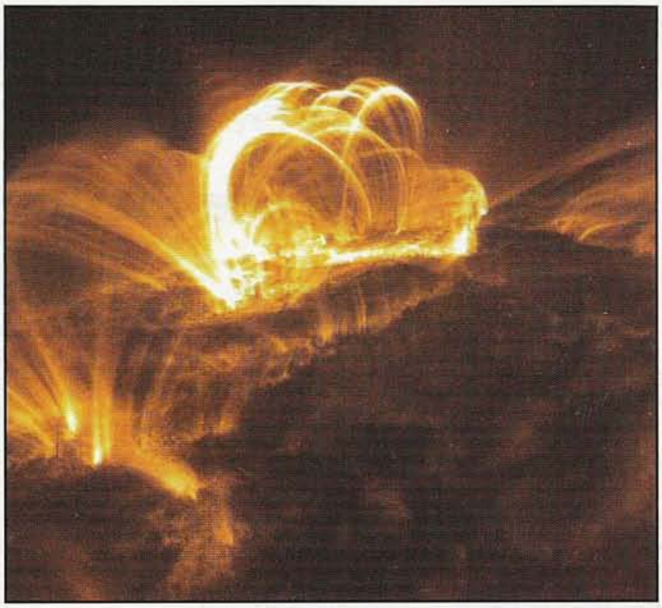


*Image B. A close-up of the September 9, 2005 flare with the Transition Region and Coronal Explorer (TRACE) spacecraft. (Source NASA/LMSAL)*

higher frequencies alive via an energized ionosphere and also provides the environment in which aurora-mode propagation is sustained.

## Coronal Holes; The Origin of Solar Wind?

Outside of these moments of solar eruptions and geomagnetic storms from related CMEs, another major player during solar cycle minimums is the continual occurrence of coronal holes and the resulting solar wind storms. When the Earth is under the influence of high-speed solar winds, we often experience periods of geomagnetic disturbances that can develop into significant storms. That in turn triggers the aurora VHFers look forward to.

A Chinese-German team of scientists has identified the magnetic structures in the solar corona where these fast solar winds originate. They analyzed images and Doppler maps from the Solar Ultraviolet Measurements of Emitted Radiation (SUMER) spectrometer and magnetograms delivered by the Michelson Doppler Imager (MDI) on the space-based Solar and Heliospheric Observatory (SOHO) of ESA and NASA and found that solar winds were flowing from funnel-shaped magnetic fields that are anchored in the lanes of the magnetic network near the surface of the sun.

"The fine magnetic structure of the source region of solar wind has remained elusive," said first author Professor Chuanyi Tu, from the Department of Geophysics of the Peking University in Beijing, China. "For many years, solar and space physicists have observed fast solar wind streams coming from coronal regions with open magnetic-field lines and low light intensity, the so-called coronal holes. However, only by combining complex observations from SOHO in a novel way have we been able to infer the properties of the sources inside coronal holes. The fast solar wind seems to originate in coronal funnels with a speed of about 10 km/s at a height of 20,000 kilometers above the photosphere."

"The fast solar wind starts to flow out from the top of funnels in coronal holes with a flow speed of about 10 km/s," states Professor Tu. "This outflow is seen as large patches in Doppler blue shift (hatched areas in figure 1) of a spectral line emitted by $Ne^{+7}$ ions at a temperature of 600,000° Kelvin, which can be used as a good tracer for the hot plasma flow. Through a comparison with the magnetic field, as extrapolated from the photosphere by means of the MDI magnetic data, we found that the blue-shift pattern of this line correlates best with the open field structures at 20,000 km."

Solving the nature and origin of the solar wind is one of the main goals for which SOHO was designed. It has long been known to the astronomical community that the fast solar wind comes from coronal holes. What is new here is the discovery that these flows start in coronal funnels, which have their source located at the edges of the magnetic network. Just below the surface of the sun there are large convection cells. Each cell has magnetic fields associated with it, and these are concentrated in the network lanes by magneto-convection, where the funnel necks are anchored. The plasma, while still being confined in small loops, is brought by convection to the funnels and then released there, like a bucket of water is emptied into an open-water channel.

"Previously it was believed that the fast solar wind originates on any given open field line in the ionization layer of the hydrogen atom slightly above the photosphere," says the second author, Professor Marsch. "However, the low Doppler shift of an emission line from carbon ions shows that bulk outflow has not yet occurred at a height of 5,000 km. The solar-wind plasma is now considered to be supplied by plasma stemming from the many small magnetic loops, with only a few thousand kilometers in height, crowding the funnel. Through magnetic reconnection, plasma is fed from all sides to the funnel, where it may be accelerated and finally form the solar wind."

Another group of scientists was surprised to discover that the structure of the sun's cooler, dense lower atmosphere, the chromosphere, could be used to estimate the speed of the solar wind. This was

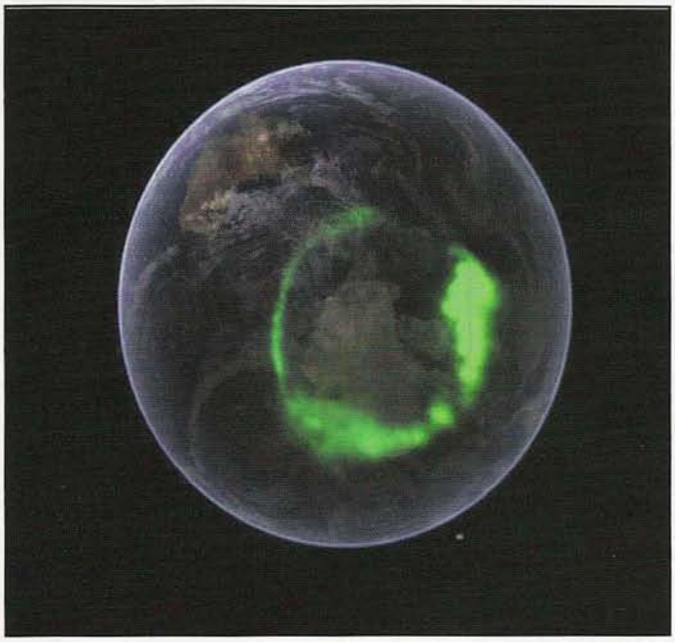


*Image C. A view of the aurora australis (southern lights) as taken by the Imager for Magnetopause-to-Aurora Global Exploration (IMAGE) spacecraft on September 11th in ultra-violet light. (Source: NASA)*


*Image D. On September 5, 2005 the C2 coronagraph observed a bulbous coronal mass ejection heading out from behind the left side of the sun. This was about where old sunspot region 798 was expected when returning for a second rotation. The first time around it produced several substantial solar storms. It was probably the source of several large solar storms that we could infer occurred on the far side of the sun. The region was tracked using the sensing techniques of helioseismology. Also, just as scientists suspected, the same region, while still just at the sun's left edge on the second rotation, erupted two days later with an X17 flare (almost off the scale) and an associated CME. At press time it has made it a third time around the sun, but is much weaker this time around. (Source: SOHO)*

unexpected, because the solar wind originates in the corona, and the chromosphere is much deeper (it lies just above the sun's visible surface). "It's like discovering that the source of the river Nile is another 500 miles inland," said Dr. Scott McIntosh of the Southwest Research Institute, Boulder, Colorado, lead author of a paper on this research published May 10, 2005 in the *Astrophysical Journal* (see figure 2).

The new work promises to increase the accuracy of space radiation forecasts. When the sun unleashes a CME (a billion-ton blast of plasma) into space at millions of miles per hour, it is likely to trigger geomagnetic storms. The VHF enthusiast benefits from a forecast that accurately identifies a pending storm, because that would signal the possible auroral propagation soon to commence.

"Just as knowing more details about the atmosphere helps to predict the intensity of a hurricane, knowing the speed of the solar wind helps to determine the intensity of space radiation storms from CMEs," said co-author Dr. Robert Leamon of L-3 Government Services at NASA's Goddard Space Flight Center, Greenbelt, Maryland.

The solar wind is gusty, much like winds on Earth, and ranges in speed from about 750,000 miles per hour (approximately 350 kilometers per second) to 1.5 million miles per hour (700 kilometers per second). You can view the current solar wind speed as measured by sending your internet web browser to <http://www.sec.noaa.gov/SWN/>.

Since the solar wind is made up of electrically charged particles, it responds to magnetic fields that permeate the solar atmosphere. Solar-wind particles flow along the invisible lines of magnetic force. When the magnetic field lines stretch straight out into space, as they do in coronal-hole regions, the solar wind will move along these magnetic lines at a very high rate of speed. However, when the magnetic field lines bend sharply back to the solar surface, like the pattern you see with iron filings around a bar magnet, the solar wind emerges relatively slowly. For over 30 years this model has allowed space weather scientists to create a crude estimate for the speed of the solar wind.

In the new work, the team has tied the speed of the solar wind as it blows past Earth to variations deeper in the solar atmosphere than had previously been detected, or even expected. By measuring the time taken for a sound wave to travel between two heights in the chromosphere, they were able to determine that the chromosphere is effectively "stretched thin" below coronal holes with their open magnetic fields, but compressed below magnetically closed regions.

The team used the observation to derive a continuous range of solar wind speeds from the structure of the chromosphere. The wider the chromospheric layer, the more it is being allowed to expand by open magnetic fields and the faster the solar wind will blow. This new method is more precise than the old "fast or slow" estimate (see figure 3).

NASA's Transition Region and Coronal Explorer (TRACE) spacecraft was used to measure the speed of sound waves in the chromosphere, and NASA's Advanced Composition Explorer (ACE) spacecraft was used to take measurements of the solar wind speed as it blew by the Earth. Comparing the data from the two spacecraft gave the connection.

"Prior to this discovery, we could only determine solar wind speed from spacecraft that were roughly in line between the Earth and the sun, such as ACE, WIND, and the Solar and Heliospheric Observatory. This spacecraft fleet was placed along the Earth-sun line because we need to know about the space weather coming our way. However, compared to the size

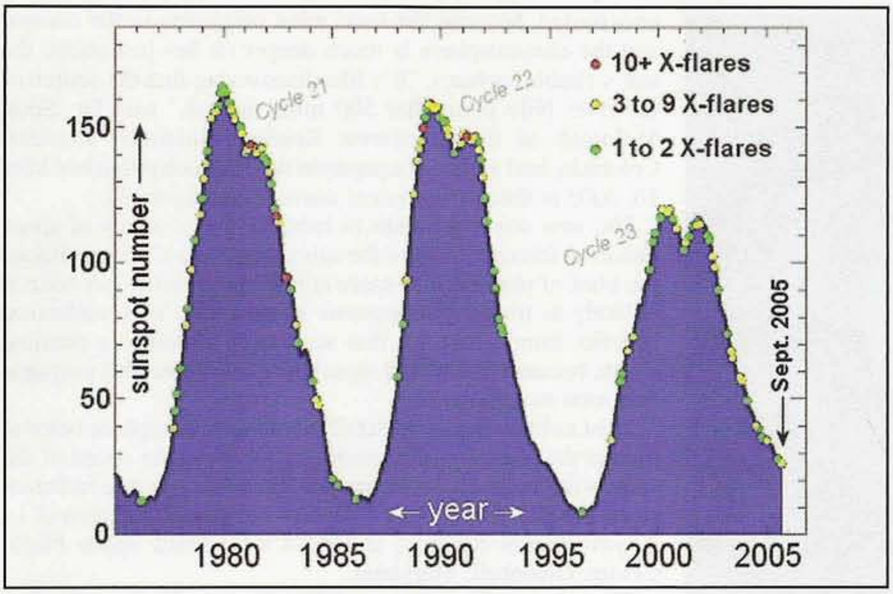



*Image E. Sunspot counts and X-flares during the last three solar cycles. Note how solar activity continues even during solar minimum. (Source: David Hathaway, NASA/NSSTC)*

of our solar system, this is a very narrow range; it's like looking through a soda straw. With this discovery, we can use TRACE to build up images that can predict the solar wind speed throughout half the solar system," said Dr. Joe Gurman, a solar researcher at NASA Goddard.

This is a welcomed development, since the radio hobbyist can now better assess the probability of geomagnetic activity that would trigger conditions useful for VHF propagation. By knowing more accurately when a solar-wind shock wave will arrive, and how intense the plasma cloud will be, combined with the orientation of the magnetic components, the VHF radio amateur/scientist can be ready for action. With the VHF radio community ready for these opportunities, more participants will be on the scene to make these openings memorable.

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

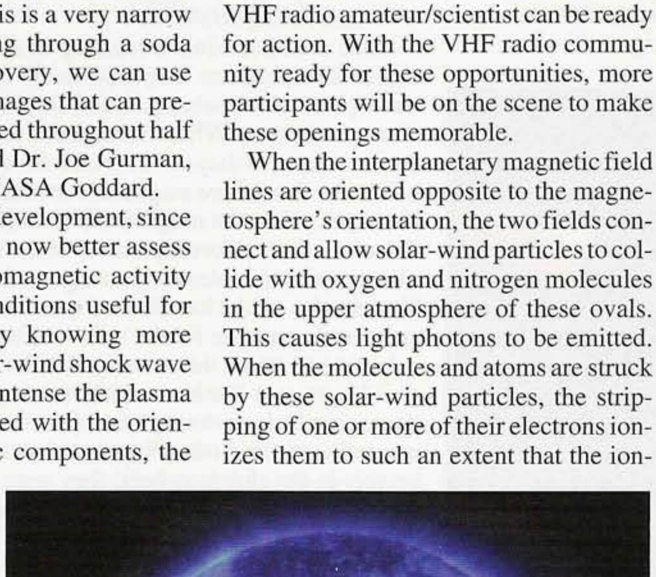



*Image F. The third return of sunspot region 798/808 (on the left of the image), still active after three rotations! (Source: SOHO)*

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

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

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

For the daily conditions, you are welcome to check my propagation resource at <http://prop.hfradio.org>, where I have the current planetary *K*-index, links to various aurora resources, and more. You can get the same information on a cell phone that is WAP-enabled by using the cell phone's web browser to view <http://wap.hfradio.org/>.

## Autumn Outlook

Autumn (November through January) is a relatively quiet season, with very little if any transequatorial propagation (TEP). TEP, which tends to occur most often during spring and fall, requires high solar activity that energizes the ionosphere enough to cause the *F*-layer over the equatorial region to support VHF propagation. The normal TEP signal path is between locations on each side of the equator. However, without the level of solar activity needed to keep the *F*-layer

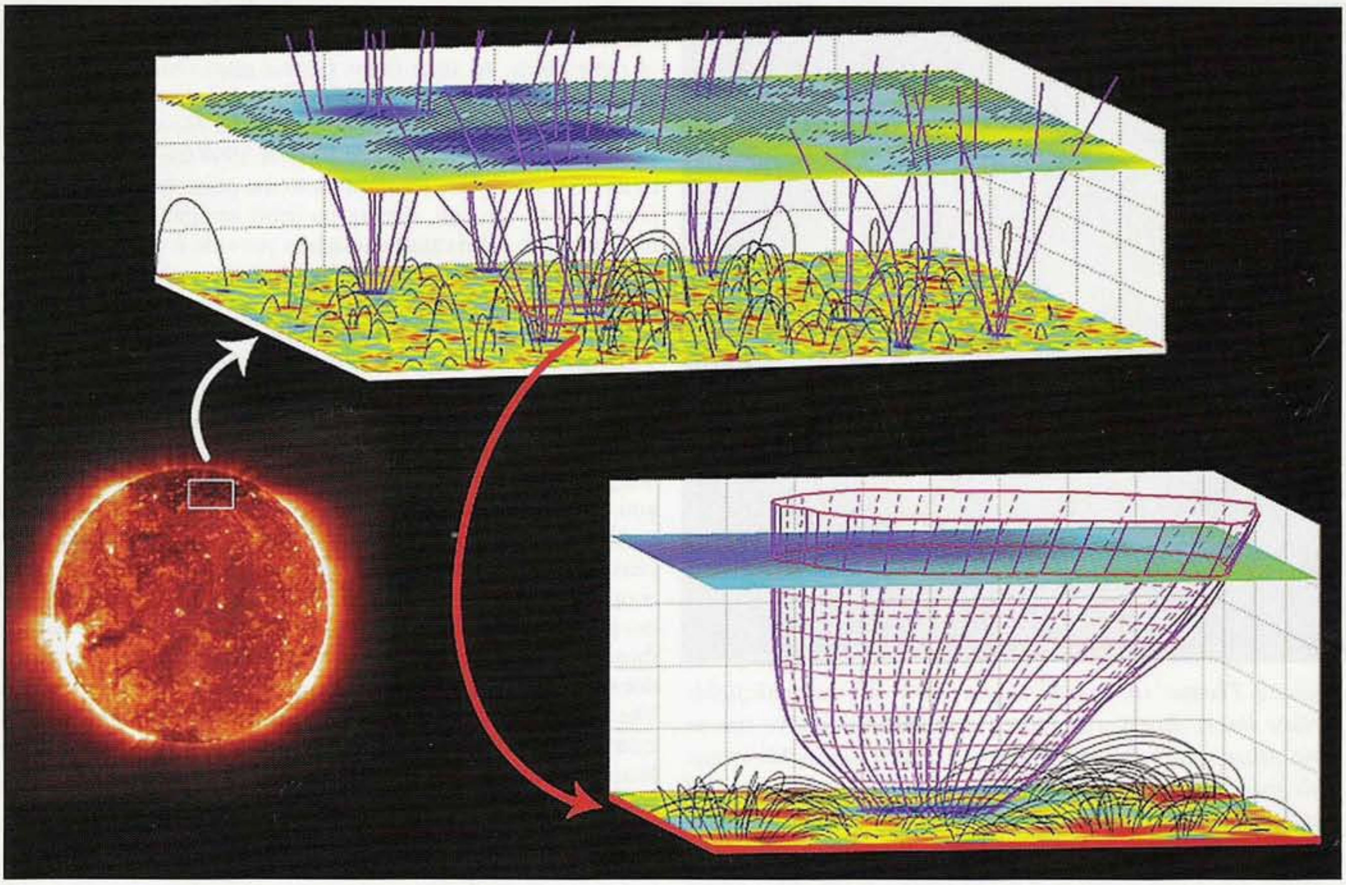


*Figure 1. This picture was constructed from measurements which were made on September 21, 1996 on SOHO (see the April 22 issue of* SCIENCE *magazine). The figure illustrates location and geometry of three-dimensional magnetic-field structures in the solar atmosphere. The magenta-colored curves illustrate open field lines, and the dark-gray solid arches show closed ones. In the lower plane, the magnetic field vertical component obtained at the photosphere by MDI is shown. In the upper plane, inserted at 20,600 km, the Ne VIII Doppler shift is compared with the model field. The shaded area indicates where the outflow speed of highly charged neon ions is larger than 7 km/s. Note the funnel constriction by pushing and crowding of neighboring loops. The scale of the figure is significantly stretched in the vertical direction. The smaller figure in the lower right corner shows a single magnetic funnel, with the same scale in both vertical and horizontal directions. (Source: MPI for Solar System Research)*

energized enough for VHF propagation, these paths don't materialize. The fall season of TEP usually tapers out by mid-November. This year, though, TEP will be rare, if it occurs at all.

Tropospheric-ducting propagation during this season is fairly non-existent, as the weather systems that spawn the inversions needed to create the duct are rare. On the other hand, using tropospheric-scatter-mode propagation is possible, but one needs to have very high-powered, high-gain antenna systems. Having dual receivers in a voting configuration would also help. The idea is to use brute force to scatter RF off water droplets and other airborne particles, and capture some of that signal at the far end with dual-diversity, high-gain receivers —not everyone's cup of tea.

In addition, since we're well past the second yearly peak equinoctial activity, aurora will occur less frequently, even during those less-frequent occurrences of solar wind storms. Don't rule out aurora altogether, though. This cycle has surprised us enough times that it might well be possible to see another major flare unleashing a huge plasma cloud on a high-speed solar-wind stream directly at the Earth, triggering massive aurora. If and when that happens, fire up your VHF sideband equipment and work the aurora!

## The Autumn Meteor Shower Season

There are a number of opportunities during this period to try your skill and use your equipment in meteor-scatter propagation. One of the largest yearly meteor showers occurs during November.

The *Leonids* meteor shower is typically the big event for November. This year it is expected to peak on November 17 at 1317 UT. There is a possible second outburst from a side trail from the comet, the 55P/Tempel-Tuttle, due at 0140 UT on November 21, most suited for Europeans. The full *Leonid* period is from about November 14 and continues through November 21.

Unfortunately, most are predicting that this year's shower will be dismal. An expected rate of only 16 to 20 bursts per hour will make the prospect for exciting meteor-shower radio propagation bleak.

The reason behind the low hourly rate lies in the size of the debris clouds left by the passing comet. These dust clouds are stretched out into long and narrow trails. The younger remains of recent passages are only ten or so Earth-diameters wide. The chances of Earth hitting something so narrow and filamentary are slim. This has proven true for most years in No-

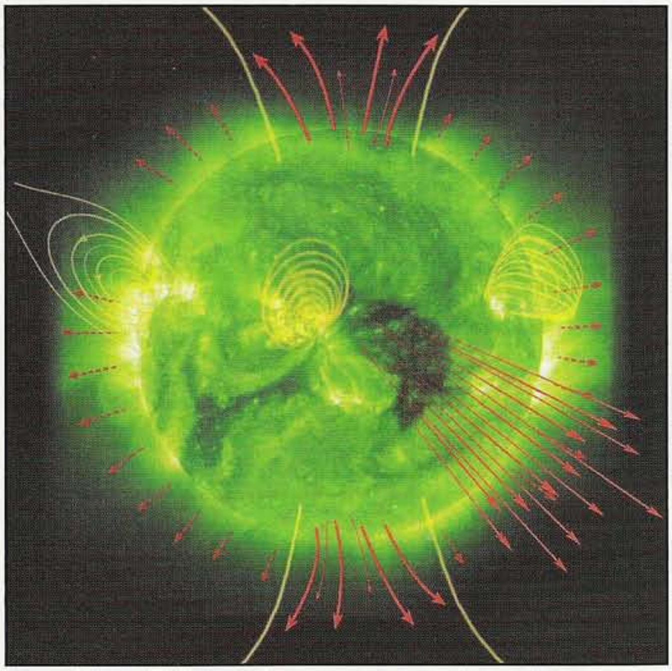


*Figure 2. The sun's atmosphere is threaded with magnetic fields (yellow lines). Areas with closed magnetic fields give rise to slow, dense solar wind (short, dashed red arrows), while areas with open magnetic fields—so-called "coronal holes"—yield fast, less-dense solar wind streams (longer, solid red arrows). In addition to the permanent coronal holes at the sun's poles, coronal holes can sometimes occur closer to the sun's equator, as shown here just right of center. (Source: September 18, 2003 image from the SOHO Extreme ultraviolet Imaging Telescope; ESA/NASA)*

vember, when we miss them completely. During these misses, Earth slips between the clouds, where there is only a sprinkling of meteoroids. At such times *Leonid* rates remain low—only 10 or 15 meteors per hour.

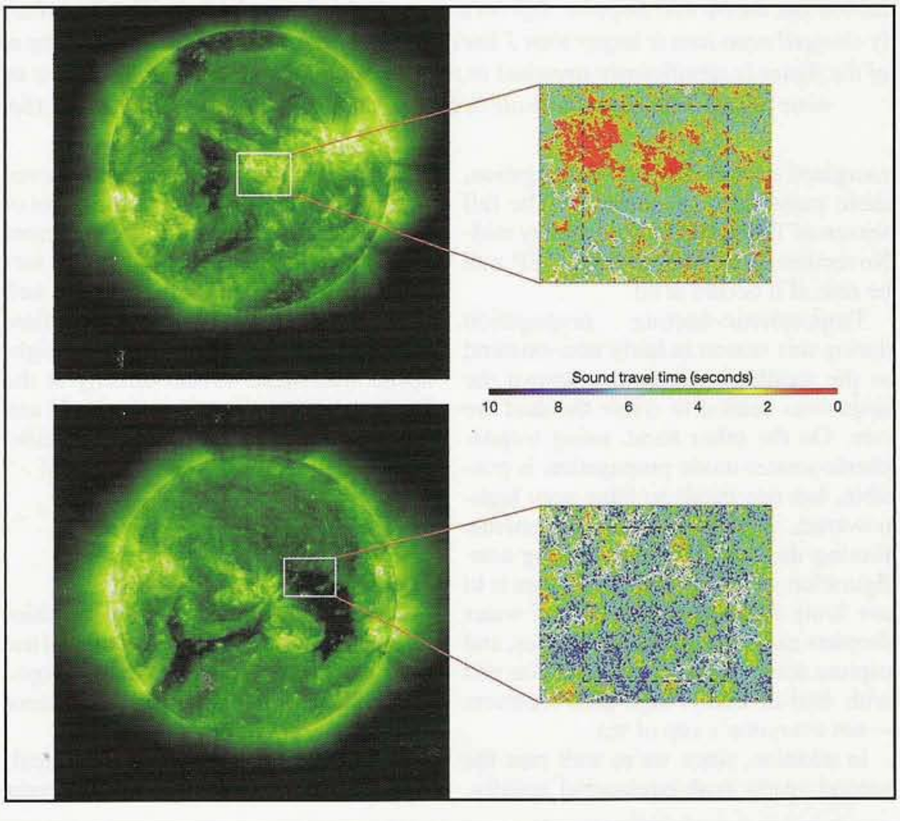
The most recent excitement during the November *Leonids* shower was between 1998 and 2002. In 1998 the comet returned to its perihelion (this term refers to the point where the comet is closest to the sun, during its orbit around the sun). This increased the debris trail enough to provide a nice increase in the hourly meteor rate. Since then, however, we've seen a steady decrease. However, it is possible that we could be surprised, if the Earth hits the dust cloud directly.

Remember that the *Leonid* radiant is best around local midnight in the Northern Hemisphere. Working VHF propagation off meteor tails (the highly ionized plasma trails left by the meteor) requires some reasonable power and gain, and good operating skill. With the latest high-speed burst-mode CW software, you possibly can work even the smaller meteors.

After the *Leonids,* the annual *Geminid* meteor shower from December 7 to December 17 will peak on December 13. This is one of the better showers, since as many as 120 visual meteors per hour (ZHR) may occur. *Geminids* is a great shower for those trying the meteor-scatter mode of propagation, since one doesn't have to wait until after midnight to catch this shower. The radiant rises early, but the best operating time will be after midnight local time. This shower also boasts a broad maximum, lasting nearly one whole day, so no matter where you live, you stand a decent chance of working some VHF/UHF signals off a meteor trail.

Finally, check out the *Quadrantids* from December 28, 2005 to January 7, 2006. This meteor shower is above average, with peaks with around 40 meteors per hour. The best day should be the morning of January 4, just after midnight, and working through predawn.

*Figure 3. Sampling an area of the sun's upper atmosphere (shown approximately by the white outlines on the full sun images at left), McIntosh and Leamon used measurements made by NASA's TRACE spacecraft of a region with strong, closed magnetic fields on July 7, 2003 (top) and another region with weaker, open magnetic field on September 18, 2003 (bottom). The areas in red in the top "time difference" image show a shallow, dense chromosphere beneath an area with slow, dense solar-wind outflow; the areas in blue in the bottom image show a deep, less-dense chromosphere below a "coronal hole" with fast, tenuous solar-wind outflow. (Source: Images on left from the SOHO Extreme ultraviolet Imaging Telescope, ESA/NASA; images on the right from* The Astrophysical Journal, *University of Chicago Press)*



Check out <http://www.imo.net/calendar/cal05.html> for a complete calendar of meteor showers in 2005.

## Working Meteor Scatter

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

Meteor-scatter propagation is a mode in which radio signals are refracted off these trains of ionized plasma. The ionized trail is produced by vaporization of the meteor. Meteors no larger than a pea can produce ionized trails up to 12 miles in length in the *E*-layer of the ionosphere. Because of the height of these plasma trains, the range of a meteor-scatter contact is between 500 and 1300 miles. The frequencies that are best refracted are between 30 and 100 MHz. However, with the development of new software and techniques, frequencies up to 440 MHz have been used to make successful radio contacts off these meteor trains. On the lower frequencies, such as on 6 meters, contacts may last from mere seconds to well over a minute. The lower the frequency, the longer the specific "opening" made by a single meteor train. A meteor train that supports 60-second refraction on 6 meters might only support 1-second refraction for a 2-meter signal. Special high-speed methods are used on these higher frequencies to take advantage of the limited available time.

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

## The Solar Cycle Pulse

The observed sunspot numbers from July through September are 39.9, 36.4, and 22.1. The smoothed sunspot counts for January through March 2005 are 34.7, 34.0, and 33.6, continuing on the steady decline of Cycle 23.

The monthly 10.7-cm (preliminary) numbers from July through September 2005 are 96.6, 90.7, and 90.8. The smoothed 10.7-cm radio flux numbers for January through March 2005 are 100.3, 98.5, and 97.2.

The smoothed monthly sunspot numbers forecast for November 2005 through January 2006 are 19.2, 16.4, and 13.7. The current cycle does seem to have a more gradual decline slope than originally predicted, so adjustments are tending to be higher with each iteration. The smoothed monthly 10.7-cm values are predicted to be 80.2, 78.0, and 76.0 for the same period. Give or take about 15 points for all predictions.

The smoothed planetary *A*-index (*Ap*) numbers from January through March 2005 are 14.7, 14.6, and 15.3. The monthly readings from July through September are 16, 16, and 21.

(Note that these are preliminary figures. Solar scientists make minor adjustments after publishing, by careful review.)

## Feedback, Comments, Observations Solicited!

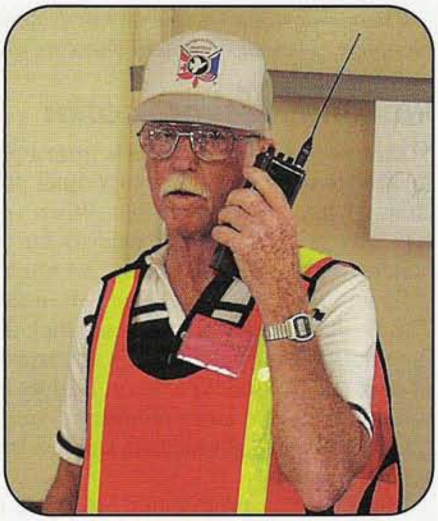
I am looking forward to hearing from you about your observations of VHF and UHF propagation. Please send your reports to me via e-mail, or drop me a letter about your VHF/UHF experiences (sporadic-*E*, meteor scatter?). I'll create summaries and share them with the readership. I look forward to hearing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

Until the next issue, happy weak-signal DXing.

73, Tomas, NW7US

 (from page 7)

The busy Red Cross Operations center "Intake" at Camp Gruber.



*Chuck Myers, KW5I, at Red Cross operations "Intake" struggles to hear his radio over all the background noise in the busy center. Shortly thereafter we purchased and handed out ear buds to each operator.*

service projects. I made a call to ARRL Section Manager John Thomason, WB5SYT, and requested a formal declaration from ARES for additional operators. E-mail was sent out from ARRL HQ to amateurs in Oklahoma requesting their help. I went to work assessing our capabilities and mission requirements.

We needed to have operators at the main evacuee processing center for the Red Cross, the medical center, the front gate, the camp's warehouse (where all the logistic supplies were being sent), a triage center, and a mental-health facility. When the Oklahoma Highway Patrol mobile command post arrived, we also posted an operator on board the 60-foot-long converted bus. We also maintained communications with the National Guard operations via the loan of one of their commercial radios. In addition, we had two operators in Incident Command, one as net control, and one to answer phones or log. We were able to communicate throughout the entire camp via VHF on simplex. As the operations went on, we added a couple of runners/floats to cover during meal breaks and shift changes. By the end of our response operations, we were staffing eleven operators during the day and six at night.

Shortly before 10 AM Sunday, Steve Palladino, an Emergency Management Officer for ODEM, arrived in the incident command. Oklahoma has spent millions of dollars on equipment that allows interoperability of communications. When I asked Palladino if the interoperability communications trailer (known as ECHO 1) was coming, Steve told me that it was "out of pocket," which is what happened to many of the "first in" resources from some agencies in our area. "Out of pocket" means that they were deployed to the major disaster in the Gulf region. Palladino and I spent a few minutes covering where we had or would have operators. He said, "You guys are great. Thanks for jumping in to help." I asked him how long he would expect to need amateur radio. Palladino then replied, "for the duration."

Amateur radio was the communications backbone at Camp Gruber. We han-

*Fred Williams, KD5NBR "NIC 5," at the microphone in IC (Incident Command).*


*The Oklahoma Highway Patrol Mobile Command Center (amateur radio optional).*

dled traffic requesting supplies for each of the various locations, provided names to the front gate as to who had access to the camp, and acted as the 911 system on the camp. You name it; we communicated it. At most disasters amateur radio can stand down in two to three days as regular lines of communication come back on line. This was going to be a long-term response. We were going to need more help and a command structure to ensure a clear chain of command and a stronger organization when interfacing with the served agencies. We put into place a command system that mirrored what many police and fire departments use with a commander and assistant commander. We also had shift commanders (NIC—Net Controller in Command) at both Camp Gruber and Red Cross HQ in Tulsa. The NIC's job was to run the shift and to be the point of contact with served agencies. This system worked well for our emergency communications operation.

One of the challenges we encountered during this operation was some of the hams who wanted to help either did not own a handie-talkie or owned one of the small, compact, low-power units. This was a small roadblock in keeping communications going 100 percent of the time. With the help of Jim Pickett, K5LAD, who worked the phones, and with the help of ARRL headquarters, we secured the donation of ten new ICOM handie-talkies. These radios were welcomed and very useful tools. The other big challenge was something all volunteers face: the desire to help where we can—help load water, or make sandwiches or coffee, etc. We all want to help. That's not a bad thing, but it sometimes just gets in the way of communications. When an amateur radio operator is "helping," the operator is not watching and monitoring the radio. The NIC held a shift briefing each shift change and explaining to operators why "helping" was not their job. NIC also discussed turning auto-power OFF on radios, another problem.

To help reduce the noise factor, we purchased and issued ear buds to everyone. Thanks to the Tulsa Area Emergency Management Agency (TAEMA), which loaned us ten orange vests labeled COMMUNICATIONS, we were more visible. All of this structure was useful in making the response a success.

The mission of those at Tulsa Red Cross HQ also changed. Their job was to maintain contact with Camp Gruber 24/7 and they were responsible for recruiting operators for the needed positions. That was a big job. Zach Miller, K5BCT, and Mike Darrol, KD5RJZ, were the NICs at Red Cross HQ and worked very hard. They put together a phone pool to call hams. Area clubs e-mailed club rosters to the comm center at Red Cross to help with the recruiting effort.

It was Tuesday, September 6 before the telephones at Camp Gruber were stable and the internet access at the camp was working. Miller, K5BCT, and Darrol, KD5RJZ, also acquired a PC that was installed at the communications center at Camp Gruber. The PC was connected to the internet, and using Yahoo messenger, we were able to send traffic back to Tulsa more effectively via the Yahoo instant messenger. That was right out of the ECOMM course . . . use what works to get the message through.

From passing emergency traffic during day-time operations at the Tulsa Red Cross headquarters right after hurricane Katrina hit to the 24/7 (from Friday 9/2 to Sunday 9/11) operations supporting the mass shelter in Braggs, Oklahoma, more than 80 Oklahoma operators worked together. There were no club politics, no Oklahoma City versus Tulsa, no old hams versus young hams. We all worked together to get the message through.

As we were standing down Sunday afternoon, September 11, Steve Palladino of ODEM said of amateur radio, "...very useful. Interoperability between agencies at all the points of contact is a very important part of disaster communications." Palladino added, "Lots of folks had radios FRS, GMRS, or commercial radios. However, some did not know how to use them or how to communicate via a radio. Hams are great; you are trained and know how use your radios and how to communicate."

At the 6 PM briefing on September 11, 2005, when the ODEM announced that amateur radio was standing down, many thanks were passed on by all the served agencies: ODEM, Oklahoma Highway Patrol, American Red Cross, Oklahoma National Guard, and more. All were very impressed with the professionalism and can-do spirit exhibited by Oklahoma amateur radio operators assisting with this ECOMM response.

We amateur radio operators on site and at the Red Cross in Tulsa packed up our gear and went home, proud to have been able to do our part to help in emergency circumstances. When all else fails, amateur radio works. ■

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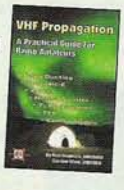


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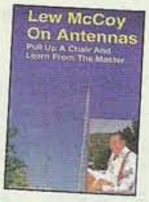


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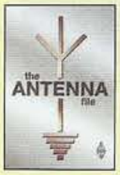


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RSGB, 1st Ed., 1992. 233 pages. A collection of outstanding articles and short pieces which were published in Radio Communication magazine during the period 1968-89. Includes ingenious designs for single element, beam and miniature antennas, as well as providing comprehensive information about feeders, tuners, baluns, testing, modeling, and how to erect your antenna safely.

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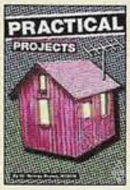


RSGB 2002 Ed, 224 pages. Packed with around 50 "weekend projects," Practical Projects is a book of simple construction projects for the radio amateur and others interested in electronics. Features a wide variety of radio ideas plus other simple electronic designs and a handy "now that I've built it, what do I do with it?" section. Excellent for newcomers or anyone just looking for interesting projects to build.

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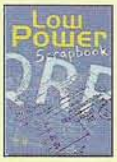


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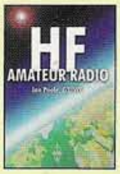


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By Dr. H. Paul Shuch,* N6TX

# DR. SETI'S STARSHIP

## Searching For The Ultimate DX

# Shouting in the Jungle

Nearly half a century of SETI science, and still not a single confirmed transmission from "Beyond." What kind of DXpedition is this?

When Frank Drake conducted the world's first SETI experiment in 1960, he was just days into the project when he heard a loud, periodic signal from Up There. "My God," he thought, "could it really be this easy?" The signal was, of course, RFI, a phenomenon with which every subsequent effort to detect evidence of extraterrestrial intelligence has been plagued. No, it *wasn't* that easy, then or now. The bands, it seems, are dead.

After a while, when the band seems dead, any sensible ham will want to stir the pot. So why aren't we calling CQ?

The whole question of transmitting from Earth is fraught with controversy. Every ham knows that if everyone is listening and no one is transmitting, no one is going to know when a band opening occurs. That's one of the reasons why we put propagation beacons on the air from exotic locations. Early on, SETIzens thought that advanced extraterrestrial civilizations would accommodate us immature Earthlings by providing just such beacons, to draw us into membership in the Galactic Club. Thus, the early SETI experiments, beginning with Drake's, concentrated on searching nearby sun-like stars for just such strong and steady beacons. If they are abundant, you'd think we would have heard one by now.

We haven't, though, and not necessarily because the bands are dead. Maxwell's laws quantify propagation, and they suggest that even a modest beacon, properly aimed, will easily be detectable by Earth's receive technology, across the interstellar gulf. Maybe, then, it's time to rethink our assumptions. Advanced civilizations, if indeed they exist, apparently *don't* announce their presence using radio waves. Do they perhaps know something we don't?

**Executive Director, The SETI League, Inc., <www.setileague.org>*
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Put out a CQ, or build a beacon of our own, many urge. If somebody doesn't break radio silence soon, the universe is going to remain a pretty lonely place. However, it's a dangerous universe out there, others argue. If you transmit, you're giving your position away to possible predators. No sane species shouts in the jungle.

Thus, the argument has raged for as long as humans have pursued SETI science. The only trouble is, no one knows what the risk of transmission really is, and we've never had tools to quantify it. Until now. . . .

It's widely recognized that not all transmissions are created equal. QRP is likely to pose less of a hazard to humanity than QRO, and a steady carrier is likely to be more detectable than a random pulse in the night. The level of risk associated with a given photon is related to its detectability, and detectability is a function of power, duration, direction, and information content. If we could assess all those, we could readily decide which transmissions are potentially hazardous and which are benign.

That is exactly what was proposed last spring in San Marino, a tiny republic perched on a mountaintop surrounded on all sides by Italy. San Marino, you see, maintained its independence for half a millennium, throughout countless wars of conquest, not by maintaining radio silence, but rather by having defensible borders in the form of steep cliffs. The ancient Roman catapults lacked the thrust to hurl rocks that high, so San Marino remained secure in its own 49 square kilometers of sovereign land.

But I digress. The Republic of San Marino hosts an annual SETI conference every March. This past March a friend of mine, an astronomer from Budapest, presented a paper there proposing a way to quantify at last the risk of transmitting from Earth. Iván Almár's proposal instantly became known as the San Marino Scale. (Yes, that's the same Iván Almár who concocted the Rio Scale for quantifying reception of SETI signals, as discussed in last quarter's column in *CQ VHF*.) Although no international body has yet adopted the San Marino Scale as a standard, it is a promising tool that helps us to contemplate the consequences of our actions.

| Value | Potential Hazard |
|---|---|
| 10 | Extraordinary |
| 9 | Outstanding |
| 8 | Far-reaching |
| 7 | High |
| 6 | Noteworthy |
| 5 | Intermediate |
| 4 | Moderate |
| 3 | Minor |
| 2 | Low |
| 1 | Insignificant |

*The San Marino Scale is an ordinal scale between one and ten used to quantify the relative risk of a given electromagnetic transmission from Earth. Each numeric San Marino Scale value correlates to a subjective measure of risk, from Insignificant to Extraordinary.*

Here's how it works: The San Marino Scale is an ordinal scale between one and ten used to assess the potential risk of employing electromagnetic communications technology to announce Earth's presence to our cosmic companions, or of replying to a successful SETI detection. In computing the San Marino index value, we must consider the power level of a given transmission not in absolute terms, but as a logarithmic ratio relative to the current background radiation from Earth in that particular frequency range. (We live on a radio-polluting planet. Only signals significantly stronger than our background noise are likely to stand out and be noticed.) We also consider where the antenna is pointing (straight down doesn't represent much of a hazard), the signal's duration (for centuries key-down certainly has been more detectable than random dits), and information content (the more we say, the more *they* learn about us). Plug all these factors into an equation, and the San Marino number emerges. The higher the number, the more hazardous a given transmission should be considered.

I won't belabor the math here. The whole scale is explained in great detail on the website of the International Academy of Astronautics,[1] SETI Permanent Study Group, which I am privileged to co-chair. You can see it, and try it on for size, by browsing to <http://iaaseti.org>. On the left-hand main menu, click on Protocols, and then on San Marino Scale to find full disclosure. There's also a JavaScript calculator there to find out just how detectable (and, by some reasoning, just how hazardous) your EME station or OSCAR uplink might be.

No, I'm not proposing that any of us stop transmitting. However, before we reply to ET's CQ or broadcast one of our own, it would be nice to know the level of risk to which we are committing our defenseless planet. The San Marino Scale will tell us that. It will also provide the would-be regulators with a quantitative tool.

For years, the SETI community has been engaged in ongoing policy and protocol discussions dealing with the possibility or advisability of issuing either binding or voluntary restrictions or prohibitions against deliberate transmissions from Earth. The proponents of the San Marino Scale recognize that not all such transmissions imply the same level of risk or hazard. We hope that the international SETI community will consider using this tool for helping to define a threshold below which no prior consultation may be required in the event of a transmission from Earth, but above which discussions should take place, and a consensus be sought, prior to engaging in active SETI or replying to received signals.

Where do I stand? As a ham, I am committed to communicating. I'm loath to hide in my hilltop fortress, fending off invading Romans. Then again, though, I'm not the sole inhabitant of this planet. If my actions have the potential to affect others, it behooves me to analyze the consequences before I commit my whole planet to a course of communications and contact. The San Marino Scale will help me do that.

73, Paul, N6TX

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