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CQ VHF

Ham Radio Above 50 MHz

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Fall 2011

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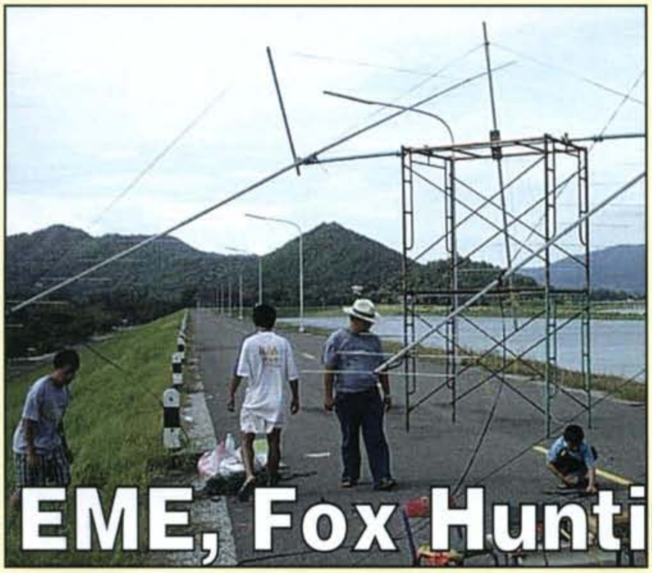

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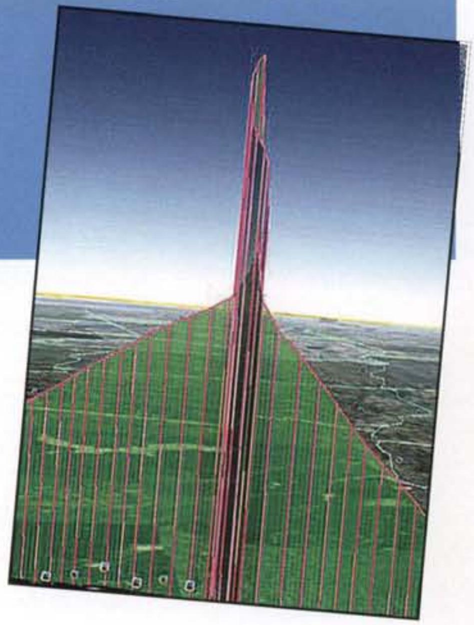

Fall 2011
Vol. 15 No. 3

FEATURES

COLUMNS

DEPARTMENTS

On The Cover: Top left: HS2CRU and HS2JFW 2-meter EME station OK03If; details see "2-meter DXCC via EME—The Journey, by KJ9I, p. 18. Top right: VE7SMX at the USA ARDF Championships 2011; see "Homing in," by KØOV, p. 50. Bottom left: The shuttle Discovery's smoke trail photographed during the Robonaut-1 mission; see "Chasing Discovery—Part1," by KJ4YNE, p. 10. Bottom right: W5IU giving instructions to hams gathered to hear ARISSat-1; see "Satellites," by W5IU, p. 76.

CQ VHF Ham Radio Above 50 MHz

LINE OF SIGHT

A Message from the Editor

It Began with One Article

The Summer 2011 issue of *CQ VHF* magazine included a special web supplement article, "Hope for *F*-Layer Propagation on 6 meters in Cycle 24" by Ken Neubeck, WB2AMU. Starting with this issue, the entire magazine will also be online in a digital magazine format. If you are reading this editorial in the print version, I invite you to check out the new digital version.

The digital version opens the readership to this magazine to anyone who has access to a computer or a smartphone or tablet. Versions are available in multiple venues. For decades I have seen articles published in magazines and conference *Proceedings* from around the world. However, until now, it has been very hard to have a common place where serious VHF-Plus experimenters and operators can share their work.

Now, *CQ VHF* magazine can be that venue. As I did with Roger Harrison, VK2ZRH, whose article on sporadic-*E* was published in the Summer 2011 issue, I invite other international amateur radio operators to have their articles featured in future issues of *CQ VHF*. Realizing that I cannot be fully aware of all of the great work that is taking place around the world, I hope that as the word spreads, others who hear about this new venue will contact us regarding publishing their work in *CQ VHF*. Hopefully, having the ability to more freely exchange ideas and research will challenge all of us who are serious experimenters and operators to further development within our particular specialty or niche.

In this Issue

Regarding our efforts to increase the technical level, we have two excellent articles on sporadic-*E* propagation. Jim Kennedy, KH6/K6MIO, contributed his article on extreme-range 50-MHz sporadic-*E* propagation. Kennedy's article is the first of three written by him and scheduled to run in *CQ VHF*. Also, Carl Luetzelschwab, K9LA, wrote the article on Polar Mesosphere Summer Echoes.

Complementing these technical articles is an end-of-summer report on 6-meter propagation written by Features Editor Ken Neubeck, WB2AMU.

In keeping with the international appeal, we asked David Schmocker, KJ9I, for permission to reprint his article on his attaining 2-meter DXCC from the September 2011 issue of *CQ Egypt* magazine. Also published in that issue is an article by Lance Collister, W7GJ, on worldwide communications on VHF. His article can be found at: <http://erasd.net/Documents/The%20 Worldwide%20Communications%20on%20VHF.pdf>.

It seems that the Middle East spring has produced an encouraging uptick in amateur radio activity in Egypt. Evidence of this increased activity can be found at the Egyptian Radio Amateur Radio Society for Development (ERASD) website: <http://www.erasd.net>. We look forward to future cooperative efforts with ERASD.

The world was fascinated with the photo of the smoke trail of the last launch of the shuttle Discovery. That photo was taken by a balloon satellite named Robonaut-1 which was launched in the vicinity of Cape Canaveral a little more than an hour before the Discovery launch. In the first of three articles on this and two other balloon satellite launches, John Pugh, KJ4YNE, tells the story of how Quest for Stars was able to get this fascinating photo.

Another balloon satellite article comes from Stephen Hamilton, KJ5HY, who, until recently, was the faculty advisor for the Cadet Amateur Radio Club at West Point. He describes a successful balloon satellite launch that took place near West Point this past spring.

Features editor Gordon West, WB6NOA, takes a first look at the ICOM IC-9100. It looks like he may have had too much fun in doing so! Check out his comments on the practicality of this new radio for the VHF-Plus enthusiast.

Add to this issue the regular columns and you have lots of good reading from cover to cover.

Spectrum Threat

ARRL Midwest Division Vice Director Rod Blocksome, KØDAS, presented a report on the National Band Plan (NBP) threat to amateur radio at this past Central States VHF Society conference. Blocksome is a member of the League's Board of Directors' ad hoc committee charged with evaluating and analyzing the NBP threat and to recommend strategies to defend our amateur radio allocations.

His report was so alarming and timely that I asked him to write an Op Ed piece about the threat. I urge all of us readers to not only read his piece, but also to act on it. He has several very informative links in the article. He also recommends that we contact the ad hoc committee's chair, Jay Bellows, KØQB, at <k0qb @arrl.net> with our recommendations. He points out that the committee is now in its second phase (recommending strategies).

Errata

In Roger Harrison, VK2ZRH's article "On the MUF of Sporadic-*E* VHF Propagation," which appeared in the Summer 2011 issue of *CQ VHF* on page 72, center column, at the end of a sentence a time and date are given in brackets; they are incorrect. Instead of "0518 UT, 13 Jan 2011," it should read: 0158-0958 UT, 21 Jan 2011. We regret any confusion.

And Finally . . .

I cannot over-emphasize the excitement I feel concerning the digital issue of *CQ VHF*. Those who keep track of demographics tell us that members of the Generation-X, or Gen-Xers, are the readers of digital content. Hopefully, we will begin to reach people in this age group with the good news about our experiments and activities in our niche of the Amateur Radio Service.

As readers of this magazine, you are already predisposed to be its evangelists. I invite you to do so, because you will be the lead force in its success.

Until next time . . .

73 de Joe, N6CL


Happy Holidays
from one *Ham* to another
KENWOOD
TS-590S

OP ED

One Reader's Opinion

The National Broadband Plan Threat to Amateur Radio

By Rod Blocksome, KØDAS*

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

There is an upheaval coming in spectrum allocations that poses a very real threat to our amateur bands above 50 MHz. It is known as the National Broadband Plan, or NBP for short, and it lays out a far-reaching plan to provide high-speed, wireless, broadband service across the United States. The establishment and implementation of the NBP is policy within the Executive and Legislative Branches of government. The plan seeks to allocate 500 MHz of spectrum for mobile broadband service in the United States by 2020 with 300 MHz of it allocated by 2015. The amount of spectrum required (some industry advocates say that 800 MHz will be required) and the plan's broad political support make this initiative particularly onerous for the Amateur Radio Service.

The FCC has conducted a "spectrum inventory" to identify candidate frequency spectrum for reallocation. The National Telecommunications and Information Agency (NTIA), which regulates the spectrum for Federal Agencies and US Military, has identified certain spectrum bands for a "Fast Track Evaluation." This is another concern, since many of our amateur bands above 50 MHz are shared with government and military users who historically have been our "protectors" against spectrum reallocations. Specifically, the FCC spectrum inventory includes a portion of our 13-cm band and our entire 9-cm band—2305 to 2310 MHz and 3300 to 3500 MHz.

Currently, the Amateur Radio Service shares 2305–2310 MHz with the Wireless Communications Service on a secondary basis. The 3300–3500 MHz band is also shared with the U.S. Government radiolocation service on a secondary basis. Our other, much more populated, bands are not identified in the candidate list—at least for now. But, there may be secondary threats if some other commercial or government service, which becomes displaced from its current spectrum band by the NBP, goes after replacement spectrum in a ham band.

What Can Amateurs Do?

I recommend several things: First, become well informed on the specific details of the NBP and related proceedings. Good places to start are the following documents:

Connecting America: The National Broadband Plan, available /www.broadband.gov>

The Plan and Timetable to Make Available 500 Megahertz of Spectrum for Wireless Broadband, October 2010, available at: <http://www.ntia.doc.gov/reports/2010/TenYearPlan_11152010.pdf>

Fast Track Evaluation of the 1675–1710 MHz, 1755–1780 MHz, 3500–3650 MHz, and 4200–4220 MHz and 4380–4400 MHz bands, NTIA Report October 2010, available at: <http://www.ntia.doc.gov/reports/2010/FastTrackEvaluation_11152010.pdf>

NTIA Fact Sheet on Spectrum Plan and Timetable, Fast Track Evaluation, NTIA, available at: <http://www.ntia.doc.gov/reports/2010/SpectrumFactSheet_11152010.pdf>

First Interim Progress Report on the Ten-Year Plan and Timetable, April 2011, available at: <http://www.ntia.doc.gov/reports/2011/First_Interim_Progress_Report_04012011.pdf>

Second, we need to develop strategies for effective defense of our amateur spectrum allocations. The collective wisdom, knowledge, and resources of all amateurs, especially those operating above 50 MHz, need to be applied to this effort. As communications technology expands with ever-increasing demands for more spectral space, so too will amateur radio. Compare the technology and occupancy of the 2-meter band in the 1950s and then 30 years later. Today our 9-cm band is like the 2-meter band of the 1950s.

Third, we need to "pick up the pace" in moving new modes and technologies into the higher frequency ham bands. The "frontiersmen" (EMEers and the weak-signal folks) have explored the 33-cm, 23-cm, 13-cm, and 9-cm bands and have shown us the way to LNAs, transverters, PAs, and antennas for these bands. Now is the time for the "settlers" to move into these bands with HSMM (High Speed Multi-Media), amateur digital TV, ATV Repeaters, and High Speed Data networks for EMCOMM and public service roles. In this regard, the current ARRL board-approved band plans for these bands are over 20 years old. What should updated band plans look like? Your inputs are requested.

Fourth, we need to support the ARRL Spectrum Defense Fund as much as our individual economic circumstances permit. The ARRL HQ staff is top notch, but it takes money to fund an effective and prolonged defense of our amateur spectrum.

The ARRL Board of Directors created an ad hoc committee charged first with an evaluation and analysis of the NBP threat

*e-mail: <rkblocks@plutonium.net>

to amateur radio, and second to recommend strategies to defend our amateur allocations. I am a member of this committee and we are now working on this second phase. The committee, chaired by Jay Bellows, KØQB, solicits and welcomes your comments, ideas, and suggestions as we move forward. He can be reached at <k0qb@arrl.net>.

Closing Thoughts

Success may be measured differently than any previous allocation proceedings against specific opponents in the past. The NBP seeks to fulfill a need 5 to 10 years down the road. What will amateur radio needs be in 5 to 10 years from now? Might not the same technology for high-speed wireless broadband be adapted and in widespread use in amateur radio then also as now?

Although the NBP is focused on the United States, international considerations will certainly come into play as other countries embrace similar broadband plans. Free market forces will likely work for common standards and frequencies across many countries. The ITU certainly will be heavily involved in spectrum allocations across the three regions.

How does one judge the value of the amateur spectrum usage compared to commercial or government users? In the three-dimensional realm of physical location, time, and spectrum, the Amateur Service might not fare well. Pick a ham band and you find that some of the hams use some of the spectrum some of the time. But is such a comparison valid? Obviously not, but how do you make the case for amateur radio with politicians who can sell commercial use spectrum for billions?

The value of amateur radio to the public must be defined in other ways—but how? As you ponder these questions, think about and consider the purpose of the Amateur Radio Service as paraphrased from FCC rules part 97.1:

1. Value to the public ...: non-commercial communications service, particularly with respect to providing emergency communications

2. .... Contributes to advancement of the radio art.

3. .... Advance skills in both communications and technical phases of the art.

4. Provides a .... Reservoir of trained operators, technicians, and electronic experts.

5. .... Enhancement of international goodwill.

N6CL, *CQ VHF* magazine Editor and *CQ* magazine's "VHF-Plus" column Editor Receives Wilson Award

Kent Britain, WA5VJB, The Central States VHF Society's Awards Manager and Antennas Editor for CQ, CQ VHF, *and* Popular Communications *magazines, presents Joe Lynch, N6CL, with the society's Wilson Award during the society's annual meeting in July.*

CQ VHF magazine Editor and *CQ* magazine's "VHF-Plus" column Editor Joe Lynch, N6CL, received the Central States VHF Society's Mel Wilson, W2BOC, Memorial Award at its annual banquet on July 30, 2011. In the photo, presenting the award to Joe is Kent Britain, WA5VJB (left), the Society's Awards Manager (and Antennas Editor for *CQ, CQ VHF*, and *Popular Communications* magazines). The award is for continuous service and dedication toward promoting VHF and UHF amateur radio activity. Lynch has served 8 1/2 years as the CQ VHF's Editor and 20 years as *CQ* magazine's "VHF-Plus" column Editor, along with editing the Society's 2003 and 2005 *Proceedings*. Lynch is also the author of *The VHF "How To" Book* (published by CQ Communications and currently out of print).

Two other major awards were also presented at the ceremony. The Chambers award for technical contributions to amateur radio went to Joe Taylor, K1JT, developer of the WSJT suite of weak-signal modes. Gene Zimmerman, W3ZZ, recently retired *QST* VHF Editor and former CQ World-Wide VHF Contest Director, was presented with the President's award for his lifetime contributions to the VHF and UHF community.

QUARTERLY CALENDAR OF EVENTS

Current Contests

January: The ARRL VHF Sweepstakes is scheduled for the weekend of January 21–23. For ARRL contest rules, see the issue of *QST* prior to the month of the contest or its URL: <http://www. arrl.org>.

Current Meteor Showers

November: The *Leonids* is predicted to peak around 0340 UTC on November 18. As with last year's shower, this year's peak may go largely unnoticed.

December: Two showers occur this month. The first, the *Geminids*, is predicted to peak around 1330 UTC on 13 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 60 meteors per hour at its peak.

The second, the *Ursids*, is predicted to peak around 0200 UTC on 23 December. It is an east-west shower, producing an average of no greater than 10 meteors per hour, with the very rare possibility of upwards of 90 meteors at its peak.

January: The *Quadrantids,* or *Quads*, is a brief, but very active meteor shower. The expected peak is around 0720 UTC on 4 January, with up to 40 meteors per hour at its peak. 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 "VHF Propagation" column elsewhere in this issue. Also visit the International Meteor Organization's website: <http://www.imo.net>.

Quarterly Calendar

Nov. 2, 2011	First quarter Moon
Nov. 8, 2011	Moon apogee
Nov. 10, 2011	Full Moon
Nov. 17, 2011	*Leonids* meteor shower
Nov. 18, 2011	Last quarter Moon
Nov. 23, 2011	Moon perigee.
Nov. 25, 2011	New Moon; partial eclipse of the Sun
Dec. 2, 2011	First quarter Moon
Dec. 6, 2011	Moon apogee
Dec. 10, 2011	Full Moon; total eclipse of the Moon
Dec. 13, 2011	*Geminids* meteor shower
Dec. 18, 2011	Last quarter Moon
Dec. 22, 2011	Moon perigee.
Dec. 22, 2011	*Ursids* meteor shower
Dec. 24, 2011	New Moon
Jan. 1, 2012	First quarter Moon
Jan. 2	Moon apogee
Jan. 4, 2012	*Quadrantids* meteor shower
Jan. 9, 2012	Full Moon
Jan. 16, 2012	Last quarter Moon
Jan. 17, 2012	Moon perigee
Jan. 23, 2012	New Moon
Jan. 30, 2012	Moon apogee.
Jan. 31, 2012	First quarter Moon
Feb. 7, 2012	Full Moon
Feb. 11, 2012	Moon perigee
Feb. 14, 2012	Last quarter Moon
Feb. 21, 2012	New Moon
Feb. 27, 2012	Moon apogee

Liftoff of Robonaut-1, the first of three balloon satellites that tracked and photographed the launch of the last three NASA shuttle launches.

Chasing Discovery – Part 1

The following is part 1 of a 3-part series capturing the final flights of the U.S. Space Shuttle program from a 20-mile-high vantage point.

By John Pugh,* KJ4YNE

On 24 February 2010 at 4:53 PM EST Space Shuttle Discovery (STS-133) lifted off for the final time from Launchpad 39A at Cape Canaveral carrying Robonaut2, a robotic replica of a human torso. Earlier on the same day at 3:39 PM EST a 1200-g balloon with a 5.035-kg payload lifted off from Chiefland, Florida to capture the final liftoff of Space Shuttle Discovery. This launch would be the first of three balloon launches to capture the final flights of the US Space Shuttle program. Both the Space Shuttle and the balloon launches would also continue to further challenge our nation's school systems to build up Science, Technology, Engineering, and Mathematics (STEM) educational programs.

It all began on a cool night in December 2010 when I received a call from my former colleague and great friend, Bobby Russell, KJ6NKA. Russell and I caught up from years of relationship neglect and he mentioned his work with students, space, and promoting STEM learning. He casually said he wanted to capture the liftoff of the final flight of Space Shuttle Discovery. I had no idea he was serious until the next call when he gave me a short list of things I could do to help. That call started a cascade of work streams for both Russell and me to put Russell's idea to work. Unbeknownst to me, Russell had been working with high school students in San Diego, California building, perfecting, and launching the same camera payloads he was proposing using the wealth of innovative ideas these young unencumbered minds were creating.

Taking a cell phone or camera or radio off the surface of our Earth where we have a protective atmosphere is not any ordinary feat. The temperature of the atmosphere is reduced by approximately 1°C for every 1,000 feet of altitude. Atmospheric pressure reduces as altitude increases and humidity plays a big factor in being able to take quality pictures as we would soon find out.

The days prior to the launch were spent testing and retesting, setting up and breaking down and setting up again, programming, uploading, downloading, printing, formatting, and organizing. We went through the checklist time and again, ran the numbers against several

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This photo of shuttle Discovery's smoke trail is one of the hundreds of still photos taken during the Robonaut-1 mission. A video showing the entire flight is available at: <http://www.youtube.com/watch?feature=player_embedded&v=hWXm5TwXgC4#!>. This video also is posted on the Robonaut-1 Mission page: <http://questforstars.com/?page_id=364>. Smoke trail still photos can be seen beginning 3:40 into the video.

different algorithms ,and found our definitive launch site.

The Launch and Recovery

On the day of the launch, Russell and I packed up everything into the back of the "chase vehicle" (my GMC Yukon XL) and casually drove the back roads for the two-hour trip to Chiefland, Florida. We arrived around lunchtime and started to scour for an appropriate launch site. Due to liability concerns, the local school system did not approve our request to launch on its property. We found a site behind the school in a cul-de-sac with a perfect open area for the winds to carry the payload above the trees out of harm's way.

Once the launch site was determined, we set off to speak with some educators and promote what we were doing. We had already been in touch with the high school administrators and decided to start with a personal introduction. We then headed over to the middle school and elementary schools, introduced ourselves, and next proceeded to get set up for the launch.

It was a beautiful winter day in central Florida. A front had just passed and we were behind the front with clear skies, dry air, and some relatively gusty low- and mid-level winds. The trajectory based on the weather would take the balloon over Chiefland to the east/southeast across the state over Ocala and then descend on the other side of the Ocala National Forest near Daytona Beach. The upper-level winds were definitely going to carry the payload a good ways across the state.

The payload consisted of several Motorola Droid cell phones graciously donated from Motorola which were placed into cutouts fashioned by the high school students who built the payload box. We also had several GoPro cameras mounted inside the box to capture both video and still images. One additional phone was used as a GPS backup using AccuTracker, and we had a Byonics transmitter transmitting telemetry data via Automatic Packet Reporting System (APRS®).

The pace of setup increased exponentially as we came closer to our launch window. We had to launch 1.5 hours earlier than the Shuttle, since our payload would take that long to reach altitude (over 80,000 feet) to capture clear pictures of the Space Shuttle launch. We needed to launch by approximately 3:30 PM EST to reach our target. While Russell worked on getting the payload ready, I focused on the balloon prep, helium setup, and taking some pictures. School was now out and some middle school kids were walking through and curious as to what we were doing. One of them was very curious, engaged us in conversation, and then quietly slipped away only to return a short while later with a small gathering of people to watch the launch.

We were now about 15 minutes away from launch. The payload was ready and we began to fill the balloon with helium. The crowd was growing larger with a few moms, a few teachers, and the assistant principal of the middle school watching us prepare to make history chasing Discovery.

We got everything tied off, attached, verified everything was working, and launched. The culmination of a few days of work combined with the fever pace of the actual launch had now led to the calm of watching a silent craft lift into the wind and out of sight.

The calm didn't last long. We now had to pack everything back up and get ahead of the balloon. We did so and were soon off tracking the balloon via APRS. It was now at ~10,000 feet and climbing rapidly. It was tracking exactly as predicted and starting to move rather quickly across the state. As we hit I-75, we noticed an anomaly in the data. It appeared that the balloon had stopped moving and was on the ground. Russell thought we had a premature balloon pop due to either an anomaly in the balloon or possibly wind shear.

At this point we watched Space Shuttle Discovery take off from a parking lot in Ocala and head back to where we thought the balloon might have landed. The 1-hour drive was filled with feelings of failure. As we pulled over and walked into the last known area (a sand pit in Archer, Florida), Russell looked at the tracker and

Courtesy Google Earth, this photo shows the flight path of the Robonaut-1 balloon satellite.

This is the mission patch for the first of the three balloon satellite launches that covered the last three NASA shuttle launches.

said, "Pierson, where in the heck is Pierson?" Pierson just happened to be where the original prediction was for landing. The balloon was coming down exactly where we expected it to come down. Oh joy! We're now 2 hours away from it. We run back to the truck and head across the state.

At this point our feelings of failure went to feelings of elation. Even though we were still 2 hours away and in the midst of "rush hour" traffic, we knew we had succeeded in at least the balloon launch. APRS proved to be the key piece of equipment that allowed us to track and see the path of the payload. We could see in real time what stations were picking up the signal and the GPS coordinates placed the payload's path in a simply perfect view using Google Maps and <http://aprs.fi>.

Once we made it to the west side of the state, our helper, Chris Munz, was standing watch at the entrance to the field where the last known position of the payload was noted via GPS. By this time it was dark, quite dark. We were prepared, however, for the darkness and drove as far as we could into the woods to find the payload. We then set off on foot to the area depicted by the last APRS readings. We searched and searched. We heard the APRS beacons, but could not find the payload in the dark after scouring the landscape for what seemed to be hours.

After regrouping overnight, Russell and I set off early the next morning. It turned out the payload had landed in a semi-cleared area behind a commercial nursery. We went to the nursery and asked for permission to search behind its active area. They agreed and within an hour we had found the payload. It turns out that the payload was in some high brush just inches from where all three of us were searching. The lesson learned: Need more conspicuous tape!

The Data Gained

We headed back to the staging site (my house) and began poring over the data. We had over 3,000 pictures, eight hours of video, and a great plot of APRS data via <http://aprs.fi>. One immediate data point became obvious. We didn't trust the prediction data when we *should* have. It turned out the GPS data was pretty much useless over 60,000 feet and that is exactly where we lost and subsequently regained telemetry data.

Another interesting data point is the payload was travelling over 100 mph on its descent from where the balloon popped at roughly 110,000 feet. Once the atmosphere became dense enough to open the parachute more and more, the payload slowed and softly landed at less than 5 mph.

The last interesting point is the winds at 30,000 to 50,000 feet were howling and carried the payload for many miles in a matter of minutes. Once through that layer the payload swiftly climbed to where it popped and began its swift decent from the edge of space.

The payload cameras managed to capture a number of great pictures of the exhaust trail of Space Shuttle Discovery's final flight. The pictures of the lingering trails of steam from the exhaust of burning hydrogen and oxygen mixed with the smoke of the solid boosters were stunning against a backdrop of the black of space and the blues of the reflection of the Earth and its vast amount of water. We learned a lot about winds, humidity, GPS, and more during this launch and managed to share some awe-inspiring pictures with the astronauts aboard Discovery, the International Space Station, and with the students who helped create history.

Conclusion

As Russell was packing up and leaving to head back to San Diego, he turned to me and said, "29 April is the next launch. Ready?"

Russell took the payload and shredded balloon to share the win with the students and show them the difference they made in capturing the final launch of Space Shuttle Discovery. The pictures speak for themselves, and the information gathered from the instruments on board made for interesting classroom discussions for weeks to come.

For more information about Quest for Stars go to <http://questforstars.com>. To see the full videos and pictures go to the website: <http://questforstars.com/?page_id=364>.

PMSE and Propagation at 50 MHz

Are Polar Mesosphere Summer Echoes a factor in 6-meter propagation? Their occurrence pattern seems to fit the occurrence pattern of 6-meter QSOs across the polar latitudes. In this article K9LA takes a brief look into the physics of the atmosphere in relation to Polar Mesosphere Summer Echoes.

By Carl Luetzelschwab,* K9LA

Polar Mesosphere Summer Echoes (PMSE) are routinely seen by VHF radars operating around 50 MHz as very strong echoes at high latitudes in the summer months. Echoes are returned from mesopause altitudes (generally 80–90 km), where the lowest temperatures in the atmosphere occur. The red line in figure 1 shows the atmosphere in terms of temperature, with PMSE altitudes bracketed in white.

PMSE Observations

PMSE were first observed extensively with VHF radar at Poker Flat, Alaska in the late 1970s/early 1980s.[1] The extremely low mesopause temperatures allow ice particles to form and grow at mesopause altitudes. Under favorable conditions the largest of these ice particles can be observed visually in the form of noctilucent clouds (NLCs).

These ice particles are immersed in the plasma of the D region, and electrons attach to the ice surfaces such that the ice particles become charged. Turbulence at mesopause altitudes results in small-scale structures in the spatial distribution of the ice particles, and hence in the electron density. These small-scale structures, or irregularities, in the electron density cause scattering and are observed as PMSE by VHF radars.

Further research has also allowed statistical patterns of PMSE to emerge. Figure 2 summarizes the diurnal and seasonal patterns of PMSE in the northern hemisphere.

The image on the left in figure 2 comes from the seminal paper by W. L. Ecklund and B. B. Balsley ("Long-Term Observations of the Arctic Mesosphere With the MST Radar at Poker Flat, Alaska," *Journal of Geophysical Research*, Volume 86, Number A9, pages 7775–7780; September 1, 1981). In addition to showing the height at which PMSE occur (the aforementioned 80–90 km), this image indicates that PMSE occur from roughly 2 AM to 1 PM local time and from 4 PM to 9 PM local time at the Poker Flat location in Alaska, with an obvious drop-out at most altitudes from 1 PM to 4 PM.

The image on the right in figure 2 comes from data in a paper by R. Latteck, W. Singer, R. J. Morris, D. A. Holdsworth, and D. J. Murphy ("Observation of polar mesosphere summer echoes with calibrated VHF radars at 69° in the Northern and Southern Hemispheres," *Geophysical Research Letters*, Volume 34, L14805, July 2007). This image shows occurrences of PMSE in the Northern Hemisphere referenced to the summer solstice (usually June 20 or June 21). PMSE are seen from about one month before the summer solstice to about two months after the summer solstice.

Figure 1. Temperatures in the atmosphere.

Another study of PMSE (M. Smirnova, E. Belova, and S. Kirkwood, "Polar mesosphere summer echo strength in relation to solar variability and geomagnetic activity during 1997–2009," *Annales Geophysicae*, 29, 563–572, 2011) arrived at two conclusions. First, there is no statistically significant trend in PMSE yearly strengths from 1997 through 2009. Second, there is a correlation with the 3-hour K index—but it may be due to the additional non-PMSE precipitating electrons that get down to mesopause (D region) altitudes when the K index is elevated.

PMSE Hypothesis

In his article in the September 2006 issue of the Japanese magazine *CQ Ham Radio* (subsequently translated into English

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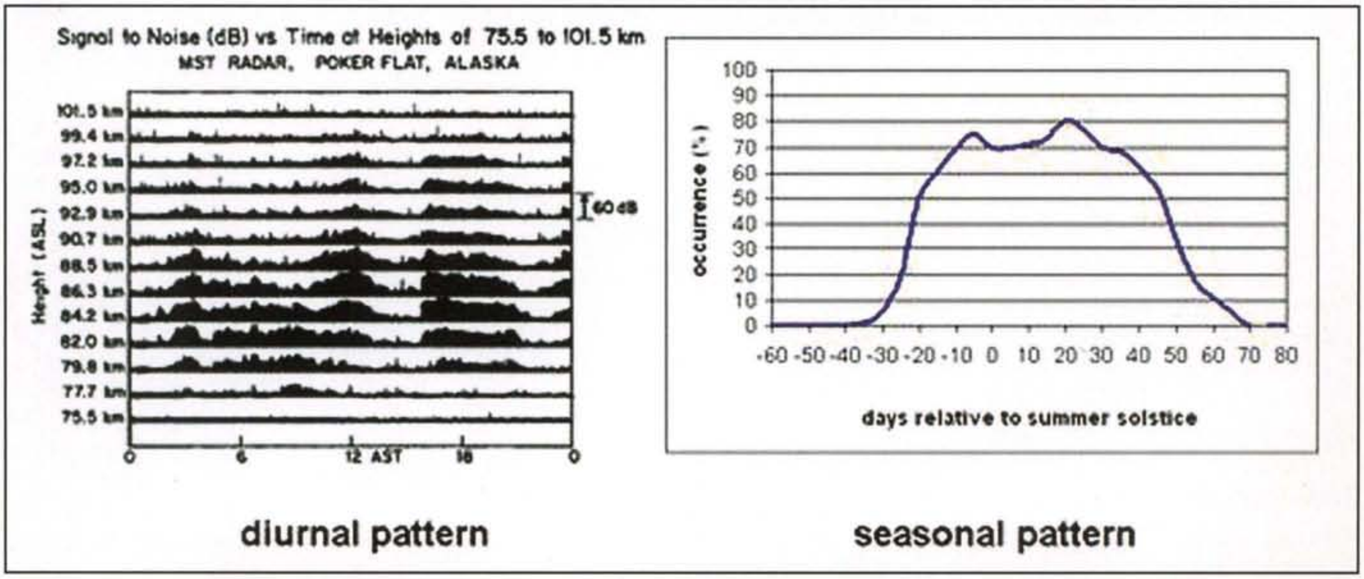

Figure 2. Statistical patterns of PMSE. (See text for citations.)

in the UKSMG's "Six News" by Chris, G3WOS), Han, JE1BMJ, first proposed that PMSE may play a role in 50-MHz propagation across the polar latitudes (for example, from Japan to the upper Midwest of the U.S.). His figure 3, reproduced herein as figure 3, shows his hypothesis.

JE1BMJ hypothesizes that an electromagnetic wave out of Japan encounters the ionosphere at the Nearest Control Point A, and is refracted by this control point such that it then goes into successive chordal hops in the PMSE region until it similarly encounters the Nearest Control Point E on the other end of the path, where it comes back to Earth. JE1BMJ believes the E region is involved in the Nearest Control Points (A and E) based on elevation-angle observations, although he suggests that it could be the F1 region.[2]

The critical issue in this hypothesis is that the wave must initially encounter the

PMSE region (point B in figure 3) at a very low grazing angle. Why is this? It's due to the extremely low electron density at PMSE altitudes, and the frequencies that this electron density could refract.

PMSE Electron Density

From the earlier explanation of why VHF radars "see" these echoes, PMSE are tied to the number of electrons in the D region of the ionosphere. At a mesopause altitude of 85 km (halfway between 80 and 90 km) at polar latitudes, the electron density during the daytime from our model of the ionosphere is around 2000 electrons per cubic centimeter.[3] This compares favorably with actual PMSE measurements of electron densities in the paper "Polar mesosphere summer echoes (PMSE): review of observations and current understanding" by M. Rapp and F. J. Lübken (*Atmospheric Chemistry and Physics*, 4, 2601–2633, 2004). The right panel of figure 4 shows this measured electron density data.

Let's be optimistic and assume from figure 4 that there are 5000 electrons per cubic centimeter. Translating this electron density to a plasma frequency gives 640 kHz. For this extremely low plasma frequency to refract an electromagnetic wave at 50 MHz requires an M-Factor of 78 (from 50 MHz divided by 640 kHz). This then says an electromagnetic wave must encounter the PMSE electron density at an angle no greater than about 0.7 degrees (a very low grazing angle indeed) per the secant law.[4]

Thus, for JE1BMJ's hypothesis to work, or for that matter any hypothesis that includes PMSE, the wave arriving at the PMSE region must be at an extremely low grazing angle to allow refraction of an electromagnetic wave at 50 MHz. What mechanisms could allow this condition to be met?

Possible Mechanisms

The most obvious mechanism could be a sporadic-*E* cloud. A sporadic-*E* cloud can have electron densities on the order of (and even greater than) 1,235,000 electrons per cubic centimeter (a plasma frequency of 10 MHz). This is more than enough to bend a ground-reflected upcoming wave enough to encounter the PMSE region at a very low grazing angle.

Since electron density (more appropriately, a gradient in the electron density) is not the only mechanism by which the index of refraction can change to bend a wave, a second mechanism could be what happens down lower in the troposphere—something akin to a temperature inversion. The factors affecting the index of refraction in the troposphere are atmospheric pressure (P), absolute temperature (T), and water vapor pressure (e) per the equation:

index of refraction =
$1 + [77.6 \times P/T + 373200 \times e/T2] \times 10^{-6}$

For typical values of P, T, and e at ground level, the index of refraction is around 1.000315. Because this is such a small amount above 1, the term in brackets is defined as N and the index of refraction of the atmosphere is defined in terms of N-units. In this ground-level example, N = 315. Furthermore, N decreases by about 0.04 N-units per meter of altitude, which is the standard lapse rate.

In a temperature inversion, the amount of N-units is slightly lower than 315 (mostly due to the higher altitude), but the lapse rate can increase to tenths of N-units per meter, which causes more bending and long distance QSOs on 2 meters and up.[5]

Plugging in values of P, T, and e from the World Meteorological Organization standard reference atmosphere (Adolph S. Jursa, Scientific Editor, *Handbook of Geophysics and the Space Environment*, Air Force Geophysics Laboratory, 1985) indicates an extremely low value of N due primarily to the extreme reduction in pressure at mesopause altitudes. Even if there was a significant gradient in N-units in the mesopause (and there could be due to gradients seen in figure 4 of the aforementioned Rapp and Lübken paper), I seriously doubt that it could generate enough bending to turn a ground-reflected wave enough.

A third mechanism could be scatter. The ground-reflected wave could be forward scattered when it encounters the PMSE region, resulting in a scattered portion of the wave encountering the PMSE region at low grazing angles.

To assess this, we can reverse-engineer the 10,000 km path in figure 4 to *estimate* how much loss from scatter could be tolerated. Assuming antenna gains of 14 dBi, calculating a free-space path loss of 147 dB, assuming on average 4 dB per ground reflection (from personal reflection coefficient data versus frequency and polarization), and assuming 1 dB of absorption per hop (from figures 7.5 and 7.6 in *Ionospheric Radio Propagation*, K. Davies, 1965) says 41 dB of scatter could be tolerated to put a 100-watt transmitted signal right at the noise floor of a typical amateur radio receiver (around –130 dBm in a 500-Hz bandwidth; this assumes man-made noise is not a limiting factor). This value of 41 dB is probably a bit optimistic, as polarization mismatch loss and

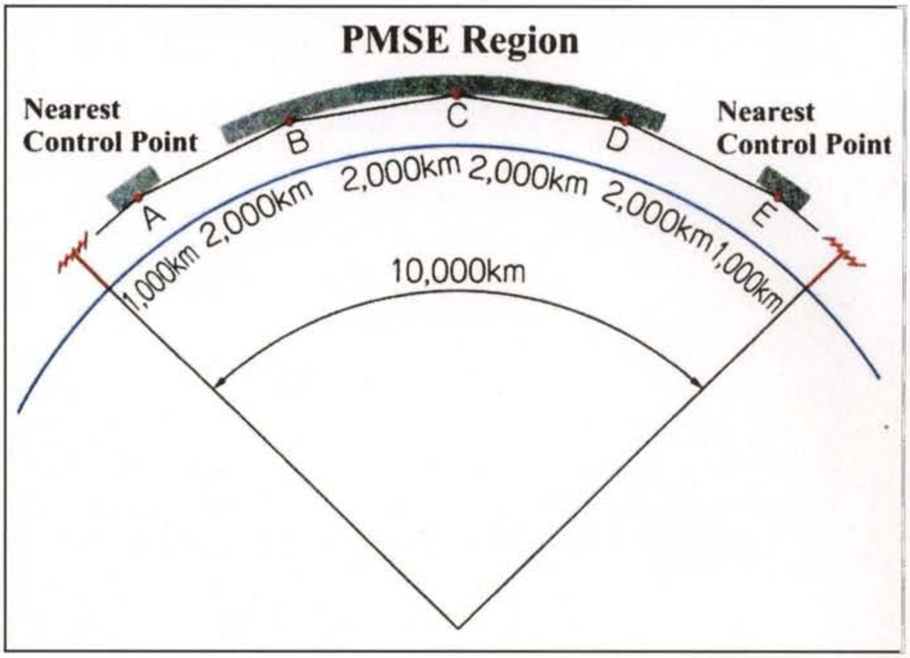

Figure 3. The JE1BMJ hypothesis.

other small losses were not taken into account.

From figure 1 of the Latteck, Singer, Morris, Holdsworth, and Murphy paper, the radar volume reflectivity of PMSE is at best 1E-11, which is a loss of 110 dB (now you know why those VHF radars need to run such high ERP). Thus, this back-of-the-napkin estimate suggests that scatter, at least in terms of amateur radio power levels and antenna gains, is many orders of magnitude away from supporting any hypothesis involving PMSE.

Comments from K6MIO/KH6, WB2AMU, and NØJK

I forwarded a draft of this article to Jim, K6MIO/KH6; Ken, WB2AMU; and Jon NØJK. I thank them for their comments, which helped me in writing this article. I'd also like to pass along their pertinent comments.

Jim states that, statistically speaking, the path midpoint of an all E-layer mode is not in a very good position for propagation, unless either the MUF is simply really high throughout or there is some sort of chordal process helping in the middle. He opines that if chordal hops are involved, then E-layer chordal hops are significantly more likely than anything involving the D layer and PMSE.

Ken comments that the polar region gets almost 20 hours of sunlight during the summer months, and this is one of the factors for increased sporadic-*E* in the area. He also is curious why these paths appear to only show up on 6 meters, and not on 10 meters. This may provide an important clue as to what's going on.

Jon points out that my earlier analysis (in the March/April 2007 issue of the *National Contest Journal*, *NCJ*) of probability versus time for multiple sporadic-*E* hops on long-distance QSOs tends to line up with observations. Jon says this tells him sporadic-*E* is either the total mechanism, or at least a significant part of the mechanism. It very well could be that we're dealing with the "control point" concept of HF propagation, which says it has empirically been found that if control points on each end of a path (2000 km from each end for the F2 region) could support propagation, then the entire path could be supported.

Conclusion

We've looked at some fundamental atmospheric physics to determine that PMSE could play a role in propagation at 50 MHz. But it would have to be in conjunction with a sporadic-*E* cloud to provide the necessary very low grazing angle to support 50-MHz propagation through a PMSE region due to the PMSE region's extremely low electron density.

In my opinion, I agree with K6MIO/KH6 that a chordal-hop mechanism involving the E region, without any PMSE involvement, could be the most likely mechanism.

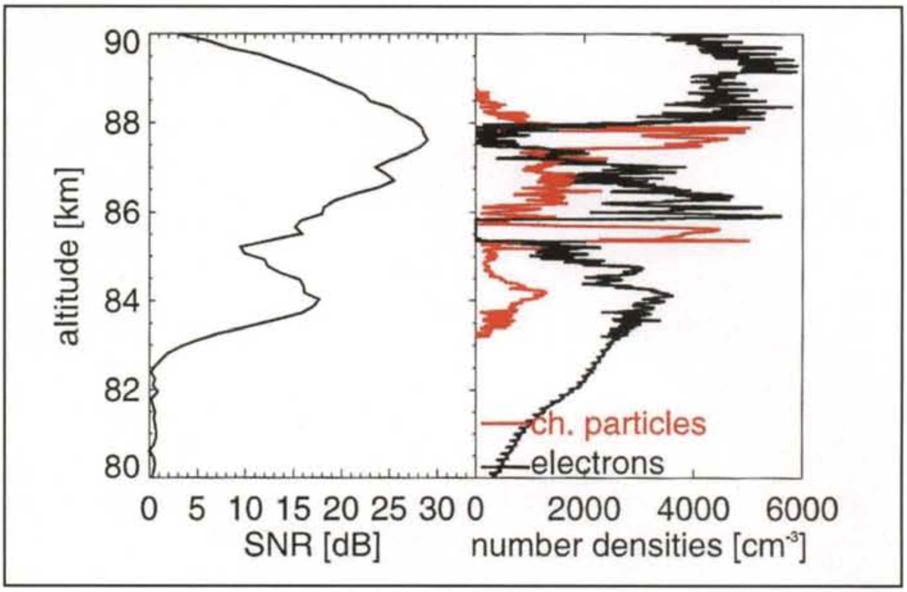

Figure 4. PMSE electron density measurements.

Footnotes

1. These VHF radars run extremely high ERP (effective radiated power). Interestingly, these mesopause summer echoes can be so strong (the left image of figure 2 shows signal-to-noise ratios up to 60 dB) that ionosondes in a quiet RF location and in a quiet noise location can see them. For example, Hai-Long Li, Jian Wu, Rui-Yuan liu, and Ji-Ying Huang noted PMSE on an ionosonde in their paper titled "Study on mesosphere summer echoes observed by digital ionosonde at Zhongshan Station, Antarctica" in *Earth Planet Space*, 59, 1135–1139, 2007. They distinguished PMSE from normal *E* and sporadic-*E* echoes through the virtual height data.

2. JE1BMJ's explanation of why the F1 region could be involved is in error as he assumed a planar Earth-ionosphere system to show that a high enough M-factor (11.5 to support 50 MHz with an F1 region critical frequency of 4 to 5 MHz) could exist. In the actual spherical Earth-ionosphere system, the M-Factor would be limited to a value of about 4 at F1 region altitudes. For more on the M-Factor, visit <mysite.ncnetwork.net/k9la>, click on the Basic Concepts link on the left, and download the pdf titled "The M-Factor."

3. JE1BMJ's statement that a high electron density is covering the JA–EU path on July 19, 2006 based on the auroral map in his figure 4 is also in error. The map shown does not directly show electron density; all it shows is statistically where visible aurora could occur from the measured flux and energy of the precipitating electrons for that specific satellite pass. From the data on the original map (obtained from the Space Weather Prediction Center in Boulder, CO, the highest electron density for that pass translates to a plasma frequency of around 2.5 MHz and those electrons only precipitated down to 125 km or so. For more on these auroral maps, visit <mysite.ncnetwork.net/k9la>, click on the General link on the left, and download the pdf titled "A Look Inside the Auroral Zone."

4. The caption for Figure 28 in the Rapp and Lübken paper comments that there could be 10,000 ice particles per cubic centimeter of radius 5 nanometer in the mesopause. If ice particles alone were somehow the refracting mechanism, this would equate to an equivalent "plasma" frequency of 900 kHz, which still requires an extremely low grazing angle (less than 1°) to refract waves at 50 MHz.

5. We have to watch it here. Down at troposphere altitudes the Earth-troposphere system is essentially planar because we're only talking a couple km of altitude. In other words, the curvature of the Earth is not seen by the wave as it travels up to the troposphere because it has so little distance to travel. Thus, a wave launched at 1 degree from the ground will encounter the troposphere at close to 1 degree, which is a very low grazing angle to start with and means a lot more refraction is not needed—at least not like higher up in the ionosphere.

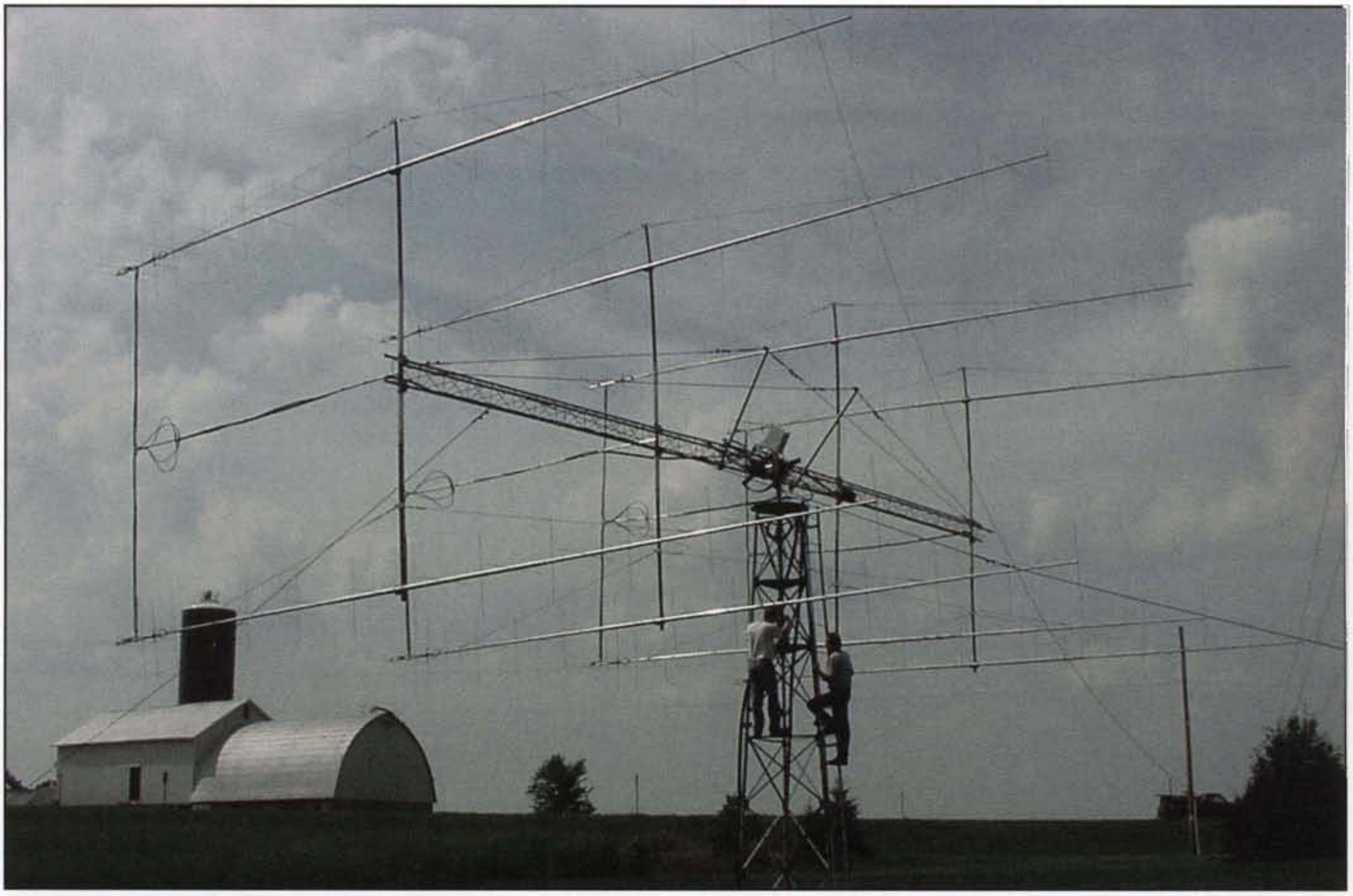

Photo A. KJ9I 2-meter moonbounce array (Oconomowoc, Wisconsin, EN53qc), eight cross-polarity Yagis on azimuth and elevation rotor. (For size reference, note KJ9I and K9VHF standing on tower.) (All photos courtesy of the author)

2-meter DXCC via EME – The Journey

Originally appearing in the September 2011 issue of *CQ Egypt*, here KJ9I writes about his journey to DXCC on 2 meters. *CQ Egypt* is the official magazine of the Egypt Radio Amateur Society (ERASD), Egypt's national amateur radio organization. For more information on ERASD, see: <http://www.erasd.net>.

By David J. Schmocker,* KJ9I

My 2-meter earth-moon-earth (EME), or moon-bounce, journey began in 1999 at the encouragement of a close friend and passionate VHF enthusiast, Ken Boston, W9GA. Ken advised that based on my EME operating goal, it could be determined on which band to pursue EME. DXCC was clearly my goal and so 2-meters presented maximum DX opportunity.

Let's Build an EME System (The Hardware)

EME requires a custom (short, stout, self-supporting) tower: I bought the start of my EME tower (old pieces from a former Coast Guard tower) which consisted of rusting legs and some cross-braces resting atop an old, disabled school bus in a junk (treasure) collector's yard. Doug Johnson, W9IIX, was instrumental in helping build the missing tower cross-braces, and he had all of the formerly galvanized but now deteriorating components stripped and hot-dip galvanized. The late Terry Ludwig, N9JUU, fabricated custom 1/2-inch thick stainless-steel (rotor, intermediate thrust bearing, and top) plates for the tower.

Then Jerry Daniels, my father-in-law, helped me set the tower, build wood forms around the tower base, and pour concrete. It turned out beautifully with 11 yards of concrete comprising the new EME foundation (a wet year kept caving in the tower hole sides; by the time weather permitted driving a heavy truck across the lawn to pour the concrete, the "enlarged" tower base hole required 11 yards!). After the concrete had set, I rent-

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Photo B. HS2CRU and HS2JFW 2-meter EME station OK03lf July 2003. Two 2M8WL Yagis on elevation rotor.

Photo C. 3DAØJR Swaziland (op: ZS5JR) HF + 2-meter EME station, KG53ms, July 2005. One Yagi on azimuth rotor.

ed a SkyTrak lift to mount the 25G cross-boom atop the waiting elevation rotor I had configured on the 3-inch $^{1}/_{4}$-inch wall steel mast. With the 25G cross-boom in place, I placed scaffolding from the ground to reach the support structure for antenna phasing lines, power divider, and other component placement.

The new KJ9I 2-meter array was completed just in time for the fall (October 2000) EME contest (at the same time, my fiancé was learning first-hand about my ham dedication). As moonrise approached during the contest weekend, I retested the whole array. The VSWR was perfect, but with my eight long-boom cross-polarity Yagis, I could hear nothing.

Concern grew as nearby W9GA reported copying multiple stations with his small single 2-meter Yagi aimed at the rising moon. What could be wrong with my array? After quick system analysis, I determined that half of my commercial phasing lines were manufactured $^{1}/_{4}$ wavelength (electrically) too short, resulting in four of the Yagis precisely canceling the other four! So I quickly fabricated four $^{1}/_{4}$-wave sections to add in series with the incorrect phasing lines to bring them to proper electrical length until I could get new ones made for permanent use. With darkness upon us, my bride-to-be climbed my new EME tower with me and held the flashlight as I quickly added the temporary sections to my phasing lines. Terrific! I could hear now . . . many very *loud* signals.

My first EME QSO was with F3VS in October 2000. Back then, virtually all EME stations used CW (except for an occasional SSB try by the big and the bold). I completed an SSB EME QSO with ON4IQ during a time when conditions were excellent.

The immense fun from EME comes from various sources:

1. Building the custom hardware for a system requires a substantial amount of mechanical aptitude and skill even with the use of commercial off-the-shelf (COTS) components.

2. Building a good-performing EME system requires meticulous attention to detail, the kind we detail-oriented types love.

3. The thrill of hearing your own signal come back to you 2.7 seconds after having been to the moon (literally) and back is immense.

4. Learning the fascinating physics of EME—doppler shift, libration fading,

etc., as well as experimenting with the great software tools available (Nova for Windows®, MoonSked for Windows®, LinRad (for Linux), WSJT (for Windows®), to name just a few.

Shortly into my DXCC journey, I added the first significant developmental tool/software application to my station. Linux Radio (LinRad) by Leif Asbrink, SM5BSZ, is a Linux-based digital signal processing (DSP) application free to the amateur community for experimentation purposes. I found LinRad to be an incredibly fun addition to my new EME system. Leif (an avid 2-meter EMEr) also has custom receiver kits available tailored for use with LinRad such that one can integrate a high-performance computer sound card, his special 2-meter EME receiver, and LinRad to see a waterfall display of 90 kHz+ slice of the 2-meter band (very useful during EME contests to see where the activity is). In addition, because there is polarity rotation involved in EME, those of us with dual-polarity Yagis (vertical and horizontal elements) could now add dual V and H feeds into LinRad and the LinRad application would automatically calculate and display the actual signal arrival angle in real time! (Have I mentioned yet that EME is fun?)

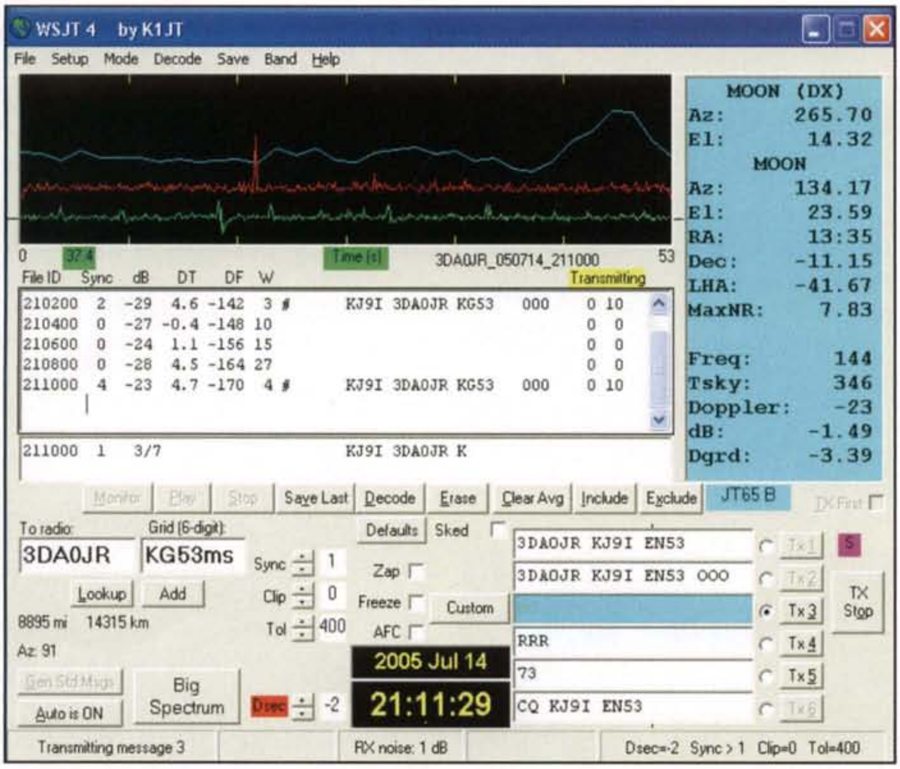

Figure 1. WSJT JT65B screen shot during my QSO with 3DAØJR.

Photo D. 9J2JD, Hannes, Zambia 2-meter EME station, KH37xj, July 2005.

Near completion of my DXCC pursuit, Joe Taylor, K1JT, introduced an innovative and clever new Windows® application: Weak Signal by K1JT (WSJT). WSJT brought the ability to dig weaker signals out of the noise using advanced coding schemes and bringing current technology to EME (and meteor scatter) platforms. WSJT brought the capability for well-equipped single-Yagi stations to transit the path from Earth to Moon and back! WSJT quickly became very popular, bringing a life infusion to the otherwise faltering EME aging demographic population. First came (EME modes) JT44, JT65, and then JT65B. As Joe continued developmental efforts, the popularity of WSJT brought much new activity and excitement to the EME scene. As one tunes the lower VHF bands today, rare is the CW signal on 2 meters EME vs. many WSJT signals (this from KJ9I, an avid CW lover and fan). Thank you, Joe, for your outstanding contribution to EME and weak-signal VHF communications.

The EME Journey Continues... an Added Handicap

A rough career transition had me living out of state for six months in Indianapolis, IN (6+ hour drive) during the weekdays and again for a year in Cedar Rapids, IA (4 hour drive) away from my home Wisconsin EME QTH (EN53qc). So now my handicap increased as my operating time was pared further, allowing just small subsets of weekends when I could borrow precious time from being with my wife to play radio despite not having seen her for a week! She was truly patient and fully supportive as I aggressively chased my EME DXCC goal. Now that my career would have me moving permanently to Iowa, could I complete my DXCC before the pending QTH move?

Throughout the years of my DXCC chase, I continued a very aggressive behind the scenes "storm" of solicitory e-mails requesting stations who either used to be 2 meters EME QRV and were now dormant, or possible new candidates to become QRV in DXCC countries I needed to give 2 meters EME a try. It would only require one Yagi on the other end, and I would indicate in my 2-meter EME schedule requests. Success stories were mixed with failures.

How Much Special Effort Does It Take to Work a New One?

During one EME contest weekend, there was a special effort by HS2CRU and

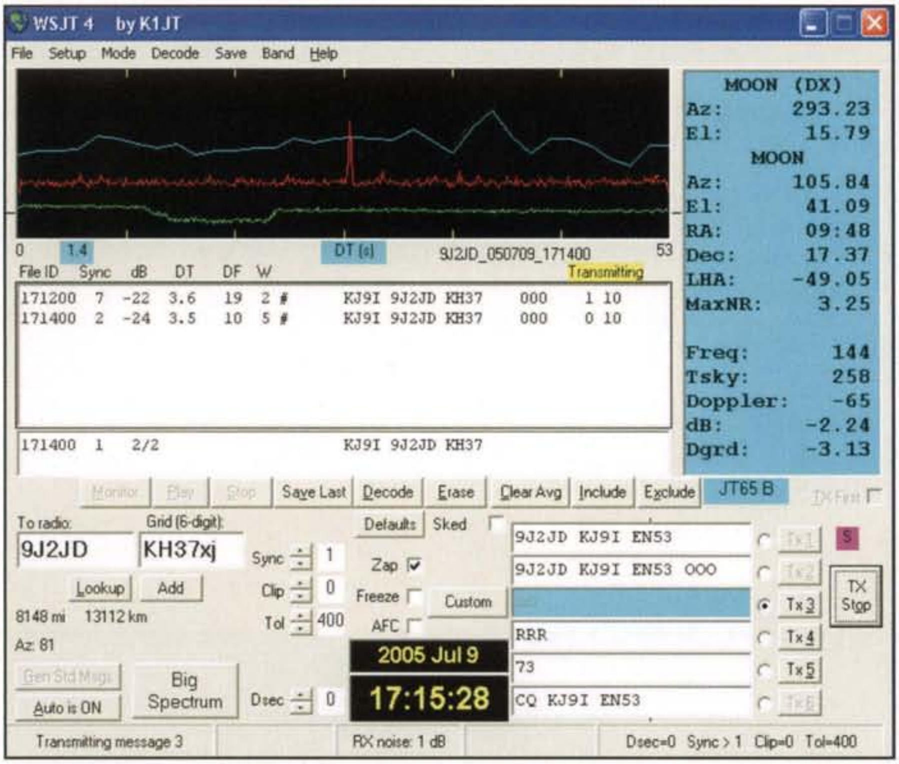

Figure 2. WSJT JT65B screen shot during my QSO with 9J2JD.

Photo E. 7P8/ZS5JR, Daniel, Lesotho, 2-meter EME station, KG40fp, September 2005.

HS2JFW (Thailand) and the local HS ham team to construct two 50-foot boom phased 2-meter Yagis placed atop 12-foot scaffolding in the middle of a vacant road for a single weekend EME effort. During this EME contest, I stayed up almost all night trying to work people. Conditions degraded significantly over the evening to the point where I grew highly discouraged, as I could no longer hear my own echoes (with an 8-Yagi array, 1.5 kW, and less than 1 dB of feedline loss!). So as my heavy head hit the operating table, I surrendered to poor current EME conditions and went to bed. The next morning, I learned that one hour after I went to bed, several other stations worked the HS team on 2 meters EME! We always remember best the contacts we narrowly missed. Lesson learned: EME conditions can change very abruptly. *Never* stop trying.

After this most disheartening experience, I encouraged the HS team to put their station up for a second try so I could have another chance to work them. They were very excited about 2 meters EME and agreed to try again during another future weekend! The amount of work they went through to transport the large Yagis and scaffolding, etc., to a remote site to operate was incredible!

Using MoonSked for Windows®, I had calculated the precise time of their local moonrise and had given them a detailed table showing the precise position of the moon for our sked. As we tried the sked, I suddenly saw the waterfall trace of a signal (on LinRad DSP application) and I soon copied HS2CRU calling me on 2 meters EME CW! He had a very good signal! I replied to him, so nervous that I mistakenly sent my callsign incorrectly at the beginning of the report series (I corrected it at the ending call set of that transmission). We completed the contact within a few minutes and this brought great joy to many in the HS team.We all were excioted by this experience! (Have I mentioned yet that EME is incredibly exciting?!)

There were many hams who made my 2-meter DXCC possible: ZL1RS, VK7MO, ON4IQ, ON4QX, DL8YHR, IV3GTH, ZS6WB (and all of the ZS team!), and many others who made special travels possible expressly to help people like me work a 2-meter EME new one.

Photo F. 7P8/ZS5JR, one Yagi with azimuth and elevation rotor.

More successes appeared from my solicitory e-mail efforts and soon I had worked 90 countries. Then 92, 95, soon 98. ... During a memorable CW sked with KH6RZ, my elevation rotor gearbox failed (gears stripped!), so with just one more DXCC to go, my array was QRT. Then I learned that parts to fix this gearbox were no longer made/available! No one said EME is easy. And one needs to have an iron stomach to tolerate the discouraging moments along with the great triumphant times.

With the resourcefulness of special friend KB8RQ, we found W5LBT and some others who helped me locate two used gearboxes on short notice to get the parts I badly needed to complete DXCC before my QTH move. I frantically replaced the gearbox atop my 2-meter EME tower the next weekend and continued my country hunt while a few stations traveled on special trips/DXpeditions to put new DXCCs on 2 meters!

ZS5JR took 2 meters with him to 7P8 and we had a sked the day after my elevation rotor was fixed! At midnight local we tried our first sked, and while my elevation rotor now worked great, I copied nothing from Daniel during the 15-minute sked. Having been short on time, I had not had the chance to upgrade to the new WSJT v6 (I did not want to experiment with new software while trying to work a new DXCC with my operating time so ultra limited), but right after the failed first 7P8 sked, I took time to download and configure the new WSJT6. Meanwhile I kept my array aimed at the Moon in preparation for our next 7P8 sked at 06:00 UTC (1:00 AM local time).

At 05:45 UTC, I got WSJT configured and put it into the monitor mode and immediately I saw 7P8/ZS5JR on the screen calling me! Could it be real (or a false decode due to my having very aggressive settings enabled on WSJT)? Using WSJT operator savvy, I checked the confidence level of WSJT and captured the screen-shot image showing his sync spike. It looked real, but how could it be because I knew the time was too early for our sked. I decided to call him back to see if it was really Daniel. So in response to the full callsigns I received, I immediately sent 7P8/ZS5JR KJ9I OOO to him ... and the next line I saw RO come back in the form of a confirmed positive solid decode!

Still not believing it could be him, I sent RRR to him and then I saw 73 come back to me. I sent "73 TNX DXCC 100" to him! Then the next morning I tried for PJ7/ON4QX and was successful working Herman! Now I had to return from my Wisconsin EME QTH to Iowa for work. I drove the 4-hour trip back to the work QTH not quite comfortable that 101 worked would get me 100 confirmed DXCCs. So keeping an eye on the logger, I learned that FS/ON4QX would be active Wednesday morning only. I drove four hours home after work Tuesday night to the Wisconsin QTH, stayed the night, and awoke early to luckily log FS/ON4QX 28 September 2005 before his elevation rotor failed, rendering him QRT. I then drove back to Iowa to work the rest of the day, now with 102 DXCC countries worked and enough to ensure confirmation of 100 countries!

From start to finish, I completed my 2-meter DXCC in just under five years (a record, I believe). It was a very exciting journey and one that I will always remember fondly.

The Party is Not Over Yet!

6 Meters Provides Surprises after Summer 2011 Sporadic-E Season

The Magic Band continues to live up to its reputation of producing unexpected propagation. In this article WB2AMU, perennial 6-meter reporter, summarizes his experiences with this year's end of the summer sometimes unexpected activity.

By Ken Neubeck,* WB2AMU

As many 6-meter operators know, sporadic-*E* activity becomes very sparse during the equinox months of September and March. In reviewing my notes for the past 20 years, typically I have seen no sporadic-*E* activity in September during many of the years, and on rare occasions, maybe two openings during the month of September. In my 20 years of participating in the ARRL's September VHF contest, I have seen sporadic-*E* activity occur twice, in 1993 and in 1994, with a short-duration opening of less than an hour from the Northeast into Florida.

6-meter Observations in Early August

Even as the summertime sporadic-*E* season for 6 meters wound down in 2011, a number of things occurred on 6 meters that continue to show why it is frequently refered to as the "Magic Band."

First, there was tremendous sporadic-*E* activity during the first week of August, and I observed a strong opening in to the Midwest from the Northeast on the evening of August 3rd, during which I was able to work many stations in Illinois and Michigan on CW. This was a good opening that lasted over two hours.

Then two days later, the Kp index reached a value of 6 and aurora openings occurred along the east coast of the U.S. I was able to work K3ZO and K1DQV in Maryland, while hearing (but not working) NWØW in Missouri and VE3EN in Ontario, Canada during the two-hour opening.

The aurora opening was sandwiched by another sporadic-*E* opening to the Midwest on August 7th that started in the morning and lasted about two hours. After that opening, the rest of the month was quiet for me in the Northeast with regard to any skywave activity on 6 meters.

The Northeast was impacted by Tropical Storm Irene during the latter part of August, and as a precaution, I took down my 6-meter antenna setup for three days. The antenna had been up for over three years, but after hearing forecasts of 50-mph sustained winds, I thought that it was wise to drop it down. As it turns out, it was a very fortunate thing that I put it up again reasonably soon after the storm, as there was significant skip action on 6 meters during September.

Date	UTC	Callsign	Grid	Mode
Sept 5	1738	KJ4E	EL98	CW
	1749	WP4O	EL87	SSB
	1752	K4KEW	EM90	SSB
Sept 13	2153	N3LL	EL86	CW
	2227	K4KEW	EM90	SSB
	2247	KK4AMC	EM91	SSB
	2251	WB4VMH	EM80	SSB
	2258	W4GCB	EM73	SSB
	2301	KE4EE	EM73	SSB
	2304	KI4FCQ	EM72	SSB
	2307	W4IMD	EM84	SSB
	2313	KT4XP	EM94	CW
	2322	W7DO	EM94	CW
	2327	W4GF	EM83	CW
	2345	W4VZB	EM83	SSB

Table 1. Stations worked by WB2AMU on 6 meters via sporadic-E on September 5, 2011.

6-meter Observations in September

On September 5th, Labor Day Monday, I worked three different stations in Florida shortly after local noon as shown in Table 1. One of the stations that answered my CQ on CW was long-time 6-meter operator Damon, KJ4E, who had been QRT from the band for 13 years after a storm damaged his tower back in the late 1990s. It was good to hear him back on the band. One of tips that an opening was occurring was I heard the W4CHA beacon in the CW band coming in. This opening fell in line with previous September 6-meter sporadic-*E* openings I have observed—narrow coverage and short duration.

The September ARRL VHF contest occurred the next week (September 10–12), and I did not observe any skywave activity on 6 meters from my portable hilltop location on Long Island, NY, although there was the potential of aurora activity because of recent sunspot and flare activity. It was two days later when a major sporadic-*E* event occurred, the likes of which I had never observed during any previous September in over twenty years of 6-meter operating.

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On September 13th, at about 5:45 PM local time, I was looking at the ON4KST Six Meter chat page when my friend Richard, CE6RC (mentioned in last quarter's column), from Chile, worked Bob, K1SIX, in New Hampshire on 50.110 MHz SSB. At that point (as discussed in the previous column), I knew that I was dealing with the likelihood of a combination sporadic-*E* plus TEP (transequatorial propagation) opening between stations in the southern part of South America into Northeast U.S. and Canada.

I called CQ on 50.110 MHz and other frequencies with no results, so I started hunting around (see figure 1). I worked N3LL in southern Florida at 2153 UTC, but I still did not hear any signals from Argentina or Chile, even though stations near N3LL's location were working into that area. After N3LL, I started working stations in the northern part of Florida as listed in Table 1 and plotted in figure 2.

At about 2300 UTC, the sporadic-*E* formation was changing noticeably, as I was hearing only stations in Georgia, South Carolina, and North Carolina, but not south of that. The stations that I contacted are listed in Table 1 and plotted on the map shown in figure 2. It is clear that

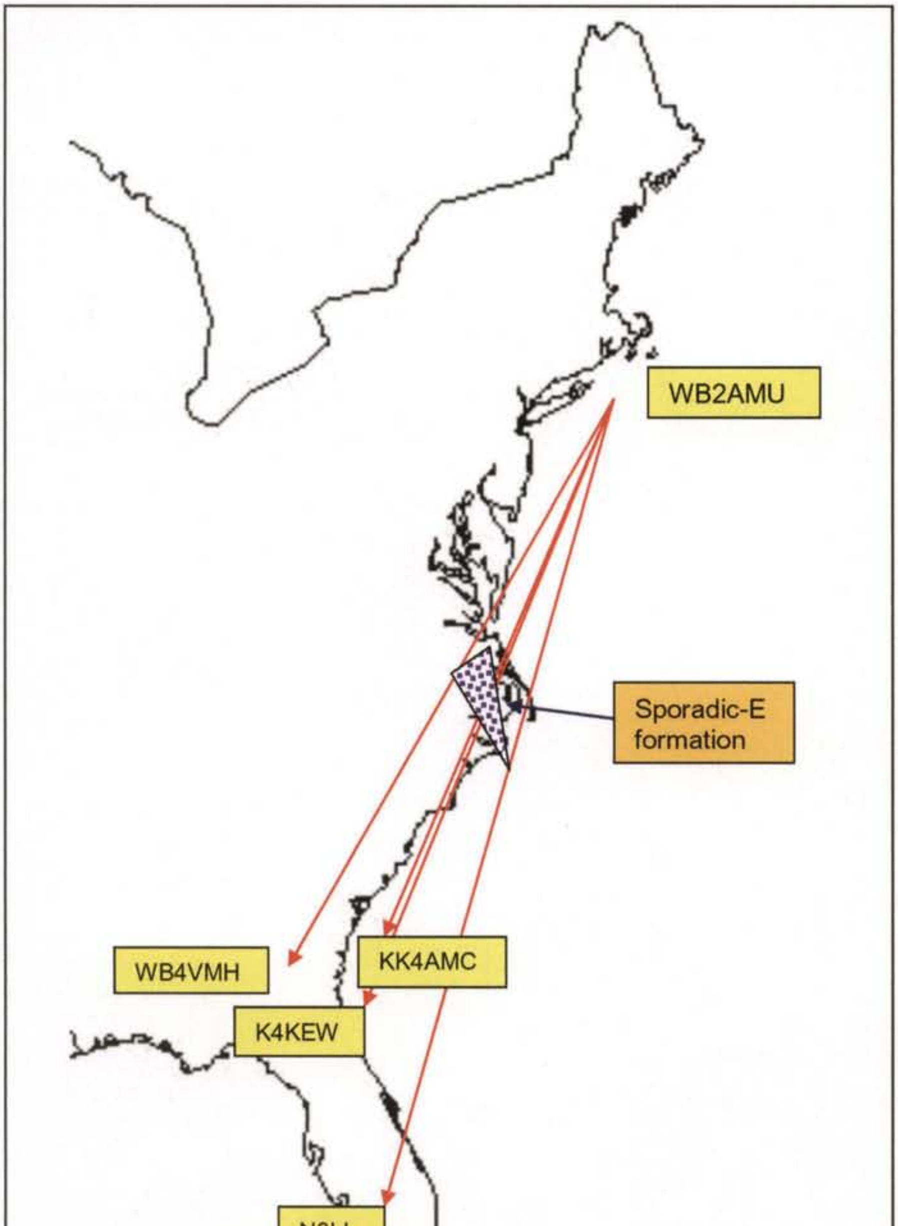

Figure 1: First hour of September 13th 6- meter opening, 2153–2251 UTC.

the sporadic-*E* formation that was plotted in figure 1 had now moved both north and south as shown in figure 2. By the time I was working the stations at 2200 UTC and after, the possibility of my working into South America via a TEP plus sporadic-*E* combination was nil. Probably there was a small window of opportunity for me when the opening started and I worked N3LL at 2153 UTC, but I did not hear him after that. It appears that the combination skip event favored other areas, not mine, and that the sporadic-*E* opening fell a little bit short for me to reach southern Florida and be able to link up with the TEP into Chile and Argentina where stations CE6RC and LW1EX were active.

This particular opening provided a good study of a somewhat rare sporadic-*E* event in September. Of note is the fact that the formation was fairly narrow and it could be seen that there was movement of the formation over a short amount of time. As I have stated many times in the past, 6 meters provides an excellent canvas for studying propagation because of the sparse amount of propagation on the band on a day-to-day basis so that when events actually occur, it becomes easier to track and understand them.

The sporadic-*E* opening is typical of past September openings in that it can be characterized as fairly narrow in coverage with rapid fading and rapid increase in signal strength. What made this opening significantly different from previous openings I have observed in September is the overall duration of the opening, lasting over two hours.

What can be concluded as to why 6-meter sporadic-*E* events like this occur during September? There is one school of thought that would consider an opening like this to be part of the sporadic-*E* summer season, even though there were several days between the major openings in August and those on the 5th and the 13th of September. It is really difficult to state why such ionization occurs during the quiet times of the year, and more research with radio observations needs to be performed.

The summer sporadic-*E* season benefits from a number of factors, including the increased amount of solar radiation during that time of year which aids in the production of metallic ions present in the E region of the ionosphere. While the solar radiation is significantly less during the month of September compared to prior months in the year, there is still an ambient amount present, along with the fact that ions are still present and have the capability to help aid in the occasional sporadic-*E* opening during that month.

During the time that this article was written, on September 24th a major CME (coronal mass ejection) was emitted by the sun from sunspot group 1302 that did not hit the Earth directly but rather gave a glancing blow. This nevertheless created some blackout conditions and apparently F2 activity on 6 meters that occurred later in the day on the 26th. The openings took place between some parts of the U.S. and the southern part of South America. I actually heard 9Y4VU in Trinidad on 50.110 MHz around 2130 but at low signal strength, while it was reported by 9Y4D that he worked 90 stations in the U.S. during the opening. Later, at 2230, I actually heard HC1HC reaching about 569 signal strength on 50.095. LU5FF reported hearing the VYØ beacon in northern Canada at 559 strength.

It was interesting to see that no massive aurora openings occurred at mid-latitudes, but the glancing blow apparently created north-south paths that appeared to be F2 in nature. This was the first F2-related opening that I have ever heard

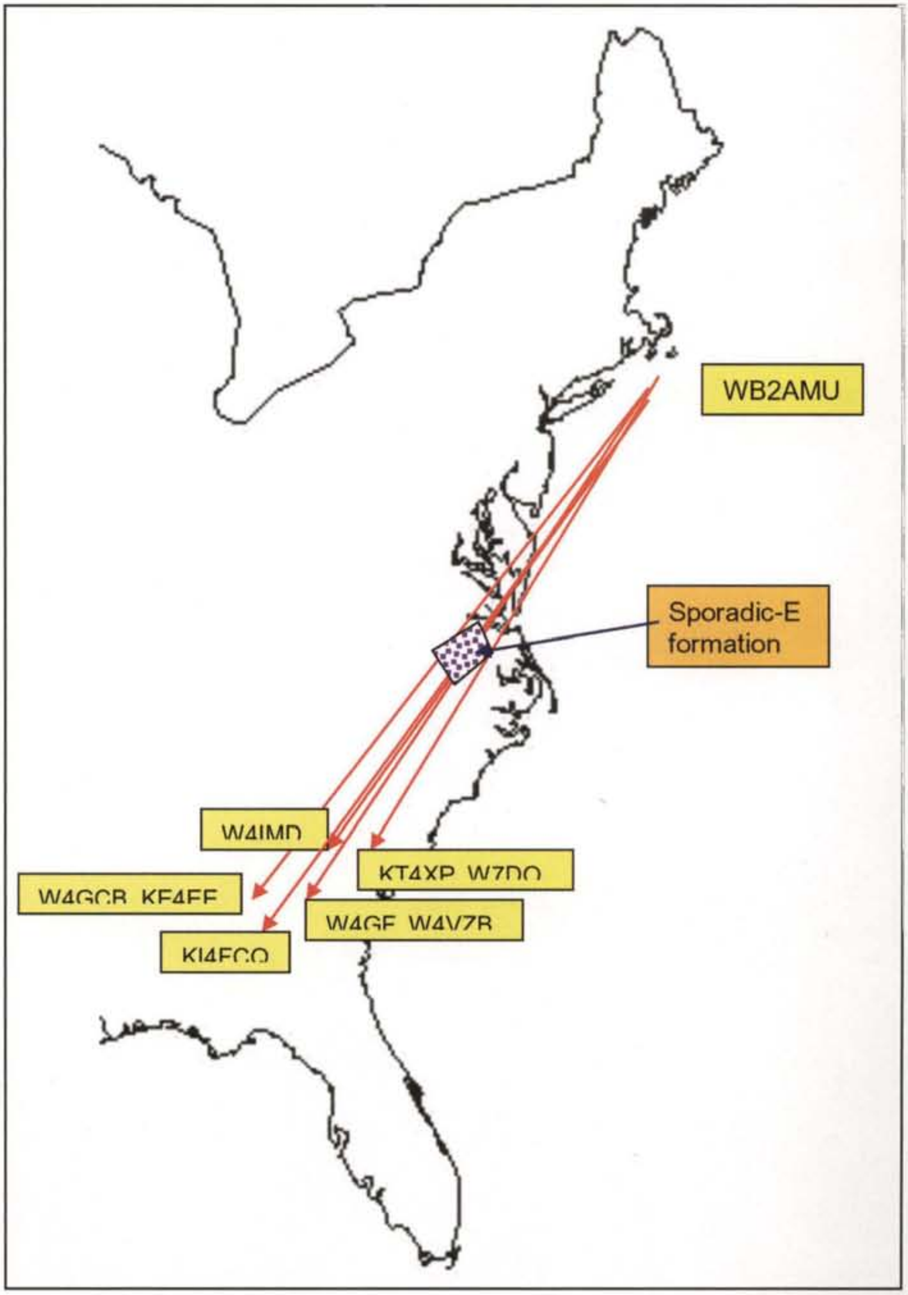

Figure 2. Second hour of September 13th 6-meter opening, 2258–2345 UTC.

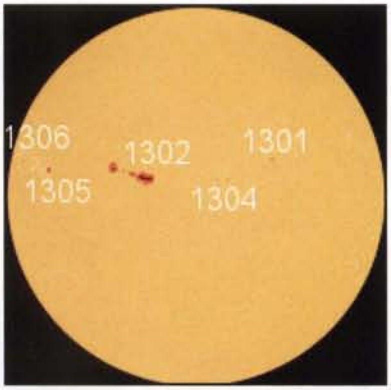

Photo A. The sun on September 27, 2011.

during the month of September, and it will be interesting to see what occurs during October as solar activity increases!

I would recommend that going forward during the time period of September into early November 2011 when sporadic-*E* activity is low but TEP is still present, it would be worthwhile to send an occasional "CQ DX" on 50.110 MHz to see if a narrow opening is present from the U.S. into South America. The chat pages and spotting pages are helpful, but random types of openings may be spotted by just regular operating procedures.

Clarifications Regarding Recent *CQ VHF* Articles

A number of comments have been made about some recent articles that I wrote for *CQ VHF*, and I am compelled to provide the following clarifications with regard to two of these articles:

1. Regarding the *CQ VHF* online article that appeared in the Summer 2011 issue, I want to emphasize the fact that most TEP openings occur during the late afternoon and early evenings, a fact that was presented in the data for the article but not emphasized enough. Those are the optimal times for listening.

2. With regard to the VHF contest article that I wrote for the Spring 2011 issue, in response to some e-mails and the issues raised in the Summer 2011 Editorial by N6CL, I want to clarify some items. First, the calculations that were performed in the example with regard to the impact of pack rovers to scores are completely valid for the ARRL January VHF Sweepstakes. However, I neglected to mention that the scoring is different for the frequencies above 432 MHz for the June and September events, so the example would be somewhat different in those cases. Nevertheless, the main point is that the impact of pack rovers on scoring is significant, and stations benefiting from working many pack rovers will dominate in certain categories of the contests such as Rover and Single Operator Portable. Also, the main focus of the article was on single operator stations, although it is also recognized that multi-operator stations may be impacted by the nuances of the scoring as well.

3. Finally, I regret not citing the original source for the modified grid maps that I used for the contest article. The original source was a grid square map put out by ICOM America that I found at a number of sites on the internet. I had modified the original map extensively, but it would have been proper for me to have cited ICOM as the original source and I apologize for this oversight. I know firsthand what it is like to have material that I have written to be used in other places and not properly referenced. In my 1995 book on the A-10 Warthog aircraft, there were a number of unique calculations and other information that was cited regarding the aircraft's performance in Desert Storm. Imagine my surprise to find that these unique calculations were used in another book on the aircraft written by someone else and came out five years later!

I also want to point out that in general the onus of verification and citing sources of material used in articles falls on the author. We, as writers, should be sure to address those issues when submitting material to any publication.

That's it for this issue of *CQ VHF*, and be sure to check out the 6 meters with all of its nuances and excitement whenever you can. It is truly the "Magic Band"!

West Point Balloon Satellite

Learning from success and problems of a previous balloonsat launch two months earlier, a team of West Point cadets, two advisor-officers, and the Academy's public affairs officer launched a second balloonsat this past May. Here former advisor KJ5HY tells their successful story.

By Stephen Hamilton,* KJ5HY

On May 13, 2011, six US Military Academy cadets, two faculty members, and one journalist set out to take pictures and video of near-space. This was the third iteration of an ongoing balloon satellite experiment to learn how to build a satellite payload and collect data from heights exceeding 80,000 feet. The first phase was a tethered balloon that contained the Cadet Amateur Radio Club's first live feed via Amateur Television. Using the Videolynx transmitter, live video from overhead was displayed at Projects Day in 2010 next to various electrical engineering and computer science senior design projects. This event caught a lot of attention, and led to the first balloon sat flight the following year in March.

The first balloon launch had many successes and failures. Overall it was a success because the balloon was launched and recovered. However, many of the data collection parts in the payload had

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Sam's Point Preserve, New York, which overlooks the Minnewaska State Park, served as the excellent launch site location. This location was predetermined by a mathematical model of current wind patterns to estimate a landing in the vicinity of West Point and away from water or mountainous terrain. (Photos courtesy of KJ5HY)

This photo is an aerial shot from the GoPro on board camera taken during the balloon's ascent. For more information on the GoPro cameras, see: <http://www.gopro.com>.

various malfunctions, and the payload's design was too complex. Therefore, the cadets were determined to find time to do one more launch before the end of the academic year with the primary goal of taking pictures and video of space. This date turned out to be the small break after final exams and before graduation week, Friday the 13th of May, 2011. Even with good planning, a balloon satellite launch is subject to misfortune, but superstition did not stop the cadets.

In planning a launch, there are numerous considerations, but more specifically at West Point, N Y, the path of the balloon is critical. If the balloon flies too far east or south, it will be destined for either the Atlantic Ocean or New York City. Either of these could result in complete mission failure. However, there are websites for predicting balloon trajectories

This high-altitude photo of the edge of the Earth was also shot by the GoPro onboard camera.

Just before landing, concerns were raised about the payload landing on a nearby runway.

based on weather and wind patterns that can assist in making sure this does not happen. Using these predictions, the first launch was in Binghamton, NY, and the balloon landed in Pawling, NY, near the Connecticut border. The predicted path and the actual path were closer than anticipated, giving the team more confidence in the path predictions.

The Landing Site

The ideal site for the second launch would be at West Point so that many could watch it, However on the 13th, the team decided to not risk a New York City landing, resulting in picking a launch site farther north at Minnewaska State Park. The new payload in this balloon was very different from the original tethered balloon, and contained two Go Pro cameras (one for still pictures and one for video), a temperature recorder, and a Byonics GPS and MicroTrak 300 to provide location updates into the APRS network. The operating SSID of the APRS was W2KGY.

The GoPro camera takes one more shot of the launch crew.

The launch was slightly delayed due to a power problem to the APRS, and it was quickly determined that if the APRS transmitter failed the mission would fail, so it had to be working correctly before the launch. Once the power issue was resolved, the APRS began to function well, and the team was ready for liftoff. A last-minute verification was performed to ensure that the cameras were turned on and recording, and then liftoff!

The Fun of a Launch

The fun really begins once the balloon is launched. The crew was split into two teams: one advance team armed with a Kenwood D710 and smartphones, and the other left behind to gather up the helium tank, tarps, and other miscellaneous supplies required for the launch. Ap-

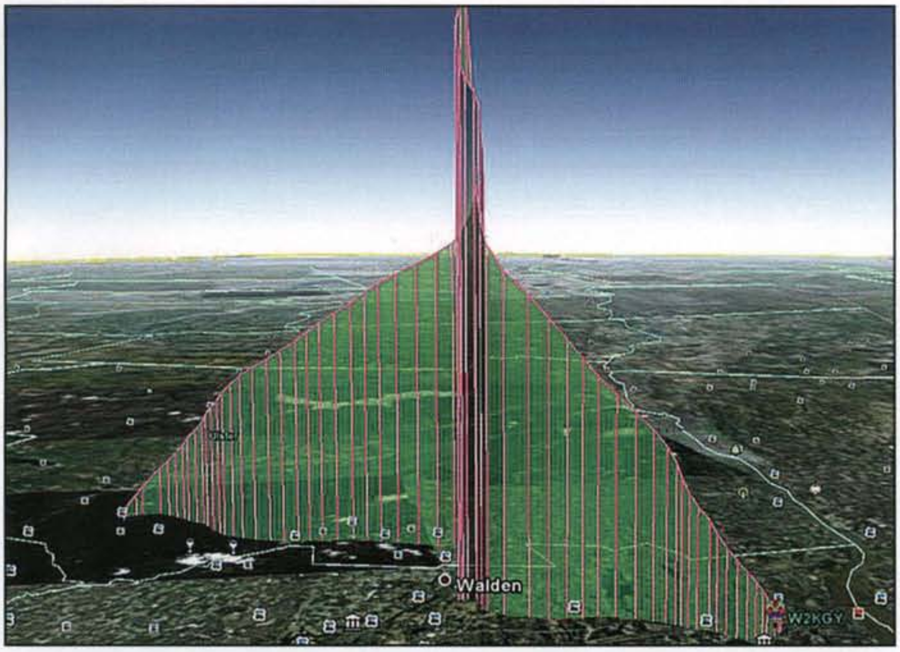
This photo was taken upon recover of the payload. From left to right, mixed front and back: Maj. Diana Loucks, KDØAYR, (P&NE), Cadets: Brett Darden, Robert Glover, Phillip Weigand, Justin Vonsik, Michael Gotschall, Anthony Gonzalez, and MAJ Stephen Hamilton, KJ5HY, (EECS). Not pictured is the West Point public affairs officer, Mike Strasser, who took this photo.

proximately one hour into the flight, the APRS reported 78,858 feet altitude, and immediately after reported 112 feet. The subsequent transmissions reported 0 feet and no coordinates. This seemed familiar, since the first launch had a similar problem where transmissions were not made above 80,000 feet. The difference was that in the first launch smartphones were used for tracking, and there was no ham radio backup. There was suspicion that the battery froze at the high altitude the first time. However, this launch disproved it, as the Kenwood continued to receive APRS transmissions, but the coordinates were not valid. Further research concluded that the GPS on board did not support high altitudes and therefore failed at high altitudes, so it is unknown how high the balloon actually went before the burst and fall back to Earth.

Once the balloon began its descent—approximately seven minutes after the last "good" altitude reading—it reported in at 59,675 feet. It also had not traveled as far south as predicted, resulting in the lead crew ground vehicle turning around and heading toward the city of Newburgh. Excitement and tension grew as the balloon appeared to be heading toward Stewart International Airport in Newburgh, NY. Many discussions began on how hard it would be to recover the payload if it landed on the runway of an airport. "Excuse me, TSA official, can you let me out on the runway to pick up a black duct-taped box and parachute containing video equipment?" That probably would not go over so well, let alone the possibility of any airplane interference. Fortunately, the balloon skirted around the airport, and landed in a parking lot.

The team arrived at the payload seven minutes after it landed, as determined by the video recording. It landed in a near-empty parking lot on an empty parking space, and next to a very busy road. Luck was clearly on the team's side this time, even though it was Friday the 13th!

A short clip of the launch, the balloon burst, and the landing can be found on YouTube at <http://www.youtube.com/watch?v=DPVFXwafskM>. The Facebook page documenting the progress can be found here: <http://www.facebook.com/pages/West-Point-Balloon-Sat/204803066214455>.



Thanks to a function in Google Earth, this photo shows the approximate path, including altitude that the balloonsat took during the time it was airborne.

Some Lessons Learned

• Initially, the camera had a lot of condensation on the weather-proofing enclosure. Adding a desiccant packet would likely resolve this issue.

• The GPS should be rated for the altitude of the predicted path. Byonics now sells a GPS specifically designed to work in high altitudes.

• Test the payload at least a day before by running it and for at least the duration of the flight, and put it in the freezer to mimic the high altitude.

• The tarp was essential in keeping the balloon under control during inflation.

• Run a path prediction a few hours past the anticipated launch time in case of a late start. A change of an hour may significantly impact the potential landing site.

• Simple is better for the payload.

First Look:

The ICOM IC-9100 Transceiver on VHF and UHF

Features editor WB6NOA had the opportunity to use ICOM's new IC-9100 all-in-one HF to UHF radio. Here he explains how it well performed for him as he listened to the Hawaii beacons on 2 meters and 70 cm. He also describes some of the other attributes applicable to the VHF-Plus enthusiast.

By Gordon West,* WB6NOA

The 2500-mile path to the Hawaii beacon on 144 MHz, 432 MHz, and 1296 MHz always is a challenge for hearing signals, as the tropospheric duct begins to form. On 144 MHz, the 2500-mile distant beacon down on 144.170 MHz can sometimes be missed when local FMers are just up the band running amplifiers. Desensitization from FM signals higher on the band is always problematic for a weak-signal radio.

On 432 MHz, the challenge of hearing the distant beacon is punctuated by 200-ms data bursts coming from my surrounding neighbors' wireless weather stations. On 1296 MHz, the sweeping radar signals will cause most receivers to stumble until the AGC action settles down.

I was fortunate to bring the ICOM IC-9100 to my QTH in California and get a first glimpse of its weak-signal capabilities at the end of this past summer's tropo openings to Hawaii. We had a lingering high-pressure system over the Pacific, and the beacons conveniently were just barely in for some initial comments on this new transceiver.

The ICOM IC-9100 is a $3600 HF/VHF/UHF radio, with heritage in the specialized VHF/UHF IC-910, along with high-frequency heritage in the IC-756 PROIII, with many similarities going all the way back to the IC-746 PRO.

With the summer tropo season fading fast, my first look would be operation on the 6-meter spectacular triple-hop openings, as well as the three beacons out in the Pacific. The power out on 50 MHz was over 100 watts, on 144 MHz was right at 100 watts, and on 432 MHz was 76 watts.

I dropped in the optional UX 9100 1.2-GHz band unit, an additional circuit board ($649), and achieved an easy 25 watts out on 1296.1 MHz.

When the 6-meter band blew open at the end of September, 50-MHz signals were wall-to-wall from the bottom of the band through 50.2 MHz. The selectivity was excellent. Furthermore, my Magic Band buddy down the street caused no desensitization when he was working high-power CW at the bottom of the band, while I was working South American sideband signals just above 50.130 MHz. With *this* rig, I couldn't even tell he was on the air.

The ICOM IC-9100 is easy to move around with its handle and rubber feet. (Photos by the author)

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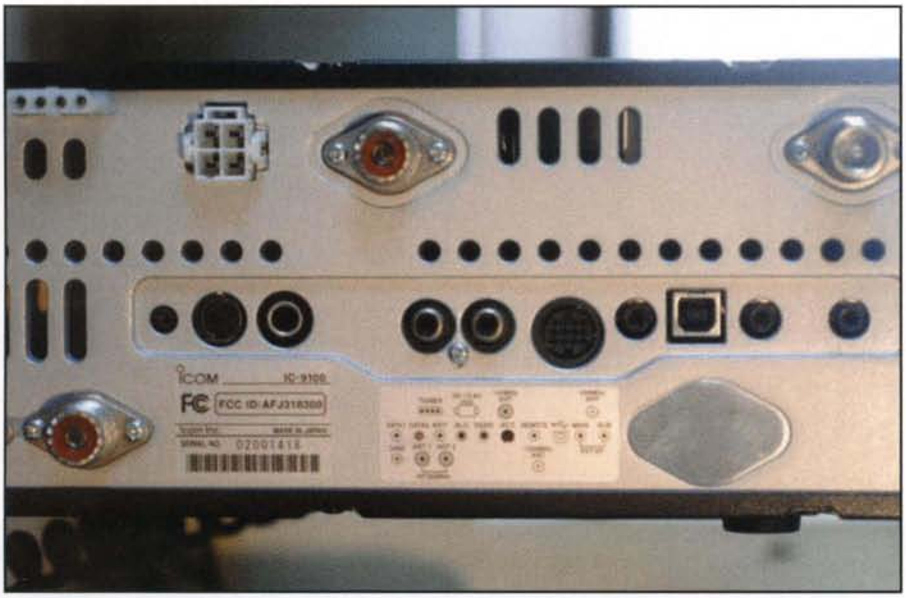


The rear of the IC-9100 is organized simply. Plus, the antenna ports are separated for easy coax connections. The silver cover in the lower right is where the optional 23-cm antenna is located.

The IC-9100 uses dual-conversion superhet receive with the image-rejection mixer, along with a *second* image rejection mixer for each band. I didn't purchase the optional filters, but the 15-kHz first IF filter was sharp enough to mitigate someone down the band from swamping the AGC.

With the two antenna connectors for high frequency through 6 meters, one ran the 4-element beam so I could watch 28-MHz beacons, with the other antenna connection going to the 50-MHz side of the transceiver. The VHF and UHF bands each have their own antenna connectors, with 70 and 23 cm using the N-type connector for each band.

On 6 meters, the adjustable DSP made for simple correction for power-line noise coming off salt-air-encrusted insulators waiting for a much needed winter-rain cleaning. Additionally, for the lady across the street with the living room dimmer light, the noise blanker allowed me to dial in just the right amount of blanking without causing strong signals on 6 meters to become harsh or distorted.

After the 6-meter band closed down, I still kept one side of the receiver on 28 MHz beacons still coming in while going up to 2 meters USB to listen around for beacons in the sub-band.

A very sad note, VHF/UHF legend Wayne Overbeck, N6NB, lost his entire weak-signal operating cabin and museum to a recent wildfire in southern California. All of his certificates were lost. Additionally, all of his gear went off the air—including his signature 144-MHz beacon, which we in southern California relied on for calibration, beam heading checks, and ducting analysis.

Therefore, without those local beacons to reply on I turned the stacked pair of long boomers out to Hawaii, made sure squelch was absolutely *off*, and cranked in digital signal processing to hush the white-noise hiss. Then I put the other receiver on 70 cm and did the same things. I noticed that the fast-acting noise blanker did a great job of mitigating the data bursts on nearby wireless weather station transmitters in the 70-cm band.

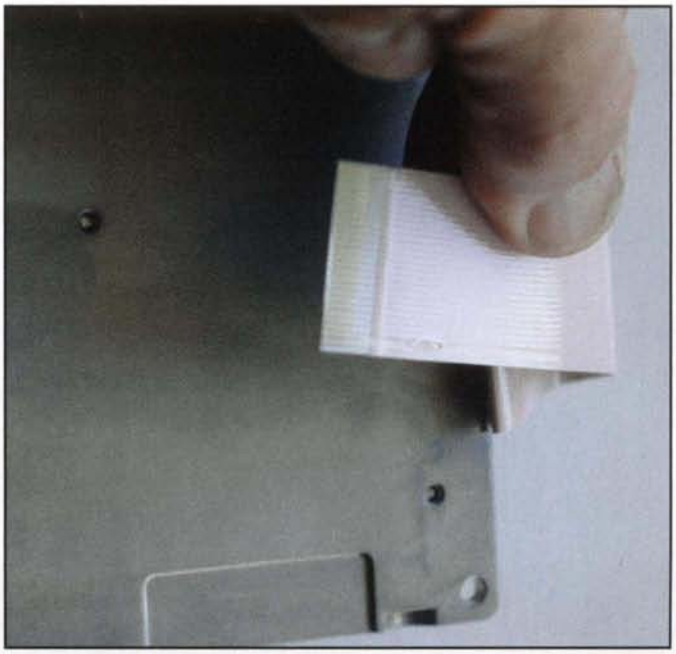
A couple hours later, my wife Sue, N6GLF, said she was hearing the 2-meter beacon from Hawaii. That beacon has a slight warble at the end of the sequence. Sure enough, this new transceiver was hearing a 75-watt signal on 144.170 MHz, 2500 miles away.

The 432.075-MHz beacon came up next in the other receiver. I was captivated to watch both signal strengths peak and ebb in unison. In all, my tropospheric-ducting monitoring, usually with three different transceivers with totally *non*-identical receiver schemes, was verified by this new receiver, all in one rig.

I have *never* seen the 432-MHz beacon dramatically peak while the 144-MHz beacon takes a nose dive. I have been told that if you are in just the right opening of the duct, a very narrow duct will greatly improve 432 MHz, with 144 MHz dropping out. Before this test with the IC-9100, I had never been able to witness this phenomenon.

Unfortunately, the signals on the 2500-mile path were not strong enough on 144 MHz or 432 MHz to get me much excited about a 1.2-GHz opening to Hawaii. Nonetheless, I listened and then played around with the IC-9100's various DSP-based filters. I found a combination that nearly eliminated ship and shore rotating antenna radar strikes.

Yes, I could tell I was getting swept by a ship's 10-GHz signal at sea. However, the interference was much less than I had been using to receive 1.2 GHz before via



Plugging in the user-installed 23-cm optional box takes just a minute. However, it is important to carefully work in the ribbon cable connection. It is stiff on purpose!

Don Hill, KE6BXT, tunes in the Hawaii beacons at the Orange County (California) Fair ham radio booth.

a transverter. I can't wait for next year's tropo season to begin, usually on July 1, to try out 1.2 MHz SSB.

On all three VHF and UHF bands there was plenty of sensitivity to give me a resting background noise of about S-2. While ICOM America offers $190 each mast-mount preamps, the tropo signals are generally strong enough that the extra gain and low noise floor wouldn't help much. However, if you are into moonbounce or have an extremely long hardline run to your VHF/UHF antenna array, these relatively inexpensive preamps might be in your future.

Although Paul Lieb, KH6HME, didn't judge the opening in September as strong enough to go "up the hill" for a QSO with me, I did make plenty of VHF and UHF tropo contacts to the Bay area, about 300 miles up the coast. Using both the stock microphone with the IC-9100, as well as Heil headsets, transmit audio reports were excellent. Also, there is an audio equalizer function, but I didn't need to change a thing.

Note: When using a Heil headset with this new IC-9100, there is no speaker audio output on one of the center pins of the octal mic jack. One reason is to accommodate the ability of separating bands by right and left channels. Therefore, Heil has an IC-9100 patch cable kit that allows for audio out the back of the transceiver to feed his custom headsets.

For conventional FM work on the 2-meter and 70-cm bands, the ICOM IC-9100 runs cool for extended transmit intervals. CTCSS is built in, along with DTCS tone, both encode and decode.

The new ICOM IC-9100 takes a place of prominence at the WB6NOA amateur radio station.

There are all sorts of scanning modes for the FM operator.

The IC-9100 also takes the plug-in $200 UT-121 digital board for D-STAR. Be sure to get the software, because the popularity of D-STAR is continuing to grow, with new systems coming on the air weekly.

The 200-page, well-illustrated instruction manual has three full chapters on digital voice mode programming, digital voice mode operation, and a full chapter on GPS using the NMEA data format.

The IC-9100 also is satellite-ready, where you might select the satellite downlink frequency on the main band and uplink frequency in the sub-band. Hold down the satellite button for one second. For the weak-signal satellites you may select normal or reverse tracking where both VFOs will keep track of each other. You will always stay on frequency during the satellite pass as you adjust the main tuning knob. For the FM satellites, if you may want to leave the 144-MHz receive band stable, but adjust the 440-MHz band for Doppler shift; that capability also is a slam-dunk! They give you an entire chapter on satellite operation, but get together with your local AMSAT member. Better yet, join AMSAT, support it, while also having the ride of your life on the next satellite pass *(see the "Satellites" column by W5IU elsewhere in this issue for more on the satellites plus AMSAT and how to join—ed.)*.

The International Space Station also is a slam-dunk with the two independent VFOs, or put them into a memory channel with the oddball split.

Yes, an electronic keyer is built in, of course. And yes, during HF RTTY contests the built-in RTTY FSK decoder is fun to watch as the messages pass by!

Aircraft receive? Sorry, no. General coverage on HF goes from a low of 30 kHz up to 60 MHz, giving you the capability to hear the 30- to 49-MHz public safety/forest fire frequencies.

On the 70-cm band, the low is 420 MHz and the high is 480 MHz, giving you receive capability of analog public safety frequencies up at 460 MHz.

Yes, the HF through 6-meter antenna tuner is built in. Yes, packet AFSK operation comes with it too, but I have not yet tried it out.

The front-panel display is a razor-sharp gray background with thick, dark black numbers and letters. No optional color display is available, but if you plan to take this rig out for Field Day or for classroom demonstrations, as I do, the high-contrast display is fabulous to see in direct sunlight. Also, this HF to UHF rig is all in one compact unit, weighing only 23 lbs. Truly, this *is* a rig that will be fun to run for your next Field Day or outside demo.

In future editions of the CQ Communications family of magazines, both in print and online, I'll cover the fabulous HF side of the IC-9100. However, for now, end of summer, the tropo signals are still pouring into the IC-9100 from up and down the Pacific coast. Furthermore, signals that were in the noise with some of my other rigs are now much easier to copy with the IC-9100. Additionally, recovered audio seems to have a "sparkle" that I've not experienced with other rigs.

Most of my other rigs are almost 20 years old. Therefore, it is great to get back to weak-signal work with a new real powerhouse radio. For more information on the ICOM IC-9100, see the manufacturer's specs at: <http://www.icomamerica.com/en/products/amateur/hf/9100/default.aspx>.

Extreme-Range 50-MHz E_s: nE_s or Chordal?

KH6/K6MIO discusses extreme-range sporadic-E. Originally appearing in the 2010 *Proceedings* of the Central States VHF Society's 44th conference, this article is the first of three on sporadic-*E* propagation by the author that are scheduled to appear in *CQ VHF* magazine.

By Jim Kennedy,* KH6/K6MIO

Even in the absence of high solar activity, 6 meters still seems to provide plenty of excitement, and also excellent opportunities for studying ionospheric propagation. The band is on the border between HF and VHF, and thus 6 meters sits at the edge of what's possible for ionospheric propagation. Unlike HF, when 6-meter propagation *does* occur, it often shows only one or two modes at a time, making it easier to sort out what's going on.

In the midst of a large number of expected, "ordinary" events, it is not uncommon for it to take some time to recognize that what at first may appear as a small number of unusual events (what statisticians call "outliers") may form a distinct, consistent pattern of their own and be a unique new class of events. The various extreme-range propagation processes discussed here seem to fall into this category.

This is the first of a series of articles that discusses a variety of very long-range propagation mechanisms that have been seen on 50 MHz, especially in the recent periods of low solar activity. For reasons to be discussed here, they appear to be either forms of sporadic-*E* propagation (E_s) or to intimately *depend on* E_s, perhaps in *conjunction with other forms* of propagation. Two specific patterns have repeatedly demonstrated propagation distances (ranges) beyond 9,000 km, and in some

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e-mail: <jimkennedy@hawaii.rr.com>

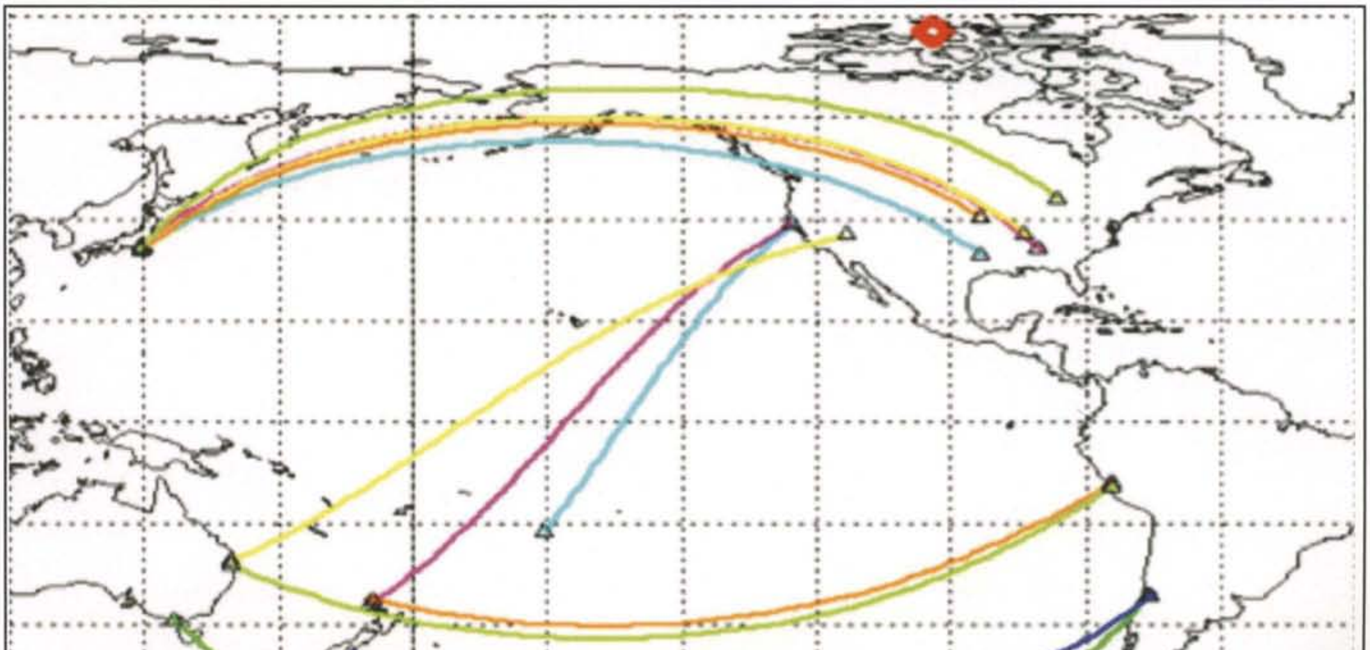

Figure 1. These examples of actual paths were observed between 2006 and early 2011. The east-west paths in each hemisphere occur during the local summer E_s season. The north-south path between southern Oceania and North America occurs during the southern summer E_s season.

cases, beyond 15,000 km, as shown in figure 1. These are:

- East-West paths whose endpoints are confined entirely to either the Northern or Southern Hemisphere, and
- North-South paths that cross the equator with an endpoint in each of the Northern and Southern Hemispheres.

The East-West Paths

Though quite long in absolute terms, technically, the links in question are "short-path" events. That is to say, they do *not* go more than half way around the world. The known paths in this category currently include multiple openings between:

- Europe (EU) and Japan (JA) and other points in eastern Asia,
- Japan and environs, and North America (NA),
- North America and Europe, and finally
- New Zealand/Australia and their environs, and western South America (SA)

The rather shorter path between Japan and the *Pacific coast* of North America has been observed many times since at least June 1977. More recently, the path between Japan and the *central and eastern regions* of the U.S. and Canada, and the Caribbean has been noticed and attracted a lot of attention. Similarly, the path between western and central North America and Europe has been active, as has the path between Japan across Asia to Europe and the Mediterranean. In the last two years, the Southern Hemisphere path between the west coast of South America, and New Zealand and Australia has emerged.

For the last several years there has been some controversy over *what* causes this propagation and even *where* in the ionosphere it occurs. The primary focus of this first article is to explore possible answers to these underlying questions, as they relate to what appears to be the "easier" case of the east-west paths. Later articles in this series will broaden the discussion.

Some Relevant E_S Characteristics

Sporadic-*E* has a number of characteristics that make it rather different from the F2 layer. E_s occurs at a height of about 100 km, while F2 occurs at about 275 km and above. The E_s ionization process is rather different and more complex than F2. Finally, the morphology of E_s clouds is also quite different from F2. Collectively, these lead to a variety of unique conditions:

E_s clouds are *very* thin vertically: tens of meters to a few kilometers.

They are also smaller than F2 horizontally: averaging around 100 km.

Large areas of ionization are actually swarms of smaller individual clouds.

E_s clouds are in motion horizontally and vertically (usually descending).

Vertical stacks of two, three, or even more layers are fairly common.

Tilted layers are common, at times by 15 degrees or more with respect to the horizontal.

The underside of an individual cloud can be curved or rippled, rather than flat.

Different E_S Latitude Zones

Sporadic-*E* behaves differently depending on the *latitude* zone through which the path passes. The characteristics of these various zones can be markedly different than that of the adjacent zones, so it is important to know which zone (or zones) the path traverses between the two endpoints.

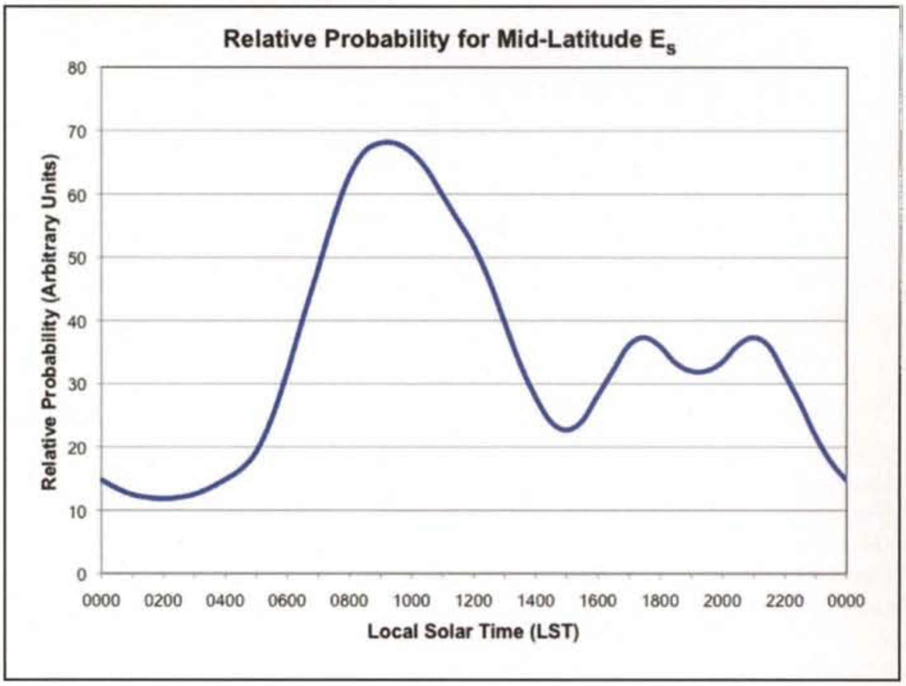

Figure 2. This stylized view of the typical diurnal behavior of mid-latitude E_s shows that the propagation probability often peaks during two time periods, a morning period and a double late afternoon and evening period.

Hop	Min (km)	Max (km)
1	1,700	2,200
2	3,400	4,400
3	5,100	6,600
4	6,800	8,800
5	8,500	11,000
6	10,200	13,200

Table 1. Ground footprints for successive nE_s hops.

The basic *geomagnetic* zones are the: Equatorial Zone, Mid-latitude Zone, Auroral Zone, and the Polar Zone. The two most important ones for the east-west propagation are the mid-latitude and auroral zones.

Mid-latitude E_s: The mid-latitude zone will be the primary subject of these discussions. While much that can be said about this regime, there are a few things that are especially important for this discussion.

Times of Year – The E_S Seasons

Mid-latitude Es has a pronounced seasonality, with a major peak in the local summer and a minor peak in local winter. This is thought to be the result of the enhancement of the number density (N_e) of long-lived metal ions caused by the vaporization of sporadic meteors in the E layer. In the *daytime*, the tilt of the northern and southern hemispheres faces them forward in the direction of the Earth's orbital motion around the Sun. The angle of this tilt is optimal during the *local* summer for its hemisphere to encounter the maximum amount of meteoric material at highest relative velocity (Haldoupis, et al. 2007).

Times of Day

There are systematic diurnal variations favoring roughly 0630 to 1230 Local Solar Time (LST) and a smaller peak around 1530 to 2200 LST (e.g., Whitehead 1989 and Jackson 2010). This diurnal dependence is linked to *tides* in the Earth's atmosphere, primarily caused by the Sun heating the daytime-side of the atmosphere. This causes it to expand upward. Then, after sundown, it cools and contracts again. This generates at least three harmonic frequencies in the tides, corresponding to once a day, twice a day, and three times a day (Haldoupis et al. 2004). This produces a variation in the local probability of E_s propagation, such as described in Figure 2 (based on work by E. K. Smith, in Davies, 1990).

Typical Path Ranges

Single-hop E_s paths ($1E_s$) out to 2,200 km and double-hop ($2E_s$) out to 4,400 km are fairly common, especially during the local summer: mainly May, June, and July in the Northern Hemisphere, and December, January, and February in the Southern Hemisphere. Three-hop paths ($3E_s$) out to about 6,600 km certainly do happen, but are less frequent.

Auroral E_s

It has been proposed that auroral E_s would play a negative role in extreme Es propagation. Auroral E_s is primarily a *nighttime* event, linked to the auroral electrojet and the auroral oval. If the path traveled from the mid-latitudes into the auroral zone, then the path should fail, since the east-west propagation is basically a *daytime* event, with mid-latitude E_s diurnal patterns.

The boundary between the mid-latitude and the auroral E_s zones is quite abrupt. While the boundary is often stated as about 60° north (or south) *magnetic* latitude, the *actual* value is very dependent on the *time of day*. The *daytime* side of the oval is pushed noticeably *poleward*, while the nighttime side is pushed correspondingly equatorward. During periods of low magnetic activity (common in recent years) the dayside auroral E_s boundary can be pushed as far poleward as 75° and more (Hunsucker and Hargreaves, 2003). Under these daytime conditions, the mid-latitude zone extends much farther north than the "typical" 60°N.

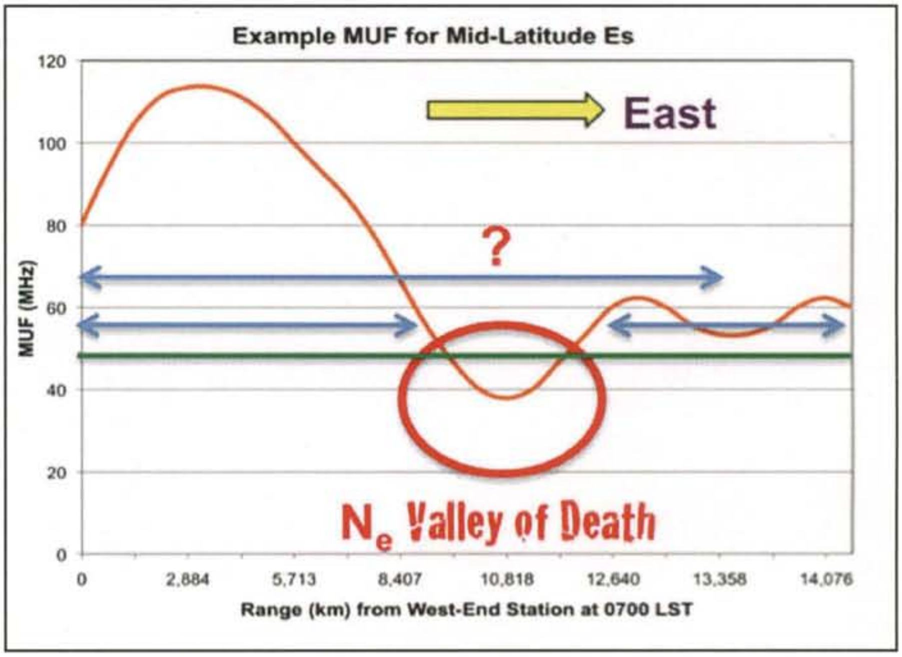

Figure 3. Figure 2 scaled to show the possible MUF eastward from the west-end station (at 30° latitude) at 0700 Local Solar Time. The green line shows 50 MHz. Skip out to about 8,500 km ($4E_s$) is between stations within the same E_s window—early to early. Late to late is also possible. Skip much beyond 8,500 km must somehow bridge the "Valley of Death" MUF gap.

East-West Extreme E_s Propagation (EWEE)

As noted, during the summer Es season there are many well-documented episodes in which short-path 50-MHz propagation has occurred over distances from 8,800 km to more than 13,000 km. If these are viewed as cases of "ordinary" multi-hop nE_s, then they represent at least four to six hops ($4E_s$ to $6E_s$). Table 1 shows the approximate near and far edges of the ground footprints for successive E_s hops (Kraft and Zimmerman, 2009). Especially for the distances *exceeding* three hops, there has been considerable speculation about whether these longer paths are the result of ordinary nE_s skip or some other mechanism(s).

The SSSP Hypothesis

Higasa (2006 and 2008) called special attention to this extreme-range phenomenon, referring to it as "Short-path Summer Solstice Propagation," or SSSP. He also raised the possibility that it might involve something *distinctly different from nE_s*. His concerns were possible:

- Excessive signal losses due to multiple D-layer transits,
- Excessive signal losses from scattering at the intermediate skip ground points, and
- Loss of the daytime path due to blockage at the auroral Es boundary (at 60°N).

He felt that these accumulated path losses would leave too little signal after five or more nE_s hops. He proposed that something else was happening in the middle of the path to keep the signal level up. Higasa, and subsequently Kusano and Obara (2007), suggested that in between the first and last skip points in the ionosphere the signal was *not* coming back to the ground on the *intermediate* hops.

The notion was that at the path's first and last ionospheric skip points there was a condition that deflected the signal path more or less parallel to the Earth's surface, instead of back down to the ground. Thus, as it went down stream, it would hit the ionosphere again, not the ground. The signal would repeat this horizontal skipping until the last skip point in the path. Here, another condition, like the first skip point, would finally deflect the signal path back down to the ground. These suggestions will be discussed in detail shortly.

Higasa further suggested that the processes might even include some form of the Polar Mesospheric Summer Echo (PMSE) process, which is basically a D-layer effect.

An Additional Mid-Path MUF Issue

There is another challenge for very long east-west E_s paths that was *not* considered in these earlier studies. These long paths necessarily involve large changes in longitude between the two end points. Thus, the Local Solar Time at the east-end station is many hours *later* than that at the west-end station.

In this regard, the information in figure 2 can be viewed in another way, in which *time* is *fixed* (as in a snapshot) at the location of the west-end station. If this is done, then its horizontal *time* axis can translated into a *distance* eastward from the west-end station. Let us further suppose that the figure 2 MUF probability can be *scaled* as a reasonable *proxy* for the actual *value* of the MUF itself over the path in question. This results in figure 3, showing the MUF from the west-end station looking toward the east.

Note that the MUF minimum between the early window and the late window can dip *below* 50 MHz. Often this seems to be the case, *but not always*. When it *does* dip below 50 MHz, then the only eastward stations *accessible* to the west-end station are those that are still in the *same* early window as the west-end station.

Much farther out, the stations within *their* late window can communicate with each other. But the N_e electron-density *gap* in the middle (the N_e "Valley of Death") would stop ordinary multihop nEs skip from going between the early and the late windows.

As a result, *in addition* to Higasa's specific concerns, there is yet another reason to explore mechanisms that might somehow provide alternative means, such as chordal and ducting, to connect the end-point stations in the opposite (early and late) windows.

Possible Mechanisms

Whatever the nature of the propagation, be it nE_s, chordal, SSSP, or something else, it will consist of some combination of effects that are allowed by Nature's rules of the game. The starting point is how the ionospheric free-electron density and the angle between layer and the upcoming signal ray path are related to the maximum usable frequency (MUF).

The M Factor

If a wave is launched vertically straight up—at a 90° angle to the ionospheric layer above—the layer will reflect the signal straight back down *if* the signal frequency is at, or below, the so-called *critical frequency*, f_0. Put another way, f_0 is the MUF in MHz for a signal going straight up and skipping straight down again. The critical frequency only depends on the variable N_e—the free-electron number density.

$$f_0 = \sqrt{\frac{N_e e^2}{4\pi^2 \varepsilon_0 m}} = \sqrt{N_e} \times (9 \times 10^{-6})$$

In this case, N_e is the number of electrons per cubic meter, while the constants are the charge of the electron (e), the permittivity of free space (?0), and the mass of the electron (m).

The value of f_0 can be determined fairly easily with a vertical-incidence ionosonde. However, one needs to be able to relate f_0 to the MUF at more useful angles, such as those actually used for communications. Fortunately, there is a simple relationship between f_0 and the *angle* between the signal path and the layer, and the MUF (f_{max}).

$$f_{max} = \text{cosec}\ (\alpha)\, f_0 = M f_0$$

M (a *multiplier* called the *M Factor*) is cosec (α), where α is the angle between the signal path and the plane of the bottom of the E-layer cloud (the angle of attack). The lower the transmitted angle of radiation, the smaller the value of *a*, the bigger the value of *M*, and the higher the MUF—all *without changing* the free electron density! Moreover, the following sections will show that there are other special circumstances that can change the ray path *after* the signal has left the antenna and that can result in very shallow angles of attack and very high, but *localized*, MUFs.

SSSP Hypothesis Scenarios

All the SSSP scenarios rely on some way to propagate signals for long distances without significant ground interactions. In general, this would be a three-step process, each of which requires certain ionospheric conditions at *every* skip point.

Insertion (*First skip point*)—The *first* skip point must *redirect* the *steep-angle* of the upcoming signal ray path so that it is *inserted* into the beginning of the series of *shallow-angle* intermediate hops.

Long Haul (*Intermediate skip points*)—The *intermediate* skip points must support *shallow-angle* forward propagation without coming to Earth.

Recovery (*Last skip point*)—The *last* skip point must *redirect* the intermediate-hop *shallow-angle* signal into a *steep-angle* ray path, to point the signal back down to Earth.

Figure 4 shows examples of some of the possibilities. As one might expect, the *Insertion* and *Recovery* steps are really the same kinds of processes, with the signals going in opposite directions. Hence, it is useful to break the communications path into categories: the required end-point conditions and the required intermediate-hop conditions. The long-haul intermediate hops are discussed first.

Intermediate Hops—The Long Haul

There are at least three plausible mechanisms for paths with no, or very weak, intermediate hops: chordal hops, E-layer ducting, and progressive refraction. These are all phenomena that have been observed in other contexts (Davies, 1990; Kennedy, 2000 and 2003). It is significant that chordal hops and ionospheric ducting both depend on the higher value of MUF due to the shallower the angle between a signal path and the ionospheric layer.

Chordal Hops

If the upcoming ray path from the ground-based antenna was somehow bent away from its original path, so that it hit a sporadic E cloud at a much shallower angle (called "grazing incidence"), then the signal could skip off the cloud, also at a shallow angle, with a *much lower* free-electron density than normal.

The skip angle would not be enough to return the ray path to the ground, but it could send the path forward nearly parallel to the Earth's surface. The path would eventually run into the E-layer again farther downstream, *without* ever

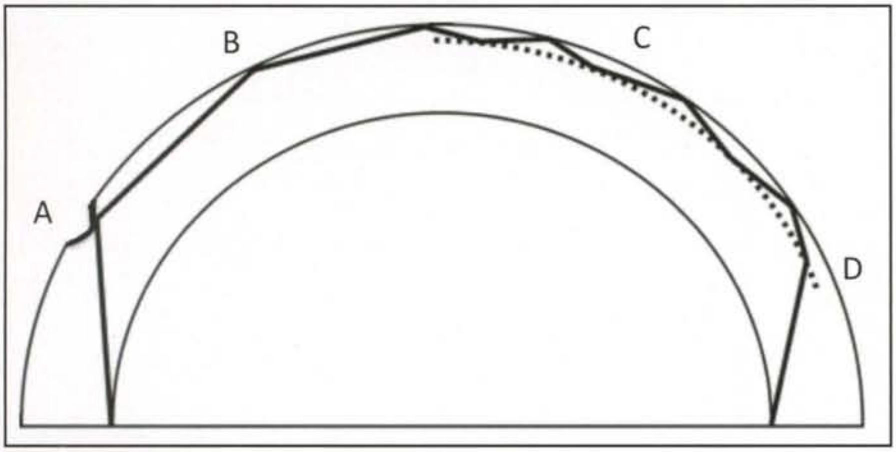

Figure 4. Combining several possibilities on one graphic: Point A shows a curved/tilted Es producing a shallow-angle ray path; B shows the resulting chordal hops; C depicts between-layer ducting; and D shows stratified refraction redirecting the ray path to the ground.

hitting the ground (figure 4, left), as a *chordal* hop. The *second* encounter with the E layer would still be at a very shallow angle, and this could produce yet another chordal hop, and so on. If suitable clouds were available farther downstream, this could go on until something else bent the path *sharply* enough to bring it back down to Earth.

E-layer Ducting

The E_s review by Whitehead (1989) points out that it is not uncommon for mid-latitude E_sE_s to be *vertically stratified* into a series of thin, stacked layers, usually spaced about 6 to 10 km apart. If, the ray path were nearly horizontal in the E region, it could get caught *skipping in a duct between* two or more stratified E_s layers—one above the other (figure 4, right).

Like chordal hops, all the skips between the layers would be at grazing incidence, so the MUF would be much higher than it would be if the ray were arriving at usual angles. The duct would not have to be continuous, either. It would only require that at several strategic points along the way there were appropriate layers to capture the signal and bend it on around the path.

Progressive Refraction

The signal could be *refracted* by a continuous weakly-ionized E-layer (or even the F-layer), such that the ray path was gradually bent around, roughly following the curvature of the Earth. This differs from ducting in that there is no real specular "skipping." The ionosphere would behave like a lens. While technically possible, this process is very *unlikely* here. It usually requires a vertically thick ionized region, which is quite the opposite of what is seen in sporadic-*E*.

Earth-to-Sky and Sky-to-Earth

The question then becomes, how did the upcoming wave get bent around at the beginning and pointed into the chordal hop or duct (or progressive refraction) in the first place, and how does it get turned around again at the end and come down? Here again, there are multiple possibilities.

Tilted and Curved Layers: While the ionosphere is often thought of as having single layers that are smooth and parallel to the Earth's surface, Whitehead (1989) also points out that it is common for Es clouds to be vertically *tilted* up to *15° or more*. At times, their lower faces form small-scale curved surfaces.

One way that the upcoming wave could be bent around to a grazing-incidence angle for chordal hops or E-layer ducting would be if the *upcoming* signal ray encountered a *adequately ionized* tilted or curved layer. Since the layer tilt or curved surface would make the angle of attack lower, the MUF would be higher than normal[1] and it could bend the ray path around and point it into a chordal hop, a

Figure 5. 2 July 2000, this shows the grid-square distribution worked from Hawaii. The regional population densities and skip gaps are reflected in the distribution of the squares worked. (Map credit Google Maps)

duct, or whatever. At the far end of the path, the same process in reverse could bring the wave back down to Earth.

Stratified Refraction: There is another less probable insertion/recovery possibility requiring at least *two* stratified E_s layers, with the lower of the two layers being *less* ionized than the upper layer. The *upcoming* signal might pass *through* the lower layer, but be *refracted* just enough so the ray path was bent over and hit the upper, *more* ionized, layer, which then skipped the signal forward nearly horizontally. Like Progressive Refraction, it is not very likely at 50 MHz in the E layer.

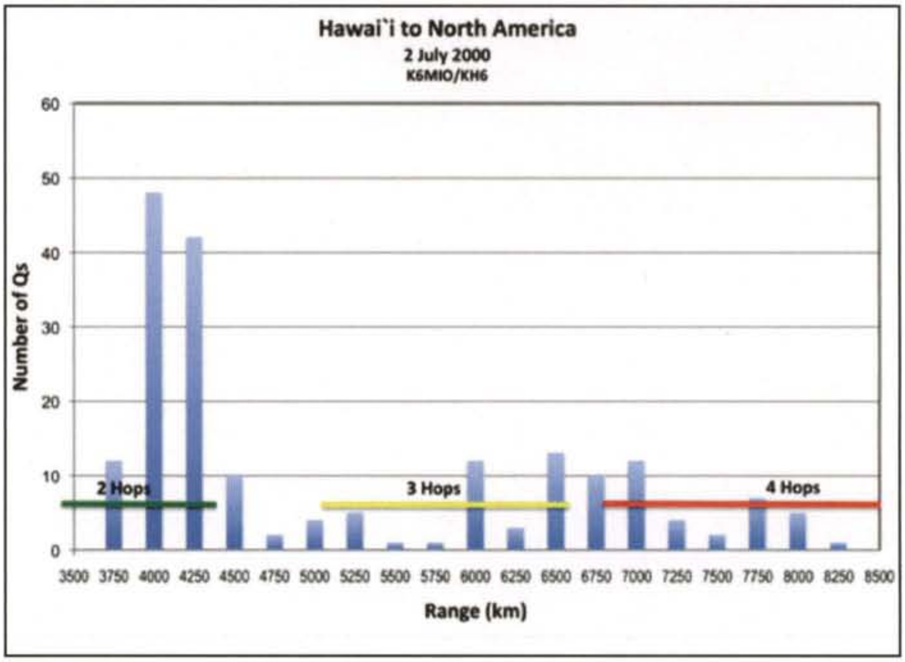

Figure 6. The number of stations worked is reflected in the distances, regional population densities, and the approximate radial locations of the various skip footprints.

Some Initial Observations

There is an axiom that says, "When you get done with all the theory, then you have to go out and *measure* something." Otherwise, the theory is without any practical basis.

Chordal and Ducting – Did It Reach the Ground?

A key question is whether the intermediate hops came down to earth *between* the endpoints. This would be easy to tell for a double-hop path over well-populated land. One would simply look for signals propagating to or from the intermediate ground point. However, this is not always easy, or even practical, on very long paths due to the geography.

There are four factors that determine whether an intervening hop came to Earth:

• Path line itself (usually a Great Circle, but not always),

• Geographical location of the ground footprints (water, smooth or rough terrain, etc.),

• Population density within those footprints (is anybody there to listen or be heard?), and

• Distance, in terms of longitude (what time is it at each *skip point*?).

A study was done to look at this by examining two different, well-documented, cases of openings at four-hop ($4E_s$) *equivalent* distances between Hilo Hawaii and the North American Mainland. This path is particularly useful because, although the first eastward hop lands in the Pacific, the subsequent hops two, three, and four all land in populated areas of North America, making it possible to determine with some confidence whether or not those last three hops came to earth in the normal way.

Hawaii – 2 July 2000

In the case of 2 July 2000, 206 QSOs were logged with stations in North America. It was possible to identify credible grid squares for 193 of these stations. The latitude and longitude of the grid-square centers for each of the 193 stations were determined and the Great Circle distance calculated between Hilo and each station's *grid square* center point. Figures 5 and 6, respectively, show the geographical location of each grid worked (often many stations in a grid), and a histogram of all the *stations* worked, as a function of path length.

Both figures show that the Hawaii signals did indeed come to Earth at hops two, three, and four. Figure 6 also shows evidence of the gaps shown in Table 1 *between* footprints, which get smaller as the hop count goes up. From hops four and beyond, the adjacent footprints overlap each other.

One should note that:

• $1E_s$ was in the ocean, so there is no information about whether it came to earth on not,

• $2E_s$ dominates, *as one might expect*; it was the closest and the signals were the strongest,

• 2–$3E_s$ long gap out to 5,750 km probably reflects the low population density at that range,

• $3E_s$ picks up toward the east end, probably due to larger population density,

• $4E_s$ produced a number of contacts, also probably influenced by population density.

There were always some signals in the gaps *between* footprints. No doubt this results from the footprint-size calculation assuming that the ionosphere is both *smooth* and *perfectly spherical*. The appearance of signals in the gaps is evidence that this is not really the case, as smooth and spherical are over simplified assumptions. Sporadic-*E* layers generally are *not* smooth and *not* flat. This leads to scattering by irregularities in the layer(s). (There will be more discussion of this point later.)

One can then conclude that the 2 July 2000 opening looks like what one would expect for nE_s—many strong signals close, fewer and weaker signals at each hop farther away.

Hawaii – 6 July 2009

The 2009 opening was another outstanding opening from Hawaii; 183 stations were worked and 167 had identifiable grid squares. However, the plots reveal that it was a quite different open-

Figure 7. The 6 July 2009 grid-square distribution worked from Hawaii. Only a handful of stations and grids were worked for hops two and three. (Map credit Google Maps)

ing from the one in 2000. In some important respects, figures 7 and 8 paint essentially the *opposite picture* from figures 5 and 6, especially at hops two and four:

• 1E_s still has no population, so it isn't clear what happened there,

• 2E_s has a *huge* population, but only a *few* (*weak*) stations compared to later hops,

• 2–3E_s still have a population-density gap that goes well into hop three,

• 3E_s is about the same as the 2000 event,

• 4E_s *dominates* the whole scene, and the signal levels were fairly *good*.

E-layer scattering still probably accounts for the signals in the gaps and those seen at the second hop. There is no 5E_s information; from Hawaii both 5E_s and 6E_s land in the Atlantic Ocean.

Unlike the 2000 opening, the *inverted* 2009 skip-range distribution shows that little of the signal came to Earth at hop two, and that hop three was better. However, hop four was strong and in good shape. This supports the notion that, in the case of *this* opening:

• Most signals propagated over the top of the hop two landing footprint.

• Quite usable signal strengths were delivered to the hop-four footprint.

• Hops three and four are, at least, *consistent* with the Higasa, and Kusano and Obara view that their SSSP may be due to the intermediate-hop ray paths *not* reaching the ground. It suggests that chordal-like hops do occur at times.

Japan – 3–4 June 2006

Looking at the JA–NA path itself, Kusano and Obara showed 2006 data from Yoshi Miyamoto, JM1DTF. Two contiguous days of those North American openings were processed the same way as the Hawaii data. In addition to the fact that these two contiguous openings demonstrated at least a five-hop range, the key things to note in figures 9 and 10 are:

• 1E_s and 2E_s from JA have no populations at all (over water),

• 3 and 4E_s has *almost* no population (very rural areas),

• 5Es ***dominates***—quite *large* population, but with *weak* signals (most were on CW),

• 6E_s is out of land, except for some of the Caribbean islands.

It should also be noted that during these two days it is not known if the ray path came to Earth at hops one, two, or four. While there is no available information about signals at these specific points, Jimmy Treybig, W6JKV was operating in Alaska during a different, but similar, opening. He reported hearing only the Japanese-end stations and that they were "at ESP levels for hours," which is consistent with weak E-layer scattering out of a main overhead path.

Certainly these findings are *consistent* with *some* of the notions of Higasa, and Kusano and Obara. However, they are also *not* conclusive. There is too little information to tell whether some or all of the intermediate hops really returned to earth or not.

Local Solar Times—Path Wide

Since the diurnal E_s MUF peaks in the morning and late afternoon/evening, another question is whether long east-west paths, with their two end skip points so widely separated in both space and time (around nine to ten hours LST), exhibit any LST preferences for the *path* as a whole.

Figure 11 shows scatter plots of each contact *greater than 8,500 km* against the west-end LST on the vertical axis and the east-end LST on the horizontal axis. The top plot shows the *northern* summer 2006 JM1DTF openings. The bottom plot shows the known *Southern* Hemisphere summer 2009–10 events, which occurred between Bolivia and Chile, and New Zealand and Australia. The longest range for these contacts was between OA4TT and VK4CZ, at just over 13,000 km, which is the equivalent of six full hops.

These $5E_s$ and $6E_s$ equivalent-distance contacts occurred between about 0730 and 1200 LST for the west-end stations and between about 1530 and 2000 LST for the east-end stations.

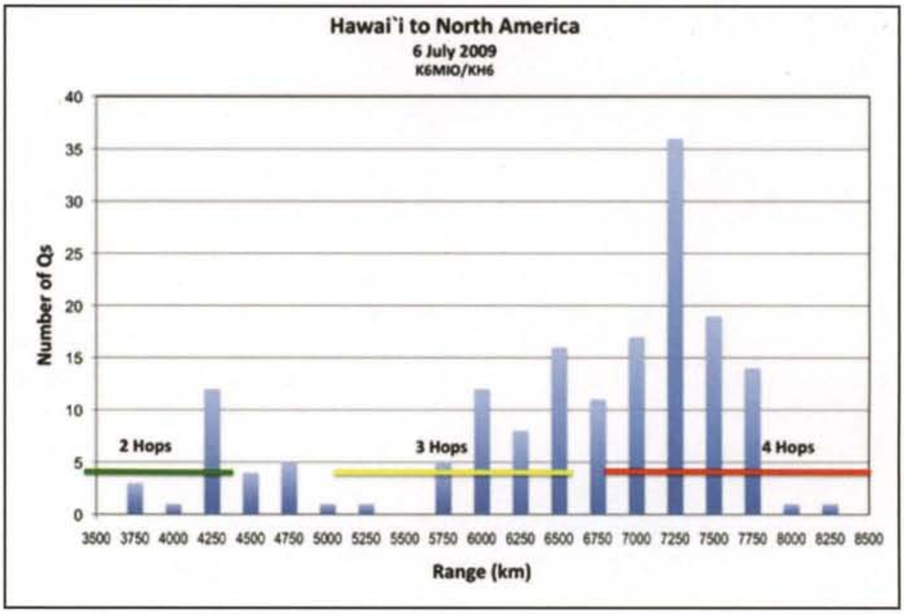

Figure 8. The distribution of stations is inverted from what one would expect. The further away the stations were, the more of them were worked.

Early Window on Late Window

Figure 11 strongly suggests that the LST near the path *endpoints* may be much *more* important than the *midpoints*. These paths seem to work best when the west-end stations are enjoying their (figure 2) morning E_s window, while the east-end stations are enjoying their afternoon-evening E_s window. It certainly appears that the first and last skip points need to be in the most favorable positions possible in order to make most of these links actually work.

Discussion and Conclusions

While there are no complete answers in every case, there are some comments and some preliminary conclusions that can be made.

Is It Some Form of Es?

The Early-on-Late Window effect seems to be pervasive for the extreme paths studied here, that is paths clearly exceeding normal $4E_s$ distances (8,800 km and beyond). While the east-west longitude difference between the two stations sets the LST time difference (about 9.5 hours, give or take), the key issue is the specific time of day that the difference chooses to appear (west-end 0630—1230 LST; east-end 1530–2000 LST). Adding to the discussion is the fact that Figure 2 also shows that the probability of E_s propagation is very low in the later nighttime hours.

These observed patterns strongly suggest that the propagation occurs at times when the first and last hops are in their respective optimum time windows for E_s to occur. The west end is in the morning E_s window, and the east end is in the afternoon-evening window, *and* the whole path *between* them is in daytime (daytime E_s is much more likely than late at night). This leads to the conclusion: *The entire end-to-end path very likely is the result of sporadic-E processes.*

Is It nE_s or Chordal/Ducting?

From a strictly observational perspective, it is very hard to distinguish chordal hops from skip-ducting hops, without some additional data, such as same-time ionograms at the expected skip points. So for now, one must be satisfied to treat them as the same class of event.

The $4E_s$-distance paths in the 2000

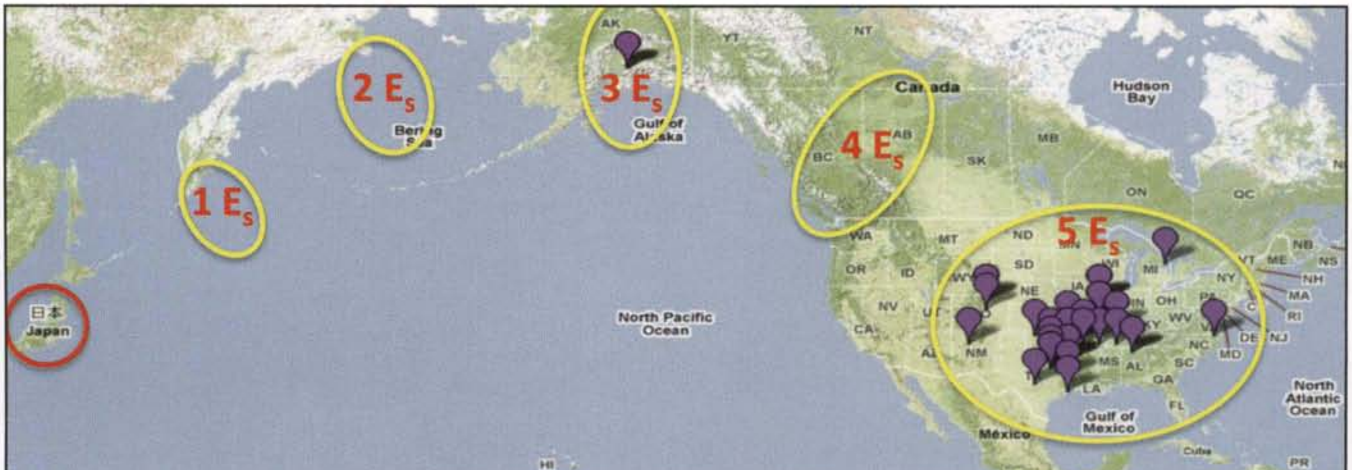

Figure 9. The Great Circle path from Japan goes northeast over water, turns southeast over Alaska, and east of Vancouver to the eastern U.S. It requires five hops; the first two would land in the ocean (also see figure 7). ((Map credit Google Maps)

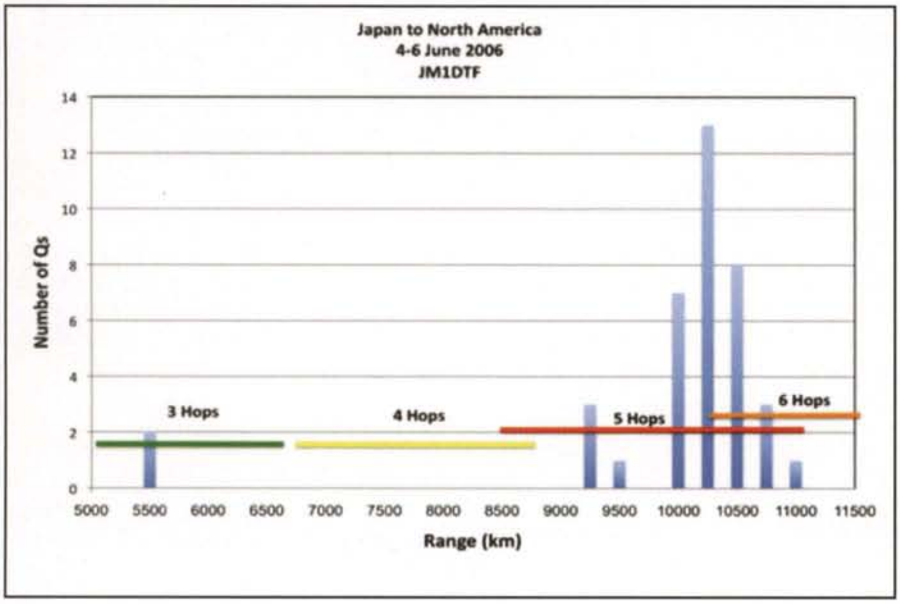

Figure 10. With the exception of two contacts at three hops (Alaska), all of the contacts were made at five-hop distances, demonstrating a typical case of what has been labeled SSSP.

KH6–NA opening provided fairly strong evidence that $4E_s$ most likely occurred, and it occurred with workable signal levels. Although hop one landed in the ocean, clearly hops two, three, and four all were there.

With the very same paths and distances, the 2009 KH6–NA opening provided fairly strong evidence that at least some of the hops were chordal/ducting in nature. In this case, E_s conditions in western NA were also known to be very poor that day. Again, hop one was in the Pacific, but the scarcity of contacts and the weak signals at hop two really behaved like scattering from the overhead path, suggesting that hops three and four were fed by a chordal or ducting process.

Taking the signal levels at face value, it appears that both the 2000 and 2009 openings were more or less equally capable of going the equivalent $4E_s$ distance.

Bridging the Valley of Death

In looking at nE_s versus chordal and ducting mechanisms, it must taken into account that there are at least two obvious situations that allow the Early and Late Window stations to communicate with each other:

1. E-layer chordal or ducting propagation across the N_e gap, which can succeed with a much lower electron density, or

2. Sufficient overall ionization so that the dip between the Early and Late windows never gets *below* 50 MHz (very long nE_s).

The evidence so far is *consistent* with both of these mechanisms working *at times* for paths greater than about 8,800 km. However, it is not conclusively in favor of either one (Kennedy, 2010). It is also fair to argue that $4E_s$ distance is not 5Es distance, and that these shorter paths may not predict what happens at the equivalent $5E_s$ and $6E_s$ ranges.

Neither nE_s nor chordal/ducting, can be eliminated as the possible mechanisms for either the end-point or mid-path hops on the extreme east-west paths.

Relationship to the Full SSSP Hypothesis

It is clear that some aspects of the SSSP hypothesis may well be correct. While nE_s has not been *excluded* as a player, neither has chordal/ducting. In fact, positive evidence has been presented for chordal/ducting occurring in *some cases* with sporadic-*E*. However, time and more study seems to have eliminated the more exotic suggested SSSP mechanisms.

Absorption and Scattering Losses

Calculations show that D-layer absorption losses are really quite small at 50 MHz, and are not likely to be an important factor. Though likely higher, nE_s ground scattering losses probably aren't as high as feared. *If* nE_s hops are happening, the longest-range conventional skip hops occur when the signal ray path only grazes the Earth's surface, rather than fully colliding with it. In these maximum-hop-length cases, the ground scattering losses would likely be much lower than for shorter individual hops.

It is also clear that on the JA-NA path, at least two of the hops would have brushed past the ocean. The scattering losses here would have been particularly low, since seawater is an excellent conductor and the signal is approaching a grazing incidence, and most of the time the ocean's surface is rather smooth, compared to mountains, forests, and big cities.

Finally, while it is true that chordal-like hops in the F2 layer may have relatively low scattering in the ionosphere (if away from the geomagnetic equator), the dynamic and fragmented structure of swarms of E_s clouds (that would cause the chordal-like hops) would themselves be a source of scattering losses. The KH6-NA nE_s and chordal openings showed that the signal strengths from the far end of the path were more or less comparable in both cases.

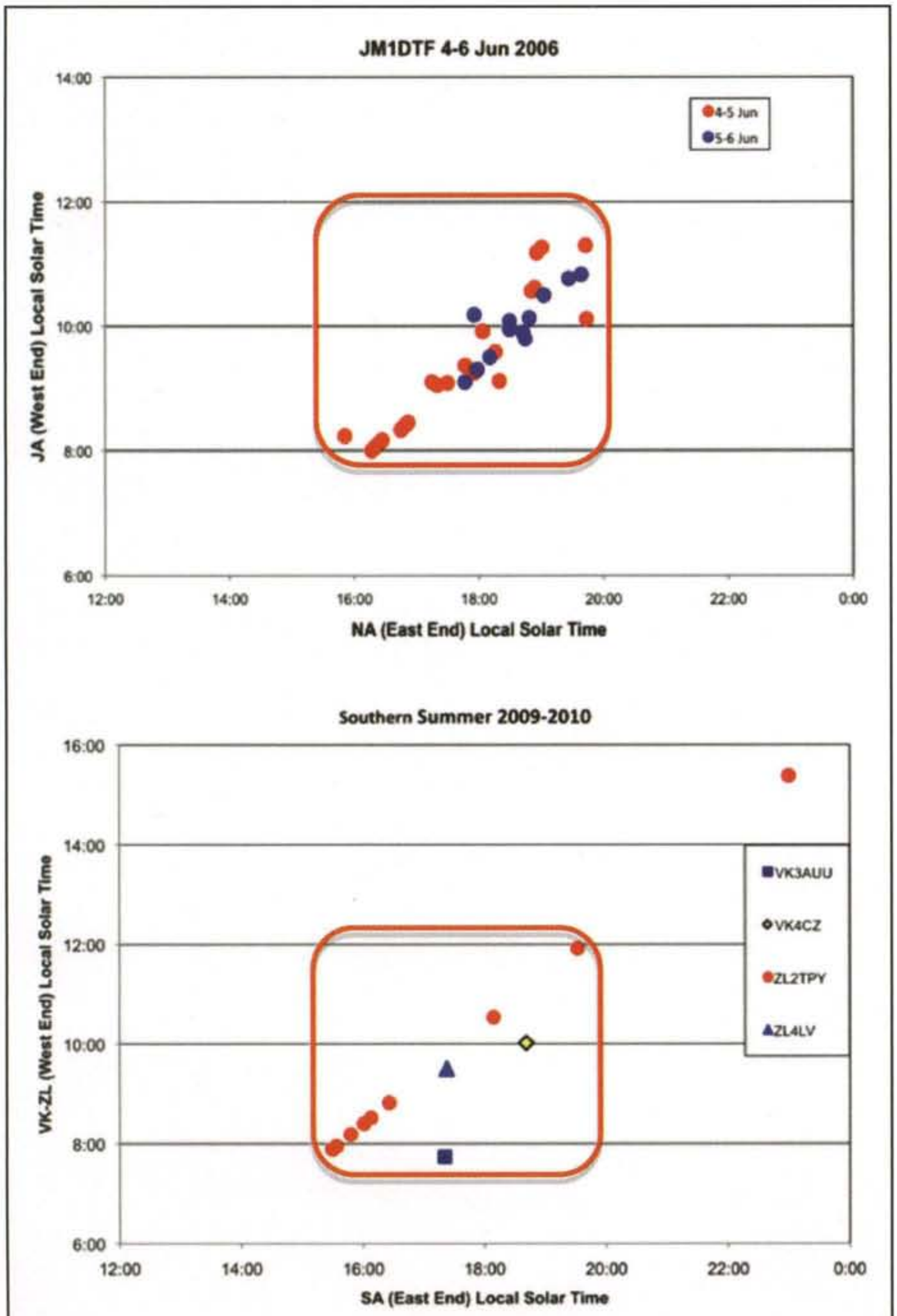

Figure 11. (A) The JM1DTF 2006 summer openings are tightly grouped in a time "box" of west 0730–1200 by east 1530–2000. (B) With one exception, the 2009–10 southern summer openings fit quite well into the same box.

Polar Mesospheric Summer Echoes

It has been suggested that the Polar Mesospheric Summer Echo (PMSE) phenomenon might play an important role in the SSSP hypothesis. While an interesting and worthwhile suggestion, on closer inspection it seems highly unlikely. As Luetzelschwab (2009; 2011—*see "PMSE and Propagation at 50 MHz," by K9LA, elsewhere in this issue.—ed.*) has pointed out, PMSE is a very weak effect that requires significant power and very large antennas to demonstrate. He also showed that the N_e in the PMSE zone (essentially the upper D layer) is many orders of magnitude too low to skip signals at any reasonable, even grazing-incidence, angle. This is especially true because since the background E layer is only 15 or 20 km higher, with significantly higher levels of N_e, it would be much more likely to support chordal effects at much larger angles of attack.

Finally and importantly, PMSE works at 50 MHz only, because the *vertical* stratification of the background electrons just *below* the E layer has a scale size of about *3 m*. This forms a *tuned* three-dimensional scattering structure. As the upcoming (vertically-incident) signal is scattered straight back down, the scattered signals from each progressive level end up in phase with each other due to the fortuitous half-wave spacing of the scattering centers. Since the 3-m stratification is in the *vertical* plane, it would *not* be useful for the largely *horizontally* propagating waves of a skip signal.

Impact of the Auroral E_s Zone

Higasa was also concerned that the signal path would pass into the auroral zone and fail at the path's northernmost extent (about 60°N). However, 60°N is usually well south of the *daytime* edge of the auroral oval, and this would not normally be a problem.

A Rose by Any Other Name

A concern that has been expressed by various people about calling the observed phenomenon "Short-path Summer Solstice Propagation," because the phrase itself equally describes ordinary, major-season, and summer sporadic-*E*, especially since it now appears that the propagation in question is a variant of E_S.

To be fair, when the term SSSP was coined there was a legitimate question as to whether it was any form of sporadic-*E* at all. However, with what seems to be the case now, it may be more descriptive to refer to the phenomenon as East-West Extreme E_s, or EWEE, as this current paper has been doing.

Open Questions – More to Come

There is a lot more to learn about this subject. The work presented here was done on the basis of the observations cited. It is inevitable that there are many other observations that were not available for this analysis and, which if examined, might lead to different conclusions.

At this writing, the overall statistics are weak. With only one minor exception, this study has only considered EWEE on the JA-NA path, and indeed for only two such openings. It will be important to further explore the Early-on-Late Window effect for more openings and on different paths, such as the NA-EU path.

It will also be important to look at paths like EU-JA. Unlike the other three known paths, it is almost *entirely over land*. While much of that intervening land has relatively low amateur radio populations, it still might offer some better answers regarding the nE_s versus chordal/ducting issue.

Future articles in this series will address additional EWEE data and additional paths, including NA-EU and EU-JA, the north-south propagation across the equator between ZL/VK and NA, and go on to explore possible real-time ionospheric conditions that may play important roles.

Acknowledgements

The author deeply appreciates the many conversations, information, advice, critical observations, and very helpful comments on the manuscript by Gene Zimmerman, W3ZZ, who was a major force in encouraging this effort forward. I also appreciate the useful discussions and comments from Bob Cooper, ZL4AAA, as well as my collaborators on earlier works, and the many other people who have shared their experiences and their logs.

Note

1. For example, the likely explanation of 2-meter Es is chordal skipping directly betweenn two tilted or curved layers, producing very high grazing-inncidence MUFs (Harrison, 2011).

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By Joe Moell,* KØOV

HOMING IN

Radio Direction Finding for Fun and Public Service

USA ARDF Championships 2011:

Medals and Fun in the "Land of Enchantment"

Just over eleven years ago, my "Homing In" column announced the search for a local radio club to host the first-ever national on-foot radio direction finding (RDF) championships in the USA. Ink on the last copy of the press run was barely dry when the Albuquerque Amateur Radio Club (AARC) answered the call. Its members were eager to put on this historic event.

Perhaps AARC's leaders didn't fully understand what they were signing up for at the time, but they were definitely up to the task. They arranged for housing, local transportation, hunt venues, maps, medals, and the endless other details of a well-run radiosporting event. With no experience to guide them, AARC members did a great job that year. They did it so well that they were asked to do it again in 2005. Since then, many have asked when the championships would return to Duke City, and 2011 was the year.

License plates in New Mexico proudly proclaim that it's the "Land of Enchantment." From September 14 through 18, it was the land of international-rules competitive RDF, also called foxhunting, foxtailing, radio-orienteering, and ARDF. This year's annual USA ARDF Championships were combined with the biennial ARDF championships of International Amateur Radio Union (IARU) Region 2, which encompasses North and South America. Anyone from any state or country, with or without a ham license, was welcome to enter the championships by paying the registration fee and traveling to Albuquerque.

The championships received good publicity via ham radio magazines, newsletters, e-mail, and the Web. We sought entrants from every part of the world and with every ARDF skill level, from beginner to expert. In the end, ten states from coast to coast were represented along with Canada, China, Germany, and Ukraine. Although there was no formal teaming among the stateside hunters, some of them had trained together and put on local practice sessions for each other.

Prepare for a Monsoon

Late summer is "monsoon season" in New Mexico. Warm moist air masses come in from the south, are uplifted in the mountains, and create thunderstorms almost every afternoon. Rains are occasionally heavy but are usually brief. The monsoons were welcomed this year because the rains ended the threat of forest fires that had persisted through the spring and early summer.

It has become a tradition for USA's championships to include an optional and informal "training camp" in the days just before the formal events get under way. This year's training was organized by Marvin Johnston, KE6HTS, of Santa Barbara, California and Jerry Boyd, WB8WFK, of Albuquerque. On Wednesday and Thursday, September 14–15, trainees made their way to Oak Flat Picnic Area, 17 miles southeast of the city. This had been the site of the 2-meter championship competition in 2005. The goal was to get a full-scale five-transmitter practice hunt completed each day before any rain set in.

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Stephanie "Stevie" Van Skiver, VE7SMX, from New Westminster, British Columbia tests her equipment on Friday. In her left hand is her 80-meter RDF set and in her right is her 2-meter equipment. She won silver medals on each band in the W21 category. (All photos by Joe Moell, KØOV)

Eleven persons took to the woods in the training days. Keith Witney, VE7MID, came from Burnaby, BC Canada and the rest were hams from six states. Marvin, who operated the electronic scoring system for the training, also cooked an after-hunt feast of Santa Barbara style tri-tip beef barbecue and all the fixings.

On Friday, about twenty additional foxtailers arrived for the formal competitions to follow on the weekend. After they registered at the event hotel and received their T-shirts, Jerry Boyd gave a PowerPoint presentation that thoroughly covered the

Ruth Bromer, WB4QZG, of Cary, North Carolina was the only competitor who had the 2-meter RDF Yagi mounted on a mast. She was a double gold medal winner in the W60 category.

rules,[1] logistics, and dangers. In accordance with standard IARU procedures, there would be five transmitters each day. The first sends MOE in Morse, the second sends MOI, the third MOS, and so forth. There's no need to know CW, just count the dits to find out which fox is on the air. MOE is on for 60 seconds, then it goes off and MOI goes on for a minute, and so forth until MO5 goes off and MOE comes back on again, and then the cycle repeats.

Competitors were divided into nine age categories, five for males and four for females. They would be started in groups every five minutes, coincident with the start of transmission from MOE. As many as four starters would be in a group, but there would be no more than one person in a given category in each group.

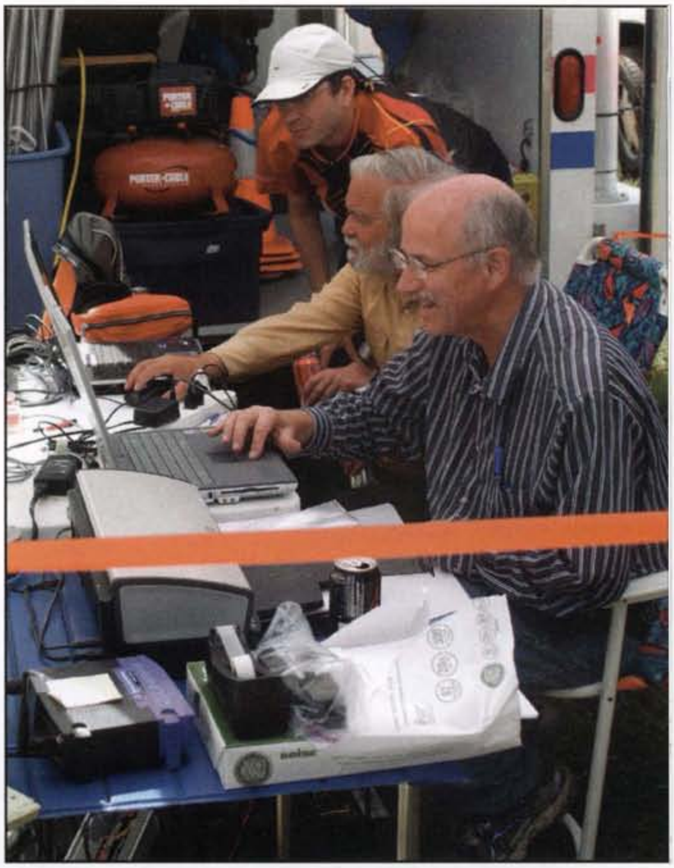
Males from age 20 through age 39 were required to seek out all five transmitters. Persons in other categories were told the numbers of the four, three, or two that they had to look for. Each hunter must perform on his or her own; there is no collaboration or cooperation allowed on the course. Hunters may not communicate with each other by any means in the woods except in an emergency.

Rules regarding GPS and other navigation aids were fully clarified. Competitors are expected to use only their maps, compasses, and RDF gear for navigation.[2] Although they may take cell phones along for emergency communication, they may not use any GPS features of the phone. All other GPS devices that have mapping screens are prohibited.

For competitive wilderness orienteering, an ordinary USGS topographical map isn't good enough. Orienteering maps must show the vegetation thickness and runability of the entire area,

At the 2-meter finish line, volunteers wrote down times as a backup to the electronic scoring system. Another volunteer had water and Gatorade ready for the finishers.

First-time competitor Thomas Krahn, KT5TK, of Houston, Texas punches in at the finish line after his 2-meter run.



After finishing, competitors downloaded their electronic scoring sticks. Their results were immediately available to everyone, thanks to the new FjwW software and a Wi-Fi broadcast. Co-chair of the organizers Jerry Boyd, WB8WFK (closest to camera) operates the FjwW computer. Next to him is Marvin Johnston, KE6HTS, operating a backup scoring system with SportIdent software. Observing is Matthias Kuehlewein, DL3SDO, of Tuebingen, Germany, who won gold in M40 category of the Visitor division that day.

as well as details such as trails, fences, and rootstock. A standard format has been published by United States Orienteering Federation. Once it's all on paper, the entire area must be thoroughly field-checked against the map for accuracy. Jerry Boyd had spent many hours compiling maps and field-checking maps for this event, with help from members of AARC and New Mexico Orienteering.

Bears, cougars, and poisonous snakes had been reported within the competition sites, so everyone was told how to handle an encounter with any of them. A potentially greater danger was a shooting range within the 2-meter competition area. Besides being marked as off-limits on the map, it was well fenced and signed.

The intense New Mexico sun at high altitude can cause severe sunburn and dehydration, so competitors were warned to use sunscreen and to carry water. They were also told what to do in case they got hurt or lost—to summon help from the New Mexico Search and Rescue Team.

The last order of business was the drawing of competitor "bib" numbers to determine who would be in each starting group on Saturday. On Sunday, the starting group order would be reversed. After that, all were invited to go outside and check their gear by finding test transmitters on 2 meters and 80 meters.

Where Are We Going?

For fairness, ARDF event organizers are encouraged to choose competition sites that have not been recently used for regular orienteering or radio-orienteering meets. This prevents anyone from having an advantage of familiarity with the venue and its terrain. It's best when the sites are kept secret so that advance reconnaissance cannot be done with existing orienteering maps, Google Earth, and so forth.

AARC did a good job of keeping the sites a secret. They announced early on that large portions of the mountains surrounding Albuquerque were "embargoed." That meant that they were off-limits to anyone planning to participate in these championships. Anyone found to have visited these areas after the announcement would not be allowed to compete.

Besides site secrecy, there are three other reasons why ARDF championships in Albuquerque have always had bus transportation to the venues. It's important for everyone to arrive and depart at the same time, parking at the sites is quite limited, and buses would provide rapid evacuation of the area in case of a fire. Furthermore, the buses make transportation much easier for the foreign visitors. The modest increase in registration fees was offset in most cases by eliminating the need for out-of-area competitors to rent their own vehicles.

Buses boarded promptly after breakfast on Saturday to go to the 2-meter hunt site. Competitors had speculated that it would be in the Sandia, San Pedro, or Sangre de Cristo Mountains, but instead the bus went north for about an hour to the outskirts of Santa Fe. Then it went north and west for another hour and entered the town of Los Alamos.

The mesas of Los Alamos were little known before 1942, when the U.S. government took over the area as the secret site of the Manhattan Project. The National Laboratory is still the main employer in this close-knit community that has 12,000 souls and an above-average number of hams. The 48,000-acre Cerro Grande wildfire in 2000 destroyed 400 homes on the mesas and there was great concern that the Las Conchas fire this summer would do the same. Fortunately, the monsoons ended this fire after it burned only a small part of the area that had been mapped for this hunt.

The bus went through downtown to the northernmost part of Los Alamos and onto Range Road, just past Guaje Pine Cemetery. There it stopped, next to a porta-potty that had been rented by the organizers for the occasion. Scott Stevenson, KC5VVB, and a crew of volunteers from the Los Alamos Amateur Radio Club were waiting.

Competitors received their 11 × 17-inch full-color maps ten minutes before start time. Most mounted the map on cardboard or foam board and covered it with clear plastic so they could mark bearings on it. The German competitors preferred cork boards with pushpins. Hunters discovered that the start and finish were only 260 meters apart in the southwest corner of the map. Would the fox transmitters be to the north in Canyon West, to the east in Canyon East, or in both?

After the starting tones, IARU Rules prohibit competitors from stopping to do RDF until they are at the end of the start corridor, out of sight of the hunters still waiting to start. Five minutes before start time, members of each group lined up at the starting line and gazed out into a corridor like none they had ever seen. Instead of the usual dirt path into the woods, it was a boulder-filled canyon. There was no need to mark it with tape as is usually done, because all knew that they would have to go to the end of this canyon and get away from its walls before they could get reliable RDF bearings.

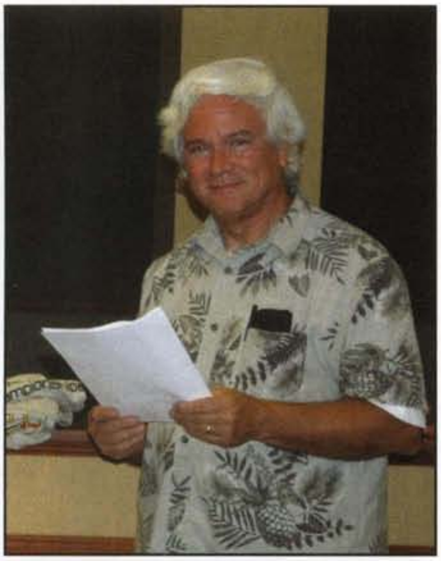
The entire mapped area encompassed about 2650 acres of forest, with ponderosa pine, pinon, and alligator juniper. At 7200 feet, the altitude posed a formidable running challenge for many hunters. The mosquitoes weren't out in force, but the forest floor had boulders in many places, making it important for them to mind their footing. The optimum straight-line course length, from start to all five foxes and then to the finish, was just over seven kilometers.

Course-setter Jerry Boyd, WB8WFK, and the LAARC volunteer crew awaited the hunters as they ran through the ending corridor to the finish line. Cold drinks and box lunches were waiting for them. Standing by to treat any injuries or illnesses were April Moell, WA6OPS, and Joan Rogers, KC5BPI. Also standing by at their homes for possible callout were members of New Mexico Search and Rescue. Fortunately, nobody got lost or stayed out in the woods more than five minutes beyond the three-hour time limit for the hunt on that day.

Medals and a Second Try

After the bus ride back to Albuquerque and a shower, everyone was ready for the awards banquet on Saturday evening at the hotel. Following the Mexican food buffet, medals were given to the top three 2-meter places in each age/gender category. There were two sets of medals, one for competitors in IARU Region 2 (U.S. and Canada only in attendance) and another set for visiting competitors from outside Region 2.

The fastest person to find all five 2-meter transmitters on the course was Volodymyr Gniedov of Ukraine, who did it in 1 hour, 12 minutes, and 28 seconds. USA's best included Vadim Afonkin, KB1RLI, of Boston, finding four required foxes in 1:24:52 in M40 and Jay Hennigan, WB6RDV, of Santa Barbara, who got his required three transmitters in 1:24:38. There were good results among stateside women, including Ruth Bromer, WB4QZG, of Cary, North



Co-chair of the organizers Mike Pendley, K5ATM, was the primary contact for lodging and transportation. He also presided at the banquet and awards ceremony on Saturday evening.

Carolina, who got her two required transmitters in 1:39:16.

Harley Leach, KI7XF, of Bozeman, Montana was the oldest competitor and was in a category by himself. Even though he was actually 69 at the time, Harley was in the new M70 category because "division age" is the age on December 31 of the competition year. Harley found his required two foxes and cruised to the finish and a gold medal in just an hour and two minutes.

The bus trip on Sunday for the 80-meter hunt was much shorter, ending in a parking lot in Cienega Canyon, about 15 as-the-crow-flies miles northeast of the hotel on the road to the Sandia Peak ski area. Then the bus stopped and the starting sequence began anew. But before that, there was a brief bus stop at the barricaded entrance to Sulphur Canyon, about 350 meters from the finish area.

Just days before, Sulphur Canyon had been closed due to multiple bear sightings. Rangers had noticed that a certain berry, found in abundance in that canyon, was attracting them in unusually large numbers. Knowing this, the organizers gave participants a special map page showing the closure area and the detour that they would have to take to get to the finish line. Not only were they in danger if they went into Sulphur Canyon, but they risked a $10,000 fine if seen by a Forest Service official there.

As they picked up their 80-meter maps, all of the hunters were planning how to do better than the day before. This time the start and finish were about a kilometer apart in the north-central portion of the map. They could tell that the transmitters would have to be in the south and east areas of the 1400-acre venue to meet the exclusion zone requirements of IARU rules.

The signal reflections that can plague transmitter hunters on 2 meters in hilly and mountainous areas are non-existent with 80-meter groundwave propagation, so it is normal for competitor's times to be shorter on this band. The altitude was slightly higher, but the course was about 17 percent shorter. Everything went smoothly for both the organizers and the hunters. Almost every performance was better.

As the competitors finished and downloaded their "e-sticks,"[3] the new FjwW scoring software[4] kept everyone apprised of the competitor standings. Results were continuously broadcast via Wi-Fi at the finish area, available to anyone with a suitable device to view them.

Can This Be Topped?

A hearty "Well done!" and thank-you to AARC and its event leaders, as named above. Special kudos to Mike Pendley, K5ATM, who was the primary contact for the hotel and for the buses. Thanks to the members of the radio clubs of Albuquerque and Los Alamos for their help. And thanks to everyone who attended for the interest, enthusiasm, and positive attitude that prevailed.

For the exact times and standings of every competitor, plus more photos, warm up your web browser. Start with the "Homing In" site for a summary and lots of images. Almost everyone who attended is pictured at least once. There is also a link to AARC's 2011 ARDF Championships website, which has the official results that include competitors' individual routes and times at every fox transmitter that he or she found.

If you missed all the fun in Albuquerque, you will have another opportunity to compete against USA's best in just a few months. Plans are now under way for the 2012 USA Championships, which are expected to take place in southern California.

National ARDF championships around the world usually take place in late summer or early fall. However, the 2012 ARDF World Championships will take place in early September at a ski resort in Serbia. To provide plenty of time for selection of Team USA and for overseas travel planning, the 2012 USA Championships must take place in May or June. More information will be in upcoming "Homing In" columns and the website.

Now is the time to start preparing your equipment and yourself for the next championships. It's also a good time to help others in your local club to do the same. Regular informal practice sessions in local parks, with or without maps, will go a long way toward developing good radio-orienteering techniques. Participating in the events of your local orienteering club will improve your ability to do map-and-compass navigating in the woods. I hope to see you at next year's national championships!

73, Joe, KØOV

Grant Van Skiver, VE7GVS, was one of four competitors representing Canada. He captured gold medals on each band in the M21 category.

Notes

1. http://www.homingin.com/intlfox. html#rules
2. There is a continuous transmitter on a separate frequency at the head of the finish corridor as an RDF aid to hunters who become lost.
3. http://www.homingin.com/epunch.html
4. http://www.ardf-fjww.com/index_eng. htm.

By Kent Britain,* WA5VJB

ANTENNAS

Connecting the Radio to the Sky

50-MHz Beams

Last time we went over a construction project for a really big 432-MHz Yagi (photo A). At the Central States VHF Society Conference I had it on the antenna range. Official gain was 14.5 dBd or 16.7 dBi. Darn close to the theorical 17 dBi gain the computer predicted.

Yeah, I know, blind luck! The plan was to build a second long Yagi and show you how to stack a pair in different configurations. Well, it didn't quite work out that way, but I do promise the second Yagi, phasing harness dimensions, and stacking information before they fire up the Arecibo dish on EME again.

This time we are going to revisit an old project, a 50-MHz beam. My problem is that I have not been able to come up with a good mechanical design. Here is your chance to come up with something better.

The idea is to come up with materials that are easy to get. We are talking about stuff you can get at one of the big building material stores such as Home Depot, or hardware stores such as Ace. That neat bracket you found in your junk box doesn't count, unless you have a couple of hundred spares for your friends. Hi, Hi.

I have looked at copper water pipe, agood conductor, but heavy and may not support itself well when you have a 12-foot length of it in the air. Electrical conduit perhaps? Years ago a friend did build a 6-meter beam for 50.4 MHz AM—yes, that long ago. But it's not easy stuff to work with and his quickly rusted. PVC pipe with some wire run down the middle of it? Questions again about just how strong a 12-foot piece of PVC pipe is when on a tower in a storm. Also, the element lengths will change slightly due to the elements being inside plastic.

Warning: A bit of physics here. Light travels slower when passing though a medium such as air, water, or glass. Radio waves travel more slowly when passing though a medium such as plastic.

You can see this with an HF antenna. If you make two 40-meter dipoles out of wire—one using bare wire, one using insulated wire—the insulated wire will need to be about a foot to a foot-and-a-half shorter to resonate on the same frequency.

So, something involving curtain rods and bailing wire perhaps?

Now for a bit of antenna theory. A dipole antenna in free space has about a 72-ohm impedance —there is some slight variation in impedance depending on the diameter of the dipole—but 72 ohms is pretty close. When you bring other objects near that dipole, the impedance changes a bit. With careful positioning of another 6-meter element, we can use the loading effects of that element to bring the impedance from 72 down to 50 ohms. There is a compromise here finding the combination of element length, element spacing, and driven-element impedance that gives good performance and a very simple antenna.

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Figure 1 shows three versions of this simple 6-meter Yagi. First on the left side is a conventional two-element 50-MHz beam. Next in the middle is another 2-element beam that goes against conventional wisdom, at least in the U.S. A two-element beam consisting of a driven element and a director has more gain and a better front-to-back ratio in a smaller package than a two-element beam with a driven element and a reflector. These are very popular in the UK where real estate is at a premium and the lads have studied their antenna textbooks. Now the reflector/driven-element combination does have a bit more bandwidth, but on 6 meters we all group together in about 100 kHz, so bandwidth is not an issue on the 6-meter band. On the

Photo A. 432-MHz beam.

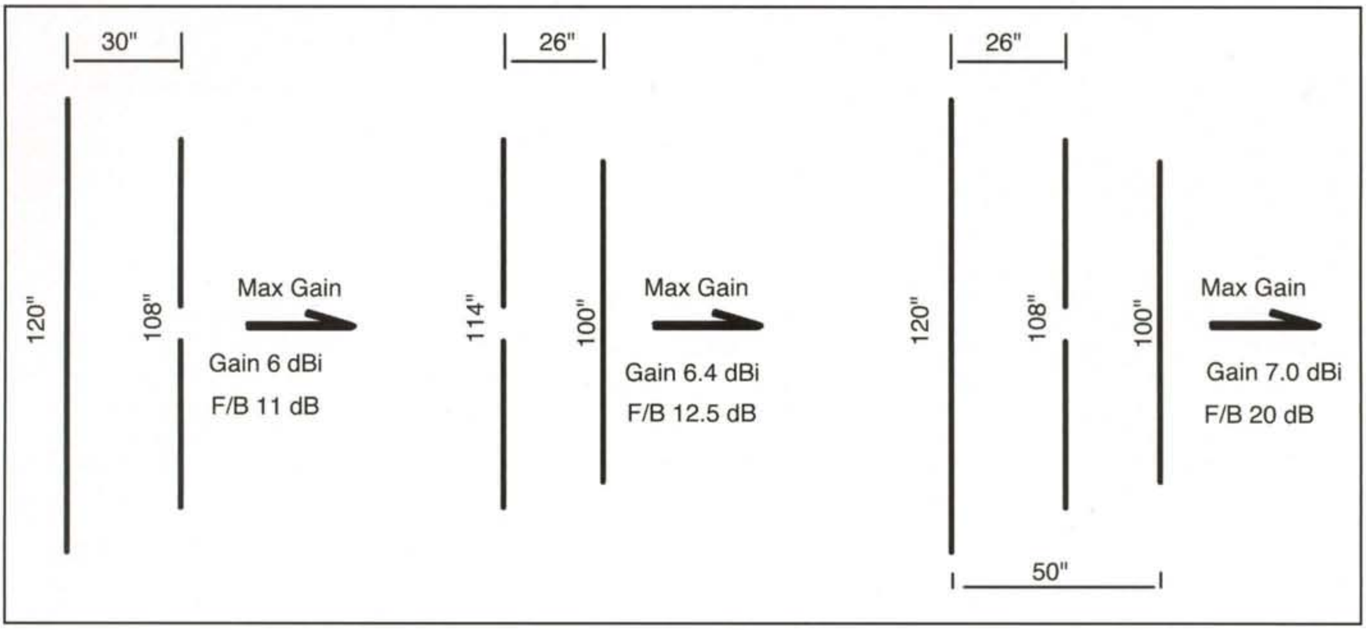

Figure 1. Three 50-MHz beams with simple dipole driven elements.

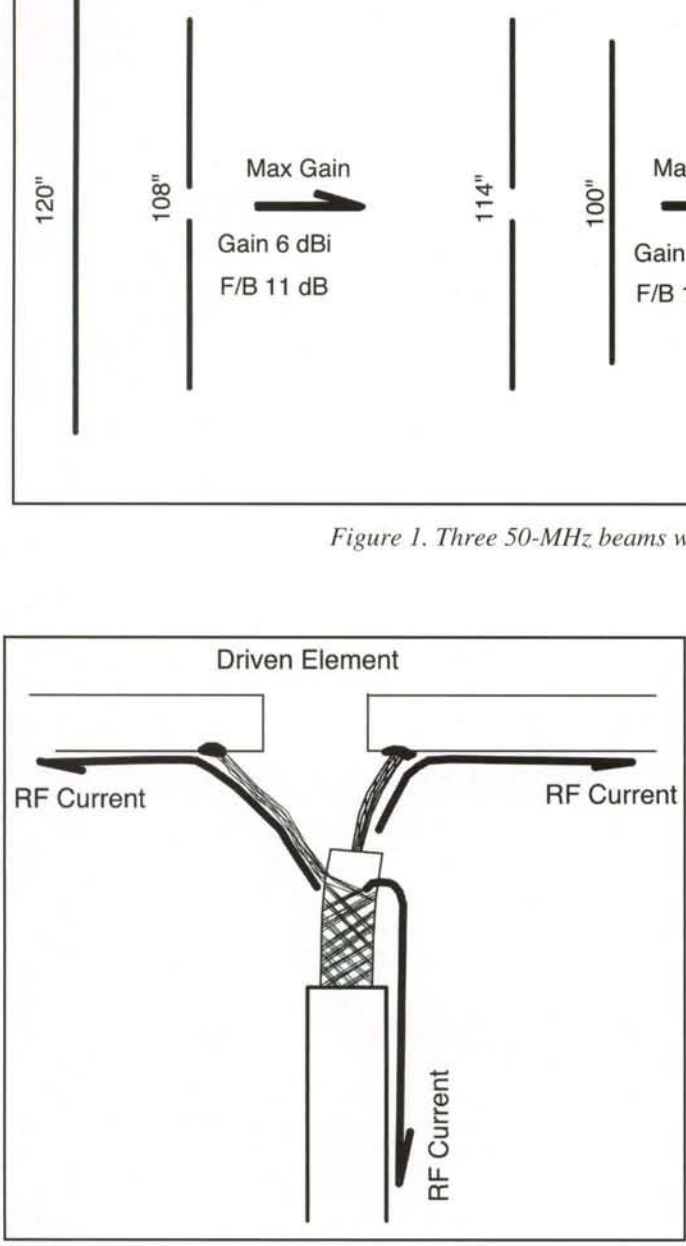

Figure 2. Drawing coax RF on coax.

right is a three-element Yagi; the extra element doesn't help gain all that much, but it really improves the front-to-back pattern.

The final length of the driven elements will be affected by element diameter, mounting configuration, and even the length of the pigtails on the end of the coax. Therefore, the lengths in figure 1 for the driven elements are a starting point. Feel free to adjust their lengths as necessary for a good SWR.

Figure 2 shows the main problem with a simple dipole feed. We like to think that all the RF current goes into the dipole, but a lot of that RF current runs around the end of the coax and back down the outside of the coax. Ever have a station where the D-104 mic, or any other metal microphone, burned your lips when you got too close? That's from the RF running back down the outside of coax. There are several problems with RF on the outside of the coax: First would be your burned lips, but that RF on the coax is not going where you want it to go. That RF current on the outside of the coax is almost all power you are losing. A balun at the feed of these beams will solve those issues, but hey, we're hams, so how about a cheaper solution!

What we need is an RF choke that blocks the RF from the coax. Here we present two simple RF choke designs. In Photo B is a couple of turns in the coax near the driven element. This is known as a noise balun. It also keeps RF noise on the outside of the coax from getting into the 6-meter rig. You want to use a small-diameter coax such RG-58 with a solid-core dielectric. I've had trouble with the foam-type coax when wound in a tight coil like this. The center conductor tends to move in hot weather with the center and shield shorting out. Two turns is not really enough, six or seven turns is probably too much, so three to five turns is plenty. A couple of cable ties, electrical tape, duct tape, or baling wire can hook the loops in place.

The next type of RF choke is the ferrite choke (photo C). The ferrite greatly increases the inductance of a straight wire until that straight wire looks like a coil. Again, two ferrite beads is marginal, and many more is a waste of ferrite. I once saw an EMI antenna with over 50 ferrite beads on its feedline, but I think someone was just having fun. Ferrite beads that fit snugly over RG-8 are hard to come by, but they work. Several years ago I used the clamp-on style ferrite beads and they worked for a while, but then sunlight destroyed the plastic and they fell off. So if you use the clamp-on style ferrite beads, put something over them such as tape, heat-shrink tubing, cable ties, etc., to hold them together. If you only have some larger beads, you can loop the coax back through the beads a couple of times.

How do you know if you have enough choke on the feedline? One way is to watch the SWR while you slide your hand up and down the coax. The amount of wiggle in the SWR reading gives you a good idea of how much RF is on the outside of the

Photo B. Noise balun.

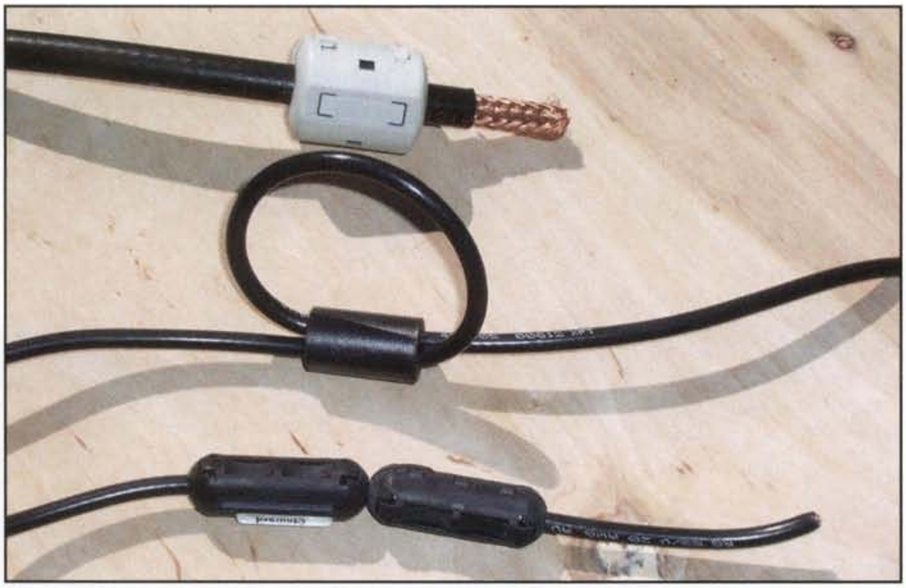

Photo C. Ferrite baluns.

coax. A little wiggle is OK; a lot of wiggle, more than a few tenths, shows you have a problem. A few more turns on that noise balun, or some more ferrite beads, are in order.

Even if you can't help your neighbor, with a good junk box these are easy antennas to build and will get you on "The Fun Band."

Future Projects

That second 20-element 432-MHz Cheap Yagi is still on my get-around-to-it list, along with how to stack the two for vertical, horizontal, left-hand, or right-hand circular polarization.

As always, I welcome antenna questions and column suggestions from readers. Many a column topic has been suggested by you. E-mail to <wa5vjb@cq-vhf.com> or <wa5vjb@amsat.org>. Also, for several dozen other antenna projects you are welcome to visit <www.wa5vjb.com> and look in the Reference section.

73, Kent, WA5VJB

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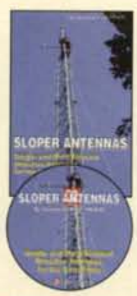

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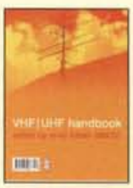

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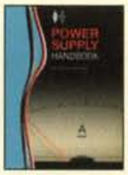

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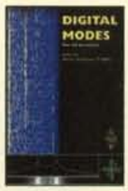

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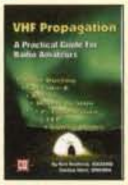

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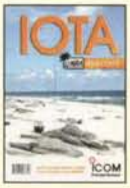

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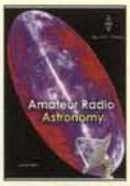

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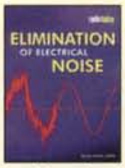

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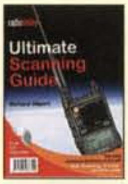

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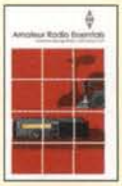

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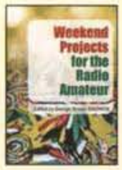

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By Bill Brown,* WB8ELK

UP IN THE AIR

New Heights for Amateur Radio

Liberty Middle School Balloon

On April 13, 2011 members of the UAH Space Hardware Club launched a balloon carrying eighth-grade student experiments from Liberty Middle School in Madison, Alabama to the edge of space.

The Space Hardware Club (spacehardware.uah.edu) is funded mostly by Alabama Space Grant and is comprised of volunteer University of Alabama (UAH) in Huntsville students who do a variety of BalloonSat and satellite design projects. They often do outreach programs with local schools, which is a great way to inspire students to pursue careers in space, science, and technology. This is a low-cost way to allow students to send their experiments into a space-like environment and allows them to run their very own space program right from their school.

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

This flight flew four student experiments from Ms Lyons' eighth-grade science class. They flew a variety of things to see what happened to them during their journey into the sub-zero temperatures and near-vacuum of the stratosphere. One experiment consisted of markers, pens, and even lightbulbs to see if they still worked after the flight.

One payload was covered with solar cells and their performance was measured with an internal Arduino board that stored the solar cell data onto an SD memory card. After flying over 85,000 feet, parachuting back to Earth 60 miles downrange and banging around in my trunk for two days, it was still operating after 54 hours!

The other payloads contained things such as bread, banana, and apple slices, a calculator, a can of soda, and a bag of popcorn. One of the payloads had party balloons filled with a variety of gases to see which ones would pop during the flight.

The flight carried two APRS transmitters as well as two high-definition camcorders. A Sony Handicam was in the last pay-

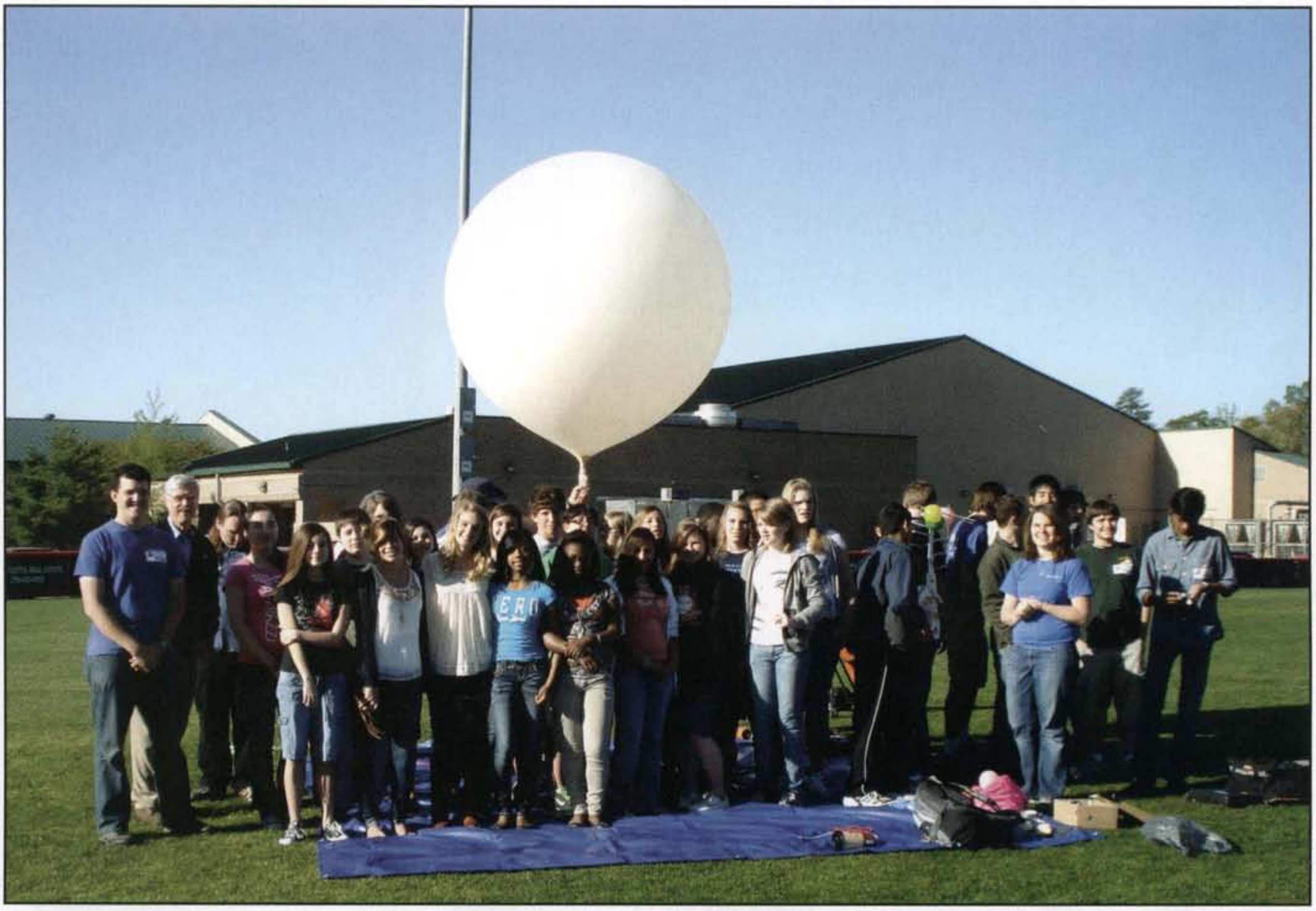

Photo 1. Liberty Middle School eighth-grade science class students with their high-altitude balloon.

Photo 2. Liberty Middle School students prepare for liftoff of their science experiments.

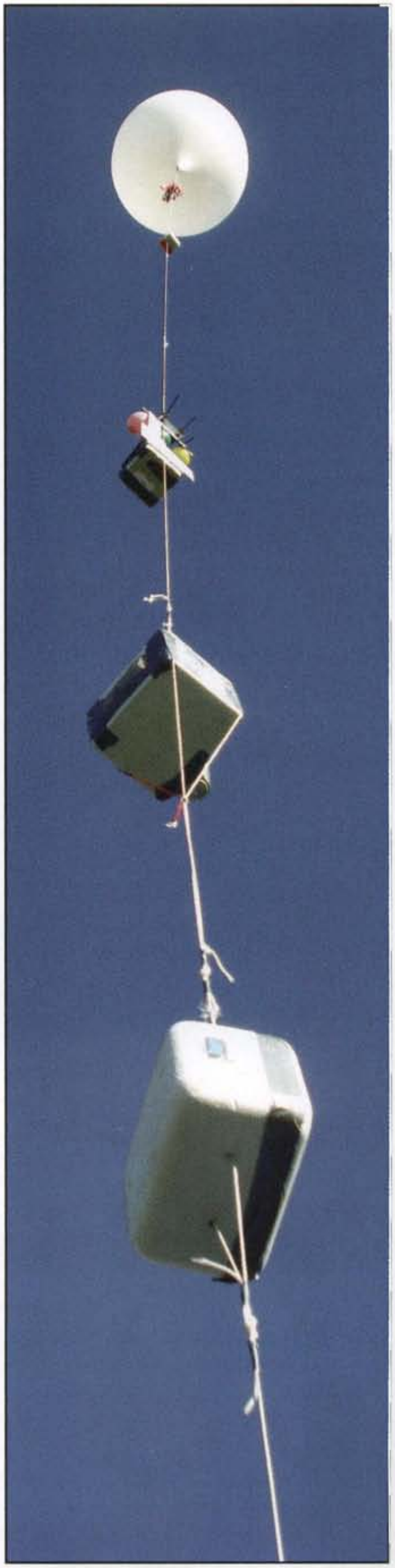

Photo 3. Student experiments just prior to liftoff.

load pointed straight up at the balloon and caught one of the party balloons popping near the top of the flight. It also recorded amazing video of the main weather balloon bursting at 85,782 feet.

Picture Perfect Flight

It was a perfect morning with clear skies and dead-calm conditions. A large crowd of students came out to the ballfield to watch the picture-perfect liftoff.

The balloon flew across the city of Huntsville with my camera payload taking beautiful snapshots of the city and nearby Lake Guntersville. After reaching peak altitude, the balloon popped and everything parachuted down to land in a pasture just each of Geraldine, Alabama.

Jason Winningham, KG4WSV, and a group from the Space Hardware Club tracked the balloon via APRS and made the relatively easy recovery from the pasture. Trust me, it's usually not this easy. We often have to climb tall trees and hike through the wilderness. But every once in awhile Mother Nature lets us off easy.

The GoPro Hero HD Camcorder

I have flown quite a variety of small camcorder units on balloons. The units I have had the most success with in the past are the Flip Ultra pocket camcorder units.

Photo 4. Liftoff.

Photo 5. The view from 85,000 feet.

I have filmed some spectacular footage with the Flip, but they have a few drawbacks. Most notably the memory is built into the unit and there is no way to extend it with an external memory card. The limit for most Flip units is two hours record time and that usually means that I miss the last few minutes of a typical balloon mission and the landing can be the most exciting part. Also, the Flip Ultra HD version does 720p Hi-Definition but won't do 1080p.

After doing some shopping for a replacement camera I finally settled on the GoPro Hero HD camera (www.gopro.com). Fortunately, I had received my new camcorder unit just prior to this flight and managed to hitch a ride with the Liberty Middle School flight at the last minute. I quickly cobbled together a payload and hooked it near the parachute pointing out at the horizon. The neat thing about the Hero HD camera is that with its intended audience of extreme sports enthusiasts, it also is perfectly designed for high-altitude ballooning, radio-controlled airplanes, ATV Hatcams, and would work well in a tiny ATV portable system, as well.

It weighs in at a mere 3.5 ounces (5.0 ounces with the optional backpack battery). The Hero comes in a nice rectangular package which makes mounting it into a styrofoam box quite easy. Although the Hero comes with a plastic housing to protect it from the elements, I opted to fly it with its lens exposed to eliminate fogging issues due to the temperature extremes it would encounter during the flight.

It can do video recording in a wide range of resolutions all the way up to 1080p mode. If you want to just take still frames with it, you can set it up to take 5-megapixel sequential stills from between 1-second to 1-minute intervals for as long as the battery lasts or until the camera memory card fills up. With the capability of using a 32-gigabyte SDHC card along with the backpack battery (which doubles the battery life), I was able to take thousands of photos at 10-second intervals for upwards of five hours during this flight.

Running the Hero at 1080p mode hi-def video with that same size memory card will provide you with at least 3 hours record time, which is more than enough to capture a full balloon mission from takeoff to landing.

I like the fact that there is no LCD screen built into the camera (an optional screen snaps on for viewing). This eliminates weight and dramatically reduces current drain to allow longer record times. A simple LCD text screen on the front is easy to use to set up the camera and even allows you to invert the image if you want to mount the camera upside down. Another great feature is the "one-button record" option. I can start it up in a preselected mode from the outside of my payload just by pushing on the front-mounted power on button.

One more nice feature that is perfect for ATV use is its capability to run a cable from the camera to output live video to a video transmitter at the same time that it is recording to the SDHC card.

Keep in mind that the lens is fixed and depending on the mode will be very wide angle. As a result, you'll have to make sure the camera lens extends beyond the edge of your container (which explains what Gary Dion, N4TXI, called the "looking out the door of a styrofoam igloo" look of the photos .

The camera was exposed to temperatures of –40° C and below and managed not only to survive but was still running when it was recovered from the pasture.

73, Bill, WB8ELK

By Mitch Gill, NA7US

EMERGENCY COMMUNICATIONS

The Role of VHF in EmComm

Are We Doing All That We Can?

"It is good to live and learn."
— Miguel de Cervantes

I came across the last quarterly issue from <www.emcomm.org> that made me begin to think about whether, as licensed amateur radio operators, we could really properly assist during an emergency. The article below I gained permission to reproduce and it is right to the point of the problem that I see out there. Do not take offense over what this person has written, as it does not apply to everyone. It is pointed at the casual reader who is interested in Emergency Communications but has spent very little time learning what to do in an emergency. Read it and give me your thoughts.

(Note that the following does not reflect on nor state the opinions of CQ VHF *nor CQ Communications—ed.)*

Montpelier, Vermont, September 1, 2011: Federal Emergency Management Agency (FEMA) Community Relations Specialists Toby Rice (left) and Hank Allen (right) discuss outreach strategy. They are deployed in support of recovery efforts following the heavy rains and flooding that accompanied Tropical Storm Irene, which struck the state on August 28, causing extensive damage. Rice and Allen are tasked with providing information to the public and gathering information from the field as part of FEMA's response. (Photograph by Savannah Brehmer)

Fading Out (or Telling It Like It Is)

We have no statistics to support our assertion that with few exceptions, most active amateurs today are mere "hobby hams." This is because when asked, most hams will reply that they are willing to help in an emergency. But they have no ongoing involvement in EmComm preparation or training and wouldn't be able to format or properly relay a RADIOGRAM if their life depended on it.

Although the word *hobby* does not appear in FCC Part 97, amateur radio has long been promoted as a "fun hobby" by the National Association for Amateur Radio, the American Radio Relay League. It is not unusual for a hobby ham to spend tens of thousands of dollars on a super station that will allow him or her to add a few more "countries" to his or her DXCC list or win a contest to obtain a highly sought after certificate or plaque.

Further, hundreds of thousands of dollars are spent every year on DXpeditions to allow hams to log a new "country" (if they can break through a pile-up of rude and inconsiderate operators). The argument for all this is often: "This prepares hams to operate in emergencies." I enjoy chasing DX and love adventure travel as much as anyone, whether it's in person or via shortwave radio from my armchair, and I have no quarrel with others who do so as a hobby activity. But never forget ... those activities, as enjoyable as they may be, have little to do with why we still have our amateur radio privileges.

Therefore, it is profitable for amateur radio associations, manufacturers of ham gear, and others to promote amateur radio as a "hobby." It is not profitable to promote EmComm or other forms of amateur radio public service, except for its "public relations value" and therefore its promotion the business of ham radio.

The sad truth is that the one or two percent of licensed amateurs who claim to be serious about "EmComm" will sign up for almost anything, as long as it's free and doesn't require any effort, training, skill, or commitment. But few are willing to donate any meaningful time or sacrifice any $$$.

"RADIO" and especially message handling by properly trained, skilled, and dedicated radio operators is rapidly fading out. The day of the grizzled public service operator in a dimly lit shack handing message traffic late into the night is nearly relegated to the territory of nostalgia buffs and cartoonists.

Satellites, computers, the internet, and e-mail have nearly seduced the majority of modern "radio men." Sadly, when all these contraptions break down during some calamity, there will be little or no means of communications. All the

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Just remember that all volunteers are valuable and can do something to help during an emergency, but being better trained increases your value. I salute you all.

emcomm eggs will have been put in a basket that has crashed and all the king's horses and all the king's men will not be able to put Humpty Dumpty back together again.

I understand that there are many of you who are dedicated to EmComm and train and learn and serve during emergencies. I have heard you during the hurricanes. I have worked with you during earthquakes and floods. You are ready and prepared and your service is a blessing to many people, but there are those who truly desire to serve during an emergency but have not taken the time to learn, through formal or informal training, what is needed to properly assist during an emergency. They show up on the air and are upset if they are asked whether they have taken the ARRL courses and/or FEMA courses in order to understand the Incident Command System (ICS) or the National Incident Management System. Or, as stated above, have never sent a RADIOGRAM or they have never worked in MARS. Many who check into local and state emergency nets are dedicated but have never worked an actual emergency and probably are not sure what to do. It is unfortunate, as their heart is in the right place and they can assist in an emergency, but they must learn to take a back seat to those who are better trained. After the event they need to take all the training that they can to ensure that they can do everything they can during an emergency. Times have changed and in today's world we really need to be trained to handle an emergency. I am not yet fully trained. Yes, I have had experience in the past in the military working as net control and I have taken many FEMA courses and was involved in MARS, but I need to take the ARRL courses as well.

Below is the basic course from the ARRL. I highly recommend it. You can find it at <http://www.arrl.org/online-course-catalog>.

Introduction to Emergency Communication
Course #: EC-001

This is a revision of our former Emergency Communications Basic/Level 1 course.

Cost: Members $50 Non-Members/Guests: $85

Description: This course is designed to provide basic knowledge and tools for any emergency communications volunteer. The course has 6 sections with 29 lesson topics. It includes required student activities, a 35-question final assessment and is expected to take approximately 45 hours to complete over a 9-week period. You will have access to the course platform at any time of day during this 9-week period so you may work according to your own schedule. You must pace yourself to be sure you complete all the required material in the allotted time.

Computer Requirements: This is an online course hosted on the Moodle online learning platform. This online learning platform is best accessed using the Internet Explorer or Firefox browsers.

Prerequisites: Before you begin the course you should have completed the following prerequisites. These courses provide a foundation for the content of this course. These are free mini-courses you can take online at <http://training. fema.gov/IS/NIMS.asp>.

• **ICS-100 (IS-100.b)** (Introduction to the Incident Command System)

• **IS-700** (National Incident Management System)

Please note: When you enroll for this course you will be asked to provide your date of completion of these courses.

Also recommended, but not required, are:

• **IS-250**, Emergency Support Function 15 (ESF15), External Affairs

• **IS-288**, The Role of Voluntary Agencies in Emergency Management

Course Requirements: This is a mentored course. You will be assigned to correspond with an experienced radio amateur who will be your resource for any questions you have about the course content. Please review the Student and Mentor Expectations included in our *Policies for Online Courses.*

1. Complete the course prerequisites noted above.
2. Read each learning unit of this course, and test yourself with the questions at the end of each unit.
3. Contact your mentor as you begin the course and share the work you have done for the designated course activities as you proceed through the course. Feel free to ask questions and engage in dialog with your mentor using the Moodle online learning platform communication and discussion tools.
4. When you are ready, take the final exam at the end of this course. A passing score is 80% or better. Your mentor will decide if you have met the requirements to successfully complete this course. This will depend on your completion of the course pre-requisites, assessment of your work on course activities, and successful completion of the final exam.

Course Syllabus

Section 1: The Framework: How You Fit In

1. Introduction to Emergency Communications
2. Amateurs as Professionals
3. Network Theory and Design
4. Emergency Communications Organizations and Systems
5. Served Agency Communications Systems
 A. Served Agency Communications Systems
 B. Working Directly with the Public

Section 2: The Networks for Messages

6. Basic Communications Skills
7. Net Operations:
 A. Basic Net Operations
 B. Introduction to Emergency Nets
 C. Net Operating Guidelines
 D. The FCC Ruling on Drills and *Employees*
8. The Net Control Station
9. Net Control Station Operator Practices
10. The Net Manager
11. Introduction to the National Traffic System
12. Specialized Net Operations
13. Severe Weather Nets

Section 3: Message Handling

14. Basic Message Handling—Part 1
15. More Basic Message Handling— Part 2

Section 4: What Happens When Called

16. The Incident Command System
17. Preparing for Deployment
18. Equipment Choices
19. Emergency Activation
20. Setting Up, Initial Operations and Shutdown

Section 5: Considerations

21. Operations & Logistics
22. Safety & Survival
23. ARES PIO: The Right Stuff
24. Alternative Communication Methods
25. What to Expect in Large Disasters
26. Hazardous Materials Awareness
27. Marine Communications

Section 6: Alternatives and Opportunities

28. Modes, Methods and Applications
29. Other Learning Opportunities

Final Assessment

(end of reprinted material)

That's it for this month, and hopefully the column will give you some food for thought regarding your emergency communications preparedness.

73, Mitch, NA7US

By Bob Witte,* KØNR

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

Ten Things You Should Know About FM and Repeaters

After they get their Technician licenses, many radio amateurs first get on the air using FM VHF. Somewhere along the way, they start to learn a few things about FM that may not be that obvious. To help this along, I've listed some things that you should know about FM operating. Maybe you already know these, but they might be good to review, as well.

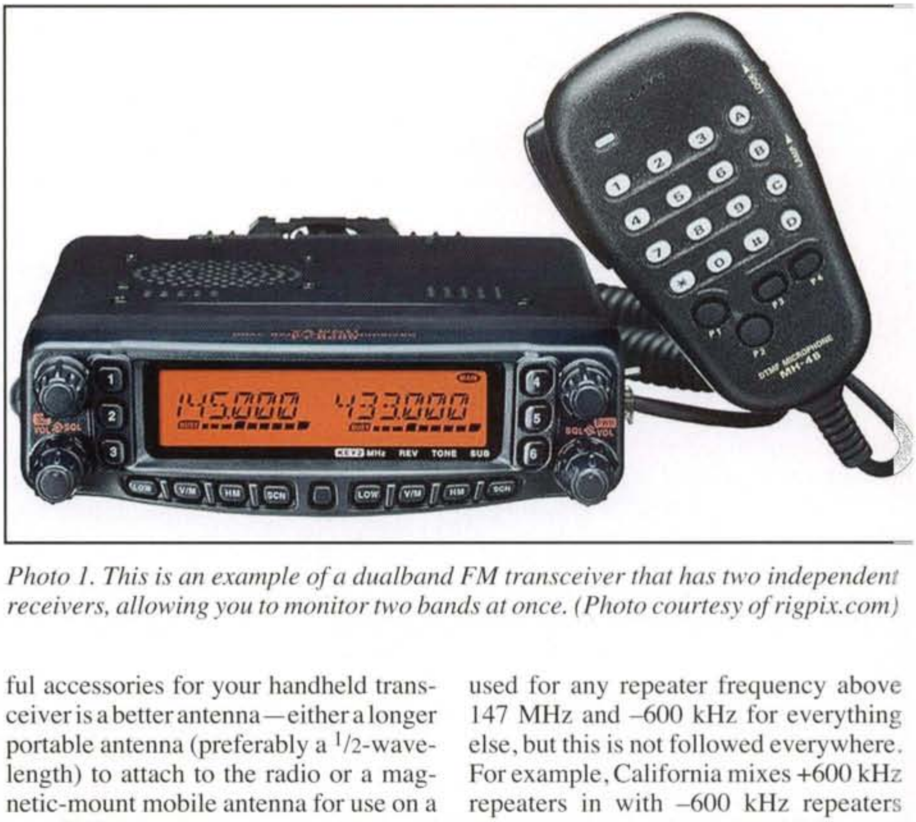

Photo 1. This is an example of a dualband FM transceiver that has two independent receivers, allowing you to monitor two bands at once. (Photo courtesy of rigpix.com)

1. Not All Dualband Radios are the Same

Dualband FM transceivers are a common radio choice, usually covering the two most popular FM bands—2 meters and 70 cm. Whether you are looking for a mobile or handheld radio, look closely at the radio features. One distinguishing feature of dualband radios is whether they have two truly-independent receivers. To keep the cost low, many radios can only receive "one frequency at a time." There's nothing wrong with this type of radio, as they are generally simpler, easier to use, and lower in cost. The more full-featured dualband radios have two independent receivers, allowing you to listen to both bands at once (photo 1). This is almost like having two radios in one, since you can monitor both bands simultaneously. Most of these rigs also allow you to listen to two frequencies on the same band, which can be handy for monitoring 146.52 MHz and your favorite 2-meter repeater at the same time.

2. A Rubber Duck is a Very Convenient Inefficient Antenna

Almost all handheld radios come from the factory with a short helical antenna commonly known as a *rubber duck*. This antenna is basically a shortened 1/4-wave antenna constructed as a coiled radiating element inside a protective rubberized coating. This antenna is very convenient but the shortened format results in rather poor performance. One of the most useful accessories for your handheld transceiver is a better antenna—either a longer portable antenna (preferably a 1/2-wavelength) to attach to the radio or a magnetic-mount mobile antenna for use on a vehicle. Photo 2 shows some optional antennas that can be used with a handheld radio. You'll end up using the rubber duck a lot, since it is so convenient, but you'll also benefit from a more efficient antenna.

3. Repeater Offsets are Standard Except When They're Not

When using a repeater, you need to have your radio programmed with the proper offset between receive and transmit frequency. In modern radios, you dial in the desired receive frequency on your rig (which is the repeater transmit frequency) and select the transmit offset. Some rigs will even select the transmit offset automatically. When you press the Push-To-Talk button, the transceiver selects the right transmit frequency so that you are transmitting on the repeater's input.

On the 2-meter band, many areas use the convention that +600 kHz offset is used for any repeater frequency above 147 MHz and –600 kHz for everything else, but this is not followed everywhere. For example, California mixes +600 kHz repeaters in with –600 kHz repeaters across the 2-meter band. In addition, you will find that offsets other than 600 kHz are used in some locations, as they attempt to cram more repeater pairs into the available spectrum. For example, in Pennsylvania some repeaters make use of a +1 MHz offset (example: repeater output of 146.475 MHz and an input of 147.475 MHz).

On the 70-cm band the standard offset is plus or minus 5 MHz. Some regions use a high repeater transmit frequency, in the range of 446 to 450 MHz, and a transmit offset of –5 MHz. Other regions do just the opposite: The repeater transmit frequency is low (say 440 to 444 MHz) and the transmit offset is +5 MHz. To make things even more interesting, some states have "high in" and "high out" repeaters interspersed.

If this sounds a bit like a confused mess, you have that correct. This is why you really should have a repeater directory

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available to give you the right information on repeater frequency and offset. The *ARRL Repeater Directory* is the most authoritative source of repeater information, but there are online repeater databases springing up on the internet.

4. Access Tones Are Rarely Standard

It used to be that most FM repeaters were carrier access, which means that the user just had to have the right frequency and transmit offset to use the machine. These days, tone access for repeaters is becoming much more common. Fortunately, all modern FM ham transceivers include CTCSS and DCS capability, so your radio is probably equipped to handle tone access repeaters. Unfortunately, you do have to program in the proper tone, otherwise the repeater won't respond . . . another reason to have an up-to-date repeater directory. I am not sure how repeater owners choose which tone to use, but it seems to be a personal and somewhat random choice. A particular radio club is likely to use the same tone on all of its repeaters, but the next club over the horizon will likely make a different choice.

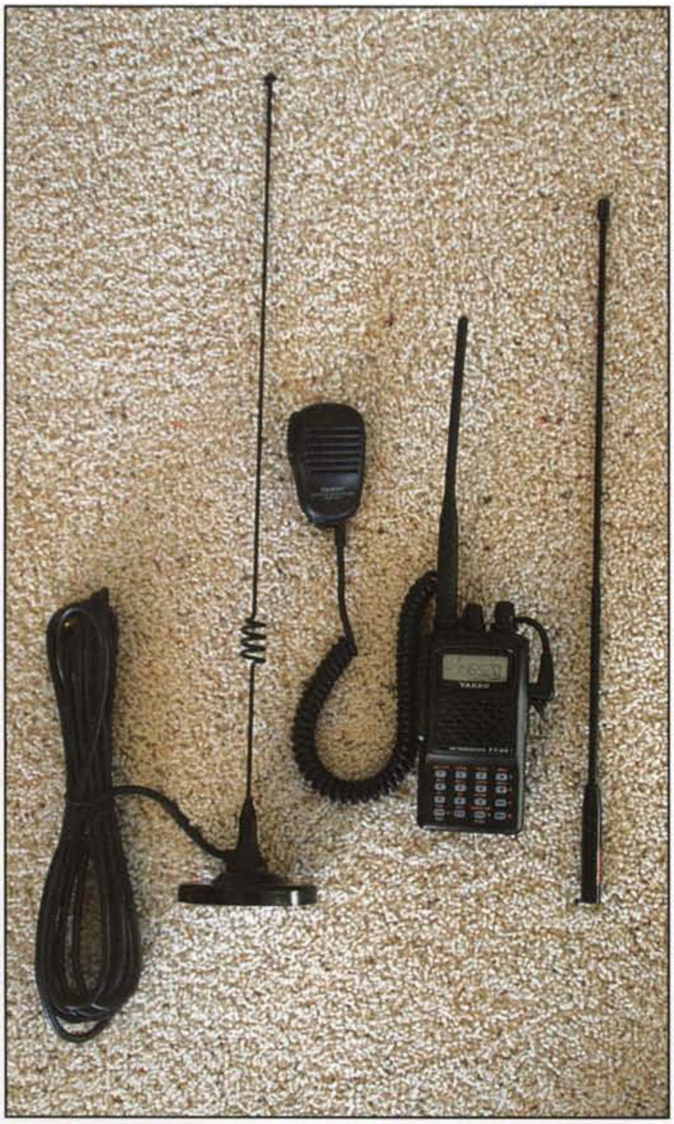

Photo 2. A handheld radio is shown here with a standard rubber-duck antenna. To the right is a extended-length portable antenna and to the left is a compact magnetic-mount mobile antenna.

All of the repeater settings can be stored in memory so that your transceiver remembers it all for you (photo 3). This means that the complexity of repeater frequency, offset, and tone is a one-time programming challenge. You won't have to deal with it on a daily basis. However, as soon as you get on the road to another area of the country, you'll have to dial in the right information for those repeaters.

5. The Repeater Is Doing Most of the Work

When operating through a repeater, keep in mind the role that the repeater is playing. It is usually sitting on a high spot with a really good receiver and a strong transmitter. A common newbie mistake is to give someone an excellent signal report through a repeater. "Your radio is doing a great job and your signal is full scale here at my location!" Of course, it's really the repeater that is putting out that full-scale signal. A half-watt handheld radio may sound great through the repeater, but that signal on the other end is from the repeater transmitter, not the HT.

6. RST Signal Reports are Rarely Used for FM

Most new hams learn about the RST reporting system (Readability, Signal Strength, Tone). A perfect signal in RST format is 599 for a CW signal, or just 59 for phone (dropping the Tone indicator). However, RST reporting is not that common for FM operating. You might hear someone say "your signal is Five Nine" if it is loud and clear. More likely, your signal report will be given in terms of FM quieting. A strong FM signal has no noise associated with it; we say that the signal is *full quieting*, because the signal has fully quieted the receiver. If the signal has noise on it, then we might say it is a little noisy or we might put a number on it such as 50% quieting. Again, think about the role the repeater is playing. The signal might be weak into the repeater, introducing noise on that connection. Or the repeater's signal may be received poorly, causing some

Standard Transmit Offset

50 MHz	Varies
146 MHz	±600 kHz
222 MHz	–1.6 MHz
440 MHz	±5 MHz
902 MHz	–12 MHz or –25 MHz
1.2 GHz	–12 MHz

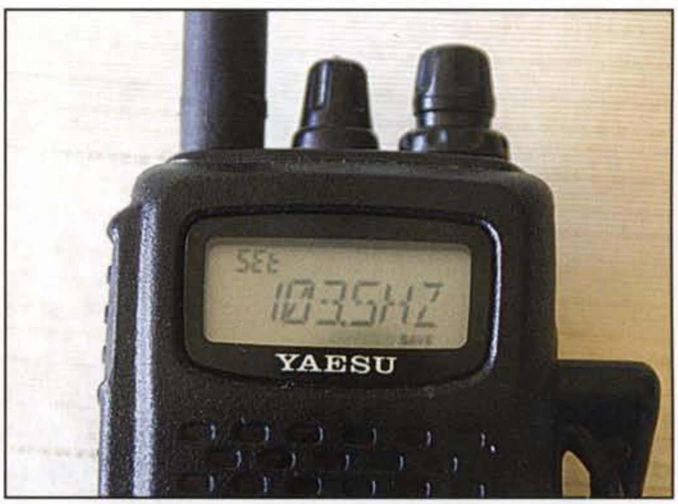

Photo 3. Most modern FM transceivers allow the CTCSS tone to be set by the front-panel controls and stored in memory.

noise on the listener's receiver. A good way to describe how well the whole system is working is how much noise has been introduced along the way.

7. FM Exhibits the Threshold Effect

FM signals sound great as long as the signal level is strong. As the signal level at the receiver decreases, it hits a point where a small change in signal level causes the signal to rapidly disappear into the noise. This is the *threshold effect*, meaning that as a signal fades it hits a threshold where it disappears quite quickly. Other modulation types, such as SSB, degrade more gradually and perform better with weak signals. You'll notice the threshold effect when driving out of range while mobile. You can be cruising along enjoying a crystal-clear conversation until you hit the point where signals start to fade. Suddenly, the other guy starts to get a bit noisy and shortly thereafter he is completely unreadable.

8. FM Exhibits the Capture Effect

When two FM signals are present on the same frequency at the same time, one of them usually wins out completely and the other one is not heard. This is called the *capture effect*, since the stronger signal is said to capture the receiver. Compare this to single-sideband or amplitude modulated signals, where the two signals tend to mix and both can be heard to some extent. Now if two FM signals are very close in amplitude, neither one will capture the receiver and you'll hear a very distorted signal, sometimes with a bit of a squeal to it. But give one signal a little more power and it will wipe out the weaker one and you'll only hear the stronger of the two signals. You'll hear this from time to time when different stations transmit at the same time by mistake; one may pop through very clear while the other one disappears.

9. FM Power Output is Constant

Frequency modulation works by taking a radio frequency carrier and modulating it back and forth in frequency, as driven by the microphone audio. When an FM transmitting is keyed, it produces a carrier with constant output power. With no modulation present (that is, you are not speaking into the microphone), a constant carrier is transmitted. As the radio operator speaks into the microphone, the frequency of the carrier is modulated or changed according to the microphone audio but the output power remains the same. The amount of frequency change due to modulation is calling the *frequency deviation*. Speaking louder or softer into the microphone normally changes the frequency deviation (up to a point at which it limits), but the output power is unchanged. Talking louder into an FM transceiver has no effect on the output power. We always want to have enough audio to properly modulate the carrier but anything beyond that is just wasted.

10. An FM Signal May Be Wider Than You Think

The standard frequency deviation for amateur radio FM is ±5 kHz deviation. That is, on the positive peaks of our voice modulation, the transmitter frequency instantaneously shifts upwards by 5 kHz. On the negative peaks, the frequency shifts down to 5 kHz below the carrier frequency. It would seem to make sense then that the total width of the signal is 10 kHz, but that is incorrect! The mathematical analysis involved with frequency modulation is very complex, uses Bessel Functions, and generally tends to make my head hurt. However, we can use *Carson's Rule*, to estimate the bandwidth of most FM signals:

$$BW = 2\ (\Delta f + f_m)$$

where Δf is the peak frequency deviation and f_m is the highest modulating frequency.

For typical amateur FM, Δf is 5 kHz and the highest modulating frequency is 3 kHz. Carson's Rule estimates the bandwidth at 2 (5 + 3) = 16 kHz. Basically, what's happening with the signal is that as it wiggles back and forth by plus and minus 5 kHz, the modulating frequencies spill over to create a wider signal.

Some areas of the country have chosen a 15 kHz channel spacing on 2 meters, but this is actually a bit tight given that signal is 16 kHz wide. The standard band plan might have simplex frequencies at 146.520 MHz and 146.535 MHz, but if two stations close together try to operate on those frequencies simultaneously they will hear some interference spilling over from the other frequency. Other parts of the country have moved to a 20-kHz channel spacing, resulting in fewer channels, but eliminating this adjacent channel interference problem. Always follow your local VHF band plan but understand that there are times when adjacent channels might be a little too tight.

Tnx and 73

This has been a light touch on some fundamental concepts concerning FM and repeater operation. Some past columns delved deeper into a few of these topics. If you want to learn more about FM in general, see the Winter 2007 issue of *CQ VHF*. For a more in depth into tone access, take a look at the Winter 2011 column.

Thanks for taking the time to read another one of my columns on the *Utility Mode*. I always enjoy hearing from readers, so stop by my blog at <http://www.k0nr.com/blog> or drop me an e-mail at the address on the first p[age of this column.

73, Bob, KØNR

Update on "FM VHF Distance from Pikes Peak, Colorado"

In my previous FM/Repeater column, I discussed the topic of FM VHF propagation from Pikes Peak. I received the e-mail reprinted below from Lauren Libby, WØLD, who did some operating from Pikes Peak some years ago. The article he refers to is "New Land Record on 3.4 GHz," *QST*, May 1990 by Lauren Libby, KXØO, available here (for ARRL members): <http://p1k.arrl.org/pubs_archive/85801>.

Lauren reports that he routinely worked 400 miles on 2 meters FM, compared to the Colorado 14er Event record (NØKE) of 375 miles, so very similar results. —Bob, KØNR

In the late 80s and 90s W$$MXY and I conducted tests from the top of Pikes Peak. Some distances worked were:

KXØO (now WØLD) to WBØDRL (now NØOY) on 2 meters – 1.2 GHz. Pikes Peak–Salina, Kansas. We worked any time, day or night, on those bands (410 miles).

On 3.4 GHz we worked W5UGO in Sand Springs, Oklahoma (565 miles).

We worked WB5AFY in Vernon, Texas on 2 meters CW and 2.4 and 3.6 GHz CW (500 miles).

Using weak-signal techniques and good antennas, 500 miles is very workable any time, day or night.

By the way, we could work Salina, Kansas anytime, day or night, on FM with 160 watts and a 13-element Yagi. —73, Lauren, WØLD

CQ's 6 Meter and Satellite WAZ Awards

(As of October 1, 2011)

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	16,17,18,19,21,22,23,24,25,26,28,29,34,39
11	GØLCS	1,6,7,12,18,19,22,23,28,31
12	JR2AUE	2,18,34,40
13	K2MUB	16,17,18,19,21,22,23,24,26,28,29,34
14	AE4RO	16,17,18,19,21,22,23,24,26,28,29,34,37
15	DL3DXX	18,19,23,31,32
16	W5OZI	2,16,17,18,19,20,21,22,23,24,26,28,34,39,40
17	WA6PEV	3,4,16,17,18,19,20,21,22,23,24,26,29,34,39
18	9A8A	1,2,3,6,7,10,12,18,19,23,31
19	9A3JI	1,2,3,4,6,7,10,12,18,19,23,26,29,31,32
20	SP5EWY	1,2,3,4,6,9,10,12,18,19,23,26,31,32
21	W8PAT	16,17,18,19,20,21,22,23,24,26,28,29,30,34,39
22	K4CKS	16,17,18,19,21,22,23,24,26,28,29,34,36,39
23	HB9RUZ	1,2,3,6,7,9,10,18,19,23,31,32
24	JA3IW	2,5,18,34,40
25	IK1GPG	1,2,3,6,10,12,18,19,23,32
26	W1AIM	16,17,18,19,20,21,22,23,24,26,28,29,30,34
27	K1LPS	16,17,18,19,21,22,23,24,26,27,28,29,30,34,37
28	W3NZL	17,18,19,21,22,23,24,26,27,28,29,34
29	K1AE	2,16,17,18,19,21,22,23,24,25,26,28,29,30,34,36
30	IW9CER	1,2,6,18,19,23,26,29,32
31	IT9IPQ	1,2,3,6,18,19,23,26,29,32
32	G4BWP	1,2,3,6,12,18,19,22,23,24,30,31,32
33	LZ2CC	1
34	K6MIO/KH6	16,17,18,19,23,26,34,35,37,40
35	K3KYR	17,18,19,21,22,23,24,25,26,28,29,30,34
36	YV1DIG	1,2,17,18,19,21,23,24,26,27,29,34,40
37	KØAZ	16,17,18,19,21,22,23,24,26,28,29,34,39
38	WB8XX	17,18,19,21,22,23,24,26,28,29,34,37,39
39	K1MS	2,17,18,19,21,22,23,24,25,26,28,29,30,34
40	ES2RJ	1,2,3,10,12,13,19,23,32,39
41	NW5E	17,18,19,21,22,23,24,26,27,28,29,30,34,37,39
42	ON4AOI	1,18,19,23,32
43	N3DB	17,18,19,21,22,23,24,25,26,27,28,29,30,34,36
44	K4ZOO	2,16,17,18,19,21,22,23,24,25,26,27,28,29,34
45	G3VOF	1,3,12,18,19,23,28,29,31,32
46	ES2WX	1,2,3,10,12,13,19,31,32,39
47	IW2CAM	1,2,3,6,9,10,12,18,19,22,23,27,28,29,32
48	OE4WHG	1,2,3,6,7,10,12,13,18,19,23,28,32,40
49	TI5KD	2,17,18,19,21,22,23,26,27,34,35,37,38,39
50	W9RPM	2,17,18,19,21,22,23,24,26,29,34,37
51	N8KOL	17,18,19,21,22,23,24,26,28,29,30,34,35,39
52	K2YOF	17,18,19,21,22,23,24,25,26,28,29,30,32,34
53	WA1ECF	17,18,19,21,23,24,25,26,27,28,29,30,34,36
54	W4TJ	17,18,19,21,22,23,24,25,26,27,28,29,34,39
55	JM1SZY	2,18,34,40
56	SM6FHZ	1,2,3,6,12,18,19,23,31,32
57	N6KK	15,16,17,18,19,20,21,22,23,24,34,35,37,38,40
58	NH7RO	1,2,17,18,19,21,22,23,28,34,35,37,38,39,40
59	OK1MP	1,2,3,10,13,18,19,23,28,32
60	W9JUV	2,17,18,19,21,22,23,24,26,28,29,30,34
61	K9AB	2,16,17,18,19,21,22,23,24,26,28,29,30,34
62	W2MPK	2,12,17,18,19,21,22,23,24,26,28,29,30,34,36
63	K3XA	17,18,19,21,22,23,24,25,26,27,28,29,30,34,36
64	KB4CRT	2,17,18,19,21,22,23,24,26,28,29,34,36,37,39
65	JH7IFR	2,5,9,10,18,23,34,36,38,40
66	K0SQ	16,17,18,19,20,21,22,23,24,26,28,29,34
67	W3TC	17,18,19,21,22,23,24,26,28,29,30,34
68	IKØPEA	1,2,3,6,7,10,18,19,22,23,26,28,29,31,32
69	W4UDH	16,17,18,19,21,22,23,24,26,27,28,29,30,34,39
70	VR2XMT	2,5,6,9,18,23,40
71	EH9IB	1,2,3,6,10,17,18,19,23,27,28
72	K4MQG	17,18,19,21,22,23,24,25,26,28,29,30,34,39
73	JF6EZY	2,4,5,6,9,19,34,35,36,40
74	VE1YX	17,18,19,23,24,26,28,29,30,34
75	OK1VBN	1,2,3,6,7,10,12,18,19,22,23,24,32,34
76	UT7QF	1,2,3,6,10,12,13,19,24,26,30,31
77	K5NA	16,17,18,19,21,22,23,24,26,28,29,33,37,39
78	I4EAT	1,2,6,10,18,19,23,32
79	W3BTX	17,18,19,22,23,26,34,37,38
80	JH1HHC	2,5,7,9,18,34,35,37,40.
81	PY2RO	1,2,17,184OM,19,21,22,23,26,28,29,30,38,39,40
82	W4UM	18,19,21,22,23,24,26,27,28,29,34,37,39
83	I5KG	1,2,3,6,10,18,19,23,27,29,32.
84	DF3CB	1,2,12,18,19,32
85	K4PI	17,18,19,21,22,23,24,26,28,29,30,34,37,38,39.
86	WB8TGY	16,17,18,19,21,22,23,24,26,28.29,30,34,36,39
87	MUØFAL	1,2,12,18,19,22,23,24,26,27,28,29,30,31,32
88	PY2BW	1,2,17,18,19,22,23,26,28,29,30,38,39,40.
89	K4OM	17,18,19,21,22,23,24,26,28,29,32,34,36,38,39.
90	JHØBBE	2,33,34,40
91	K6QXY	17,18,19,21,22,23,34,37,39
92	JA8ISU	2,7,8,9,19,33,34,36,37,38,39,40
93	YO9HP	1,2,6,7,11,12,13,18,19,23,28,29,30,31,40
94	SV8CS	1,2,6,7,18,19,23,26,28,29
95	SM3NRY	1,6,10,12,13,19,23,25,26,29,30,31,32,39
96	VK3OT	2,10,11,12,16,34,35,37,39,40
97	UY1HY	1,2,3,6,7,9,12,18,19,23,26.28,31,32,36
98	JA7QVI	2,40
99	K1HTV	17,18,19,21,22,23,24,26,28,29,34
100	OK1RD	2,6,7,8,9,11,12,13,18,19,21,22,28,39,40
101	S51DI	1,2,6,18,19
102	S59Z	1,2,6,7,10,12,17,18,19,22,23,24,26,31,32
103	UY5ZZ	1,2,3,6,7,10,11,12,13,18,19,29,31,32,39
104	UX0FF	1,2,6,7,10,12,13,18,19,22,28,29,31,32
105	EI3IO	1,3,12,18,19,23,29,30,31,32
106	JJ2BLV	2,4,5,7,8,9,16,18,19,34,35,36,37,38,40

Satellite Worked All Zones

No.	Callsign	Issue date	Zones Needed to have all 40 confirmed
1	KL7GRF	8 Mar. 93	None
2	VE6LQ	31 Mar. 93	None
3	KD6PY	1 June 93	None
4	OH5LK	23 June 93	None
5	AA6PJ	21 July 93	None
6	K7HDK	9 Sept. 93	None
7	W1NU	13 Oct. 93	None
8	DC8TS	29 Oct. 93	None
9	DG2SBW	12 Jan. 94	None
10	N4SU	20 Jan. 94	None
11	PAØAND	17 Feb. 94	None
12	VE3NPC	16 Mar. 94	None
13	WB4MLE	31 Mar. 94	None
14	OE3JIS	28 Feb. 95	None
15	JA1BLC	10 Apr. 97	None
16	F5ETM	30 Oct. 97	None
17	KE4SCY	15 Apr. 01	10,18,19,22,23, 24,26,27,28, 29,34,35,37,39
18	N6KK	15 Dec. 02	None
19	DL2AYK	7 May 03	2,10,19,29,34
20	N1HOQ	31 Jan. 04	10,13,18,19,23, 24,26,27,28,29, 33,34,36,37,39
21	AA6NP	12 Feb. 04	None
22	9V1XE	14 Aug. 04	2,5,7,8,9,10,12,13, 23,34,35,36,37,40
23	VR2XMT	01 May 06	2,5,8,9,10,11,12,13,23,34,40
24	XE1MEX	19 Mar. 09	2,17,18,21,22,23,26,34,37,40
25	KCØTO	17 Mar. 11	None

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, P.O. Box 449, Wiggins, MS 39577-0449. 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>.

**P.O. Box 449, Wiggins, MS 39577-0449; e-mail: <n5fg@cq-amateur-radio.com>*

By Keith Pugh,* W5IU

SATELLITES

Artificially Propagating Signals Through Space

ARiSSat-1 "On Orbit," Project Fox – AMSAT's First CubeSat, and AMSAT Space Symposium

ARISSat-1 is now "on orbit" and available for use. Next let's review what's going on in the world of Project Fox, our next satellite. Finally, let's preview the AMSAT Space Symposium 2011.

ARISSat-1 On Orbit

ARISSat-1 was deployed from the ISS during a Russian Space Walk on 3 August 2011. According to the pre-launch predictions: *Once launched, due to a very low altitude orbit and battery uncertainties, it will only be usable for two or three months.* Accordingly, its life is nearly over. Optimistically, it might last as long as six to nine months. Now that it has been on orbit for two months and continues to "fly like a butterfly," I'm going to make a "WAG" that we will still have it with us for Christmas 2011 and possibly on into early 2012. This is not an official entry into the "Chicken Little Contest" that is going on as we speak. We need to use ARISSat-1 to the greatest extent possible while it is with us. If you haven't already done so, get it into the schools immediately.

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In the beginning, life for ARISSat-1 was rough. It was banged around some getting out of the ISS and into position for launch. During that time, it was noticed that the 70-cm antenna was broken/missing and that delayed deployment for several hours. Finally, a decision was made to go ahead and launch it with a broken 70-cm antenna. That turned out to be a good decision (really the only logical decision possible) and the satellite worked well after the initial wait for the timers expired. It doesn't hear as well as it should on 70 cm with a short (1.5-inch instead of 9-inch) antenna, but it does work and a number of contacts have been made through the Linear Software Defined Transponder (SDX). Telemetry worked well and we were "off and running" with the new "Bird."

After about a week into its life, it became apparent that the battery was already experiencing difficulty. Telemetry showed a steady decrease of terminal voltage and indications were that one or more cells were having difficulty. After a number of anxious moments, the battery failed, but fortunately, it failed in the "open" state instead of a "shorted" state. This allowed the Max Power Point Trackers and their software to take total control of the situation. The satellite now operates whenever it is in sunlight and shuts down when in eclipse. One complicating factor is the start-up timer. The

"Satellites" column editor Keith Pugh, W5IU, giving instructions to the hams gathered to hear ARISSat-1 at the Austin Summerfest this year. (Photo courtesy of N6CL)

satellite has to go through this 15-minute timer whenever it comes back into sunlight. Barring further battery changes, we should be "good to go" for the rest of ARISSat-1's time in space.

The telemetry system works very well. Thanks to the many telemetry contributors worldwide, and Douglas Quagliana's (KA2UPW/5) software and servers, it is possible to easily look at near real-time telemetry on your iPhone, notebook, or home computer at any time. I find myself looking at ARISSat-1 several times a day, wherever I am, via a tracking program and the telemetry on my iPhone. Use your imagination and discover what you can do with this telemetry. It is an excellent topic or tool for a school science or math class.

If you like Slow Scan Television (SSTV) then ARISSat-1 is just for you. Many SSTV frames have been contributed to the SSTV Library for you to browse or add to. Some of these are canned frames from the satellite, while many more are real shots of the Earth, sky, oceans, etc., from the on-board cameras.

Earlier I mentioned the "Chicken Little Contest." This is an opportunity to predict the demise of ARISSat-1 and see who gets it right. There are other contests and awards as well. Many happy hams and students have already received certificates for just hearing the "Bird," contributing telemetry, etc. People are accumulating the "secret words" from the voice messages for entry into the "Secret Word Contest." The CW Contest is just starting as hams and students decipher the callsigns of the many hams who contributed to the Amateur Satellite Program over the years. Whoever copies the most callsigns correctly will be recognized.

All of this can be accomplished with just a radio, a simple antenna, and a computer. Get in on the action now! Hopefully, ARISSat-1 will still be on the air when you read this. If not, there are three more "waiting in the wings" for future launch opportunities.

What better way to introduce science, Ttechnology, engineering, and mathematics (STEM) into the classroom. Visit <http://www.arissat1.org< and <http://www.amsat.org> regularly. Stay tuned for additional updates!

Project Fox AMSAT's First CubeSat

Now that ARISSat-1 is "on its way," AMSAT has returned to work on Project Fox. This effort was approved by the AMSAT's BOD a couple of years ago but had been overtaken by the ARISSat-1 effort. With the recent failure of batteries on AO-51, this project takes on more urgency. It has now been split into a two-phase program, FOX-1 and FOX-2. FOX-1 will be a replacement for the FM transponder on AO-51 done quickly due to the current urgency. FOX-2 will include a software-defined linear transponder and other features. Development of FOX-2 will lag FOX-1 due to limited assets. Further details are available at: <http://www.amsat.org/amsat-new/fox/>. Project FOX will be a major feature of the 2011 AMSAT Symposium and General Meeting this year.

AMSAT Space Symposium and General Meeting

By the time you read this, it probably is already too late to plan to attend the AMSAT Space Symposium and General Meeting in San Jose, CA, on 4–6 November 2011. The BOD meeting was 3–4 November, giving additional insight into how AMSAT operates. The format was the same as ever, featuring the following:

- AMSAT Board of Directors Meeting
- Technical and Operational Presentations
- Attitude Adjustment
- Banquet with Featured Speaker and Prizes
- Area Coordinator's Breakfast
- Tour of Local Area of Interest
- Satellite Beginners Programs
- Rag Chews and Discussions

I will give a full report in my next column. If you have missed it this year, plan to attend next year. It's always a good way to spend part of your vacation and learn about our fascinating hobby.

Summary

Let's welcome ARISSat-1 to the classroom and the ham shack now that it's on orbit. It represents a golden opportunity to showcase amateur radio and amateur radio satellites to kids in the classroom and promote STEM while having "hands on" and "heads on" fun. Use it while it's here. *Remember the limited time available for its use!*

Continue the Amateur Radio Satellites in Education theme with Project Fox. It is a natural carry on to ARISSat-1 and will be AMSAT-NA's next satellite. Support FUNCube, a similar AMSAT-UK satellite that may launch before Project Fox.

Please continue to support AMSAT's plans for the future of amateur radio satellites. AMSAT is now updating its web page at <http://www.amsat.org> on a much more regular basis. Satellite details are updated regularly at <http://www.amsat.org/amsat-new/satellites/status.php>. Follow the projects and progress of AMSAT-UK at <http://www.uk.amsat.org/>.

'Til next time . . . 73, Keith, W5IU

By Tomas Hood,* NW7US

VHF PROPAGATION

The Science of Predicting VHF-and-Above Radio Conditions

We're Moving Up in Cycle 24!

Solar Cycle 24 is moving steadily toward its maximum activity period, a peak that is still several years away (at least; solar scientists predict 2013, but this columnist thinks it may be later). The recent months have proved to be exciting, as the sunspot counts are up, and the overall energy as measured by both the 10.7-cm radio flux as well as the hard x-ray background radiation levels (between the 1- to 8-Angstrom wavelengths) is averaging higher.

As this edition of this column goes to press, the Sun remains highly active, having just broken some sunspot Cycle 24 records so far. An active sunspot region, NOAA Active Region 11302 (for short, 1302), rotated into view on September 22, 2011, offering plenty of activity right from the start. At 1029 UTC, a long-duration magnitude X1.4 x-ray flare erupted from this region, located right on the Sun's northeastern limb. The magnetic structures seen at many wavelengths were stunningly beautiful. The flare itself lasted over four hours, starting with the initial X1.4-level explosion, but continued to expel amazing amounts of energy during the long four-hour decline (see the movie I created showing this event in various wavelengths, at <http://nw7us.us/x14s22_1.html>). This sunspot region now had everyone's attention!

As Active Region 1302 rotated away from the eastern limb, it increased in size and was followed by other sunspots. By September 24, this one sunspot became the largest sunspot yet (at press time) in Cycle 24, measuring an incredibly huge 1300 millionths of the solar hemisphere. Sunspot observers report the day's Ssunspot area as the sum of the corrected area of all observed sunspots in units of millionths of the solar hemisphere. The combined total of all sunspots for the 24th was a huge 1930 units. That's the largest area yet recorded during this cycle. September 24 also became the day with the highest 10.7-cm radio flux reading so far in this sunspot cycle—190! We have

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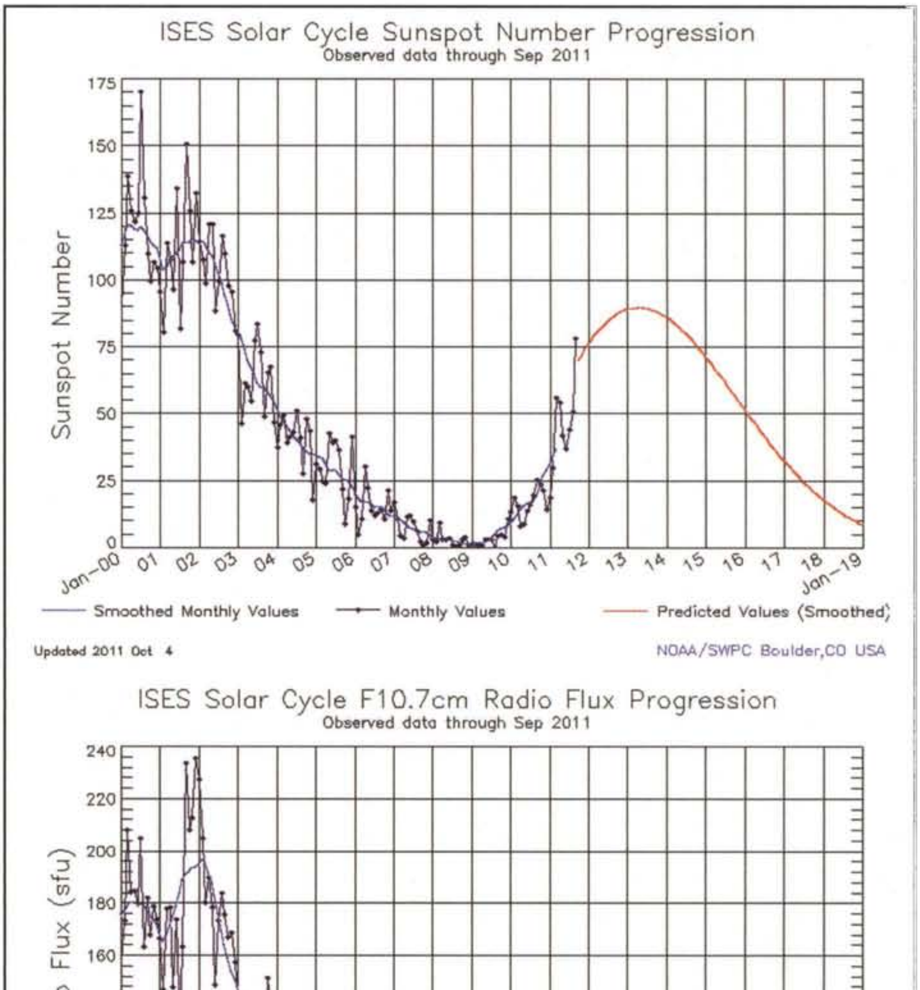


Figure 1. Sunspot Cycle 24 progression charts showing the huge, sharp rise in September 2011. There was a lot of discussion about the variable nature of the Sun, and the dismal conditions from May through August, but this sort of variability is quite normal during any sunspot cycle. It is clear that this sunspot cycle is on its rise. This results in a hint of VHF propagation via the F2*-region over some regions, and more so as we see the steady rise in the 10.7-cm radio flux. (Source: Space Weather Prediction Center [SWPC]/The National Oceanic and Atmospheric Administration [NOAA])*

not seen a flux reading this high since November 2, 2003, when it was also 190. That's a long eight years ago. Additionally, the background x-ray flux (1–8 Angstroms) reached the highest yet, at C2.7, in Cycle 24 on September 25, .

Compared with last year's solar activity, this season is hot! Under such activity levels, VHF propagation this season via the *F2*-region of the ionosphere is becoming a reality. Certainly, 10 meters has been a player since September.

One interesting development under the recent increase in solar activity is the transequatorial propagation (TEP) seasonal openings that last until November. TEP, which tends to occur most often during spring and fall, requires high solar activity, as it takes a strongly-energized *F*-region over the equatorial region to support VHF propagation. The normal TEP signal path is between locations on each side of the equator. With the level of solar activity finally increasing, this year these TEP paths came alive and should continue to play until tapering out by mid-November.

A secondary seasonal peak in sporadic-*E* ionization at the end of December should also result in some short-skip openings on low VHF between distances of about 800 and 1300 miles at the end of December and early in January. Reports even after the end of the 2011 summer *Es* season indicate surprise openings when no one expected them, so be vigilant and watch for 6-meter openings throughout November, December, and January.

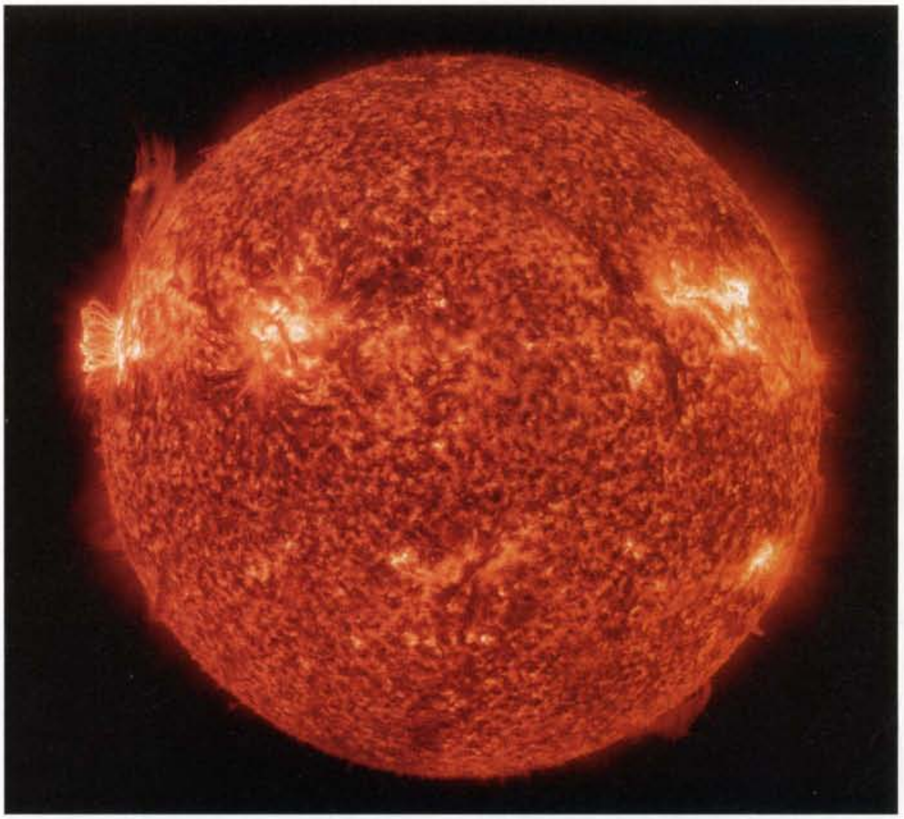


*Figure 2. The Solar Dynamics Observatory (SDO) Atmospheric Imaging Assembly (AIA) captured an X-class x-ray flare on September 22, 2011. The magnetic structure was complex and powerful forces kept the eruption active for over four hours. This resulted in an extended radio blackout on the shortwave frequencies up into the low VHF range, as well as sweeping noise on the VHF bands. Later in the week, as the sunspot, NOAA Active Region 1302, rotated toward the center of the solar disc, additional solar x-ray flares unleashed coronal mass ejections (CMEs) toward the Earth, resulting in geomagnetic storms and related aurora. This provided opportunity for auroral-*E *propagation for VHF enthusiasts. (Credit: Solar Dynamics Observatory [SDO]/Atmospheric Imaging Assembly [AIA])*

With the TEP season and the seasonal summer sporadic-*E* (*Es*) season behind us, what hope do we have during this fall season for long-distance VHF communications? Of course, we can try working an amateur radio satellite. Expect some periods of aurora due to strong geomagnetic storms, since the increase in solar activity includes coronal mass ejections (CMEs). These CME events can trigger geomagnetic storms with sufficient energy to ionize the *E*-region over not only polar regions, but over high- to mid-latitude regions.

When the Interplanetary Magnetic Field (IMF) lines that extend out from the Sun are oriented opposite to the Earth's magnetosphere's orientation, the two fields connect and allow solar-wind particles to collide with oxygen and nitrogen molecules in the upper atmosphere of the polar regions. 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*-region of the ionosphere. The level of ionization depends on the energy and amount of solar-wind particles able to enter the atmosphere.

While correlations exist between visible and radio aurora, radio aurora could exist without visual aurora. Statistically, a diurnal variation of the frequency of radio aurora QSOs 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 amateurs 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 geomagnetic conditions,

you are welcome to check my propagation resource at <http://sunspotwatch.com>, where I have the current planetary *K*-index (*Kp*) links to various aurora resources, and more.

Meteors

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

For the 2011 *Leonids* shower, two peaks are predicted. Appearing to radiate out of the constellation of Leo from November 15 through 20, the shower is active from November 6 through November 30. The peaks are expected on November 18 at 0340 UTC, and possibly on November 16 at 2236 UTC.

This year might produce enhanced rates, but only from the perspective of radio systems; the size of the comet dust is on the order of 10 to 100 microns and thus might not produce many visual meteor trails. However, remember that with a high hourly rate, even tiny patches of ionized *E*-region meteor trail in sufficient quantity could support VHF propagation.

Since the source of the *Leonids*, the Tempel-Tuttle comet, passed closest to the Sun in February 1998, the years following were expected to produce very strong displays. The greatest display since 1998 was the peak of 3,700 per hour in 1999. Every year since has been sig-

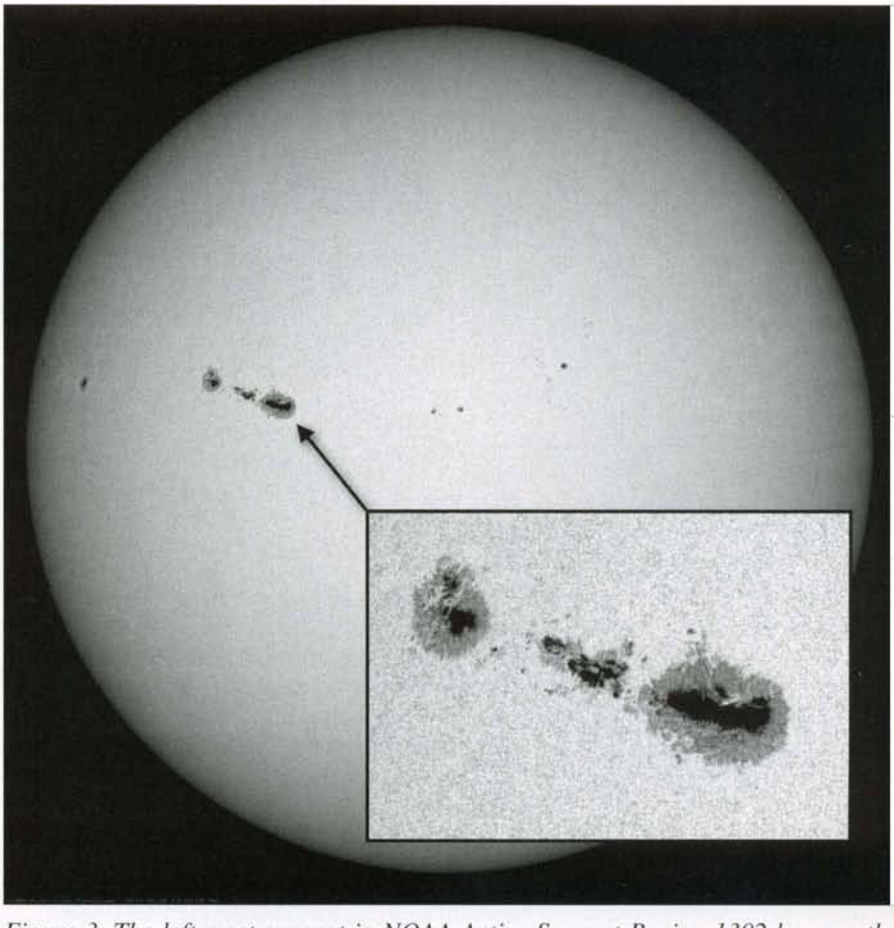


Figure 3. The left-most sunspot in NOAA Active Sunspot Region 1302 became the largest single sunspot so far in sunspot Cycle 24, measuring an incredible 1300 millionths of a solar hemisphere! This sunspot group unleashed a number of X-class flares, as well as a multitude of C- and M-class flares during its march across the solar disc during September 2011. It was so active that it made international news, triggered aurora events, and helped push the 10.7-cm flux to a record high of 190 on September 24th. This activity turned on the highest shortwave frequencies; the 10-meter amateur radio band became a worldwide DX band day after day. VHF came alive with TEP and F2*-region propagation, as well. September clearly was the most active sunspot month yet in Cycle 24 (as of press-time). (Credit: SDO/Helioseismic and Magnetic Imager [HMI])*

nificantly less active. However, this year forecasters say that we may see an hourly rate of 30 to 50. The best window to start trying meteor-scatter-mode propagation is just past midnight, peaking after 2 PM local time and continuing until morning twilight. Any morning between the 16th and the 20th might be good, based on last year's results.

Watch for the *Ursids* from December 17 through 26 with a maximum on December 23 between 0200 and 0400 UTC. Many people miss this, but it could have an hourly rate as high as 50. In 2008, it reportedly had two peaks with an hourly rate of 30 to 35. There might be a another peak on December 22 at about 2100 UTC. The *Ursid* radiant is circumpolar from most northern locations, and culminates after daybreak, while it is highest in the sky later in the night. This one could be a good VHF player.

The *Geminids* are possibly the most reliable of the annual showers. While the duration of this meteor shower is shorter than that of others, there's a definite plateau of maximum activity. The *Geminids* begin to peak during predawn on December 14, with a quick climb to its maximum rate of around 140 per hour. Its window is from December 5 through 20. In North America and Canada, VHF enthusiasts will have the best opportunity to work meteor-scatter propagation from December 13 through the wee hours on the 14th, but as *Geminids* are a "long tail" event, expect continual opportunity, though less often, several days or nights after the peak.

Finally, check out the *Quadrantids* from December 28, 2011 to January 12, 2012. This meteor shower may peak with around 60 meteors per hour, to up to 200. Again, the best time is to start just before midnight and work through predawn.

Check out <http://www.imo.net/calendar/> for a complete calendar of meteor showers. A great introduction by Shelby Ennis, W8WN, on working high-Sspeed meteor scatter mode is found at <http://www.amt.org/Meteor_Scatter/shelbys_welcome.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 (preliminary) observed sunspot numbers from July through September 2011 are 43.9, 50.6, and 78.0. The observed sunspot number of 78 for September is the highest yet for sunspot Cycle 24, as of press time. The smoothed sunspot counts for January through March 2011 are 31.0, 33.4, and 36.9. This upward trend clearly indicates that sunspot Cycle 24 is now fully "awake" and moving toward a distant sunspot cycle maximum.

The monthly 10.7-cm (preliminary) numbers from July through September 2011 are 94.2, 101.7, and 134.5. These numbers are much higher than one year ago, with September taking the record for the highest yet in sunspot Cycle 24. The smoothed 10.7-cm radio flux numbers for January through March 2011 are 91.2, 92.7, and 95.8. The activity level is now high enough to support 10-meter propagation over many paths via the *F2* region, with reports of some 6-meter propagation as well.

The smoothed planetary *A*-index (*Ap*) numbers from January through March 2011 are 6.7, 6.8, and 7.2. The monthly readings from July through September 2011 are 9, 8, and 13. September became a highly active month, with many days of geomagnetic storm-level activity due to coronal mass ejections. This in turn provided a lot of auroral-*E* propagation events. This level of activity will continue to increase in 2012 as we move ever closer to solar cycle maximum.

The monthly sunspot numbers forecast for November 2011 through January 2012 are 67, 70, and 74, while the monthly 10.7-cm flux forecast is 120, 123, and 127 for the same period. Give or take about eight points for all predictions.

(Note: 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. I'll create summaries and share them with the readership. I look forward to hearing from you.

Up-to-date propagation information is found at my propagation center: <http://sunspotwatch.com/>. If you are using Twitter, follow @hfradiospacewx for space weather and propagation alerts, and follow @NW7US to hear from me about various space weather and amateur radio news. Facebook members should check out the *CQ VHF* Magazine Fan Page at <http://www.facebook.com/ CQVHF>, and the Space Weather and Radio Propagation Group at <http://www.facebook.com/spacewx.hfradio>.

Until the next issue, happy weak-signal DXing.

73 de Tomas, NW7US

By Dr. H. Paul Shuch,* N6TX

DR. SETI'S STARSHIP

Searching For The Ultimate DX

The Strange Case of the Oscillating Amplifier

I had an interesting technical query recently from James Brown, W6KYP, an amateur radio astronomer and active SETI League member. Jim has been engaged in the microwave search for possible extraterrestrial signals since 1977, an ongoing effort which garnered him the Giordano Bruno Memorial Award, the SETI League's highest technical honor, back in 2005. He was having problems with his low-noise preamplifier, as he explained in an e-mail:

> My system has been acting strangely for a while, so I took the Head End electronics down, pulled out the LNA (Radio Astronomy Supplies, 28 dB gain), and set it up on my bench. When I have the LNA input terminated in a good 50 ohm terminator, I get –36 dBm out of the LNA as measured on my HP Power Meter and 8484 sensor. I don't see anything on my spectrum analyzer, but it only goes to 1.5 GHz so it may be oscillating at a higher frequency. The power supply is solid and quiet. Question: What should I see on a terminated LNA that is working right?

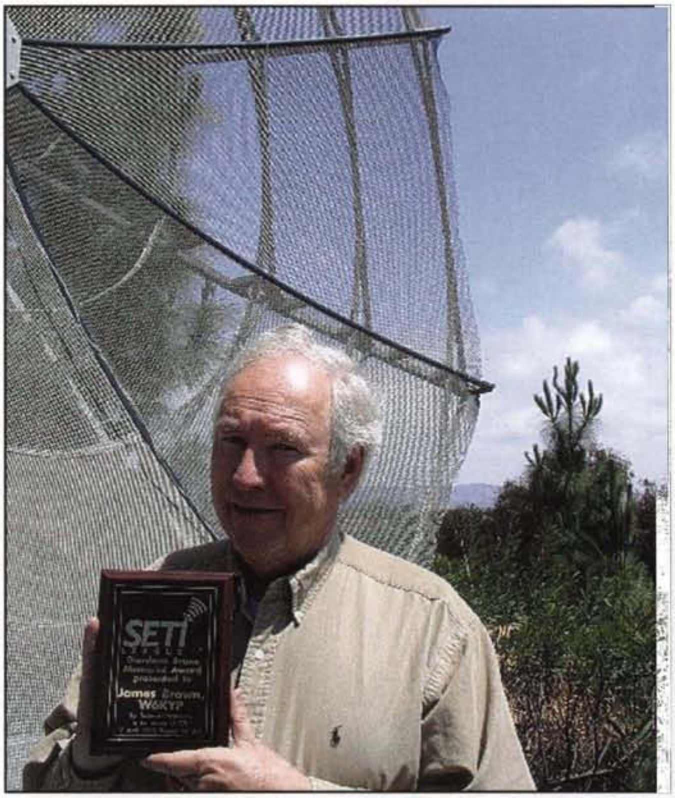
The problem of oscillating amplifiers (call them oscifiers, if you wish) has been with us since first hams discovered the concept of regeneration, so it's not surprising that Jim suspected amplifier instability for causing his problems. An oscillator is, after all, just an amplifier with infinite gain. Let me explain:

We define gain as the ratio between output-signal and input-signal levels. Now whenever there is an output signal, we should be able to reduce the input signal level and watch that output decrease accordingly. This response would indicate a stable, linear amplifier. Sometimes that doesn't happen; we reduce the input and the output signal doesn't go down. Such a response would represent an instable (or extremely nonlinear) amplifier. As the input signal approaches zero, for a constant output, we can say that the gain of the amplifier is approaching infinity.

Of course, dividing by zero is mathematically prohibited. Therefore, we can never really achieve infinite gain, but we can get the same effect by feeding some of the output signal back into the input circuit, in the proper phase relationship. This is how we build oscillators—make an amplifier and introduce regenerative (in-phase) feedback.

Often, feedback occurs when we don't want it to. It's easy to see why. In a simple vacuum-tube triode amplifier, for example, the grid may be the input and the plate circuit the output. Both grid and plate are pieces of metal separated by an insulator (vacuum), so a capacitor exists between output and input, which can facilitate feedback. For this reason, we often have to neutralize triode amplifiers (modify the feedback path so as to prevent oscillation). A similar situation exists in solid-state amplifiers, of course, because a reverse-biased semiconductor junction is also a capacitor.

Early in my engineering career, I worked for an aerospace company designing microwave amplifiers. Mine got a reputation for being oscillation-prone (OK, so were everybody else's; the state of the art was not very mature back then). When one of my colleagues needed an oscillator for a particular application, a coworker once told him, "Just ask Paul to design you an amplifier."



Jim Brown, W6KYP, with his radio telescope and Bruno Award plaque. (W6KYP photo)

When you terminate the input port of an amplifier in its characteristic impedance (say, with a properly matched dummy load), you would think that there could be no input signal. Thus, any signal present at the output would be caused by feedback, and an indication of oscillation. Jim Brown was thinking along these lines when he ran the power-meter test described in his e-mail. But in fact, there is *always* an input signal generated within the dummy load, unless it is chilled to absolute zero. This signal is thermal noise, which varies with temperature. If present, it will be amplified by the gain circuit and result in a possibly measurable output signal. Jim's question, in effect, was: "How much thermal power should I see at the output of my amplifier?"

As a first order approximation, let's consider the amplifier's noise figure to be near zero. That is, its internally generated noise is negligible—it is a *low noise* amplifier, after all. Thus, all we have to do now is calculate the thermal noise generated by the dummy-load resistor.

**Executive Director Emeritus, The SETI League, Inc., <www.setileague.org>*
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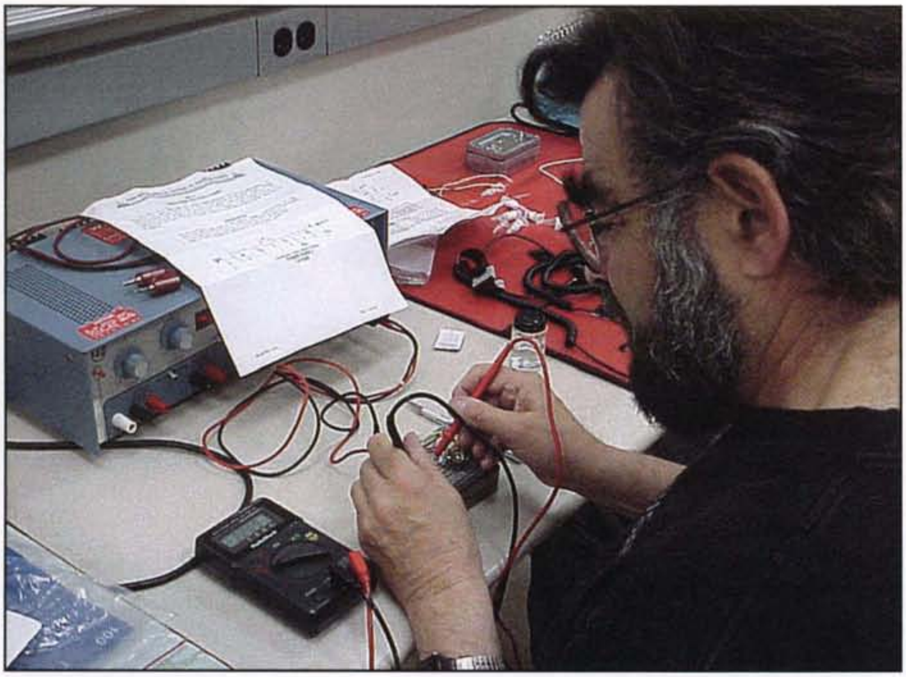

Astrophysicist Malcolm I. Raff, WA2UNP (SK), assembling and testing a low-noise preamplifier at The SETI League's 2003 technical symposium. Mal's amplifier did not *oscillate! (N6TX photo)*

Let's consider that load resistor to be a perfect thermal black body. Boltzmann's Law says its noise power (in watts) equals kTB. In this equation, k is Boltzmann's Constant (1.38×10^{-23} Joules/Kelvin). T is the physical temperature of the black body, in Kelvins (for lab temperature, you can assume 300K). And B is the bandwidth in which the noise power is being measured, in Hz (that is, cycles per second).

Invoking unit analysis, we can prove that the Boltzmann equation is dimensionally consistent:

$$kTB = (\text{Joules/Kelvin}) \times (\text{Kelvins}) \times (\text{Cycles/Sec}) = (\text{Joules/Sec}) = \text{Watts}$$

Now since Jim was measuring noise with an HP 8484 power sensor, whose passband is 10 MHz to 18 GHz, one might assume the bandwidth B to use in this calculation to be about 18 GHz. However, remember that the power sensor is going to be placed at the *output* of an amplifier with a much more modest bandwidth. Thus, the only part of the load resistor's noise power that counts is that part within the LNA's passband. Let's say the SETI LNA passes frequencies from 1.3 to 1.7 GHz. That's a 400-MHz bandwidth, which is what we'll use for B in Boltzmann's Equation.

OK, let's calculate. Noise power Pn (coming out of the load resistor, in the amplifier's passband) is kTB:

$$Pn = kTB$$
$$Pn = (1.38 \times 10^{-23}\ \text{J/K}) \times (300\ \text{K}) \times (400 \times 10^{6}\ \text{Hz})$$
$$Pn = (1.66 \times 10^{-12})\ \text{watts} = 1.66 \times 10^{-9}\ \text{mW}$$

Converting to logarithmic measure, that's a power level of –88 dBm.

This is the noise power that gets amplified by the LNA. Jim's LNA has 28 dB of gain, so the –88 dBm of noise, after being amplified, comes out of the amplifier at a level of –60 dBm.

OK, now the noise Jim was seeing on the power meter is –36 dBm, which is a whopping 24 dB stronger than the noise he should be seeing. That's a power level about 250 times higher than it should be. From this I conclude that yes, W6KYP's amplifier is probably oscillating.

How's that for a long answer to a simple question? My main point is, the noise power coming out of a properly operating amplifier is entirely calculable (and now you know how to calculate it).

73, Paul, N6TX

Author's Note:

Dr. SETI thanks Kevin Murphy, ZL1UJG, for pointing out a glaring mathematical error in an early draft of this column.

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