CQ VHF

Ham Radio Above 50 MHz

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Summer 2013

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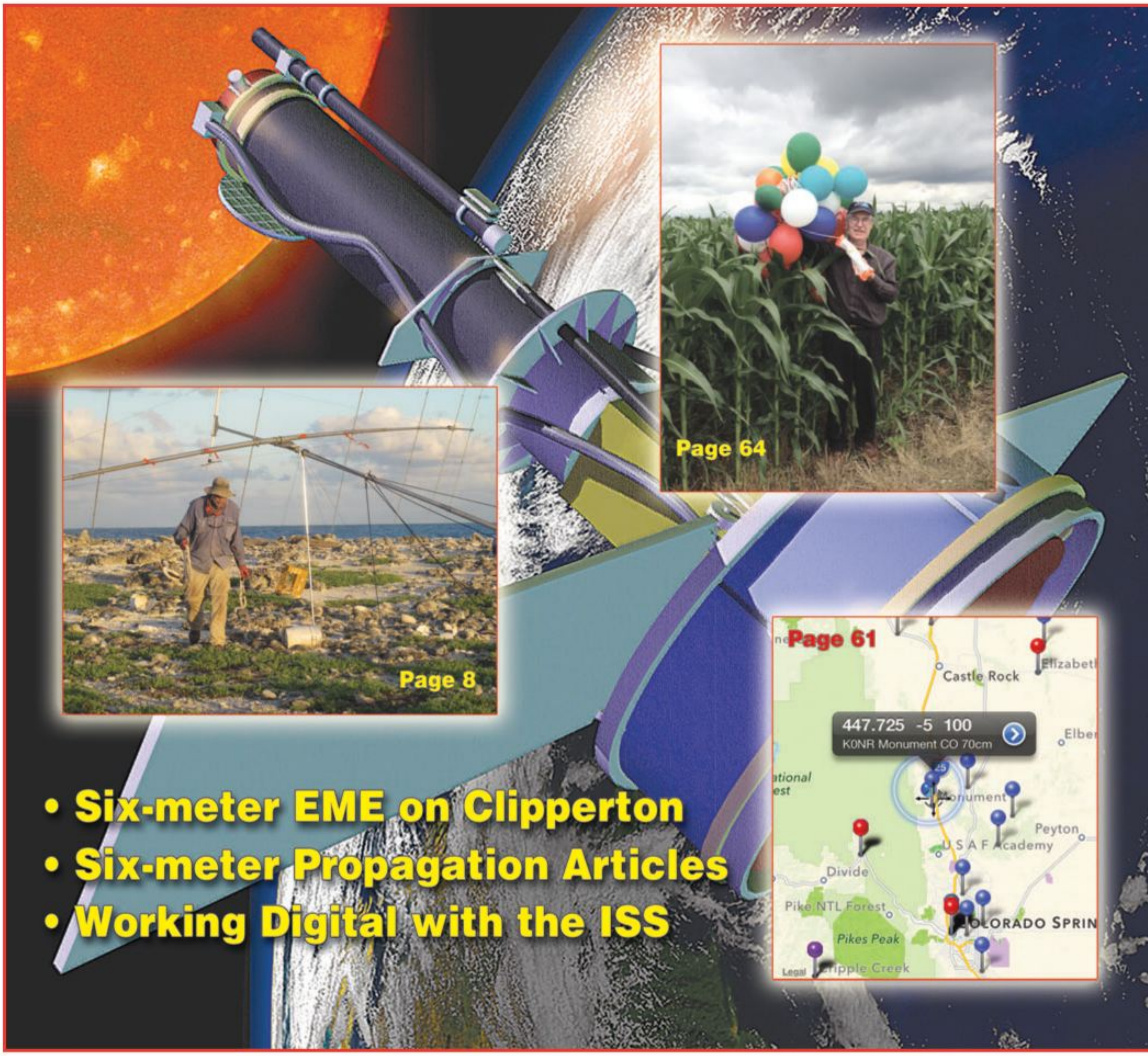

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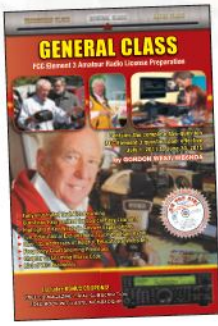

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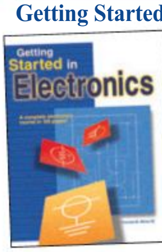

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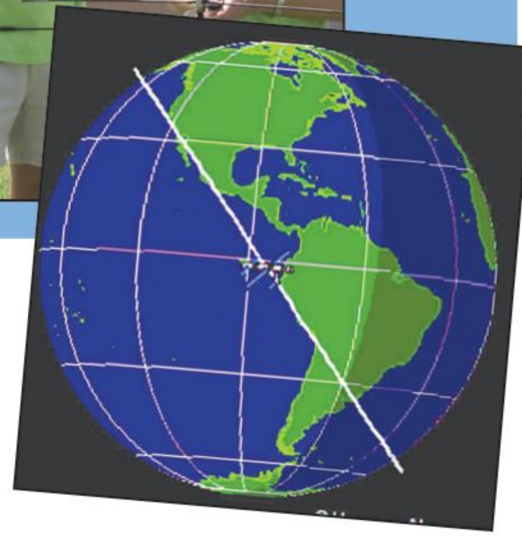
FEATURES



COLUMNS

DEPARTMENTS

On The Cover. Main photo: From the "VHF Propagation" column by NW7US, this is an artist's conception of the IRIS satellite in orbit (photo credit NASA); for more information see page 70. Left-hand inset photo: In the article "Six Meters EME from Clipperton 2013" the author, W7GJ, is shown constructing and erecting the 6M8GJ Yagi; for details see page 8. Top right inset photo: From the "Up In The Air" column, author WB8ELK makes a successful recovery of a party balloon payload; see page 64. Bottom right inset photo: In this issue's "FM" column by KØNR, this is a part of the figure in the article showing the Repeaters app, which has the ability to map the location of repeaters; for more information, see page 61.

CQ VHF Ham Radio Above 50 MHz

LINE OF SIGHT

A Message from the Editor

Jobs That Didn't Exist Ten Years Ago

In early July Alasdair Allen posted an article on the *Make* magazine website (http://makezine.com/2013/07/06/10-maker-jobs-that-didnt-exist-10-years-ago/) entitled "10 Maker Jobs That Didn't Exist 10 Years Ago." Being fascinated with the article, I decided to see how many of them had an amateur radio connection. Here are the jobs from Allen's article:

1. Quadcopter Pilot: Recently, there has been a discussion concerning the use of aerial-based sources for recovery of payloads. Suggestions include planes, pilot's powered paragliders (PPGs), and drones. Among the drones suggested are those quadcopters. Indeed, an R/C quadcopter can be flown upwards of 100 feet in altitude, which can be an aid in helping to recover otherwise camouflaged payloads. Watch for more of this discussion creeping into the balloonsat community.

2. Crowdfunder and **7. Personal Space Engineer:** I combined these two because both were featured in the Spring 2013 issue of *CQ VHF* magazine in Zac Manchester, KD2BHC's article "KickSat, Bringing Space to the Masses." Zac's Kicksat satellite project was funded through Kickstarter and Zac epitomizes the definition of personal space engineer. KickSat is not the only satellite having been funded or potentially to be funded by crowdfunding. Two other cubesats, CAT: A Thruster for Interplanetary Cube Sats, and LunarSail were listed at the time of my writing this editorial. Watch for other projects and personal space engineers to appear in the not too distant future.

3. Makerspace Manager: While as far as I can tell, there is not anything like what Allen and Gui Cavalcanti describe (see: Cavalcanti's "Is it a Hackerspace, Makerspace, TechShop, or FabLab?" [http://makezine.com/2013/05/22/the-difference-between-hackerspaces-makerspaces-techshops-and-fablabs/]) being used in amateur radio product development. The closest to such a concept might be what takes place behind the doors of Elecraft and Flex-Radio as each works on its product development. Even so, this is an area that deserves a serious look. For example, in Oklahoma there are small business incubator locations that are available for nominal rent for the purpose of product development. Additionally, as Cavalcanti points out, some colleges and universities have built-in incubator labs.

4. Digital Fabricator: Great strides have been made in the development of the 3D printer in recent years. It was three years ago when I was a mentor for STARBASE-2, an after-school program sponsored by the Department of Defense. The particular program in which I was a participant was located at Hamilton Middle School (now Hamilton Elementary School) in Tulsa, Oklahoma. My job was to work with sixth graders to help them with CAD drawings of parts of a signaling device. During the semester the students were taught how to create the drawings. After each student had completed the drawings, the class went on a field trip to the Air National Guard base to watch the 3D printer create the parts. When all of the students' parts were printed, they added a battery and an LED and assembled the parts into the signaling device. Then I taught the students Morse code and watched them send messages to each other. Now, just three years later, because of the ease of availability, the 3D printer can be used for designing and printing enclosures for projects.

5. App Developer: The proliferation of iPhone and Android (and to a lesser extent Windows) based cell phones and tablets have led to an exponential development of applications, or apps. There is a growing cottage industry involved in developing and selling apps for the various platforms. One's imagination is the only limit in what can be developed for these portable platforms.

6. Bio-Hacker: While at present there is little exploration in the area of bio-hacking, there may be a potential for the development of biofuels for satellite propulsion. For example, the CAT: A Thruster for Interplanetary CubeSats project mentioned above is exploring the use of water as a thruster. Are there other possible low-cost thrusters awaiting development?

8. Data Scientist: This issue of *CQ VHF* magazine features another fascinating 6-meter propagation article by Jim Kennedy, K6MIO/KH6, entitled "Worldwide Six-Meter Es: 27–29 June 2012." While the data that Jim collected for his article is miniscule compared with Allen's point about data collection and storage, the points he makes about data are well-taken. For example, what if there were monitoring stations around the globe working on gathering data pertaining to 6-meter propagation?. With such massive amounts of data gathered comes the possibility of wholesale analyses of data that would result in understanding more about the "Magic Band" and thereby make predicting its usefulness much more accurately.

9. UX Designer: To say that a UX document is another tool for brainstorming is to grossly under-define it. Boon Chew expertly unpacks its use in his article "The Purpose of a UX Document (http://gluethink.com/2011/02/27/the-purpose-of-a-ux-document/). In short, as Allen indicates, UX design is about both software and hardware "and how the users interact with objects around them." While I am not privy to what happens inside the walls of either Elecraft or Flex, as an owner of products from both companies, I have been involved in reading the mail of listservs for both companies' products. As such, I see some of the design and redesign work taking place within these listservs. I would suggest that each company employ a UX Designer who can pull together the outcomes of their respective efforts.

10. *MAKE* Magazine Editor: Alasdair Allen points out that the first issue of *Make* magazine was published in January 2005. Almost any issue of *Make* magazine has a project that has either direct or indirect amateur radio application. Indeed, there are amateur radio operators who regularly write for the magazine.

And Finally . . .

By contrast to *Make* magazine's relatively short history, the rebirthed version *CQ VHF* magazine has been around for a bit more than 11 years, plus approximately three years in its original version. When it first reappeared with the Spring 2002 issue, the primary focus was on weak-signal VHF-and-above activity. During these past 11 years the focus has changed to include more coverage of cubesat, balloonsat, and specialty operating such as Summits on the Air (SOTA). I also have been on the lookout for VHF-and-above open-source-oriented articles. If you have an article, or an idea for an article that needs development and covers the VHF-and-above frequency spectrum, please let me know. I will work with you to to perhaps publish it in a future issue of *CQ VHF* magazine. Please contact me at <n6cl@sbcglobal.net>.

73 de Joe, N6CL

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QUARTERLY CALENDAR OF EVENTS

Current Contests

August: The **ARRL UHF and Above Contest** is August 3–4. The **50 MHz Fall Sprint** is August 10. The first weekend of the **ARRL 10 GHz and Above Cumulative Contest** is August 17–18.

September: The **ARRL September VHF QSO Party** is September 14–16. The second weekend of the **ARRL 10 GHz and Above Cumulative Contest** is September 21–22. The **144 MHz Fall Sprint** is September 23. The **ARRL 2.3 GHz and Above EME Contest** is September 28–29.

October: The **222 MHz Fall Sprint** is October 1. The **432 MHz Fall Sprint** is October 9. The **902+ MHz Fall Sprint** is October 12. The **ARRL International EME Contest (50–1296 MHz Round 1)** is October 26–27.

November: The **ARRL International EME Contest (50–1296 MHz Round 2)** is November 16–17.

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

Current Conferences and Conventions

August: The **Austin Summerfest** is August 2–3. The **Huntsville Hamfest** is August 17–18.

September: The **TAPR/ARRL Digital Communications Conference** will be held September 20–22, in Seattle, Washington, at the Cedarbrook Lodge. Reservations: 1-877-515-2176. For more information, see the URL: <https://www.tapr.org/dcc.html>.

October: The **Microwave Update** conference is to be held October 18–19, in Morehead Kentucky at Morehead State University. Please see the Microwave Update website for registration and hotel reservations information: <http://www.microwaveupdate.org>.

November: The **AMSAT-NA Space Symposium and Annual Meeting** will be held November 1–3, in Houston, Texas, at the Marriott Hobby Airport Hotel. Reservations: 1-713-943-7979. Ask for the AMSAT Block or use the code AMSAMSA. For more information, please see the AMSAT URL pertaining to the symposium at: <www.amsat.org/?page_id=551>.

Calls for Papers

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

Microwave Update: A call for papers has been issue for the Microwave Update conference, to be held in Morehead, Kentucky. The deadline for proceedings paper submissions for is August 30. The Word file format (text) is preferred for these papers. The deadline for the presentation version of selected papers is September 15; PowerPoint (slides) file format is preferred for presentations. If you are interested in submitting a paper for publication in their *Proceedings*, then please e-mail your papers, as well as questions or comments regarding the technical program, to <mud2013@downeastmicrowave.com>.

AMSAT-NA 2011 Space Symposium: Technical papers are solicited for the AMSAT Space Symposium and Annual Meeting to be held November 1–3, in Houston, Texas. Proposals for papers, symposium presentations, and poster presentations are invited on any topic of interest to the amateur satellite program. Papers on the following topics are solicited: Students & Education, ARISS, AO-51, P3E, Eagle, and other satellite-related topics.

Camera-ready copy on paper or in electronic format are due by October 1, 2013. Papers received after this date will not be included in the printed *Proceedings*. Abstracts and papers should be sent to Dan Schultz, N8FGV, at <n8fgv@amsat.org>.

Meteor Showers

August: Beginning around July 17 and lasting until approximately August 24, you will see activity tied to the *Perseids* meteor shower. Its predicted peak is on August 12 between 1815 and 2045 UTC. The κ-*Cygnids* meteor shower is expected to peak on August 17.

October: The *Draconids* is predicted to peak on October 8 around 0830 UTC. The predicted ZHR may reach storm levels. The *Orionids* is predicted to peak on October 21.

November: The *Leonids* is predicted to peak on November 17, either 1000 or 1600 UTC. As with last year's shower, this year's peak may go largely unnoticed.

For more information on the above meteor shower predictions see Tomas Hood, NW7US's "VHF Propagation" column in this issue. Also visit the International Meteor Organization's website: <http://www.imo.net/files/data/calendar/cal2013.pdf>.

Quarterly Calendar

The following is a list of important dates for VHF-Plus enthusiasts:

Aug. 3	Moon apogee
Aug. 3-4	ARRL UHF and Above Contest
Aug. 6	New Moon
Aug. 10	50 MHz Fall Sprint
Aug. 12	*Perseids* meteor shower
Aug. 14	First quarter Moon
Aug. 17-18	ARRL 10 GHz and Above Cumulative Contest Round 1
Aug. 19	Moon perigee
Aug. 20	Full Moon
Aug. 28	Last quarter Moon
Aug. 30	Moon apogee
Sept. 5	New Moon
Sept. 12	First quarter Moon
Sept. 14-16	ARRL Sept. VHF QSO Party
Sept. 15	Moon perigee
Sept. 19	Full Moon
Sept. 21-22	ARRL 10 GHz and Above Cumulative Contest Round 2
Sept. 23	144 MHz Fall Sprint
Sept. 26	Last quarter Moon
Sept. 27	Moon apogee
Sept. 28-29	ARRL International EME Competition (2.3 GHz & Up)
Oct. 1	222 MHz Fall Sprint.
Oct. 4	New Moon
Oct. 8	*Draconids* meteor shower
Oct. 9	432 MHz Fall Sprint
Oct. 10	Moon perigee
Oct. 11	First quarter Moon
Oct. 12	902+ MHz Fall Sprint
Oct. 18	Full Moon
Oct. 18	Penumbral lunar eclipse will be visible in the Americas, Europe, Africa, and Asia.
Oct. 21	*Orionids* meteor shower
Oct. 25	Moon apogee
Oct. 26	Last quarter Moon
Oct. 26-27	ARRL International EME Competition (50-1296 MHz Round 1)
Nov. 3	New Moon
Nov. 3	Hybrid solar eclipse will be visible in Eastern Americas, Southern Europe, and Africa
Nov. 16-17	ARRL International EME Competition (50-1296 MHz Round 2)
Nov. 6	Moon perigee
Nov. 9	First quarter Moon
Nov. 17	Full Moon
Nov. 17	*Leonids* meteor shower
Nov. 22	Moon apogee
Nov. 25	Last quarter Moon
Dec. 2	New Moon

Six Meters EME from Clipperton 2013

Ranked among the rarest countries on many hams' lists, Clipperton is indeed rare for weak-signal operators. Here W7GJ tells the story of how he worked EME from that sliver of an island.

By Lance Collister,* W7GJ

Thanks to the generous contributions from many 6-meter DXers, I was able to join the TX5K team to add a serious, dedicated 6-meter operation to that DXpedition. Unfortunately, the period scheduled for the Clipperton operation was over the worst week of the month (March) for 6-meter EME. Of that time, the better EME days at the beginning and end of the operation were eliminated by our reaching the island a day later than expected, and our having to tear down earlier than expected.

However, as expected, there was TEP to South America every evening, which provided most of our 6-meter contacts, and Rick Royston, KF4ZZ, made many of those contacts. Furthermore, half of the EME contacts were made on the first night, so I sure am glad I was able to get everything going for that first moonrise!

Lance Collister, W7GJ, in front of the M2 6M8GJ antenna used for the 6-meter station of the TX5K Clipperton Island DXpedition.

The Trip

The 92-foot *Shogun* sport fishing boat was to transport the gear and team members to the island. Some of us boarded the *Shogun* in San Diego, but the boat picked up most of the European team members in Cabo San Lucas. The *Shogun* was comfortable, the crew was great, and the food was plentiful and surprisingly good. However, the ten-day trip from San Diego to Clipperton, plus the seven-day return trip, became rather tedious. Photo 1 shows the route that we took to and from Clipperton.

The highlight of the trip for me was the magical approach to Clipperton Island on the evening of Wednesday, February 27.

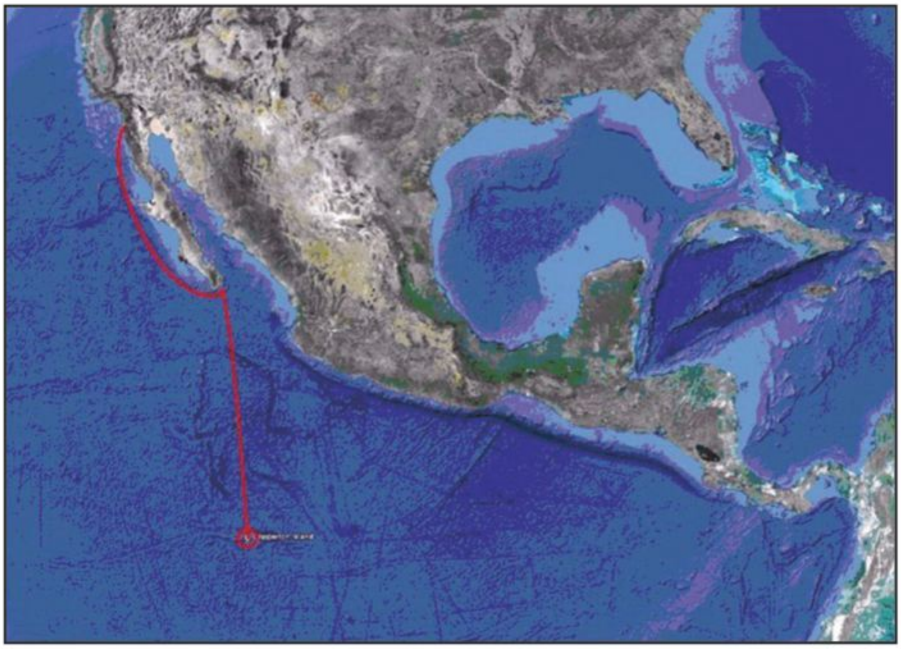

Photo 1. The route we took to and from Clipperton Island. (All photos courtesy the TX5K team)

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

Photo 2. First attempt to test out landing. You can see the other side of the atoll and the internal lagoon in the background.

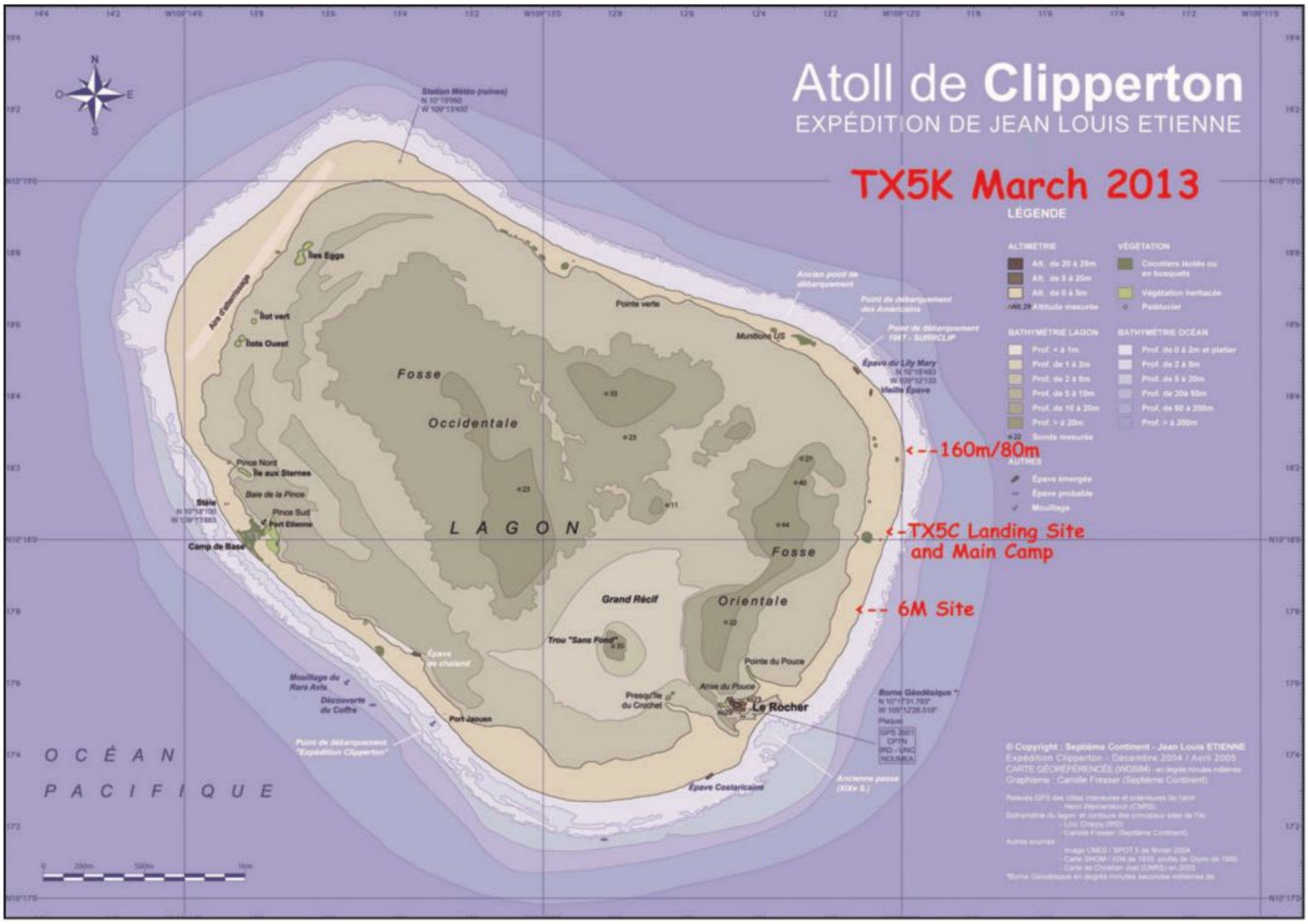

Photo 3. Map of Clipperton Atoll showing the locations of the TX5K landing and operating sites.

The full moon was rising over the calm sea, and porpoises were escorting us next to the bow as the faint outlines of scattered palm trees loomed on the dark horizon.

The last day of February was spent circling the island, searching for the most suitable place to land. The dangerous surf was high all around the island and changed with the tide, which was extreme due to the full Moon. By afternoon, a site was selected and zodiac shipments to shore were begun at dawn Friday. Photo 2 shows one of the zodiacs on the way to the island. Photo 3 shows the landing and main operating site, along with the locations of the 6-meter and 160/80-meter sites. I was able to go ashore with my 6-meter gear late morning on Friday, March 1.

The Landing

I was essentially on my own to set up the 6-meter station as far away from the HF operations as possible, and then race to get things set up to operate EME all night. I immediately began carting all my equipment (along with the generator, operating tent, sleeping tent, table, chairs, water and gasoline, etc.) 360 meters south of the main camp and landing zone, trying to gain enough distance from all the other generators, radios, computers, lights, fans, etc., of the main HF camp to get a location quiet enough for weak-signal work.

Photo 4. Constructing and erecting the 6M8GJ Yagi just before sunset on March 1.

I first selected a spot for the antenna, just 50 meters from the pounding surf. Then, I marked out a place for the operating tent at an azimuth of 325 degrees from the antenna, a direction between JA and W6, where I would never be aiming the antenna. The generator tent was located an additional 50 feet beyond the operating tent in the same direction in order to minimize any electrical noise.

I started out setting up the 8-foot by 8-foot 6-meter operating tent so I would have a safe place for all the equipment, which was sitting out in the open, surrounded by hundreds of masked boobies. I was very grateful for the assistance of

Photo 5. Aerial view of the 6-meter site.


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KG-UV6D
VHF/UHF
Dual Band 2.5kHz VFO steps,
2013 Narrowband compliant, standard SMA antenna,
FCC Certified
TH-UVF1A
TX: 144-148/430-450MHz
RX: 136-174/400-470MHz Plus FM Broadcast(RX)
2013 Narrowband compliant, standard SMA antenna conn.
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5 Watts, 435 Memories,
Dual Frequency RX,
Internal Vox
Compact Design
TH-K20A
144MHz 5.5 Watts Backlit LCD, Wx Alert, Keypad Entry, CTCSS/DCS 200 Memories
ICOM
IC-80AD
144/440MHz D-STAR Built-in, 5 Watts, 1052 Memories, Wideband Rx, Backlit LCD & Keypad. Free CS-80 download cloning Software from Icom.
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LDG ELECTRONICS
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ALINCO
ASTRON CORPORATION
QJE PS30SWV
DC Power Supply
DC 13.8V Output:
(9-15V adjustable)
Output current:
0-30A, 25A cont.
Ripple & Noise:
<15m Vp-p
QJE PS50SWIII
50Amp Switching Power Supply
13.8 VDC at 40 amps continuous,
Adjustable output voltage from 9 to 15 VDC
QJE PS30SWI
DC Power Supply
Output voltage:
DC13.8+0. 3V
Output current:
0-30A, 20A cont.
QJE PS30SWIV
30 amps Max (10% duty cycle), 20 amps continuous
110/220 VAC.
NEW!
QJE PS23SWI
DC Power Supply
23A cont./25A max., Only 3.5 pounds.

LouPhi Locke, who came by to help me stand up the frame and install the cover over the tubular metal frame of the small structure. I then proceeded to set up the generator tent and the generator.

Because we were a day late in landing on the island, it was struggle to get the 6-meter beam assembled and up before nightfall on the first day of March, but I did get the antenna up just after sunset, in time for moonrise on the second day of March UTC. Late in the afternoon, I rushed to assemble the 6M8GJ Yagi before sunset, and finally got it set up just as night fell. Photo 4 shows me putting the finishing touches on the antenna. Photo 5 shows an aerial view of the layout of the 6-meter site.

On the Air

I had packed an LED Coleman lantern and was able to set up the equipment, including installing the transformer in the Alpha 8406 amplifier, by headlamp and lantern light. I tied down the antenna securely aimed at moonrise and began calling OH2BC, whose moon was just about to set. I never copied anything from Kari, but at 0536 UTC March 2, I completed the first contact from the 2013 Clipperton Island DXpedition by working G8BCG. Photo 6 shows the antenna pointing at the moon at dawn. I stayed up all that night working stations under the rapidly degrading EME conditions. My last contact of that 25-contact session was nine hours later with N6BBS as my moon was setting.

Photo 6. Beaming up at the moon just before sunrise as the moon was beginning to set around to the southwest. Note the ← masked booby in the foreground.

Photo 7. Six-meter site looking toward the main campsite.

I was incredibly fortunate to be able to visually aim the antenna on all but the very last days (after the sun rose and the faint sliver of the moon was no longer visible in the daylight). Although I did have my calibrated aiming circle installed at the base of the rotating mast, it was always reassuring to be able to confirm that the elevation was also correct and that the antenna was right on target! We also were very lucky in having only three *very* brief rain episodes, each lasting only a few minutes.

The effort to establish the remote 6-meter operating site so far to the south of the HF camps really paid off. We had absolutely *no* noise at all—at least not *electrical* noise. Rick, KF4ZZ, measured the ambient audio levels from the constant wind and hungry boobies as being between 75 and 80 dB. Photo 7 shows the proximity of the 6-meter site in relationship to the main campsite.

To give you some idea of the din, we had trouble hearing the generator rev up when we went into transmit mode. But the boobies were great neighbors, and stayed away from the antenna. The rats (except for one stubborn one that had to be eliminated) usually scampered away

Photo 8. Boobies everywhere surrounding the 6-meter site.

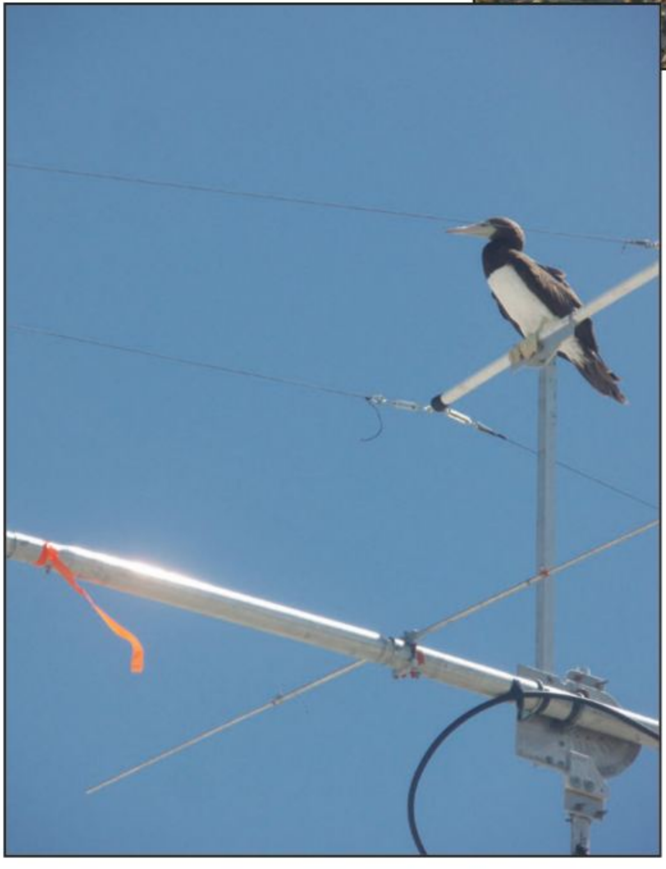

Photo 9. A booby even perched on the antenna.

Photo 10. Inside the 6-meter operating tent with Rick Royston, KF4ZZ, during the final day of EME operations.

as we approached them to tie down the antenna. Also, our totally sealed sleeping tents provided more than adequate protection from the ubiquitous crabs.

Although it was primitive and remote, the 6-meter camp became home, and I loved all the masked boobies who surrounded us and became very used to our presence. Photos 8 and 9 show the ever present, fearless, yet tame boobies surrounding the 6-meter site. They actually were like outdoor pets that trusted us, and I missed them when we left.

At least at the 6-meter camp, we had no problems with crabs or rats (aside from the one who didn't seem too afraid of me and sat only a few feet from my feet eyeing me). Also, the prevailing breeze kept the wind blowing through out tents so we could sleep whenever we needed to, even if it was quite warm.

However, the continuous salt spray from the pounding surf did take its toll on the antenna and equipment. The antenna receive performance seemed to degrade a bit every day. On March 7, I went back to hand logging TEP contacts when I found that I could no longer type numbers on my laptop computer. And on the next to last day of operation, March 8, the 100-watt module in my K3 was damaged and stopped working between EU moonset and the start of NA moonset.

No longer being able to drive the Alpha 8406, I quickly dismantled the Alpha amp and packed it up to make space on the operating table for my switching power supply and the M^2 6M-1000 solid state amp, which fortunately only requires 3 watts of drive. The open antenna relays in the 6M-1000 were not as reliable in the salt air as the vacuum relays in the Alpha amp, but did provide a couple more EME contacts and a number of additional TEP contacts. Photo 10 shows the tail end of the last day of EME with Rick, KF4ZZ, assisting.

In addition to missing a good day for EME at the beginning of the trip, I missed most of the last two EME days, when conditions were just beginning to improve. That left me with the worst week of the month for EME. Of course, I was very disappointed in the EME results, and the fact that I had no terrestrial propagation toward NA, aside from two contacts that were apparently linked to a sporadic-*E* opening. Photo 11 shows the last moonrise.

Breaking down camp and leaving proved to be uneventful—except for a bit of rocky waters—both onshore and off as photos 12 and 13 show. Even so, all of our gear was stowed onboard the *Shogun* and we made a safe voyage back home.

Photo 11. Moonrise before dawn on the last day of operation, Saturday, March 9.

Summary

The final 6-meter results were 317 overall contacts (212 SSB, 53 CW, and 52 JT65A). JT65A was used to contact XE2AT on D-layer scatter and LU5FF on TEP; the other 50 JT65A contacts were EME. The EME contacts with 21 countries were broken down as follows: One contact each with ES, F, FK, GM, GW, I, LA, OH, SP, and UT. Two contacts with HA, OK, SM, VE, and ZL, Three contacts with G, ON, S5, and OZ. There were 17 contacts with USA stations.

Eleven additional DXCC countries were added via terrestrial mode, bringing the total DXCC count up to 32. TEP and sporadic-*E* added CE, CP, CX, HC, HK, LU, OA, PY, XE, YS, and ZP. I worked only one station in the USA on sporadic-

Photo 12. Fighting the rough surf while trying to launch the zodiac.

E, and that was K5RK during a sporadic-*E* opening with a very small footprint. I did complete with K9SM on what sounded like a meteor burst, but the only locations close enough for meteor scatter were in Mexico, so I am assuming he was either operating portable there or via a remote station.

While the number of EME stations worked was not as high as my operation from Fiji, the results were surprisingly close and suggest that another dedicated EME DXpedition to some rare place during the *best* week of the month for 6-meter EME could yield at least 50 to 60 contacts. Despite all the difficulties encountered, the EME results were better than the Rarotonga, Samoa, and Niue operations. As it turned out, I had no access to any internet at any time, so could only tell if a station received my RRR, completing the contact if I received 73s from them.

Overall, I think the 6-meter part of the project was a success. Fifty 6-meter EME QSOs on just a few limited days at the worst time of month was a very pleasant surprise. Plus, over 200 TEP QSOs certainly gave a lot of South American stations a new DXCC country on 6 meters.

My generator worked flawlessly, which was great. The equipment worked well except for the problems caused by the continuous salt-laden spray that never stopped blowing through everything.

In retrospect, the site I chose to set up the 6-meter operation had some challenges because of its proximity to the pounding surf, but it afforded great ground gain on moonrise, and also toward Mexico, the USA, and South America. If I had to do it again, I think I would try to go to the same place and hope that the weather was as good, because if it were really stormy, we would have been washed over at that spot, as evidenced by the plastic detritus that was strewn from the ocean front to the lagoon.

Problems and Positives of the DXpedition

Very briefly, here are a few of the problems that were encountered:

1. Delay in landing by a day while searching for a place that would permit us to get through the reef.

2. My having to haul all the equipment, operating tent, sleeping tent, generator, fuel, water, etc., by hand cart south of the landing point and set it up before nightfall. This was very time consuming as well as exhausting.

3. Gasoline rationing in the middle of the week forced us to only run barefoot when beaconing or working TEP; there was no EME on those days anyway because of the high degradation, but it limited our ability to put out a big signal on terrestrial propagation on those days.

4. The antenna location 50 meters from the pounding surf caused everything to be drenched in salt spray. The result was that the antenna performance degraded daily, my K3 became inoperable at over 10 watts, the 6-meter1000 amplifier relays became intermittent on receive, and the numbers and a few other keys on my laptop computer no longer worked. I had to copy and paste them from the station log.

5. My operation was forced to shut down earlier than planned because of anticipated difficulty in leaving the island on time, causing me to miss valuable moon time of improving conditions.

6. The consistently high winds made it

Photo 13. Reeling in the unmanned raft full of supplies as it returns to the Shogun *amidst rough seas.*

W7GJ, working 6 meters during the TX5K Clipperton Island DXpedition.

difficult to move the antenna around, especially at night, because it had to be well tethered.

7. All my clothes, along with my LMR600 coax, were washed in salt water in the hold of the ship for ten days en route to the island, and the cardboard boxes containing all my gear were destroyed. The connectors on the 25-foot emergency extra length of LMR600 coax were all corroded, so I had to use jumpers in series with the 50-foot length so it would reach the operating tent.

8. The 6-meter operating position was too far to connect with the Wi-Fi network that would permit real-time posting of the 6-meter contacts via the DXA page, and it turned out that there was no way for me to access the chat pages even via a low-bandwidth telnet client. At least on my other DXpeditions I was able to get messages out by occasional internet connections.

9. A number of large 6-meter stations apparently were not able to get on the air to work this rare DXCC.

10. I had hoped for some terrestrial propagation toward Asia, but did not have any.

11. Ground gain on moonset was not as good as I had hoped.

12. Unlike the situation for the HF operators, whose gear was being shipped home for them by the DXpedition funds, I had to figure out some way to ship my entire gear home from San Diego pier at my own expense.

A few of the unexpected positive events included:

1. Only a few storms dropped only a few minutes of rain.
2. We were able to depart the island around noon on Monday despite the tidal extremes associated with New Moon.
3. Nobody was seriously injured.
4. At least some people who made the effort to get on EME got a new country despite the poor EME conditions and the obstacles on my end.
5. It was possible to endure the extreme heat by cutting open the operating tent to let the wind blow salt and sand through, and generally the evenings were quite bearable.
6. The French public TV crew got some great photos of the 6-meter EME operation, and hopefully we will be able to pass some of these on to you eventually.
7. There was absolutely *no* interference from the HF operations, so the effort to get down far to the south of them was successful.
8. Ground gain on moonrise was outstanding due to the proximity of the antenna to ocean.
9. I was very pleasantly surprised to get two USA stations in the log on terrestrial propagation.
10. I made the first contact of the group from TX5K by working G8BCG on EME.

And Finally

Many, many thanks again to all of you for your support and effort in watching for us. It certainly was a *huge* effort by everyone, and I only regret that I could not put more stations in the log—including W7GJ. However, it was the most successful combined HF/6-meter EME DXpedition to date. Given all the difficulties I faced, though, I am inclined to stick with the solo operations in the future.

Worldwide 6-Meter *Es* 27–29 June 2012

A rare occurrence on the Magic Band is very long sporadic-E propagation. Here K6MIO/KH6 reports on a few days when that happened on June 27–29, 2012 and why they happened. A similar version of this article appears in the 2013 Central States VHF Society's "Proceedings."

By Jim Kennedy,* K6MIO/KH6

Over the last decade or more there have been many instances of very long 6-meter sporadic-*E* (*Es*) propagation. Some of these events have been very prolonged and produced very long "short path" propagation. Of all of these, the series of openings that occurred over the period of 27–29 June 2012 may be the most remarkable example of this sort of worldwide propagation seen so far.

As the world turned on 27 June 2012, the band opened at about 0550 UTC from the Asian Pacific Rim into Europe. Following the Sun, at about 1200 UTC, it switched over to Europe into North America. Still later that day, the propagation moved westward again, and opened about 2330 UTC, this time from North America into Japan until about 0300 UTC on the 28th. In varying degrees, this pattern was repeated on the 28th and 29th. Figure 1 shows instances of these paths with ranges of 8800 km or greater (the equivalent to five or more normal *Es* hops). At such distances these were almost always weak-signal CW contacts.

Of all these, the openings of 29 June were the most prolific. One opening between North America and Europe lasted some ten hours, although the path footprints moved around during that time. Late on the 28th and early into the 29th, there was a three-hour period when a properly situated European station might work into the Asian Pacific or North America, depending on which way the beam was headed at the time.

Sporadic-*E*

Before going more deeply into this family of openings, a quick review of *Es* may be helpful in sorting out what happened. This should start by looking at sporadic-*E* seen strictly as an *ionospher-*

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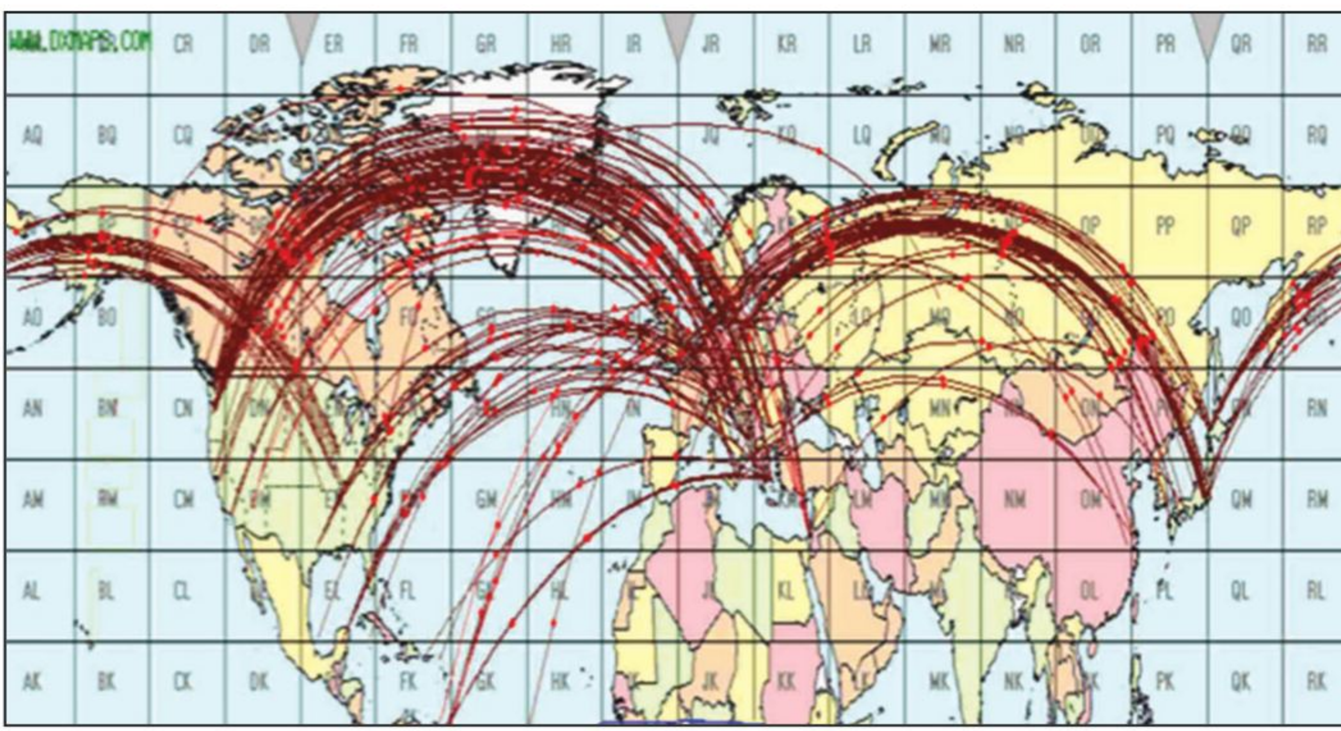

Figure 1. This figure shows northern 6-meter activity during 27–29 June 2012. To avoid covering up most of the map, this only shows contacts over paths of 8,800 km or more! (Map credit: <http://www.dxmaps.com>)

ic phenomenon. The second step will be to look at the *propagation phenomena* that sporadic-*E* can produce.

E-layer: Boring

The *E* layer is located roughly between 95 and 135 km above the Earth's surface. Normally, its free-electron ionization is spread out thinly over a nominal 40 km vertical expanse. So, most of the time, this "background" free-electron density is really quite low. At midlatitudes it rarely produces MUFs (maximum usable frequencies) above 22 MHz or so. As a result, during these "normal" periods, it does *not* produce any interesting VHF propagation, although it can produce propagation in lower portions of the HF bands.

Sporadic-*E*: Not So Boring

To the physicist, "sporadic E" refers to the *occasional* formation of very thin, yet very dense, clouds of free electrons in the *E* layer. *Es* usually occurs between 105 and 115 km. With the right combination of conditions, *horizontal* wind shears in the *E* layer, interacting with the Earth's magnetic field, can lead to a *vertical compression* of these background electrons. This forces a large number of electrons from a large space to be squashed down into very thin layers (flat clouds) with very high electron densities. When this happens, the MUF can soar to quite high values, ocassionally well above 50 MHz.

Es Has Many Forms

The Earth's magnetic field plays a major role in the formation of sporadic-*E* clouds. The *angle* of the field's direction with respect to the *E* layer, and the field's *local intensity*, are both key factors affecting the impact on the clouds, and when and where they are formed. This gets a little more complicated because the Earth's geographic and geomagnetic poles are *misaligned* by about 10°. This leads to two different latitude–longitude systems: one geographic and the other geomagnetic.

Both the angle of the field direction and its intensity vary significantly with the *geomagnetic* latitude. For example, the field lines point *up vertically* near one magnetic pole, become *horizontal* over the geomagnetic equator, and then point *down vertically* at the other magnetic pole. Near a magnetic pole, the lines are closer together and the field is much more intense. As a result, there is a strong relationship between magnetic latitude and how *Es* and *Es propagation* behave at a given point.

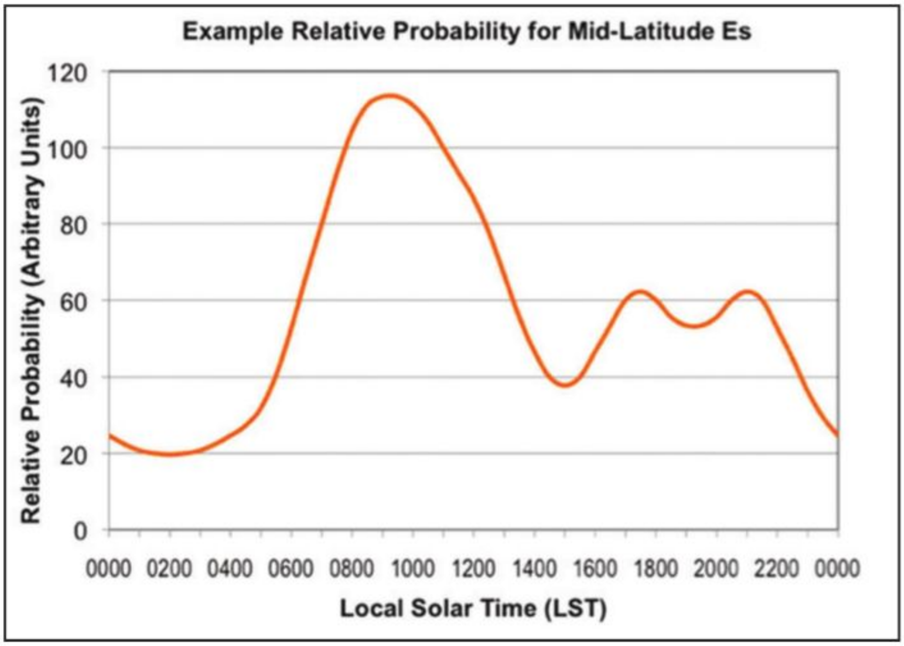

Figure 2. This stylized view shows the typical time-of-day behavior for Midlatitude Es. *The propagation probability often peaks during two time periods, a morning "window" and late afternoon into evening peak "window." The times are in Local Solar Time (LST).*

On a worldwide basis, *Es* shows up in four major forms which depend on four geomagnetic latitude zones: Equatorial, Midlatitude, Auroral, and Polar. (There are also some sub-forms within these zones.) Three of these major forms will come into play a little later in this discussion.

Midlatitude *Es*

Since there are many things that must come together to cause the occurrence of

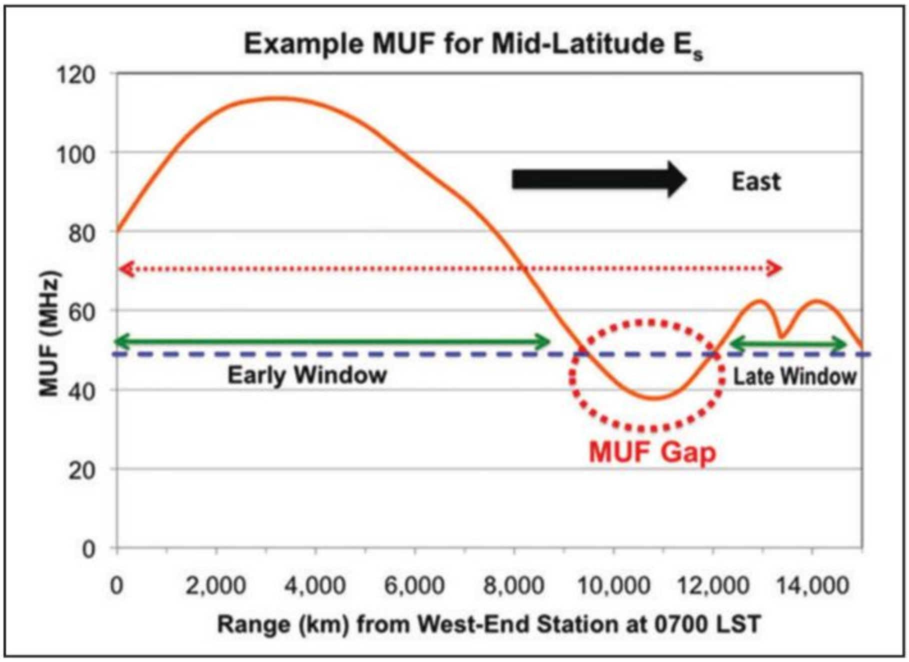

Figure 3. Here figure 2 data are remapped to show the MUF as a function of distance east from the west-end station at 0700 LST. The blue dashed line shows 50 MHz. In this example, the MUF drops below 50 MHz at points (red dotted oval). Solid-green arrows show reachable paths within each window. The red dotted arrow shows what's possible if the MUF Gap is bridged.

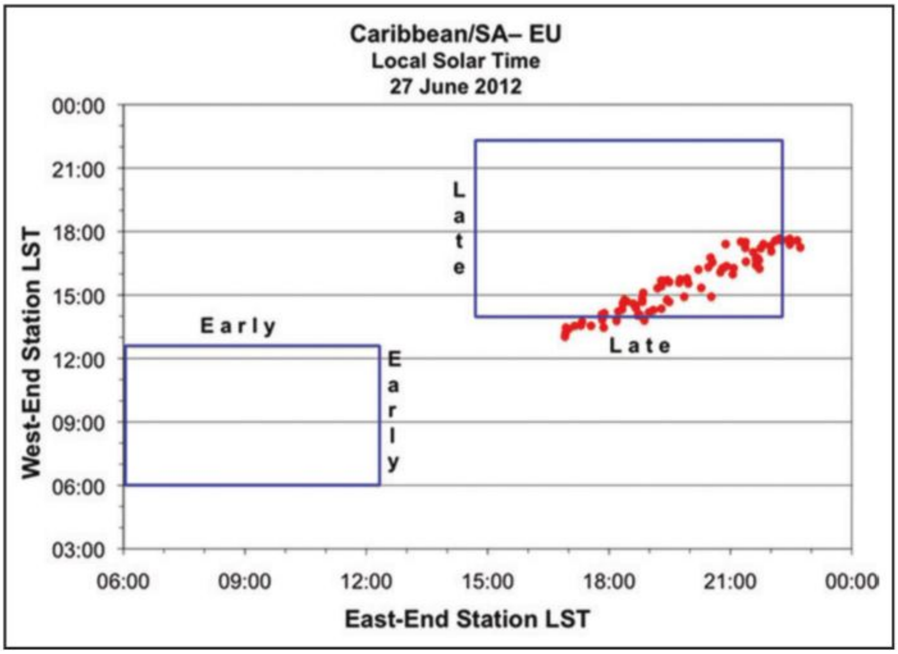

Figure 4. This transatlantic path is less than 8,500 km. Both endpoint stations are in their overlapping afternoon-evening LST window. (The band was not open during the early window.) This is a typical example of 4Es.

Ground Footprints for Successive nEs Hops

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
7	11,900	15,400

Table 1. See text.

Es (not all of which are clearly understood), it is very difficult to predict where and when *Es* will occur at any given time. However, there are observed statistical relationships that do hint at when, and roughly where, *Es* and *Es* propagation *might* occur. It turns out that these relationships vary widely from one *Es* latitude zone to the next. The Midlatitude Zone lies roughly between magnetic latitudes 20° and 60° both north and south. The exact boundaries are a bit fuzzy, depending on current conditions.

Summer is Good. Midlatitude *Es*, commonly denoted as simply "*Es,*" displays a clear seasonal effect. The *Es* occurrence probability is much higher in the *local* late spring and summer. Thus, the northern and southern hemisphere "*Es* seasons" are six months apart.

Local Solar Time is Important. It is also well known that certain times of day are better for *Es* than others. It's important to note that the "time" in question is the *local solar time* (LST). Evidence suggests that this variation with the time of day is due to the overlapping of at least three "atmospheric tides" driven by the Sun heating up the atmosphere on the daylight side. The resulting up and down drafts play a role in creating the thin *Es* ionization clouds.

Figure 2 shows a typical *relative* probability plot for Midlatitude *Es* formation, as seen at the location of a single station. (The *total* probability depends on other things, as well.) Overall, the figure shows that in the local summer, Midlatitude *Es* has a higher probability of occurring during mid morning, and then again in the later afternoon on into evening. These two propagation opportunities are called the "early window" and the "late window." It is important to keep in mind that LST is the *true solar time* at the precise location of the station, not the *time-zone* clock time. Of course, the Sun doesn't know anything about Daylight Savings Time either.

How Far Can *Es* Go? Generally speaking, the maximum possible length of a *single Es* hop (1Es) is determined by the *height* of the reflecting layer, and the curvature of the Earth. The higher the ionospheric skip point, the farther "over the hill" the signal can go. Typically, a single *Es* hop runs about 2,000 km. As the accompanying Table 1 (Ground Footprints for Successive nEs Hops) shows, it runs from about 1,700 to 2,200 km. When the ionization is particularly intense (leading to very high MUFs), sometimes much *shorter* hops occur. However, that's not the focus here.

Direction makes a difference: In order to say how far *Es* can take a signal (with-

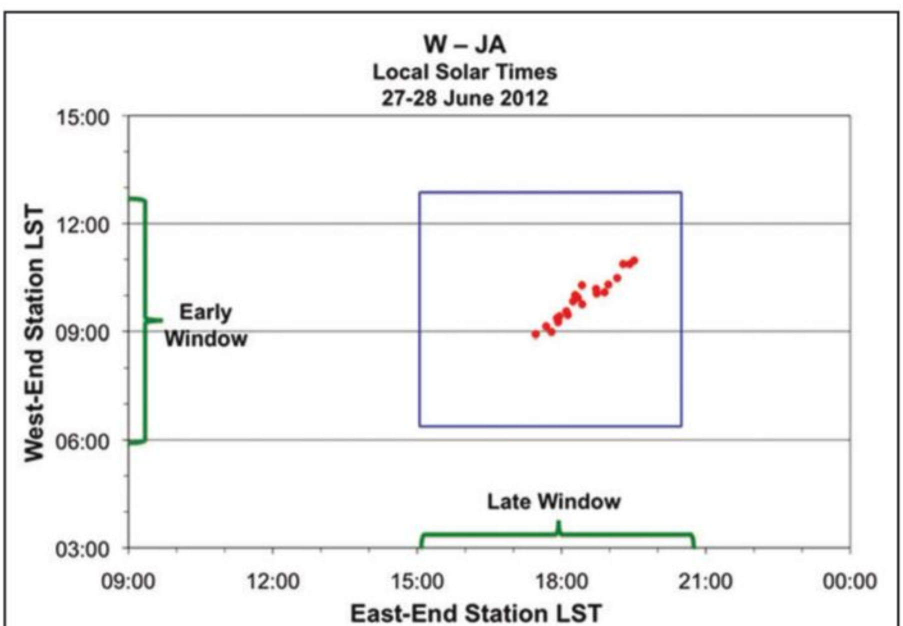

Figure 5. Paths greater than 8,500 km usually occur when the west-end station (JA) is in its morning Es *LST window and the east-end station (W) is in its afternoon-evening window. This is the Early-on-Late Effect. W–JA is a typical EEWE path.*

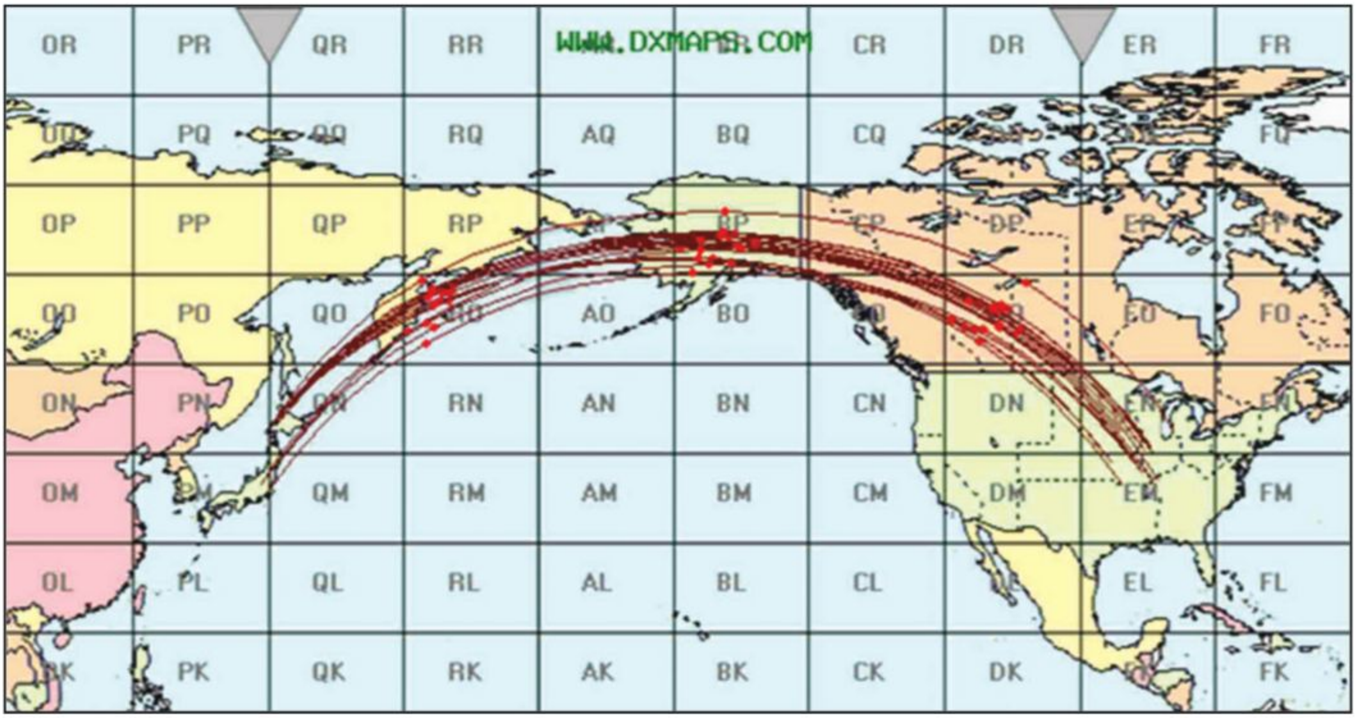

Figure 6. This was the only opening between North America and the Asian Pacific (US-Japan). Starting at about 2330 UTC on 27 June 2012, it continued until 0140 UTC on 28 June 2012—just over two hours. No contacts were less than 9,303 km and the longest was 10,305 km. (Map credit: <http://www.dxmaps.com>)

out help from any other propagation mode), it turns out that one has to look at a number of less obvious limits. For example, its been mentioned that the different geomagnetic latitude zones have different cloud formation characteristics. These include the different times of day that *Es* clouds are likely to form, and thus be available to skip signals.

North-South, not so good: Sandwiched in between the Equatorial and Auroral *E*s Zones, the Midlatitude *Es* Zone's north-south extent is roughly 4,500 km. Therefore, even if one were at the northern edge of the Midlatitude *Es* Zone, and aiming south, there is only *space* for about two *Es* hops before running into the Equatorial *Es* Zone. In that new zone, with its different characteristics, there may not be any *Es* clouds at that time to carry the signal farther. Of course, going across the Midlatitude Zone starting from south to north faces a similar problem at the Auroral *Es* Zone boundary.

East-West is better: On the other hand, from inside the Midlatitude Zone, if one aims an antenna in an east-west direction, there is a range of azimuths that will allow the signal path to stay in the Midlatitude Zone for up to more than 13,000 km!

But East-West has time limts: The spherical shape of the Earth will finally force an east-west path out of the Midlatitude Zone, but that's not the most pressing issue. What is crucial is that the Local Solar Time at the stations at the two ends of the path will be *different*, because they are at different east-west longitudes. Thus, somewhat akin to passing from one latitude zone to another on a north-south path, here on an east-west path there is no guarantee that the stations at *both* ends of the path will have the needed favorable *time-of-day Es* conditions, at the *same* UTC, because they have *different* LSTs.

Earlier work (Kennedy, 2010 and 2011) showed a way to visualize this by first starting with the *Es* probabilities in figure 2. Then, one makes an assumption that if the *probability* of *Es* is higher at a given time, then the *MUF probability* is *also* likely to be higher at the same time. Figure 3 shows the *time-based* information shown in figure 2, but transformed into a plot of what the *MUF* might look like at a *fixed* point in time. In this case, it's a snapshot of what the west-end station might see when looking east at its 0700 LST. From there, using the longitudes on a Great Circle path, the rest of the *times* are transformed into *distances* from the west-end station, at that *same* UTC.

When the band is open, it shows that the west-end (0700 LST) station will be inside the same early LST window as stations farther eastward—perhaps out to about 8,000 km, depending on the MUF. Therefore, stations within the *same* window have the possibility of working each other. In the meantime, much farther east, beyond 12,000 km, other stations may be talking to each other during their late window. However, the MUF *between* the morning and evening windows is usually *below* 50 MHz. Normally, then, there is a problem getting beyond the first 8,000 km to work those late-window stations. This dip electron density has been called the MUF Gap.

However, there are circumstances in which the MUF Gap can be bridged. One way is if the MUF were so high *over the whole path* that the MUF *never drops* below 50 MHz. Another way would be if the signals crossed over the top of the gap by means of chordal or *Es* ducting hops—that is, skipping from cloud to cloud, without coming to Earth in between. There is good evidence that both things do happen (Kennedy, 2010). The point is not to explain which of these might be operating at a given time, but merely to say that at times they each can happen.

The result is that ordinary multiple-hop *Es* (nEs, where *n* is the number of hops) is possible on the *same* LST peak out to about 8,000 km. That's about four *Es* hops (4Es). Anything beyond that point must rely on extraordinary conditions to bridge

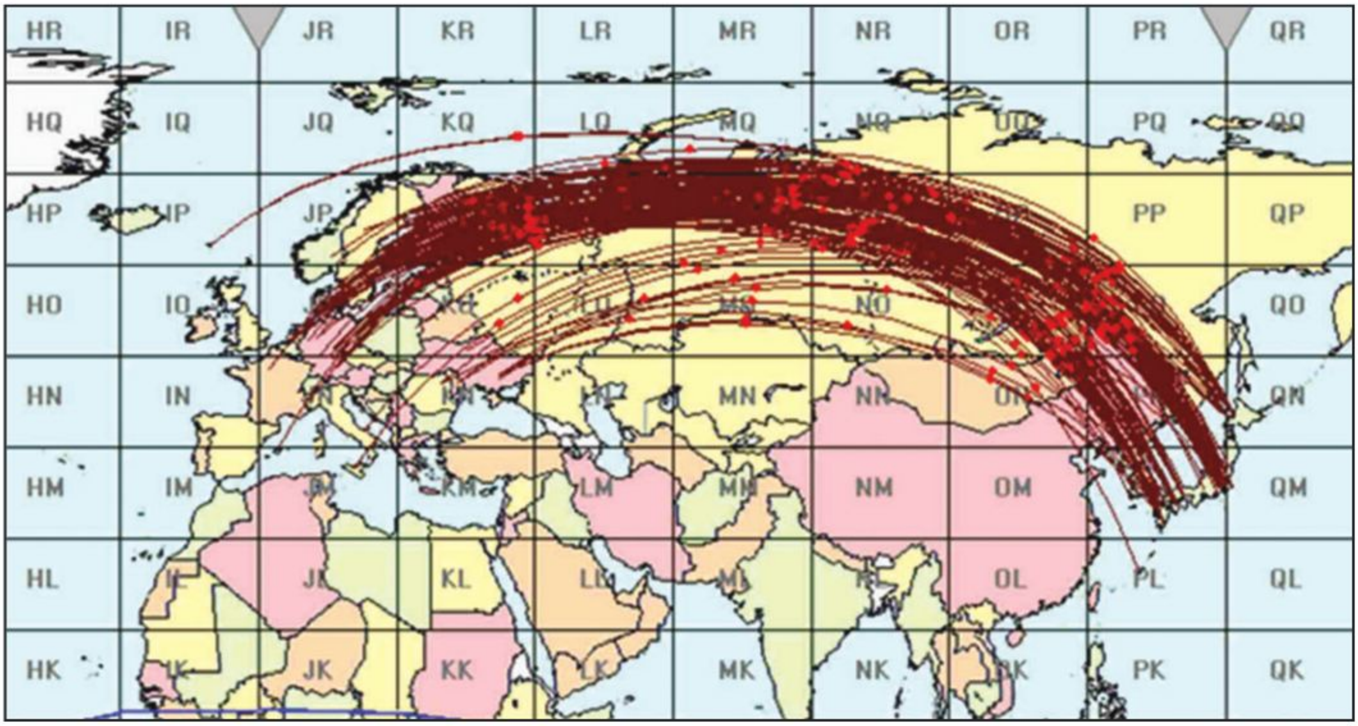

Figure 7. These Asian Pacific to Europe contacts were 7,500 km or more, during 0430–1000 UTC on 29 June 2012. There are three distinct west-end footprints—Western Europe, Eastern Europe, and Northern Europe. The northern-most European region will be the focus of a later discussion. (Map credit: <http://www.dxmaps.com>)

the MUF Gap. These kinds of paths have been as Extreme East-West Es, or EEWE (Kennedy and Zimmerman, 2011), which may be either *nEs beyond* four hops, or a hybrid of nEs with some kind of chordal process in the middle.

Telling the Difference. There is a useful way to tell the difference between simple *nEs* and EEWE, which provides more information than one would get by simply looking at the path length. It's a graphical approach that compares the actual contact-station LSTs at *each* end of a specific contact.

For each contact, the west-end station's LST is computed using the station's actual grid-square longitude (*not* the time-zone value). Then, the same is done for the east-end station's LST for the *same* contact. Finally, the contact is plotted as a point, with the west-end station LST value on the vertical axis, and the east-end station LST value on the horizontal axis.

If the given contact is the result of one to four *Es* hops, then it is likely that the LSTs at both ends will both appear somewhere in the *same* peak LST time "box." Figure 4 shows a typical example where both ends of the path are within the *same Es* peak (the afternoon-evening peak in this case), even though they are at different longitudes.

However, the long EEWE paths seem to need all the help they can get. Observations have shown that for a given contact each of the west-end and east-end stations are *almost always* found in their *own* respective peak LST times. Therefore, the west-end station is in its "early" LST window (morning) and the east-end station in the "late" LST window (afternoon-evening).

Thus, whatever happens in the gap in between, it appears the path *endpoints* usually have to be in the optimal time slots for the first and last hops to take place. This is referred to as the "Early-on-Late" effect. Figure 5 shows an example of an EEWE-type opening between the US Midwest and Japan. This west-end versus east-end LST diagnostic plot will also come into play a bit later.

The World in Thirds

When one looks at the June 2012 openings that produced thousands of contacts from 5,000 km to over 10,000 km, the geography of the Northern Hemisphere land masses seems to divide the world into three path groups: Europe/Middle-East to North America over the Atlantic, North America to the Asian Pacific over the Pacific, and finally the Asian Pacific to Europe over land. These broad path groupings show up clearly in figure 1.

With the volume of contacts that occurred, it is difficult to produce path graphics without some important details becoming buried in the sheer volume of path tracks. At the same time, it is a bit intellectually dangerous to edit data to highlight certain features for fear of hiding still other important facts. Nevertheless, a certain amount of this needs to be done to "reduce the noise." As an example, many, many contacts were made at 1Es, 2Es, and 3Es distances, and generally these have been removed from the dataset to highlight the contacts made at ranges equivalent to 4Es and higher.

North America to the Asian Pacific

This path opened late on 27 June 2012 UTC and continued into the 28th, for a total of about two hours. Compared to the openings between other geographical regions during these few days, two hours may sound a bit short. However, there are good reasons for it. It's a very long path between the US Midwest and Japan, and it has a very small land target within the *Es* footprint at the JA end. The *minimum* range is over 9,300 km with a maximum range over 10,000 km. Thus, it takes an

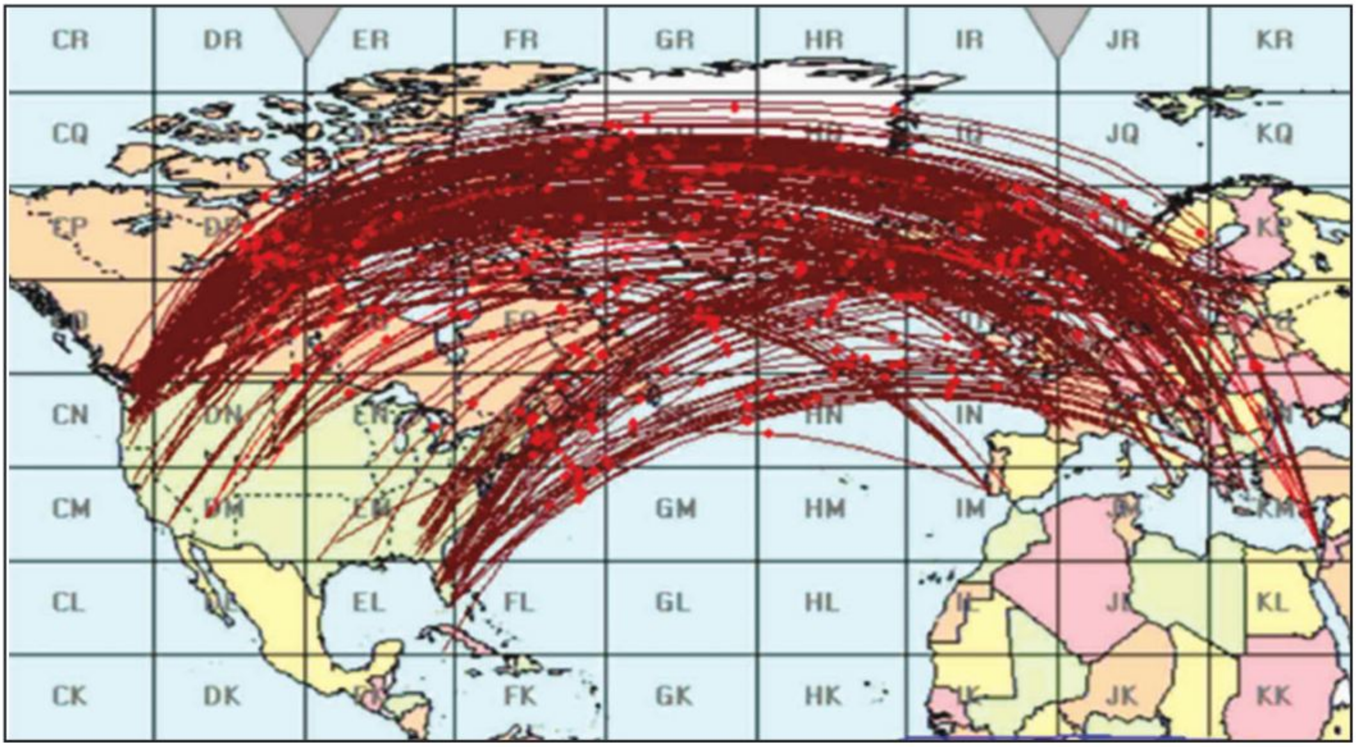

Figure 8. These are North America to Europe and Middle East contacts with ranges of 7,500 km or more on 29 June 2012 during 1300–1724 UTC. There are three fairly distinct west-end areas, the US east coast and nearby Caribbean, and a very small focused area in W7/VE7, with a scattering of other contacts mainly in the western US. (Map credit: <http://www.dxmaps.com>)

equivalent of 5Es, just to get there at all.

While many other paths discussed here have workable footprints at this range, they also have shorter available footprints that lie along the similar path azimuths. This allows for longer openings on the *clock*, but not necessarily to the same end points at the same time. In the current case, the large width of the Pacific Ocean, coupled with a near absence of radio operations anywhere else along that path, means 5Es distances are normally the *shortest* that can occur.

Figure 6 may help to make this point. About the only Japan path that is seen goes over the northern Pacific, then Alaska, and then northwestern Canada. The first place it comes to Earth—where there is *anyone to talk to*—typically is in grid fields EM and EN and others near by, and that corresponds rather nicely with the theoretical 5Es footprint. The LSTs at each end of the circuit corresponded with the usual Early-on-Late effect, as shown in figure 5.

The Asian Pacific to Europe/Middle East

These paths opened on 27, 28, 29, and 30 June UTC. Paths longer than 8,000 km generally began around 0600 LST on the west end and around 1500 LST on the east end. This is consistent with the Midlatitude Early-on-Late effect. However, there were some important exceptions, and they will be addressed a bit later.

Figure 7 shows the contact paths for 29 June at distances of 7,500 km and greater. At this range limit, the plot shows a mixture of 4Es and 5Es distances. There is a second west-end footprint near the boundary between the KN and KO grid fields. It samples a different part of the *E* layer than the northern and more western paths, in that it only reaches a maximum of about 63°N geographic latitude.

In contrast, the paths from the Asian Pacific into western and northern Europe arched up to geographic latitudes between 63°N and 73°N. Most of the *northern* European end-points are "buried" under the flow of paths going farther to the west. Northern Europe will be explored in more detail a little later.

Europe/Middle East to North America/Caribbean

Various paths between Europe and the Middle East to North America opened at different times on the 27, 28, and 29 June. However, the opening on the 29th was clearly the most prolific, and the most wide-ranging, as shown in figure 8. No doubt the most exciting path was the extraordinary link between a few grid squares in Washington, Oregon, and British Columbia, from there going into Europe, the Mediterranean, and the Middle East. Of these contacts, 80% were longer than 8,000 km, and the longest was nearly 9,800 km. There will be a further discussion of the W7/VE7 path shortly.

Then Some Quirky Things Popped Up

This series of openings was *not* typical. The intensity and longevity clearly were *not* every-day occurrences. The *Es* clouds were geographically very widespread, and persistently regenerated on a global scale as the Earth turned. It appears that frequently the MUF Gap between the early and late windows simply was not there. There were at least two cases that suggest there may have been a link between Midlatitude *Es* and Auroral *Es* and/or Polar *Es*.

Midlatitude *Es* on Steroids

While the Early-on-Late plots did conform well to previous thinking on almost all of the paths, there were two in which, *in addition* to Early-on-Late, something else turned up that had not been seen before. Both the Asian Pacific-Europe

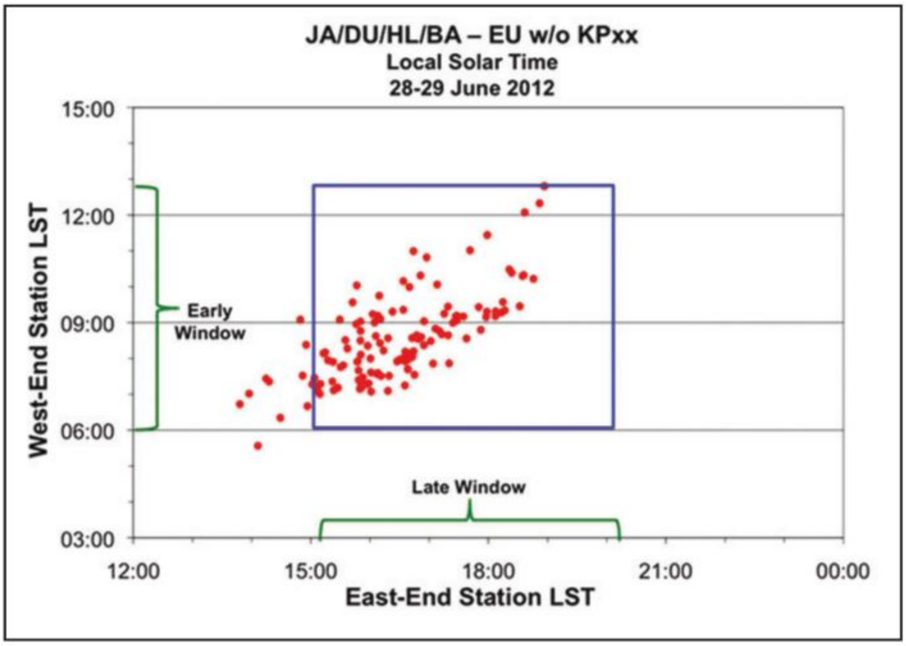

Figure 9. The Asian Pacific with Europe path—without the Northern European contacts—has a large Early-on-Late component, but also a "tail" out of the box to the lower left, probably due to MUF Gap filling

path (figure 9) and the Europe–Pacific Northwest path, especially near grids CN84-88 (figure 10), showed a distinct "tail" coming out of the Early-on-Late box to the lower left. There may be more than one explanation, but these data from 28–29 June UTC are from the *peak* of all the activity seen in this series of openings. Obviously, the *E* layer was very energized and, without doubt, the MUFs were very high.

A simple explanation might be that in both cases the MUF Gap between the west-end and east-end stations was largely filled in. That is to say, at certain times the MUF had *not* dropped below 50 MHz along the whole path. Therefore, there *was* propagation through the usual gap between the early and late windows. This does require that the *west-end* stations got into their *morning* window before the path could open, which they did. However, in both cases, it was not as simple as just MUF Gap filling. There was something else involved as well. To better set the stage, a review of Auroral *Es* behavior is in order.

Auroral Es (aEs)

Earlier in the discussion it was noted that, as far as sporadic-*E* is concerned, there are four broad magnetic-latitude zones. Sporadic-*E* occurs in all of these zones, but the driving circumstances are different to some degree in each one, so there are important behavioral differences, depending on which zone one is talking about.

In the Auroral Zone, the Earth's magnetic field lines are at a steep angle to the *E* layer itself and the field is very intense. Unlike the Midlatitude *E* layer, which is primarily ionized by solar radiation, the auroral region primarily is ionized by high-energy *particles* from the Sun that enter from above and become trapped in the Earth's magnetic field system, and then contribute to the formation of aurora.

"Radio Aurora" is *Not* aEs. It is also important to realize that there is more than one form of *E*-layer radio propagation associated with auroras. The most commonly known form is often called "radio aurora." While it does arise from the *E* layer, it actually is a form of "field-aligned irregularities" (FAI), a type of backscatter propagation. It normally produces heavily modulated (distorted) backscatter signals caused by electron-density variations moving through the Earth's magnetic field.

aEs is Different. True aEs behaves much like Midlatitude *Es*, with some variations. As with Midlatitude *Es*, summertime is the best season for aEs. However, unlike *daytime* Midlatitude *Es*, aEs is largely a *nighttime* phenomenon with a broad window peaking around local midnight (North and Jarvis, 1988). Another important point is that true aEs clouds *do not* form in the visible aurora region itself. Rather, they form on the *equatorward* side of the oval, just beyond the region of the visible aurora.

During quiet geomagnetic conditions (Kp = 3 or less), nighttime aEs clouds sometimes form so densely that they become altogether opaque to radio

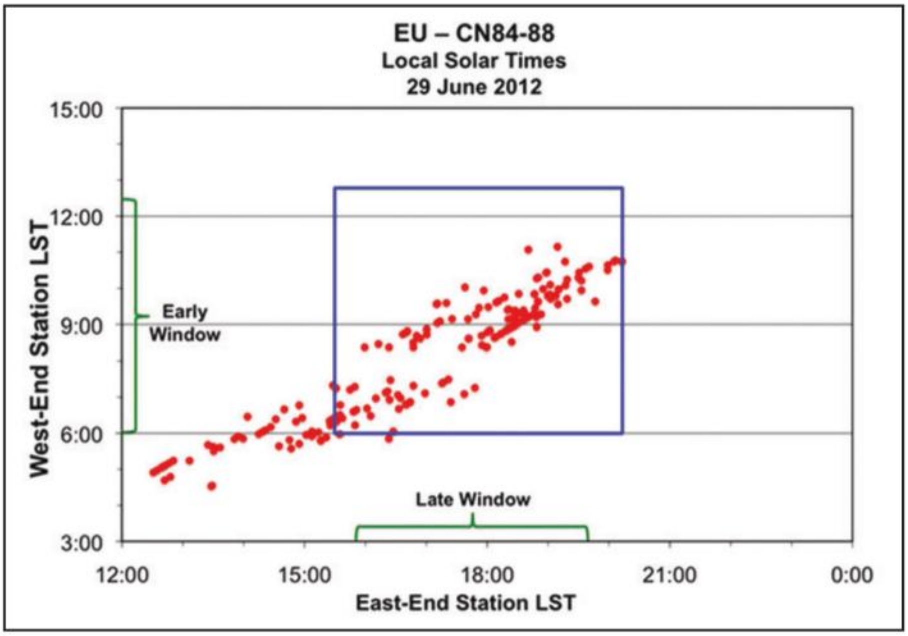

Figure 10. The Europe-W7/VE7 path has a large Early-on-Late contribution, and a very long "tail" off to the lower left, and a nearly one-hour gap from west-end during its 0730-0830 LST. In addition to MUF Gap filling, it appears that the tail was due in part to a west-end Auroral Es hop. See the text for more details.

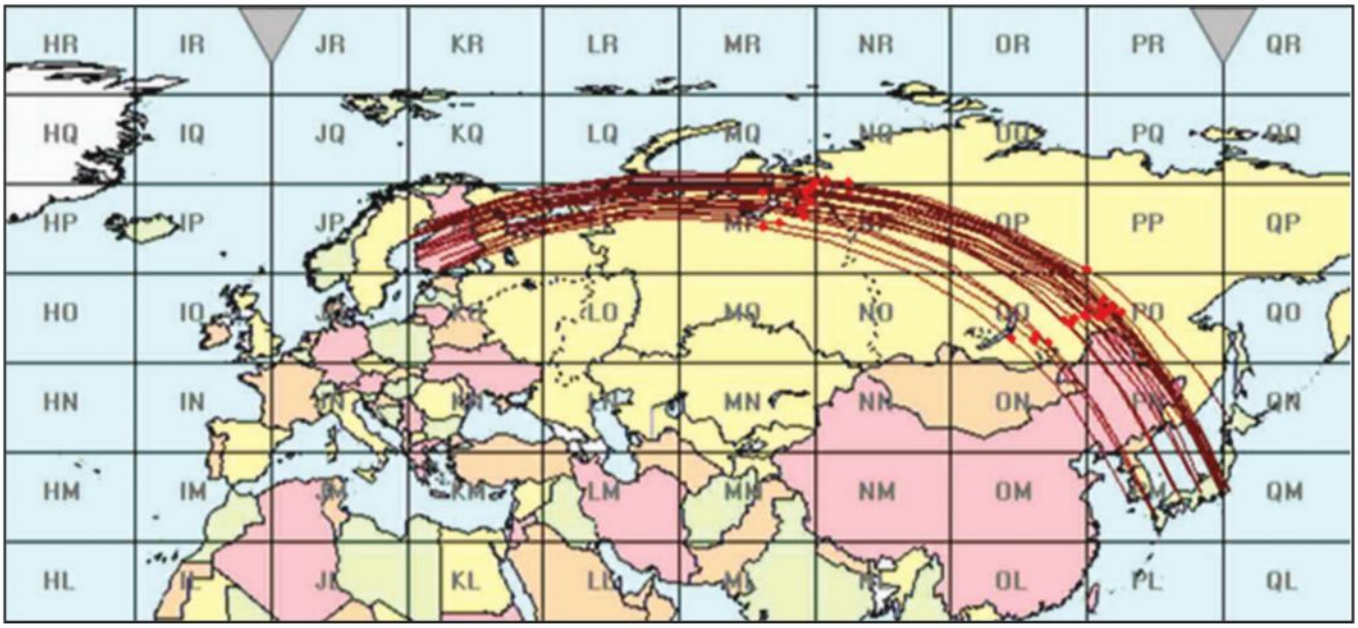

Figure 11. These contacts are between Asian Pacific stations and the mostly Finnish stations with a few Swedish stations in grid field KP. Part of the opening occurred very early on the west end and was very focused on this footprint. Auroral Es *seems to have been involved; see also Figure 12. (Map credit: <http://www.dxmaps.com>)*

waves. They skip *everything* back down as aEs propagation, keeping any of the signals from reaching through to the *F2* layer (Hunsucker and Hargreaves, 2003). This is usually referred to as *F-layer blanketing*.

It is commonly accepted that on the sunward side of the planet the solar wind and other high-energy solar particles are always pushing the oval *away from the Sun* and toward the geomagnetic poles, which leads to its oval (rather than circular) appearance. Some people talk about the auroral oval moving toward or away from the magnetic pole on a daily basis, especially during periods of high magnetic activity. However, others have a slightly different way of looking at it.

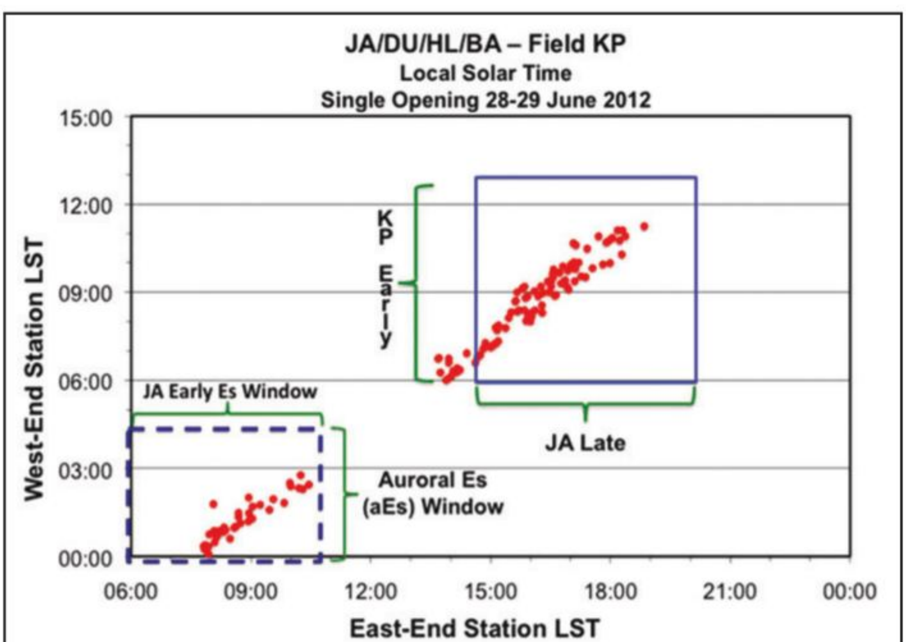

Figure 12. The right-hand LST groupings for only the grid field KP with the Asian Pacific show the typical Early-on-Late effect, with a slight "no-Gap" signature. The dashed box in the lower left-hand corner shows what appears to be a link from west-end Auroral Es *to eastern Midlatitude* Es.

Some researchers suggest that the *basic shape* of the auroral oval doesn't actually change much at all (e.g., Newell, et al. 2010). Their picture is that since the Earth is turning under the Sun, it appears to someone on the Earth that the oval is moving throughout the day. Actually, the oval is standing still, and the Earth is turning under the oval. They point out that when fluctuations occur in the incoming particle streams, it isn't so much that the auroral oval band (the ring of enhanced activity) is moving one way or another, as it is that the *width* of the band expands *both* inward *and* outward, toward the equator *and* toward the pole. That is, the band stays on the same centerline and gets wider (mostly on the nighttime side). As a result, *both* the inside and outside boundaries expand, in opposite directions. On the equatorward side, that means that visible aurora and aEs are seen to occur farther south (in the Northern Hemisphere).

Finnish Magic in Field KP

The second quirk showed up on the Asian Pacific to northern Europe paths. These all were shown earlier in figure 7. However, the path to the KP grid field was largely hidden by the paths that went beyond it to footprints at least one full *E* hop farther into more western and southern Europe. The path to northern Europe is seen more clearly in figure 11. The data have been filtered to exclude all paths except those that land in grid field KP—largely Finland.

Not withstanding the Figure 7 filtering, a part of that opening was, in a sense, really a *separate* opening that occurred very early in the west-end morning. It was actually *very focused* on just the KP field region, and *nowhere else*. The path LST patterns are shown in figure 12. In the center, one sees the now-familiar long-tail signature of a very high mid-path MUF, allowing propagation through the MUF Gap between the two ends of the circuit, such as seen previously in figures 9 and 10. However, note that the lower left-hand corner shows something altogether unique.

aEs to *Es* Linking

The dashed box in the lower left of figure 12 shows that there was an active path functioning from slightly before 0000 LST at the west-end field KP. In itself, this is quite consistent with the west-end Auroral Zone *Es* skip time window. If so, then the only reason it was working all the way back to the Asian Pacific is that it was catching the *east-end* stations in their Midlatitude Es morning window.

This "early" window opened at about 2330 UTC and lasted about two-and-a-half hours. This roughly translates into west-end (KP) LSTs from 0000 to 0230, which is well into their peak time window for aEs. Actually, both the first *and* second ionospheric skip points are within the aEs "nighttime" window (the Sun was just coming up in field KP as the band closed). The remaining east-side skip points where inside the regular Midlatitude *Es* morning window.

As mentioned before, the place where aEs clouds form is not within the auroral oval but close to it on the equatorward side. Thus, it would be interesting to see where the skip points were in reference to the oval. This was explored using auroral oval data provided by the Ovation Prime project at NOAA's National Geophysical Data Center (NGDC). Figure 13 shows that all of the skip points are south of the oval boundaries. Importantly, the first two skip points are *just* south of the edge, and presumably right where they would need to be in order to find aEs.

A second approach was to look at what the ionosphere itself might have been doing. Utah State University researchers have developed a data-driven three-dimensional ionospheric model that shows the likely state of the ionosphere as

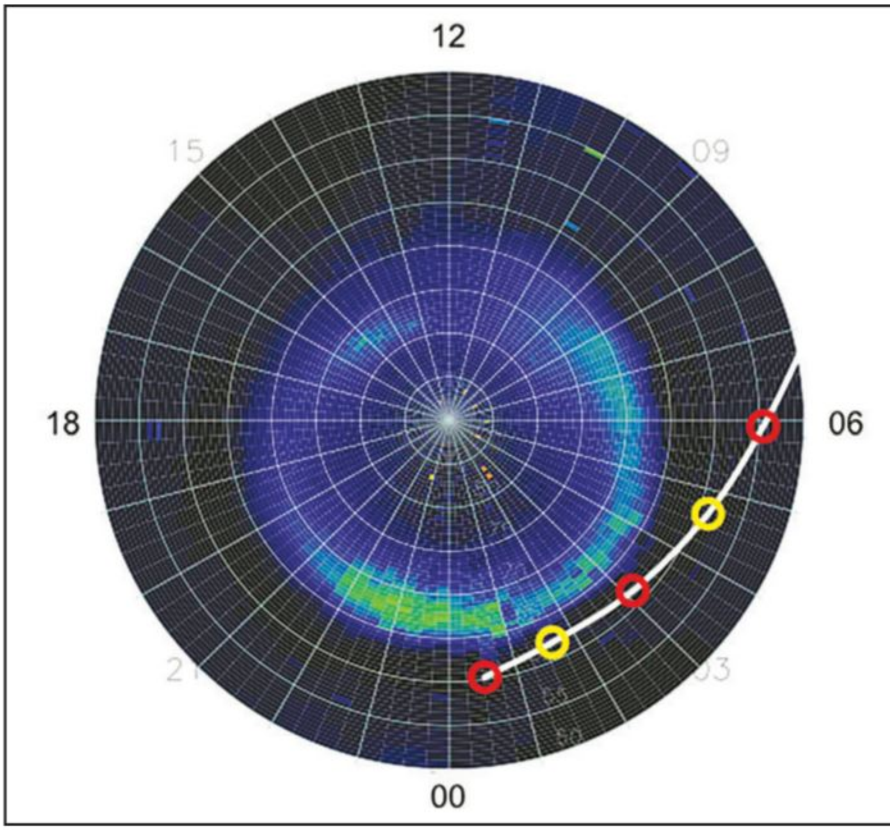

Figure 13. This shows the auroral oval in geomagnetic coordinates at 2330 UTC on 28 June 2012. The Local Solar Times at the radial longitudes are around the outside. The Sun is always at "12.".White circles show geomagnetic latitudes from 90°N (center) to 50°N (outer ring). Red circles are the ground footprints and yellow circles are the ionospheric skip points. The eastern-most field KP to Asian Pacific skip points (lower right) were just beyond the southern edge of the auroral oval. (Auroral map credit: Ovation Prime images by NGDC)

a function of time. It is called Global Assimilation of Ionospheric Measurements model, or GAIM (Schunk et al., 2004). However, it is important to know that this model does not attempt to describe short-term transient events, such as sporadic-*E*. Rather, it describes the probable *E*-layer background ionization levels, which form the electron "reservoir" that the vertical compression effects use to create the thin, highly compressed *Es* clouds. So while it does not show the *Es* itself, it can show regions where the background ionization is more likely to produce high *Es* MUFs, if *Es* forms there.

Figure 14 shows that near the southern edge of the auroral oval region there was a long, narrow "finger" of enhanced *E*-layer ionization at about 105 km that ran "ahead" of, although quite *separate* from, the larger daylight Midlatitude *E* ionization structure. This is just where it was needed to convey the signals over into the east-end, just catching the eastern morning window into the Asian Pacific Rim. There will be more on this ionization finger and its separation from the Midlatitude *Es* shortly.

W7th Heaven and the Far North

Continuing with quirks, something that stood out to many people was the extended opening between several grid squares in the northwest corner of the US lower 48 and adjacent grids in western Canada (primarily, but not exclusively, CN84-88). Figure 15 shows a path map that was filtered to show only contacts made with these particular west-end grids. Meanwhile, the east end of the circuit was much wider, both east-west and north-south, with the heaviest concentration in grid fields JN and JO, but also reaching as far west as field IP and as far east as field KM. Recently, Bernhardt and Lofgren (2013) have provided a most interesting "insiders'" view of the W7-end action.

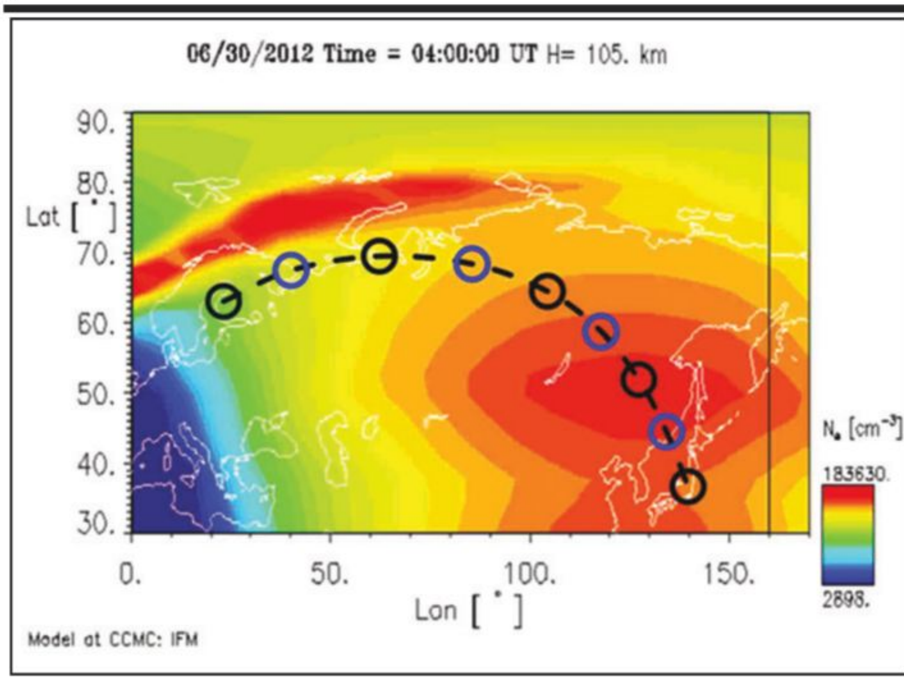

Figure 14. The grid field KP with Asian Pacific path is plotted on the USU-GAIM E-*layer ionospheric model (geographic coordinates) for the early opening. Blue ionization is the weakest and red the strongest. Black circles are ground footprints and blue circles are ionospheric skip points. The two west-most skip points appear to link the signal to the two morning Es skip points to the east. The finger of elevated background ionization corresponds roughly with the location of the auroral oval. (Ionospheric map credit: USU-GAIM and CCMC)*

The band opened as early as about 1244 UTC (about 0430 LST) on 29 June and continued for six-and-a-half hours until about 1921 UTC, except for a 54-minute pause starting about 1541 UTC (breakfast time in W7). The earlier figure 10 shows an odd LST pattern in two respects. First, it shows a very early start, around 0430 LST in CN84-88. The second peculiarity was the nearly hour-long path shut down, which was then followed by more hours of active propagation. Like the Asian Pacific with grid field KP, the west end of the path was very focused. By far the majority cof contacts were made with CN84-88.

An aEs Asymmetry

The *geographic* latitudes of the Auroral Es Zone are *not* the same in the Western Hemisphere as in the Eastern Hemisphere. In both east and west, the zones are located in reference to the Earth's *geomagnetic* poles. The geomagnetic pole in the north is offset from the geographic pole about 10° down into the geographic Western Hemsiphere. This shifts the western nighttime auroral oval about 10° to the south. It's just the opposite in the Eastern Hemisphere, where the

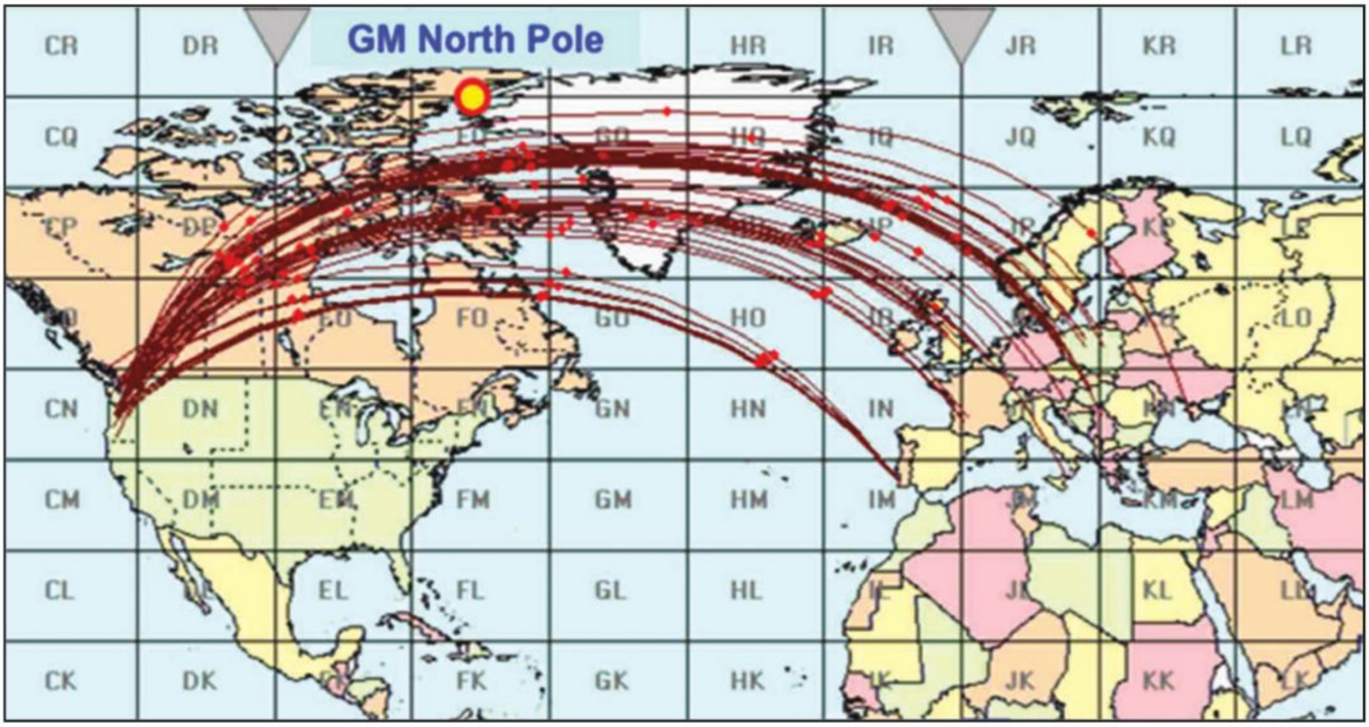

Figure 15. This west-end W7/VE7 with Europe path is also very focused, not unlike the Asian Pacific with field KP. The LST patterns also showed similar distinctive characteristics. Note the Geomagnetic North Pole. In this case, in addition to Midlatitude Es, both Auroral and Polar Es *seemed to have been involved. (Map credit: <http://www.dxmaps.com>)*

nightime auroral oval is offset about 10° to the north. Since Auroral *Es* is a nightime phenomenon, the *geographic* location of Western Hemisphere aEs is found a total of about 20° south of where it would be found in the nightime eastern hemisphere.

By contrast, the *geographic* latitude of Midlatitude Es Zone is determined by the position of the Sun, as the Earth rotates on its *geographical* axis. Thus, the eastern and western hemispheric Midlatitude *Es* zones are more or less at the same latitudes in the same season. As an overall result, in the Western Hemisphere, the latitude of the *nightime* aEs region is pushed down into the same geographic latitudes that are occupied by the *northern* edge of the *daytime* Midlatitude *Es* Zone. In the Eastern Hemisphere, the Auroral and Midlatitude regions generally do *not* overlap.

This is clearly seen when comparing the ionization fingers in figures 14 and 16. Note that figure 16 shows the USU-GAIM model for the background *E*-layer ionization reservoir. Like the Eastern Hemisphere side, it has a distinct west-end finger of ionization running just below the south edge of the auroral oval. However, in this case, the finger is *directly connected* to the main body of the daytime *E*-layer background ionization. Viewed in time-lapse, they seem to move westward together.

Figure 17 also shows that the path had its first west-end skip point just south of the auroral oval, and thus it was well positioned for a west-end aEs hop *early* in the opening when nighttime aEs conditions were still in place. In this image, the one-hour gap was caused by the collapse of the west-end aEs hop when the Sun rose high enough to shut down aEs there. Then, the path reopened an hour later when the Sun continued rising high enough and the morning midlatitude Es *replaced* the aEs.

The first skip point going eastward is positioned just south of the finger. It is not clear whether this feature should be regarded as a part of the midlatitude *Es* structure or aEs. Perhaps, in this regime, there is not much difference. As can be seen, from there on farther east it seems to be in a region of fairly uniform background ionization until it reached the European end of the path.

Figure 17 also points to another puzzle: The two *central* skip points are both actually on the *inner* edge of the auroral oval and rather near the North Geomagnetic Pole. The path actually reached 78°N geomagnetic. It turns out that this particular region usually is, and was in this case, one of the weakest, and most northern, points in the oval band.

Polar Zone *Es*. The W7-Europe path has been very rare, so it should come as no surprise that it results from a low probability confluence of events. The arguments above rely at least in part on *Es* linking with aEs, but that does not explain what happened clear up near the Geomagnetic North Pole. This is the realm of Polar *E*s.

Polar Es is primarily a summertime, daytime phenomenon, during periods of low geomagnetic activity. It forms deep inside the oval, on the sunward side (where aEs almost never forms). It occurs frequently during those conditions, and it can last for many hours (MacDougall, et al., 2000). All three days of these openings were geomagnetically very quiet. The *Kp* averaged 1.5 over the whole period. The individual three-hour values ran from 1 to 3, but were overwhelmingly dominated by 1s and 2s. As a result, it is very likely that the two central skip points were both the result of Polar *Es*.

Summary and Comments

It goes without saying that the 6-meter band openings of 27–29 June 2012 were both exciting and unexpected. Nature was certainly showing off. For whatever reason, the geophysical conditions from *Es* were simple extraordinary.

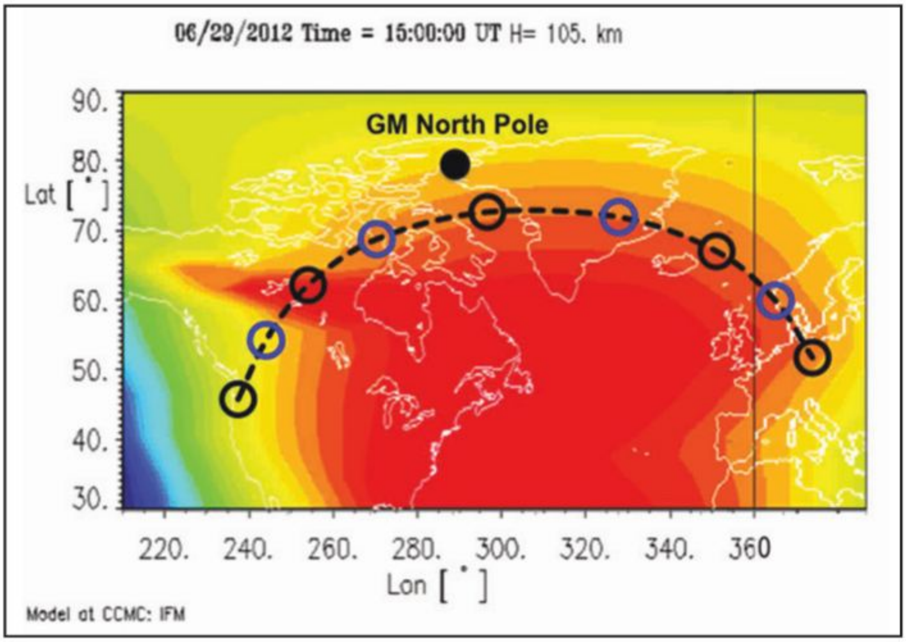

Figure 16. The path between CN84-88 and Europe follows the contour of the Midlatitude daytime E*-layer background ionization throughout most of the path, except when crossing the left-hand side ionization finger. This finger probably led to the early start of the opening around 1244 UTC. Note the Geomagnetic North Pole. Blue is the weakest and red the strongest background* E*-layer ionization density. (Ionospheric map credit: USU-GAIM and CCMC)*

General Thoughts. The vast bulk of the contacts seem to be explained comfortably by ordinary Midlatitude *Es*, which nevertheless appeared with a very *extraordinary* geographic coverage and for a surprising length of time. As a byproduct, there are good examples of the MUF Gap filling—that is, adequate ionization to support propagation at times of day that are not seen very frequently, and it appears that there were some relatively rare polar-region *Es* effects as well.

Es Range Limits. The fact that there are four different basic *Es* regimes based on their latitude zones, and that they each have favored times of day (LST) characteristics, places limits on how far *any one Es* zone can propagate a signal. Depending on the location of the stations, the Midlatitude Zone has a two-hop maximum on north-south paths. On east-west paths the usual limit is about four hops, unless there are extraordinary circumstances. If the MUF is extremely high over the path length, or there are conveniently placed chordal-like hops in the middle, then five or even six hops have been seen.

On the other hand, the narrower latitude ranges of the other three *Es* modes restrict their individual ranges more severely. However, when circumstances conspire to allow signals to propagate successfully from one *Es* zone to the next, then the *total* range can be surprisingly long in many directions, as happened in June 2012.

Auroral *Es*. When trying to characterize the different flavors of *Es* propagation, the temptation is to try to make it all very simple—that is, this mode does this, and only this, and that mode does that, and only that. However, nature is rarely so black and white.

As far as Auroral *Es* is concerned, it favors the local summer, and the hours of about 1800 to 0600 LST. These two conditions were met in the events described above. One piece, which does not fit quite as nicely, is that aEs is more common during periods of elevated geomagnetic activity, and that was *not* the case during these openings. Of course, that *doesn't* mean that aEs can't occur during lower levels of activity, but only that it is less common. As noted earlier, when aEs *does* form in quiet geomagnetic conditions, it also can be very intense.

Another interesting observation was the very focussed west-end ground footprints seen in both the suspected aEs paths. The W7 and field KP openings. It is not clear that this was a feature of the aEs (or also Polar Es in the W7 case), but it is curious that both west-end displayed the very confined footprint.

Auroral Ionization "Fingers". The fact that the geographic relationship between the nighttime fingers of auroral ionization and the large daytime Midlatitude *E* ionization structures is different in the Western Hemisphere than in the Eastern Hemisphere appears to have played a role as the drama unfolded. It seems likely that the early start of the W7 events, and then the following "one-hour gap," was the result of the band initially opening with an aEs first west-end hop, which later faded until the daytime Midlatitude *Es* picked up.

Polar *Es*. The Polar *Es*, essential for the W7 events, seemed to have had ideal circumstances. It favors summertime, midday at the skip points, and low geomagnetic activity. All these conditions were there. Even though the path was open for several hours, that path went so deeply into the auroral oval that it was very near the *physical location* associated with noon LST (the Geomagnetic Pole). Those two central skip points were very likely due to Polar *Es*.

This Wasn't The First Time. While not at the magnitude of these 2012 openings, there have been a few earlier episodes of the Pacific Northwest—Europe path during the local summer *Es* session. The band opened briefly in June 2001, and again on July 8 and July 22 in 2003. These seemed to open at about the same time of day as the main body of the 2012 events—around 1600-1700 UTC. Of these earlier openings, the July 8 event seems to have lasted the longest, with contacts into the CN84-88 regime including other grids in British Columbia, as well as the northeastern seaboard, all at about the same time.

Acknowledgements

The author wishes to express his appreciation to a number of people who have made contributions to this effort. Gabriel Sampol, EA6VQ, and his dxmaps.com QSO database, have been the most valuable source of the data and path maps that made this study possible. Chris Patterson, W3CMP, called these events to my attention in the first place. Albert Noe, KL7NO, kindly shared some of his first-person experience with radio aurora and aEs. Linda Kennedy, WH6ECQ, is greatly appreciated for her diligent proofreading of the drafts.

The National Geophysical Data Center (NGDC) provided Ovation Prime images of the auroral oval for the dates involved. NGDC is a part of the National Oceanic and Atmospheric Administration, which is an agency of the US Department of Commerce. Both the USU-GAIM team and the NASA Goddard Community Coordinated Modeling Center group made the ionospheric model data possible. The USU-GAIM Model was developed and made available by the GAIM team (R. W. Schunk, L. Scherliess, J. J. Sojka, D.C. Thompson, L. Zhu) at Utah State University. The Community Co-ordinated Modeling Center group at the NASA Goddard Space Flight Center ran the computer models for the selected dates and times.

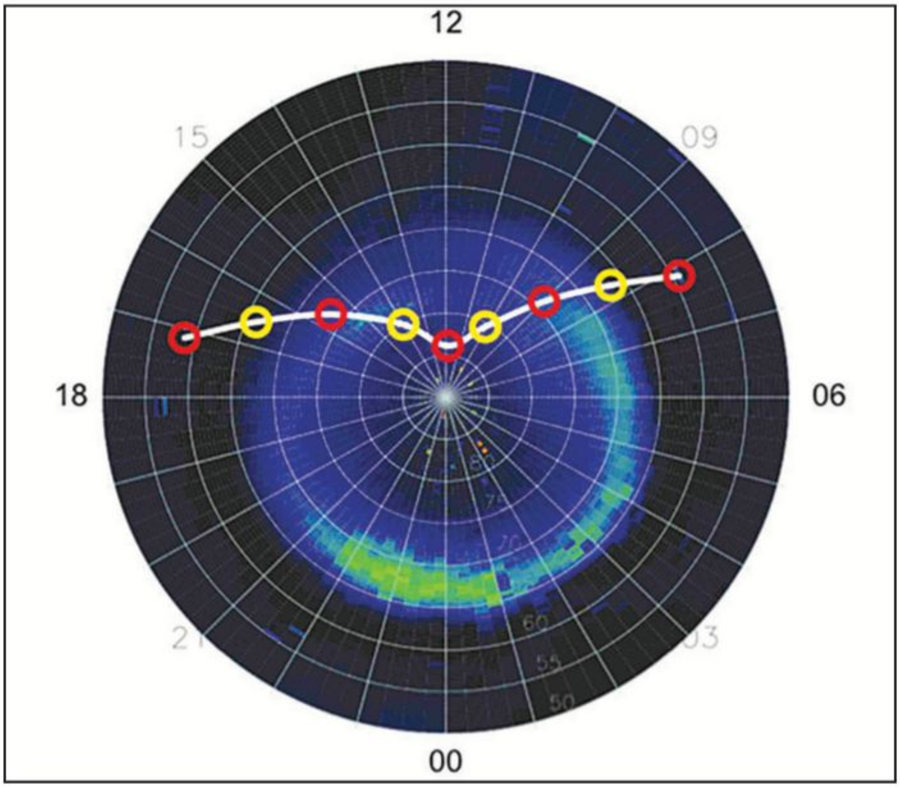

Figure 17. The path from CN84-88 to Europe transits the auroral region. The two middle skip points were well inside the auroral oval and near the North Geomagnetic Pole. This 1500 UTC snapshot is midway through the opening. The Local Solar Times at the radial longitudes are around the outside. The Sun is always at "12." White circles are geomagnetic latitudes—90°N (center) to 50°N (outer ring). Red circles are the path ground footprints and yellow circles are the ionospheric skip points. (Auroral map credit: Ovation Prime images by NGDC)

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Add ISS Packet Operation to Your Satellite Activity

Use equipment already in your shack, or acquire it cheaply.

By JoAnne Maenpaa,* K9JKM

This article is aimed at introducing new amateur radio satellite operators to ARISS packet operations using radio equipment that they may already own. It is intended to be a guide to repurposing their terrestrial equipment for a start on space activities using the strong and predictable downlink of the ISS.

Meeting STEM Goals Gets Amateur Radio Aboard the ISS

The amateur radio station aboard the International Space Station (ISS) is known as the Amateur Radio on the International Space Station (ARISS) program. Many astronauts and cosmonauts have amateur radio licenses. Amateurs from the ISS partner countries, in the USA, Russia, Japan, Europe and Canada, have set up the ARISS program to foster amateur radio communications between the astronauts and cosmonauts who reside on the station and stations on the ground.

ARISS was the first amateur radio project to gain access to the International Space Station, as it helps NASA fulfill Science, Technology, Engineering, and Math (STEM) goals for education. ARISS is an international educational outreach program partnering the participating space agencies—NASA, Russian Space Agency, ESA, CNES, JAXA, and CSA—with AMSAT, the ARRL, and IARU organizations from participating countries.

ARISS offers an opportunity for students to experience the excitement of amateur radio by talking directly with crew members on board the International Space Station. Teachers, parents, and communities see, first hand, how amateur radio and crew members on ISS can energize youngsters' interest in science, technology, and learning.

In the current launch environment, amateur radio in space enthusiasts have discovered that it has become nearly impossible to gain a free (or even low-cost) launch opportunity simply so that a bunch of hams can talk with each other. We generally have to be ready to explain our added value to a launch to even get the ear of the people in charge. The ARISS amateur radio gear on the ISS provides added value in its STEM educational mission. The beneficial side effect for amateur radio operators is that the ARISS station remains available for general amateur radio usage when it is not engaged in educational contacts. Since the signal from the ISS generally is very strong, this is where you can take advantage of trying your hand on the "easiest of the Easy Sats."

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Most Commonly Used ISS Amateur Radio Frequencies

Mode V APRS (Worldwide APRS Digipeater)	
Uplink	145.8250 MHz FM 1200 BPS
Downlink	145.8250 MHz FM 1200 BPS
Mode U APRS (Worldwide APRS Digipeater)	
Uplink	437.5500 MHz FM 1200 BPS
Downlink	437.5500 MHz FM 1200 BPS
Mode V/V Crew Contact (Regions 2 & 3)	
Uplink	144.4900 MHz FM
Downlink	145.8000 MHz FM
Mode V/V Crew Contact (Region 1)	
Uplink	145.2000 MHz FM
Downlink	145.8000 MHz FM
Mode U/V (B) FM Voice Repeater (Worldwide)	
Uplink	437.8000 MHz FM
Downlink	145.8000 MHz FM
Mode V SSTV Imaging	
Downlink	145.8000 MHz FM

Table 1. Most commonly used ISS amateur radio frequencies.

Easiest of the "Easy Sats"

Where to Listen: Knowing where to listen and where to transmit are important first steps to getting started. Table 1 shows the most common ARISS amateur radio frequencies. There are a few additional "special modes," such as a 1269.500-MHz FM uplink, that are rarely, if ever utilized. School contacts use the 145.800-MHz downlink with unpublished uplink frequencies used at the school site. The most commonly used ISS amateur radio frequencies are summarized in Table 1. Many hams spend a lot of time listening for ISS crew activi-

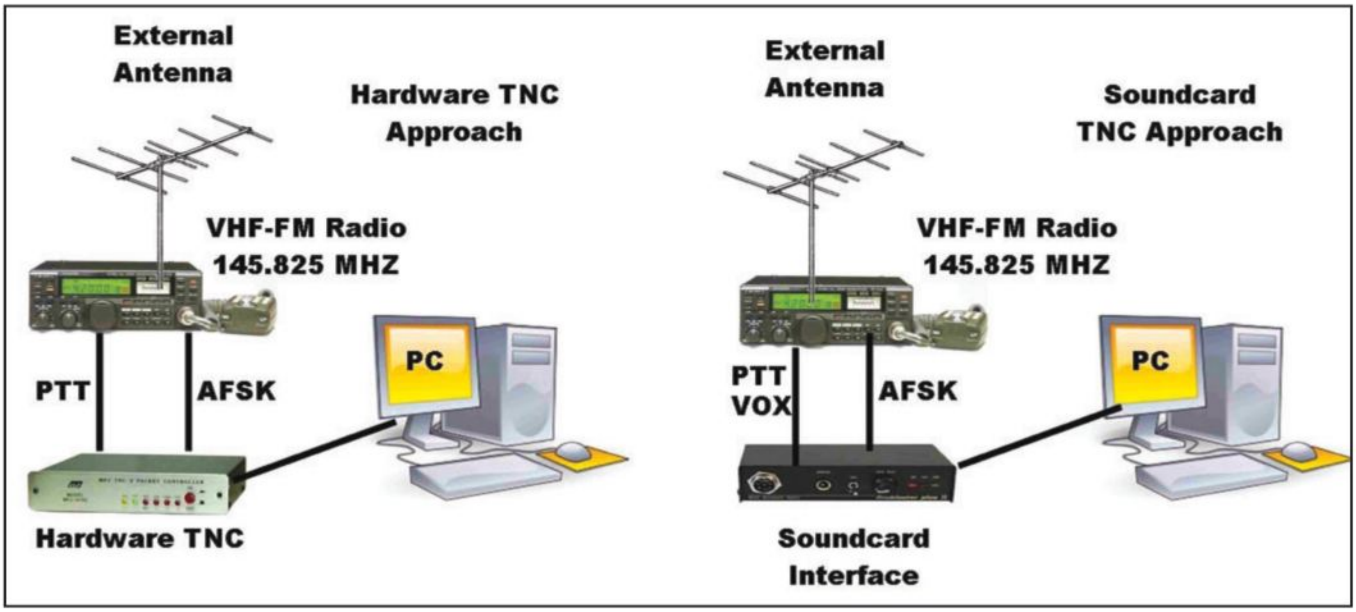

Figure 1. Examples of packet stations; left, using a hardware TNC and right, using a soundcard interface.

ty on the strong 145.800-MHz downlink. They often express disappointment that no FM voice activity had been heard for weeks. Crew activity depends a lot on their time available plus personal interest in making random contacts. Some prior crews frequently made voice contacts, while use of the ARISS amateur radio gear is limited to school contacts for other crews.

Packet is Where It's At (Most Often, It Seems)

Packet activity from the ISS is often noted on the 145.825-MHz downlink. The uplink is on the same 145.825-MHz frequency. Since the crew rarely engages in keyboard contacts, most of the packet activity you are hearing originates from Earth stations using the ARISS digipeater. Lacking packet gear you will only hear the brzzzzz-brap sound of the 1200-baud audio frequency shift keyed (AFSK) signal. You will need to know when the ISS is within range of your station.

Know When to Listen—Tracking Resources

Getting on the air with the ARISS packet digipeater likely can be accomplished with amateur radio gear you already own. No special amateur radio equipment beyond what is used for terrestrial contacts is needed to begin taking your first steps toward amateur radio in space. This means if you do not own certain items they likely can be acquired inexpensively. Think of ARISS packet radio as regular ham radio (including packet) aimed skyward.

The good news is once you have equipped your station for ARISS packet and learned the ropes for ARISS operation, your station will be ready for those rare voice contacts with the ISS crew. You will just need to switch the packet gear for a microphone and start calling.

Get Your Station Going on 145.825-MHz Packet

When packet radio was popular on VHF/UHF many years ago, you may have acquired a TNC (Terminal Node Controller) which you interfaced to your FM radio. There were many packet bulletin-board systems and personal packet mailboxes that were accessible via the TNC. That activity has diminished over time, largely having been replaced by the internet. You may have a TNC sitting on the shelf collecting dust. This same "old" hardware, capable of operating 1200-baud AX.25 AFSK modulation, is still useful for packet radio operation via the ISS. There were many models of the AX.25 TNC, including the MFJ-1270C TNC-2 Packet Controller and the Kantronics KPC-3 TNC.

If you do not have a TNC that you used in the "old days," these often can be purchased rather inexpensively at a hamfest. When you see a good deal, grab it if you prefer the hardware approach to packet operation.

In the years since the peak of the hardware TNC-based activity, software for sending and receiving the AFSK packet signal has been created for the soundcard in your personal computer. Your computer will perform the functions previously provided by a TNC hardware box.

In addition to the soundcard software you will need to install a soundcard interface between your radio and your computer to adapt the signal levels to be compatible with the digital signal processing done by the soundcard. You have a few options to this approach, as well:

- Build a soundcard interface from plans found on the internet.
- Rigblaster by West Mountain Radio $100–$300 (http://www.westmountainradio.com)
- Donner Digital Interfaces ($40–$100, http://www.donnerstore.org)

Whether you choose the hardware TNC or the software/soundcard TNC approach depends on what gear you have on-hand. The accompanying figure illustrates the two options between hardware and soundcard interface.

Overview of the Hardware TNC Approach: A hardware TNC requires a cable between it and your personal computer's RS-232 port. Many of the TNCs are sold with a cable that per-forms this function. Others come with a wiring diagram showing you which pins you need to connect. Additionally, a cable is required between the TNC and your radio. If you previously had your TNC interfaced to your radio for terrestrial packet operation, the connections remain the same for ISS packet operation. The personal computer needs to run a terminal emulator program so you can control the TNC, initiate messages, display received messages.

Overview of the Soundcard TNC Approach: The connection between your PC, the soundcard, and the soundcard interface consists of three separate connections:

• You need to route the soundcard's LINE OUT connection to the interface. This will go to your TRANSMIT audio connection on the radio.

• You need to route the audio output from your receiver to the interface's received audio to the LINE IN connection on your soundcard.

• The serial port is used for push-to-talk rig control. Some stations have had success with using the VOX on the radio to key the rig during transmit. This is dependent on the type of radio you own (if this is available). Setting the sound drive levels may require careful adjustment so the radio reliably switches to transmit.

An External Antenna is Recommended: The downlink signal from the ISS is very strong, but you will not have much luck trying to get your packets through the digipeater with an indoor antenna or with the flexible antenna on your HT. The good news is that your external antenna does not require full OSCAR-class tracking and control. Many enjoy success with a VHF vertical antenna on the roof of the house. A small beam need not be complex. A 3-element VHF beam at a fixed elevation of 15–20 degrees on a small TV rotor is all that is necessary.

Overview of Operating Through ISS Using the TNC

Much of terrestrial packet operation consists of you requesting a CONNECTION to another station. Packet communication via ISS almost exclusively relies on using CONNECTIONLESS operation. The AX.25 protocol defines these types of packets as UI packets. An UI packet is pretty much transmitted out there for anyone and everyone to receive and copy. When stations transmit UI packets the AX.25 protocol will not be waiting for all of the handshake messages to complete; this very much simplifies the message exchanges. There are a few parameters in the TNC that make UI operation an easy mode to operate:

Every AX.25 packet that you transmit consists of two main parts: The Packet Header & Message Text. The Header contains your callsign, which you set with the MYCALL command. Other packet stations will "know" it is a UI packet—a packet for everyone—based upon what you set in the UNPROTO command.

The most basic, barebones UNPROTO needed for ISS packet is simply set UNPROTO CQ VIA ARISS. You can add additional routing later as you become more familiar with packet operations. This is all you need for your packet to get into space and be digipeated back to Earth.

Assuming I have my UNPROTO defined as above, now all I need to do to transmit an UI packet from my station is to enter a short text message via the keyboard and terminal program on the PC. This requires the use of the TNC's CONVERS command as outlined here:

• Set UNPROTO CQ VIA ARISS.

• Enter CONVERS mode from the cmd: prompt on your TNC screen.

• Enter a short message such as Greetings from JoAnne via the space station and hit <enter>.

• You should see your TNC key your rig and send the message.

While you are in CONVERS mode all input from your keyboard is transmitted every time you hit the <enter> key. To exit the CONVERS mode at the end of a pass use Control-C (usually) to get back to the TNC cmd: prompt.

When the TNC-2 hardware is in a connection with a specific station node or in the CONVERSE mode it generally does not display all packets. Refer to the TNC command summary table for details, but setting MONITOR ON, MALL ON, MCON ON will allow you to see all of what is going on the channel. Refer to the TNC-2 command table for details.

On-The-Air Example Using the TNC

The latest real-time ARISS packet activity is usually displayed on this web page: <http://www.ariss.net/>.

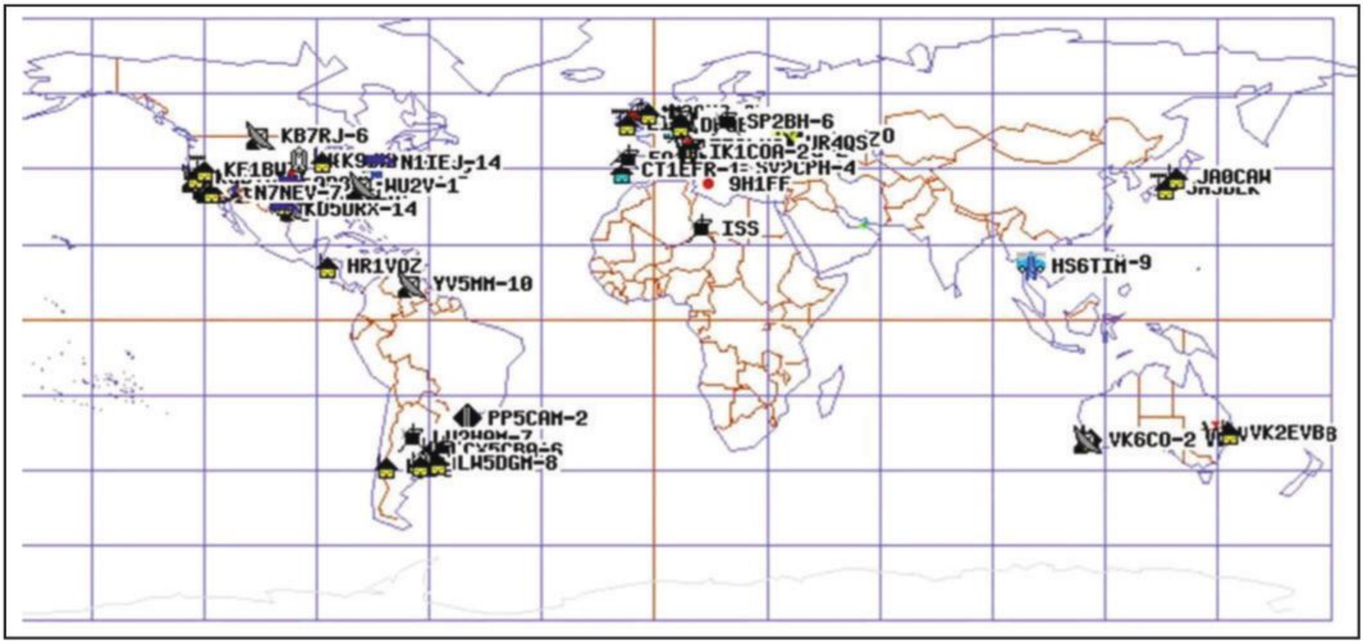

Figure 2. World map showing stations heard via ariss.net.

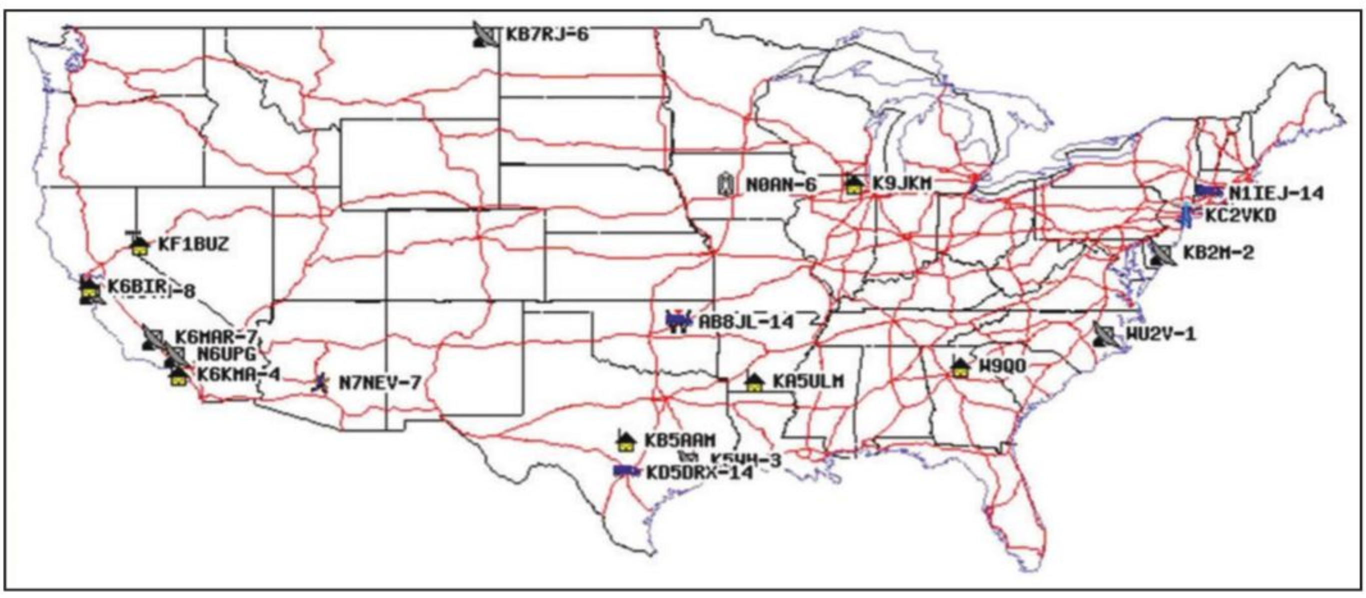

Figure 3. USA map showing stations heard via ariss.net.

You will find a couple of nice features on this web page. You will see a real-time "heard" list of everyone who has had their UI packets digipeated by the spacecraft. There is also a map display that will show the QTH of stations who provide APRS formatted location information. Figures 2 and 3 illustrate the screen showing the stations heard on the map At the bottom of the pages you can view the entire packet of the most recent traffic from the spacecraft.

APRS format location information? No! *You do not need to run any extra APRS software to be displayed on the map.* You can generate the APRS format directly at your keyboard if you wish to show up on the map. If you wish to simply send text messages to be digipeated via the spacecraft jus type your message without the location data. While your QTH is not showing on the map, your packets will, in fact, still be digipeated—and that you will see on your screen.

Where do you find your APRS location information? This is just your GPS location. If you do not have access to a GPS box simply find your QTH on Google Earth (in the View -> Grid menu).

Therefore, if I would like to display K9JKM on the map and send a message to my fellow space-packeteers I should send a text string using the UNPROTO and CONVERS steps previously outlined, and make my message look like the example below:

=4211.29N/08827.08W-Hi from JoAnne near Chicago in EN52 <enter>

The parts of the message string can be explained as:

• =4211.29N/08827.08W is simply the = character plus my QTH info from Google Earth

• The – is the 'dash' or hyphen. It tells the map to display me as the little house with antenna icon. The ARISS packet page above has a link where you can find other icons for you on the map

• Hi from JoAnne near Chicago in EN52 <enter> can be any message text you wish. You will likely have better luck getting through and being digipeated if you transmit short messages.

• If I see someone on the downlink who I would like to have a keyboard QSO with all I would need to do simply enter the message from the keyboard without any APRS-formatted location: Hi Bob, good to see you this pass will just send Bob (and everyone reading the packet mail) your message.

The <http://www.ariss.net/> web page also shows a packet log of stations that have successfully digipeated. I highlighted one of my digipeats in the example below. I was digipeated by the RS0ISS-4* callsign (this is the callsign of the ARISS packet alias). The asterisk shows the last station to digipeat my packet. N6VUD-2 is running a SAT-GATE to transfer the packets to the internet and on to the web page.

00:00:01:25 : K6KMA-4]APRS,RS0ISS-4*,qAr,GWS 2:=3349.51N/11806.91W-

00:00:01:35 : VA7VW-6]WA6YET,RS0ISS-4*,qAR,N6VUD-2:Hello from Ron in Vernon BC DO00ig

00:00:01:40 : K9JKM]CQ,RS0ISS-4*,qAR,N6VUD-2:=4211.29N/08827.08W-Greetings

00:00:01:45 : KD5DRX-14]TU4RUY,RS0ISS-4*,qAR,N6VUD-2:`1D2 {u/]"4;} Quinnesec Mi

00:00:01:45 : KB7RJ-9]TX5YXP,RS0ISS-4*,SGATE,WIDE2-2,qAR,N6VUD-2:`p]Ml!}k/]";m}146.520MHz QTH

Plentywood in NE MT=

00:00:01:51 : K6BIR]APU25N,RS0ISS-4*,qAR,N6VUD-2:=3739.56N/12206.43W - {UIV32N}

00:00:02:15 : VA7VW-6]K6KMA-4,RS0ISS-4*,qAR,K6SJC:Hello from Ron in Vernon BC DO00ig

Summary of the Hardware TNC-2 Commands

The actual syntax to enter the commands into your TNC (from the cmd: prompt) likelywill vary according to the manufacturer. Table 2 gives a list of parameters that seem to be common to most TNC-2 controllers used for 1200 baud packet.

Overview of Operating the ISS Digipeater Using Your Computer's Soundcard and Software

Operating packet without the traditional standalone TNC requires a combination of software and hardware connection. See figure 4 for an overview of the soundcard and radio connections.

• Software will generate and decode the AX.25 packet signal using the digital signal processing capabilities of the soundcard in your computer.

• A soundcard interface box is needed to set the proper sound levels between the computer and the radio.

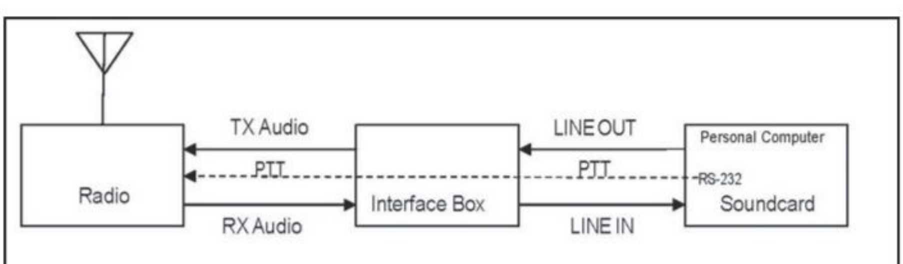

Figure 4. Overview of soundcard and radio connections.

• Push-to-talk (PTT) rig control is often generated by the software by setting selected pin(s) of the RS-232 serial interface. Some radios such as a Yaesu FT-857D will reliably switch between TX and RX function if the VOX levels are set in the radio's operating menus.

• If you have already interfaced your radio to the soundcard for other amateur radio applications such as RTTY, PSK31, JT65, SSTV you are already set for AX.25 ARISS packet operation with the ISS. All you need is to download, install, and configure some free software.

Because the connections between your radio and the soundcard interface of your choosing are specific to your situation we will defer discussion of this because you need to consult your radio operator's manual and the instruction book of the soundcard interface. Careful research before buying an interface box will reveal that many of the leading brands will also sell you an interface cable kit specific to your radio.

Setting Your Soundcard Levels: As mentioned, if you are already using your soundcard for other amateur radio applications, such as PSK31, etc., then usually the same settings can be used for packet. Figure 5 is a screenshot of the volume slide controls used for setting the soundcard levels. If needed, use the "Wave" slider control to set the transmit level; use the "Line In" slide control to set the receive level.

Summary of the TNC Commands

TNC Parameter	Value	Description or Action
MYCALL	Your Callsign	Default is NOCALL, but you want others to know you are there.
DAYTIME	YYMMDDHHMM	Used if you want to timestamp the packets you are receiving.
MONITOR	ON	Displays all packets on the frequency
MALL	ON	Displays all packets on the frequency (connected or unconnected)
MCOM	ON	Displays the AX.25 protocol with the message
MCON	ON	Allow you to see all packets even when in CONVERS mode
MSTAMP	ON	Monitored packets are timestamped
MRPT	ON	Displays the entire digipeat path for the packets.
CONSTAMP	ON	Connect and disconnect status messages are timestamped
HEADERLN	ON	Header information is displayed on separate line from message text
PASSALL	ON	TNC will accept and display packets that have errors (noise)
PASSALL	OFF	TNC will only accept and display packets that have complete CRC.
CONVERS	<enter>	Mode to type packet message from keyboard directly to the TNC
MHEARD	<enter>	Displays your TNC's "heard" list (updated only when PASSALL OFF)
UNPROTO	CQ VIA ARISS	Most basic string for ARISS to copy, route, and digipeat your packet
UNPROTO	CQ VIA W3ADO-1	Basic string for PCSAT-1 for DAYTIME ONLY operation.

Table 2. Summary of the TNC commands.

Install the Software You Need: The software you need for ARISS packet operation is available for free download. The items you will need include:

• AGWPE (figure 6): Written by George Rossopoulos, SV2AGW, it is an acronym for "SV2AGW's Packet Engine." It originally wascreated as a TNC management utility and has many super features of value to TNC users, plus it has the ability to encode and decode packet tones using your computer's sound card. Download from <http://www.sv2agw.com/ham/agwpe.htm>.

• UISS (figure 7): Written by Guy Roels, ON6MU, it is designed for UI packet communication (unproto) packet with ISS. This will be your user interface for packet communications with the ISS. This software is free for amateur and non-commercial use. A PRO version is available and donations are welcome. Download from <http://users.belgacom.net/hamradio/uiss.htm>.

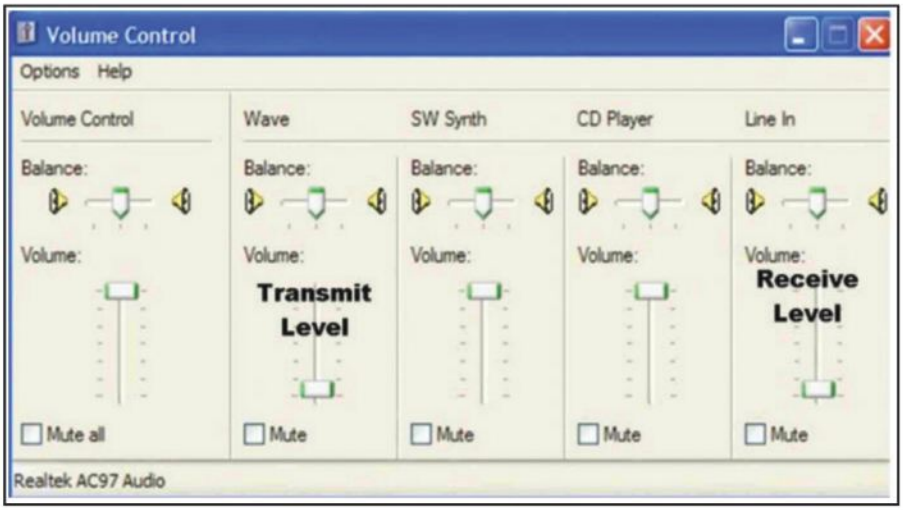

Figure 5. Screenshot of volume slide controls used for setting soundcard levels.

• Installation and user guides for the software packages are included on their websites. Here are a few links to websites that will give you the information needed to get on the air quickly:

• The "golden" reference for soundcard packet configuration and operation is the "Sound Card Packet" site by Ralph Milnes, NM5RM: http://www.soundcardpacket.org/

• Additional help for installing AGWPE is written up in a word document, "An Easy Set Up For Soundcard Packet" by Karl Berger, W4KRL. These are basic instructions for getting started but you will not need the WinPack steps outlined. (We're using UISS instead.) <http://www.w4ovh.net/SoundcardPacketSetup.doc>.

Figure 6. Screenshot of AGW packet engine.

• Mineo Wakita, JE9PEL, has published several on-line references for the installation and use of UISS: <http://www.ne.jp/asahi/hamradio/je9pel/ui32uiss.htm>.

• UISS setting up APRS satellite: <http://www.ne.jp/asahi/hamradio/je9pel/uiss agwp.htm>

• The UISS site has a reference page: <http://users.belgacom.net/hamradio/uisslinks.htm>

Example Operating Session with the Soundcard

All of the necessary parts are installed—and the ISS is approaching. Here is an example of an operating session to further acquaint you with this mode of operating.

1. Always start AGWPE first. Click on the AGWPE icon on your desktop and you will see the following splash screen telling you things are running. The splash screen will go away in about 10 seconds. You will also see the AGWPE Packet Engine startup "bubble" appear in the toolbar. You can "X" (to exit) the bubble but AGWPE will continue to run as shown by its icon in the toolbar. You can left or right click on the icon to get to AGWPE configuration settings if you ever need them.

2. Start UISS. Click on the UISS icon on your desktop and the program will open to the operator screen.

a. Your UNPROTO string CQ VIA ARISS is set by using the pull down menus in the To and Via windows in the top/left of the screen.

b. The APRS-formatted location information which was also used in the hardware TNC configuration is entered in the TX Text/Data window.

c. The MHEARD command used with the hardware TNC to show who is on the frequency has its equivalent display shown in the MHEARD list on the right side of the screen.

d. To transmit my packet configured for digipeating via ARISS =4211.29N/08827.08W just click on the Text/Data button in the top row.

e. UISS will show all of the packets being received when the ISS is within range. Your packet will be highlighted when you (and everyone else in range) receives the digipeated packet.

3. Optionally you can display the stations you receive on an APRS-format map. In the example in figure 8, UI-View shows the stations received that were transmitting their location data during a pass of the ISS over the eastern half of North America.

a. Start AGWPE first and then start UI-View.

In summary, the previously mentioned screen at <http://www.ariss.net> will also update in the same manner whether the packet came from a hardware or software TNC.

A Note about a Packet "Hard-Connect" to RSØISS-11 BBS

In a word: Please don't! The ISS PBBS with the ID RSØISS-11 operates in the same manner as a terrestrial Packet BBS

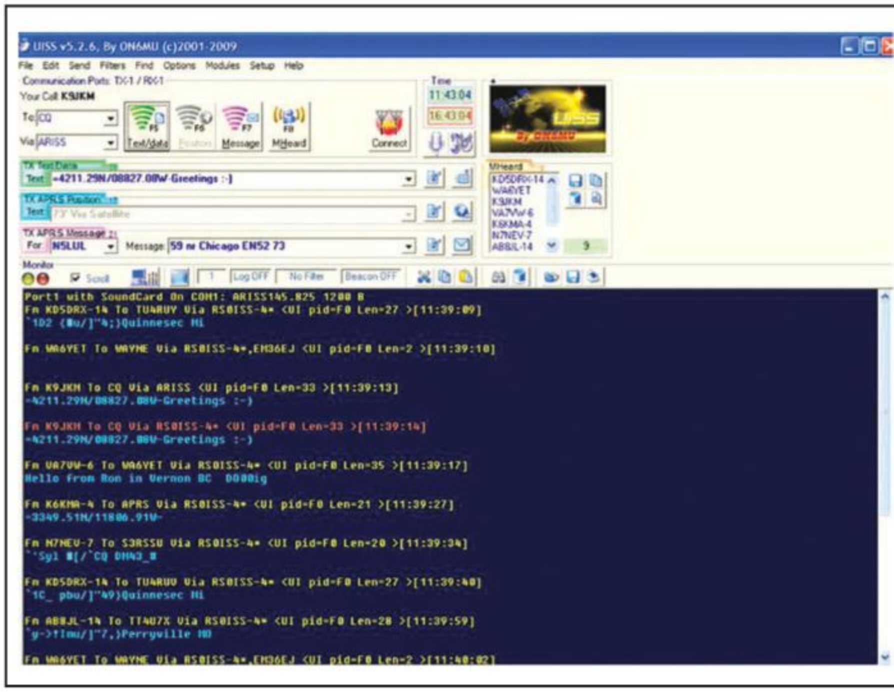

Figure 7. Screenshot of UISS packet software.

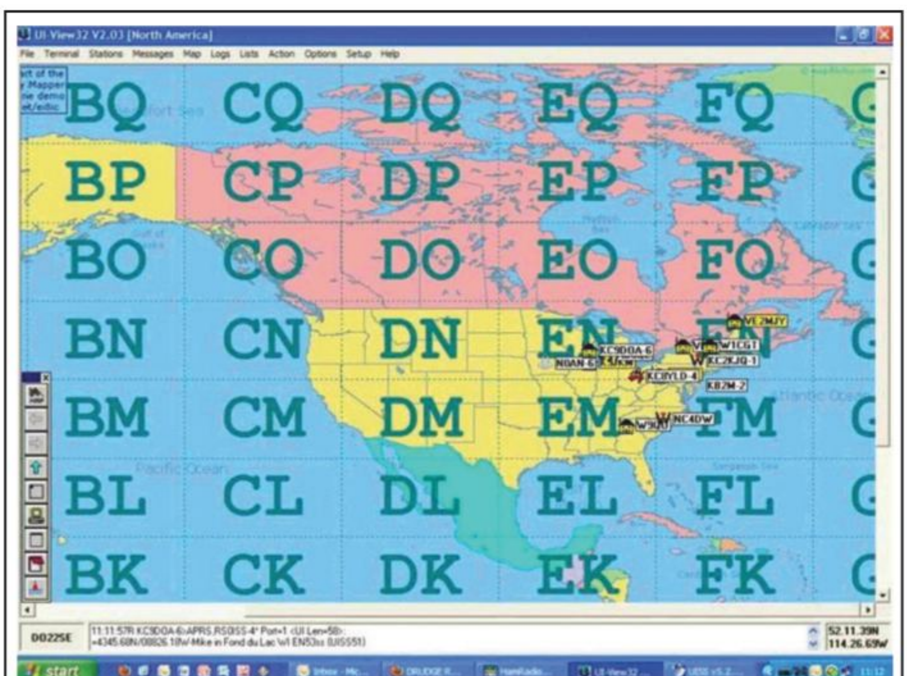

Figure 8. Screenshot of UI-View showing stations received that were transmitting their locations during a pass of the ISS over the eastern half of North America.

Figure 9. Screenshot of the AMSAT Tools webpage (http://www.amsat.org/amsat-new/tools/) showing the position of the International Space Station.

operates. A "hard-connection" (C RSØISS-11) establishes a full AX.25 connection which brings the entire messaging handshaking protocol into operation. The handshake messages will faithfully repeat, and repeat, and repeat per protocol until they are properly acknowledged. The usual case is that there are many stations sending packets to the ISS resulting in data collisions when RS0ISS-11 is expecting its handshake. Everyone tuned into the pass will see the endlessly repeating AX.25 handshake bytes until the sequence times out. You may have been out of range for several minutes already but the ISS is still listening for you.

Know When to Listen—Tracking Resources

If you have experimented with amateur radio satellites you may already own a tracking program which will let you see

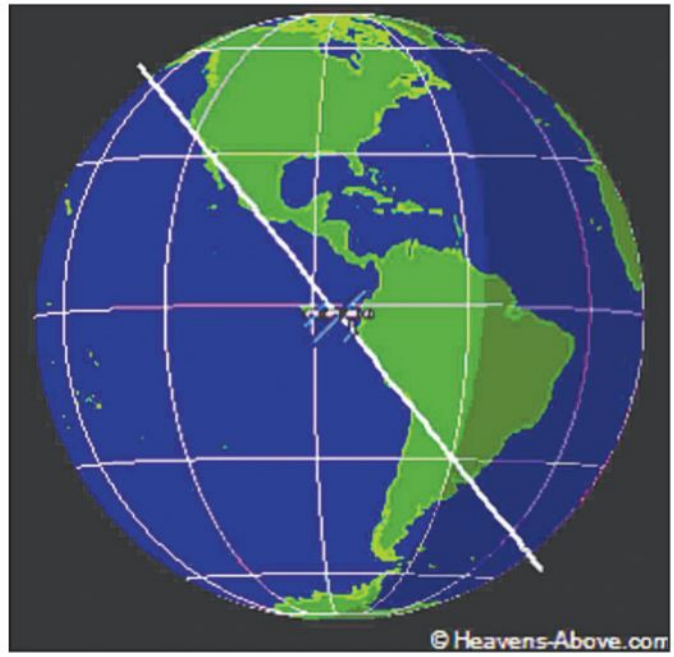

Figure 10. Screenshot of the Heavens Above webpage (http://www.heavens-above.com) showing the position of the International Space Station and many other satellites.

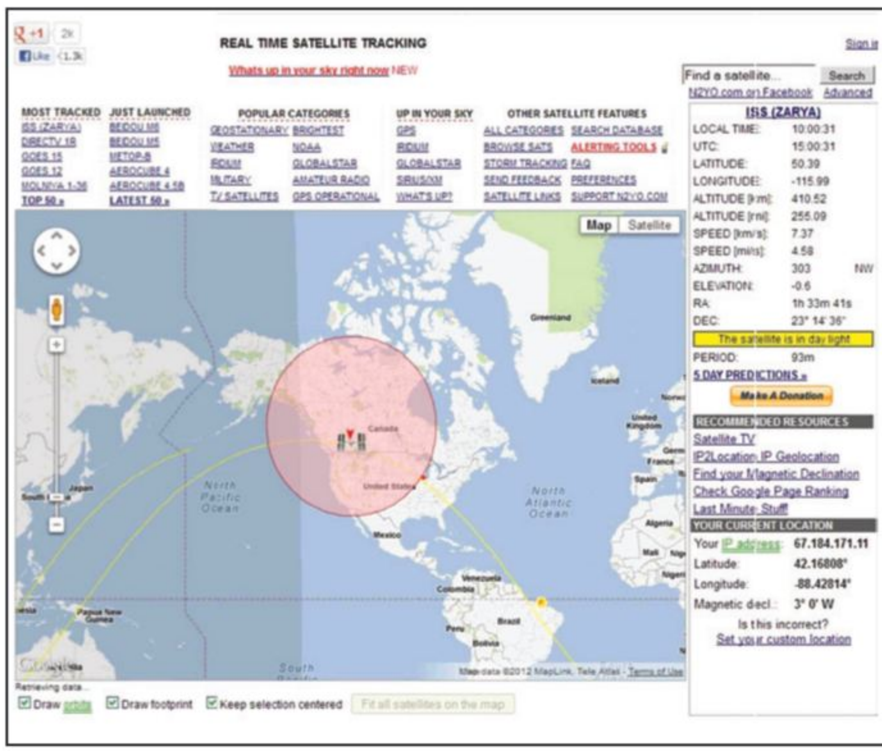

Figure 11. Screenshot of N2YO Real Time Satellite Tracking web page (http://www.n2yo.com/).

when the ISS is within range of your shack. If you are new to this phase of the hobby this section will point you toward several on-line resources that you can use right away without additional special preparation.

Tracking Resources on the Web: This section is geared toward helping the beginning operator track the ISS. You will find several resources on the web to help you track the ISS without needing to install dedicated tracking software. These tracking pages are considered to be "close enough" in the case of calculating when the ISS is within range of your station. This is because the downlink signal from the ISS is so strong and the 145.825-MHz downlink frequency does not require tracking the Doppler shift for you to be able to make successful contacts.

• The AMSAT Tools webpage (figure 9): <http://www.amsat.org/amsat-new/tools/>.

• You can select the ISS by using the pull-down menu:

• The Heavens Above webpage (figure 10): <http://www.heavens-above.com> will allow you see the current position of the ISS and many other satellites:

• The N2YO webpage (figure 11): <http://www.n2yo.com/> is an excellent tracking resource featuring a real-time map that updates in your browser window:

• The ISS Fan Club webpage (figure 12): <http://www.issfanclub.com/> includes a tracking widget showing the current location of the ISS. It also includes the latest known status of the downlink frequencies as reported by amateur radio stations worldwide.

Tracking programs: As discussed, the *web tracking screens will get you started and will be quite adequate in many instances for casual operating.* Installing a tracking program on your computer is the next step. I am mentioning this as your second option due to the learning curve with all of their features adding another level of complexity. But, once learned, your own tracking program on your computer in the shack will give you the best level of prediction with display features tweaked for your personal preferences. You will also have the capability to track and display the position of multiple spacecraft. Tracking software will enable many interesting features:

• Real-time position display on a map
• Real-time position data including azimuth and elevation to point your antenna
• Predict future passes
• Advanced features include:
• Rotor control to automatically aim your antennas
• Rig control to track the Doppler shift.

Examples of three popular tracking programs for your PC are included in the following:

1. Nova (figure 13) by Northern Lights Software Association: <http://www.nlsa.com/>
2. SatPC32 (figure 14)
a. This program is written by Erich Eichmann, DK1TB. He has donated all the proceeds from the software to

Figure 12. Screenshot of ISS Fan Club webpage (http://www.issfanclub.com/).

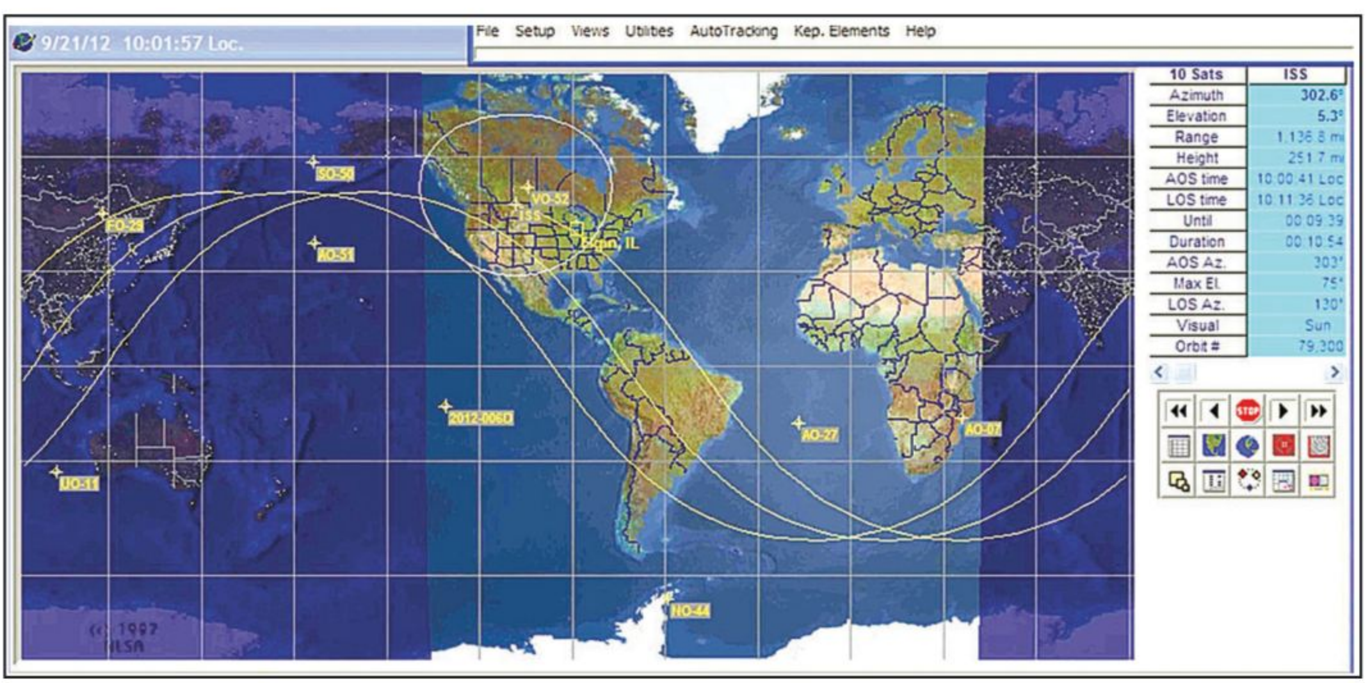

Figure 13. Screenshot of Northern Lights Software Association (http://www.nlsa.com/) satellite tracking software.

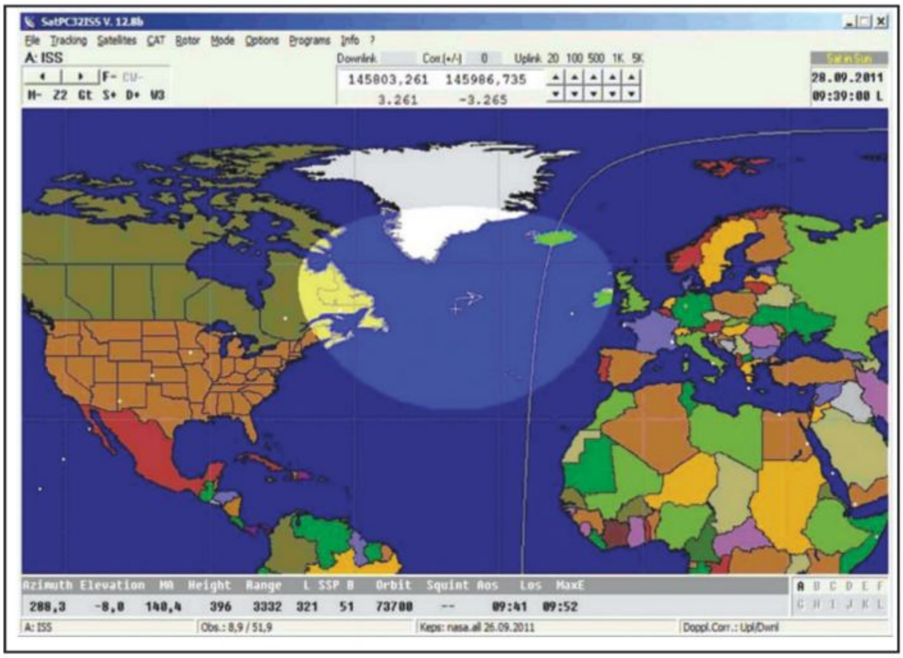

Figure 14. Screenshot of SatPC32 (http://www.dk1tb.de/indexeng.htm) satellite tracking software.

AMSAT. You download the software and receive assistance from his website: <http://www.dk1tb.de/indexeng.htm>>

b. You can get the program in a demonstration mode to try it out for free. You can purchase this software from the AMSAT store online: <http://store.amsat.org/catalog/product_info.php?cPath=2&products_id=50>

c. After purchasing the software, Martha will send you a license key to use to unlock all the features of the software.

3. GPredict (figure 15): <http://gpredict.oz9aec.net/>.

a. Gpredict is a real-time satellite tracking and orbit prediction application. It can track an unlimited number of satellites and display their position and other data in lists, tables, maps, and polar plots (radar view). Gpredict can also predict the time of future passes for a satellite, and provide you with detailed information about each pass. Gpredict is free software licensed under the GNU General Public License.

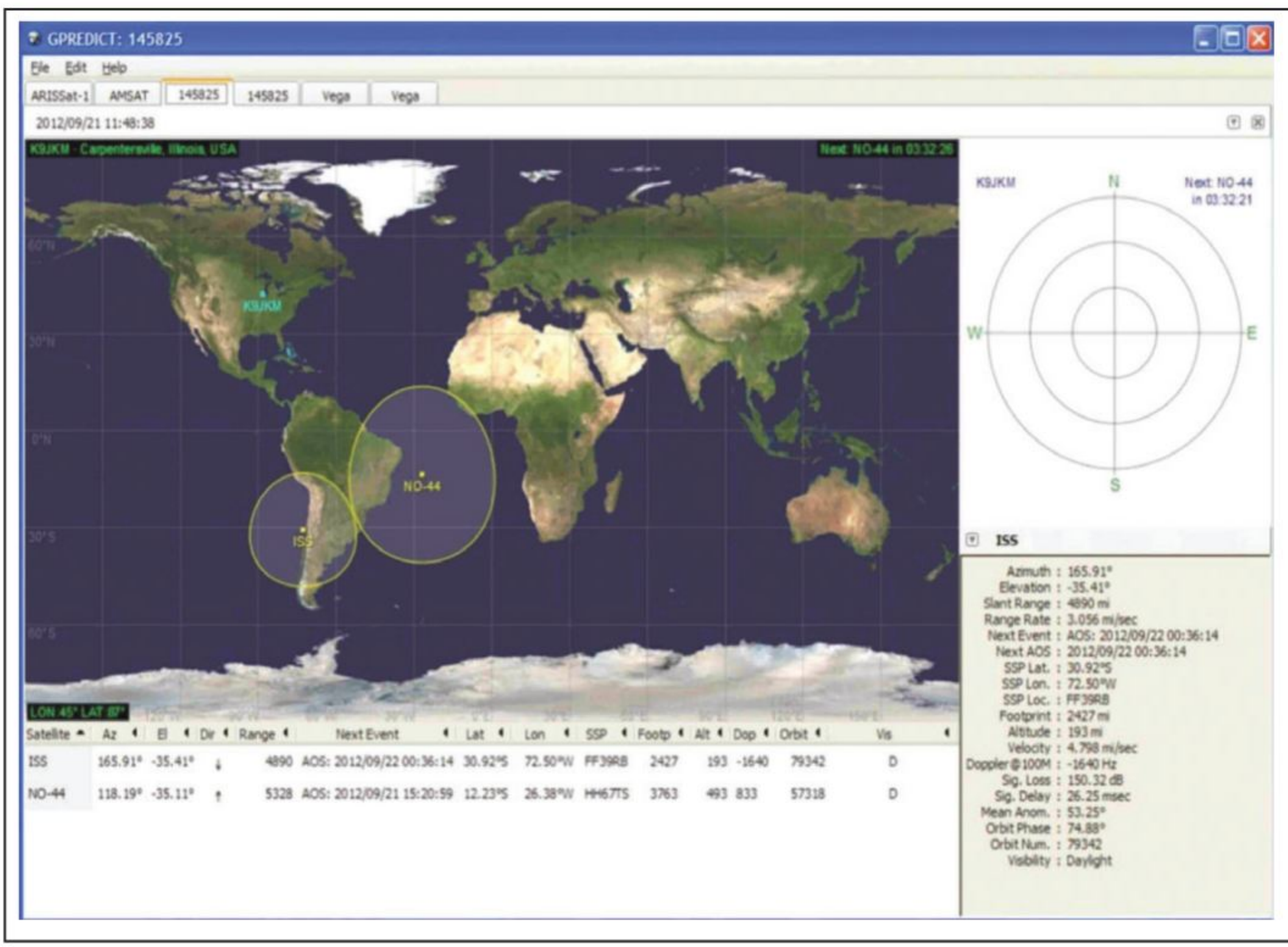

Figure 15. Screenshot of GPredict (http://gpredict.oz9aec.net/) real-time satellite tracking and orbit prediction application.

Swapping the UZ7HO Soundmodem Packet Program in Place of AGWPE

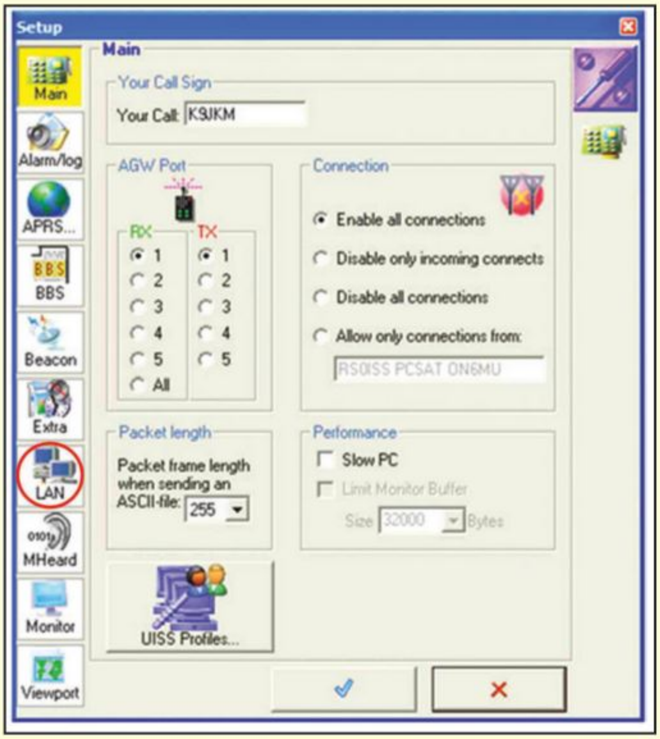

Figure 16. Setup of UISS with the red circle showing the LAN selection.

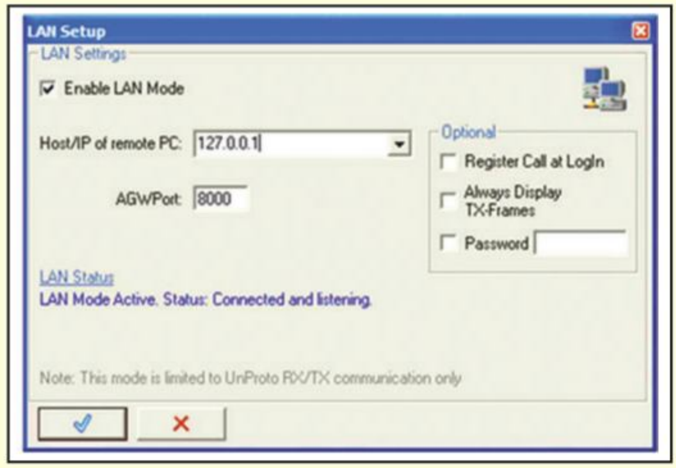

Figure 17. LAN setup.

Many operators note that often a strong sounding downlink is heard from the ISS but the AGWPE and UISS combination of software will not decode and display the packet message. This is because the checksum was not correct. Losing only a bit or two of the digital packet due to noise or fading will result in that packet's checksum not being correct. AGWPE only passes the received packets that have a correct checksum. When using a hardware TNC with the PASSALL command enabled you can see all packets, including the incomplete packets, or with reception errors. Often the packets with errors contain enough useful data for a human to still understand them. However, in the software TNC emulation this command is not available.

I have read of other operators' experiences having better error condition response using the UZ7HO Soundmodem software in place of the AGWPE packet engine. Conveniently the UZ7HO Soundmodem software, an AX.25 packet TNC for your computer's soundcard, can be used in place of the AGWPE software mentioned in this article. Either program will work but the setup in UISS differs for the UZ7HO software.

To get started using this optional approach get the UZ7HO Soundmodem from <http://uz7ho.org.ua/packetradio.htm>. Download and unzip these files: sm2ch45.zip; user_guide_v045b_EN.pdf.

The setup guide and user guide are easy to follow. I tuned my receiver to the 144.390 MHz APRS frequency. I immediately saw the APRS messages. Good! The setup is receiving. I tuned back to 145.825 MHZ ARISS packet frequency to wait for the next ISS pass over my station.

The UISS program will require settings to be changed to operate with UZ7HO Soundmodem:

1. In UISS top menu select Setup -> UISS -> LAN and you will see the screen in figure 16:

2. In LAN setup (as shown in figure 17) click on 'Enable LAN Mode' Host 127.0.0.1 Port 8000

3. UISS may ask you to restart, go ahead and restart UISS. To return back to operation with the AGWPE software unclick the 'Enable LAN Mode' option and restart UISS.

For normal operation start the UZ7HO Soundmodem first. Then start UISS. When both programs are running UISS will show it has connected with the Soundmodem, as shown in figure 18:

Your setup is now ready for the next ISS pass! To send your APRS position report click on the UISS Text/Data button. You can enter custom messages for quick packet contacts with other stations into the TX APRS Message box and then click on the Message button.

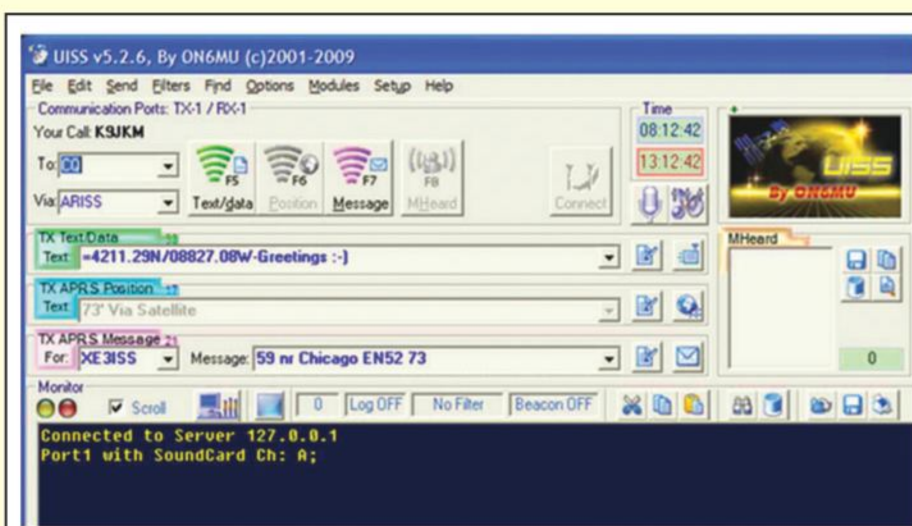

Figure 18. UISS showing connected with the Soundmodem.

Preserving Weak-Signal Frequencies

The amateur radio frequency spectrum is constantly threatened. In particular, the weak-signal spectrum's existence is most fragile. In this article WB6NOA writes about how we can preserve our precious slice of amateur radio's frequency spectrum.

By Gordon West,* WB6NOA

The current Element 2 Technician Class examination has only *one* (out of 396) test question regarding the voluntary weak-signal band plan. It is this question:

T2A10: What is a band plan, beyond the privileges established by the FCC?

A. A voluntary guide line for using different modes or activities within an amateur band.

B. A mandated list of operating schedules

C. A list of scheduled net frequencies

D. A plan devised by a club to use a frequency band during a contest

Answer A is correct.

Two other test questions deal with mode-restricted subbands, such as operation from 50.0 MHz to 50.1 MHz, and 144.00 MHz to 144.10 MHz, CW ONLY, found in the Rules 97.305 (a) (c).

Many new ham radio operators are not aware of what happens down in the weak -ignal portion of the VHF and UHF bands, which are:

• 28.2 MHz to 28.3 MHz Beacon sub-band, receive only, recommended

• 50.06 MHz to 50.08 MHz Beacon sub-band, receive only, recommended

• 50.1 MHz to 50.3 MHz SSB, CW, and Digital; NO FM.

• 144.10 MHz to 144.275 MHz CW, SSB, Digital; NO FM.

• 144.275 MHz to 144.300 MHz Propagation Beacons, receive only, recommended

• 222.050 MHz to 222.060 MHz Propagation Beacons, receive only, recommended

• 222.10 MHz to 222.150 MHz SSB, CW and Digital—NO FM!

• 432 MHz to 432.3 MHz Weak Signal—NO FM

• 432.30 MHz to 432.40 MHz Propagation Beacons, receive only, recommended

• 1295.0 MHz to 1296.2 MHz CW, SSB, and Digital—NO FM

• 1296.200 MHz to 1296.400 Beacons, receive only, recommended

By the FCC Rules, the following frequencies, 50.0–50.1, and 144.0–144.1 MHz are CW only and 219.0–220.0 MHz is data only. Going by just the FCC Rule Book, new operators may not realize, nor recognize, weak-signal voluntary band plans.

Recall twenty years ago when Radio Shack™ came out with the Version 1 of the HTX-202? This was the first time in ham radio history that Radio Shack would get involved in marketing 2-meter ham transceivers for new Technician Class operators. Guess what frequency this FM handheld powered up on?

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Weak-signal operator Mike Staal, K6MYC, ready to hit the 2-meter band with his new solid-state amplifier.

A. 146.52

B. 147.00

C. 145.00

D. 144.10

Answer D!

The error in programming created unbelievable QRM for weak-signal operators. Thanks to the immediate efforts of Bob Miller, K2RM, the default turn-on frequency was moved up to 146.000 MHz in a hurry!

The Technician Class ham radio question pool will be revised next year. Be assured that I have authored several additional questions about the voluntary band plans, and no FM in the weak-signal portion of the bands. With the popularity of 2 meters and 70 cm FM operation nowhere near its heyday of 10 years ago, there is plenty of space for FM simplex communi-

New hams given an old radio may not realize that FM is discouraged below 144.300 MHz.

cations well above the weak-signal portions of the bands.

If we regularly occupy our "protected" portions of the weak-signal band from errant FM operation, we quickly can approach an FM station and politely ask it to move up the band, out of the weak-signal portion. Most errant FM operation in the weak-signal portion of the band is from new operators, and they usually are more than willing to take suggestions, and move their FM simplex communications up to 146.52, .55, and .58 MHz.

Even so, go gently with the new operators. If you pounce on them straight out of the chute, they may pull out the *FCC Rule Book*, and flatly state there is nothing specific in the FCC rules that prevents FM operation on 144.200. Even though the rules do promote good amateur radio practice, each operator may have his own translation. Start gently, and usually FM operation in the weak-signal portion of the band will move elsewhere.

During VHF and UHF contests, weak-signal operators make good use of the voluntary band plan by spreading out, working weak-signal modes for some good DX range. One mode, WSJT, is a great way to get beginners on to weak-signal digital operation, with a better understanding that there is a lot more to our VHF and UHF bands than just voice FM!

Yet this digital mode could be used on either frequency modulation or single sideband. For rovers participating in multiple "hot spots," the use of FM for their digital work makes good sense for beginners, in that tuning the FM signal is non-critical!

ARRL Vice Director, Marty Woll, N6VI, comments, "[R]overs are out to maximize their scores, which generally means maximizing the number of digital contacts they make, and the number of

Gordo flies the Innovantenna on 6 meters for Field Day with great results and no FM activity heard below 50.300 MHz.

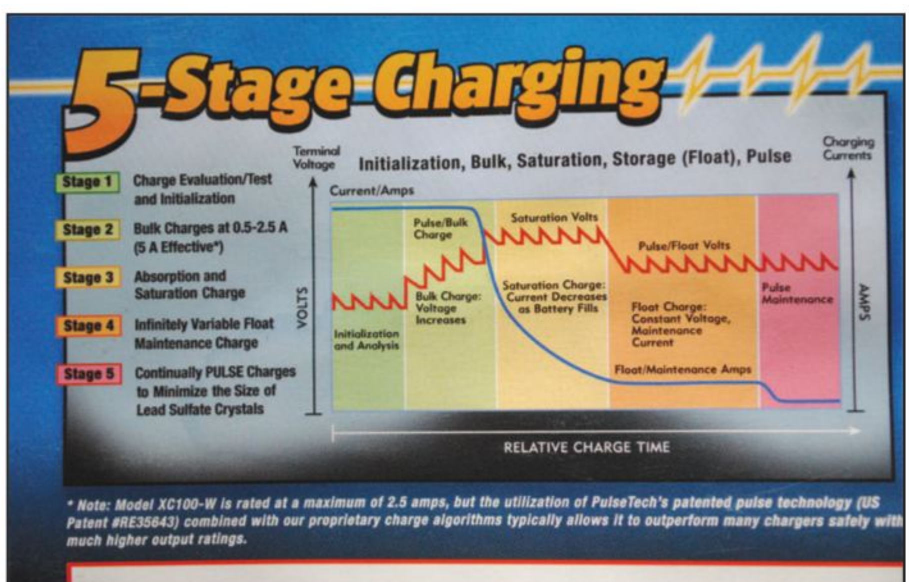
Worse than FM ops on 6-meters are errant birdies from a nearby TV.

locations they visit. … 50.265, 144.265, and 432.265 MHz were fairly well removed from most of the activity on contest weekends. The same frequency on which they make their internal runs serves as the IF frequency for transverters that get them on the six or more higher bands they operate…"

Marty further points out that using FM speeds up the contact process, and minimizes time spent by new operators tuning signals in the SSB mode, adding: "Even then, we try to wean the newbies gradually off the reliance on FM, and encourage them to build their SSB tuning skills. But that can't be done all in one [contest] weekend."

On the other side of the issue, using FM for a digital mode in the weak-signal portion of the band is the absolute legal requirement to monitor the frequency before transmitting. "[S]o I followed them up from 6 meters to 2 meters, where they used 144.265, and then 432.265, and since they were already talking by the time I QSYed, I'm guessing there was no pausing to see if the frequency was in use…" he concludes. Another apt observation!

Groups such as the San Bernardino



Regularly work your weak-signal bands on weekly nets in order to hold the weak-signal portion of the bands.

Microwave Society (SBMS@ham-radio. com) plus other weak-signal groups are our number one guardians of weak-signal portions of the bands. So support your local weak-signal and microwave group, and let's together work up our voluntary band plan visibility so we all may spread out and make the best use of frequencies governed by our "Gentlemen's Agreement" spectrum use.

The new Icom 9100 on the air. Only SSB should be used on these frequencies, not FM.

Even if FMers are cross-polarized to weak-signal horizontal polarization, they still can cause QRM.

Window of Opportunity: TEP plus Sporadic-*E* Link

While 6 meters is known as the "Magic Band," lately its performance mostly has been noted for propagation's disappearance acts. Here WB2AMU describes one of those rare times in this cycle when propagation existed between the extreme North and South American latitudes.

By Ken Neubeck,* WB2AMU

The spring of 2013 presented a major window of opportunity for 6-meter operators in the northern tier states of the U.S. and lower parts of Canada to be able to work into the southern-most parts of South America. With the way current Cycle 24 has been behaving, many VHFers realized that there may not be many more windows of opportunity left.

Northern-Tier Stations into South America on 6 meters, a Two-Part Equation

(1) Transequatorial Propagation Path

For stations in the northern parts of the U.S. and Canada to be able to work countries such as Chile and Argentina in the southern part of South America on 6 meters, the best way is through the combination of TEP (transequatorial propagation) and sporadic-*E* (*Es*). However, this is not as easy as it seems.

TEP is *F*-layer ionization that occurs over the Earth's magnetic equator. Typically it shows up during the higher periods of solar activity associated with a sunspot cycle. In comparison to east-west *F2* associated with high solar flux values (typically SFI [solar flux index] greater than 180) that appear on 6 meters, it takes moderately high SFI values (over 130 on average) to energize the area over the geomagnetic equator to allow TEP to occur on 6 meters. (It occurs regularly on 10 meters, as well).

It has been observed that 6-meter TEP generally is present only during the fall and spring equinox periods. This is primarily because of the favorable positioning of the Earth's field lines with respect to solar activity emitting from the Sun. Also, because of various factors, TEP typically is a late-afternoon into early-evening event.

Thus, during the time period of late September into early November and late March into early May, late afternoon TEP between Florida and Argentina on 6 meters has been fairly common during recent years. In the past, I have been in Florida in the Orlando area and have heard Argentina coming in on 6 meters during the late afternoon.

(2) Sporadic-E Path

The second part of this two-part equation is the presence of sporadic-*E* at the time TEP occurs. Not only does sporadic-*E* have to be present, but it has to be positioned in the right place where the southern end of the *Es* path ends up in the southern U.S. region, in the general area of southern Florida or southern Texas. Of

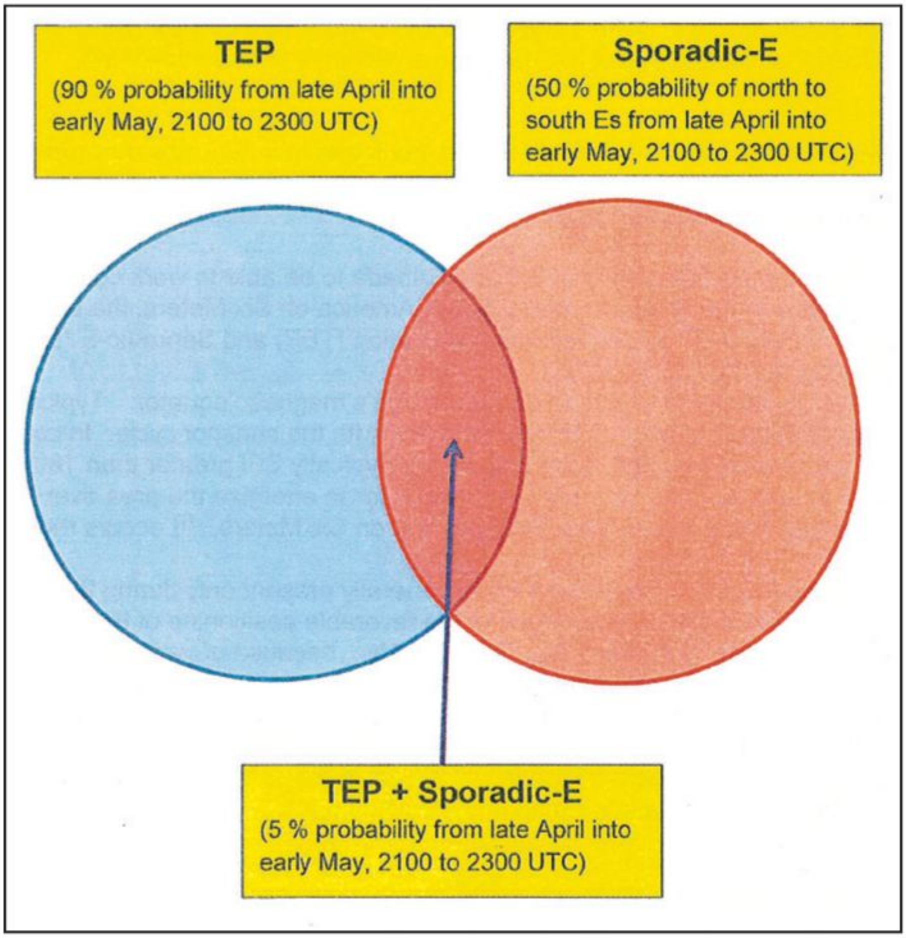


Figure 1. Probability of TEP plus sporadic-E link during Spring 2013.

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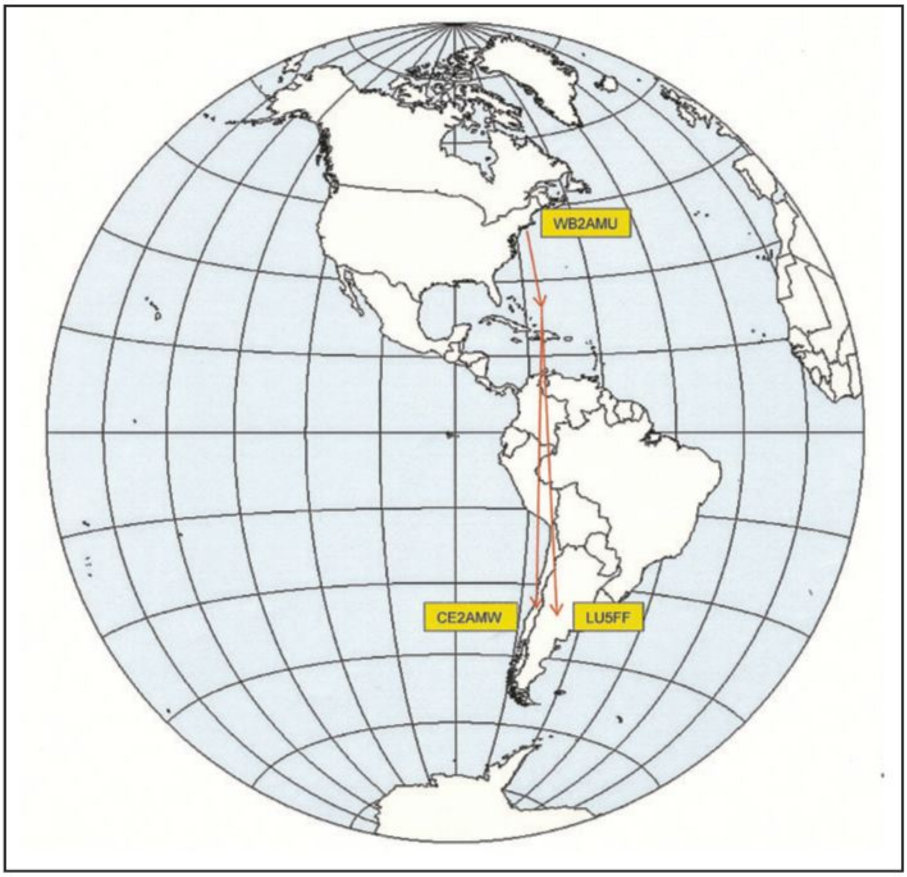

*Figure 2. Plot of TEP plus sporadic-*E *path from New York to Chile and Argentina. This figure shows the combination path for the 6-meter CW QSOs made by WB2AMU in New York with CE2AWW in Chile and LU5FF in Argentina. The first leg of the path from WB2AMU goes into the general area of the Caribbean via a sporadic-*E *opening, and from that area into South America is the TEP path.*

course, too, the sporadic-*E* path has to occur late in the afternoon. This is always a tricky thing, because the duration and strength of sporadic-*E* openings is variable and unpredictable.

Traditionally, sporadic-*E* propagation picks up after May 1st in the Northern Hemisphere at an average rate of one out of every three days with strong periods lasting three or four days in a row. The best months for the summer sporadic-*E* season are during June and July. Unfortunately, TEP activity is virtually nonexistent during those two months.

Thus, for a VHF operator located in the northern tier of the U.S. and lower part of Canada, the transitional period of April/May 2013 was looking like one of the best opportunities to work long-range DX on 6 meters using the combination of the TEP mode coupled with the sporadic-*E* (*Es*) mode.

During the last cycle, Cycle 23, I had a TEP plus sporadic-*E* opening that occurred as late as May 24, 2000, when I worked LU5VV at 2230 UTC. Prior to May 2013, I was guessing as to what would be the best days for an opportunity of sporadic-*E* plus TEP combination. I made up a Venn diagram as shown in figure 1.

Combined TEP plus Sporadic-E

During late April into early May 2013 I began to monitor 6 meters on a daily basis around 2100 to 2300 UTC. The active days of TEP plus sporadic-*E* combinations for May 2013 generally occurred in the time window of 2100 to 2300 UTC for May 7, 8, 9, 10, and 16. Active stations from South America included Dale, VE7SV, operating as CE2AWW during his stay in Chile in early May, and Javi, LU5FF, from his home station in Argentina (see figure 2). CW appeared to be the best mode to use because of general weakness and fading of the signals.

Dale, CE2AWW, began working stations in the higher latitudes of North

Month	Possible Propagation	Occurrence
January	Sporadic-E	3 to 5 days
February	Sporadic-E	1 to 2 days
March	Aurora	1 to 2 days
	TEP (into southern US)	3 to 5 days
April	Aurora	2 to 5 days
	TEP (into southern US)	5 to 10 days
	TEP plus Sporadic-E	1 to 2 days
May	Sporadic-E	10 to 15 days
	TEP plus Sporadic-E	2 to 3 days
June	Sporadic-E	20 to 25 days
July	Sporadic-E	20 to 25 days
August	Sporadic-E	10 to 15 days
	Aurora	1 to 2 days
September	Aurora	1 to 2 days
	Sporadic-E	1 to 2 days
	TEP (into southern US)	2 to 3 days
	TEP plus Sporadic-E	1 to 2 days
October	Aurora	2 to 5 days
	Sporadic-E	2 to 3 days
	TEP (into southern US)	2 to 3 days
	TEP plus Sporadic-E	1 to 2 days
November	Sporadic-E	2 to 3 days
	F2	3 to 5 days?
December	Sporadic-E	3 to 5 days
	F2	3 to 5 days?

Table 1. Forecast for 6-meter activity for North America during 2013. (Updated from article presented in the Fall 2012 issue of CQ VHF*)*

America via the TEP plus sporadic-*E* combination on May 7, when he worked W8 and W9 stations from the Midwest in the late afternoon. This continued on to May 8, when he worked K1TOL in Maine and VE2XK in Quebec. On May 9, Dale worked K2DRH in Indiana and some western U.S. stations in the 7th call area.

This set the stage for terrific results during Dale's last day in Chile on May 10. I was hearing several weak signals coming in and out. I heard Dale's CW signal peak up at around 2230 on 50.101 and I managed to work him. In addition, I had heard CE3SX on SSB and CE3RM on CW but could not work them. I did manage to finally work Javi, LU5FF, a short time after working Dale. Several stations in the northern part of the U.S. managed to work stations in both Chile and Argentina on the May 10.

Ironically, my home computer was in for repair on the day that I worked Dale when he was in Chile. I had no benefit of tracking and I had been monitoring the band throughout the day with various sporadic-*E* openings into the Midwest and even two-hop events into the western U.S. When I went down to my station in the basement, I could hear the band was wide open and there were three stations from Chile that I could hear and were fading in and out.

It was interesting to see how deep into the summer sporadic-*E* season that TEP continued to be observed. As some geomagnetic activity was noted during the last week of May, when the *Kp* index reached six a few times, some limited TEP resulted. Such a case was observed on June 1, when LU5FF was actually heard by southern-tier U.S. stations at around 1900 UTC and weakly by northern U.S. stations via an apparent sporadic-*E* link. I actually heard LU5FF's CW signal, albeit it weakly, for about 20 seconds breaking through the noise on 50.108 MHz. Thus, this is an even later date than the May 24, 2000 signal mentioned earlier in this article.

Thus, as always, 6-meter operators should be prepared for anything happening on the "Magic Band," even propagation modes such as TEP into the summer months!

Table 1 gives an indication as to what kind of 6-meter activity could be expected, and so far, up to early June, it is accurate. There is an indication of the TEP plus sporadic-*E* combination shown for the month of May.

After the beginning of June there was some geomagnetic activity that occurred and seemingly impacted conditions on 6 meters, especially with regard to sporadic-*E*. The ARRL June VHF contest— held on June 8, 9, and 10—saw no sporadic-*E* activity in the northeast on the 8th and a small narrow skip into the south on the morning of the 9th. Sporadic-*E* activity was observed elsewhere in the U.S., primarily in the Midwest. The week that followed saw very little sporadic-*E* activity, during a time in which significant openings should have been observed. It will be interesting to see how much geomagnetic activity is generated as the solar cycle moves forward during the balance of the year with regard to inhibiting sporadic-*E*, inducing some aurora events and possibly some *F2*-layer activity on 6 meters.

There probably will be at least one more opportunity during Cycle 24 for northern-tier stations in the U.S. and Canada to work into southern South America via the TEP plus sporadic-*E* link combination, during September through early November 2013. The number of events probably will be less than what occurred during May 2013, because sporadic-*E* will occur at a more reduced rate during the fall months. However, southern-tier stations should still see TEP on almost a regular basis.

Miscellaneous

Over the past six months (as I write this in late June) I have been branching out into the field of aircraft photography, as well as writing articles about aircraft, with recent efforts published in monthly magazines such as *Combat Aircraft* and in monthly newspapers such as *Atlantic Flyer*. This has been the natural extension of my regular job, along with certain opportunities that frequently come about to take photos and write articles. I will still try to continue to write for *CQ VHF* magazine as events unfold on 6 meters and other VHF bands over the next few critical years of Cycle 24.

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By Joe Moell,* KØOV

HOMING IN

Radio Direction Finding for Fun and Public Service

Next USA ARDF Championships, plus a Threat to 33 cm

When was the first gold rush in the USA? If your answer is 1848 at Sutter's Mill in California, you are late by almost fifty years. The first substantial gold strike was in Cabarrus County, North Carolina in 1799, just outside the Uwharrie Mountains.

In just a few weeks, fans of all-on-foot hidden transmitter hunting will "rush" to these same forests of oak and pine for USA's national championships of Amateur Radio Direction Finding (ARDF), which is also called foxtailing and radio-orienteering. Some will be striving to earn positions on ARDF Team USA for the next world championships, while others will be there just to have fun and learn all they can about this growing ham radio activity.

As ARRL's appointed ARDF Coordinator for the USA, it's my pleasant duty to get together with ham radio and orienteering groups around the country to select locations for these annual championship events. The story of this year's site goes back to 2009, which was the first year that the championships were in a northeastern state. Before then, most of the hotbeds of ARDF activity were in California, New Mexico, and other western states.

Vadim Afonkin, KB1RLI, organized the 2009 championships.[1] He wanted to make sure that the Northeast was well represented, so he began putting on introductory ARDF sessions in Franklin Park and other mapped sites in the Cradle of Liberty. He sought out young athletes who might be interested in a new challenge and found some in the Cambridge Sports Union. CSU is an athletic club that concentrates on four sports: running, race-walking, cross-country skiing, and orienteering. Brendan Shields, Ian Smith, and Lori Huberman were three CSU orienteers who thought that adding radio to their map-and-compass runs through the forest was an excellent new challenge.

Lori is a graduate student in microbiology at Harvard. She has always been at home in the woods, because her parents taught orienteering skills to her as a child. She explained ARDF to her mother, Ruth Bromer, WB4QZG, and Ruth immediately decided to come to the championships in Boston to try it for herself.

Those June 2009 ARDF medal runs at the 2000-acre Blue Hills Reservation south of Boston were a physical test for everyone, with trails that went up and down 300-foot hills. Years of orienteering experience were a big help to the CSU competitors. In the two separate events on consecutive days on 2 meters and 80 meters, all of the CSU participants were among the top three stateside finishers on at least one day. Lori and Ruth won gold medals in their age/gender categories on each band.

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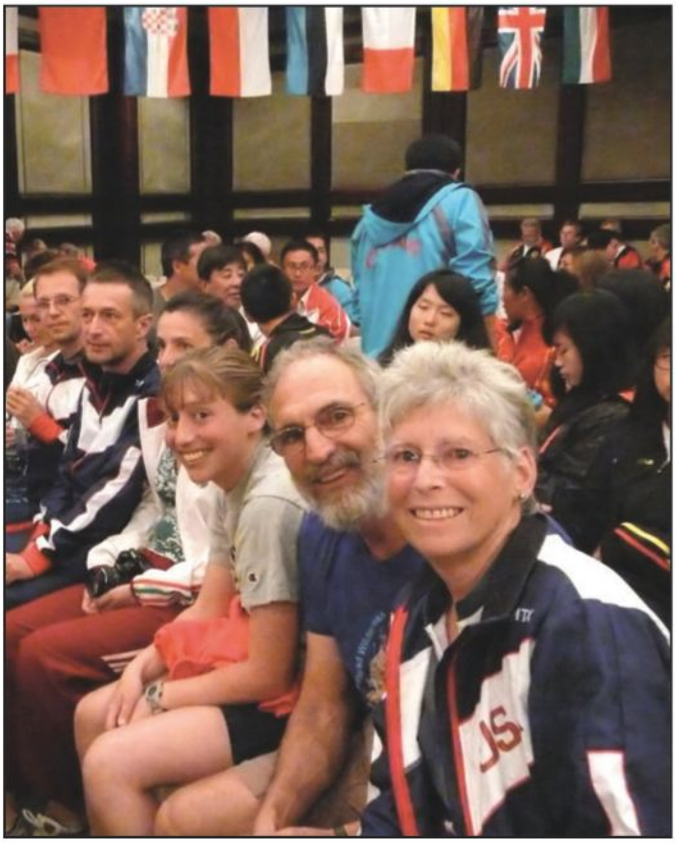


Awaiting the start of a medal ceremony at last year's ARDF world Championships in central Serbia are Ruth Bromer, WB4QZG (closest to camera), Joseph Huberman, K5JGH, and Lori Huberman. Ruth and Joseph are organizing this year's USA and IARU Region 2 Championships. (Photo courtesy WB4QZG)

Lori and Ruth had so much fun that in the following May they traveled to Oxford, Ohio for the Tenth USA ARDF Championships. There they repeated their medal-winning performances and earned places on ARDF Team USA for the trip to Opatija, Croatia for the World Championships that September. There they were up against the best and most experienced radio-orienteers from 32 nations and they did amazingly well for first-timers. On the first competition day, Ruth and her teammate Karla Leach, KC7BLA, captured silver medals for being second only to the Russian team on 80 meters in the category for women over age 60.[2]

On the second day, Ruth finished in fourth place in W60 on 2 meters. Her time was 14 minutes shorter than the bronze medalist, but the bronze winner found one more transmitter. Lori finished fourth in her age category that day. She was one of only six competitors in that category who succeeded in finding all five 2-meter transmitters on a very difficult course in soaking rain.

Accompanying Lori and Ruth to Croatia was father and husband Joseph Huberman, K5JGH, who is also an accomplished orienteer. Joseph said he wasn't ready to try ARDF at that time, but after Lori and Ruth won gold at the 2011 USA Championships near Albuquerque, he decided to join the fun. At the 2012 USA Championships at Mt. Laguna, California, he took gold in his category in the 2-meter contest and bronze on 80 meters. He also had the fastest pace in the new foxoring competition.[3] Ruth picked up a gold on 80 meters and a silver on 2 meters. Lori won gold on both bands.

All three members of the Huberman/Bromer family went to Kopaonik, Serbia for last year's World Championships. WB4QZG and KC7BLA again took home team medals. Ruth also won a bronze medal in the World Cup competitions for individuals and placed fourth in her category in the sprint and foxoring competitions.

ARDF in the Uwharries

As President of Backwoods Orienteering Klub (BOK), K5JGH likes to organize orienteering events and he is good at it. Thus, I was very pleased when he and Ruth offered BOK as host of this year's USA ARDF Championships near Asheboro, North Carolina. The events will be organized very much like an orienteering "A-meet" with each person responsible for his or her own lodging and transportation while there.

Joseph and Ruth picked the third week and weekend of October for this year's events. "It's just too hot and muggy before that," they told me. Many of the participants will arrive Tuesday, October 8 to pick up their packets at the headquarters hotel and check their RDF equipment. The physical activities start on Wednesday with practice courses on 2 meters and 80 meters. Thursday morning brings model events of sprints and foxoring, followed in the afternoon by the championship foxoring event. Friday morning will be the sprint championship event with awards presented thereafter.

Competitors who cannot be present for all five days will arrive Friday for the classic championships. There will be model events on 2 meters and 80 meters Friday afternoon, followed in the evening by a briefing for everyone about procedures and safety. Saturday morning will be the full-course 2-meter main event, followed in the evening by the official banquet and awards presentation. The full-course 80-meter main event will be on Sunday morning with awards presented afterwards, in time for those who must hurry home.

WB4QZG is registrar for the championships. Registration is very simple with the online entry form that she posted on the BOK website.[4] The standard registration package includes all of the weekend model and classic ARDF events. There are small additional charges for sprint, foxoring, and the weekday practices. To encourage you to get your registration in early, there are modest late fees for registration after September 15.

Setting the courses for these championships will be Nadia Scharlau of Cary, North Carolina, with radio support from Charles Scharlau, NZØI. Nadia learned ARDF as a youth in the Soviet Union and won her first gold medal by competing for USSR at the European Championships in 1984. Charles discovered ARDF in the Puget Sound area of Washington State and competed in our national Championships for the first time in 2001. Both of them have represented USA at the World ARDF Championships four times in the last decade. In 2006 at Primorsko, Bulgaria, Nadia became the first Team USA member to win a World Championships medal.

This year's USA championships are being combined with the championships of International Amateur Radio Union (IARU) Region 2 (North and South America). Previous Region 2 championships have drawn competitors from numerous European and Asian countries including Australia, China, Czech Rep., England, Germany, Japan, Russia, Sweden, and Ukraine. There is a growing ARDF movement in Canada, and that country is expected to field a team to compete for the Region 2 medals. Of course, the majority of the participants will be from the United States.

USA's ARDF Championships are open to anyone of any age who can safely navigate in the woods with hand-held radio gear for several kilometers. Participants will be divided into eleven age/gender categories as defined by IARU. Don't worry if you are inexperi-

Charles Scharlau, NZØI, and Nadia Scharlau test their 2-meter ARDF equipment at the USA and IARU Region 2 Championships near Albuquerque. They will provide the transmitters and set them out in the forest for this year's championships in their home state of North Carolina. (Photo by Joe Moell, KØOV)

enced at radio-orienteering, as this is a chance to learn from experts. Most will be licensed hams, but an amateur radio ticket is not a requirement. I hope to see you there.

More Commercial RDF on 33 cm

In June, the amateur radio press reported an FCC order that could change amateur radio activity on the 33-cm band. This order approved commercial operation of a new radiolocation service covering about 30% of the band. Before doing so, the FCC established to its satisfaction that Part 15 users of the band would not be adversely affected. However, the FCC did not consider the impact on amateur radio and the ARRL did not enter the proceedings.

Sounds strange, doesn't it? There is much more to the story than has been reported, so let's start at the beginning. Since 1985, when amateur radio was first given access to the 902–928 MHz band, our allocation has been secondary and on a non-interference basis. The top primary user was and is government radiolocation, including US Navy radars. These radars don't usually operate on shore, so that has not been a problem for us.

Next in line to government operations are industrial, scientific, and medical (ISM) uses such as RF heating for shrink-wrapping. Since ISM devices don't receive, we are not likely to interfere with them. The next primary 33-cm service back then was Automatic Vehicle Monitoring (AVM), followed by amateur radio. Last on the list were unlicensed devices operating under FCC Part 15 rules, which state that they must not cause interference to any licensed user and must accept any interference from licensed users.

Although AVM had been around since 1968, it did not pose a problem for amateur radio at the beginning. Then in the early 1990s, the International Teletrac Corporation, a subsidiary of Pacific Telephone (Pac-Tel), began turning on its stolen vehicle tracking and recovery system,[5] intended to be a major competitor to LoJack.[6]

Teletrac used wide-aperture time-difference-of-arrival (TDOA) direction finding technology to accurately determine the locations of transponder-equipped vehicles. There are TDOA RDF sets for ham radio use,[7] but they all have a narrow aperture (one-half wavelength or less antenna spacing). Teletrac antennas were miles apart instead of inches apart. All receiver sites listened for a very short RF burst from the vehicle and passed along what they heard (exact time of signal, the strength, and ID) to the main system computer. The computer selected the four strongest site signals and determined the nanosecond differences in their time of arrival. Then it took about three seconds for the computer to use multilateration algorithms to calculate the exact vehicle location. Accuracy was typically within 100 feet. To cover its 4500-square-mile service area in four southern California counties, Teletrac installed 41 receiving sites.

At a meeting between Pac-Tel and leaders of the Southern California Repeater and Remote Base Association (SCRRBA) in January 1990, Pac-Tel made it clear that any interference from hams to its Teletrac network would not be tolerated. Rather than risk litigation if a SCRRBA-coordinated repeater were to cause QRM to the sensitive AVM receivers, SCRRBA wrote a new band plan. No ham activities were coordinated in the 903–912 and 918–927 MHz ranges, keeping them clear for AVM. Weak-signal work and repeater inputs were placed from 902–903 MHz, well separated from high-power paging transmitters that were proliferating above 928 MHz. Repeater transmitters on mountaintops and at other communications sites were coordinated from 927–928 MHz.

In 1993, the FCC saw the potential for more "intelligent highway" services in the 33-cm band and issued PR Docket 93-61. The eventual Report and Order morphed AVM into the Location and Monitoring Service (LMS). There would be three frequency blocks for licensed tracking systems using multilateration (M-LMS) as well as other blocks for LMS services that didn't involve multilateration, such as electronic toll collection. Existing licensees were grandfathered and new LMS licenses were issued after competitive bidding.

Teletrac Departs and Hams Advance

Non-multilateration LMS users proliferated in the years following, but 33-cm M-LMS did not grow because of the advent of the Global Positioning Service in a different band. GPS is the ultimate wide-aperture multilateration system. Its accuracy and reliability became unmatched once Selective Availability was turned off and the Wide Area Augmentation System came into widespread use. It wasn't long before Teletrac abandoned the stolen-vehicle recovery market and land-based TDOA, changing its business model to commercial fleet tracking with GPS.

With no worries about interfering with Teletrac, hams in southern California and elsewhere increased their 33-cm activities. SCRRBA developed a new bandplan[8] and began coordinating voice and ATV repeaters in larger portions of the band. Now there are almost 30 open voice repeater coordinations on the SCRRBA list.[9]

Realizing that M-LMS was not advancing as anticipated, the FCC opened Docket 06-49 to re-examine the matter. No Report

John Kemper, W6JN (SK), demonstrates VHF RDF with a Yagi at a meeting of the South Bay Amateur Radio Club in March 2007. (Photo by David Harmon, KE6OJN)

and Order has been issued so far, but the FCC has reaffirmed two important interference provisions of the previous docket's Part 90 rules:

FCC 90.361 is a "safe harbor" for hams and Part 15 device manufacturers, stating that if they operate in accordance with their own service regulations and a few other specific restrictions (power, antenna gain and height), then M-LMS operators cannot seek remedy for any interference from them.

FCC 90.353 requires that M-LMS licensees be able to demonstrate by field tests that they do not cause unacceptable levels of interference to Part 15 devices. That's right; bottom-tier unlicensed Part 15 equipment such as cordless phones and the Marco Polo pet locator[10] must be protected from QRM by licensed higher-tier LMS signals! However, 90.353 gives no such protection to licensed amateur radio operators.

As of the end of 2011, there are 614 area licenses in effect for M-LMS. Most remain inactive as assets of holding companies, non-profits, partnerships, and individuals. But one company, with 228 licenses, is poised to make a big change to the M-LMS scene. Progeny LMS, LLC wants to use its licenses to do things that GPS can't, driven by increasingly stringent E911 requirements.

Since 1997, wireless carriers have been required to provide information to 911 dispatchers about the location of callers. Some providers, such as AT&T, added TDOA positioning technology to their GSM tower networks while others, including Verizon, include GPS receivers in subscribers' handsets to transmit position.[11] Both methods have significant limitations, especially when callers are indoors or in "urban canyons" of streets and sidewalks between tall buildings.

The FCC wants more reliable E911 call locating, with greater position accuracy and the ability to determine from which apartment in a high-rise a call is being placed. NextNav LLC,[12] the parent company of Progeny, claims that its system can give 26-meter location accuracy 67% of the time and can determine height above ground to within two meters.[13]

Progeny beacons would be concentrated in areas where GPS is ineffective. Receivers in cell phones would perform multilateration of the strong 33-cm coded signals from the transmitters just as some carriers' phones do with weak GPS satellite signals. Because this is a one-way (tower to handset) path instead of the two-way handshake protocols of Teletrac and other M-LMS systems that were envisioned in Docket 93-61, Progeny needed a waiver of the Part 90 provisions that called for two-way systems and vehicular networks. The FCC opened Docket 11-49 to consider these waivers and granted them in December 2011.

The waiver proceedings brought some other users of 33 cm out of the woodwork. One was Itron, Incorporated, a leading manufacturer of "smart" power meters. Itron opposed the waiver out of concern that its 33-cm meter-reading networks would be disrupted. The FCC told Progeny to perform tests per 90.353 to show there would be no "unacceptable interference," whatever that means. The Commission provided no testing guidelines, merely telling the parties to work it out themselves. (Doesn't this sound a lot like the ham-versus-BPL squabbles of recent years?)

To shorten a very long story, there were several rounds of tests and arguments. Progeny proclaimed that no harm will come to any Part 15 devices, but other entities such as Itron, the New Jersey Turnpike Authority, and the Wireless Internet Service Providers Association remained unconvinced. The FCC decree of June 5, 2013 gave the win to Progeny and issued a go-ahead to NextNav to turn on its systems. In its decision, the FCC proclaimed that Part 15 devices would adapt because "they are designed for operation in an interference environment."

Progeny holds M-LMS licenses in 115 Economic Areas (markets) covering about two-thirds of the USA. One system in the San Jose, California area is already operating and was used for the interference tests. Almost forty additional systems are built out and ready to go on-air between 919.75 and 927.75 MHz. More than 80% of the southern California 33-cm open repeater outputs are in this range, as well as NTSC ATV activities and wideband digital links.

The ARRL did not enter these proceedings because amateur radio is below LMS in the 33 cm user hierarchy and our service is not included in the testing requirements of FCC 90.353. So will the Commission's demands for ever better E911 location services force 33-cm amateur operations back to the days of pre-GPS Teletrac? I welcome your comments.

John Kemper, W6JN, SK

Another RDF innovator has passed away. John P. Kemper was born in 1924 and grew up on his parents' orange ranch in Anaheim, California, where he experienced a major flood in 1937. After reading in the local newspaper that a "radio ham" provided the only viable communication until telephone service was restored, he became determined to become one.

John built his first radio set from scratch, following the instructions in a *Popular Mechanics* article. At age 15, he became W6SCO and was an avid ham for the rest of his life. In World War II, when he was only age 17, John began working at the FCC's Monitoring Station in Santa Ana, California, intercepting and monitoring war-related radio transmissions. He was said to be a top-notch Morse code operator.

Later, as a Staff Sergeant in the U.S. Army, W6SCO was assigned to an intelligence unit that monitored and decrypted CW transmissions from the Pacific theater. After the war, he returned to the FCC as an electronic engineer/inspector, eventually managing the inspection program for three states. In 1948, he created and built the first FCC monitoring vehicle for field engineering work. One year later, he designed a microwave monitoring vehicle, the first in the country, which became the FCC standard.

John went to work at the Federal Aviation Agency (FAA) in 1961, where he continued his legacy of firsts. He was instrumental in the development of several electronic frequency management devices that are still used today. After retiring in 1982 as Chief of FAA Frequency Management and Leased Telecommunications for the Western-Pacific Region, he became an author, trainer, and consultant. Through Kemtelcom, his own company, he continued to supply the FAA and other agencies with his K-95 Handheld Radio Direction Finder.

I first met W6SCO in the 1980s when he was experimenting with Doppler RDF for rapid resolution of interference in the 120-MHz aircraft band. He was the "go-to" person for any interference to aviation communications and nobody was more serious about it. Later, he changed his callsign to W6JN. Although he received twenty special service and performance awards in his years with the government, he was most proud of the Paul McAfee Award. It was given to him by the Society of Airway Pioneers in 2009 for his leadership in the field of RFI, including designing and overseeing the production of equipment to resolve threats in the National Airspace System.[14]

In Closing . . .

I would like to hear from you about RDF pioneers you have known. I am also interested in news about hidden transmitter hunting activities in your locality, both in vehicles and on foot. Did your club participate in this year's CQ World-Wide Foxhunting Weekend? Be sure to send stories and photos to me right away for the wrap-up article, which I am preparing for the February 2014 issue of *CQ* magazine. 73, Joe, KØOV

Notes

1. http://www.homingin.com/boston09.html
2. Team scores in each category are aggregates of individual scores in that category. Teammates may not assist one another on the course.
3. http://www.homingin.com/sprints.html
4. http://www.ardf.us
5. I detailed the Teletrac AVM system in my "Homing In" column for the July 1991 issue of *73 Magazine*.
6. The LoJack stolen-vehicle recovery system uses Doppler RDF technology in the 170-MHz range. I described it in detail in my "Homing In" column for the May 1991 issue of *73 Magazine*.
7. An example is the Vector-Finder series of RDF sets from National RF Inc. (http://www.nationalrf.com/vector-finder.htm)
8. http://www.scrrba.org/BandPlans/33cm.htm
9. http://www.scrrba.org/BandPlans/ Open33cmRepeaters.html
10. Marco Polo was detailed in my "Homing In" column for the Winter 2013 issue of *CQ VHF* magazine. It is a spread-spectrum Doppler RDF system, but it operates under FCC Part 15.
11. The CDMA technology used by Verizon is not compatible with TDOA positioning.
12. http://www.nextnav.com
13. Position is determined by TDOA, while height is determined by differential barometric pressure measurements.
14. http://en.wikipedia.org/wiki/National_ Airspace_System

By Keith Pugh,* W5IU

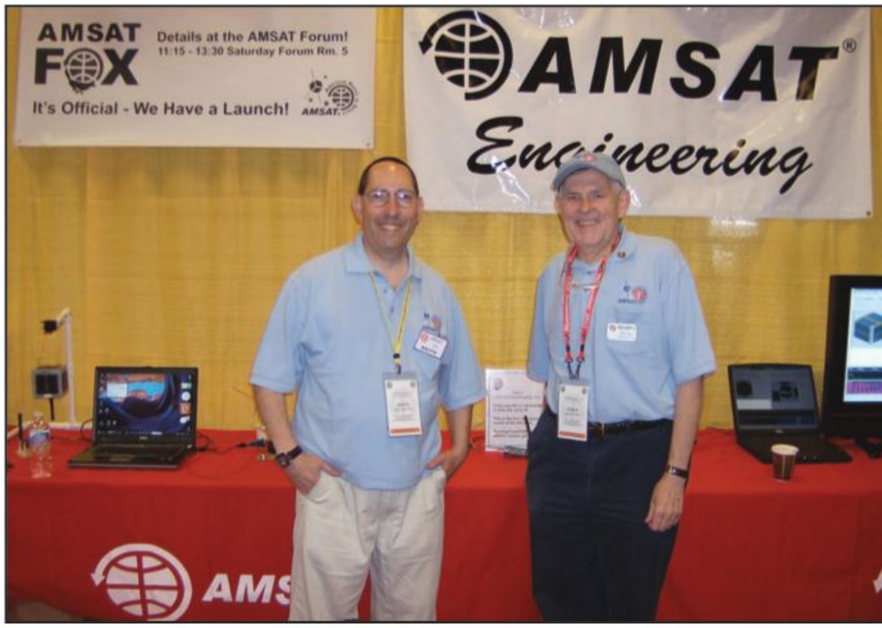
SATELLITES

Artificially Propagating Signals Through Space

Dayton, Ham-Com, Field Day, ARISS Update, and What's New for Working the Birds

Each Year May and June are always busy with attending the Dayton Hamvention®, Ham-Com in Plano, Texas, and operating Field Day. This column will address the highlights of these events along with some new additions to equipment available for working the amateur radio satellites.

Recent school/group contacts with the ISS (International Space Station) have featured Canadian and Italian astronauts along with equipment changes on board the ISS and corresponding changes in ground station requirements.



Tony Monteiro, AA2TX, AMSAT VP of Engineering, and Wendell Fisher, W2BFJ, Software Engineer at the AMSAT Engineering table at Dayton 2013. (KB1SF photo)

Dayton 2013

I hope no one missed visiting the AMSAT booth at the 2013 Dayton Hamvention® because of a slight change of location. This year the usual four tables in line on one side of an aisle were exchanged for two tables on either side of an aisle. Booths were slightly rearranged. Most comments about the change were favorable. The outdoor AMSAT Satellite Demonstration Area (where I spend most of my time) remained unchanged and was busy throughout the Hamvention®.

The engineering side of the indoor booth featured Project Fox with displays of actual hardware and a new full-size, paper model of Fox-1 that you could obtain for display in your own station. Related projects from our education partners were featured as well. AMSAT Engineering representatives were available to discuss all facets of the projects at all times. By the way, FOX-1 is now promised a launch in November of 2014.

A full slate of topics was addressed in the AMSAT Forum on Saturday, including State of AMSAT, Project Fox, FUNCube, ARISS, and AMSAT in Education. Videos of these and other topics are available via the following URL: <http://www.youtube.com/user/AMSATNA>.

On the lighter side, we enjoyed the usual pub dinner on Thursday evening, followed by a special tour of the recently expanded DARA (Dayton Amateur Radio Association) clubhouse and station, W8BI, something every amateur radio club should have. On Friday evening we attended the AMSAT/TAPR Banquet followed by an excellent and humorous after dinner speaker Bruce Perens, K6BP.

If you've never been to the Dayton Hamvention®, I recommend you try it. Warning, though! You may become "hooked." I was hooked after my first one in 1983. We would love for you to visit the AMSAT booth and functions, and we will even "put you to work."

Ham-Com

If you can't make it to Dayton, by all means support your local hamfests. A long-standing one in my area is Ham-Com in Plano, TX. For those of you who are geographically challenged, Plano is a suburb of a better-known city to the east of Fort Worth—Dallas. This one has been going on in June for many years and is the premier event in the western part of the country. We always have an AMSAT presence with a booth, speakers, and demonstrations.

Another long-standing feature of Ham-Com is the annual Boy Scout Merit Badge Class. This year we were able to get a large group of Scouts (approximately 150) out for "back-to-back" amateur radio satellite demos utilizing HO-68 (listen only) and FO-29. Of course, it was impossible to let each Scout talk on the Bird on a 10-minute pass, but we did involve them as much as we could. This had been done on a smaller scale in previous years, but this year we tried for the whole group. This demo was well received and probably will become a feature of future Ham-Coms.

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Barry Baines, WD4ASW, AMSAT President, "hawks our wares" at the AMSAT Booth. Note the new FOX-1 Model in the middle. (KB1SF Photo)

In keeping with AMSAT in Education, we were able to interest a group of students from the University of Texas at Arlington (UTA) led by Tracie Perez, KF5UYL, at the AMSAT Forum and another satellite demo. Actually, Tracie had seen our demo notice on amsat-bb and sought us out. They are engaged in a satellite project at UTA and were anxious to learn more about amateur radio satellites.

ARRL/AMSAT Field Day 2013

By way of review, it is possible to earn 100 bonus points, plus contact points and a "free station" in the ARRL Field Day event. However, for purposes of this event, all satellite contacts are treated as a single "band." AMSAT sponsors a similar event that runs concurrently in which each satellite is treated as a separate "band." The principal difference is score keeping. Due to problems with overcrowding—especially on the FM birds—both events only permit one contact per FM transponder.

This year we were down to only one FM Bird, SO-50, and three linear transponder (SSB/CW) Birds: AO-07, FO-29, and VO-52. The ISS was available too, but only for digipeating. Even the linear transponder birds were very crowded, making contacts difficult. At my station, large trees in all directions, except nearly overhead, made contacts even more difficult. The vegetation is particularly hard on the 70-cm frequencies, which are an uplink on some Birds and a downlink on others. It's still fun to set up and operate a satellite station for Field Day and it always gets a lot of attention.

Through no fault of our own, my club will have to change Field Day locations next year, so we may lose the tree problem; however, we may not be able to withstand the Texas heat without the shade.

ARISS Update

The past few months regarding ARISS (Amateur Radio on the International Space Station) have been full of joys and challenges. The joys have been the many excellent Canadian contacts made with Chris Hadfield, KC5RNJ/VA3OOG, and Italian/South American contacts done with Luca Parmitano, KF5KDP, of Italy. Of course there were more made with other countries and astronauts, but these "favorite son" contacts were in the majority. A large poster featuring Chris Hadfield followed him around to all of the Canadian provinces, as he made contacts in each of them. It has been signed by all of the students who asked questions and will be presented to Chris this fall. A picture of this poster along with members of the Royal Canadian Mounted Police (RCMP) in Yellowknife, Northwest Territory, is included in this column.

The challenges are related to a failure within the Kenwood D-700 radio located in the Russian segment. This caused a rush of re-scheduling and checkout activity to recover the lost school contacts and continue with the Ericsson VHF radio located in the Columbus Module. This is a much lower powered radio and has different antenna issues as well. The upshot of all of this is greater emphasis on ground

Boy Scouts huddled around Douglas Quagliana, KA2UPW, Keith Pugh, W5IU, and Clayton Coleman, W5PFG. Douglas, Keith, and Clayton are in the upper right part of the picture. Only Clayton's face is visible. (KB5YBQ photo)

Group photo of the Radio Merit Badge Class at Ham-Com 2013. Approximately 150 Scouts were there. (KB5YBQ photo)

station capability to help offset the differences in the ISS component. Successful contacts are being made, but we suffer with occasional fades and dropouts that were greatly minimized with the Kenwood Radio. The good news is that at least a partial repair has been made on the Kenwood and we may be able to return to it when the nature of the repair is better understood. Meanwhile, there is activity aimed at procuring and installing a better radio for the Columbus Module.

Activity is well under way for inclusion of ham TV in the Columbus Module. This could start as early as this fall on a limited basis. More details will be available in the *CQ VHF* Fall issue column.

What's New for Working the Birds

In recent months two new products have been introduced by Mark Spencer,

Chris Hadfield's poster with three Mounties from the Royal Canadian Mounted Police (RCMP) at the Yellowknife, NWT, ARISS contact. (Photo supplied by VE1WPH)

WA8SME, of the ARRL to assist the operator in working satellites.

First, a broad-band receive pre-amp covering the NOAA Polar Orbiting Weather Satellites, 2 meters and 70 cm, has been released and is now available through the AMSAT store. This is a receive-only pre-amp and must be protected from transmitting through it. I have used it and it works well for its intended purpose. It is a great addition to a portable station.

Yours truly, W5IU, at the radios in the AMSAT demo area while others look on and listen. (KB1SF photo)

Second, Mark has developed a board called "Satellite CAT Interface for Working the Analog Birds" to help the owner of an FT-817–class rig work the linear transponder "Birds" with a single radio. It's not ideal but is much cheaper than a second radio. It can be adapted to other radios such as the FT-857, FT-897, IC-706, and IC-7000. I have built the kit and installed it with one of my FT-817s. It works and I'm trying to find the time and place to actually make some contacts with it. A kit is available from the ARRL and the device is described in articles in the October 2012 issue of *QST* and in the *AMSAT Journal*.

Mark and others are working on additional devices to assist the amateur radio operator, student, and teacher with affordable amateur satellite communications. Watch Mark's YouTube Video cited in the publications above.

Summary

Continue to operate on the birds as much as possible. Use your equipment in all of its modes and on all of its frequencies. Attend the excellent conferences and symposiums dedicated to work in these areas. It's too late for Central States VHF Conference in the Chicago suburbs (Elk Grove Village, IL) July 25–27, and the AMSAT UK Space Colloquium in Guildford, Surrey, UK, July 19–21 this year. However, plan to attend Microwave Update at Morehead State University, Morehead, KY, October 18–19, and/or the AMSAT Space Symposium November 1–3 in Houston, TX, if possible this year. I've been attending these functions since 1983 and never tire of them. I don't understand everything I hear, but a little bit rubs off each time. If you're not careful, you learn something every day (and at every conference).

Please continue to support AMSAT's plans for the future of amateur radio satellites. There are new things happening every day. Refer to the newly re-designed AMSAT web page at <http://www.amsat.org> for details. This web page is still a "work in progress" as this is being written, but more functionality re-appears every day. Follow the projects and progress of AMSAT-UK at <http://www.uk.amsat.org/>. Keep current with overall satellite status at: <http://www.dk3wn.info/p/?s=active+satellites&x=0&y=0>. Near real-time status is available at: <http:// oscar.dcarr.org/>.

'Til next time!

73, Keith, W5IU

By Bob Witte,* KØNR

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

Repeaters: There's an App for That

On the VHF/UHF ham bands most areas of the country have plenty of repeaters and repeater frequencies from which to choose. Often the challenge is figuring out which repeaters are in your area, along with the proper offset and CTCSS tone. Well, don't worry. . . .*There's an app for that!*

Repeater Directory

The most authoritative source for repeater information is the *ARRL Repeater Directory* (figure 1). This book is published each year with updated information on all of the coordinated repeaters in the U.S. and Canada. The directory is organized by frequency band, then state or province. To find a repeater, you just flip through the pages for the band of interest in your location.

The ARRL also offers the same information as a Windows® software application called *TravelPlus for Repeaters. TravelPlus* includes a map system and supports an external GPS device.

There are also online repeater databases that can be accessed via the web. One good example is RepeaterBook.com, which lists repeaters in the United States, Canada, and Mexico.

iOS and Android Apps

As smartphones and tablets have grown in popularity, a number of software apps have become available for locating repeater information on both the iOS (Apple) and Android operating systems. These mobile devices are particularly useful since most of them have GPS receivers or other geolocation devices built into them. Instead of having to flip through the pages of a repeater directory, you can just push the control that says "find repeaters near me now." This is very handy.

In this article, we'll focus on repeater directory apps that cover the entire U.S. There are apps that are specific to local areas and also ones that try to cover the entire world.

The *RepeaterBook* app by ZBM2 Software (operating systems iOS and Android; cost free) is an app associated with the website by the same name, using the same repeater database (figure 2). This app covers the U.S. and Canada and has selectable filters for displaying specific bands (6 meters, 2 meters, etc.) and specific attributes of the repeater (FM, D-STAR, APCO 25, IRLP, EchoLink, etc.)

The *iHam Repeater Directory* app by Sublime Sun/K1SLM (operating system iOS; cost $4.99) covers repeaters in the United States (figure 3). This app lets you select all frequency bands or any single band, which is not quite as flexible as the RepeaterBook app. In addition to listing repeaters in a particular area, this app includes a mapping feature that plots a selected repeater's location (more on that later). This app allows the user to edit repeaters in the directory and to add additional ones not included in the standard database.

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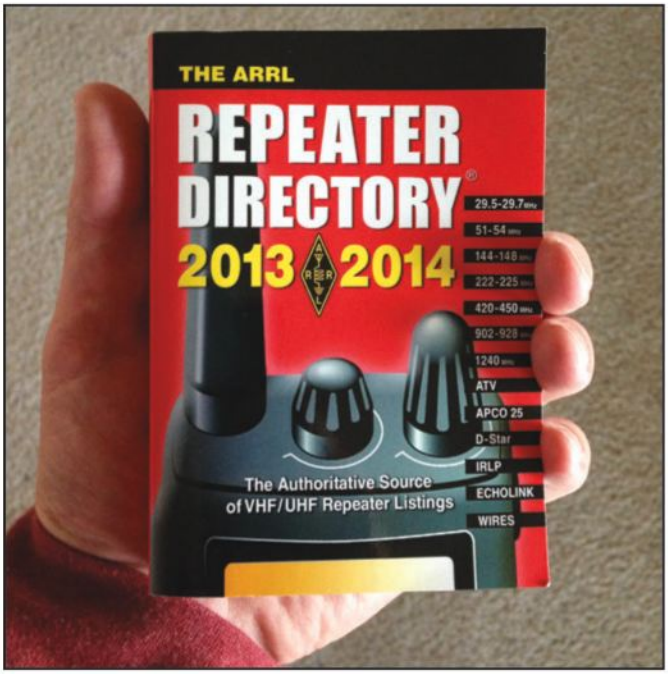

Figure 1. The ARRL Repeater Directory *is the authoritative source for VHF/UHF repeater listings.*

The *Repeaters* app by David Fleming, W4SMT (operating system iOS; cost $4.99) covers repeaters in the United States (figure 4). This app also includes a mapping feature and the ability to edit and add to the list of repeaters. It does not include the option of displaying repeaters in a specific frequency band.

The ARRL has a Repeater Directory app in beta testing on the Android platform. This app is currently free and includes a mapping feature. At the time of this writing in late June, I was unable to find out what future plans the ARRL has for this app.

It's the Data

There are two main things to consider regarding these apps: the usefulness of the software and the database that the app uses. All three of these apps do a good job with the software and choosing one will be based on personal preference. Having access to good data on repeaters is a critical factor for these apps. Historically, the official reference on repeaters has been the *ARRL Repeater Directory*, since this data is supplied by the various frequency coordination bodies across the U.S. and Canada. However, this means that the data only changes once per year when the repeater directory book is updated.

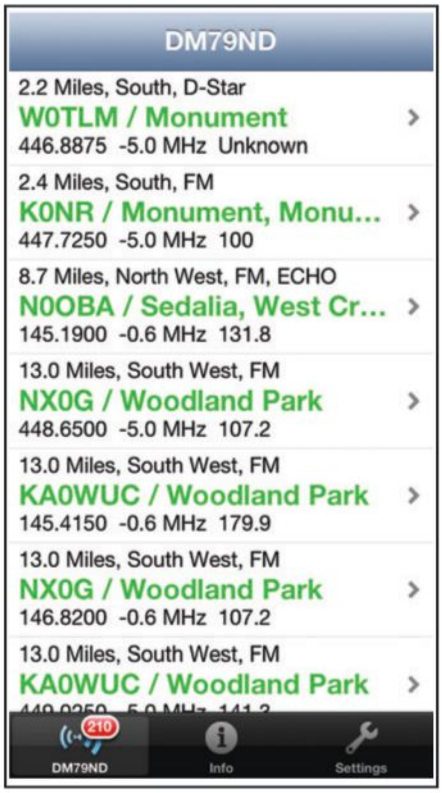

Figure 2. The RepeaterBook *app shows a listing of available repeaters in a particular location.*

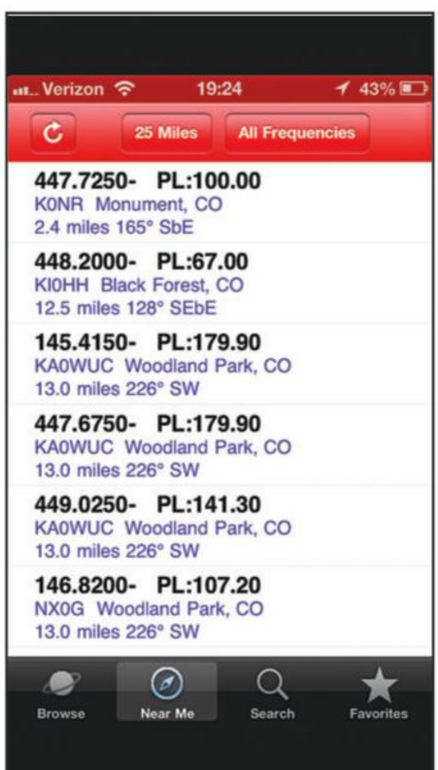

Figure 3. The iHam Repeater Directory *app lists repeaters in a particular area.*

RepeaterBook says that its repeater information comes from "commonly available resources. The Internet and other HAMs (sic) are our best sources." Its website is set up to allow registered users to add or change repeater information in the master database. I checked the information on my UHF repeater and found it to be accurate, including a link to the page on my website that describes the repeater.

The iHam website says, "The database used by iHam Repeater Database was created by hand using a variety of publicly available information sources." You have the option of editing your local copy of the database on your smartphone and e-mailing in any errors that you find. The W4SMT website says that the data for the *Repeaters* app "has been collected from various sources, with the vast majority coming from the K5EHX.NET repeater search-engine database."

I have been trying out these three apps to see how accurate the information is for repeaters in my area (Denver/Colorado Springs, CO). All three of the apps had most of the local repeaters listed but the RepeaterBook app was the most complete, since it included a few repeaters that had recently come on the air. It is important to note that this is a limited test and does not represent usage across all of the U.S.

A few interesting issues emerged as I used these apps. The RepeaterBook app showed a repeater that was about eight miles away from my location that I didn't know about. It turns out that the repeater had been in operation for some time on a *Shared Non Protected (SNP)* frequency pair in the 2-meter band. Years ago, the Colorado frequency coordination body had set aside a few repeater pairs for use by any repeater, without the need for coordination. The repeater operator has to use tone access and tolerate interference from other repeaters on the same frequency. I checked the *ARRL Repeater Directory* and confirmed that the repeater was not listed there either. Since it is not a formally coordinated repeater, it was not included in the repeater information submitted to the ARRL. However, because the RepeaterBook information can be updated by any registered user, it has the repeater listed.

The mapping feature on the iHam and Repeaters apps is a really nice feature, but it reveals a problem with available repeater information. The actual geographical locations of many repeaters

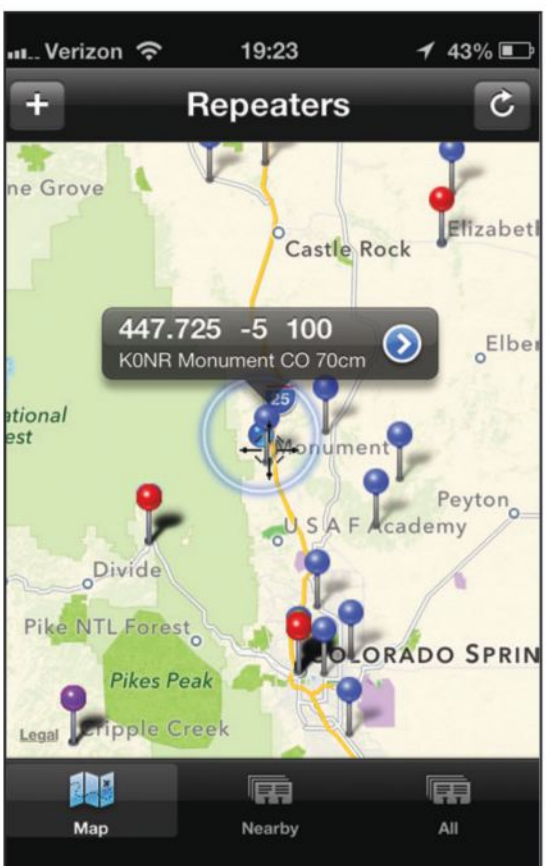

Figure 4. Some apps have the ability to map the location of repeaters. The Repeaters *app is shown here.*

are not included in the database. Instead, the nearest city or town is usually listed. The end result is the position of mountaintop repeaters is shown as downtown locations. In larger cities, there are dozens of repeaters all plotted on the same latitude/longitude associated with the city center. The mapping feature is still useful, since it gives you a rough idea of where the repeater is located. Just don't assume that the precise location shown is correct.

Conclusions

With the popularity and usefulness of smartphones, these repeater directory apps are the way to go. I probably have purchased my last printed repeater directory. (OK, maybe I'll keep one copy around in case all else fails.) All three of these apps did a reasonable job, so you won't go wrong with any of them. However, I have to give the edge to the RepeaterBook app since it is free and the repeater information was more up to date, at least in my area. Your mileage may vary.

Tnx and 73

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 shown on the first page of this column.

73, Bob, KØNR

By Bill Brown,* WB8ELK

UP IN THE AIR

New Heights for Amateur Radio

It's A Party!

To celebrate my dad's 88th birthday and as an early celebration of the 21st anniversary of my 39th birthday, my family met at my brother's house near Cincinnati, Ohio for a 4th of July family reunion.

The house was filled to capacity with 148 party balloons. There were multi-colored balloons everywhere. When my dad (Joe Brown, WB8MSJ), my brother (Jeff Brown, N8UEJ), and I get together some interesting experiments often result. During the party a question popped up about just how high a standard latex party balloon can go before it bursts. My niece Holly and my nephew Matthew also wanted to know if we put all 148 balloons together would they lift into the sky. We decided that wouldn't be a good idea.

Since I always carry a balloon tracking payload of some sort with me whenever I travel, we decided to hold a contest to see who could guess the peak altitude a large quantity of party balloons would reach before returning to the ground.

After the inevitable popped balloons as the kids played along with grown-ups inhaling helium to sing the "Lollipop Guild," we managed to salvage 42 balloons for our experiment.

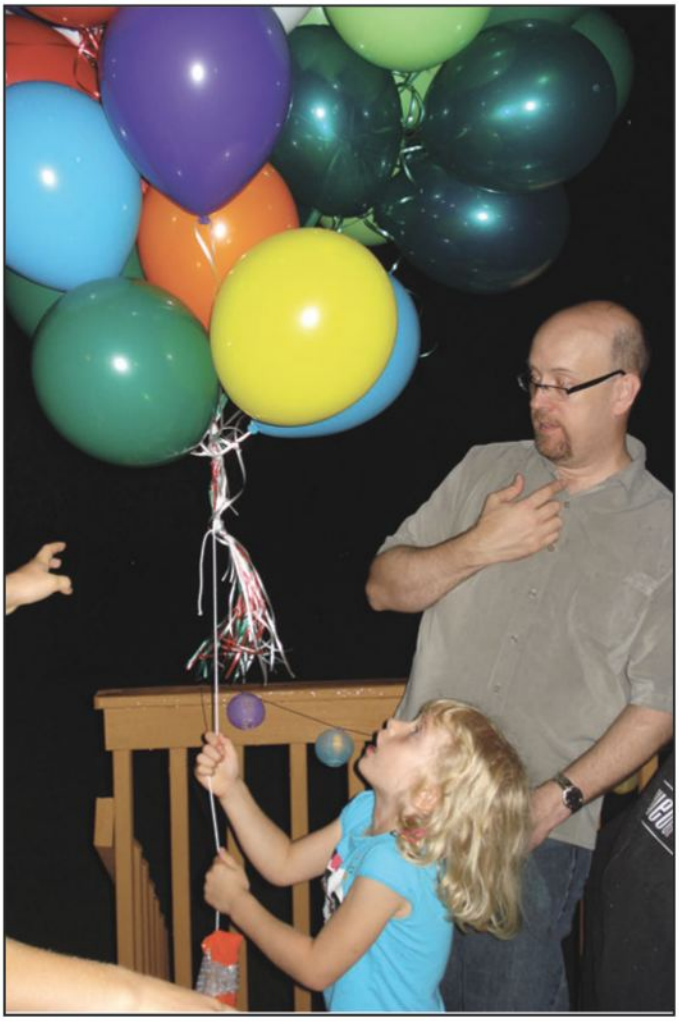

Photo 1. My niece Holly launches the party balloon payload while her father, Jeff Brown, N8UEJ, looks on.

HAB Supplies Tracker

Anthony Stirk, MØUPU, has been creating some micro-miniature high-altitude balloon trackers and GPS modules. You can find his creations at his HAB Supplies company: <http://ava.upuant.net/store/>.

Anthony developed a prototype board called the pAVA which incorporates a very tiny u-Blox MAX 6 GPS receiver and antenna, an RFM22B 434 MHz transmitter along with an Arduino-based Atmel 328p processor chip. This miniature marvel can transmit upwards of a 50-milliwatt RTTY signal on the 70-cm band and weighs less than an ounce. We left it at the default setting of 10 milliwatts output. Powered by two AAA lithium batteries this board can transmit its location and altitude for upwards of 18 hours. Not bad for a total payload weight of under two ounces. Just perfect for a party balloon special. I just happened to have one in my car, so I just mounted it on a small piece of foam and wrapped it with some bubble wrap.

We Have Liftoff

Amidst a barrage of 4th of July skyrockets and bottle rockets, we gathered on my brother's porch. After an enthusiastic countdown, my niece Holly launched the balloons as they headed on their journey to answer our question.

The 42 multi-colored balloons carried our payload aloft at a steady clip after a few near misses by a skyrocket or two. To receive the 434-MHz USB telemetry I used a FunCubeDongle Pro+ plugged into my Netbook's USB port, HDSDR software interface, and dl-FLdigi to decode the 50-baud ASCII RTTY signal. I used a 5-element Arrow Antenna pointed out the window and had perfect copy of the balloon's location and altitude throughout the flight.

After just 20 minutes the balloons had drifted 6 miles to our north and finally leveled off at 4209 feet (1283 meters). Then it gradually started to come back down at almost the exact same rate as it went up. Just 20 minutes after leveling off, our party-balloon payload landed 12 miles north of us. The Google map showed the landing site in a small tree farm easily accessible by a road. We decided to head out after it the next morning to search for it during daylight.

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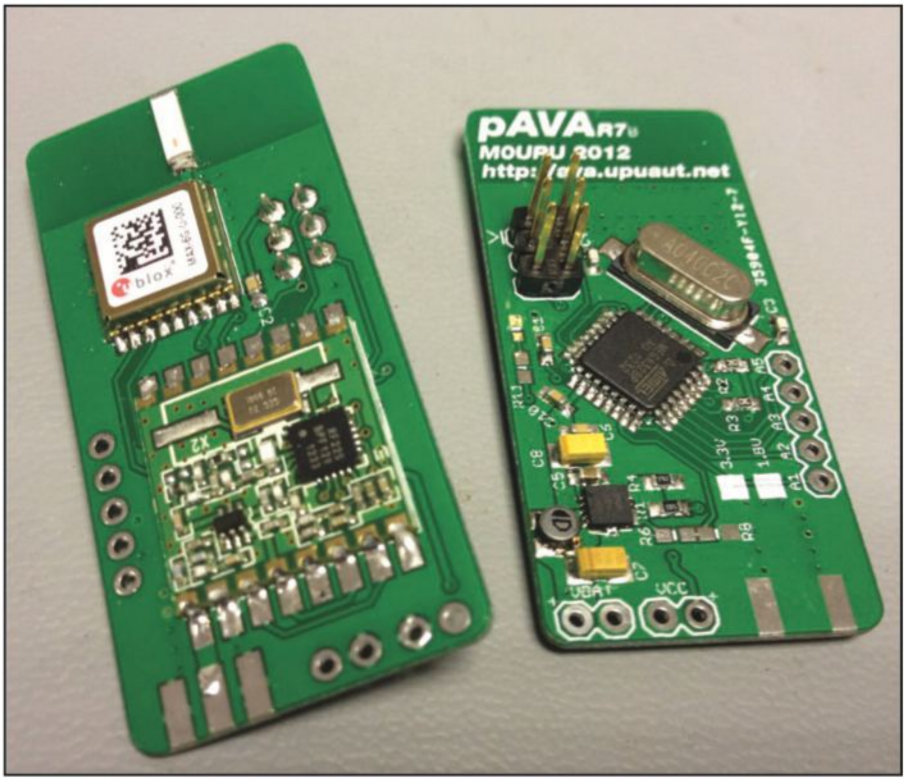

Photo 2. The micro-miniature pAVA R7 GPS tracker from HAB Supplies.

Surprise Recovery

We arrived at the tree farm expecting to make an easy recovery of bright balloons sitting out in a field. However, when we arrived at the coordinates there was nothing to be seen anywhere. My co-pilot, Bev Teter, KK4RPQ, wondered if it had landed in the tall cornfield across the street from the tree farm. We looked across the cornfield but didn't see anything that resembled brightly colored balloons. Then I caught a brief glimpse of a green color that was slightly different than a normal cornstalk. We walked about 50 feet into the corn and found that all of the red balloons and our payload were lying on the ground between the rows of corn and only a couple of green balloons were near the top of the cornstalks but none were above the corn, having lost most of their helium during the night.

This was a fun flight solving a question that I've often wondered about, all thanks to incredible micro-miniature of modern GPS and transmitter technology, and of course we had a blast popping dozens of balloons to get everything back in our car.

73, Bill, WB8ELK

Photo 3. The party balloons and tracker were found nestled in between two rows of corn about 50 feet from the road.

Photo 4. Bill, WB8ELK, makes a successful recovery in the cornfield.

By Kent Britain,* WA5VJB

ANTENNAS

Connecting the Radio to the Sky

Transmission Lines . . . and more

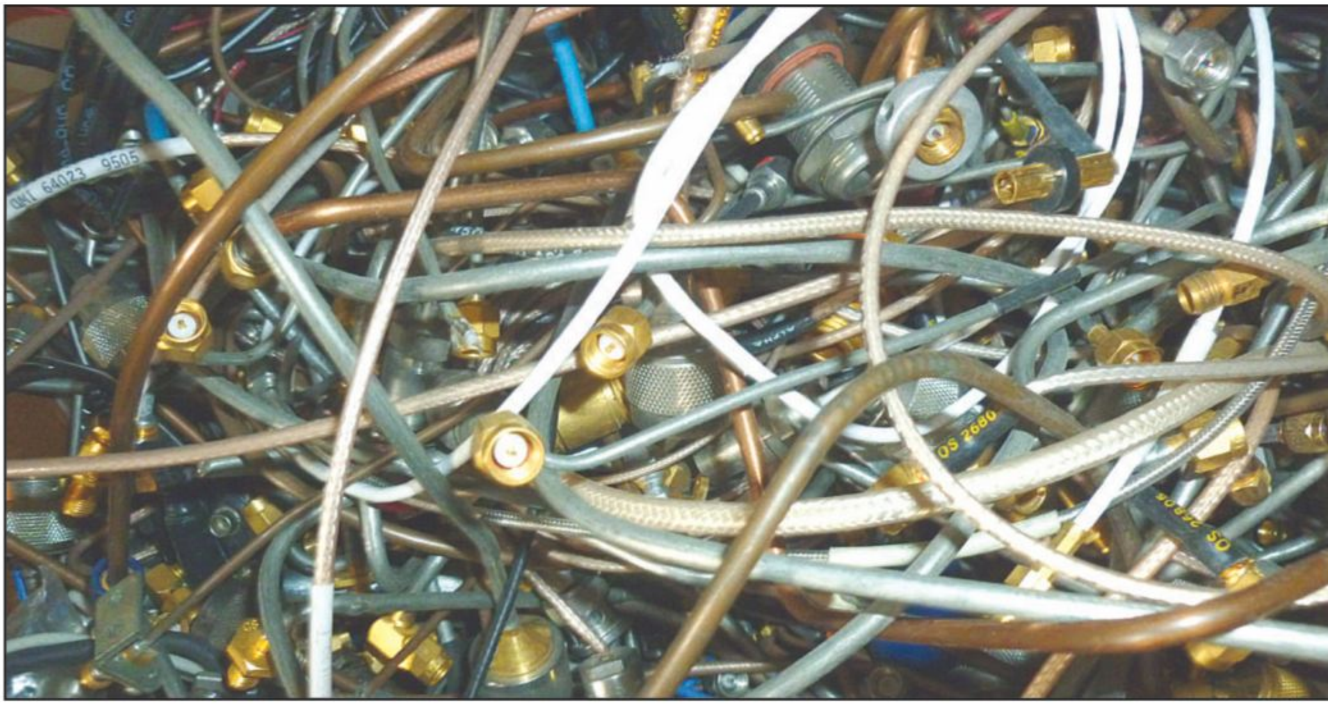

Photo A. A small sample of my simi-rigid coax collection.

This time we will be looking at transmission lines and a few techniques for your tool box. (See photo A.)

Quite often you may want to go from a 50-ohm to a 72-ohm line as in figure 1. This is much like the old fable about boiling a frog. Put the frog in the pot and slowly turn up the heat, so it's nice and warm. The frog never realizes he's in the cooking pot until it's too late.

We all know that a sudden change in impedance causes an impedance bump, or SWR. But what happens when we boil that frog? That is, we change the temperature/impedance slowly. There is no sudden bump or change in impedance, thus no SWR reflection. (I can just see all the e-mails now. An SWR is a reflection, and I know that, but it really brings across the point.)

In figure 2 we have the classic quarter-wave power divider: a 50-ohm line, then two 75-ohm lines to split the power, then our two 50-ohm loads. This type of power divider can be used to combine the input of two amplifiers, combine the output of two amplifiers, or combine two antennas. The power divider makes for handy combiners and is used in many antenna projects. If the two loads are not well matched, there are advantages to adding a 100-ohm balancing resistor, but we will leave the resistor in these examples. The quarter-wave power dividers as in figure 2 are well balanced over about 10% bandwidth, and usable over a 20% bandwidth.

But let's say I want to combine two broadband amplifiers, or perhaps two wide-band antennas such as two discones or two log periodics. Now we need a good impedance match not on one frequency, but a wide range of frequencies. Here is where the tapered lines shown in figure 3 become quite useful.

The ideal way is to taper the diameter of the center conductor. It's possible, but certainly not easy in most cases. Another way is to taper the shield as in photos B and C. A belt grinder works great, and if you get desperate, a good old file will do the trick.

You want the taper to be at least a quarter wave on the lowest frequency on which you plan to use the divider/combiner. With tapered line, longer is better.

Also, if you are looking to match most any impedance between 50 and 120 ohms, have a look at figure 4. You just need to spend at bit more, or a bit less, time on the belt sander.

On a printed circuit board, a tapered line is much easier to do. In photo D is a power divider using a tapered line.

Backing up a bit, the height and width of a patch antenna determines the center frequency and bandwidth of that patch. It also affects the impedance of the patch. On this particular board, the patches have been designed to have a 100-ohm edge impedance. I bring the two 100-ohm traces together, and they look like a 50-

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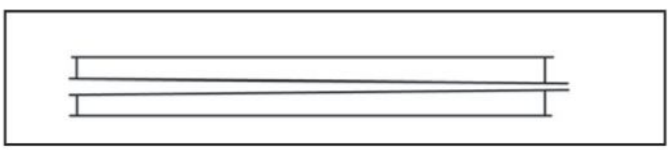

Figure 1. 50- to 75-ohm tapered coax.

ohm load. I then taper the 50-ohm line down to 100 ohms again, bring in the other 50–100-ohm taper, and this gives me a 50-ohm feed point in the middle.

On this board the little hole in the middle is a connection to the back ground plane and the coax is soldered on to the back of the patch array.

Yes, I could have done all this impedance matching with odd quarter-wave multiples of different impedance lines. This way the 100-ohm lines can be any length. Oh, they have to be the same length, but there is no magic length.

It's the same for the 50–100-ohm taper lines. Again, there is no magic length for a proper impedance match. I sure made the board layout a lot easier.

For a much longer length of coax, there is a technique I really don't recommend:

I have seen others take a length of copper-shielded coax and slowly lower it into an acid bath and etch away the copper at a

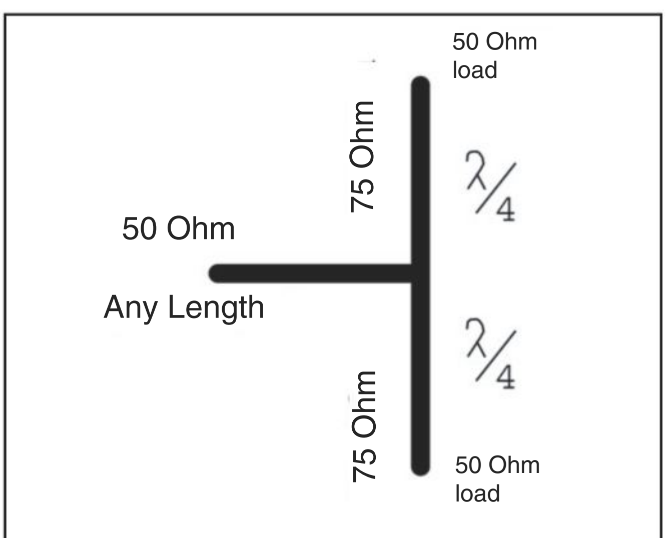

Figure 2. Impedance of different shield trims.

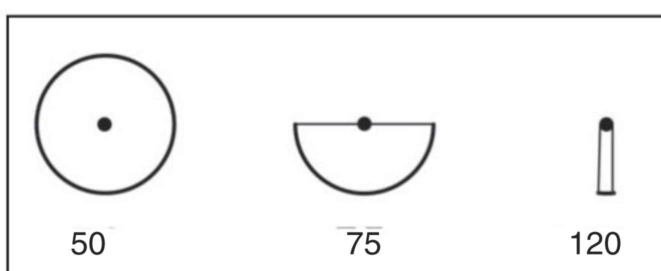

Figure 3. Classic quarter-wave power splitter/combiner.

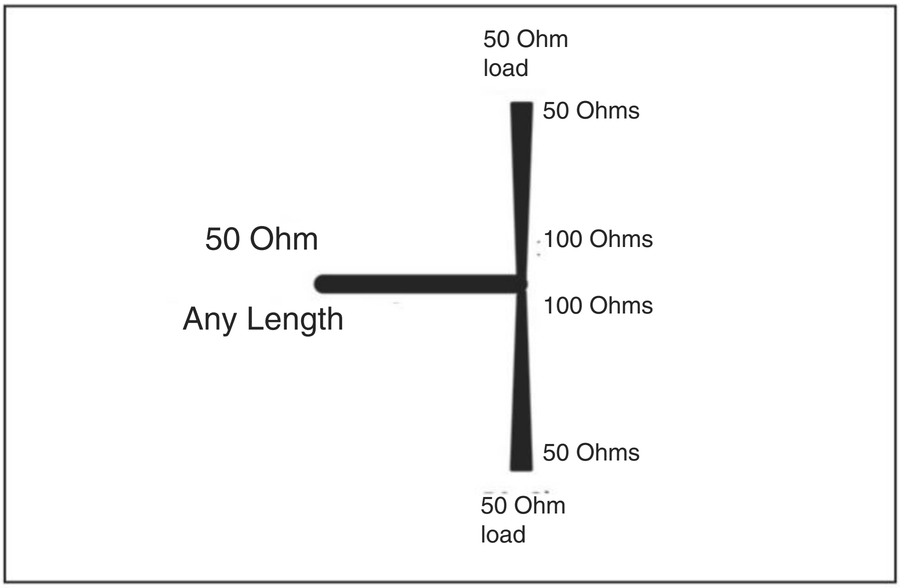

Figure 4. Tapered line power divider.

tapered angle. It worked fine, took a bit of cleanup, but I know I don't have a large pan of acid strong enough to etch away copper like that on my work bench, nor would I want one!

Here is another technique for making 75-ohm semi-rigid coax from Terry, W5ETG, shown in photo E. The RG-141 semi-rigid coax is used in a lot of surplus equipment and has very low loss. At microwave frequencies that little RG-141 coax has about the same loss as RG-8. Now this technique only works for short pieces, up to 6 inches or so, but you grab the center conductor with a pair of pliers and put it out. The Teflon ® relaxes a bit and the hole shrinks a bit. You pulled out a 19-gauge wire, and if you work quickly, you can push a 24-gauge back in. Do this quickly, as you don't want to wait more than a few minutes, or the Teflon® will spring back too much. With the smaller center conductor you have just converted 50-ohm coax to 75-ohm coax!

This last one is a technique I learned from W5LUA (see photo F). When we get way up in frequency, phase matching mixers, amplifiers, circular polarized antennas, etc., apply.

Phase-matching lines to critical lengths can be very tedious. You can take some of that Teflon® insulation from some RG-141 coax and cut it into thin wafers.

Then slide the wafer over the center pin of the male SMA connector, increasing its length while you tighten the connectors. This is only good for about 1/8-inch maximum before the SMA pins no longer mate, but it has proven handy.

As always we welcome questions and column suggestions from our readers. An e-mail to wa5vjb@cq-VHF.com is a good way to contact me. For other antenna articles and construction projects you are welcome to visit my website, <www.WA5VJB.com>.

73, Kent, WA5VJB

Photo B. Tapered coax.

Photo C. Tapered coax side view.

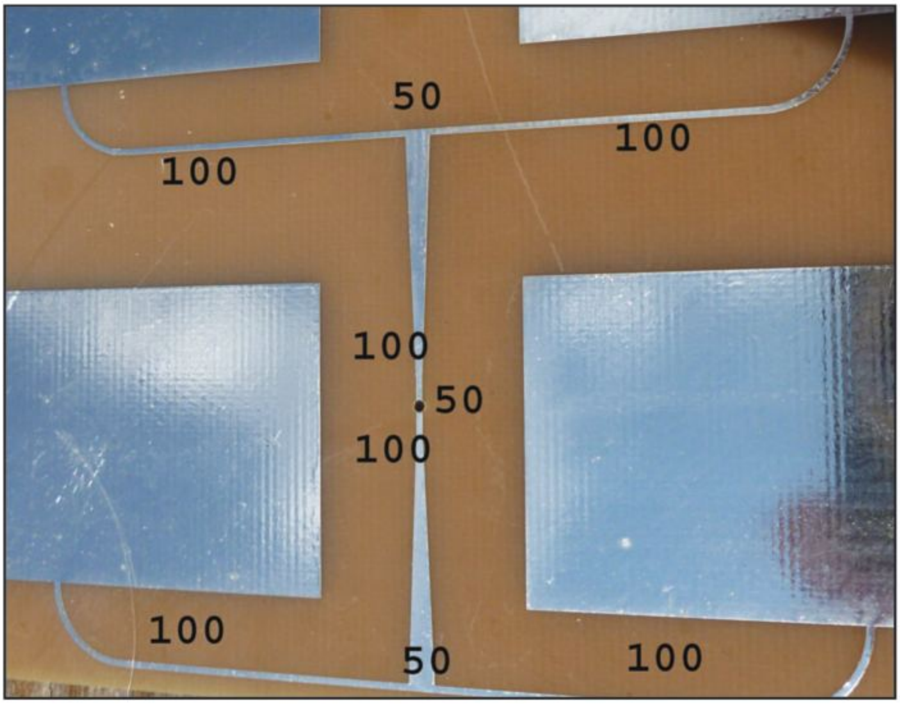

Photo D. Tapered power divider for a quad patch antenna.

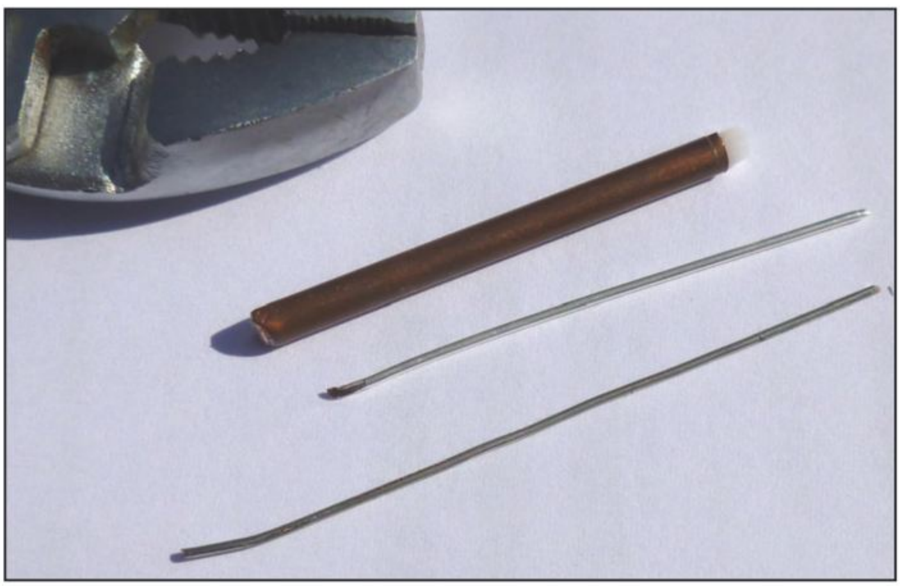

Photo E. Converting 50-ohm coax to 75-ohm coax.

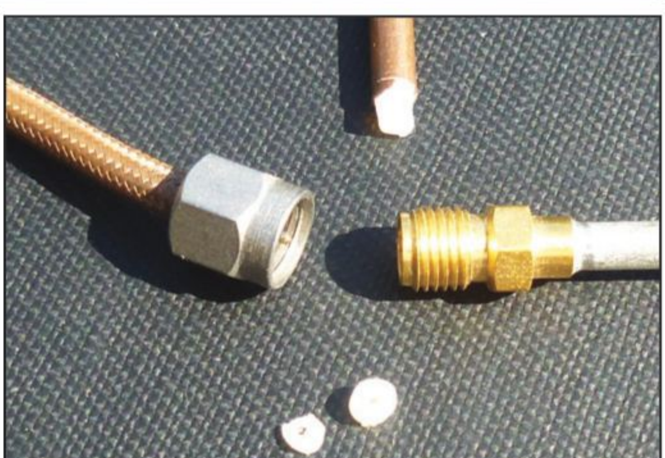

Photo F. SMA spacers.

By Tomas Hood,* NW7US

VHF PROPAGATION

The Science of Predicting VHF-and-Above Radio Conditions

Why the Sun Matters on VHF

In the last few editions of this column, we have been looking at the ionosphere, space weather, and the Sun. Those who follow this column know that VHF radio communications is directly affected by the variable Sun. Sunspots, coronal mass ejections (CMEs), the Earth's geomagnetic field, the ionosphere, and even terrestrial weather all affect how our radio signals get from transmitter to radio receiver. Taking a look at the Sun is helpful in gauging its activity, and therefore helpful in figuring out what sort of conditions we might experience while trying to get our radio signal from our station, through the atmosphere via the ionosphere, to a distant station.

With the space age came a way to deploy many of these special instruments out into space, beyond the natural filtering of the atmosphere. In 2010, NASA launched a United Launch Alliance Atlas V-401 rocket with a spacecraft tasked with observing the Sun and solar dynamics (space weather) with some of the most advanced instruments yet. This spacecraft is called the Solar Dynamics Observatory (SDO). SDO is the first satellite under the Living With a Star (LWS) program at NASA, and is the most advanced spacecraft ever designed to study the Sun. During its mission, it is examining the Sun's magnetic field and providing a better understanding of the role the Sun plays in Earth's atmospheric chemistry and climate. SDO provides images with clarity ten times better than high-definition television. It transfers all of this comprehensive science data faster than any other solar observing spacecraft. The images often included in this column are captured by the special instruments aboard SDO.

SDO sends approximately 1.5 terabytes of data back to Earth each day, which is equivalent to a daily download of half a million songs onto an MP3 player. The observatory carries three state-of-the-art instruments for conducting solar research.

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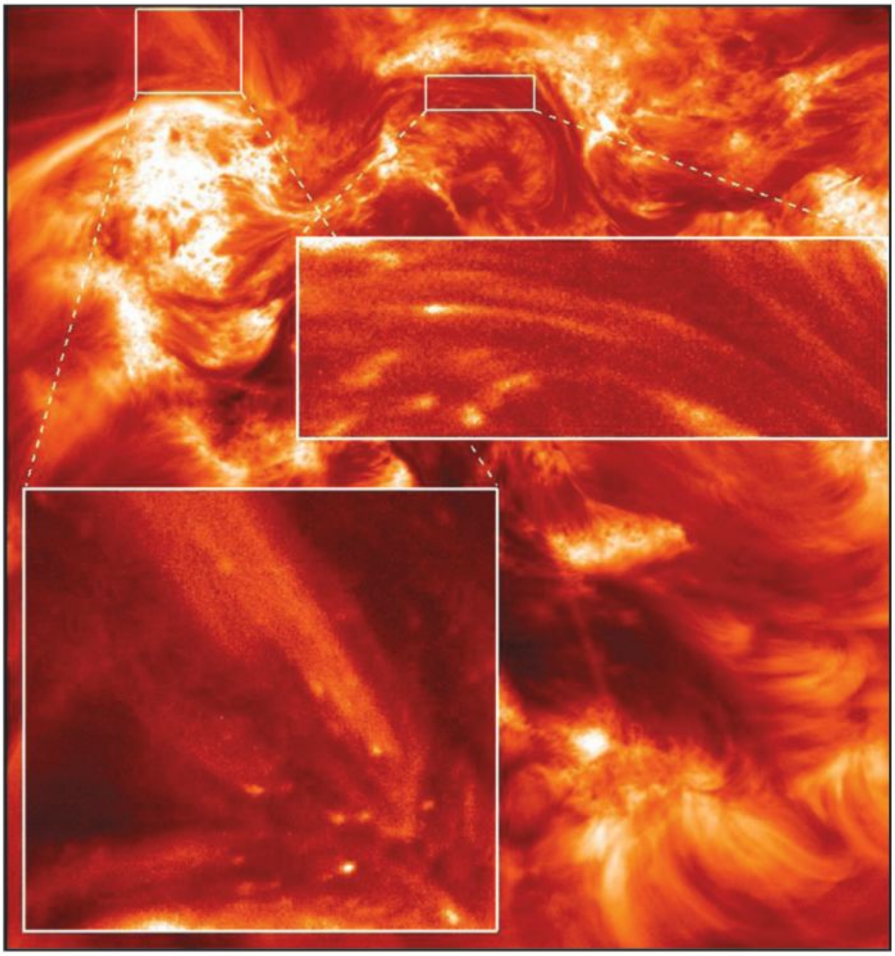

Figure 1. Image of an active, magnetically complicated region of the Sun captured by the new Hi-C instrument. It shows plasma in the outer solar atmosphere at a temperature of 1–2 million degrees Celsius. The inset box at bottom left shows "sparkle" features that are releasing vast amounts of energy into the corona. The box at top right shows a close-up of part of a solar filament where "blobs" of solar plasma flow along thread-like "highway" structures. (Credit: NASA, MSFC, and UCLan)

The Helioseismic and Magnetic Imager (HMI) maps solar magnetic fields and looks beneath the Sun's opaque surface. The experiment deciphers the physics of the Sun's activity, taking pictures in several very narrow bands of visible light. Scientists will be able to make ultrasound images of the Sun and study active regions in a way similar to watching sand shift in a desert dune.

The Atmospheric Imaging Assembly (AIA) is a group of four telescopes designed to photograph the Sun's surface and atmosphere. The instrument covers ten different wavelength bands, or colors, selected to reveal key aspects of solar activity. These types of images show details never before seen by scientists (for example, watch a movie utilizing the high-definition imagery captured by SDO's AIA instruments of a plasma ring formed on the Sun by massive magnetic structures (http://g.nw7us.us/15bzQvV).

The Extreme ultraviolet Variability

Experiment (EVE) measures fluctuations in the Sun's radiant emissions. These emissions have a direct and powerful effect on Earth's upper atmosphere—heating it, puffing it up, and breaking apart atoms and molecules (of interest to radio communicators, since this directly affects the ionosphere).

"These amazing images, which show our dynamic Sun in a new level of detail, are only the beginning of SDO's contribution to our understanding of the Sun," said SDO Project Scientist Dean Pesnell of Goddard.

In April, NASA released an incredible movie that shows a massive solar prominence erupting on March 30, 2010. (You can view it at <http://g.nw7us.us/15bABVA>.) "We've seen solar prominences before—but never quite like this," says Alan Title of Lockheed Martin, principal investigator of the AIA. "Some of my colleagues say they've learned new things about prominences just by watching this one movie."

The successful launch and deployment of SDO is great news for radio hobbyists, on many levels! "SDO is our 'Hubble for the Sun'," says Program scientist Lika Guhathakurta of NASA headquarters. "It promises to transform solar physics in the same way the Hubble Space Telescope has transformed astronomy and cosmology."

"No solar telescope has ever come close to the combined spatial, temporal and spectral resolution of SDO," adds Title. "This is possible because of the combination of 4096 × 4096-pixel CCDs with huge dynamic range and a geosynchronous orbit which allows SDO to observe the Sun and communicate with the ground around the clock."

Because specific wavelengths convey information about different components of the Sun's surface and atmosphere, scientists use them to reveal the "secrets" of our constantly changing and varying star.

New, Additional Views of the Sun

New spacecraft with specialized instruments have been developed and deployed to further help our understanding of our Sun, and how the Sun creates space weather. Never before have we had such a high-definition view of the inner workings of the Sun's atmosphere. These new instruments add to the already stunning capability of SDO.

One recent development is the exciting Hi-C instrument (High-resolution Coronal Imager), which has already uncovered an amazing amount of detail within the hot outer atmosphere of the Sun (the corona). The camera imaged electrified plasma at about 1 million degrees C and exposed phenomena scientists had never seen before. The Hi-C camera was launched on a sounding rocket on 11 July 2012 and was a collaboration between NASA, the University of Central Lancashire (UCLan), and many international partners.

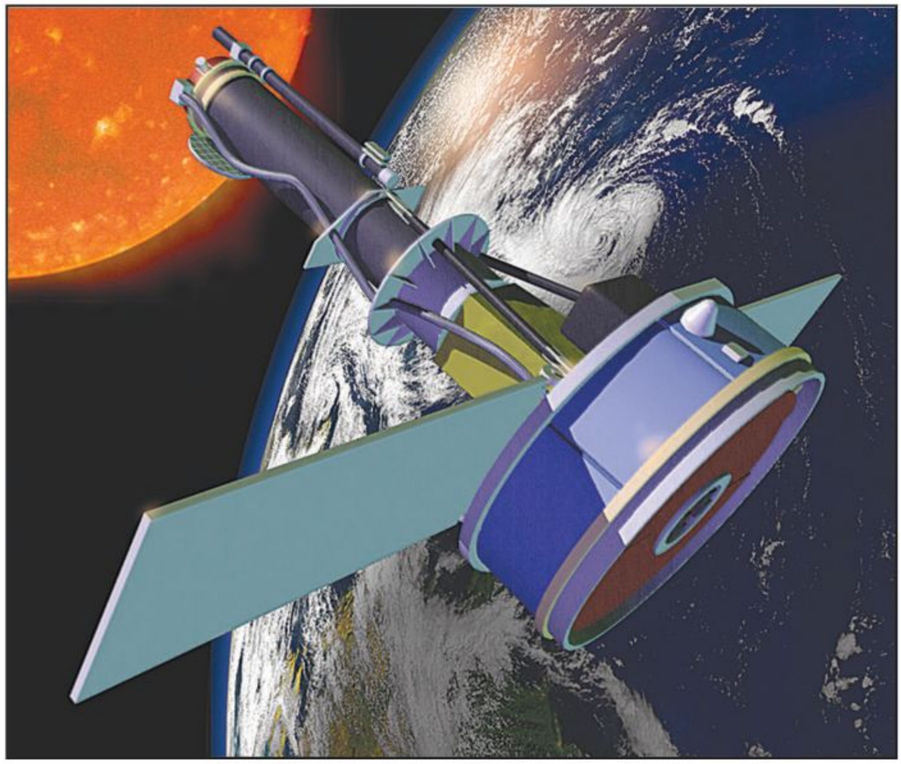

Figure 2. Artist's conception of the IRIS satellite in orbit. (Credit: NASA)

The team of scientists that created the special camera discovered fast-track "highways" and intriguing "sparkles" that may help answer a long-standing solar mystery. UCLan solar physicists have been analyzing the data and have focused on two interesting phenomena. In a movie captured by the Hi-C camera (watch the movie at <http://g.nw7us.us/12adqrZ>), the box on the bottom left shows a blown-up area of dynamic "sparkles" which give out an enormous amount of energy. The box on the top-right shows a more detailed view of fast plasma flows observed along magnetic field lines. Both observations are unique and have not been seen with previous instrumentation. Understanding the corona on the smallest scales is vital for uncovering how the Sun's atmosphere is heated to such high temperatures.

The new camera observed the Sun in extreme ultraviolet light and focused on a large, magnetically active sunspot region. During their study, scientists discovered a number of new features in the corona, including patches of gas moving along "highways," bouncing and deflecting along these passages, and bright dots that alternate between "on" and "off" rapidly, which the scientists call "sparkles."

In the new images, small concentrations of electrified gas (plasma) at a temperature of about 1-million degrees Celsius are seen racing along highways shaped by the Sun's magnetic field. These blobs travel at around 80 km per second (the equivalent of 235 times the speed of sound on Earth). These highways are 450 km across.

The flows of solar material are inside a plasma filament, a region of dense plasma that can break away outward from the Sun. These eruptions, known as CMEs, carry billions of tons of plasma into space. If a CME travels in the right direction it can interact with Earth, disturbing the terrestrial magnetic field (the geomagnetic field, the activity of which we report in the *Kp* and *Ap* indices) in a "space weather" event that can have a range of destructive consequences from damaging satellite electronics to overloading power grids on the ground—but which often create a perfect chance for the VHF radio enthusiast to propagate a radio signal off the ionospheric *E*-region during the resulting auroral events. The discovery and nature of the solar highways allows scientists to better understand the driving force for these eruptions and help predict with greater accuracy when CMEs might take place.

Another new set of images could help explain an enduring mystery of the Sun. Astronomers have long struggled to understand why, with a temperature of 2-million degrees, the corona is around 400 times hotter than the solar surface. Hi-C images reveal dynamic bright dots that switch on and off at high speed.

These "sparkles" typically last around 25 seconds, are about 680 km across, and release at least 1024 Joules of energy in

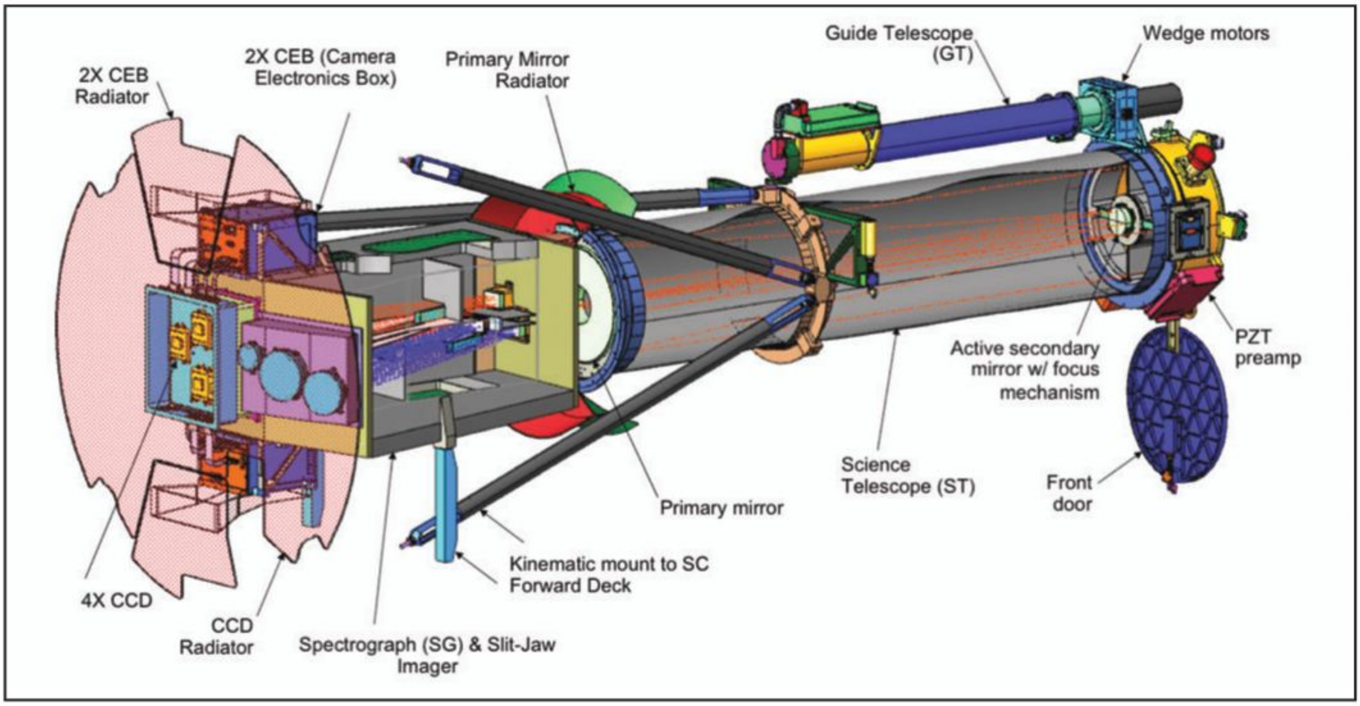

Figure 3. This cutaway diagram shows the IRIS spacecraft components, without solar panels for clarity. (Credit: NASA/LMSAL)

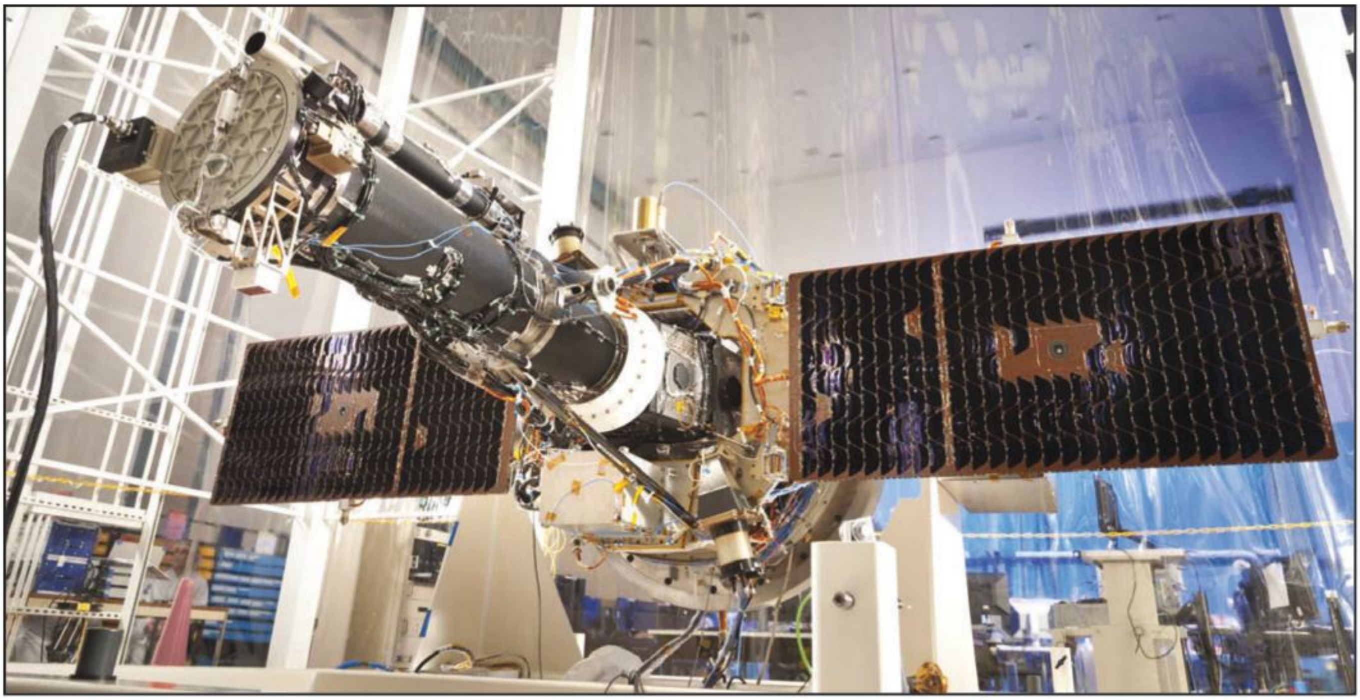

Figure 4. The fully integrated spacecraft and science instrument for NASA's Interface Region Imaging Spectrograph (IRIS) mission is seen in a clean room at the Lockheed Martin Space Systems Sunnyvale, California facility. The solar arrays are deployed in the configuration they will assume when in orbit. (Credit: Lockheed Martin)

each event, or around 10,000 times the annual energy consumption of the population of the United Kingdom (based on information from the UK Department of Energy and Climate Change). The sparkles clearly show that enormous amounts of energy are being added into the corona and may then be released violently to heat the plasma.

You can read more about the Hi-C sounding rocket and camera at <http://g.nw7us.us/12aebBp>.

The Interface Region Imaging Spectrograph (IRIS) Spacecraft

Using a Pegasus rocket on June 26, 2013, NASA deployed a new spacecraft that adds a powerful tool to the line-up of instruments now observing the Sun in amazing detail. NASA's Interface Region Imaging Spectrograph (IRIS) spacecraft was successfully launched and placed into orbit for a new study of our closest star's atmosphere. Such a study is important for many reasons, but to the VHF radio communicator, it plays a key role in understanding the science of the Sun and how the Sun affects space weather.

The IRIS mission is to understand the interface between the Sun's photosphere and corona, a fundamental challenge in solar and heliospheric science. The IRIS mission opens a window of discovery into this crucial region by tracing the flow of energy and plasma through the chromosphere and transition region into the corona using spectrometry and imaging.

IRIS is designed to provide significant new information to increase our understanding of energy transport into the corona and solar wind and provide an archetype for all stellar atmospheres. The unique instrument capabilities, coupled with state-of-the-art 3-D modeling, will fill a large gap in our knowledge of this dynamic region of the solar atmosphere. The mission will extend the scientific output of existing heliophysics spacecraft that follow the effects of energy release processes from the Sun to Earth.

In the many years since the telescope was first used to observe the Sun, scientists have learned that the Sun is a gaseous sphere with a large "atmosphere." This atmosphere can be divided into three major sections, at which we'll now take a closer look.

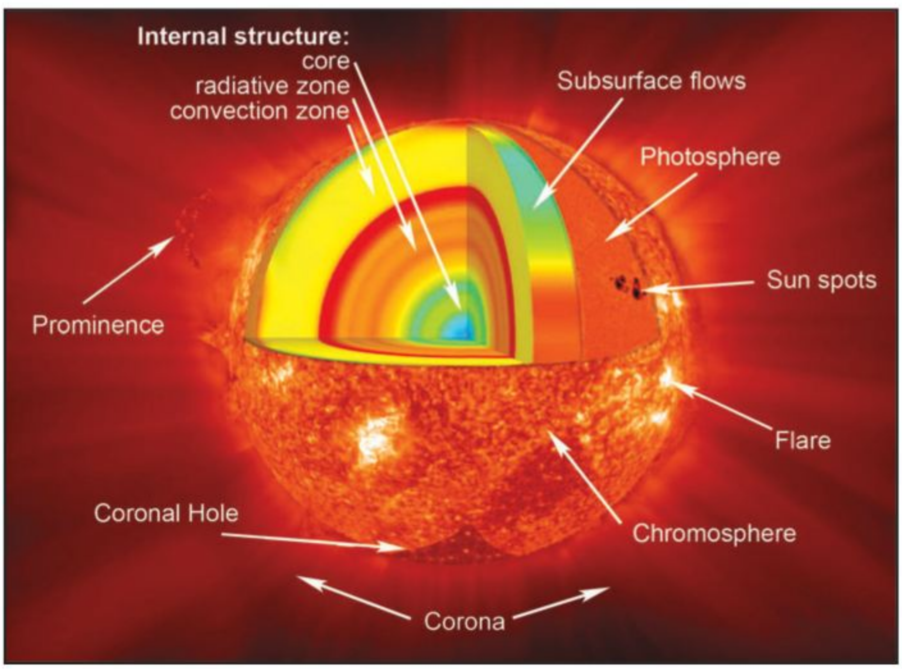

Figure 5. The sun and its atmosphere consist of several zones or layers. From the inside out, the solar interior consists of: the core (the central region where nuclear reactions consume hydrogen to form helium; these reactions release the energy that ultimately leaves the surface as visible light.); the radiative zone (extends outward from the outer edge of the core to base of the convection zone, characterized by the method of energy transport—radiation.); the convection zone (the outer-most layer of the solar interior extending from a depth of about 200,000 km to the visible surface where its motion is seen as granules and supergranules). The solar atmosphere is made up of: the photosphere (the visible surface of the Sun); the chromosphere (an irregular layer above the photosphere where the temperature rises from 6000°C to about 20,000°C); a transition region (a thin and very irregular layer of the Sun's atmosphere that separates the hot corona from the much cooler chromosphere); the corona (the Sun's outer atmosphere). Beyond the corona is the solar wind, which is actually an outward flow of coronal gas. The Sun's magnetic fields rise through the convection zone and erupt through the photosphere into the chromosphere and corona. The eruptions lead to solar activity, which includes such phenomena as sunspots, flares, prominences, and coronal mass ejections. (Credit: NASA/Goddard)

The Photosphere

When we observe the Sun through a simple white-light projection instrument (like the telescope and white-paper screen), we think we're seeing the "surface" of the Sun, but this visible projection is only revealing the deepest region of the Sun's atmosphere, known as the *photosphere*.

We don't see fully into the 300-kilometer depth of the photosphere because the density of the gases in this region increases so rapidly, it quickly becomes opaque to our telescope. And, while the mass that makes up the photosphere only contains about one-fifth of a billionth of the mass of the Sun, it is from the photosphere where most of the solar energy is radiated. This energy is in the form of visible and infrared light—and that is exactly why it is known as the photosphere, which means "light sphere." Additionally, this is the area of the Sun in which sunspots appear.

The Chromosphere

Sunspots are the darker (cooler) regions on the Sun which develop because of complex magnetic regions causing a slow-down of the solar convection, cooling the region where these magnetic structures punch through. When we view the photosphere and these sunspots, though, we cannot see the complex magnetic structures involved. Much more complex solar structures can be "seen" by viewing the region above the photosphere, known as the *chromosphere* (or "sphere of color"). If we wish to view the chromosphere, we either have to have special equipment, or we have to observe it during a total eclipse (either natural or man-made).

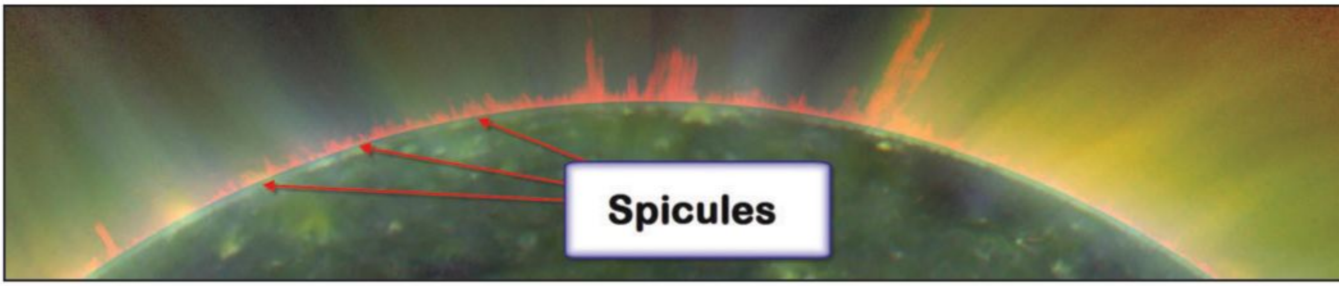

Figure 6. Using special instruments aboard the Solar Dynamics Observatory (SDO) spacecraft, this composite of several images taken at various wavelengths reveals features in the Sun's chromosphere. In this image, we can clearly see the many spicules. (Credit: SDO)

If we view the chromosphere during an eclipse, it appears as a reddish ring (some say, of fire!) around the solar disc. When all of the light from the solar disc is blocked from our view, the chromosphere finally can be revealed.

Specially equipped telescopes can also see the chromosphere. If hydrogen-alpha (H-alpha) filters are added to the telescope, their very narrow spectral band-pass can allow us to view the chromospheric region and observe the complex structures it contains. Using these instruments, we can produce the *filtergram,* a powerful tool for observing solar activity.

Some amazing sights can be seen in the chromosphere! Often, we can see "whispy" jets of solar plasma rising out away from the Sun. These jet-like structures are known as *spicules* and span a few hundred kilometers in diameter. These are what give the reddish ring around the eclipsed solar disc the common name "the solar ring of fire."

The temperature of the solar atmosphere from the photosphere to the upper chromosphere changes rapidly with height, particularly near the upper chromospheric region known as the *transition region*. The temperature just above the photosphere is approximately 6,500 to 5,000 Kelvin (K). After the height of about 500 km, the temperature rises until approximately 2,200 km, where the temperature jumps rapidly from about 7,000 K up to about 24,000 K!

Within the photosphere (from about 0 to 500 km), the temperature drops due to a decrease in the density of negative hydrogen ions. This reduces the ability of the photospheric gas to absorb energy. Above 500 km, the temperature increases gradually because of non-radiative energy transport. This results in an increase in the ionization of hydrogen atoms as well as a greater number of free protons and electrons. The electrons become available for collisional excitation of specific atoms and ions, which then de-excite by emitting radiation at the specific atomic spectral lines. However, there is a process that hinders the control of temperature, causing the temperature to increase very sharply by nearly 20,000 degrees above 1,900 km above the photosphere.

Above the lower chromosphere, the solar magnetic field begins to play an important role. Magnetic field lines in an ionized gas or plasma are susceptible to wave motions. These waves are created when a magnetic field line is pulled sideways and then released. Tension in the field line sets up an oscillation. This is one of the methods that is probably responsible for heating the regions of the chromosphere above the lowest levels.

The Corona

The solar corona is the outer-most region of the Sun's atmosphere. When we

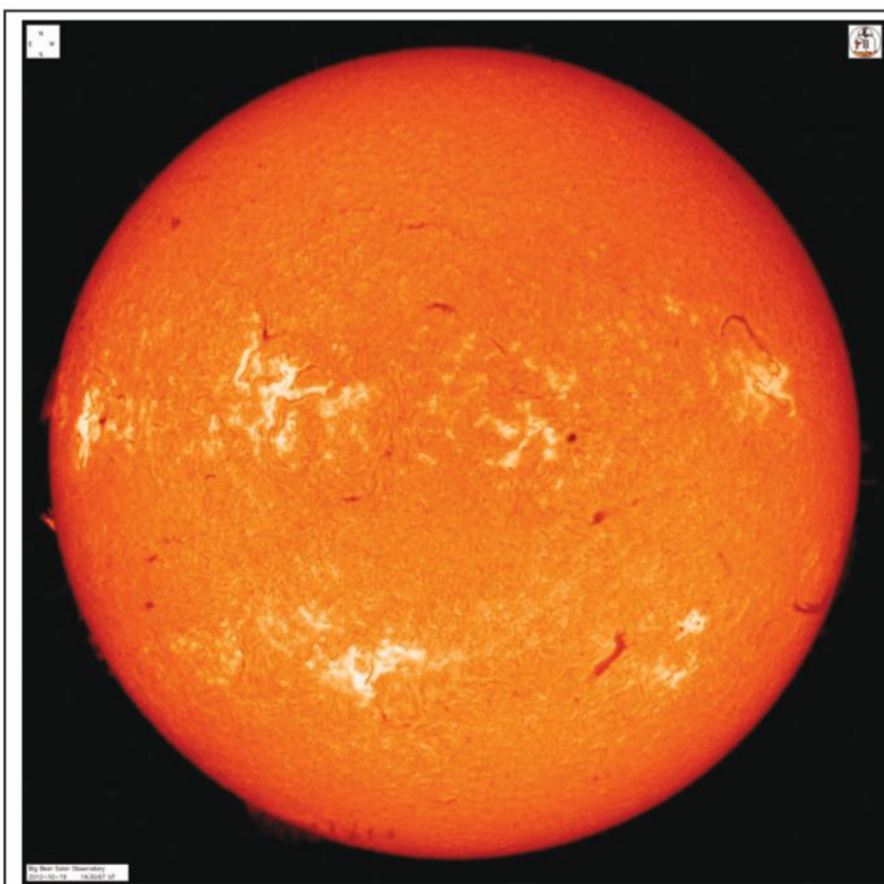

Figure 7. This image, taken on 19 October 2012 at the Big Bear Solar Observatory, was created using an H-alpha wavelength filter. This filter allows us to observe layers of the chromosphere, which is rich in active solar structures created by complex magnetic activity and plasma movement. (Credit: Big Bear Solar Observatory)

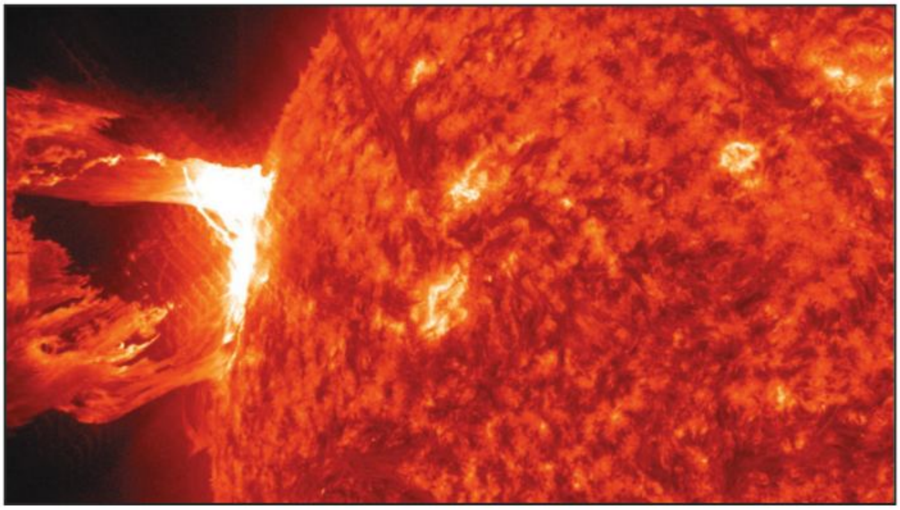

Figure 8. Scientists want to understand what causes giant explosions in the Sun's atmosphere, the corona, such as this one. The eruptions are called coronal mass ejections, or CMEs, and they can travel toward Earth to disrupt human technologies in space. To better understand the forces at work, a team of researchers used NASA data to study a precursor of CMEs called coronal cavities. (Credit: NASA/Solar Dynamics Observatory [SDO])

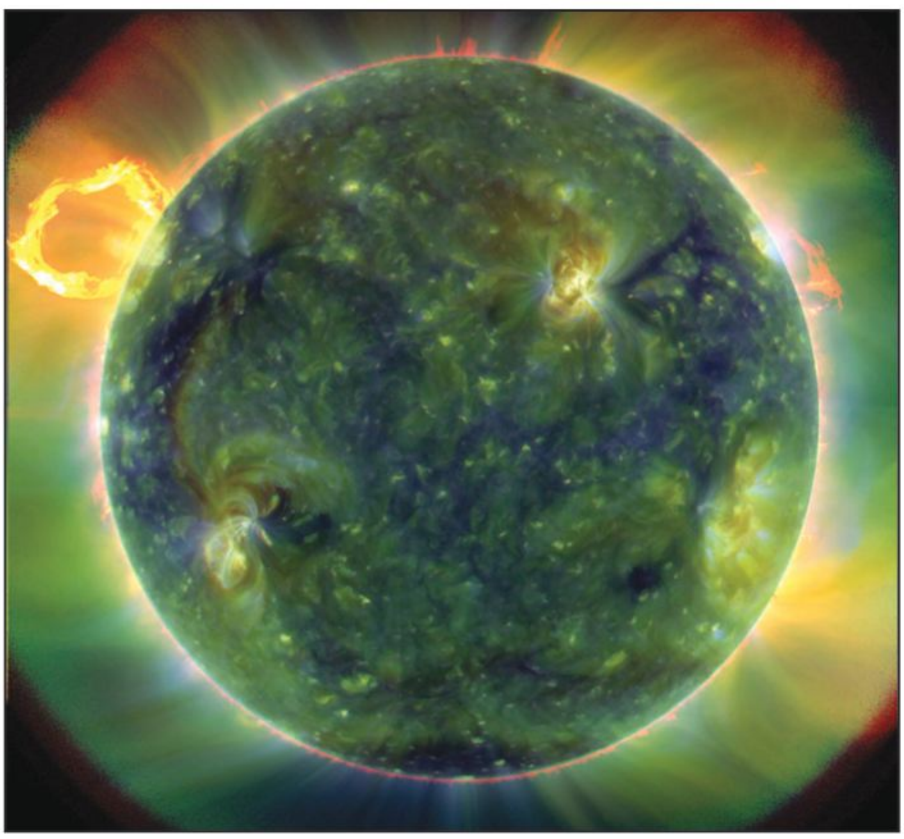

Figure 9. This stunning image is a composite made up of various individual images of the Sun, each taken at a different wavelength corresponding to a specific temperature. At these various temperatures, the special instruments aboard the spacecraft can "see" the different heights of the solar atmosphere. This image reveals the chromosphere and the coronal region of our Sun. The massive arching structure rises out of the chromosphere and is known as a solar prominence (or filament). Such structures may break away from the gravitational pull of the Sun and become a CME. (Credit: SDO)

view the Sun in white-light images, we see streamers, plumes, and other structures that extend outward from the solar chromosphere. While the temperatures in this region do vary, the average temperature is approximately 2,000,000 degrees Kelvin, with the exception of areas directly above active sunspot groups. In these regions, the corona's temperature can increase substantially higher.

Coronal temperatures are capable of generating x-rays and extreme ultraviolet light at wavelengths less than 100 nanometers (nm). The corona is also the origin of radio signals with wavelengths greater than a meter. This means that while the energy radiation from the corona is much less than that of the photosphere, the range of radiation from the corona is very much larger.

Scientists and astronomers have created special instruments, known as coronographs, which artificially block out the photospheric light by using an occulting disk. In other words, they create an artificial eclipse; a natural eclipse affords the same viewing opportunity. Typically, these instruments are located on mountaintops so as to be above weather, but more importantly, to be as high as possible to minimize the amount of atmosphere that could obscure the view. With the launch of the Solar Dynamics Observatory spacecraft, scientists now have an even closer view, and this column often includes images from SDO, showing the coronal region at various extreme ultraviolet wavelengths (and they are stunningly beautiful!).

Scientists have found that the corona changes shape over time-scales of minutes to years. The former is due to coronal transients, while the latter is related to the activity level of the Sun during the course of a sunspot cycle. An example of transient activity can be seen in images taken of coronal mass ejections, where we see huge clouds of coronal material bursting out away from the Sun, and the corona ripples in a very short time period.

Comparing a coronographic image taken during a sunspot cycle minima with one taken during sunspot maximum when many active sunspot groups are present, the difference in corona size and shape is pronounced. During the quiet phase of the cycle, the corona seems diminished, keeping much closer to the Sun; then during the cycle's peak phase the corona expands far out away from the Sun.

When viewing the corona in white-light, typically with an occulting disk,

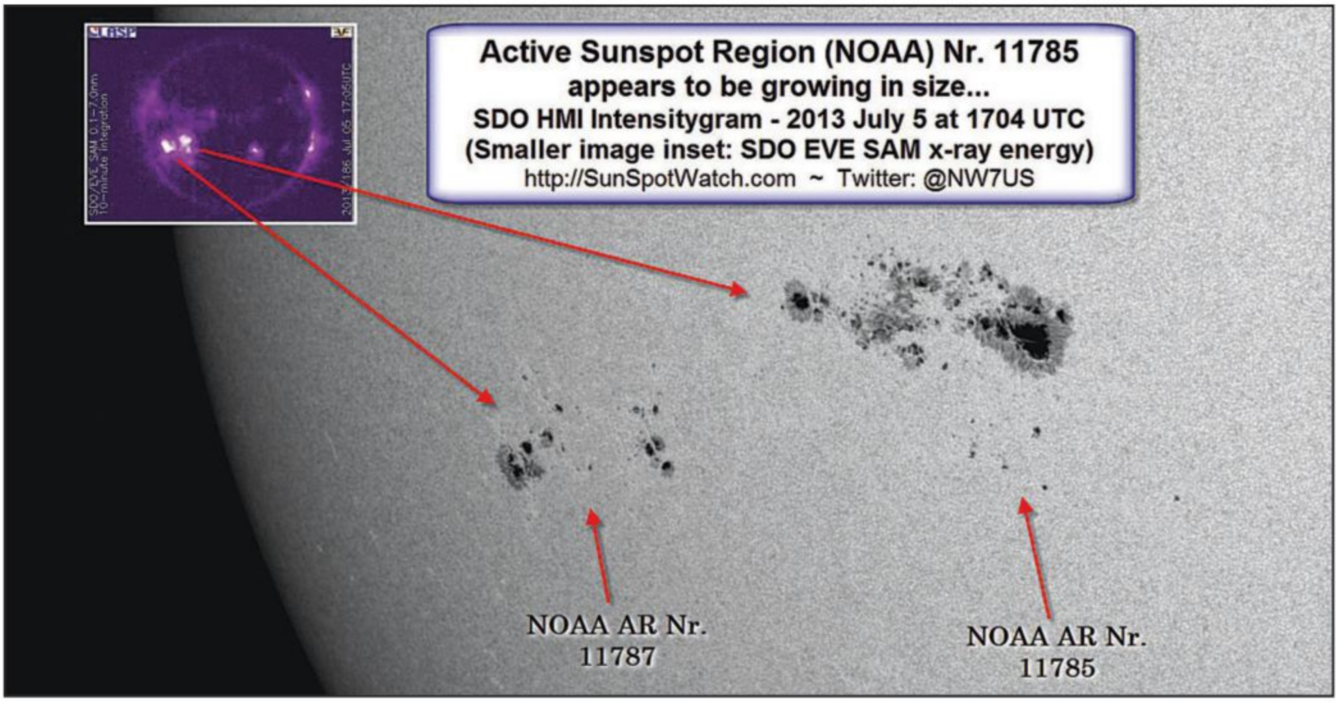

Figure 10. An active sunspot region (NOAA Active Region Number 11785) helped propagaiton on the highest HF band, and perhaps helped 6-meter propagation as well during July. This sunspot region is one of the biggest yet in sunspot Cycle 24. (Credit: SDO/EVE/AIA/HMI)

we're actually seeing the white-light radiation emanating from the photosphere. This is due to scattering of photospheric light off fine particles and free electrons. This light, seen in the white-light observations, are the same color as the Sun's photosphere.

The free-electron scattering component of the corona is known as the "K-Corona," named after the German Kontinuierlich (meaning "continuous; without break, cessation, or interruption in time"). It is the primary component of the observed light from a distance near the photosphere out to about 700,000 km above the photosphere (or about two solar radii as measured from the center of the Sun). The particle-scattered component of the coronal light is known as the "F-Corona," because this light contains a specific spectral "line" (a slice in the spectrum) known as a "Fraunhofer" line.

Both the K and F components of the corona decrease in intensity with increasing distance from the Sun. Beyond about 2.5 solar radii from the Sun's center, the F component dominates in brightness.

The intensity of coronal brightness is only about one millionths of the solar photosphere. If the corona could be moved well away from the Sun, it would have the same brightness as the full Moon. Of course, this is about as bright as the daytime sky as seen from Earth at sea level. That way observing the white-light corona at sea-level become difficult. Having a "front-seat" observatory such as the SDO spacecraft has revolutionized the way we can observe the Sun and the corona.

One important feature that occurs in the corona is the coronal hole. Additionally, CMEs appear to originate in the corona (which is why they are called *coronal mass ejections*).

An IRIS View of the Corona

The Interface Region Imaging Spectrograph (IRIS) uses very high-resolution images, data, and advanced computer models to unravel how matter, light, and energy move from the Sun's 6,000 K (10,240 F / 5,727 C) surface to its million K (1.8 million F / 999,700 C) outer atmosphere, the corona. Such movement ultimately heats the Sun's atmosphere to temperatures much hotter than the surface and also powers solar flares and CMEs.

"This is the first time we'll be directly observing this region since the 1970s," says Joe Davila, IRIS project scientist at NASA's Goddard Space Flight Center in Greenbelt, Maryland. "We're excited to bring this new set of observations to bear on the continued question of how the corona gets so hot."

A fundamentally mysterious region that helps drive heat into the corona, the lower levels of the atmosphere—namely two layers called the chromosphere and the transition region—have been notoriously hard to study. IRIS will be able to tease apart what's happening there better than ever before by providing observations to pinpoint physical forces at work near the surface of the Sun.

Armed with these instruments, solar and space weather scientists are poised to unlock new ways to forecast and understand the moment-by-moment interaction between the Sun and Earth (the Sun-Earth connection), and how space weather develops and impacts our Earth environment—including the ionosphere and geomagnetic fields. This, in turn, will equip the radio amateur with both a new understanding of this science, but, hopefully, more reliable ways to forecast when we can play on VHF with the hope of harnessing exotic modes of radio propagation.

The Solar Cycle Pulse

During the month of July, one of the biggest sunspot groups yet (NOAA Active Region AR11785) in current solar Cycle

24 emerged in the Sun's southern hemisphere. It did not produce many flares, but was responsible for increasing the 10.7-cm flux level to a point where some 10-meter F-region propagation was possible. Additionally, it was speculated that some of the tropo and sporadic-*E* propagation on the 6-meter Magic band was enhanced by these higher flux numbers.

The observed sunspot numbers for April through June 2013 are 72.4, 78.7, and 52.5. The smoothed sunspot counts for October through December 2012 are 58.6, 59.7, and 59.6.

The monthly 10.7-cm (preliminary) numbers for April through June 2013 are 125.0, 131.3, and 110.2. The smoothed 10.7-cm radio flux numbers for October through December 2012 are 119.2, 120.1, and 120.1.

The smoothed planetary *A*-index (*Ap*) numbers for October through December 2012 are 7.4, 7.3, and 7.5. The monthly readings for April through June 2013 are 5, 10, and 13. This indicates a possible increasing trend in space weather and solar activity during the last half of 2013.

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

The monthly sunspot numbers forecast for August through October 2013 are 79, 82, and 83. The monthly 10.7 cm numbers are predicted to be 131, 134, and 135 for the same period.

Feedback, Comments, Observations Solicited!

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

Advertisers' Index

CQ's 6 Meter and Satellite WAZ Awards

(As of July 1, 2013)

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	KØSQ	16,17,18,19,20,21,22,23,24,26,28,29,34
67	W3TC	17,18,19,21,22,23,24,26,28,29,30,34
68	IKØPEA	1,2,3,6,7,10,18,19,22,23,26,28,29,31,32
69	W4UDH	16,17,18,19,21,22,23,24,26,27,28,29,30,34,39
70	VR2XMT	2,5,6,9,18,23,40
71	EH9IB	1,2,3,6,10,17,18,19,23,27,28
72	K4MQG	17,18,19,21,22,23,24,25,26,28,29,30,34,39
73	JF6EZY	2,4,5,6,9,19,34,35,36,40
74	VE1YX	17,18,19,23,24,26,28,29,30,34
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	17,18,19,22,23,26,34,38
80	JH1HHC	2,5,7,9,18,34,35,37,40.
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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	1,18,19,32
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.
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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	1,2,18,19,29
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	2,7,8,9,11,13,18,19,21,22,28,39,40
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	UXØFF	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
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108	PE5T	1,2,3,6,12,18,19,22,27,29,30,31,32,39
109	SP3RNZ	1,2,3,6,7,13,18,19,23,24,26,28,31,32
110	W9VHF	17,18,19,21,22,23,24,26,28,29,30,34,36,39
111	UT5URW	1,2,3,4,6,7,10,11,12,18,19,29,30,31,32
112	KR7O	18,19,21,22,23,26,28,33,34,35,36,37,39,40
113	K8SIX	19,13,17,18,19,21,22,23,24,26,29,30,34,37
114	K7CW	16,18,19,21,22,23,24,26,28,33,34,35,36,37,39

Satellite Worked All Zones

No.	Callsign	Issue date	Zones Needed to have all 40 confirmed
1	KL7GRF	8 Mar. 93	None
2	VE6LQ	31 Mar. 93	None
3	KD6PY	1 June 93	None
4	OH5LK	23 June 93	None
5	AA6PJ	21 July 93	None
6	K7HDK	9 Sept. 93	None
7	W1NU	13 Oct. 93	None
8	DC8TS	29 Oct. 93	None
9	DG2SBW	12 Jan. 94	None
10	N4SU	20 Jan. 94	None
11	PAØAND	17 Feb. 94	None
12	VE3NPC	16 Mar. 94	None
13	WB4MLE	31 Mar. 94	None
14	OE3JIS	28 Feb. 95	None
15	JA1BLC	10 Apr. 97	None
16	F5ETM	30 Oct. 97	None
17	KE4SCY	15 Apr. 01	10,18,19,22,23, 24,26,27,28, 29,34,35,37,39
18	N6KK	15 Dec. 02	None
19	DL2AYK	7 May 03	2,10,19,29,34
20	N1HOQ	31 Jan. 04	10,13,18,19,23, 24,26,27,28,29, 33,34,36,37,39
21	AA6NP	12 Feb. 04	None
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
26	TI5RLI	10 July 12	2,16,19,22,23,24,26,34

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 Dr. H. Paul Shuch,* N6TX

DR. SETI'S STARSHIP

Searching For The Ultimate DX

How It All Began . . . Richard Factor, WA2IKL

Due to unintended editing errors, this column from the Spring issue is being reprinted here in its originally submitted from from the author.—ed.

In previous columns, I've told the tale of how New Jersey industrialist Richard Factor, WA2IKL, founded the non-profit SETI League, in the wake of Congress cancelling the short-lived NASA SETI program. But how exactly did I, a tenured Full Professor with a promising academic career, get roped into becoming its Executive Director? Well, campers, gather 'round the fire, and I'll sing you a little song:

Richard was a ham friend. Since he didn't live so near,
He'd call me on the telephone, maybe once a year,
So we could catch up on our lives. Early one December,
Richard rang me up. It was a call I'd long remember.
My wife had gone out Christmas shopping. I was home alone,
With lots of time to talk to my friend Richard on the phone.

"So, what's new with you?" he asked. He kept his questions short,
To give me lots of time to file as detailed a report
As I was wont to give. This time, I tried to make it clear
That I had had a busy and most interesting year
Teaching some, and flying some, and getting on the air
Not so very often, just to talk to here and there.

"And you?" I reciprocated. "Tell me, how's your life?
Are you still a bachelor? Did you ever take a wife?"
"I may be deluded," Richard said, "but I'm no dunce.
Marriage is the same mistake I never did make once."
Richard then went on, of matters serious and petty,
Until he asked me, "Do you know what's going on with SETI?"

I was well aware that NASA's funding had been cut,
And the search for life was in its final phases. But…
Maybe private funding would appear to save the day.
We can carry on, I said. There has to be a way.
Richard and I talked on for an hour and a half
About this situation that could make you cry, or laugh.

(It's no more a secret, so now I'm free to tell:
His callsign. Richard's WA2IKL.)
Then he dropped his bombshell, and at last I came to see
This wasn't idle chit-chat — he was interviewing me!

The author, N6TX (left), and SETI League founder and president Richard Factor, WA2IKL, still run The SETI League together. And, they still talk on the telephone every December.

"I'm impressed there's so much about SETI that you know.
I've founded a non-profit. Would you like to run the show?"

I was being asked to turn my back on something great:
A job for life, backed by the taxing power of the state,
With pension and full tenure, for a chance to tackle real
Fringe science with uncertain funding. I began to feel
There's just no way that I could pass up such a cushy deal!
So, I told Richard that his offer had a strange appeal.

I first took a sabbatical from teaching, just to find
I liked the change. And so, the next semester, I resigned.
Those twenty years of teaching quickly slipped into the past.
Two decades now I've run The SETI League. It's been a blast!
The classroom was another life that I can scarce remember,
And all because my ham friend, Richard, called me that December.

73, Paul, N6TX

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By Dr. H. Paul Shuch,* N6TX

DR. SETI'S STARSHIP

Searching For The Ultimate DX

Pleiades

The SETI League, Inc. is pleased to count as its membership base an eclectic mix of enthusiasts from all walks of life. In addition to amateur radio, many of our members share an interest in astronomy. Thus, in addition to "what's your favorite ham band," they often have been known to ask one another, "What's your favorite constellation?"

For me, that's always been an easy question to answer. My constellation of choice has long been the Pleiades, otherwise known as the Seven Sisters, as well as Messier Object 45. This gorgeous open cluster of hot, blue, extremely luminous stars, all about 100-million years old and perhaps 400 light years distant, shows up in the winter sky as a fuzzy smudge punctuated by six bright stars. (If you are fortunate enough to be in an area with extremely dark skies, and possess both excellent eyesight and a keen imagination, you can maybe make out a seventh.)

In Greek mythology, the Pleiades are the seven daughters of the titan Atlas and the sea nymph Pleione. In astrobiology, this cluster is especially interesting because one of its stars, HD 23514, is not only similar to our sun in luminosity and mass, but is also parent to a swarm of hot dust particles. This recent discovery by the Spitzer Space Telescope, believed indicative of planetary formation, bodes well for the SETI enterprise, the validity of which depends upon an abundance of extra-solar planets.

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All of this makes the Pleiades interesting indeed. However, truth be told, what makes the Seven Sisters special to me is neither mythology, nor astronomy, nor astrobiology, but rather family. For, as it happens, all seven of my siblings happen to have been female. Here's a bit of family history (in verse, of course):

My father and my mother had a daughter and a son, and so I had a sister. But she's not the only one,
Because when Dad remarried to a woman with three kids, He adopted all of them. And when my father did,
They became my sisters too. So, I had sisters four, Both adopted and biological. But wait, there's more! For my Mom remarried too. And by his former spouse,
Her husband had two daughters. They did not live in our house, Still they were my sisters too. But, no, we are not done.
Dad had another late-in-life, half-sister to his son. Between step, and adopted, and natural, and half,
That totals seven sisters—quite enough to make me laugh. Six of all those sisters are still very much alive.
The eldest, sadly, left us at the age of sixty five. So, of all my seven sisters, six are burning bright.
The seventh is no longer here to grace the sky at night. Like the Seven Sisters constellation in December, Only six are visible. The seventh, I remember.

The above column is dedicated to the memory of my eldest sister, Robin Joy Burke, who would have been delighted by SETI success.
73, Paul, N6TX

Astrophotograph of the Pleiades.(Courtesy of Wikimedia)