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Ham Radio Above 50 MHz

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Winter 2010

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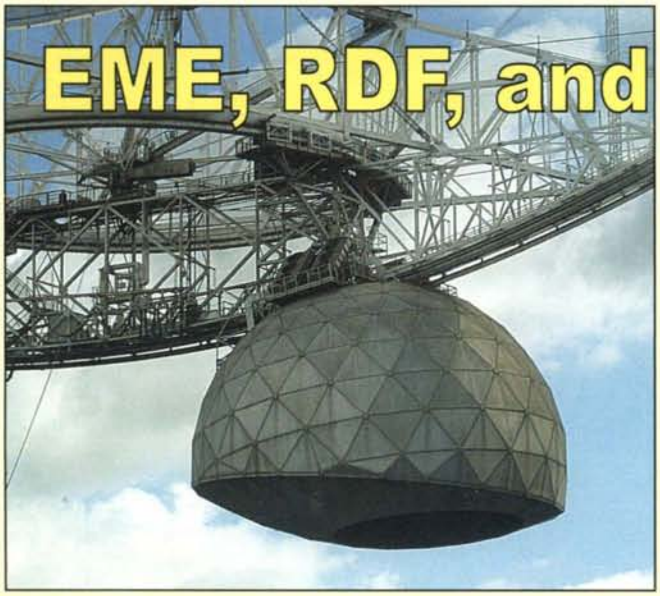

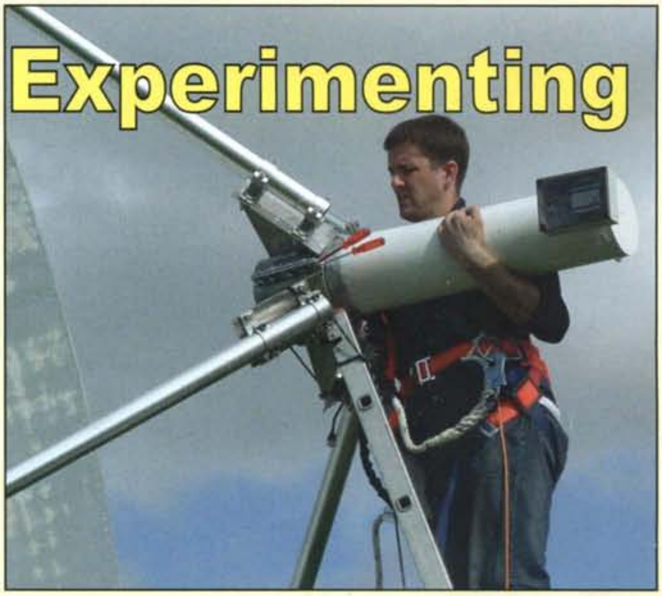

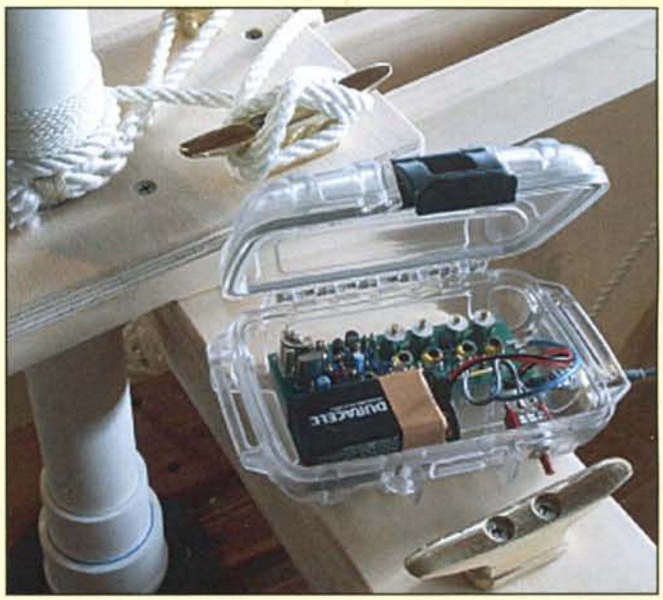

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CQ VHF Ham Radio Above 50 MHz

LINE OF SIGHT

A Message from the Editor

Echoes of Apollo: The Parkes Dish Story

Beginning on page 6 in this issue you find Pat Barthelow, AA6EG's summary of last year's Echoes of Apollo very successful, worldwide EME operation. In his article you will also read a bit of history of the Apollo 11 television transmission and the tremendous role that Australia played in making it possible for us to see the live pictures from the Moon on July 21, 1969. Buried within Barthelow's article is this URL: <http://www.publish.csiro.au/?act=view_file&file_id=AS01038.pdf>, which is a pdf of John Sarkissian's paper "On Eagle's Wings: The Parkes Observatory's Support of the Apollo 11 Mission."

Sarkissian's paper is a fascinating summary of the role that three of Australia's giant dishes played in tracking and broadcasting live pictures from Apollo 11's Lunar Module. He points out that when the TV camera on the Lunar Module was switched on (by activating its circuit breaker), three dishes received the signals simultaneously. They were Goldstone, Honeysuckle Creek, and Parkes. NASA began the broadcast by choosing the Goldstone received TV signals first. For the first few minutes of the broadcast, NASA alternated the signals between those received by Goldstone and Honeysuckle Creek. After 8 minutes and 51 seconds, the Parkes signal was used and they stayed with it thereafter. The paper is rather lengthy, 25 pages long. However, I have summarized some of the main points (and have included the name of the third Australian giant dish that was used in Apollo 11 communications) in the March 2010 VHF Plus column in *CQ* magazine.

Regarding the photograph of the Parkes dish that appears on page 6, I am deeply grateful to Gabby Russell, the Communications Officer, Susan McMaster, the General Counsel, and Kim Higgins, the Personal Assistant to the General Counsel for the Commonwealth Scientific and Industrial Research Organisation (CSIRO) of Australia for their gracious assistance in locating and granting permission for our publishing that photo. All three of them were most helpful in their assistance with the photo, and also Gabby was the one who highlighted Sarkissian's paper for me.

Echoes of Apollo 2010

In his article Barthelow also announces this year's Echoes of Apollo event. Taking place over the weekend of April 16–18, it will be in honor of Apollo 8. Again, it will be an EME event with participation encouraged by the big dishes. This year's event will include Arecibo, which is expected to be on the air on its favorite band, 70 cm.

If you have not seen a picture of Arecibo, take a look at Keith Pugh, W5IU's Satellite column, beginning on page 44. He had the good fortune to visit Arecibo as part of a QCWA cruise to Puerto Rico.

New Authors, New Column

With this issue we introduce two authors who are new to this magazine: Rick Campbell, KK7B, and Tom Dean, KB1JIJ. Rick is one of the most prolific writers and experimenters in our hobby. He states that along with our amateur radio license comes a mandate to design, build, and experiment. He begins a series of introductory experimental articles focusing on how easy it is to get on 6 meters CW QRP starting on page 27. Look for future articles on easy experimental ideas for the VHF-plus ham.

Tom takes over as the ATV columnist from Miguel Enriquez, KD7RPP. Tom is a junior at the United States Military Academy and a member of the Academy's amateur radio club. Concerning the club's VHF-plus activities, Tom writes the following:

> The USMA Amateur Radio Club has been working on a BalloonSat project over the course of this past year. We are currently hoping to launch in mid-spring this year. The project will fly various payloads which have been built as a joint project between the Academy's Amateur Radio, Astronomy, and Electronic Experimenter's Clubs. Payloads will include ATV, APRS, and packages to measure properties of the atmosphere. The launch will either take place in Colorado or the Northeast.

More on the Academy's ARC can be found in the March 2010 VHF Plus column in *CQ* magazine.

Tom begins his column on digital amateur television (D-ATV) on page 50. With each successive installment of his column we will follow Tom as he develops his D-ATV station. Also in this issue, Miguel assumes his new duties as the Education columnist (titled The VHF-Plus Classroom). In his first column, which begins on page 74, he discusses the vital role of Elmers in the classroom.

Eighth Year

With this issue of *CQ VHF* magazine we have completed eight years of publishing the relaunch of this publication. It has been fun and it has gone fast. In reflecting back on these past eight years, I think that the most fun I have is going to the various conferences, hamfests, and club meetings, as well as balloon launches. I have met so many new people in our niche of our hobby. I have gone to various parts of the country and visited many cities.

While my travels have been fun, I think that the most rewarding aspect of this position as your editor is the finding and developing of new writers. Our writers cover a number of topics, from history to all of the different technical niches, to fun operating, to emergency communications, to experimentation and design.

While I believe that we have the best authors in amateur radio, I am always looking for new talent. If you have a story to tell, I would be delighted to have you join us and share your story.

Happy New Year

Even though you are receiving this issue in February, I believe that it is not too late for you to receive a wish for a Happy New Year. May this coming year be full of fun and excitement as you pursue your interest in our niche of our wonderful hobby. Until next time…

73 de Joe, N6CL

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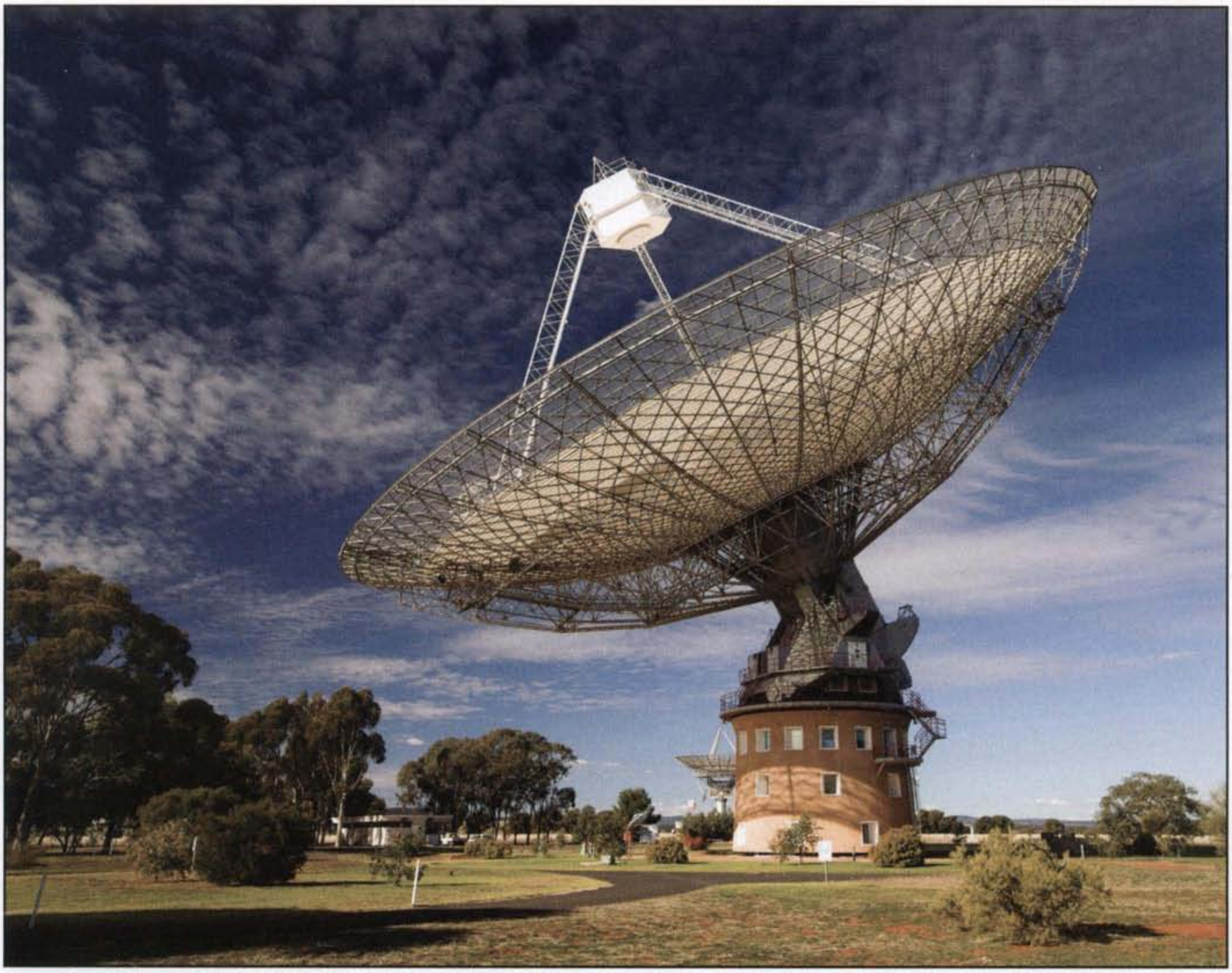

CSIRO's Parkes Dish was the focal point of the 2000 movie The Dish, *which was about its involvement in the reception of Apollo 11's transmissions. (Photo credit: David McClenaghan, CSIRO)*

Echoes of Apollo 2009/2010

Last year's Echoes of Apollo EME event was a worldwide success. Here AA6EG provides a bit of history associated with the large dishes, summarizes some of the main operations, and announces the year's EOA event.

By Pat Barthelow,* AA6EG

"It was the best of times, it was the worst of times . . ." Charles Dickens wrote. As I recall, from my limited perspective, the journey taken by so many that helped in the success of Echoes of Apollo 2009, I settle into some warm and fuzzies, also accompanied by a few more stress wrinkles here and there that appeared on me during the journey. However, if feedback is any indication, EOA 2009, aka World Moon Bounce Day, an EME/Science outreach event and a concept for future EME events, did very well.

Most folks involved had a very enjoyable time. For EOA to have happened, a huge amount of new ground had to be learned, by me in particular, as I am a newcomer to EME and approach it from an unusual background, in which my non-ham big-dish experiences encouraged me to apply big dishes to EME in a way not commonly done before. From my experiences with EOA I have learned that today, more than ever before, there are under-utilized or even abandoned large dishes eminently suit-

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

able for EME applications that can be sought out and used by the amateur radio community.

EOA Moonbounce Origins and Objectives

Fundamental to the EOA event origins was the realization that EME has a certain snap and pizzazz to up-and-coming technophiles that could attract them to modern ham radio, and maybe if experienced by the very young, could set a waypoint in their educational development and life experience leading them to science, space, and technology careers. In addition, the seasoned veterans of EME, a rather small but technically astute group of the amateur radio community, could have a bunch of fun with the unusually strong SSB signals provided by the commercial dishes—such as SRI near Stanford University; the dish at the University of Tasmania at Mt. Pleasant; and Dwingeloo in The Netherlands—which were brought in to participate along with the big dishes already out there custom built by so many in the EME community.

For details of early events leading up to EOA, get a copy of the Spring 2009 issue of *CQ VHF*. My chance cyberspace meeting with Robert Brand and his colleagues of On-Time Virtual Assistant (OTVA, see <http://www.otva.org> and <http://exotc.com/wordpress/?p=254>) formulated the basis for creating EOA. OTVA has a lot of seasoned individuals with history and experience in the Apollo program and was looking to celebrate the coming anniversaries of the Apollo Moon missions. I suggested to Robert that a world moonbounce event might dovetail nicely with their celebrations, especially if we could get the Parkes or Tidbinbilla (Honeysuckle Creek) dishes to participate. Those two dishes in southeast Australia provided critical capability of ground-station connectivity with the Apollo Moon missions and still exist.

Apollo 11's Moon Landing, Moon Walk Video

The initial Apollo 11 Moon landing video was received from the moon by the 26-meter Honeysuckle Creek Dish, part of the NASA space tracking network, Australia, which, by the way, was moved in the 1980s to Tidbinbilla at the Canberra Space Complex and very recently retired.

Speaking of those under-utilized or even abandoned large dishes mentioned above, here is an opportunity for some local Australian ham clubs. Perhaps they could propose to use the historic Honeysuckle Creek Dish for EME and science outreach.

CSIRO's Parkes Dish had a movie made about it called *The Dish*. Much creative license was taken in the movie details of how Parkes operated during the Apollo 11 mission. However, the movie was very entertaining, and the real shots on/at the dish were spectacular.

There is another very accurate story of the Parkes and Honeysuckle Creek coverage of Apollo 11 on the web. One of the best technical write-ups available is entitled "On Eagle's Wings" by John Sarkissian of Parkes (see <http://www.publish.csiro.au/?act=view_file&file_id=AS01038.pdf>, <http://www.parkes.atnf.csiro.au/news_events/apollo11>, <http://members.tip.net.au/~mdinn/TheDish/>, <http://www.honeysucklecreek.net>. See a great walk through videos of

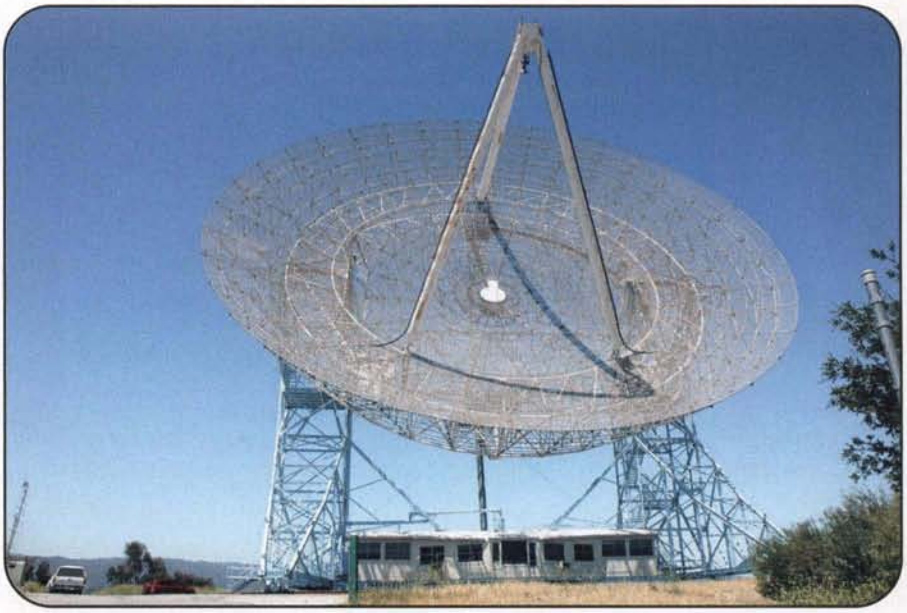

Photo of the SRI dish used during the EOA event. (Photo courtesy of Jim Klassen, N6JMK)

The author standing next to the SRI dish feed horn. (Photo courtesy of N6JMK) the Parkes dish at: <http://www.youtube.com/watch?v=VsoIeojQCcc&feature=related>. In retrospect it is astounding to note that NASA initially did not plan to have a camera aboard Apollo 11 to record the momentous moon-landing event.

The SRI EOA Team

I was fortunate enough to be able to assemble a California team of seasoned radio amateurs with moonbounce experience and was able to connect with some highly skilled big-dish professionals who all were essential to make the California EOA operation happen successfully. Special thanks go to many people whose expertise, experience, and hard work were applied in a relatively short time period. The whole team turned out to produce an awesome performance during EOA.

A phone call and a proposal to management at the 45-meter SRI dish resulted in granting permission to use the dish in EOA last June. Thank you, SRI! Dish management and SRI technical staff were immensely helpful, in some instances even volunteering their time for feed mounting, setup, and tweaking, and in overcoming a (typical) host of technical challenges encountered during EOA, as well as the trial-run event which took place about one month prior to EOA weekend. The technical challenges, procedures, construction, measurements, repairs, and modifications encountered and overcome by Team SRI—both the hams and the SRI dish staff—if reviewed in detail could fill another five pages of this magazine. We won't do that, but would be glad to discuss the details "off line," so to speak. Send me an e-mail at: <apolloeme@live.com>, or visit my blog: <http://www.echoesofapollo.wordpress.com>.

Then, of course, my thanks to lead ham engineers and "Team SRI" for sourcing and constructing the SRI station: Dave Smith, W6TE; Lance Ginner, K6GSJ, master systems engineer and troubleshooter; and Mike Staal, K6MYC, EMEer extraordinaire and owner of M^2 Antenna Systems, Inc. Dave brought aboard select ham team members Jim Klassen, N6JMK, and Wayne Overbeck, N6NB. John Morrice, K6MI, loaned some of the RF lineup feeding the dish. John, Dave Smith, and Mike Staal provided the essential, expensive pieces in the 23-cm RF chain at SRI and the expertise to assemble, troubleshoot, repair, and make it work. Mike's high-power APX-4 with six each 2C39 water-cooled tubes in an array cavity came back to roost at SRI, where it was used for EME by Mike at SRI in the 1960s. During the course of EOA, the APX-4 suffered some arc-over problems, and we went back to a lower power SSPA (solid-state power supply). Dr. Michael Cousins, of SRI, obtained for us a corrugated Horn from the inventory at SRI for a 23-cm feed. At the initial shakedown test, Dave, W6TE, and the SRI crew set up the horn for linear polarization, which worked, but was a compromise. Later it was equipped for circular polarization for the main event. Jim, N6JMK, oversaw site logistics and Team SRI safety. Well-known moonbouncer from "Down Under" Doug McArthur, VK3UM, did a wonderful job organizing EOA EME skeds and real-time news updates during the event, and as always provided a booming EME signal from his station in Glenburn, Victoria, Australia.

Dr. Dave Leeson, W6NL—a well-known ham, Stanford professor, and W6YX Ham Radio Club Advisor—was a wise mentor and guardian angel to us "newbie" and veteran EME hams at SRI. Looking over our shoulders, he contributed sage project management advice during the dynamic and often high-pressure preparation periods leading up to EOA. Lance Ginner, K6GSJ, with some fifty years of history in ham satellites, proved to be essential to the team as a seasoned technical support engineer who saved the day more than once with his expertise. He also had a dream microwave shop in his nearby home garage with a gold mine of spare components, including relays, preamps, etc. Lance and his incredible wife Wanda were also fabulous hosts and provided the SRI team with an unforgettable poached halibut dinner on their outdoor patio within view of the SRI dish. Thanks, Wanda and Lance!

All of these folks played fundamental roles in the success of the SRI operation during EOA 2009.

Eric Stackpole, KF6JBP A New Moonbouncer

At the SRI facility during EOA we welcomed a young ham visitor, Eric Stackpole, KF6JBP. Eric recently graduated from San Jose State with a degree in mechanical engineering, and he provided us with a surprise, heartfelt validation of our science outreach objectives. Eric did some moonbounce operating at SRI, his first. The mile-wide grins from Eric during EOA were priceless.

Eric Stackpole, KF6JBP, who wrote after his EME experience, "EME rocks my world." (Photo courtesy of KF6JBP)

Eric has since spent an internship at NASA-Ames designing CubeSat de-orbiting systems. He is now very busy in mechanical engineering graduate school, with a full NASA grad school scholarship. I am sure that in the future you will see great contributions in the area of science from Eric, probably things related to space communications or rocket science. I plan to bring Eric on board for future EOA team events. I sent Eric the YouTube EOA video produced by the Team Tasmania hams, which includes Eric's voice as heard via EME from SRI at the Tasmania Mt. Pleasant dish. Here is Eric's e-mail to us after seeing that video:

> This is great! I CAN HEAR MY OWN VOICE FROM THE MOON! I forwarded it to basically everyone I know. I wanted to thank you not only for showing me this, but also once more for organizing the event. As I mentioned before, that evening I spent during Echoes of Apollo probably changed my life, and I will remember it forever. Please let me know of any other activities like it. EME rocks my world! 73, Eric.

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

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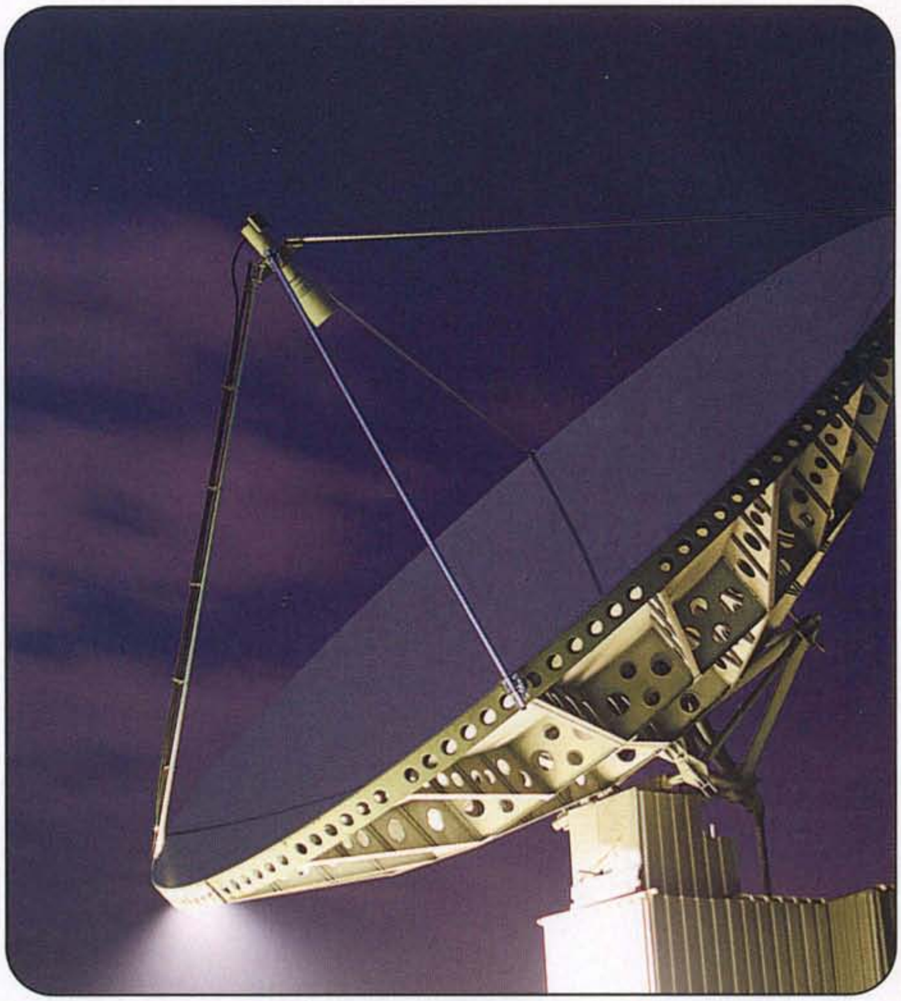
Of course, the SRI dish and team were just one of the players in the worldwide EOA event, and thanks have to be voiced to the many participants who made the EOA event a success. I am sure all the EOA EME players around the world have lots of their own stories to tell.

EOA/EME Chur, Switzerland, HB9MOON

Christoph Joos, HB9HAL, aka HB9MOON, really put together a great team which built and runs the great 10-meter dish EME station, HB9MOON, in Chur, Switzerland (http://www. radiosky. ch). Chris and his team initiated a wonderful public-relations effort and had about 300 visitors during the EOA event, many of them youngsters, and generated a Swiss TV national network news story of their participation. See the network TV coverage of the HB9MOON participation at: <http://www.youtube.com/watch?v =BUVoiEJd86s&translated=1>.

During EOA, Christoph got permission from the government authorities to broadcast children's messages of peace via moonbounce from the HB9MOON station. There is a recording off the moon of those broadcasts at <http://www. radiosky.ch/Podcast/Friedensbotschaft %20HB9MOON.mp3>. Other exploits of HB9MOON can be seen on YouTube as well.



A nighttime view of the HB9MOON dish in Switzerland. (Photo courtesy of Radiosky)

Dwingeloo Dish, The Netherlands

The Dwingeloo 25-meter dish, lovingly restored and operated under the management of the CAMRAS group, and its return to use from radio astronomy to EME, is and has an amazing story that can fill another issue of this magazine. Suffice to say that Jan Van Muijlwijk, PA3FXB, Dick Harms, PA2DW, Robert Langenhuysen, PAØRYL, and a large, dedicated volunteer team have put years of work into bringing the historically significant Dwingeloo dish back to service now as one of the most advanced and successful large EME dishes in the world, including on-line SDR EME receivers.

By special permission of the Swiss government children were allowed to send messages of peace from the HB9MOON station. (Photo courtesy of Radiosky)

Tasmania to Dwingeloo via the Moon on .003 watts!

I think the 3-milliwatt QRPp EME QSO via JT65 between the Mt. Pleasant dish, University of Tasmania, and the Dwingeloo dish (http://www.camras.nl) in Holland stands out one of the real highlights of EOA, World Moon Bounce Day. Details on the Mt. Pleasant dish are at: <http://www.phys.utas.edu.au/physics/mt_pleasant_observatory.html>. A paper on recent activities at Mt. Pleasant can be found at: <http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20080032625_2008033028.pdf>.

Hobart, Tasmania Mt. Pleasant Observatory

The University of Tasmania's Mt. Pleasant 26-meter dish, in Hobart, originally was planned only to be a receiving station, as they had incredibly sensitive and expensive liquid-helium-cooled LNAs at the feeds for which they could not guarantee protection from damage if high power amateur transmitting equipment was used at the feed. These preamps had been used in the professional radio astronomy work at Mt. Pleasant.

Due to some careful and supportive analysis by Dr. James Lovell and his UTAS team, the situation was analyzed and it was decided that some very low TX power could be done without harming the LNAs and set up of a 10-milliwatt station for EOA was authorized.

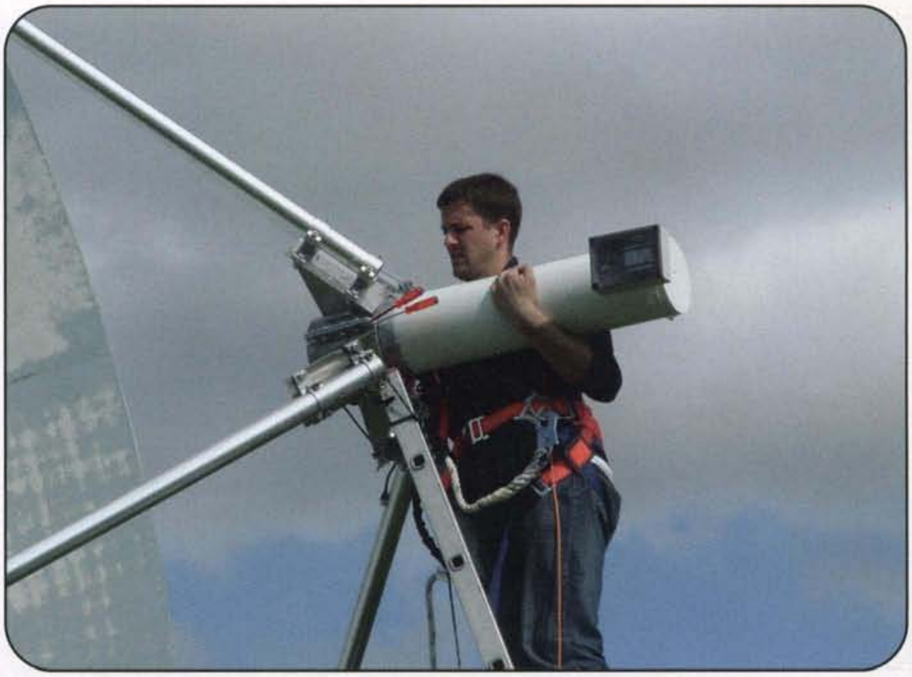
Rex Moncur, VK7MO, Justin-Giles Clark, VK7TW, and the University of Tasmania staff technician Eric Baynes, VK7BB—who I will refer to as Team Tasmania (TT)—essentially built the EME QRPp station at the dish, experiencing the trials and travails of breaking new ground (of any first-time EME station) at the Mt. Pleasant dish. Team Tasmania's ambitious work under tight deadlines and working around the observatory's professional bookings included: building and trying a couple of different feed antennas, including a three-turn helix and a septum polarized choke feed; building down converters (VK7BB), 1296-MHz bandpass filters; and bringing in Rex's preamplifiers and a GPS frequency reference.

TT had an interference problem from the Hobart Airport, which they solved with bandpass filters. TT EME tests with Dave Scott, VK2JDS, still showed some station performance deficits, which TT brainstormed and quantified using sun noise measurements.

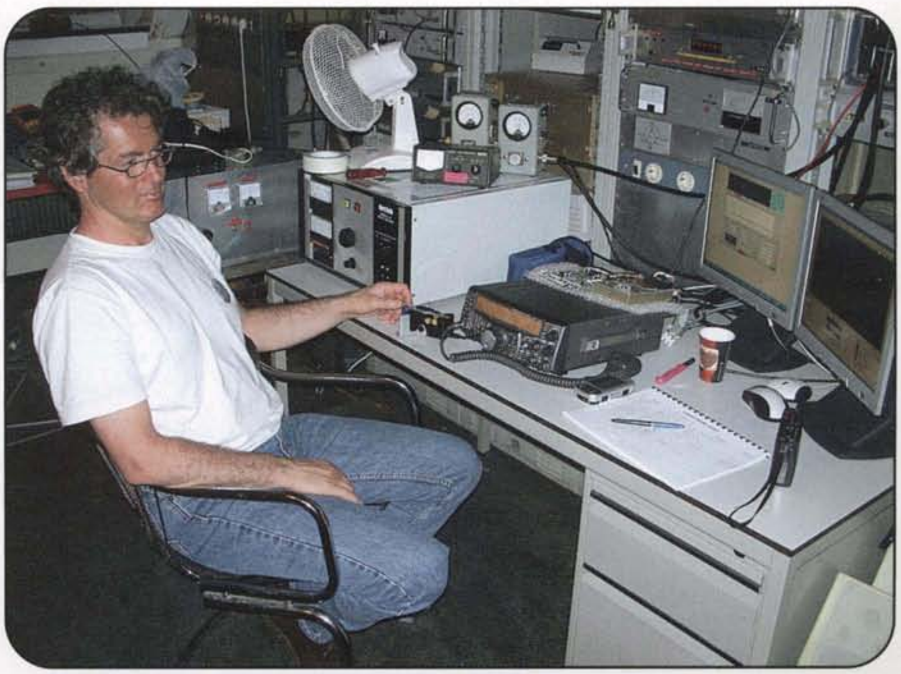
However, lots of tweaking later, including design and refabricating a new mount for a new septum polarized choke feed succeeded. The septum polarizer with choke feed once mounted and with a lot of work from TT achieved a sun noise level of 25 dB, a few dBs from ideal.

Eric, VK7BB, was the go-to guy for the antenna work. Those of us who have been there and done that are familiar with the climbing harness, safety hooks, man lifts, and the rest of the drill, and know from experience that there is rarely any such thing as a 1-hour, or usually even a 3-hour, rigging visit with feed modifications and can really appreciate the amount of work performed by Team Tasmania.

After all that work, TT conducted successful SSB receiving tests with Doug, VK3UM, and his 400 watts fed to an 8.6-



Christoph Joos, HB9HAL/HB9MOON, installing the OM6AA designed dual-mode, septum polarizer at HB9MOON's 10-meter EME station. (Photo courtesy of HB9HAL)



Dick Harms, PA2DW, at the controls of the Dwingeloo EME station. (Photo courtesy of CAMRAS)

Justin Giles-Clark, VK7TW, sitting on the floor of the Mt. Pleasant control room trying to figure out how to be able to transmit a signal and not blow out the liquid-helium-cooled LNAs. (Photo courtesy of VK7TW)

meter Kennedy (converted Apollo era surplus) dish. Then TT studied the possibility of 10 milliwatts of JT65 with Jan, PA3FXB, at the PI9CAM 25-meter dish in Dwingeloo. On World Moon Bounce Day they were able to do the first test of their JT65 setup, achieving –27.8 dB signal levels for Moon echoes after careful feed-position adjustments. Both dishes probably had a gain spec slightly higher than 50 dBi, which is normally unheard of gain at 23 cm in amateur EME. Early SSB QSOs at 5/7 with Doug, VK3UM, brought smiles and squeals of delight from the kids who heard their own names coming off the Moon's surface.

Dave, VK2JDS, had ham copyable 5/2 SSB signals at Mt. Pleasant, not quite copyable by the kids, so they went to JT65 and continued to awe the kids who now saw (and photographed) their own names *printed* coming off the Moon. Eric Stackpole, KF6JBP, at SRI was copied at 5/7 for a short while until another preamp went, and the SRI team had to do a repair. TT carried on, with visits from the media and QSOs with VK3UM, with all being suitably impressed.

The TT QRPp JT65 continued at 30 milliwatts with the European window opening, initially hearing Dan, HB9Q (15 meter dish), who reported a –23 dB signal, with –29 dB at 10 milliwatts. Then the PI9CAM, 25-meter Dwingeloo dish, was worked first at 10 milliwatts then reduced to 3 milliwatts, producing signals of –26 dB. A try at 1 milliwatt was not successful. The 3-milliwatt EME QSO surely must be a world record! Three milliwatts is quite a bit less power than a single LED keyfob flashlight! TT produced an excellent video documentary of their participation: <http://www.youtube.com/watch?v=AHGXp4Afr4g>.

Rex and Justin's article on the Tasmanian-Dwingeloo QSO was reprinted from the Wireless Institute of Australia's *Amateur Radio* magazine in the September 2009 issue of *CQ* magazine in the VHF Plus column by N6CL. Accompanying that article are comments from the Dutch side that appeared on the Moonnet reflector.

WIRED Magazine and *The New York Times*

On both the SRI trial run and the EOA weekend Lisa Sonne, a reporter for *WIRED* magazine, attended, took notes, did interviews, and did some guest-op EME herself. Lisa joined Ashley Vance, a reporter from *The New York Times* and a *NYT* photographer, and they all interviewed nearly the entire SRI team, including the SRI professional staff, and produced two stories for *WIRED* (http://www.wired.com/); Wireless Institute of Australia's *Amateur Radio* magazine, Volume 77, Number 8, August 2009, and <wiredscience/2009/06/moonbounce/> and <http://www.wired.com/wiredscience/2009/07/ham-operators-shoot-the-moon/>. EOA made the June 27, 2009 *New York Times* front page and had considerable photos and "column inches" (http://www.nytimes.com/2009/06/27/technology/27moon.html).

Apollo 8 Astronaut William Anders on EME

During EOA, Apollo 8 astronaut William Anders, from his home in the state of Washington, joined us in an EME voice chat. (http://en.wikipedia.org/wiki/Apollo_8). Anders is very well known for taking the stunning and thought-provoking "Earthrise" photo from his Apollo 8 spacecraft while orbiting the Moon. Anders' EME QSO was captured and preserved by Ben Bailey, W4SC, who was at the station of well-known EMEer Joe Demaso, K1RQG, who, from Maine, monitored the Anders EME QSO. The two EME stations in QSO were SRI and Joe Martin, K5SO, in New Mexico. Astronaut Anders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Dave Smith, W6TE, demonstrating EME to Ashlee Vance, The New York Times *reporter. Lower left is Jim Wilson, the* NYT *photographer. (Photo courtesy of Dave Smith, W6TE)*

Lisa Sonne, a reporter for WIRED *magazine, having an on-air EME conversation with Apollo 8 Astronaut William Anders. (Photo courtesy of N6JMK)*

was on a telephone link to K5SO. Thanks a ton to all of you for capturing that astronaut EME QSO. The audio file of astronaut Anders' QSO is at: <http://k5so.com/K5SO_W6SRI_D2000Hz_20090628_171651.wav>.

EOA 2010: Arecibo

EOA 2010 is set for April 16, 17, and 18 starting at noon on Friday and lasting through 17:00 Sunday, both West Coast time. This year will have on board the highly endangered, biggest EME dish of all at the Arecibo Observatory in Puerto Rico probably on 432 MHz but possibly other bands. As this article was being prepared, discussions with Angel Vazquez, WP3R, and Dr. Nolan were ongoing. As I finished this article in early January I received word that they were very willing to join EOA on 432 MHz with a possibility of multiple bands.

I would encourage the ham community to become advocates for preservation of Arecibo, now at serious risk of closing. See these websites for Arecibo advocacy and networking: <http://arecibo-science.org/Newsletter.html>, <http://www.planetary.org/programs/projects/advocacy_and_education/space_advocacy/20080703.html>, <http://setiathome.berkeley.edu/arecibo_letter.php>, <http://www.arecibo-observatory.org/friends.html>, and <https://www.policyarchive.org/bitstream/handle/10207/19327/R40437_20090305.pdf>.

Final Thoughts

EOA 2009 was a wonderful, challenging journey for all involved, with *all* being the keyword, because all of them should be proud of their EOA and lifetime EME accomplishments and acknowledged for those accomplishments. Many people have been named and acknowledged here, but in the limited available print space many more have not and cannot be acknowledged in this article. The use of internet URL references in this article is a big multiplier for distributing content and acknowledgement of other's accomplishments. Please use them, and communicate and teach one another. Spread the word.

If you embark on a similar adventure, while you are doing so, please realize that the risks and challenges taken and overcome towards an objective are not only technical, but also personal and sometimes professional. Realize that anyone in a professional position to grant favors to a (any) visionary ham project is taking risks, has a boss, and has his or her own set of in-house issues—aka politics—to deal with and that their decisions have consequences, hopefully good ones.

As a result, sometimes some of the heroes and angels who take those risks on your behalf would prefer to remain unnamed. Find out if that is the case. Understand that when you are breaking new ground, often you are also treading on ground (turf) that has been groomed by others over a long time period. When you hear (hopefully before) the 12-gauge pump cycled, slow down, become a diplomat, and become friends with your new neighbors. Learn from them. Also, realize how extremely difficult it is to make everyone happy in a massive volunteer effort.

Try your best to go out of your way to acknowledge your volunteer teammates, since in the "real" world a lot of the acknowledgement is in the form of a paycheck, and that makes a lot of the blood, sweat, and tears of a job tolerable. Realize, as I have, that working with people in a large volunteer organization is very often *far* more difficult and time consuming than working with dBs, noise figures, Az and El, HPAs, and dish alignment.

Again, thanks to all who participated, and I look forward to hearing you off the Moon or perhaps on 20 meters CW soon.

Amateur Radio and the Cosmos
Part 3 – A New Dawn

Have you ever wondered about the origin of the term "sky noise," or why the 10.7-cm solar flux is such an important measurement? Here WB2VVA discusses these items and much more about the sun.

By Mark Morrison,* WA2VVA

It was during a field trip to the local phone office when my classmates and I received our second Bell Labs experience, an early demonstration of the touch-tone and picture telephones. Of the former, we'd be challenged to see who could dial faster, the person using a touch-tone phone or a rotary. The rotary challenger put up a good fight, for everyone knew how to speed up the dialing process by forcing the dial in reverse, but it was a fight to be lost. The touch-tone phone just couldn't be beat. Also, the picture phone, which seemed pure science fiction, would become a highlight of the New York World's Fair in 1964. The connections of these innovations to our story may not be obvious, but the technology behind them was rooted in decades of mathematics and scientific research taking place at Bell Labs during the first half of the 20th century. Ever vigilant to provide the best phone service in the world, the many innovations and scientific breakthroughs at Murray Hill touched our lives in many unexpected ways.

In his book *Forty Years of Radio Research,* wireless pioneer George C. Southworth provides a rare glimpse inside Bell Labs, including the work of two associates, Dr. Harry Nyquist and Dr. J. B. Johnson[1]. In 1928 Johnson theorized that all electronic circuits generated noise depending on their absolute temperature and the band of frequencies under consideration. Nyquist theorized that "Johnson noise" is a form of one-dimensional black-body radiation existing even in systems of such circuits. Although the weakest link would appear to be the "first circuit noise," such as that of the antenna in a radio receiving system, Southworth wrote, "mature thought showed that the first circuit was really the medium to which the antenna was coupled. In particular cases the medium might include particular objects in interstellar space … one of the most obvious heavenly bodies was the sun."

In those days receiver noise wasn't considered much of a problem, but once radar came on the scene, with weak signals awash in circuit noise, things changed quickly. Indeed, the signals of interest were so weak that even noise from celestial bodies, such as the sun and even the Milky Way Galaxy, had the potential to interfere with radar operations. It was J. S. Hey who first associated certain problems with British radar to noise from the sun rather than enemy jamming.

In 1942, Southworth pondered the work of an earlier physicist, Max Plank, who in 1901 revolutionized the world of physics with his quantum theory for black-body radiators. This theory predicted "the total amount of [solar] energy falling on the earth" and "specified the amount of power contained in each unit bandwidth being sent out." Although the amount of energy predicted to fall within the microwave region would be small, well below the noise level of a typical 1940s receiver, Southworth wondered if a "double-detection" receiver developed for waveguide research and "groomed" for low noise might do the job. Southworth connected this 9400-MHz receiver to a small parabolic dish using a section of waveguide and directed one of his associates, A. P. King, to aim the antenna toward the sun as shown in figure 1.

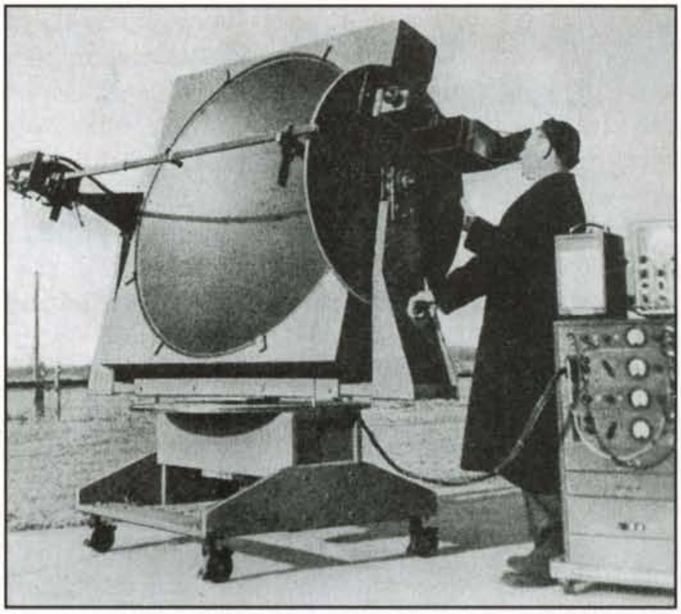

Figure 1. Monitoring and measuring solar energy, 1942. From Forty Years of Radio Research, *by George C. Southworth. Note that this photo itself is referred to in the book at "Reprinted by permission from* Scientific Monthly *82, 55-66, 1956."*

Almost immediately a small but definite increase in noise was detected, as indicated by a panel-mounted milliamp meter. However, there was more. Southworth knew that if the received energy could be measured, Plank's theory could be used to predict the temperature of the object radiating it. Thus it was that on June 29, 1942 the first centimeter radio emissions from the

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

sun were not just detected and measured, but the temperature of the sun was determined by radio. It is interesting to note that Robert H. Dicke, the same Princeton physicist who later confirmed the "Big Bang" noise detected by Penzias and Wilson, made a related instrument with the ability to switch the receiver between the antenna and a reference of known temperature, thus providing a means of calibration. Known as the Dicke Radiometer, this instrument allowed for much greater accuracy and was used by Dicke himself to measure the temperature of the sun and moon in 1945.

Much of the work of Southworth and Dicke went unreported due to the war effort and concerns that such information might reveal the state-of-the-art being achieved in the field of microwaves. However, this did not seem to apply to amateur radio operator Grote Reber, W9GFZ, who performed solar observations from his backyard observatory and reported on his work in important journals of the day. During this time it appears that Southworth corresponded with Reber, as did another Bell scientist Dr. Charles Townes, who it turns out was another neighbor of mine.

When Karl Jansky first detected radio signals of extraterrestrial origin, few astronomers gave it much attention. Later, when Reber detected radio emissions at even higher frequencies, first at 160 MHz and then at 480 MHz, most astronomers were still not convinced. However, two Harvard astronomers also with backgrounds in amateur radio did take notice and started to work on a theory to explain the origin of these signals. One was Fred Whipple, the well-known comet pioneer who also played a major role coordinating the observations of amateur astronomers during the International Geophysical Year (IGY) of 1957–1958. The other was Jesse Greenstein, Whipple's student, who went on to become a well-known astronomer in his own right.

The inverse relationship between radio intensity and frequency established by the combined work of Jansky and Reber presented something of a dilemma to astronomers. According to Plank's theory, the intensity of thermal noise should increase, not decrease, with frequency. The numbers from Jansky and Reber seemed to show otherwise, suggesting the source of these signals was something non-thermal. Although Jansky believed these emissions were related to ionized gas clouds, other scientists—including Whipple, Greenstein, and Townes—continued working on the problem of trying to develop their explanation of the origination of these signals.

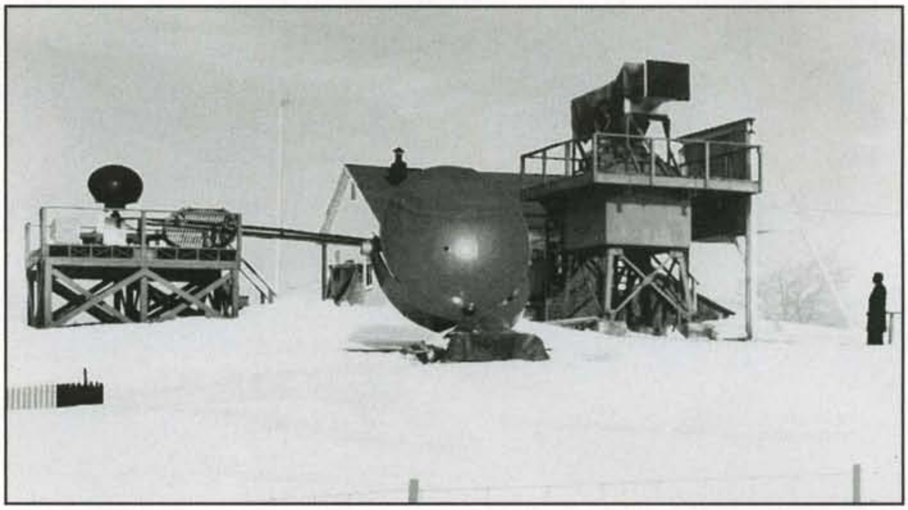

Figure 2. Dish used for 10.7-cm solar observations. Taken from a letter from Covington to Reber (http://jump.cv.nrao.edu/dbtw-wpd/Textbase/Documents/grgc-covington-reber-12141951.pdf).

In 1946, while working at Murray Hill, Townes developed a theory that ionized gas would require much higher (meaning outer space) electron temperatures than were generally accepted at the time. Townes published his work in an article entitled "Interpretation of Radio Radiation from the Milky Way," in which he mentions both Reber and Southworth.[2] In an e-mail to this author, Townes indicated that while Bell Labs didn't hire many astronomers, when they did it was mainly for its microwave expertise. He also described an early interest in radios "as an amateur" and how he built one at the suggestion of a cousin who was an engineering professor.

By the spring of 1947, Reber was preparing to join the Bureau of Standards, including the relocation of his dish from Wheaton, Illinois to Stirling, Virginia. By joining the Bureau he would become more of a mainstream researcher, which was something of a disappointment to Southworth. In a letter dated March 13, 1947 Southworth remarked, "I must, however, confess to a tinge of regret to see you pass from the fast-thinning ranks of individual workers.[3] Your ability to carry on with limited facilities has won the respect if not indeed the admiration of all who know about you."

Two of the last contributions Reber made as an independent researcher were his observations of a solar burst at 480 MHz in November 1946 and his presentation of the paper "Solar and Cosmic Radio Waves" at the Joint I.R.E.-U.R.S.I. meeting held in Washington, DC that year. It was during that meeting when Reber met Karl Jansky for the first time, as well as another radio astronomer performing solar observations in Canada, Dr. Arthur Covington, VE5CC. In a letter from Reber to Jesse Greenstein dated May 16, 1947 Reber describes Covington as "a very smart fellow who is not afraid to get his hands dirty" and describes how Covington appeared to have detected the same solar bursts at 3000 MHz that Reber detected at 480 MHz.[4]

In an article called "The Development of Solar Microwave Radio Astronomy in Canada" Covington describes how his combined interests of astronomy and amateur radio, coupled with inspiration from Reber's activities, got him into radio astronomy.[5] In the years that followed, Covington would build several radio telescopes, first using parts borrowed from a surplus SCR-268 radar set as well as waveguide technology that just happened to operate at 10.7 cm. In November 1946, Covington used this equipment to monitor the sun during a partial solar eclipse and, using an optical telescope for comparison, observed how the solar flux changed as the moon covered a large sunspot. This suggested that sunspots were the source of high levels of radiation at 10.7 cm and, ultimately, that a relationship existed between solar flux and the sunspot number. Figure 2 shows a picture of the 4-foot dish used for Covington's 10.7-cm solar observations (left side of picture) as well as other equipment used by Covington at the Goth Hill Radio Observatory in Ottawa, Canada.

Although the familiar parabolic dish was used for Covington's 10.7-cm discovery, later he used a 150-foot slotted waveguide array borrowed from Canada's Microwave Early Warning system to create an interferometer capable of resolving features of the solar surface even with clouds obscuring the sun. By orienting the length of this straight line array in an east-west direction, as Reber had done in Wheaton years earlier, the sun's microwave energy would be detected one slot at a time as it crossed overhead. As a result of this activity, Covington estimated that the solar atmosphere above the sunspots can reach the incredible temperature of 1.5-million K!

Much of the work that Covington performed was used during the International Geophysical Year of 1957–1958 and for many years the 10.7-cm solar flux observations from Ottawa were reported by WWV, something familiar to amateurs of the day. It should be noted that 10.7 cm has since been officially recognized as the standard for solar flux measurements and the earliest such records can be attributed to the early work of Covington.

While physicists studied sources of celestial noise and their potential to affect phone communications, Bell Labs researchers also worked on more practical issues, such as improving the overall phone experience. One of the biggest problems was the way subscribers connected to the central phone office using slow rotary-type phones. To this end, Harry Nyquist developed a pushbutton phone for which he was awarded a patent in 1941 as shown in figure 3. Although not the phone that my classmates and I experienced on that field trip so many years ago, its success within the phone company no doubt spurred the development of the more familiar consumer touch-tone phones that followed.

As the phone system grew, so did the complexity of the relay system used to direct all those calls. It was another Bell scientist, Dr. Claude Shannon, who would come to solve this problem. Having already developed Boolean algebra, a kind of math that allows binary systems to be reduced to their simplest form, and recognizing that relays are a form of binary system, Shannon used his Boolean algebra to significantly reduce the complexity and number of the relays then employed.

In 1948, Shannon would further apply his skills in mathematics to extend some of Nyquist's earlier work on telegraphic transmissions. Shannon's publication[6] of

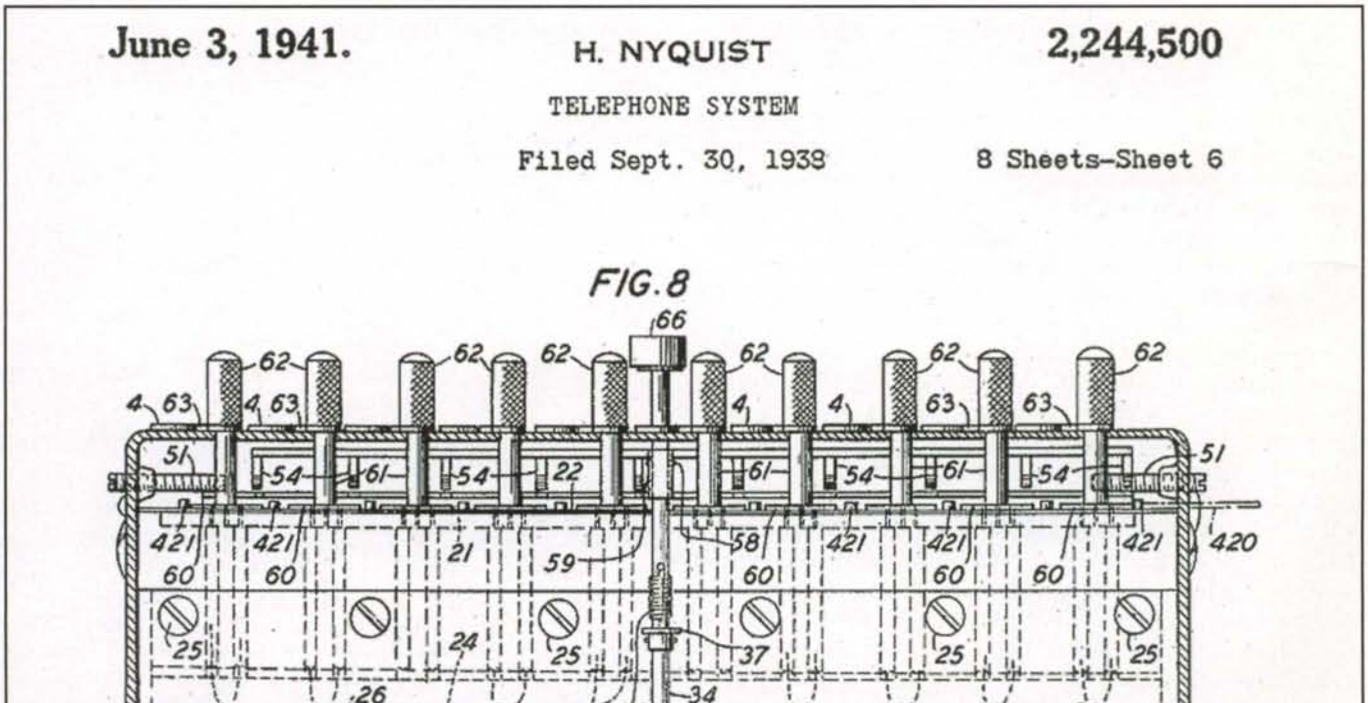

Figure 3. Harry Nyquist's patent for a push-button telephone. U.S. Patent Office.

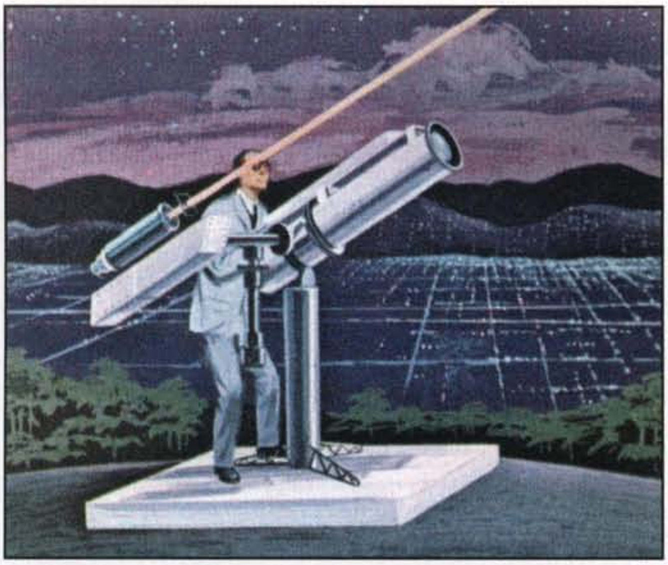

Figure 4. Early laser used for range-finding. From American Space Digest, *published by Schick Safety Razor Company in 1963 with photo credit given to Hughes Aircraft Company.*

"A Mathematical Theory of Communication" is considered the classic text on information theory, the foundation of digital communications, cell phones, digital music, picture phones, and satellite TV receivers. Without such techniques, our ability to communicate with deep-space probes millions of miles from Earth would be severely hampered, with the weak signals that are trying to be detected awash in noise. It is interesting to note that Nyquist's earlier work used the same coded characters that amateur radio operators were using at the time: Morse code! How interesting that the solutions to so many phone problems have found other applications in modern-day life.

In the late 1950s Charles Townes and Arthur Schawlow would develop the maser, the lowest noise microwave receiving apparatus of the day. One of the claims in the 1960 patent (2,929,922) assigned to Bell Labs is that a device of this type could also be used on optical wavelengths, thus pre-telling the future development of the laser.

In 1961, scientists were pondering various applications for the laser. Perhaps the first practical application can be attributed to Hughes Aircraft as shown in figure 4, which appeared in *American Space Digest* published by the Schick Safety Razor Company in 1963. This device, known as a Colidar, for Coherent Light Distance and Ranging, used a ruby laser to transmit a pulse of light to distant objects and an optical telescope to detect reflections. Although developed primarily for rangefinder applications, the patent issued to T. H. Maiman on November 14, 1967 (3,353,115) disclosed an instrument capable of tuning over a 500-GHz range for both optical radar as well as communications purposes. It is interesting to note that amateur radio operator George F. Smith, K6BYV, ex-W5GSD, played a role in developing the laser rangefinder in the early 1960s.

One problem using a laser for interstellar communications would have been light interference from the sun. Such "optical noise" would make it difficult if not impossible to discriminate the laser light amidst all this other light. To this end Charles Townes made the brilliant suggestion that a laser could still be used for interstellar communications, despite the proximity of any planet to its nearby sun, by taking advantage of the way certain wavelengths of the sun are absorbed in its atmosphere. A spectrograph of the sun shows obvious dark lines that could be filled in using laser light of just the right wavelength. Also, by using short pulses of high power, the laser would be more readily visible to those searching for it.

In a letter[7] written by Covington, VE5CC, to Reber, W9GFZ, on March 2, 1961 Covington remarks:

> [I]t is interesting, I think, to realize that radio wave techniques grew out of the early optical experiments, and now with the introduction of the laser, the flow of ideas has returned once more to the investigations in the optical region. This has started completion of the circle, and perhaps we are now entering a new era in which there should be tremendous consolidation of scattered fields of experience.

By the early 1960s the techniques of Nyquist, Shannon, and others would find application in a new kind of radio platform, the satellite and space probe. In his book *Communications in Space* published by Holt, Rinehart and Winston in 1966, [8] Leonard Jaffe, K3NVS, comments:

> It is only because ground station technology was available in the areas of low noise microwave devices, large accurate parabolic antennas and high power wide bandwidth microwave amplifiers in the general time frame of the late 1950s and early 1960s that any practical consideration could be given to communications satellites. Most of this technology came from other applications areas—radio astronomy and radar; to name two. Ten years ago, the best ground station receiver sensitivity would have been inadequate by a factor of ten for a practical commercial communication satellite system. It is truly fortuitous that this ground station technology has come along at just the time that spacecraft power technology was reached a state requiring such a technology.

In Part 4 of this series we'll examine the role of the amateur radio enthusiast as he ventures into space using satellites and space probes.

As long as man has walked this planet he has witnessed the sun rising steadily in the east and setting in the west. Each new dawn has brought the promise of a new day. When man first saw the sun rise in a different light, using radio waves, he became witness to a new dawn, bringing hope not just for a new day, but for his further understanding of the Cosmos.

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Rare Visual Tropo Duct Surprises the Microwavers

What started out this past November as a Thanksgiving Day turkey dinner on the beach for a group of amateur radio operators turned into six hours of looking inside a tropospheric duct! Here is how it happened.

By Gordon West,* WB6NOA

Every Thanksgiving a group of us southern California ham radio operators head to the beach to drop a turkey into boiling oil. Many times we bring along a radio and set up a small 3-element beam. However, this year, rather than operating, we were just going to soak up the sun and spot some faint indications of the common fall inversion layer.

A quick Doppler radar weather check before we headed to the sand clued us in on the last day of a persistent high-pressure system over the southland. There was not a cloud in the sky and the indicated sea surface winds were at nearly zero.

"What caught *my* eye was the Doppler radar return echoes of a phantom curtain of reflection about 10 miles off shore," commented Suzy West, N6GLF. "On the short drive down to the beach, I couldn't imagine how the weather service was getting such strong echoes," added Suz. Soon we were to better understand what the radar was showing. However, before we get started with our understanding, let's do a quick review of normal atmospheric dynamics.

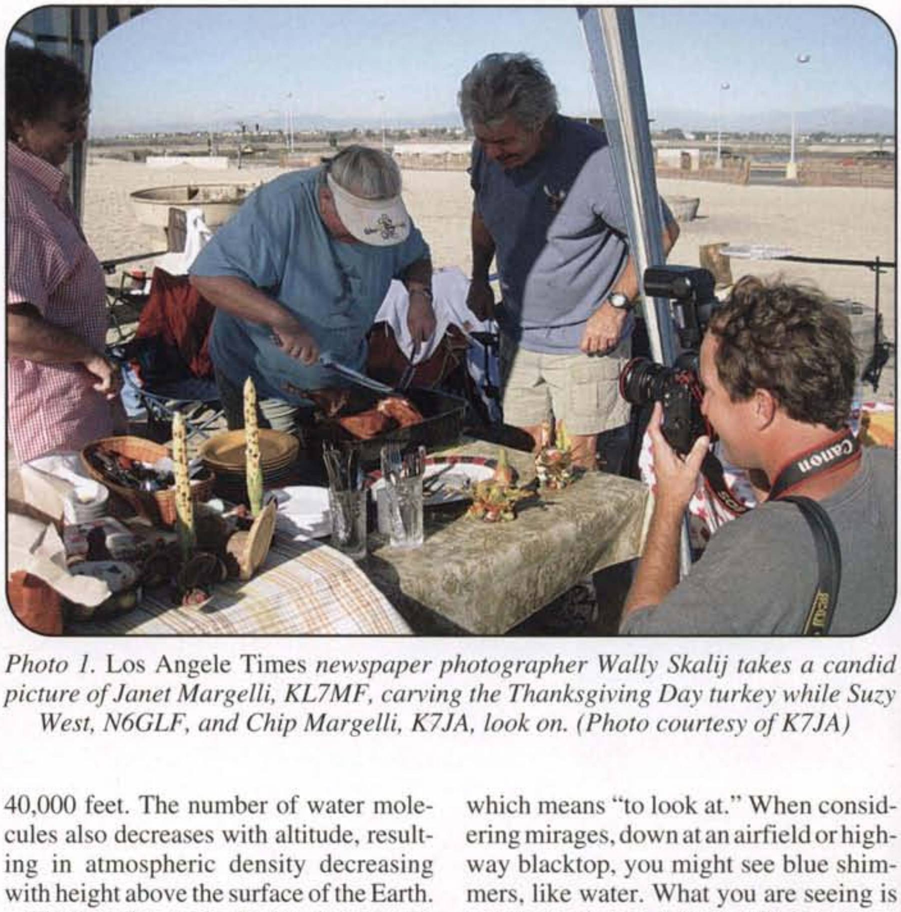


Photo 1. Los Angele Times *newspaper photographer Wally Skalij takes a candid picture of Janet Margelli, KL7MF, carving the Thanksgiving Day turkey while Suzy West, N6GLF, and Chip Margelli, K7JA, look on. (Photo courtesy of K7JA)*

Microwaves and light waves normally travel 1.1 times farther than the optical horizon. The formula used to calculate the distance of the radio horizon, in kilometers is $D = \sqrt{17h}$, where h is the height of the antenna above water. As ham operators, we know this as 4/3 radio horizon, traveling slightly farther than the visual horizon on a normal day. This day, however, would not be "normal"!

Our atmospheric dynamics exhibit a decrease in air pressure with altitude in an approximately logarithmic manner. The higher we go, the less air pressure there is. Air temperature also decreases with altitude, approximately 20° Fahrenheit for every mile of increasing altitude up to 40,000 feet. The number of water molecules also decreases with altitude, resulting in atmospheric density decreasing with height above the surface of the Earth.

The bending of both visual and radio waves is called *refraction*. The refraction of "normal" air is slightly higher than unity, around 1.000345. We know the refractive index of air *increases* in the presence of a stationary high-pressure system; as the heavier air within the high begins to sink, it is called *subsidence*). It bottoms out just above land, lakes, or seawater and becomes compressed with the continuing influx of descending air. Squish air and it gets warmer. This thin, and sometimes as occurred on this day, thick stratified band of warmer air can create a mirage, our English word that comes from the French word *mirer*, which means "to look at." When considering mirages, down at an airfield or highway blacktop, you might see blue shimmers, like water. What you are seeing is not water. Rather, it is the refraction from the blue sky above. This is called an *inferior* mirage, where you look *down* and see the image of something *above*.

Microwave operators usually work DX from the *superior* mirage, which is an inverted image *above* the image that is sometimes far beyond the horizon. A superior mirage is usually seen as an elevated band of trapped smoke or haze, with well-defined visual characteristics of the duct itself. Here in southern California, we rely on the every July *superior* tropospheric duct that allows our 2-meter and 70-cm signals to traverse from the mainland to Hawaii, and to hear Hawaii

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

Photo 2. This is a well-developed phantom curtain which was caused by a temperature inversion that had developed about ten miles off the coast. Notice how it looks like a mountain range. As the day wore on this curtain would take on various shapes. The other photos in this article illustrate the changing shape of the curtain. (Photo by K7JA)

Photo 3. Notice how the curtain has changed shape from photo 2. The center has elongated and the "mountain ranges" on each side of the center hole have pushed up. (Photo by K7JA)

VHF/UHF radio operators loud and clear at this end of the circuit. We need to be either below or within superior duct to take advantage of this type of long range tropo. Driving to a tall peak will sometimes put us *above* the duct, and we then hear absolutely nothing!

Most extraordinary, seldom occurring, and almost never photographed is the *Fata Morgana,* named after King Arthur's wicked half-sister, the sorceress Morgan le Fay, who, according to some legends, lived in a crystal palace under the waves and manifested her magical powers by creating mirages. On Thanksgiving Day we witnessed a Fata Morgana. A Fata Morgana is a unique occurrence of stratified (layers) of illusion changing in slow motion, exaggerating both height, width, and perceived closeness as the light moves through layers of different temperatures.

Our second clue (radar being the first clue) was a distant shoreline where a one-story house looked like a 20-story skyscraper. "Everything was elongated; houses looked like they were on stilts, and our customary headland looked like the cliffs of Dover," commented Chip Margelli, K7JA. As far as we could see, everything seemed to stretch upward.

"I especially liked the balancing act of a distant sailboat mast-to-mast with another upside down," added Janet Margelli, KL7MF. Even super tankers waiting to come into the ports of Los Angeles and Long Beach had normal dark-colored hulls, but their superstructures looked like Mt. Everest!

We estimated that the multiple layers were hugging the ocean and extending up about 500 to 1000 feet. Images within the mirage were distorted, but with a definite breakpoint above the mirage, turning back to a normal view.

Photo 4. This photo was taken a bit north. Notice the difference in the consistency of the curtain to the right of the ship. (Photo by K7JA)

Photo 5. The tropo gap is clearly visible in the center of the photo. (Photo by Walter Skalij)

Photo 6. Gaps in tropo are clearly evident on either side of the center of this photo. An oil derrick is in the center. Furthermore, a tanker is visible on the right side. (Photo by Walter Skalij)

Photo 7. This photo shows the now much closer tanker and the deterioration of the propagation wall going from the center of the photo to the right edge of the photo. (Photo by Walter Skalij)

As Thanksgiving Day and turkey were to come upon us, more magic began to appear on the horizon. Our local Catalina Island began to distort, and what appeared as a small isthmus near the west end of the island first evolved into a wide-open canal. Then, five minutes later, the image turned into towering cliffs on each side of the canal. Finally, five minutes later, it turned into a well-constructed bridge with a perfectly formed tunnel below! The extreme west end of the island, just off the bow of the anchored ship, became so distorted that it seemed to be larger than most other portions of the island.

It gets even better: A military-owned island, well offshore, called San Clemente Island, is seldom seen from the mainland at beach level. It is simply over the horizon. Not that day! At first, a band of black "smoke?" appeared to rise from the general direction of this other island and continued to build and build until suddenly the most majestic, detailed radio tower popped into view, shimmering in the sunlight. The tower reached taller and taller, and almost instantly developed a massive capacity hat on top. Then, in the blink of an eye, the whole island disappeared and became muddled in the brown distortion off in the distance.

The local newspaper photographer (who just happened to be there) was intent on capturing the sun's fleeting moment of "green flash" exactly as it dipped below the horizon, usually seen only in the tropics. He was in for a great surprise! He switched over to his longer lens to capture as many of these rare tropo shots as possible.

As the sun slowly sank, it grew horns, flattened out, turned square, broke into pieces, momentarily dipped and resurfaced, and then did a swan dive into the ocean with a plasma *blue* flash! All of this activity occurred too quickly to capture on film.

What does all this have to do with VHF/UHF/microwave DXing? Plenty:

1. Look for improved DX conditions within the stationary high.

2. Look at weather-service radar images on the computer.

3. Look for an elevated tropo haze formation hanging on the horizon.

4. Position yourself for extended long-range tropo contacts, listening for propagation beacons.

5. Visually scan a flat horizon and look for unusual images

Not often can the microwave DXer be treated to a *visual* band opening!

Dr. Ernest K. Smith, Jr. (1922–2009)

A Reflection on his Impact on Propagation Studies

We amateur radio operators who take advantage of sporadic-E propagation owe a lot to Dr. Ernest K. Smith, Jr., ex-N6HQK, for all of the research he contributed to analysis of this mode. In this article WB2AMU eulogizes Smith by briefly summarizinng his massive amount of contributions to propagation research.

By Ken Neubeck,* WB2AMU

Sad news came to the scientific community in October 2009 when it was learned that Dr. Ernest K. Smith had passed away at the age of 87. Dr. Smith was instrumental in the area of characterizing the sporadic-*E* phenomenon, a major propagation mode that is experienced by those who frequent the VHF bands such as 6 and 2 meters, among others on the ham bands. In addition, Dr. Smith was a radio ham for a number of years, holding the callsign N6HQK until it expired early in 2009.

Dr. Smith's major achievement towards the better understanding the sporadic-*E* phenomenon was that he was instrumental in the reduction of the vast amount of hourly ionosonde data that was collected from around the world from different station locations. The data was used to come up with worldwide sporadic-*E* occurrence maps that were presented in the late 1950s in his two major works: *Worldwide Occurrences of Sporadic-E* (his first major work and his thesis, 1957) and *Ionospheric Sporadic-E* (1962), which he co-authored with Dr. Matsushita.

Dr. Smith was born in Peking, China in 1922 to Professor Ernest K. Smith and Grace Goodrich Smith. He left China in 1940 to go to America to attend Swarthmore College and then he completed his PhD at Cornell University. His career spanned several positions which he held for different government organizations, including the National Bureau of Standards, NOAA, the Jet Propulsion Lab, and as an adjunct faculty member at Colorado University.

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

Dr. Smith initially got involved in the research of sporadic-*E* in 1949 while he was attending Cornell University for his Masters degree. He was presented with the problem of proving whether sporadic-*E* propagation was the cause of television interference caused by reception of distant stations. As Dr. Smith stated, "This was when I felt I was in the right place at the right time with the right background." From this point, he wrote papers that discussed sporadic-*E* data based on some amateur radio data and TV DX reception reports. Dr. Smith may have been the first scientist to conclusively demonstrate that the midpoint of a TV DX reception path fell near an ionosonde station where the ionograms showed strong indication of sporadic-*E*. He also found that the more data that was accumulated on sporadic-*E* the more consistent the statistics became, thus allowing for the construction of worldwide sporadic-*E* occurrence maps.

The importance of Dr. Smith's work in the area of sporadic-*E* cannot be understated, particularly in the early days of categorizing the behavior of this phenomenon. The collection of hourly ionosonde data from each station and then combining it with other ionosonde stations to be able to construct probability maps for the different seasons was a major accomplishment because of the amount of work that was involved. This was all done by hand calculations and manual labor during the 1950s before the age of computers!

Dr. Smith's main strength, in my opinion, was the fact that he developed an intuitive feel for the data that resulted in the

Dr. Ernest K. Smith (ex-N6HQK). (Photo by Boulder Torch Club)

specific construction of these maps (see figure 1 for an example). First of all, he was able to define the different zones of Earth related to sporadic-*E* behavior: the north and south aurora zones, the north and south temperate zones, and the equatorial zones. Second, he was able to determine the division of the data for the Northern and South Hemispheres into three seasonal categories: the summer season, the winter season, and the combined fall/spring equinox period. It was through Dr. Smith's research that some form of statistical probability could be established with regard to the summer season, the winter season, and the equinoxes.

In addition, through the collection of this massive data, it became apparent to him and others working with him that Japan and parts of Asia had the highest incidence of summertime sporadic-*E* with the highest measured critical frequency and measured maximum usable frequency (MUF) on a yearly basis. Conversely,

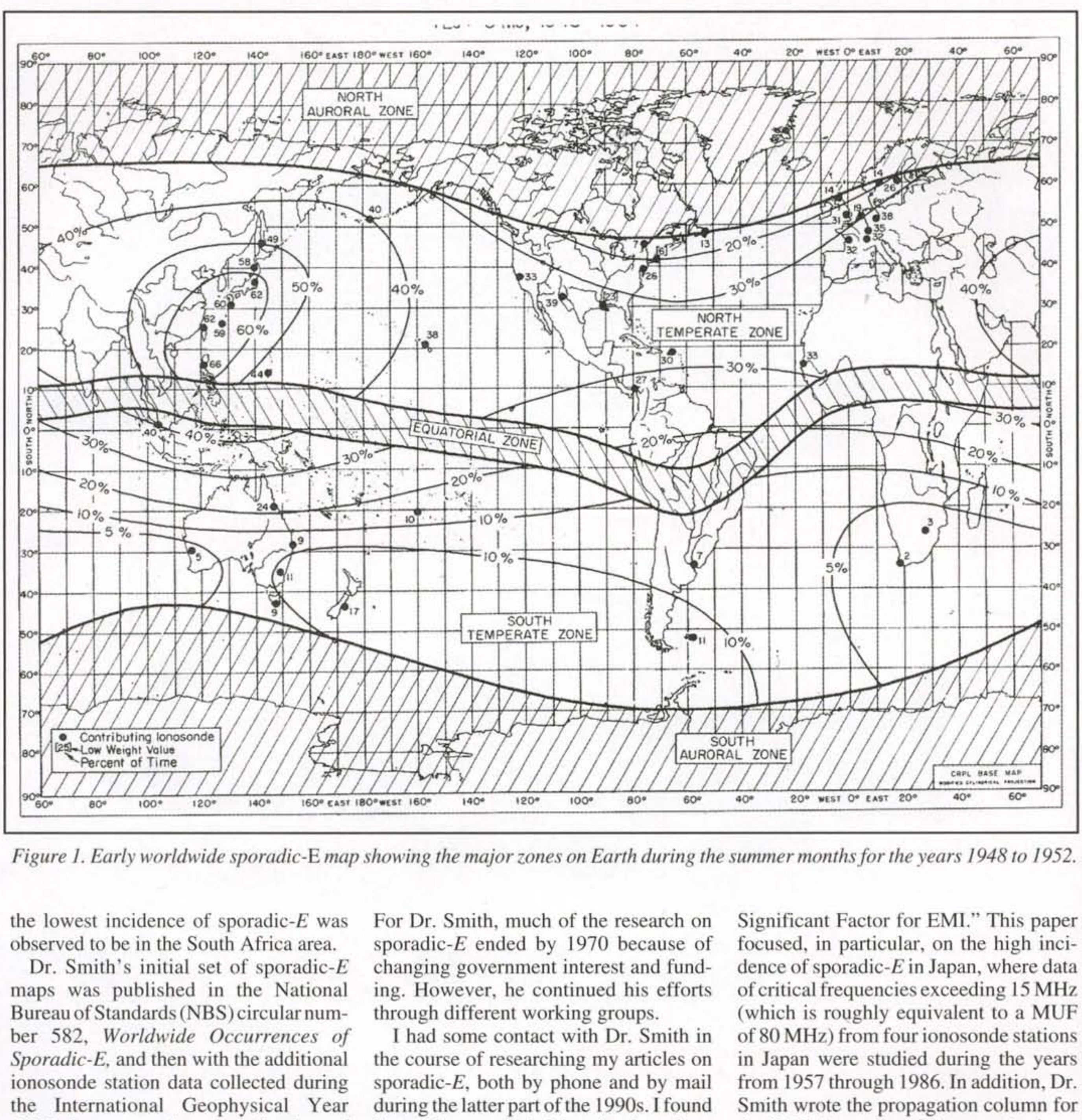


*Figure 1. Early worldwide sporadic-*E *map showing the major zones on Earth during the summer months for the years 1948 to 1952.*

the lowest incidence of sporadic-*E* was observed to be in the South Africa area.

Dr. Smith's initial set of sporadic-*E* maps was published in the National Bureau of Standards (NBS) circular number 582, *Worldwide Occurrences of Sporadic-E,* and then with the additional ionosonde station data collected during the International Geophysical Year (IGY), he presented a more refined set of maps in his co-authored book *Ionospheric Sporadic-E.*

Dr. Smith cited in his papers the importance of early 6-meter studies involving amateur radio, specifically the one that took place from 1949 through 1951 and included about 350 North American radio amateurs. He also noted that in one study conducted by the Air Force in 1965, the approximate size of a sporadic-*E* formation could be determined by the plotting of the paths of amateur radio reception reports involving 50-MHz contacts.

For Dr. Smith, much of the research on sporadic-*E* ended by 1970 because of changing government interest and funding. However, he continued his efforts through different working groups.

I had some contact with Dr. Smith in the course of researching my articles on sporadic-*E*, both by phone and by mail during the latter part of the 1990s. I found him to be most helpful and soft spoken, along with being generous with providing information for my articles. In one of his earliest responses to a question, he sent me a copy of *Worldwide Occurrences of Sporadic-E.* He seemed very glad that there was current interest in the sporadic-*E* phenomenon by VHF hams such as myself.

In his later years, Dr. Smith continued pursuing his interest in the high incidence of sporadic-*E* in Japan with a paper that he co-wrote with Professor Kyoshi Irarashi in 1997: "VHF Sporadic-E – A Significant Factor for EMI." This paper focused, in particular, on the high incidence of sporadic-*E* in Japan, where data of critical frequencies exceeding 15 MHz (which is roughly equivalent to a MUF of 80 MHz) from four ionosonde stations in Japan were studied during the years from 1957 through 1986. In addition, Dr. Smith wrote the propagation column for the *IEEE Antenna and Propagation* journal, which was published monthly.

Several VHF hams were able to meet Dr. Smith when he made a presentation at the Central States VHF Conference in 1999 in Kansas City, Missouri, where he reviewed his observations and personal reflections on sporadic-*E* from the early years. His presentation is documented in the *Proceedings* for that conference and has been published by the ARRL. It is definitely worth reading. The VHF community owes a lot to the work that was performed by Dr. Ernest K. Smith.

Beginning Experiments on the VHF Amateur Bands

In this issue of *CQ VHF* we welcome Rick Campbell, KK7B, one of the most prolific writers of amateur radio related technical articles and designers of amateur radio projects. Here he gives us a peptalk of sorts concerninng our mandate to build, modify, and experiment. He then describes using a 6-meter to 40-meter converter to operate QRP CW on the 6-meter band.

By Rick Campbell,* KK7B

I have been experimenting on VHF since I discovered as a young teen that I could spread coil turns in an FM transistor radio and tune in signals above the FM broadcast band. In those days, the VHF ham bands were populated by experimenters. Everyone's station had some homebrew gear, and my beginner's questions were welcomed by gentlemen who were willing to put down the soldering iron long enough to help me get a station on the air. Those early days led me to degrees in physics and electrical engineering and a long and varied career in basic research, university teaching, and designing the microwave radios inside cell phones.

Over the years the VHF bands evolved from the playground of experimenters to something else. Homebrew gear is now rare, and gentlemen with soldering irons who understand the inner workings of radio technology are not as visible. However, they are still around, often retired from careers in electronics and radio. I'm not ready to retire yet, but I'd like to re-create some of those early VHF games that I played and observed in my early years. There is still no better place to explore the magic of radio than the VHF bands—with small antennas, low power, slow CW, easy modulators, simple test equipment, and basic receivers. This series of articles will introduce basic experiments and experimental gear for the VHF amateur. We'll start with a low-power signal source, and then progress through receivers, modulators, more capable antennas and stations, portable operation, etc.

Our amateur radio license is more than permission to transmit; it is also a license to build, modify, and experiment with transmitters, antennas, and signals. For a large and very interesting group of amateurs, experiments are the focus of amateur radio and often result in spin-off technology for other services. Amateur experiments are different from simply operating a radio to make contacts, and require different equipment as well. Fortunately, we can get started exploring radio science at very little expense. The most basic radio experiment is generating and radiating a signal, picking it up on an antenna, and listening to it. We need a receiver, which you may already have, and a low-power VHF signal source. Low power is essential for several reasons: You want to pick up the signal across the room without overloading your receiver; you want to connect experimental modulators and amplifiers to the output; and you don't want to interfere with other amateurs while experimenting.

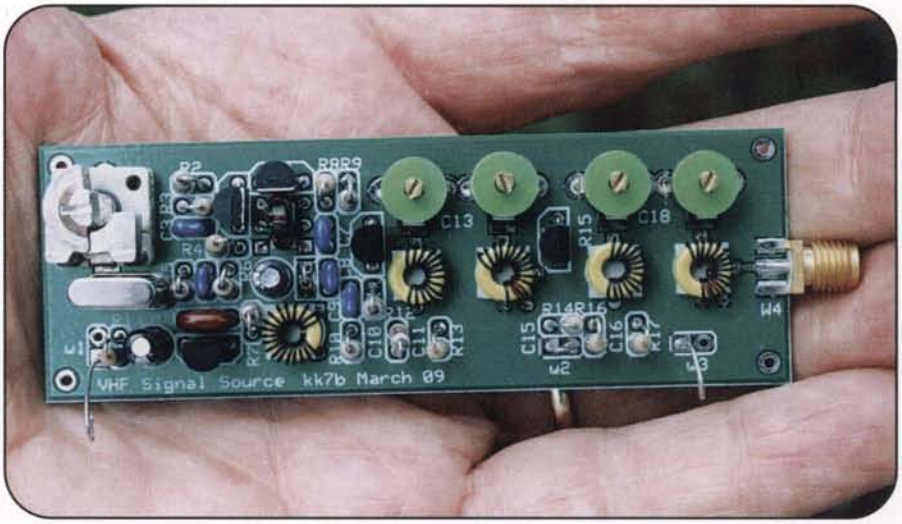


Photo A. A 10-milliwatt CW source available as a kit from Kanga US.

CW is a good choice for many reasons, but the obvious one is that CW provides a constant frequency and amplitude to make repeatable measurements. Your signal source isn't just a low-power transmitter; it's a signal generator for your bench as well. You don't need to learn to communicate using Morse code to operate a CW signal generator. However, if you are going to radiate it on the air connected to an antenna, you need to be able to send your own amateur callsign to identify the transmissions. You don't even need a key; a push-button switch will do, and you can write the dots and dashes on a piece of paper until you have your own callsign memorized. Fast CW is for HF; VHF experimenters use slow CW. It is more effective when signals are weak, and we are more interested in making one difficult contact than racking up a large number of contest points per hour.

Photo A is a 10-milliwatt CW source available as a kit from Kanga US for $27. It has a few chip components and some toroids to wind, so if you haven't done any construction you will need some

*e-mail: <ecekk7b@gmail.com>

guidance. One of the most interesting experiments is to find out how far away you can hear a 10-milliwatt 50.100-MHz signal, and for that goal you will need a friend. Find one who has a magnifying glass and a fine-tip soldering iron. The complete schematic and other construction details are on the Kanga website: <http://www.kangaus.com/>.

The Signal Source Circuit

The CW source has three sections: a crystal oscillator, frequency multiplier, and narrow-band amplifier. The crystal oscillator generates a signal at one-third the desired output frequency. By generating the frequency at HF, we can use a stable fundamental-mode crystal oscillator with a variable capacitor in series with the crystal to vary the frequency by a few kHz above and below the frequency marked on the crystal.

We then multiply the frequency by three in a single-transistor circuit. There are many clever frequency-multiplier circuits, but few work as well as this old standard, and very few are simpler or more reliable. Following the frequency multiplier is an amplifier with a double-tuned circuit on its input and output. When tuned to the desired third harmonic of the crystal oscillator, all the other close-in outputs from the frequency multiplier are more than 70 dB down. The harmonic levels at 100 MHz and 150 MHz meet FCC regulations for direct connection to an antenna. This is a very clean signal source.

It is not necessary to understand all the subtle circuit details at this time. The sky was blue for a long time before Rayleigh worked out the electromagnetic theory to explain why. A good experimenter gets things working first and makes some measurements before trying to understand what it all means. That is the first rule: Get it working and then ask questions. Children and college students like to ask a lot of questions first to delay starting an assigned task. Authors of technical articles receive many questions via e-mail. The good ones almost always come from folks who have started a project and encountered a puzzling result.

Bill Kelsey has set up a Yahoo group, VHFkits (see <http://groups.yahoo.com/group/vhfkits/>), where we can quickly answer any questions that arise. As you start to build and measure VHF hardware, the first thing that improves is the quality of your questions.

The VHF signal source in photo A may be connected to a 50-ohm resistor and homemade Morse code key as shown in figure 1, or connected to a simple dipole antenna as shown in figure 2. I find the combination of low power and homemade Morse code keys is the easiest way to get folks over any fear of putting a signal on the air. With the 51-ohm resistor connected, anyone can try the key. With an antenna, you need to send your callsign every 10 minutes. Use the formula for the length of a half-wave dipole from your Technician License exam to figure out how long the antenna should be.

Now that the source is on the air (use the resistor first), tune a receiver to

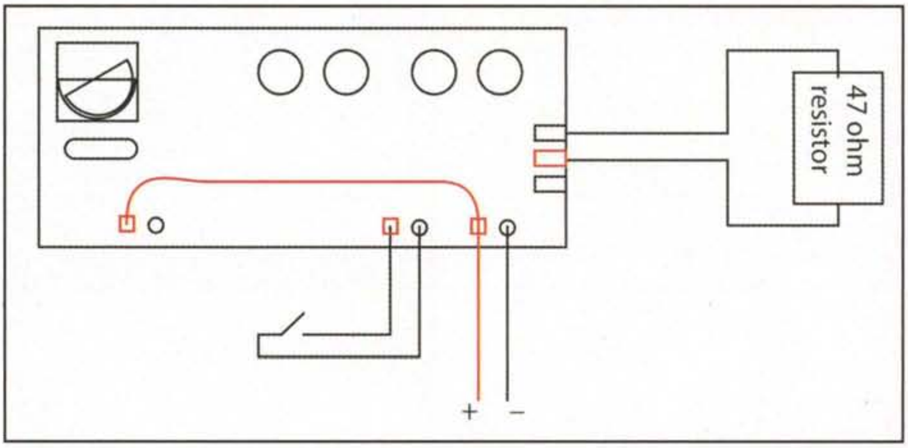


Figure 1. The VHF signal source in photo A may be connected to a 50-ohm resistor and homemade Morse code key.

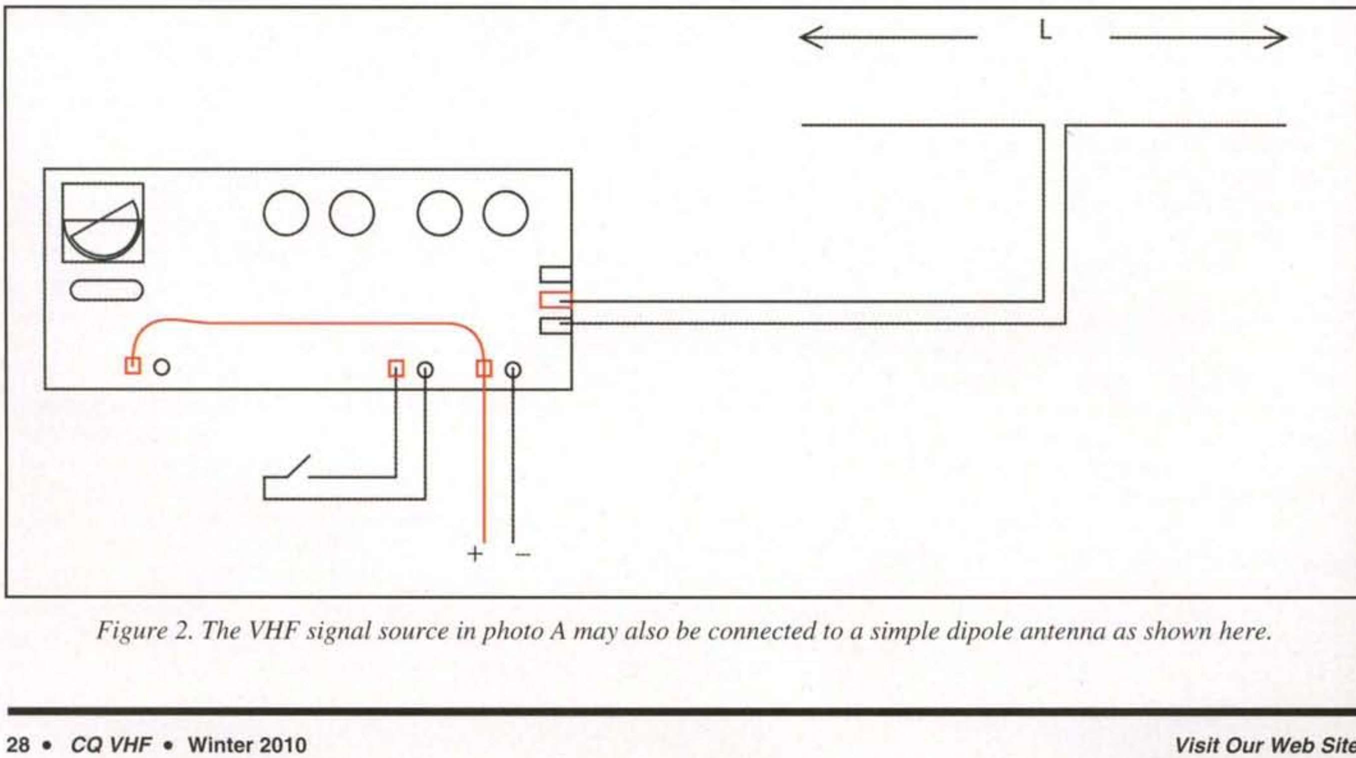


Figure 2. The VHF signal source in photo A may also be connected to a simple dipole antenna as shown here.

50.100 MHz and press the key. I recommend starting with the VXO capacitor plates fully meshed, which should put the signal below 50.100 MHz, in the CW portion of the 6-meter band. You can tune in the signal on an HF/6-meter transceiver, any of the new radios that cover most of the bands between 160 meters and 70 cm, a wide-range receiver, or a hand-held that will tune 6 meters. I keep a little ICOM Q7a on the bench for a check of my VHF signals.

Even with a resistor across the output, you will be able to pick up the signal across a room. The simple power detector circuit in figure 3 may be connected to the output to allow you to tune the four variable capacitors in the narrow-band amplifier. More examples of simple power detectors are in *Experimental Methods in RF Design*, available from ARRL. The plastic on top of the trimmer capacitors is transparent enough that you can tell if the plates in the capacitor are fully meshed. Start with the capacitors at half mesh, and you will be close. It is possible to tune the output filter to 33.4 MHz (16.7 × 2) or 66.8 MHz (16.7

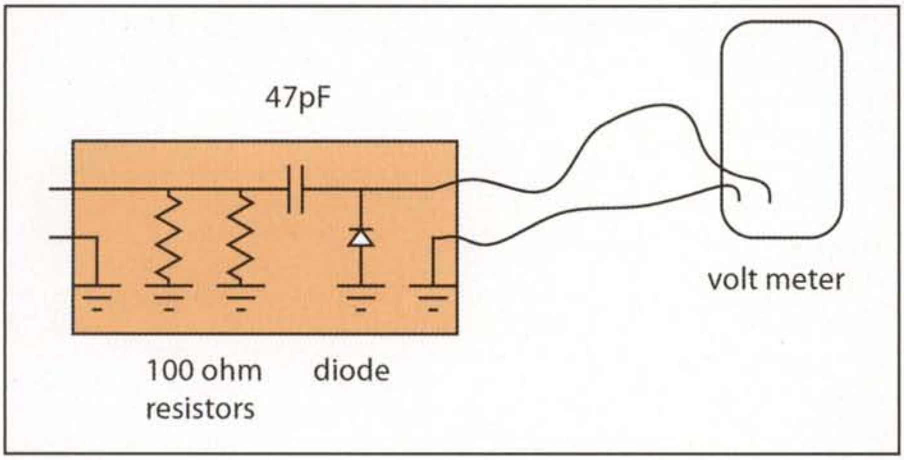


Figure 3. Even with a resistor across the output, you will be able to pick up the signal across a room. This simple power detector circuit may be connected to the output to allow you to tune the four variable capacitors in the narrow-band amplifier.

Photo B. An ultra-portable 6-meter CW rig that I put together to take across the lake in a small sailboat.

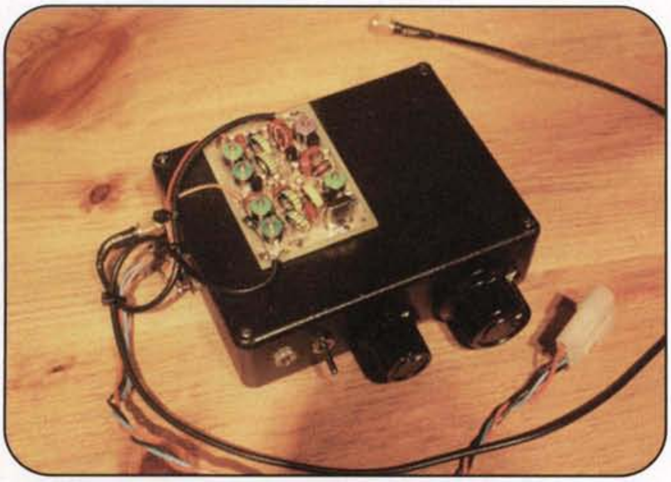


Photo C. If you want to get a head start on a very capable 6-meter receiver, check out the Rcx1 6- to 40-meter receive converter on the Kanga US website. Shown here is that little receive converter taped to the top of a little 40-meter SSB-CW receiver, a microR2 from Kanga.

× 4). You can be sure you are tuned to the right output by starting with the capacitor plates half meshed, and listening on the receiver to make sure the signal gets louder when you have the signal source tuned for maximum. If you have an oscilloscope, you can use it instead of the diode detector by connecting the high-impedance scope probe across the 51-ohm resistor. This way you can see the output waveform and use the scope timebase to confirm that you are tuned to 50.1 MHz. Most experimenters eventually own an oscilloscope, and once you do it is hard to live without one.

Low-Power Experiments

Ten milliwatts on 6 meters is not a lot of power, but with the right antenna and a good receiver the signal can be heard on any path where you can see the other station, as well as shorter paths with obstructions in the way. If you have a friend within a mile or two who has an outside antenna and a rig that will copy CW, hang the dipole outside, send your callsign with the key, and see if he can hear you. Six-meter dipole antennas are easy to set up and take down, and can easily be disguised to look like something other than a radio antenna. The center of the dipole is more important than the ends, so if the available space is too short, let the ends droop.

Suppose you hang your 6-meter dipole from the apartment balcony, and your friend a half mile away can hear you nicely on his FT-817. You'd like to make a two-way contact, but all you have is the CW signal source and a handie-talkie that covers 6 meters. Turn your HT to AM receive mode and have your friend transmit some CW. Leave the signal source on, but with the key up. Move your HT with its rubber-duck antenna around near the signal source, and you might hear some Morse code. There will be a place that gives you the best CW signal. How is that possible? The HT has an AM receiver! Actually, this is the oldest way to receive continuous-wave Morse code. You tune in your AM receiver, and somewhere nearby, a weak CW oscillator at almost the same frequency as the signal you want to receive. The two signals beat together inside the receiver, and the difference frequency goes to the audio amplifier and out the speaker. In the old days, the nearby CW oscillator was called a "local oscillator." In fact, it still is—but now it is usually inside the receiver. The math is a bit more complex, but it can also work with an FM-only HT. Try it!

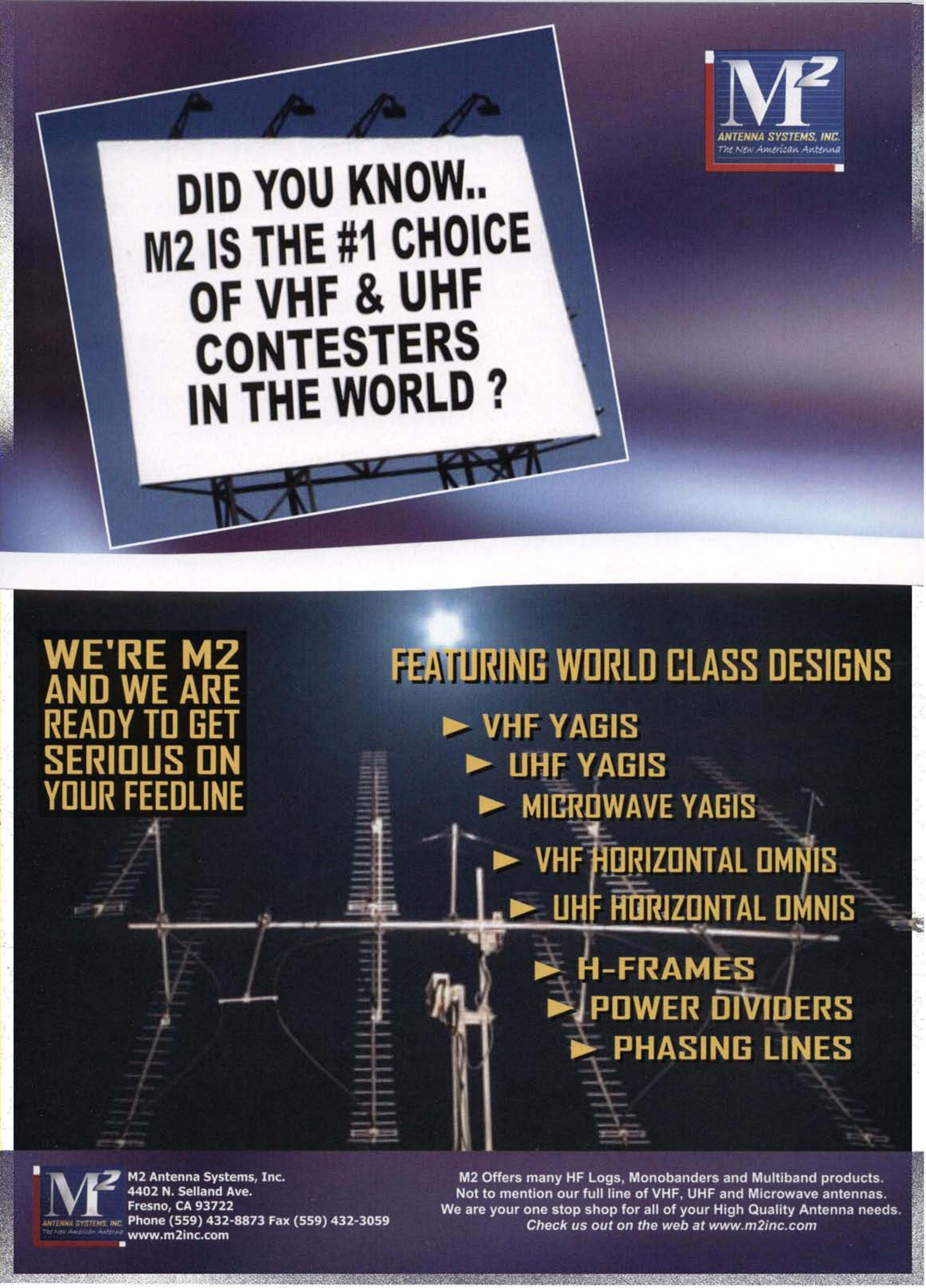
At this point clever experimenters will start sketching all sorts of ultra-portable 6-meter CW rigs. Photo B shows one that I put together to take across the lake in a small, wet sailboat. The 10-milliwatt CW source is in the waterproof container with a 9-volt battery. The signal from the other station is received on the IC-Q7a that rides in another waterproof box with a dipole and log book. I use the rubber duck for receiving and the good antenna (hauled up the sailboat mast) for transmitting, because the other station has a good receiver and much more transmit power.

The next steps involve more power and a better receiver—and a few other decisions. One watt of CW will work the world with a good antenna and band opening, but that will require a better receiver and some good CW operating skills. Perhaps you'd like to experiment with voice modes. AM is easy, but that will require a different crystal for 50.400 MHz. DSB and SSB are also fairly easy to generate, and we'll play with those as well.

For anyone who wants to get a head start on a very capable 6-meter receiver, check out the Rcx1 6- to 40-meter receive converter on the Kanga US website. We'll describe that in more detail next time, but meanwhile, photo C shows that little receive converter taped to the top of a little 40-meter SSB-CW receiver, a microR2 from Kanga. Any 40-meter SSB receiver will work, but some of them are much cooler than others.

Until next time . . .

73 de Rick, KK7B



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Digital Wattmeter Element for the Bird Model 43 Wattmeter

Long a mainstay in amateur radio shacks, the Bird Model 43 Wattmeter has one very important weakness—the analog meter. Here WA8SME describes how he replaced the rather pricey meter with a digital meter element he designed and built for his Model 43.

By Mark Spencer,* WA8SME

My Bird Wattmeter is tied for second place as my most important and most used piece of test equipment. First place, hands down, goes to my voltmeter; my MFJ Antenna Analyzer shares the second place slot with the wattmeter; and my oscilloscope comes in third.

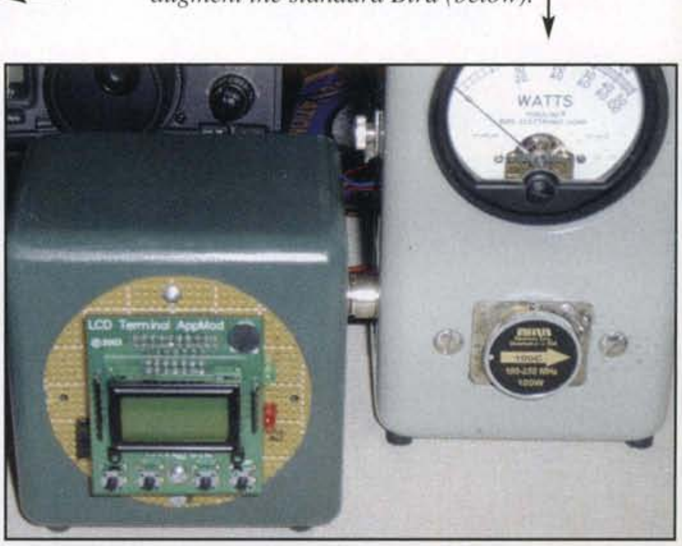
**ARRL Education and Technology Program Coordinator, 774 Eastside Rd., Coleville, CA 96107*
e-mail: <mspencer@hughes.net>

The wattmeter has been an invaluable asset in installing and maintaining my satellite ground station antenna system. It is rugged, reliable, and fairly easy to use except that you have to enter the forward and reflected watt readings into a formula to calculate the VSWR. This really isn't that big a deal and keeps the dust off the gray matter. However, I did have a friend who dropped his wattmeter and broke the analog meter element. That got me thinking: How much would it cost if my meter experienced the same fate? Wow . . . around 150 bucks to replace the analog meter movement!

That thought was the catalyst for the project detailed here, a replacement or add-on digital meter element that could more affordably bring a broken Bird Wattmeter back to life and do some of the SWR and power-loss calculations for me. The digital wattmeter element is designed to actually replace the analog meter element inside the Bird or be mounted in an external enclosure to augment the standard Bird (figures 1 and 2).

The digital wattmeter element is based on a PIC®16F688 microcontroller and an inexpensive LCD display module. Refer to the circuit diagram of figure 3 for the following discussion of the circuit. The digital wattmeter element is powered by a 9-

Figures 1 & 2. The digital wattmeter element is designed to either replace the analog meter element inside the Bird Wattmeter (left) or be mounted in an external enclosure to augment the standard Bird (below).



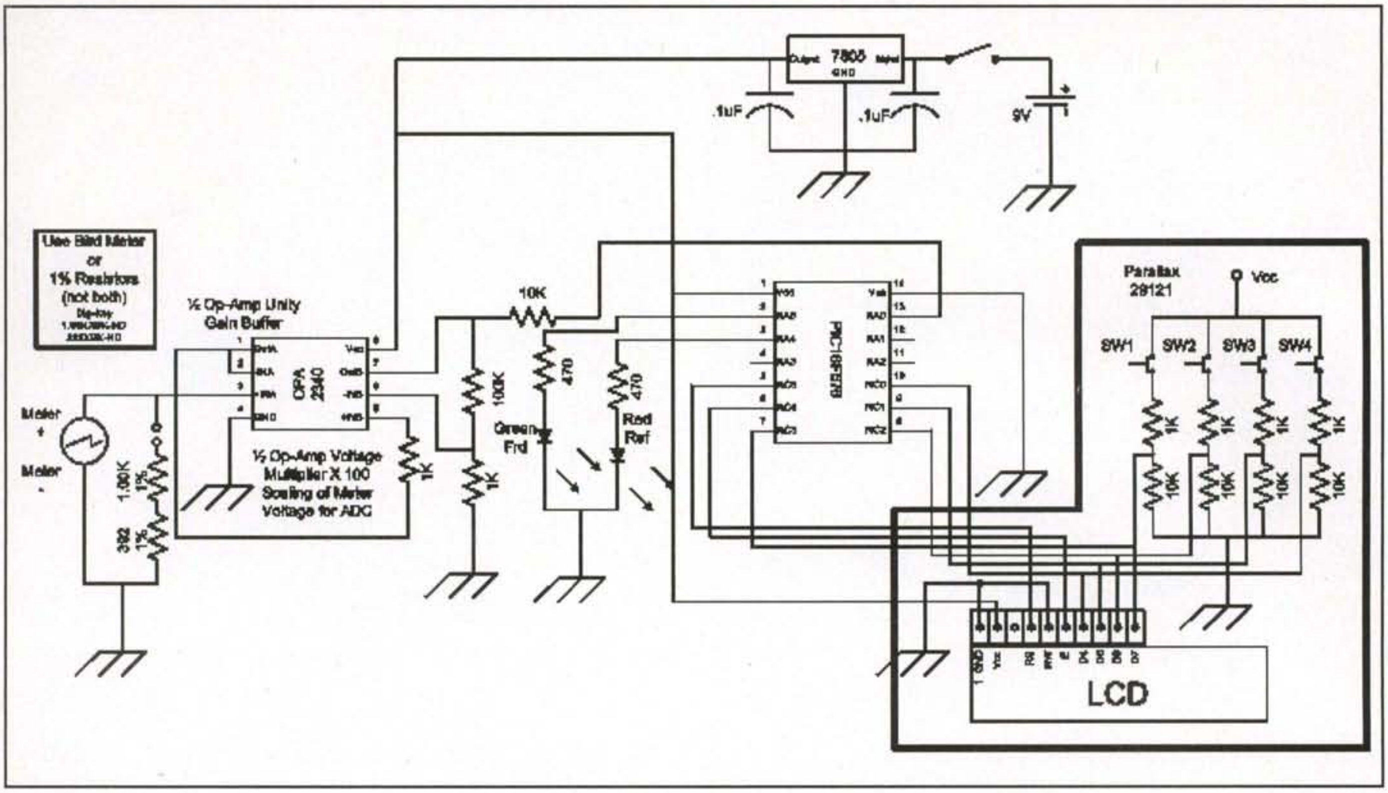


Figure 3. Alternate Bird Wattmeter meter element circuit diagram.

volt battery with the voltage stepped down and regulated to 5 volts by one half of the OPA2340.

The op amp is configured as a unity-gain buffer between the Bird Wattmeter and the digital wattmeter element circuit. The OPA2340 op amp requires a single voltage source, and this simplifies the circuit (at some added cost for the device). The input precision resistors that are shown in parallel with the analog meter are inserted into the circuit by a jumper. These resistors are required in the circuit to replace the resistance of the analog meter element if the digital meter will replace the analog meter, but they are not required if the digital meter will be used in conjunction with the analog meter. The other half of the op amp is configured as a times-100 voltage multiplier. The voltage across the analog meter (or the precision resistors) is on the order of 40 mV at full scale. The voltage multiplier boosts this voltage to approximately 4 volts to make it easier to measure with the PIC analog to digital (ADC) circuit.

The PIC is programmed to read the voltage from the wattmeter with the on-board 10-bit ADC, scale and calculate the watts being sensed (forward or reflected), calculate the SWR and power loss, and display the data on the LCD. A more detailed explanation of the programming logic will follow shortly. The final component of the circuit is the LCD module which includes a two-line eight-character LCD display and four momentary switches for user input, all in one convenient package. Two LEDs round out the circuit and provide a visual indication when forward power (green LED) or reflected power (red LED) is being measured in real time.

The prototype of the digital wattmeter element mounted in the Bird analog meter mounting ring is shown in figures 4 and 5.

Using the PIC ADC to measure the voltage produced by the wattmeter during operation is fairly straightforward. However, the correlation between voltage and watts is not a linear function, and this makes the mathematical conversion a bit more complicated. Figure 6 is the graph that shows the relationship between the measured watts and the ADC values. I used graphing calculator technology to do a curve fit of the watts to ADC graph, and then in turn used the resulting function in the PIC program to calculate the watt value from the measured ADC value. The curve fit function is:

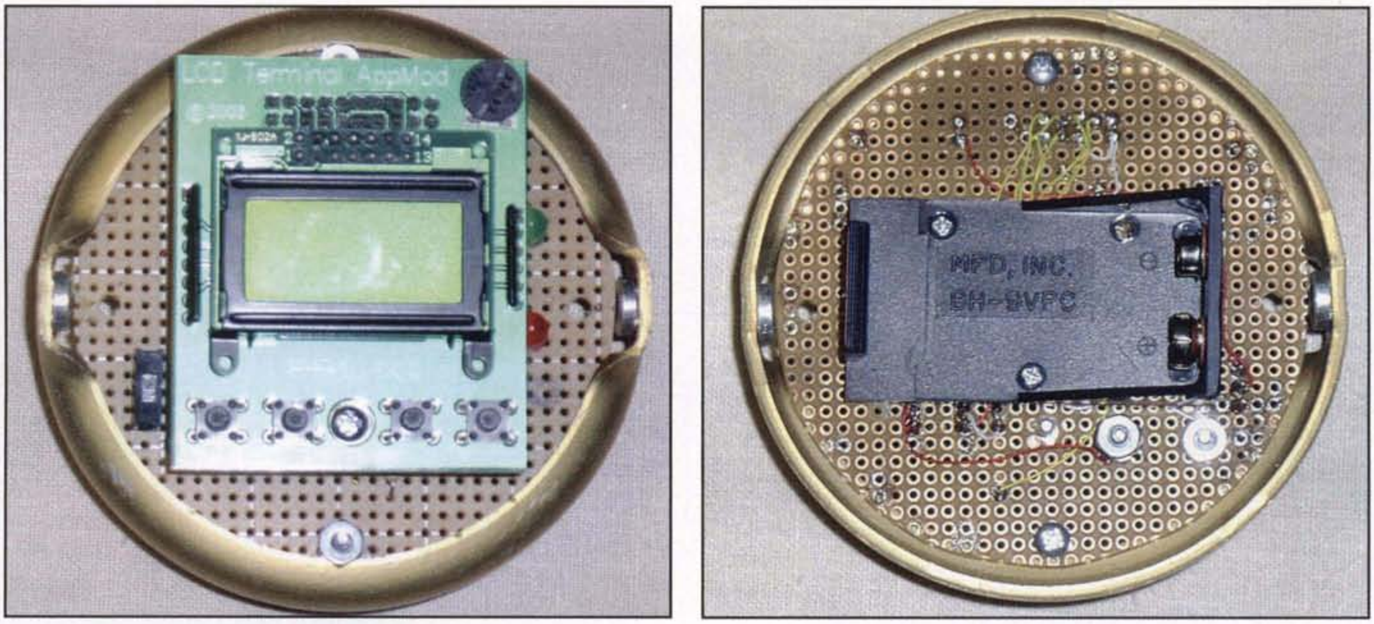
$$\text{watts} = 4.988 \times 10^{-6}\,\text{ADC}^2 = 1.652 \times 10^{-3}\,\text{ADC} + 0.00538$$

With a calculated value for watts, the PIC software continues by calculating the VSWR and power loss using the following formulas:

$$\text{VSWR} = \frac{1 + \sqrt{\dfrac{\text{Watts}_{Ref}}{\text{Watts}_{For}}}}{1 - \sqrt{\dfrac{\text{Watts}_{Ref}}{\text{Watts}_{For}}}}$$

$$\text{loss}_{dB} = -10\log\left(\frac{\text{Watts}_{For} - \text{Watts}_{Ref}}{\text{Watts}_{For}}\right)$$

I generally program PICs using assembly language. However, these formulas would have been a pretty daunting challenge to program in assembly. A C-compiler was the



Figures 4 & 5. The prototype of the digital wattmeter element mounted in the Bird analog meter mounting ring.

answer. The C-compiler allows the programmer to use the power of the higher level computer language C and then translates the C code into assembly and machine language code that is used by the PIC. Unfortunately, these hefty formulas require a lot of computer memory space to store and execute the code. I prefer to use PICs that have 2 kilobytes of memory (for cost reasons, and also most of my projects do not require a lot of memory), but in this case more memory was needed (approximately 6 kilobytes) and the PIC16F688 has this amount of memory (with a modest increase in cost of a buck or two).

The best way to go through the program logic is to describe how the digital meter element is used in operation. When power is first applied to the digital meter element, the PIC and the LCD are initialized, the previous scaling factors used are recalled from EEPROM, and the meter defaults to reading forward power. The green LED illuminates and the digital meter is ready to go.

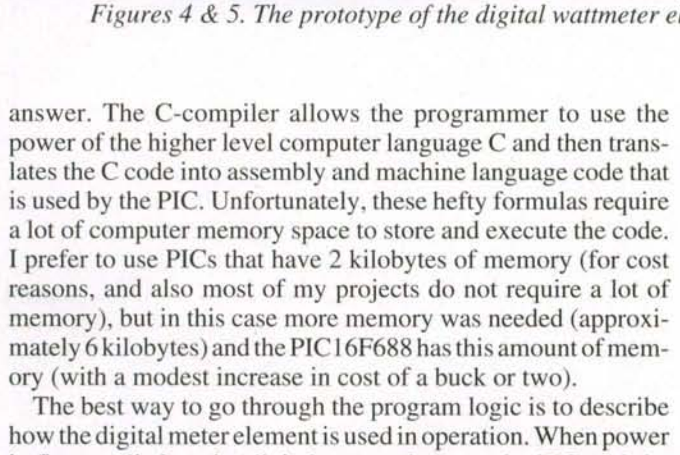


Figure 6. Graph that shows the relationship between the measured watts and the ADC values.

As illustrated in the figures, there are four pushbuttons that are part of the LCD unit (I'll label them buttons 1 through 4, from left to right, for this discussion). The two middle buttons (2 and 3) are programmed to select either reflected or forward power as the active wattage being measured. When first turned on, the display will have 0000.00 F (for zero watts forward) on the first line of the LCD, and an R (for reflected) on the second line. The green LED will also be illuminated as a visual indicator of forward power. There may be some random noise on the ADC that will give non-zero wattage indications when power is not applied to the Bird Wattmeter. When you press button 2, the digital meter element will switch over to measuring reflected power, the green LED will extinguish, the red LED will illuminate, the last forward watt reading will remain on the top line of the LCD, and the reflected power will be displayed on the second line of the LCD. To revert to measuring forward power, press button 3, the red LED goes out, the green LED comes on, the last reflected power read remains displayed on the second line of the LCD, and the current forward power is displayed on the top LCD line.

The Bird uses interchangeable slugs that are calibrated for frequency and power, and then the slug is rotated in its directional socket on the front of the Bird to measure forward or reflected power. The Bird analog meter has three scales that are applied during reading and/or calculations depending on the power of the slug in use: 0 to 100 for 10-, 100-, and 1000-watt slugs; 0 to 50 for 5-, 50-, and 500-watt slugs; and 0 to 25 for 25- and 250-watt slugs. The digital wattmeter element needs to be set to the appropriate scaling to display and make accurate calculations. The right-hand pushbutton (4) on the LCD unit is programmed to toggle through the various slug watt values when pressed by the user. When button 4 is pressed, the watt scale for both forward and reflected readings is displayed on the appropriate line of the LCD. Holding button 4 will step through the various scaling factors for the active channel (forward or reflected); release the button when the desired scaling factor is reached. This value is stored in EEPROM of the PIC

Figure 7. While applying power to the wattmeter, press button 1 to calculate the VSWR and power loss. The top line of the LCD will display the SWR and the second line will display the power loss in dB.

and is retrieved when the digital meter is subsequently powered-up. Press the appropriate button to select the other measurement channel to set its scaling factor. During my typical operating, I use the 100-watt slug to measure forward power and the 5-watt slug to measure reflected power, so these are the scaling factors that I use most frequently.

After you have the scaling factors set up, you're ready to take some SWR readings. Have the appropriate slugs on hand. I'll illustrate with the 100- and 5-watt slugs. Install the 100-watt slug and rotate it to the forward direction. Turn on the digital meter element. Apply power to the Bird Wattmeter and the forward power will be displayed. While the forward power is being displayed, press button 2 to switch the digital meter element over to reflected power (the forward power is now stored and displayed on the LCD). Turn off the transmitter RF. Swap out the slug to the 5-watt slug and rotate it in the reflected direction. Again apply transmitter power to the Bird Wattmeter and the reflected power will be displayed on the LCD. While applying power to the wattmeter, press button 1 to calculate the VSWR and power loss. The top line of the LCD will display the SWR and the second line will display the power loss in dB (figure 7). When you release button 1, the digital meter element will revert back to measure reflected power.

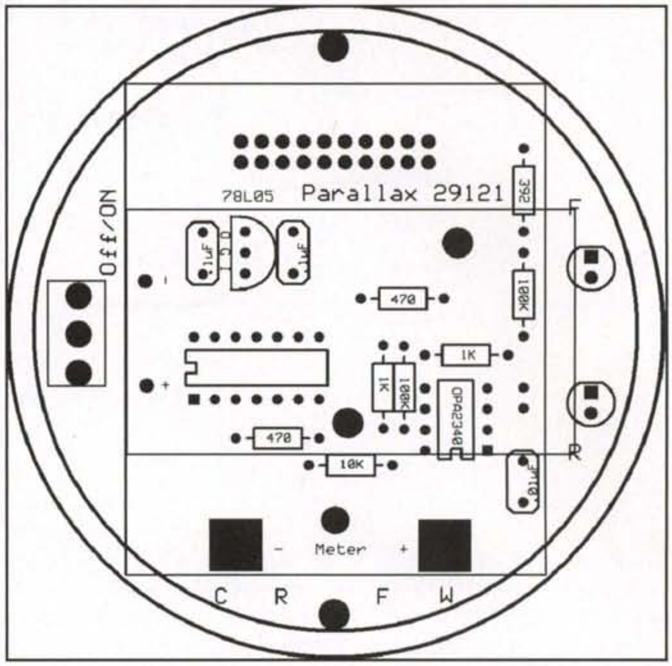


Figure 8. Prototype of the PCB the author plans to have manufactured for the project.

Some of you may be concerned with the accuracy of the digital meter element, and this is a legitimate concern considering all the conversions of voltages to ADC values, converting integers to float values and back again, curve fitting, and all the calculations going on and the rounding errors that result. Using the PIC and doing the calculations with limited variable sizes does introduce some rounding errors, but frankly so does using your eyes to read an analog meter. I have found that the digital meter element is about as accurate as using the eyeball and calculator. You just have to recognize that even though the digital meter element will display numbers to two decimal places that does not necessarily mean that the displayed results are accurate to the hundredth.

Summary

This little project has turned out to be pretty useful. I plan to get a PCB manufactured for the project to make it more professional looking and more rugged. Figure 8 illustrates what I have in mind. The final cost of the digital wattmeter element turns out to be a fraction of the cost of a replacement analog meter. The addition of the calculated VSWR and loss figures is a nice feature. I encourage you to consider duplicating this circuit to enhance your Bird Wattmeter, repair your Bird, or put into service that good deal on a broken Bird you got at the last hamfest. I will conclude with a bad pun intended, "A Bird in the hand…" Well, you know what I mean.

If you would like more information about this project, feel free to contact me at <mspencer@hughes.net>.

Digital Television: The New Ham Frontier

Among the many talks presented at the 2009 ARRL/TAPR Digital Communication Conference was one by WA8RMC on digital television. This article is based on his talk and the paper that was published in the conference Proceedings.

By Art Towslee,* WA8RMC

United States broadcast digital television started in the early 1990s and the official transition to all digital took place in June 2009. Amateur digital television started somewhere around 2000 mainly in Europe with on-air signals not appearing until around 2002 when some digital-board sets became available. Since then amateur digital TV repeaters in Europe have been increasing in popularity, but sadly the interest seems to be lacking in the USA.

In January 2004 the ATCO Group (Amateur Television in Central Ohio) in Columbus, Ohio installed a DVB-S digital output to its repeater, which has been in service 24/7 since then. As of July 2009, the ATCO Group is still the only one in the USA with a digital ATV (Amateur Television) repeater output.

The ATCO repeater digital output uses DVB-S modulation which we believe is the best choice for amateur television. The following discussion details more fully why we feel it is best, along with operational experiences to back it up. I know of no other group, in the USA or Europe, that justifies it with "in service" data. Therefore, we are able to back up our statements with results and not just theoretical details.

**e-mail: <towslee1@ee.net>*

DATV Advantages over Analog

Picture quality is near perfect. Strong and weak signals are all "P5," which is a snow-free signal. Historically, analog ama-

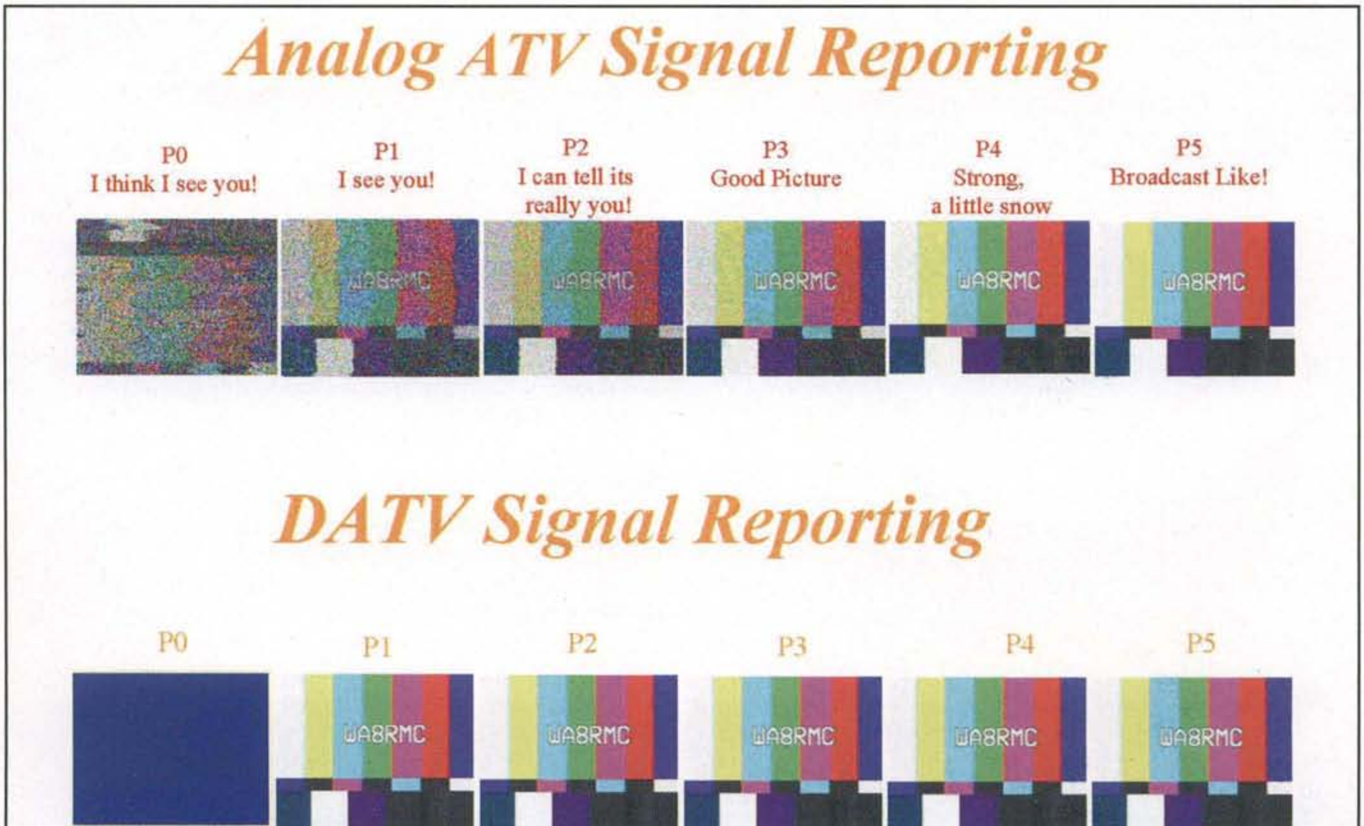


Figure 1. Comparison of signal reporting between analog and digital signals. Notice that in digital one either sees a blue screen (P0) or a clear signal (P1–P5).

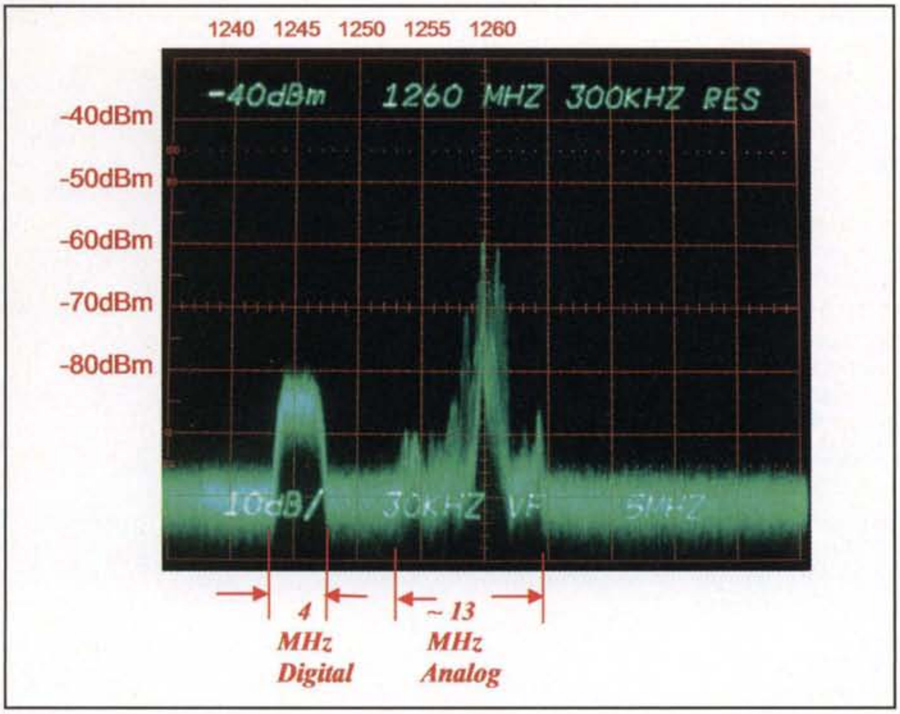


Figure 2. Bandwidth of digital versus analog signal.

teur television signal strengths are indicated by the "P" unit system where P0 is a barely detectable signal and P5 is snow-free. The strengths increase in 6-dB steps from P0 to P5, so P5 is 6 × 5 = 30 dB stronger than P0. That's for analog. A digital signal that produces a blank receiver screen with a P0 signal will produce a P5, or snow- free, picture if it's only 1–2 dB stronger. Therefore, in the analog world, if the signal strength was 1–2 dB greater than P0, the viewer would see a barely discernable picture; in the digital world the viewer would see a snow-free picture. (See figure 1.)

Noise and multipath cancellation possible. The DVB-S QPSK modulation scheme uses FEC (forward error correction) to cancel the effects of atmospheric/manmade noise and multipath (ghosting). The noise is handled by the Viterbi software algorithm and multipath is handled by the Reed-Solomon software algorithm, which are highly complex effective ways of handling the data streams but beyond the scope of this discussion. Since the DVB-S modulation scheme is intended mainly for satellite-to-ground communication, multipath is minimal, so correction requirements are also minimal and simple but adequate for ATV applications.

Noise reduction. As mentioned above, the Viterbi coding algorithm reduces noise due to atmospheric and manmade influences, but is minimal. Here also, hams are willing to tolerate some noise disturbances in the picture. However, it doesn't show up as the typical noise flashes in the picture as seen on an analog screen. Instead it will appear as either a momentarily frozen picture or as momentary checkered squares scattered through the picture. Therefore, as you can imagine, it would be intolerable for a commercial broadcast signal but quite acceptable for hams!

Can occupy less bandwidth. A commercial 8VSB digital broadcast signal occupies a fixed 6-MHz bandwidth and is not subject to modification. The DVB-S signal bandwidth, however, can be tailored to meet the users' requirements. Therefore, it can be made wider or significantly narrower than 6 MHz with corresponding trade-offs. If a narrower bandwidth is needed, video quality will suffer and fast motion may pixelate. By "pixelate" we mean that checkered squares will appear in the picture where the data cannot be refreshed accurately. For most ham applications, we are not showing video of car races and the person "on camera" is usually not moving rapidly, so again, this normally is not a problem. We have found that a forward error correction value of about three-quarters with a 3.125-meg Symbol rate is adequate for normal motion with two video streams in a 4-MHz channel. (See figure 2.)

Less transmit power required than analog for same range. Because the digital signal contains more data than an equivalent analog signal, less power is needed to transmit an error-free signal. Also, the signal envelope contains more peak power spread out more evenly across the occupied bandwidth allowing more information within the carrier envelope. An analog signal has most of the power closest to the signal center carrier, but the digital signal is spread out more evenly across the spectrum. As a result, the digital signal looks more square as viewed on a spectrum analyzer as seen in figure 2. As a rough rule of thumb, the digital signal transmit power can be as low as one-tenth of the power of an analog signal for the same received signal quality. Example: The ATCO digital QPSK 2.5-watt 1245-MHz signal is received about the same as its 30-watt 1260-MHz analog signal. (Both signals use identical antennas at the same elevation 10 feet apart).

It's neat to be on the cutting edge (bragging rights). Last but not least, it's neat to be able to tell people that your signal is the latest digital technology coming from a home-built amateur transmitter. A number of club members have been acquired just because of that fact. Many people like to be a leaders, right?

DATV Disadvantages

Most DATV is in Europe. Up to this time, it's clear that the European hams are more creative with regard to DATV. They pioneered it in the early stages starting at the turn of the 21st century. I don't know the real reason why, but guess that many are still building their own equipment, whereas many Americans have given in to simply buying what they need and "plugging it in" to get them on the air. That's not necessarily bad, but it doeslimit DATV operation here in the USA.

Transmit boards are expensive. Transmit boards available from European sources are *not cheap,* and as we all know, USA hams are rather "thrifty"! The board sets usually will run over $1500 for a 2.5-watt signal! It is therefore clear to me that the Europeans who spent a few years writing and perfecting the needed code want to be reimbursed for their effort. I can't blame them, but it doesn't sit well with our "thrifty U.S. hams," so to this date … no economical solution.

Transmit boards are difficult to build. Well, not really, but the *hardware* is the easy part, as a number of manufacturers have created individual ICs at reasonable prices. However, writing the *software* code for these is another matter. What we *really* need is to have some experienced ham software engineers knowledgeable about digital TV sit down and help write some usable code for a board set. Creating the hardware around the code is "a piece of cake," but I don't know of anyone willing to take time away from his "real job" long enough to create useful software for the good of DATV.

Modulators require interlaced video. This is not a major drawback but one must be aware of it. To my knowledge, the software written for all boards available now require full interlaced NTSC video for error-free MPEG-2 compression to take place. Almost all cameras output interlaced video, but ID generators *do not.* The most common ID generator is the ElkTronics ID board used to generate the station ID for most ATV repeaters, but it does not have interlaced video, so as a result the signal pixelates and frequently freezes, making the signal almost unusable. I know of no commercially available interlaced video ID boards. Because of this the ATCO group custom-made one from a Sandisk picture-frame board and loaded it with the needed video ID slides. Maybe future software designs will overcome this problem.

Transmit delay of 1 to 2 seconds. There is about a 1- to 2-second latency delay during the MPEG-2 compression (transmitter) and decompression (receiver). Most of the time it is of novel interest being able to watch the analog transmission and then the digital transmission occur with a 1- to 2-second offset. However, if any DATV linking between repeaters is anticipated, it may be very cumbersome when using full duplex for people at each end to wait a couple of seconds before responding to a given comment. (Full duplex will create a 2- to 4-second delay). However, that may be fun to watch also, so who knows. Maybe that's more entertainment!

Ungraceful fade margins. Analog has a graceful fade margin. That is, the picture is recognizable while noise and signal fading increase and decrease from snow-free down to within about 3 dB of disappearing altogether. Digital, however, is unforgiving, as it stays absolutely snow-free down to within about 1 to 2 dB of the threshold. Therefore, the digital signal will remain viewable longer, but when that "cliff effect" point is reached, the signal is totally gone with no visible traces of it. The corresponding analog signal may have excessive snow, but viewable traces of the signal remain, allowing antenna optimization efforts. Thus, analog has an advantage when receiving a weak DX signal under rapid fading conditions.

Broadcast Standards, Overview, Major Standards

ATSC (8VSB) North America
DVB-T (CODFM) Europe Terrestrial
DVB-C (QAM) Europe and USA cable (numerous variations)
DVB-H (QAM) Europe handheld
DVB-S (QPSK) Europe and USA satellite

8VSB disadvantages

Modulation scheme is very complex.

Fixed 19.4-megSymbol data rate and 6-MHz bandwidth are not modifiable.

Amplitude modulation (vestigial sideband) needs high-linearity amps.

If amps are not linear enough, too many transmit errors and screen blanks occur.

Audio channel not receivable on some TV sets.

Ham band not available on standard unmodified TVs.

430–450 MHz no good; cable setting in some TVs default to QAM.

902–915 MHz no good; above TV tuning range and crowded with Wi-Fi.

1240–1300 MHz no good; this is above TV tuning range.

Special receive converter required for ham applications.

Cannot use when receiver is in motion (no mobile operation).

DVB-T disadvantages

Receivers not in use in USA.

Needs high signal-to noise-ratio receivers.

DVB-T set top boxes not available in USA.

DVB-C disadvantages

No common standard. Many variants used by each cable company.

Common receiver not available.

DVB-H disadvantages

No well-defined standard.

No receivers available.

DVB-S: Why is it Best for D-ATV?

DVB-S Advantage Summary

Used free-to-air receivers are readily available.

Receivers are "cheap"—$10 to $50 on eBay.

New receivers are $125 at local satellite stores.

High-linearity amplifiers not required to transmit error-free signal.

If amps not linear—excessive transmit signal spectral regrowth occurs but minimal errors.

Inexpensive LDMOS "brick" amplifiers for transmit can be used and are easy to build.

Format multipath cancellation is adequate for ham use.

Modulation method not subject to motion limits—tested okay for mobile.

Less bandwidth needed than others for acceptable picture.

Bandwidth modifiable for motion/resolution trade-off selections.

Multiple video channels within single carrier possible.

Seems best for ham space shuttle D-ATV communication.

DVB-S Details

Modulation method. QPSK (Quadrature Phase Shift Keying) frequency modulation is used exclusively here. QPSK basically means that the signal is phase (FM) modulated in four quadrants of 360 degrees to essentially contain at least four times the data as a simple FM signal.

Encoding. As in most other standards, MPEG2 is used here also for data encoding. Forward error correction is employed using Viterbi and Reed-Soloman coding to correct for noise and multipath effects. The degree of correction is selectable as needs dictate, making DVB-S very desirable because it allows the user to change it for various conditions.

Linearity requirements. Linear amplifiers in the transmit chain can become *very* expensive. Therefore it is important for ham use to employ the transmission method most tolerant of non-linearities. DVB-S is it! Since the modulation method is

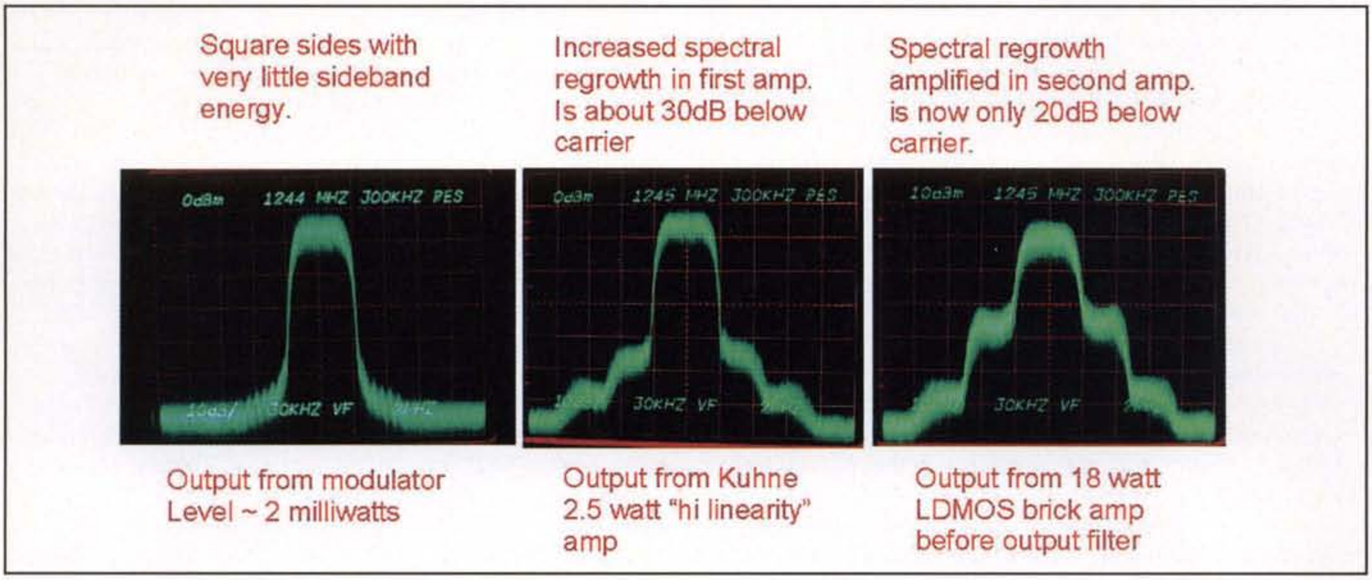


Figure 3. Comparison of signals at various power levels.

frequency modulation, it is inherently insensitive to non-linearities. This is not entirely so, but it is found that an amplifier can be close to its 1-dB compression point before the error correction approaches its limit. This is *huge,* as it opens up the transmitter design choice tremendously. Simple LDMOS "brick" amplifiers such as the Mitsubishi RA18H1213G unit are ideal for use on the 1240–1300 MHz band to get a 10-watt (average) digital signal from as little as a 50-milliwatt source. That brick has a bias input allowing for adjustment of FM or linear operation, making it easy to see what the limit is for a given configuration. Now non-linearities *do* cause other problems, though. Each time the signal passes through an amplifier stage, it creates spectral re-growth in the output waveform proportional to the degree of non-linearity. These are sidebands above and below the main envelope at a reduced amplitude level. Therefore, although the signal has minimum errors, the overall bandwidth will be wider. This may be a problem in some cases where the allocated channel is defined or where it just makes sense to minimize spectrum interference. The bottom line is to choose the highest linearity amp affordable and then use a good interdigital type of steep-skirted bandpass filter to remove the remaining sidebands. See the spectrum analyzer comparisons in figure 3.

Power level measurements. At this point it is worth noting that output-power-level measurements using a standard Bird wattmeter are *not* accurate. The output spectrum envelope is somewhat rectangular instead of sinusoidal, so average power measurements do not apply. Because of this rectangular waveshape, most of the power is at peak values longer, making measurements with a Bird or bolometer wattmeter read the measurements higher than they actually are. I personally feel that the only meaningful value is the actual peak reading obtained reliably with a spectrum analyzer. If you use a Bird wattmeter, I would divide its reading by at least three to get the actual transmit power. Also, when designing an amplifier chain, I'd make sure the amplifier input will handle 10 times more input power than the peak value of the digital signal (100-mw peak DATV signal to a 100-mw rated amplifier to prevent excessive power dissipation).

ATCO Repeater Summary

The ATCO Group Inc., originally organized in 1980, is located in Columbus, Ohio and serves approximately 85 ATVers within a 50-mile radius. It is our purpose to further the exchange of information and cooperation among members; promote amateur television knowledge, fraternalism, and individual operating excellence; and conduct activities that advance ATV general interest and welfare.

We operate an ATV repeater installed in the fall of 1994 with five outputs (427.25 MHz AM, 1245 MHz DATV (DVB-S), 1260 MHz FM, 2433 MHz FM, and 10.450 GHz FM) and four inputs (439.25 MHz, 1280 MHz analog/DATV, 2398 MHz, and 10.350 GHz). A 3-watt DVB-S output was installed in January 2004 and has been in operation 24/7 since then. A 10-watt amp was added in June 2009.

We conduct weekly net meetings on 147.48 MHz at 9:00 PM EST/EDT on Tuesdays which serves to introduce newcomers, discuss ATV topics, and announce news. It is the simplex "gathering spot" for audio activity with control capabilities for the ATV repeater.

Recently, we began streaming our weekly net meetings on the internet for the benefit of those beyond the metropolitan Columbus, Ohio area. All are welcome to join in. Just tune in at <http://www.batc.tv>, select "ATV Repeaters," and then scroll down to WR8ATV and click on "view stream." There you can both see and hear us during the net starting at 9 PM. The streaming is on every Tuesday from approximately 8:30 PM EST/EDT till about 10 PM or whenever the net closes.

We publish a newsletter four times a year containing local events, late-breaking ATV news, construction articles, tips/techniques, meeting announcements, and whatever else we can find that has ATV interest. The newsletter and other ATV topics can be viewed on our homepage at: <http://www.atco.tv>.

We help provide security video coverage each year for various local public events such as our annual Independence Day fireworks show (which draws over 500,000 observers), various parades, local air shows, and observation video of airport disaster drill activity. We also provide local severe weather observation to help identify potential damaging storms for the public.

We have spring and fall events where we gather to share ideas, plan future activities, enjoy free food, have door prizes (for everyone), and usually conduct a mini hamfest with trunk sales in the meeting-place parking lot. We normally have a few pizza parties where we can enjoy the companionship of others.

We are working on a link to connect the Columbus and Dayton repeaters. We found an ideal site halfway between us (35 miles from Columbus and 30 miles from Dayton) that we have been working on for a number of years now. We had it operational before the Dayton repeater had to relocate and we now have started over. We are considering a digital link but are concerned about the latency issues. That is, there is a 1- to 2-second delay in sending and receiving the signal, so a full-duplex link may turn out to be difficult for acceptable communication. With a repeater link, the delay is effectively doubled, because it occurs at both ends!

ATCO DVB-S Operational Results

Our digital (DVB-S) 1245-MHz signal has been operational since January 2004 with a 2.5-watt signal receivable within about a 20-mile range. Recently we added a power amp to boost the output to about 10 watts average, extending the range to roughly 40 miles. There are about 15 ATCO club members with digital receive capability using surplus "Free To Air" digital receivers obtained on eBay for about $50 each. Some additional people have obtained various receivers from eBay and elsewhere for $10 to $75. All have worked okay and have had no trouble locking onto our DVB-S signal using only a minimal loop Yagi antenna mounted less than 30 feet in the air.

I personally have a 20-element loop Yagi mounted 30 feet up my tower permanently pointed to the repeater 15 miles away connected to 75 feet of 7/8-inch heliax. In the shack I have a two-way splitter with my analog receiver connected to one port and the digital receiver connected to the other. Tests have proven there is 10 dB of excess signal needed for simultaneous P5 picture reception on both receivers.

The transmitter DVB-S board set of choice is the Netherlands D-ATV boards. We use two MPEG-2 encoder boards connected to an I/Q baseband board and then to a 1.8-milliwatt modulator/exciter board providing us with two channels of video. The 1.8-milliwatt signal is fed to a Kuhne Electronics ultra linear amplifier (we were told high-linearity amps were a *must* at the time) costing about $500 alone. The Kuhne 2.5-watt output was connected directly to the antenna until recently when an LDMOS "brick" amp was added to produce a 10-watt (average by Bird wattmeter) signal. That output is fed to a custom-made inter-digital bandpass amp with steep skirts with a bandpass of 5 MHz. Using 3.125-meg Symbol rate with a three-quarter FEC, our overall signal is about 4 MHz wide excluding the spectral regrowth sidebands. This correlates closely with the formula: signal bandwidth = 1.3 × symbol rate. With the filter in place the resulting signal on a spectrum analyzer looks very clean with the regrowth signal down more than 50 dB from peak carrier.

We have tested mobile operation with great success. The DVB-S modulation scheme is supposed to be reasonably insensitive to motion, and we proved that it indeed is! The vehicle in motion was accelerated to over 50 mph with no loss of signal. In fact, the normal signal flutter and fading was very surprisingly non-existent. While traveling under a bridge underpass, the signal was maintained with only a momentary picture freeze unnoticeable if not looking for it. The normal analog mobile ATV signal flutter, which was very annoying, was virtually gone with digital!

Finally, a word about why we ended up using 1245 MHz for our digital signal. We originally had our analog signal on 1250 and digital on 1260. One morning my wife answered the phone and told me, "You had better take this call!"

It was the FCC monitor from Detroit who had been tracking our analog ATV signal because of an interference complaint! It turns out that since our 1250-MHz signal identified with a bulletin-board sequence for four minutes every half hour, it was interfering with the local Ohio Department of Transportation (ODOT) reception from a Russian GPS 1250-MHz signal used in its surveying efforts. Since ODOT couldn't find the interference source after six months of searching, they called the FCC. The FCC drove from Detroit to Columbus and found our signal source after about a half hour.

I was then contacted and initially told that we were okay and legally operating within our assigned band. Later I was notified that because of a recent FCC clause saying that interference to Radio-Navigation was prohibited in the 23-cm band, we had to vacate. We finally ended up with our analog signal on 1260 MHz and the digital one on 1245 MHz, leaving 1250 MHz clear. That was okay until I added the power amp. Now the added spectral regrowth extended the upper bandpass to 1250 and again caused them interference. (They were not shy about telling me so.) After I added the interdigital filter, no phone calls! This is a story worth telling, because it demonstrates the real need for a good bandpass filter. I still tell others how we interfered with a Russian GPS satellite! It sounds bizarre until you know the details.

CQ's 6 Meter and Satellite WAZ Awards

(As of January 1, 2010)

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	17,18,19,22,23,26,34,37,38
80	JH1HHC	2,5,7,9,18,34,35,37,40.
81	PY2RO	1,2,17,184OM,19,21,22,23,26,28,29,30,38,39,40
82	W4UM	18,19,21,22,23,24,26,27,28,29,34,37,39
83	I5KG	1,2,3,6,10,18,19,23,27,29,32.
84	DF3CB	1,2,12,18,19,32
85	K4PI	17,18,19,21,22,23,24,26,28,29,30,34,37,38,39.
86	WB8TGY	16,17,18,19,21,22,23,24,26,28.29,30,34,36,39
87	MUØFAL	1,2,12,18,19,22,23,24,26,27,28,29,30,31,32
88	PY2BW	1,2,17,18,19,22,23,26,28,29,30,38,39,40.
89	K4OM	17,18,19,21,22,23,24,26,28,29,32,34,36,38,39.
90	JHØBBE	2,33,34,40
91	K6QXY	17,18,19,21,22,23,34,37,39

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

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

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

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

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

By Keith Pugh,* W5IU

SATELLITES

Artificially Propagating Signals Through Space

The New, The Old, and The Meetings: ARISSat-1, SO-67, HO-68, UO-11, AMSAT Symposium, and QCWA

Two new amateur radio satellites, SO-67 and HO-68, were launched recently. One old "Bird," UO-11, returned to life briefly, and progress is being made on design, construction, and testing of ARISSat-1. I will discuss these satellites and go over the process of integrating them into the active satellite inventory. Reports on the AMSAT 40th Anniversary Celebration during the AMSAT Space Symposium and of a visit to the Arecibo Observatory in Puerto Rico during the QCWA Cruise Meeting will round out this column (photos of this event are shown throughout the column).

John Ross, WA5WOD, Mike Scarcella, WA5TWT, Andy MacAllister, W5ACM, at the QCWA meeting on board the MS Eurodam.

ARISSat-1

Shortly after the Amateur Radio on the International Space Station (ARISS) meeting in the Netherlands, we learned that the Russian ORLAN Space Suit that was to be used for SuitSat-2 had to be discarded due to a shortage of storage space on the International Space Station (ISS). This development left ARISS without a framework to house the planned electronics hardware. Fortunately, the free up-mass allocation for delivery of the hardware and the launch EVA commitment were still retained. This led to the rapid design of an alternate hand-launchable space frame to house the hardware. This new satellite has now been renamed ARISSat-1.

Fabrication of the space frame and the electronics hardware is now nearly complete. Software is still in development utilizing prototype hardware and is now nearly ready for integration with the flight hardware. Final integration with the flight hardware is planned for early 2010. A Flight Safety review of the entire satellite is now in progress and should also be complete in early 2010. Current plans are to ship ARISSat-1 to Russia for up-mass to the ISS in mid 2010. Final deployment will be on a Russian EVA in late 2010 or 2011.

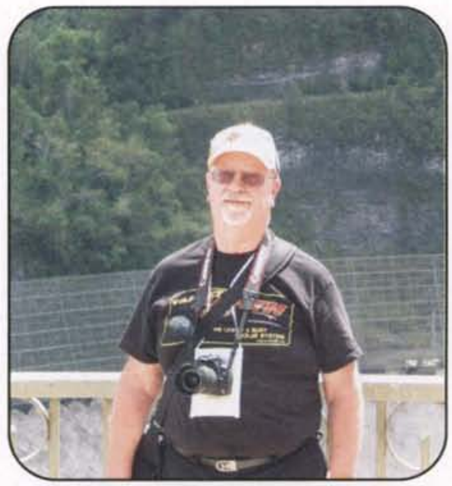
*3525 Winifred Drive, Fort Worth, TX 76133
e-mail: <w5iu@swbell.net>

ARISSat-1 will have many capabilities, including a Software Defined Linear Transponder (SDX), SSTV, FM voice beacon, and a CW beacon. It will contain batteries, a smart battery charge regulator, and solar panels to provide a useful life for the satellite that should equal its time in space. It will re-enter within six months to a year from launch.

ARISSat-1 hardware and software are being developed in a modular form so that the designs can be reused on other future satellites. ARISSat-1 will thus become an inexpensive test bed for future AMSAT satellites.

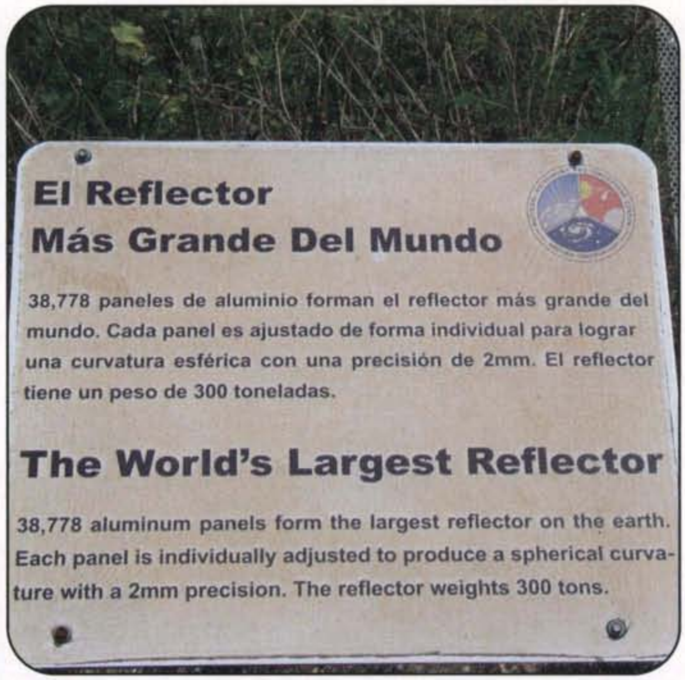
SO-67 (SumbandilaSat)

The second South African satellite, SumbandilaSat, was launched by a Russian vehicle from Baikonur Cosmodrome in Kazakhstan on 17 September 2009. The amateur radio transponder is a secondary feature of the satellite and has had to take a "back seat" to the primary experiments; however, it is being checked out and operated on a non-interference basis.


Bill Hulse, W5NI, who was also at the QCWA meeting on the MS Eurodam.

The FM voice transponder is very strong (5 watts) and has some unusual operating characteristics that require some newly developed custom operating techniques. For example, care must be exercised to avoid over-deviation. A long "squelch tail" on the transponder coupled with PL access has created the necessity

The 1000-ft. diameter reflector of the radio telescope at the Arecibo Observatory in Puerto Rico.



The plaque describing the Arecibo radio telescope's reflector.

for new operating techniques. Hams are getting used to these techniques and operations now are very successful.

Scheduling of the transponder is under the control of the primary South African ground station; however, this ground station is seeking advice from regional controllers around the world for development of the transponder schedule on a continuing basis. Ultimately, there will more amateur radio operation on the "Bird" when the primary experiments are complete. Full details are on the AMSAT-SA web page: <http://www.amsatsa.org.za/>.

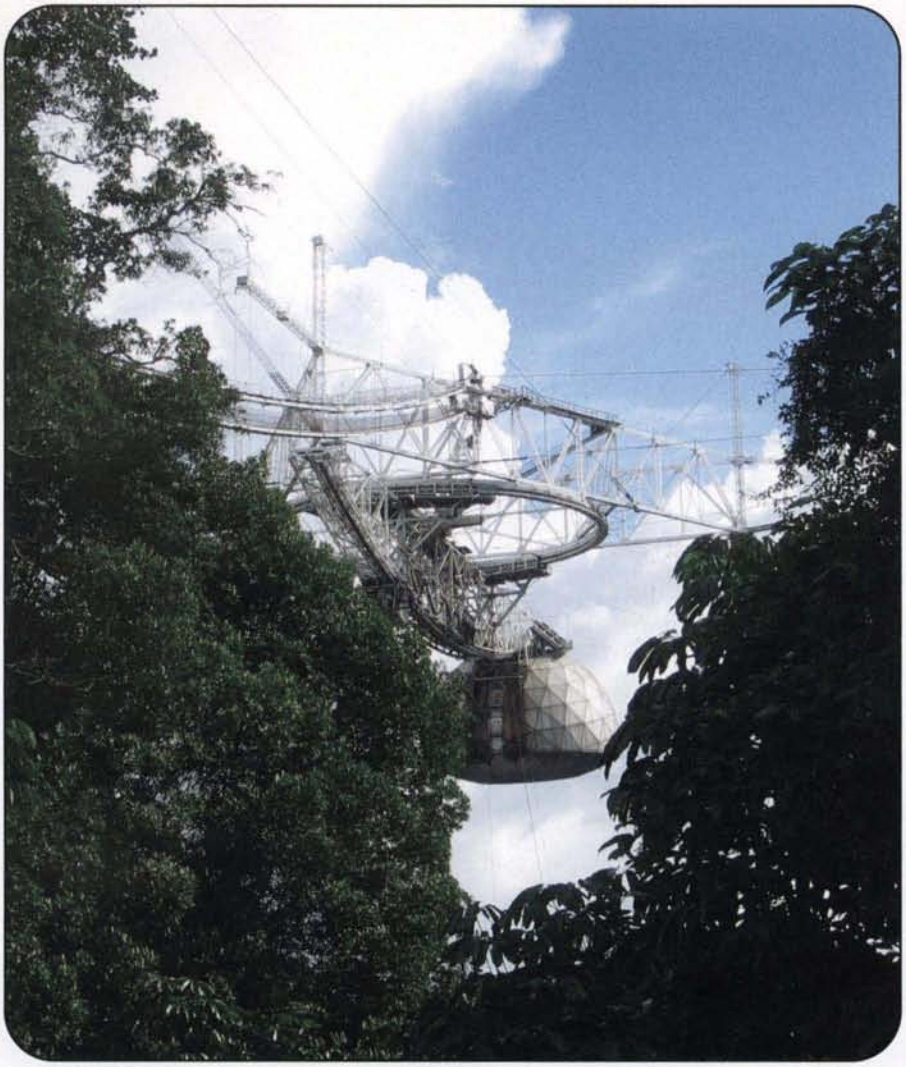
Current frequencies and modes are:

Mode V/U (J) FM Voice Repeater (Use narrow FM on the uplink)
Uplink: 145.8750 MHz FM, PL 233.6 Hz.
Downlink 435.3450 MHz FM

HO-68 (Hope OSCAR 68)

Originally known as XIWANG-1 (XW-1), or Hope-1, this dedicated amateur radio satellite was launched on 15 December 2009 from China on a Chinese launch vehicle. It is in a High Low Earth Orbit (High LEO) at 1200 km altitude, giving it a relatively large footprint. On an overhead pass at my QTH (Fort Worth, Texas) it is possible to have the entire North American continent in the footprint at once. The eastern third of the U.S. should have relatively easy access to western Europe, and the western two-thirds of the U.S. should have access to Hawaii. Access to the northern quarter of South America is available from quite a bit of the U.S.

HO-68 has a CW beacon, a linear V/U transponder, a V/U FM voice transponder, and a V/U packet capability. Initial testing of all of these capabilities has been very successful. I am especially impressed by the linear transponder. It reminds me somewhat of AO-07, AO-10, and AO-13.



First view of the feed of the Arecibo Observatory in Puerto Rico.

Full details are available on the China AMSAT web page: <http://www.camsat.cn>. Current frequencies and modes are as follows:

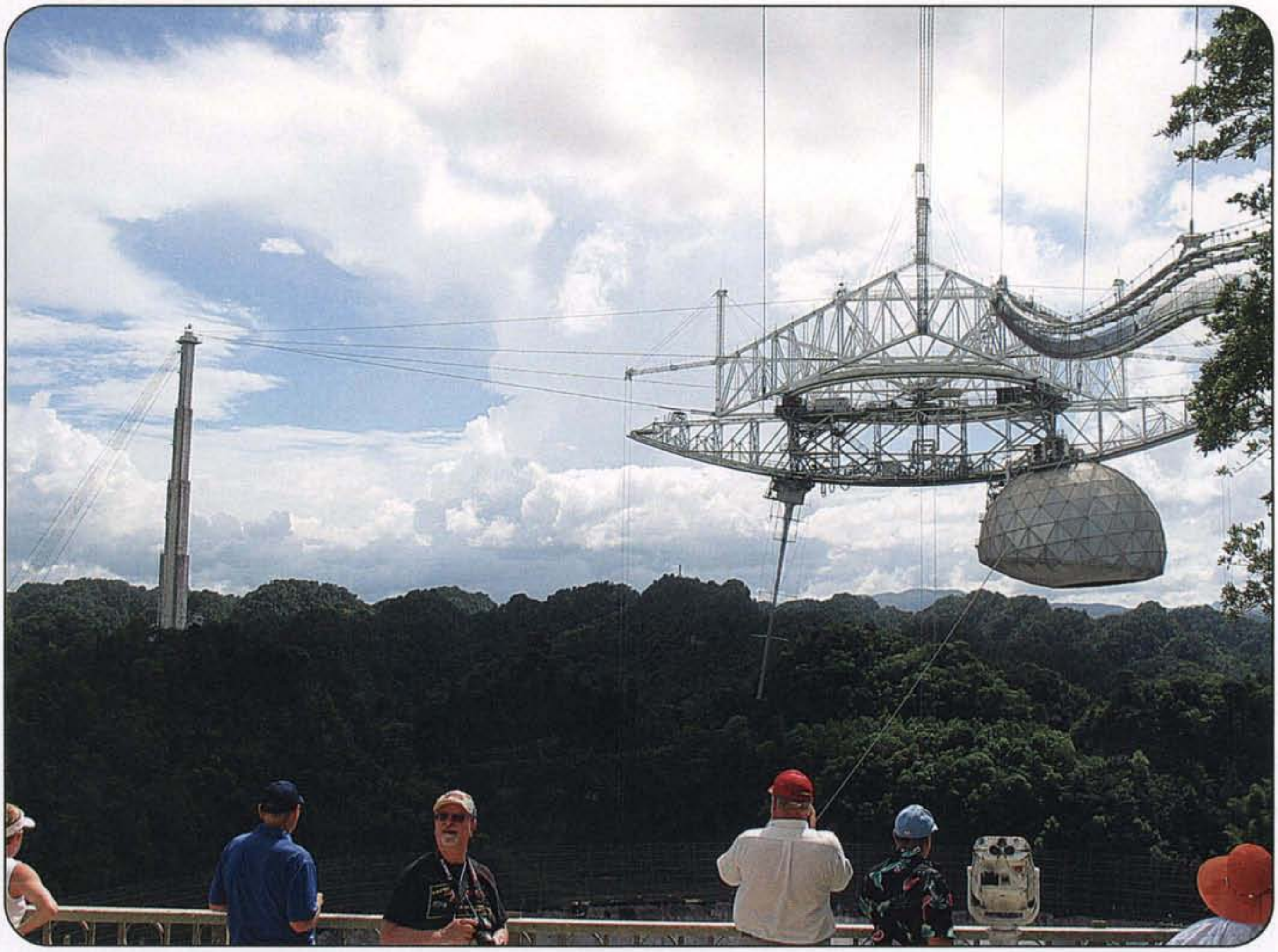
Mode V/U (J) FM Voice Repeater (30 dbm [1 w]):
Uplink: 145.8250 MHz FM, PL 67.0 Hz.
Downlink: 435.6750 MHz FM

Mode V/U (J) Linear Transponder (Inverting) (30 dbm [1 w]):
Uplink: 145.9250–145.9750 MHz SSB/CW
Downlink: 435.7650–435.7150 MHz SSB/CW
Mode V/U (J) PacSat BBS (30 dbm [1 w]):
Uplink: 145.8250 MHz AFSK 1200 BPS
Downlink: 435.6750 MHz AFSK 1200 BPS
Mode Beacon (23 dbm [200 mw]):
Downlink: 435.7900 MHz CW

Watch this one carefully as it develops!

UO-11

On 1 March 1984, UO-11 was placed in orbit on a Delta launcher from Vandenberg AFB in California. This satellite was developed by the University of Surrey in England with additional help from all over in six months. After a rocky start, it went on to have a very successful long time in space. It carried the first store-and-forward digital communications experiment and a number of other capabilities. It retained nearly full function until about the year 2000 and started to lose function after that. About a year ago (November 2008) it went off the air completely and was declared "legally



Overall view of the feed.

dead." Its old familiar buzz was heard again in November 2009! It lasted for only a few days but went away again. It has returned once more since then and may be back occasionally. Current theories about its operation can be found at: <http://www.g3cwv.co.uk/>.

AMSAT Space Symposium 2009

On 8–11 October 2009, AMSAT celebrated its 40th anniversary during the AMSAT Space Symposium 2009 at the Baltimore-Washington International Airport Four Points Sheraton. The AMSAT Board of Directors met on Thursday and Friday, the symposium was on Friday through Sunday, and the ARISS Ops Team met on Sunday. The AMSAT Annual General Meeting was on Saturday afternoon. Martin Collins of the National Air and Space Museum was the after dinner speaker at the Saturday evening banquet. The AMSAT Area Coordinators Breakfast was on Sunday morning before the IARU International Satellite Forum.

After welcoming the incoming board members, a new slate of officers was elected and appointed. Complete minutes of the BOD meeting are available in the *AMSAT Journal*. Highlights were the planning and status of ARISSat-1, discussion of the next major AMSAT Project (a 1U Cubesat), potential alliance with the University of Florida in Gainesville for educational outreach projects and potential location of the laboratory, and alliance with the State University of New York at Binghamton for educational outreach projects. All of these items were summarized for the membership at the annual meeting by President Barry Baines, WD4ASW, on Saturday afternoon.

Papers on a variety of satellite-related topics were presented on Friday and Saturday. *Proceedings* of the symposium are available from AMSAT. All attendees were given a copy of the *Proceedings* and of Bill Tynan, W3XO's great new book entitled *AMSAT – The First Forty Years.*

The ARISS Operations group met on Sunday morning for the first "Face-to-Face Meeting" of this group at the hotel and on EchoLink worldwide to discuss the direction of ARISS Operations. This meeting provided a valuable forum for the group.

I went away from these meetings with a renewed confidence in AMSAT. The new organization has faced up to a realistic set of goals and appears to have a new slate of officers who can carry them out.

QCWA

This may seem to be an unusual turn of events to discuss the Quarter Century Wireless Association (QCWA) in an amateur radio satellites column, but there

Feed detail.

are reasons. First, the meeting was to be held on the *MS Eurodam* of the Holland America Line while touring the eastern Caribbean. Second, several of my friends —mostly fellow "satelliters"—were going on the trip, and last, the highlight of the trip for me was to be a visit to the Arecibo Observatory in Puerto Rico. Even if you are not familiar with radio astronomy you probably have heard of and/or seen the Arecibo Radio Telescope in movies such as "Contact" and the "Agent 007" offerings. We had a half-day dedicated tour of the telescope. I have included photos of some of the people, and parts of the telescope. This is a truly amazing device and ranks as one of the marvels of the engineering world.

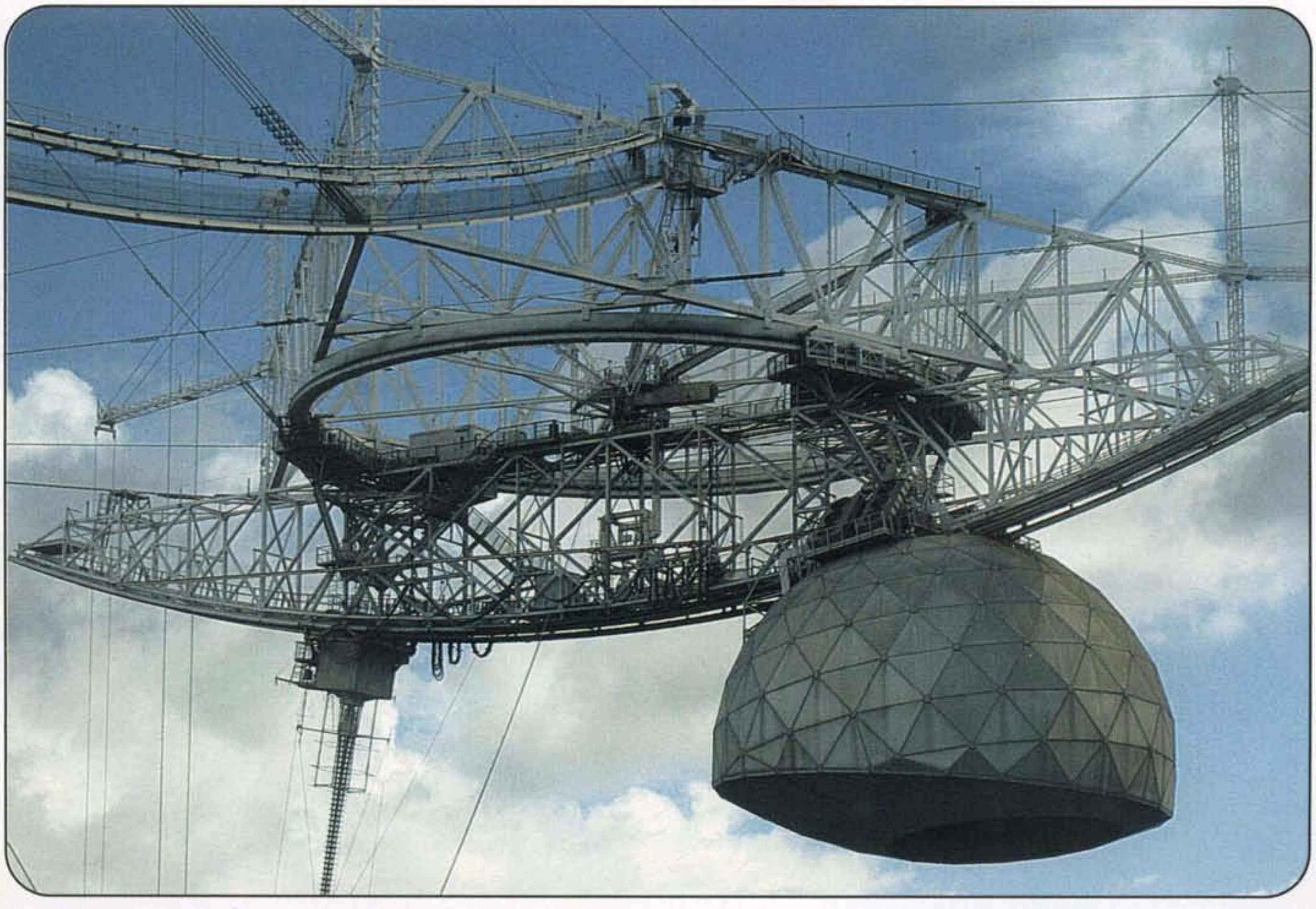
Oh, yes! Some of us did work satellites from the deck of the *Eurodam* while at sea, but unfortunately satellite pass times and scheduled eating times were in conflict on numerous occasions. Guess which event won! The food on these cruise ships is excellent, by the way!

Summary

Let's welcome the "new Birds" into the flock and continue to listen for the "old Birds." Congratulations to South Africa and China for excellent additions to the "flock."

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

'Til next time! 73, Keith, W5IU



Greater detail of the feed.

By Thomas Dean,* KB1JIJ

ATV

Amateur Television – Methods and Applications

Digital Amateur Television – An Introduction

Tom Dean, KB1JIJ, is currently a junior at the United States Military Academy at West Point. Tom has been licensed since 2002. His operating interests include HF contesting and digital modes. He is active in the Academy's amateur radio club, W2KGY, where he is involved in building the Academy's first CubeSat. Tom is a student of electrical engineering. His academic interests include signal processing, software defined radio, and complex variable methods in partial differential equations.

In his column, Tom plans to explore non-traditional methods and applications of Amateur Television. He also wants to help show that building an amateur television station is not quite as difficult as it might appear. It has been a long-standing goal of his to have an easily-obtainable digital amateur radio setup that would operate in manner comparable to current analog methods in amateur television. —N6CL

*e-mail: <Thomas.Dean@usma.edu>

Amateur Television has been on the UHF bands for quite some time. In the past, it has been standard practice to match the standard for commercial broadcasting of television on the amateur bands, making operating ATV easily accessible to the typical ham. The recent mandate from the FCC that all terrestrial broadcasts must be digital raises the possibility of making digital amateur television, or D-ATV, common practice. There are many advantages to transmitting digital signals. The use of compression allows for the ability to send higher resolution videos in the same bandwidth. Additionally, forward error correction schemes allow for weaker signals to be received with less error. Unfortunately, transmitting the digital signal is a slightly more difficult task than standard ATV.

This issue's column provides an overview of digital television emission standards, and presents several theoretical approaches that could be used to create a digital television station. There has been no widespread use of D-ATV other than experimentation, but hopefully in the near future this will become as common as ATV is today.

Digital Television and the ATSC

There are several possible ways to encode and modulate a digital television signal. Cable-based systems tend to rely on a modulation technique known as 64-level Quadrature Amplitude Modulation (64-QAM). Alternatively, terrestrial broadcast stations rely on a different modulation method that is similar to that used by analog television, 8-level Vestigial Sideband (or 8-VSB). This type of emission is more suited for terrestrial channels, and is therefore used in the Advanced Television Systems Committee (ATSC) standard which was adopted by the FCC. The standard also incorporates a forward-error-correction scheme which is optimized for a terrestrial environment. If a D-ATV station uses a commonly accepted standard, the

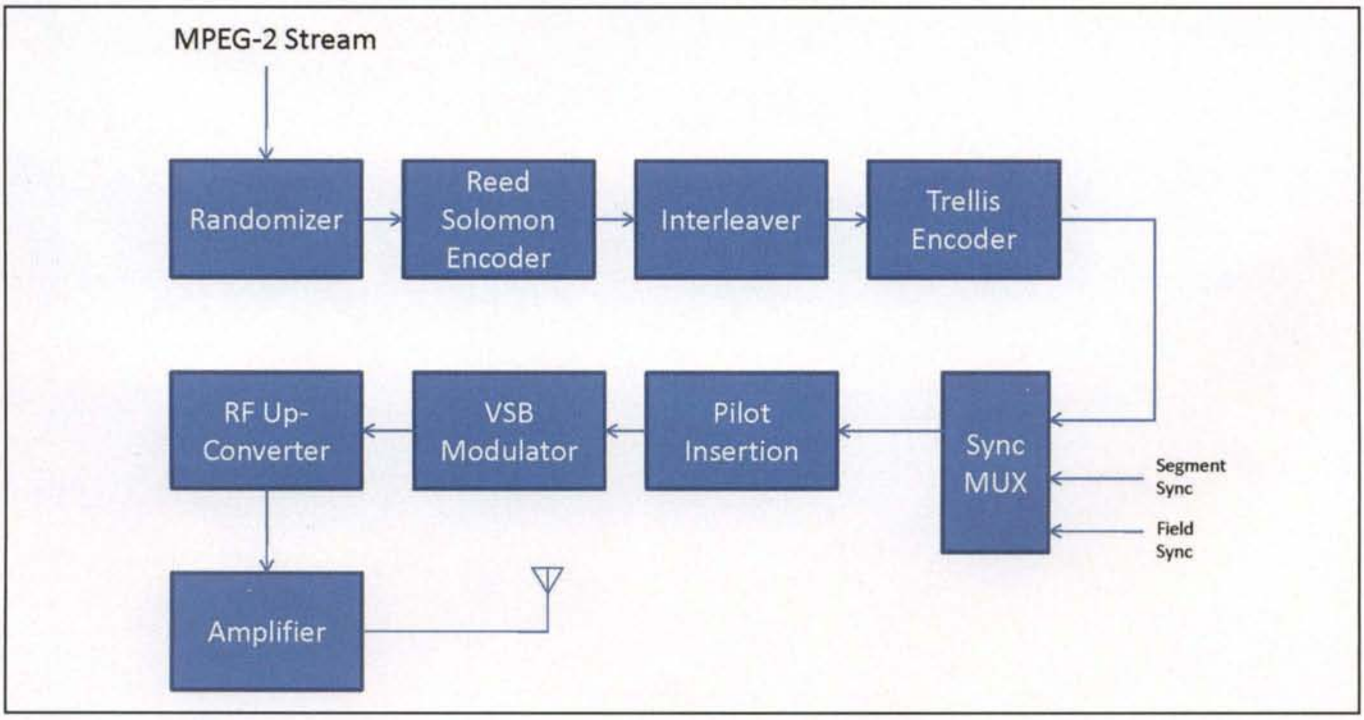
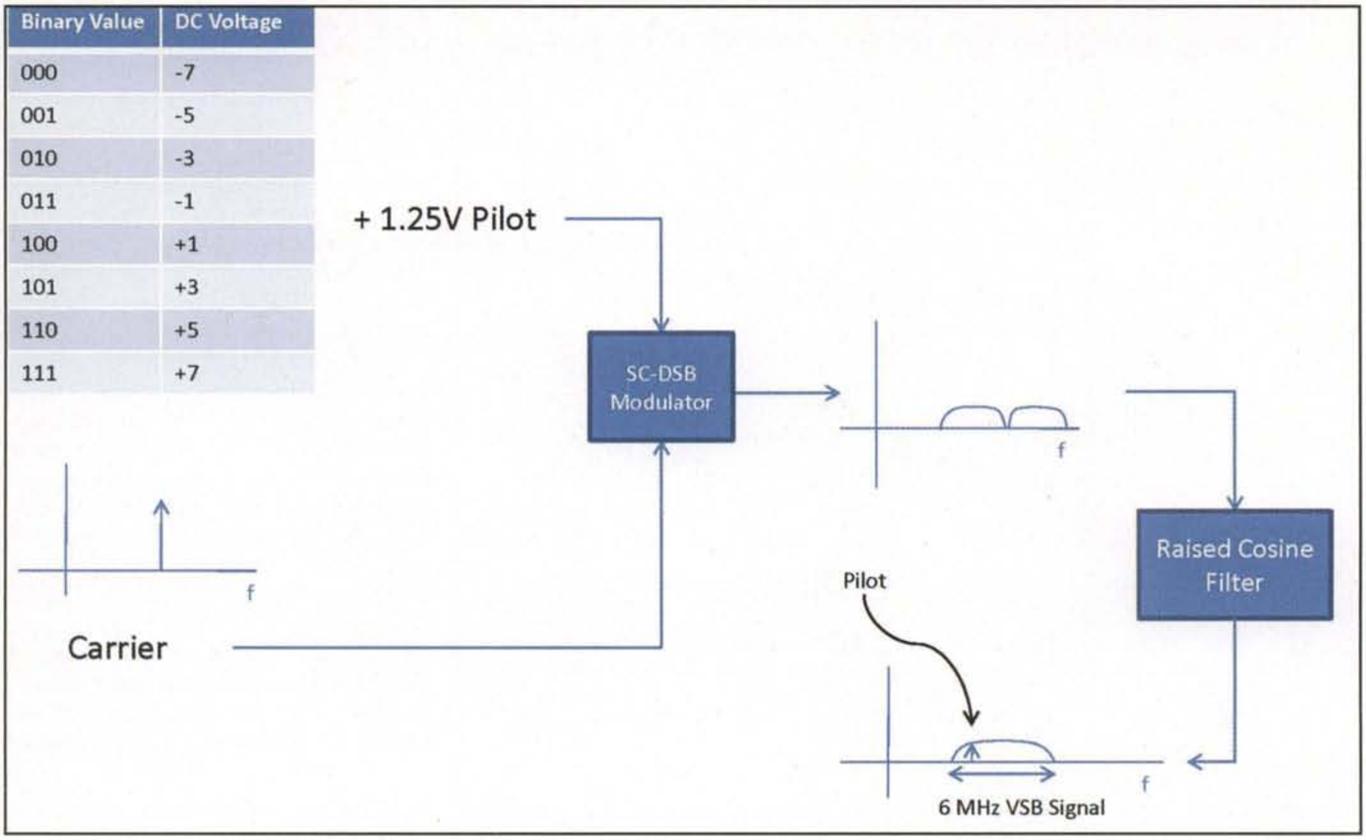


Figure 1. Block diagram of an ATSC transmitter.



Binary Value	DC Voltage
000	-7
001	-5
010	-3
011	-1
100	+1
101	+3
110	+5
111	+7

Figure 2. The VSB modulation process.

demodulation of the signal becomes much like the demodulation of an ATV signal; the signal must be down-converted to a standard broadcast TV frequency and can then be displayed on an off-the-shelf digital television. For this reason, I would recommend the use of ATSC for any D-ATV projects.

Emission Overview

A video signal must go through a series of steps before it becomes an ATSC signal. The signal must first be digitized and compressed into an MPEG-2 stream. This stream can contain both the audio and video signal of the transmission. It is not uncommon to find cameras that will output an MPEG-2 stream, as this is the same format adapted by the HDV standard used in most camcorders. Additionally, there many commercial boards available that will digitize and compress an analog video signal.

The MPEG-2 stream is then taken through forward error correction. The data is typically first randomized[1], and then sent to a Reed-Solomon encoder followed by an interleaver and a Trellis Encoder[2]. There are options within the standard to allow additional forward-error correction to be added, at the expense of video quality, to help in more adverse conditions. Synchronization signals are then inserted into this stream. This separates the signal into fields and segments. The purpose of the synchronization signals is to help the receiver lock onto the signal.

At the heart of the ATSC standard lies the vestigial sideband modulation (VSB). This method of modulation is very similar to double-sideband modulation. In order to modulate a digital stream into VSB, three bits at a time are mapped to one of eight possible DC voltages. A small DC voltage is also added to each symbol, which results in a small pilot carrier being generated in the final signal. This pilot signal helps the receiver to lock on and detect the ATSC signal. This signal is then mixed with a carrier to create a double-sideband, suppressed-carrier signal. The signal is then turned into a VSB signal simply by running it through a filter which removes most of the lower sideband, leaving the entire upper sideband and a portion of the lower sideband. This modulation method is very similar to the analog NTSC standard, and, like the analog signal, fits with a 6-MHz channel. ATSC is capable of providing up to 19.39 Mbps of data in this channel.

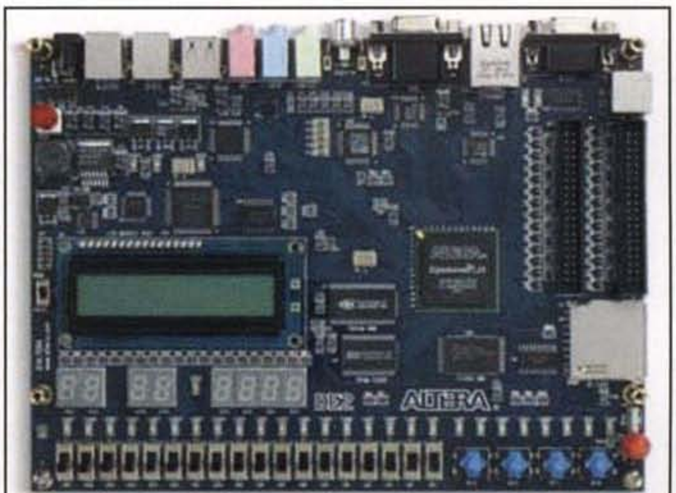


Figure 3. The Altera DE2 board. (Courtesy of Altera)

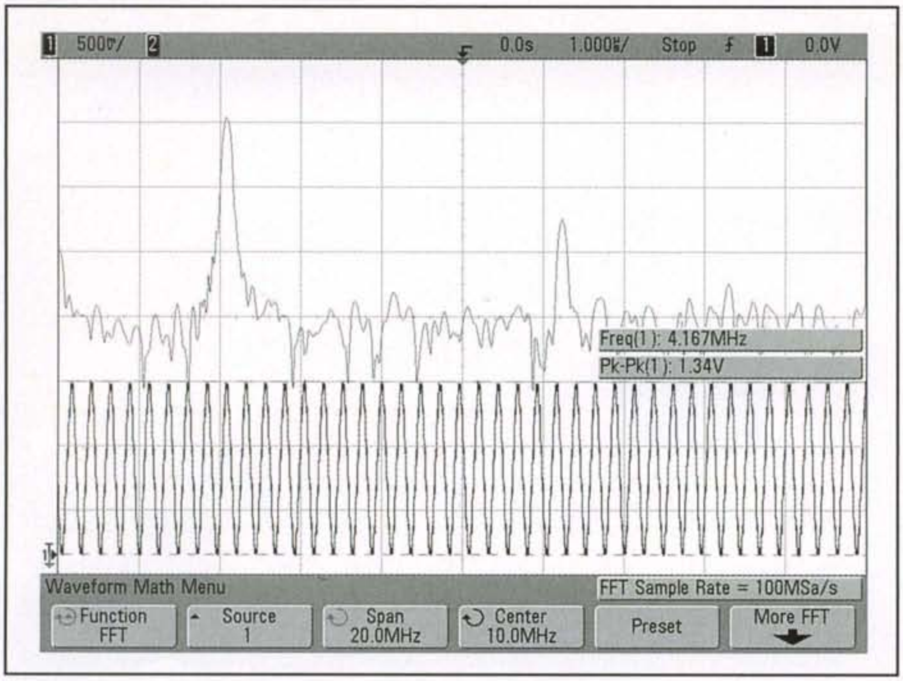


Figure 4. An HF carrier generated by the DE2 using the video DAC and the corresponding FFT.

Possible Approaches to a D-ATV Station

Unfortunately, there are not a large number of commercial systems available that create video signals in the ATSC format. While it is fairly common to see an analog signal be modulated into RF to be displayed on the TV, interchange of digital signals is typically accomplished using non-RF techniques such HDMI or similar interfaces. This makes it a slightly more difficult problem to be able to transmit digital video.

Since we are already dealing with a digital signal, it lends itself well to be processed via software-defined radio. If you have dealt with SDR, you are most likely familiar with the Universal Software Radio Peripheral, or USRP. This board was developed with the intention of demodulating HDTV television signals and has done so with some success. The USRP is programmed through GnuRadio, which links together processing blocks of C code using Python script. Creating an

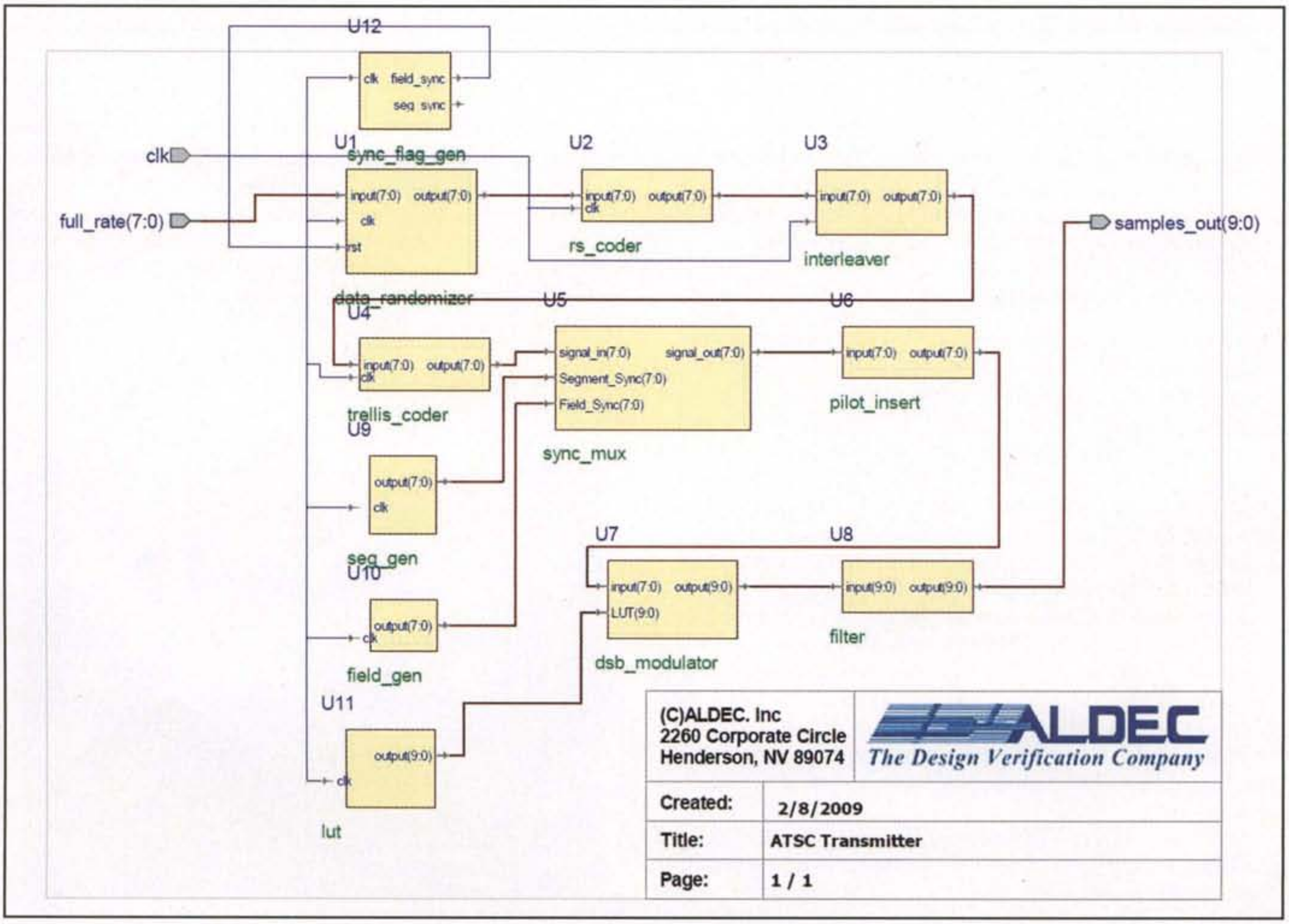


Figure 5. Designing an ATSC transmitter for the DE2 board using active HDL.

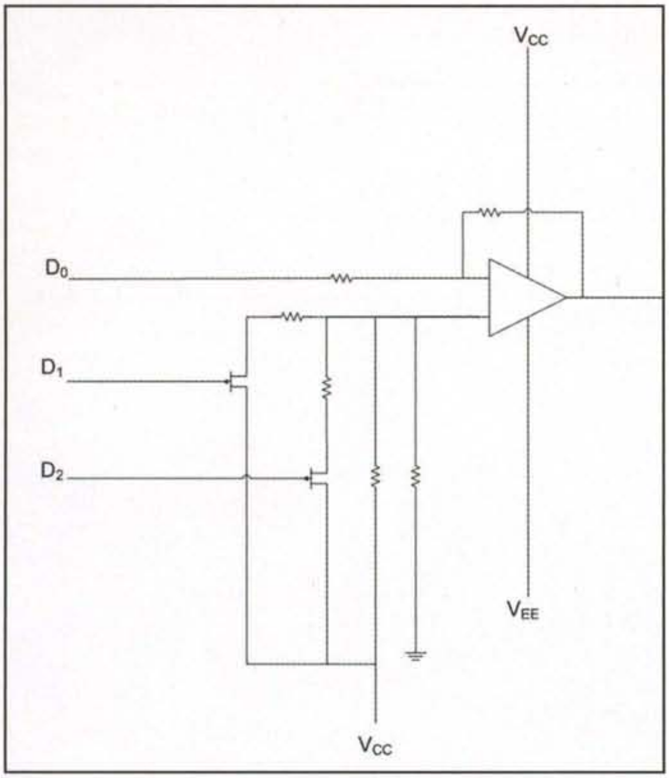


Figure 6. A simplified design for a DAC using a summing amplifier. Op-amps won't operate well at the data rate needed, so a summing amp would need to be designed with CMOS chips capable of operating fast enough.

ATSC transmitter would be a matter of programming each component that is needed to end up with the ATSC signal and then linking it together. GnuRadio, in fact, comes with many of the building blocks needed to accomplish such a task. Such an approach is limited by the processing power of the computer, the bandwidth of the USB interface, and the rate at which the video can be streamed into the computer to be processed. Taking a raw video feed and turning it into an MPEG stream is not a simple task. Combined with the other processing required, most computers would have trouble transmitting ATSC in real time.

Another approach would be to move away from a computer, but still remain entirely in the digital realm. Many of the processes involved were designed to be done in hardware rather than software, so this approach is more feasible. An FPGA[3] would be a great tool to accomplish much of the processing required after an MPEG stream is acquired. Since working with FPGAs can be somewhat difficult, there are several development kits that can take away the necessary board work. The Altera DE2 board contains a JTAG programming interface as well as a video DAC which is designed for creating signals for an analog VGA monitor. I have had a fair amount of success using this DAC to create baseband radio signals. It seems to me to be entirely possible to program the DE2 board to do all the processing post MPEG compression to create a baseband RF signal. This signal could then be up-converted and amplified to create a full ATSC transmitter. To me, this approach seems to be the simplest and most practical method.

A third approach would be to use traditional modulation methods to create the 8-VSB signal. Much of the processing of the video stream would still have to be done in the digital realm, but the modulation would not be unlike designing an ordinary AM modulator, but with a larger bandwidth. The bit stream could be mapped to the DC signal using a DAC, or a minimalist could try designing his own DAC using a summing amplifier. Such an approach would require considerably more engineering, but could result in a lower cost product.

Conclusion

D-ATV is the future of amateur television. There are many advantages that digital television offers over analog television, one of which is picture quality. It would also be a very easy leap to move from having a D-ATV station to being able to have a high-definition station. One of the more difficult components of designing a digital station is dealing with the quantity of the data and amount of computations involved in processing the video feed. This makes such a project better suited for a more hardware-oriented approach. Such a project is certainly achievable. I hope to be able to start making HD QSOs sometime in the near future!

Notes

1. While it may seem counterintuitive to randomize the data before sendingit, it actually helps to reduce the amount of error that is received. Since the amount of noise that the signal will encounter during its transmission is random, the spacing and number of errors that it receives will also be random. Much like conducting random sampling for a poll across a population, we are more likely to get an accurate reconstruction of our errored signal if we rely on a random representation of the signal.

2. Trellis coding, like Reed-Solomon coding, is a method of forward error correction. The point of forward error correction is to add redundancy to the data being transmitted in order to reduce the number of errors that are received. While Reed-Solomon error correction encodes a block. of data at one time, Trellis coding works with any length of code and encodes a stream of data. Trellis coding is closely related to convolutional coding, where redundancy is added to a signal by creating multiple streams from mixing the signal with different forms of time-delayed versions of itself. In ATSC, each symbol contains 3-bits (coming from the fact that we have 8-level VSB). Trellis coding works by sending differently mixed and delayed signals to each of the separate bits. This type of error correction, combined with Reed-Solomon error correction, allows us to approach very close to the theoretical limits for the amount of information that can be contained in a noisy channel.

3. An FPGA is a Field Programmable Gate Array. It is essentially a very large array of logic gates that can be programmed to perform a specific function. An FPGA is a great advancement from older technology such as masked ROM, or Programmable Logic Devices (PLDs), as they can programmed in a much more flexible manner and are much more scalable. FPGAs can contain a very large number of gates and can be used to make up very complicated systems. They are very useful in digital signal processing and for prototyping Application Specific Integrated Circuits (ASICs). They are programmed through the use of a hardware description language such as VHDL (Very high speed integrated circuit Hardware Description Language) or Verilog.

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By Joe Moell,* KØOV

HOMING IN

Radio Direction Finding for Fun and Public Service

En Route to Croatia via Ohio

Did you watch the Tour de France bicycle race coverage last July? It is amazing to see the effort that all of these champions, as well as most regular weekend riders, put into optimizing their gear. Each one seeks out just the right shifters, cranks, hubs, pedals, and saddles to make up a custom cycle that is perfect for him or her.

It is the same way with hams who love on-foot hidden transmitter hunting under international rules, which is called foxtailing, radio-orienteering, and Amateur Radio Direction Finding (ARDF). As they progress in skill and interest, these radio athletes look for gear that is best at giving them useful bearing information without slowing them down while navigating through the forest.

Last time I told you that most radio-orienteers start out on 2 meters with a three-element direction-finding Yagi. Elements are made from a steel measuring tape or another flexible material. These antennas are easy to construct[1] and work with any handie-talkie or scanner if you add an offset-type RF attenuator[2] to knock down the signal as you approach a fox transmitter.

After a few hunts, some foxtailers "graduate" to a special ARDF receiver with tone-pitch signal indication and automatic attenuation, such as Sniffer MK4 by Bryan Ackerly, VK3YNG.[3] Others prefer to stick with manually operating the attenuator, because it gives them a better "feel" of the distance to the transmitter. Are these the same type of people who prefer to drive a stick-shift vehicle?

ARDF can be just a refreshing walk in the park, but winning a medal usually requires some running—lots of it if you are in a category with top-tier competitors. Therefore, your ARDF setup should be designed to be carried safely and efficiently while running. Having the antenna in one hand and the receiver in the other just won't do. Everything should fit together in a single assembly with a handle that doesn't require an awkward hand position. You may be carrying it for over two hours at a time, so make it comfortable.

In formal competitions, additional transceivers and GPS sets with displays are not allowed. Competitors are given an orienteering map with standard color coding for vegetation plus symbols for trails, fences, boulders, gullies, and so forth. These maps are normally printed on 8.5" × 11" or 8.5" × 14" paper.

Many radio-orienteers choose to cover the map with clear plastic and mount it onto a flat surface that is secured to the 2-meter Yagi. That makes it easy to see the entire map while running and to mark bearings with a crayon or grease pencil. Discarded political campaign signs printed on weatherproof corrugated material are ideal for map boards. The downside is

Vadim Afonkin, KB1RLI, finishes the 2-meter competition on the sand at the 2009 IARU Region 1 championships in Bulgaria. Like most European radiosport enthusiasts, he has a special orienteering outfit that includes gaiters to protect his lower legs from the brush. (Photo courtesy of Vadim Afonkin, KB1RLI)

that if it is a windy day, the board turns the antenna into a sail, making it difficult to hold steady.

Champions at ARDF who are also experienced at classic orienteering prefer to fold their maps down to about four by four inches and to "thumb" them. They hold the map in their free hand, oriented so that their direction of movement is at the top, placing the thumbnail right on top of their location. As they turn and travel, they update the map's orientation and the thumb's position. They may count their steps to determine how far along a trail they have progressed. Using this technique, they never lose track of their own position on the map.

What you wear is important, too. Good running shoes are a must. Orienteering tops and pants of nylon or mesh are popular among European foxtailers, because they fully cover arms and legs, yet they are cool and allow easy movement. "In Sweden, we are not allowed to run in the forest with short pants

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

At the 2009 USA and Region 2 ARDF Championships near Boston, Susanne Walz, DG4SFF, of Germany used this board and pushpins to keep track of her bearings and her position on the map while out on the courses. (Photo by Joe Moell, KØOV)

and short-sleeved shirts," says Per-Axel Nordwaeger, SMØBGU. "That is due to an outbreak of hepatitis, or something similar, about three decades ago."

"Nobody could figure out why only orienteers got the disease," P-A continues. "Then they noticed that many of them ran the same paths in the forest and got scratches from trees and bushes. Doctors suspected that blood was getting on the branches and being transferred from one runner to another. We changed the clothing requirement and it solved the problem."

Carry a bottle of water with you on the course. If it will be very warm, consider a "camelback" water pouch with a hose for sipping on the run. Don't forget a granola or energy bar and a whistle, in case you need to summon help.

Earn a Trip to Opatija

Every even-numbered year, the hams of one nation invite those of all others to come to a forest to see who is best at radio-orienteering. This year, the 15th World ARDF Championships (WC) will take place near Opatija, Croatia. Over 300 competitors are expected to take to the forest courses on 2 meters and 80 meters.

Opatija is on the Bay of Kvarner on the Adriatic Sea. It is about 80 miles southwest of Zagreb, the country's capital. One-hundred miles to the west, across the Adriatic, is Venice, Italy. For over 125 years, the resort there has been a magnet for artists and other members of European high society, especially during the winter months. Composer Gustav Mahler and writer Anton Chekhov were among those who spent time in these Austrian and Hungarian villas to jump-start their creativity. Today, tourists like to visit its 14th-century Benedictine abbey, the nature park at Mount Ucka, the woods that are full of Bay Laurel, and three nearby medieval towns.

Participants will arrive in Croatia on Monday, September 13. They will be transported to the Hotel Opatija, where they will rest and prepare for the equipment testing session and opening

Vadim Afonkin, KB1RLI (left), was recognized on stage at the 2009 Region 1 championships for his efforts promoting ARDF in North America. Shaking his hand is Panayot Danev, LZ1US, representing the host country and the international ARDF Working Group. (Photo courtesy of KB1RLI)

ceremonies on Tuesday. Competition days are Wednesday and Friday, with a full day of rest and tourism on Thursday. For team members, the package cost of competitions, accommodations, food, and excursions is 320 Euros. Each person is responsible for this fee as well as for his or her transportation from home to Croatia and back.

This year's WC will follow the latest revision of radio-orienteering rules, approved in September 2009 by the IARU Region 1 ARDF Working Group. New three-transmitter categories for men over age 70 and women over age 60 were added, making a total of six categories for men and five for women. Effective course lengths are now specified for each category, ranging from 6 to 12 kilometers.

The USA has had a team at every WC since 1998, and this year's team may be the biggest ever. We will be competing against countries that have had well-established ARDF programs, often government funded, since the 1960s. Russians, Ukrainians, and Czechs took home over 90 percent of the medals in 2008. On the other hand, some countries have never had medal winners, but their teams greatly enjoy participating and learning.

The USA continues to improve in the sport. Nadia Scharlau won the USA's first WC medal when she captured third place in her category on 80 meters in 2006 in Bulgaria.[4] George Neal, KF6YKN, earned a bronze medal on 2 meters in the 2008 WC near Seoul, Korea.[5] The USA had four top-ten category finishes that year.

Most nations select their ARDF team members by staging a national championship event. The USA has held one annually since 2001. In even-numbered years, it must take place in the spring to allow time for finalization of ARDF Team USA and preparation for WC travel in the late summer or fall.

In odd-numbered years, the championships can take place in the summer, making it possible to utilize high-altitude locations such as Lake Tahoe that are too wet or cold in the spring. Also in odd years, the three IARU regions are encouraged to hold championships. Here in Region 2 (North and South America), only the USA and Canada have established ARDF programs at this time. The USA's national championships have been combined with IARU Region 2 Championships since 2001. Plans are in the works to have the Region 2 Championships be in Canada for the first time in 2013.

In June 2009, the USA's championships took place in a northeastern state for the first time. Vadim Afonkin, KB1RLI, set outstanding courses on both 2 meters and 80 meters in the 7000-acre Blue Hills Reservation near Boston.[6] One quarter of the participants had never competed in a formal on-foot transmitter hunting event before, and of these, 80 percent live in eastern Massachusetts. Vadim, who learned ARDF in his native Russia as a youth, continues to promote and develop the sport in the Bay State by putting on regular practice and training sessions. His protégés will be formidable competitors at upcoming USA championships and are expected to earn positions on Team USA.

Three months after his big event in Boston, Vadim represented USA at the 2009 IARU Region 1 ARDF Championships in Ozbor, Bulgaria. He participated on the courses and in the training camp just prior. Because the USA is not a Region 1 country, Vadim had to compete as a visitor and he was ineligible for medals. However, at the medal ceremony, he was invited up to the podium and received an award for his work in developing ARDF in this part of the world. It was presented by Panayot Danev, LZ1US, who is Bulgaria's representative in the ARDF Working Group.

To Ohio in May

Stepping forward to host the 2010 USA championships are some very enthusiastic hams in the Cincinnati, Ohio area. It's no surprise that ARDF is popular in the region bounded by Interstate 275 and points north, which includes nearby parts of Kentucky and Indiana. Nowhere in the country is there a greater concentration of excellent orienteering sites with deep forest, steep hills, and networks of trails.

USA's ARDF Championships are open to all, regardless of radio-orienteering skill level or ham radio licensing status. For the second year, registration for the USA's national championships will be at no charge for first-time participants and for participants coming from outside North America. Members of ARDF Team USA will be chosen from the winners of these championships in Ohio and from the 2009 championships near Boston.

Everyone will gather on Friday, May 21 for informal practice and equipment testing at a site to be announced. That will be followed on Saturday by the formal 2-meter competition at another site with a cookout for all participants afterwards. On Sunday, the 80-meter competition will take place in yet another location, followed by the medal awards ceremony.

This year's co-chairs are Bob Frey, WA6EZV, and Dick Arnett, WB4SUV. They have trained in the area for years and traveled to the WC four times. In 2003, they put on the highly successful Third USA and Second IARU Region 2 ARDF Championships, headquartered at Miami University in Oxford, Ohio. Both of them, as well as two other organizers, want to qualify for the WC again. To make that possible, each will be setting one of the two courses and running the other.

Bob Frey, WA6EZV, and Brian DeYoung, K4BRI, will put out the 2-meter course. Dick Arnett, WB4SUV, and Matthew

Robbins, AA9YH, will be responsible for the 80-meter course. Additional assistance will come from members of the OH-KY-IN Amateur Radio Club, Orienteering Cincinnati (OCIN), and the Butler County VHF Association.

As of this writing, the exact competition sites have not been finalized, but Bob and Dick have put the following locations on the embargo list: Hueston Woods State Park, Oxford Nature Preserve, Ceasars Creek State Park, Englewood Park (Dayton), Mounds State Recreation Area (Indiana), and East Fork State Park. Anyone who will be competing in the 2010 ARDF championships may not go into these areas until then, to prevent them getting an unfair advantage of familiarity with the terrain.

As it becomes available, more information is being placed in the official website of the 2010 championships,[7] including registration forms, local lodging information, and hunt frequencies. A pre-championship ARDF training camp on May 19 and 20 is a possibility, so look to the site for information about how to express your interest in that. Bob and Dick are also organizing the annual Foxhunting Forum at the Dayton Hamvention® one week earlier. That popular session is tentatively scheduled for Friday, May 14 at 11 AM in Room 2 of Hara Arena, although it may change to 2:45 PM.

Doppler or Beam?

Many of the questions in my incoming e-mail are about equipment selection for vehicular direction finding at VHF and UHF frequencies. Which is better, a hand-turned beam or an add-on Doppler set? Of course the answer is "It depends." For instance, when tracking a source of malicious interference, a four-element quad protruding through a hole in the car roof is not very stealthy. The four quarter-wavelength whips of a Doppler array are much easier to conceal. Before his untimely death in 2006, Mike Obermeier, K6SNE, tracked down numerous repeater jammers and bootleggers with a Doppler array mounted in the bed of his truck, covered with a non-metallic shell to make it invisible from the outside.

On the other hand, an array of quarter-wavelength whips selected one at a time has much less gain than a Yagi or quad. When the signal to be tracked is distant and weak, that's impractical. For competitive 2-meter mobile hunts, my van is equipped with a rotating quad and RF attenuator on one receiver and a Doppler set with its array behind the quad on the roof, connected to another receiver. Usually, signals are very weak after leaving the hilltop starting point. It is not uncommon for the quad to be the only way to get bearings until I have driven about three-quarters of the way to the hidden T and the Doppler comes into range.

What about transmitter hunting in urban areas where there are many surfaces to reflect VHF/UHF signals? When signal strength and stealth aren't overriding factors, which method is better at getting accurate bearings in these high multipath situations? That topic is of great interest to engineers at cellular and wireless companies, as well as to other commercial users of VHF/UHF.

Two researchers from the Applied Electromagnetics and Wireless Lab of Oakland University in Rochester, Michigan did an extensive study to get answers to that question. Their findings were

Bob Frey, WA6EZV, will be a co-chair of the organizers for the 2010 USA ARDF Championships near Cincinnati. Here he shows his 2-meter ARDF gear to Kentaro Kurogi and Masahiko Mimura, the two visiting competitors from Japan, at last year's championships near Boston. He has mounted his map onto a discarded campaign sign that is taped to the elements of his Yagi antenna. (Photo by KØOV)

Dick Arnett, WB4SUV, runs the 2-meter finish corridor at the 2009 USA and IARU Region 2 ARDF Championships on his way to a gold medal in the M60 category. Dick is a co-chair of the organizers for this year's championships in Ohio. (Photo by KØOV)

detailed in a paper published by the journal *Physical Communication*.[8] Aloi and Sharawi compared three RDF systems at 2400 MHz. Each was mounted on a vehicle inside a 195' × 213' parking garage. Bearings were taken one at a time on 488 transmitters in 122 locations inside the garage, at four heights above ground for each location. A second set of data was taken with everything the same, except that there were 46 other vehicles surrounding the car with the RDF sets.

Of course the researchers didn't have that many actual transmitters or take that many actual bearings. In fact, they didn't take any field bearings at all. They didn't even build any RDF equipment. It was all done with computer simulation. The RDF sets were represented by algorithms. The parking lot was created as a model in Wireless InSite,[9] a commercial software package. That program traces many signal-ray paths between each transmitter and receiver, including reflected paths via surfaces of the parking lot and the other cars. The parking-lot model was quite detailed, including concrete, glass, rubber and metal in the floor, ceiling, support posts, and the other cars.

The first method to be simulated was amplitude-based, analogous to RDF with a Yagi or quad. The researchers wrote pseudo-code for an automated system with eight directional dual-polarization antennas, each covering a 45-degree segment of azimuth. Received power levels from the antennas were calculated and then compared to determine the signal bearings. Two possible half-power beamwidths for each antenna were simulated, 45 degrees and 90 degrees.

The second system was a classic sequentially-switched Doppler set with a circle of zero-gain vertical antennas, switched sequentially into the receiver. That switching imparts a FM component to the incoming signal at the fixed frequency of the pseudo-rotation. The relative phase of that added modulation is a function of the direction of arrival of the incoming signal.

The third RDF system was described as "digital PLL." It had the same set of vertical antennas in a circle, but the relative signal phase at each whip was measured by a bank of phase-locked loops. That information was compared against a table of the expected relative phases that had been calculated for each whip at all azimuth directions. The perceived bearing was the direction of arrival for which the table values produced the best fit for the target phase information. This is analogous to a multi-element time-difference-of-arrival (TDOA) RDF system.

Some of the study conclusions seem obvious. Any experienced hidden-transmitter hunter could have predicted them. For instance, a RDF antenna on top of the car roof worked better than one underneath it. Narrow (45-degree beamwidth) directional antennas gave better accuracy than wide (90-degree beamwidth) antennas in the amplitude-based system. Accuracy of each method was better with no other cars nearby than it was when surrounded by cars. Bearings were better when the transmitters were 70 inches above ground, compared to lower locations. No surprises there.

The big question was which of these RDF methods was most accurate in high multipath. To determine this, the researchers compared target azimuth as perceived by the simulated RDF sets (the bearings) with the actual target azimuth. If the bearing was within plus or minus 22.5 degrees of being correct, the data point was judged as a PASS. If the bearing was off by more than that, it was judged as a FAIL.

The amplitude-based method won the contest handily. Pass rates for the 45-degree beamwidth car-top-mounted receive antenna in the garage were between 65 and 89 percent. Equivalent pass rates for the better Doppler (8 elements) were only 10 to 20 percent. The eight-element TDOA system was only slightly better than the Doppler, with pass rates ranging from 15 to 24 percent.

This simulation assumed an "ideal" Doppler RDF system, which is probably better than the Doppler you are using for transmitter hunting. Many hams have antenna sets with non-optimum antenna RF switches, which creates an undesired amplitude response that degrades the bearing accuracy.[10] Antenna position on the vehicle can have a significant effect on accuracy, too.

A 10- to 20-percent probability of bearings within 22.5 degrees of being correct makes the Doppler technique seem almost not worthy of consideration. However, these researchers did not test the method that hams use to compensate for the basic inaccuracies of fixed-location Dopplers: Increase the effective baseline by taking readings from multiple places.

Hams with Doppler experience know that bearings from their sets at fixed locations are always suspect due to multipath, so they keep their Doppler-equipped vehicles in motion whenever possible. They average the bearings obtained from many points along the road, either with computer assistance or just by eyeballing the display. That goes a long way toward improving Doppler RDF accuracy and making it on par with beams and other amplitude-based techniques for VHF/UHF mobile transmitter hunts.

I have two suggestions for future research with these models:

1. Acquire a set of data with the RDF-equipped cars moving along a track within the parking garage, taking multiple bearings and averaging. That would quantify the improvement that can be obtained by increasing the effective baseline.

2. Bearings that are in error by 22 degrees do not give useful results when triangulated, so acquire additional data sets with pass criteria of plus or minus ten degrees error and five degrees error. That will provide an even better comparison of the three RDF methods in high multipath.

Many thanks to all of the *CQ VHF* readers who have sent in their stories, questions, and ideas for future column topics. Whether you prefer vehicular "T-hunts" or all-on-foot foxhunts, make 2010 your year to get more involved in ham radio direction-finding activities. Encourage other hams to do so also. Then let me know what is happening in your area so I can pass it along to other readers.

73, Joe, KØOV

Notes

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2. http://www.homingin.com/joek0ov/offatten.html
3. http://www.foxhunt.com.au/
4. http://www.homingin.com/bulgaria.html
5. http://www.homingin.com/korea08.html
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7. http://www.usardf2010.com/
8. D.N. Aloi, M.S. Sharawi, "Comparative analysis of single-channel direction finding algorithms for automotive applications at 2400 MHz in a complex reflecting environment," *Physical Communication* (2009), doi:10.1016/j.phycom.2009.08.002
9. http://www.remcom.com/wireless-insite
10. More information on Doppler RDF sets and how to optimize them is in my "Homing In" column for Spring 2004 entitled "Get Better Performance From Your Doppler Set."

By Kent Britain,* WA5VJB

ANTENNAS

Connecting the Radio to the Sky

Stacking Yagis

I would like to start out with a bit of an apology to the readers of both *CQ VHF* and *CQ*. I try to avoid the having the same topic in my columns in both magazines, but stacking Yagis has been a hot topic of late. Nothing seems to get a group of VHFers to take off in a dozen different directions than a discussion on how far apart you need to space your 50-, 144-, 222-, and 432-MHz Yagis to minimize interaction. Also, I can go into a bit more detail here than I could in *CQ*.

First we start with a concept that will make university professors cringe, but it works quite well for our applications. The subject is capture area.

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

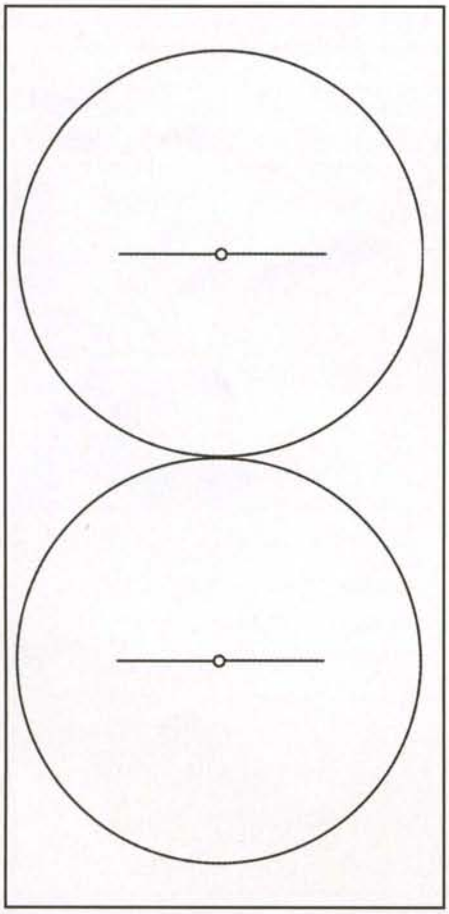


Figure 1. Capture area of two Yagis stacked for maximum gain.

Think of capture area like you would a panel of solar cells. If you want twice as much power from a solar panel, or 3 dB more DC power, you need twice as much area. In this case we will call it capture area. An antenna with 3 dB more gain will also have twice as much capture area.

In figure 1 are two identical antennas. While I drew the capture area as a line, in reality it is a tapered area with very fuzzy boundaries. You want to stack the antennas at a distance where their capture areas overlap just a bit. A little more overlap and you have a cleaner pattern and less losses in the phasing harness. Farther apart and you get a little bit more gain, but more masts and longer phasing lines are needed, and in the end you lose most of that extra gain. Also, for those of us with EME arrays, stacking for optimum suppression of side lobes is taking this exercise to an entirely new level.

In figure 2 I chose a 144-MHz and a 432-MHz Yagi. Of course, any two bands could be used, and a higher gain Yagi would have a larger circle. To prevent interaction between the two antennas we need to stack them as shown in figure 3, right? No, because we have to consider the capture area of the Yagis on the same frequency at the same time. In figure 4 you can see how the capture area of the 144-MHz Yagi is very small at 432 MHz, and the 144-MHz capture area of the 432-MHz Yagi is next to nothing. This means we can safely stack the antennas much closer together. Just think of some of the VHF rover stations with over a dozen antennas on their roof racks.

At the 2009 Microwave Update conference I had an opportunity to run some quick tests on the antenna range. While measuring a 432-MHz beam, 50-ohm terminated 902-MHz and 1296-MHz Yagis were mounted at different heights as shown in photo A. At spacings as close as 6 inches the gain change was only a few tenths of a dB at 432 MHz. I had to space them where the U-bolts were actually touching before the gain dropped a full dB. Also, I think much of that was SWR losses where the elements from the other Yagi got close to the 432's driven element. After all, on HF it is quite com-

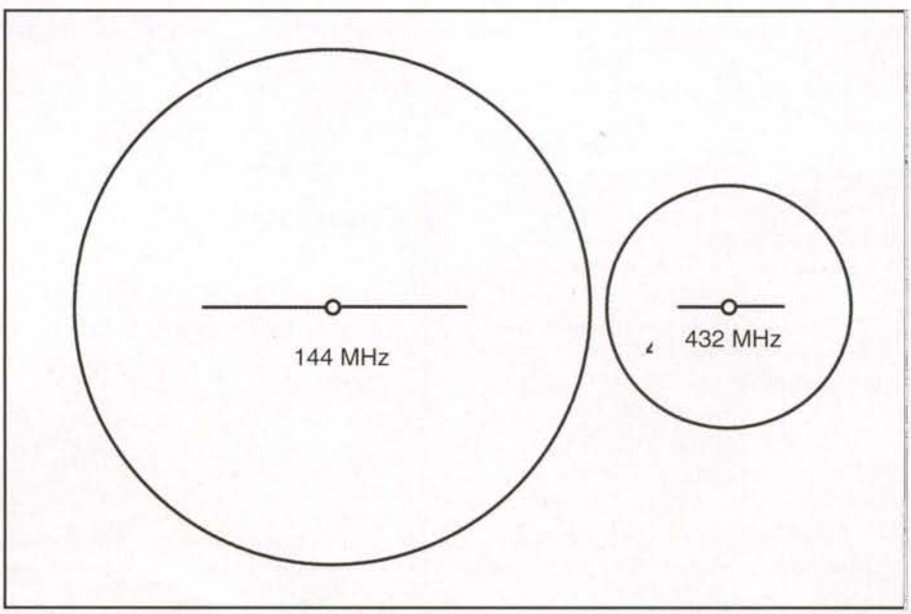


Figure 2. Relative capture area of Yagis for different bands.

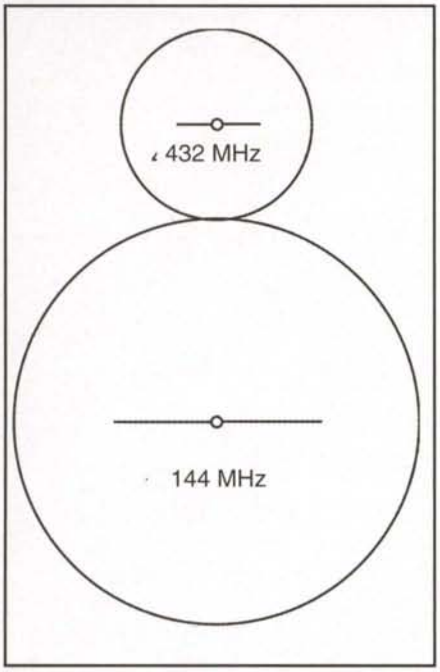


Figure 3. The stacking distance for dissimilar Yagis.

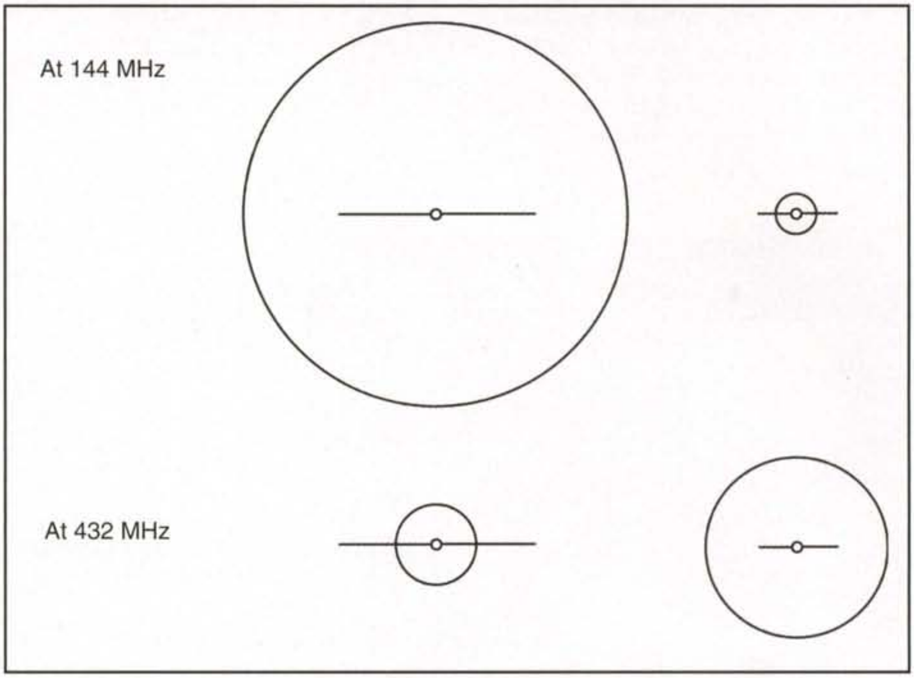


Figure 4. Relative capture area of the Yagis on the same frequency.

mon to build Yagis for two, three, and even five bands on the same boom.

The bottom line is that you can mount a higher band Yagi very close to a lower frequency Yagi with virtually no interaction. The next question is what changes are there in the higher band Yagi? Well, with snow coming down as I write this column, it will take warmer weather to make those measurements. However, I'm just a curious as you are, so stand by.

Pitfalls in Helix Antenna Construction

Without a doubt, the UHF+ antenna with the most myths is the helix. Dozens of websites have simple calculations for determining the dimensions for your desired frequency. There is a problem, though. The calculations themselves come out about 3 dB too high. However, few hams actually build the helix per the assumptions behind those calculations.

The helix in photo B looks good, but it doesn't work. I'll be going into the assumptions and construction pitfalls next time.

Letters, Letters, We Get Letters

From Mark, we have some questions concerning recent advertisements about "low-noise" VHF antennas. An antenna picks up all signals, both the signal you want and the signals you don't want. Below 2 MHz there are antenna designs that do a good job of picking up skywaves better than local noise and they are called low-noise antennas, but that is not the case with Yagis.

In figure 5 I have plots from two versions of a Cheap Yagi. Note that one has much smaller back lobes than the other. When it comes to extreme communications such as moonbounce, any signal coming in from the back of the antenna is just system noise. In this case low noise means very low side and back lobes. For ragchewing or repeater service you would never hear any difference. Thus, low noise is another way of saying the Yagi has a very clean pattern.

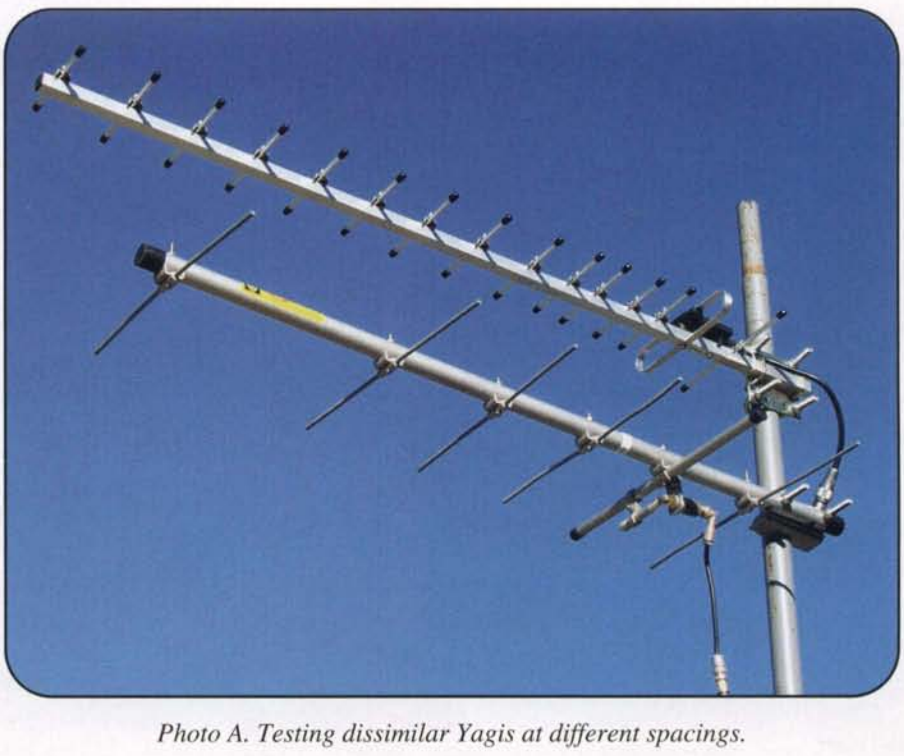


Photo A. Testing dissimilar Yagis at different spacings.

It's one thing to have a "Mickey Mouse" antenna, and it's another thing to have an antenna with Mickey Mouse printed on it. At the Microwave Update 2009 conference we had the antenna ranges set up. Photo C shows here Doug, KA2UPW/5, with his combination L-Band/S-Band collapsible dish based on a Disneyland folding parasol. Not bad—just over 16 dBi gain on both 1269 MHz and 2402 MHz.

Again, we welcome your antenna questions and topic suggestions. Just drop a note to my QRZ.com snail-mail address or an e-mail to <wa5vjb@cq-amateur-radio.com>. For other antenna articles and projects, you are welcome to visit <www.wa5vjb.com>.

73, Kent, WA5VJB

Photo B. Pitfalls when constructing helix antennas.

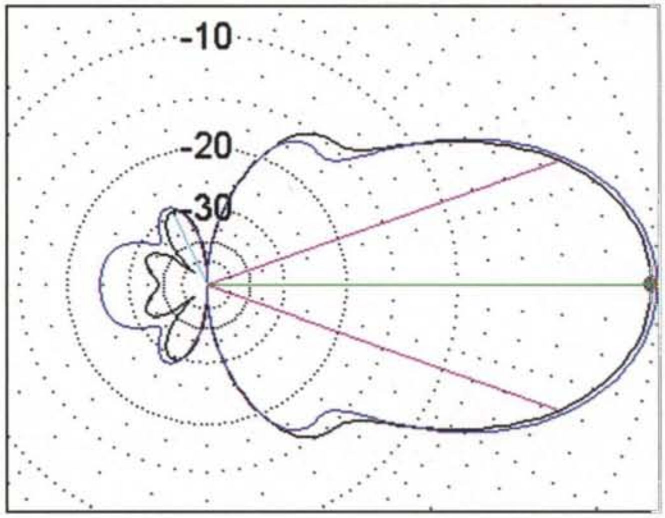


Figure 5. Low back lobes and low noise.

Photo C. Mickey Mouse L-Band/S-Band collapsible dish.

By Bob Witte,* KØNR

FM

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

Repeaters: Open or Closed?

The FCC recently reaffirmed the legitimacy of *closed repeaters* by dismissing a petition to modify Part 97 of the FCC rules to eliminate closed repeaters. In this column, we'll take a look at this controversial issue and try to explain the FCC's actions.

What is a Closed Repeater?

The ARRL website (www.arrl.org) gives us this simple definition: Closed repeater—a repeater whose access is limited to a select group.

Sometimes called a *private repeater*, a *closed repeater* is intended to be used only by a specific group of radio amateurs. How this exclusivity is enforced varies, but usually includes a strong dose of social pressure. In other words, if you show up on a closed repeater you are likely to be verbally encouraged to find another repeater. (The amount of politeness in the delivery of this message tends to vary dramatically!) Closed repeaters may also employ some technical methods to keep unwanted users out, including various forms of tone access (CTCSS, DTMF, DCS, etc.). However, keep in mind that the use of tone access does not necessarily mean the repeater is closed. Years ago, the use of CTCSS was often associated with closed repeaters, but these days many open repeaters use tone access to avoid a variety of interference problems.

For closed repeaters that are supported by a formal organization, repeater usage is usually limited to club members only. Membership eligibility may be tightly controlled (such as requiring sponsorship by current club members), or it may just require an application with payment of dues. Another common model for a closed repeater is for a few individuals to collaborate on putting up a repeater and make it available to only their social group. In this case, being "in the group" can be very informal.

There are varying degrees of "closed" when it comes to repeaters. For example, many open repeaters choose to keep special features such as autopatch operation or repeater linking restricted to members only. Some closed systems will go ahead and operate "open" during an emergency situation. Some closed repeater groups are open to adding new members to help support the cost of the repeater system, while other groups prefer to limit membership to the core group.

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

Why Closed Repeaters?

There are a number of reasons why groups or individuals decide to make their repeater systems closed. The most common reason seems to be the idea of keeping particular types of individuals and operating styles off the repeater. One closed repeater system states this clearly on its website with the motto "no scum bags." If you dig deeper into this, you may find that these repeater licensees have had trouble in the past with certain repeater users spoiling the use of the repeater for the larger group. Ham repeaters are more than just pieces of radio gear on a hill; they have a social aspect to them. Over time, groups that hang out on a repeater tend to develop acceptable patterns of radio operation *for that repeater*. Like-minded operators are attracted to the same repeater systems and tend to have compatible operating habits.

Some repeaters sit quiet all day long except for a few short calls and a scheduled net or two. Others are known as ragchew machines and get a lot more use. Some systems are dedicated to specific ham interests such as ARES, RACES, DX, etc. In most regions, a new ham gradually figures out the personalities of these repeater social groups and migrates to one they find to be comfortable. Now imagine some of the ragchew-oriented folks getting on a repeater that has users who prefer a quiet channel and you can see some conflict. If that's not enough, toss in some diversity of political and social views and it can get ugly. With a closed repeater, the group attempts to actively control who is allowed on the repeater and keep things operating the way they prefer.

Another reason for closed repeaters is the *financial support* argument. Repeaters are expensive and require significant time and money to keep them functional. Some repeater owners get very frustrated when a few users hog the machine while not contributing any financial support. Pull out the club roster for your local repeater group and compare it to the callsigns you hear every day on the repeater. You may be surprised at how many regular users don't pay dues to support the repeater. Requiring a paid-up club membership to use the machine is one solution to that problem.

Another argument for keeping a repeater closed is because there are *complex features* on the system. Consider a group that puts up a repeater system that has many options for linking together different channels and repeaters. They may conclude that the users need to be trained to use the system and decide to limit access to carefully selected hams who have the competency to operate the system. This training requirement (and perhaps membership requirement) results in a closed system.

Supporting these arguments for having a closed repeater is the underlying principle of *private property*. The repeater owner thinks, "This repeater is my amateur radio station and I decide who has access to this equipment." Nowhere in the FCC rules does it say an amateur operator has to allow everyone use of his station.

Arguments Against Closed Repeaters

Many people argue against allowing closed repeaters from simply a fairness point of view. Locking people out of a repeater is discrimination and just seems like the wrong thing to do in this friendly hobby of amateur radio. Sometimes this is articulated as being inconsistent with *good amateur practice* (Part 97.101a).

A more specific argument is found in Part 97.101(b), which says:

> Each station licensee and each control operator must cooperate in selecting transmitting channels and in making the most effective use of the amateur service frequencies. No frequency will be assigned for the exclusive use of any station.

FCC Rules Specific to Repeaters

§97.205 Repeater station.

(a) Any amateur station licensed to a holder of a Technician, General, Advanced or Amateur Extra Class operator license may be a repeater. A holder of a Technician, General, Advanced or Amateur Extra Class operator license may be the control operator of a repeater, subject to the privileges of the class of operator license held.

(b) A repeater may receive and retransmit only on the 10 m and shorter wavelength frequency bands except the 28.0–29.5 MHz, 50.0–51.0 MHz, 144.0–144.5 MHz, 145.5–146.0 MHz, 222.00–222.15 MHz, 431.0–433.0 MHz and 435.0–438.0 MHz segments.

(c) Where the transmissions of a repeater cause harmful interference to another repeater, the two station licensees are equally and fully responsible for resolving the interference unless the operation of one station is recommended by a frequency coordinator and the operation of the other station is not. In that case, the licensee of the non-coordinated repeater has primary responsibility to resolve the interference.

(d) A repeater may be automatically controlled.

(e) Ancillary functions of a repeater that are available to users on the input channel are not considered remotely controlled functions of the station. Limiting the use of a repeater to only certain user stations is permissible.

(f) [Reserved]

(g) The control operator of a repeater that retransmits inadvertently communications that violate the rules in this Part is not accountable for the violative communications.

(h) The provisions of this paragraph do not apply to repeaters that transmit on the 1.2 cm or shorter wavelength bands. Before establishing a repeater within 16 km (10 miles) of the Arecibo Observatory or before changing the transmitting frequency, transmitter power, antenna height or directivity of an existing repeater, the station licensee must give written notification thereof to the Interference Office, Arecibo Observatory, HC3 Box 53995, Arecibo, Puerto Rico 00612, in writing or electronically, of the technical parameters of the proposal. Licensees who choose to transmit information electronically should e-mail to: prcz@naic.edu.

1. The notification shall state the geographical coordinates of the antenna (NAD-83 datum), antenna height above mean sea level (AMSL), antenna center of radiation above ground level (AGL), antenna directivity and gain, proposed frequency and FCC Rule Part, type of emission, effective radiated power, and whether the proposed use is itinerant. Licensees may wish to consult interference guidelines provided by Cornell University.

2. If an objection to the proposed operation is received by the FCC from the Arecibo Observatory, Arecibo, Puerto Rico, within 20 days from the date of notification, the FCC will consider all aspects of the problem and take whatever action is deemed appropriate. The licensee will be required to make reasonable efforts in order to resolve or mitigate any potential interference problem with the Arecibo Observatory.

In other words, licensed amateur radio operators can use any frequency (within their license privileges). Therefore, they should be able to use any repeater.

Conventional FM repeater technology is not frequency agile. A repeater owner sets up a repeater to function on a specific pair of input/output frequencies, tunes the transmitter, receiver, and duplexer to operate on that pair, and it stays there. This creates a direct correspondence between a particular amateur radio station (the repeater) and a specific frequency (actually a pair of frequencies). The FCC actively encourages repeater owners to work with their local frequency coordinator to select a frequency pair that is not already in use, with the expectation that the frequency coordinator will not coordinate another repeater on the same frequency in the same general location. Most ham radio activity isn't tied to one frequency; if the frequency I want to use is busy, I just turn the dial and find another one, just as good as the first one. Thus, the *shared frequency* argument is that a coordinated closed repeater is essentially assigned a frequency for the exclusive use of a particular group of stations. This seems inconsistent with Part 97.101(b).

The FCC Decision

The recent petition submitted by Murray Green, K3BEQ, used the *shared frequency* argument against allowing closed repeaters. According to the FCC dismissal letter, the petition requested "...that the Commission amend Section 97.205(e) of its Rules to prohibit a repeater station licensee or control operator from limiting the use of a repeater to only certain user stations, unless a user blatantly violates the Commission's Rules." The FCC rejected the argument, saying, "Coordination does not and cannot result in assignment or establish control of an amateur service channel, and nothing in the rules prohibits other amateur stations from using the channels for which a repeater has been coordinated when they are not being used by the repeater."

Now that is a rather odd statement by the FCC, since generally accepted operating practice is to *not* transmit on the input or output frequency of a repeater unless you are intending to use that repeater. Operating simplex on the input or output of a repeater is highly likely to create interference with users of that repeater.

More importantly, the FCC upheld the principle that the repeater licensee or control operator is responsible for the proper operation of the repeater. The dismissal letter says, "Section 97.205(e) merely enables a repeater licensee or control operator to control the repeater, so that he or she can ensure the repeater is properly operated as required by Section 97.105(a)." In other words, limiting the use of the repeater to only certain user stations is an important tool for ensuring the repeater is operating in compliance with FCC rules.

This is very consistent with FCC enforcement actions over the last decade.

Take a look at the warning letters on the FCC Amateur Radio enforcement page. They include multiple letters to amateur radio operators who have been told to stay off a particular repeater. Included in the typical FCC letter is this statement:

> The Commission requires that repeaters be under the supervision of a control operator and not only expects, but requires, that such control operators be responsible for the proper operation of the repeater system. Control operators may take whatever steps they deem appropriate to ensure compliance with the repeater rules, including limiting the repeater use to certain users, converting the repeater to a closed repeater or taking it off the air entirely.

Clearly, the Commission has chosen to back the repeater licensees and control operators even to the extent of excluding users from a repeater. While this can result in dictatorial behavior by a repeater owner, to not support this principle opens the door to repeater owners not being able to effectively control their systems. One ham told me once, "In the limit, all repeaters are closed, because you as a repeater licensee must be able to exclude certain operators to protect your license."

What does this decision mean for the average repeater user? Not much. Let's face it: Our main problem is not being excluded from repeater systems. A much bigger issue is that there are lots of excellent repeaters on lots of channels, available but hardly ever used. If you find yourself locked out of a closed repeater, there is likely another one around that will meet your needs. So look around and find the repeater group that fits your operating style. You'll be a lot happier and so will the users of the closed repeaters.

Tnx and 73

Thanks for taking the time to read another one of my columns on the "Utility Mode." Closed repeaters are controversial and I have tried to treat the topic in a balanced and factual manner. This article is completely my opinion and does not necessarily reflect the views of *CQ VHF* management and staff. I always enjoy hearing from readers, so drop me an e-mail with your thoughts. 73, Bob, KØNR

References

ARRL Repeater Glossary: <http://www.arrl.org/tis/info/pdf/repgloss.pdf>

FCC Letter Dismissing the K3BEQ Petition: <http://hraunfoss.fcc.gov/edocs_ public/attachmatch/DA-09-2559A1.pdf>

FCC Amateur Radio Enforcement Page: <http://www.fcc.gov/eb/AmateurActions/Welcome.html>

QUARTERLY CALENDAR OF EVENTS

Current Contests

The **European Worldwide EME Contest 2010**: Sponsored by DUBUS and REF. The EU WW EME contest is intended to encourage worldwide activity on moonbounce. See: <http://www.marsport.org.uk/dubus/EMEContest2010.pdf>.

Spring Sprints: These short-duration (usually four hours) VHF+ contests are held on various dates (for each band) during the months of April and May. See N6CL's VHF Plus column in *CQ* magazine for a future announcement.

The **2 GHz and Up World Wide Club Contest**: Sponsored by the San Bernardino Microwave Society, this contest runs the second weekend of May. Rules are at: <http://www.ham-radio.com/sbms/club_test/2ghz_up_test.html>.

Conference and Convention

Southeast VHF Society: The 14th annual conference will be hosted in Morehead, KY, April 22–24. For information go to: <http://www.svhfs.org/>.

Dayton HamVention®: This will be held as usual at the Hara Arena in Dayton, Ohio May 14–16,. Go to: < http://www.hamvention.org>.

Calls for Papers

Calls for papers are issued in advance of forthcoming conferences either for presenters to be speakers, or for papers to be published in the conferences' *Proceedings*, or both.The following organizations and/or conference organizers have announced calls for papers:

Southeastern VHF Society Conference: Technical papers are solicited for the 14th annual Southeastern VHF Society Conference to be held in Morehead, KY on April 23–24. Papers and presentations are solicited on both the technical and operational aspects of VHF, UHF, and Microwave weak signal amateur radio.

The deadline for the submission of papers and presentations is February 5, 2010. All submissions should be in Microsoft Word (.doc) or alternatively Adobe Acrobat (.pdf) files. All text, drawings, photos, etc. should be black and white only (no color). Submissions for presentation at the conference should be in PowerPoint (.ppt) format, and delivered on either a USB memory stick or CDROM or posted for download on a website of your choice.

Please indicate when you submit your paper or presentation if you plan to attend the conference and present there or if you are submitting just for publication. Papers and presentations will be published in the conference *Proceedings*. Send all questions, comments, and submissions to the program chair, Robin Midgett, K4IDC, via <K4IDC@comcast.net>. For further information about the conference go to: <http://www.svhfs.org>.

Central States VHF Society Conference: Technical papers are solicited for the 44th annual Central States VHF Society Conference to be held in St. Louis, MO on July 22–24. Papers, presentations, and posters on all aspects of weak-signal VHF and above amateur radio are requested. Please contact the folks below if you have any questions about the suitability of a topic. Strong editorial preference will be given to those papers that are written and formatted specifically for publication, rather than as visual presentation aids. Submissions may be made via the following: electronic formats (preferred) via e-mail; uploaded to a website for subsequent downloading; on media (3.5" floppy, CD, USB stick/thumb drive). Deadline for submissions: May 1. For more information, contact CSVHFS President Ron Ocho, KOØZ, at <ko0z@arrl.net>.

Quarterly Calendar

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

Feb. 5	Moon last quarter.
Feb. 7	Poor EME conditions.
Feb. 13	Moon apogee.
Feb. 14	New Moon. Poor EME conditions.
Feb. 21	Moderate EME conditions.
Feb. 22	First quarter Moon.
Feb. 27	Moon perigee.
Feb. 28	Full Moon. Excellent EME conditions.
Mar. 7	Last quarter Moon.
Mar. 7	Very poor EME conditions.
Mar. 12	Moon apogee.
Mar. 14	Moderate EME conditions.
Mar. 15	New Moon.
Mar. 20	Spring equinox.
Mar. 21	Moderate EME conditions.
Mar. 23	First quarter Moon.
Mar. 28	Moon perigee. Excellent EME conditions.
Mar. 30	Full Moon.
Apr. 4	Poor EME conditions.
Apr. 6	Last quarter Moon.
Apr. 9	Moon apogee.
Apr. 11	Moderate EME conditions.
Apr. 14	New Moon.
Apr. 18	Poor EME conditions.
Apr. 21	First quarter Moon. *Lyrids* meteor shower.
Apr. 24	Moon perigee.
Apr. 25	Very good EME conditions.
Apr. 28	Full Moon.
May 2	Very poor EME conditions.
May 5	Eta Aquarids meteor shower.
May 6	Moon apogee. Last quarter Moon.
May 9	Moderate EME conditions.
May 14	New Moon.
May 16	Poor EME conditions.
May 20	Moon perigee. First quarter Moon.
May 23	Good EME conditions.
May 27	Full Moon.
May 30	Very poor EME conditions.
June 3	Moon apogee.
June 4	Last quarter Moon.
June 6	Moderate EME conditions.
June 12	New Moon.
June 13	Poor EME conditions.
June 15	Moon perigee.
June 19	First quarter Moon.
June 20	Moderate EME conditions.
June 26	Full Moon.
June 27	Very poor EME conditions.
July 1	Moon apogee.

—EME conditions courtesy W5LUU

Meteor Showers

The *α-Centaurids* meteor shower is expected to peak on February 8 at 0530 UTC. The *γ-Normids* shower is expected to peak on March 14. Other February and March minor showers include the following and their possible radio peaks: *Capricornids/Sagittarids*, February 1, 1500 UTC; and *χ-Capricornids*, February 13, 1600 UTC.

The *Lyrids* meteor shower is active during April 16–25. It is predicted to peak around 2200 UTC on the 22. This is a north-south shower, producing at its peak around 10–15 meteors per hour, with the possibility of upwards of 90 per hour.

A minor shower and its predicted peak is *π-Puppids* (peak on April 23, at 2200 UTC). Other April, May, and June minor showers include the following and their possible radio peaks: April *Piscids*, April 20, 1500 UTC; *δ-Piscids*, April 24, 1500 UTC; *ε-Arietids*, May 9, 1400 UTC; May *Arietids*, May 16, 1500 UTC; and *o-Cetids*, May 20, 1400 UTC. June *Arietids*, June 7, 1700 UTC; *zeta-Perseids*, June 9, 1700 UTC; and *β-Taurids*, June 28, 1600 UTC.

For more information on the above meteor shower predictions please see Tomas Hood, NW7US's propagation column beginning on page 71 as well as the International Meteor Organization's website: <http://www.imo.net>.

By Mitch Gill, NA7US

EMERGENCY COMMUNICATIONS

The Role of VHF in EmComm

EmComm – Then and Now

I have been an amateur radio operator for over forty years and have seen the many changes our hobby has gone through. Many of those changes have been for the better, but some came with a certain amount of aggravation. It seems that change is hard for most of us "old timers" but more readily accepted by younger hams.

Prior to 9/11, if there was an emergency your local government agencies would be clamoring for the assistance of local hams. We would merely arrive on site and be assigned a communications task, even if we were just as a backup for their communications. I remember as a kid seeing a mobile emergency setup of a local ham. It consisted of a Swan 500C and power supply with a trunk full of radios, cables, antennas, and parts—all stuffed neatly in a Studebaker. Now a ham can fit almost the same capabilities into a backpack.

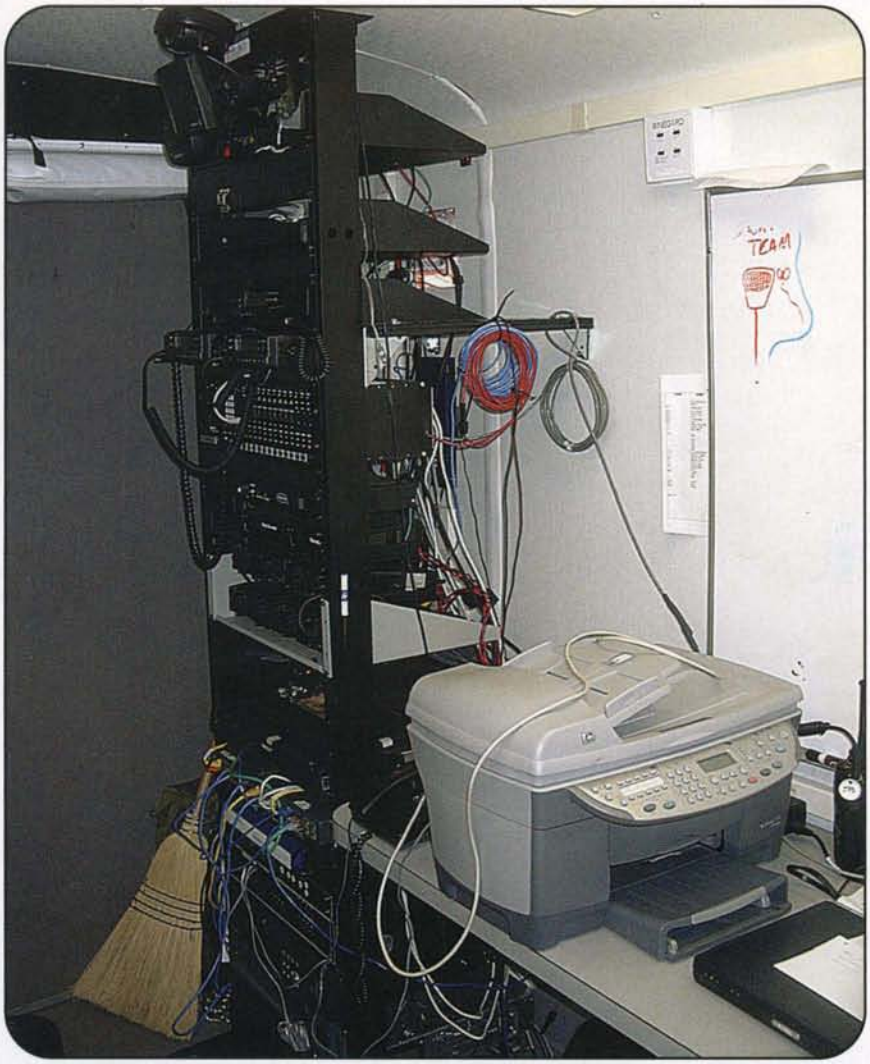
Just prior to 9/11 our state (Washington State) and counties demanded that all emergency volunteers have an emergency volunteer card. This card protects the state in the event that a volunteer was hurt while assisting in an emergency by giving him/her medical insurance for that time period. I am sure that many other states are requiring this as well. In today's post-9/11 era many organizations also require training that is given for free by the Federal Emergency Management Agency (FEMA). Some organizations may require background checks or additional training provided by the ARRL.

The real question is whether all this training is necessary in order to assist our fellow man.

I can only speak from my personal experience. As a member of the Washington National Guard and the Subject Matter Expert (SME) in emergency communications, I was asked to be a member of the first team from our state to fly to New Orleans after Hurricane Katrina.

**29838 SE 285th Place, Ravensdale, WA 98051*
e-mail: <na7us@arrl.net>

This is the team that brought the first air-to-ground communications into New Orleans after Hurricane Katrina. The author is in the first row second from the left.



A communications van brought in by another state to assist in communications.

New Name for MARS

The former Military Affiliate Radio System has been re-christened as the Military Auxiliary Radio System and has been charged with a new mission in the area of Homeland Security. Bruce Tennant, K6PZW, has the details:

"Yes, MARS does have a new mission. On Wednesday, December 23, the Department of Defense issued an official Instruction concerning MARS that is effective immediately. This Instruction gives the three MARS services—Army, Air Force, and Navy/Marine Corps—a new focus and their first major revision since January 26, 1988.

"In the past, MARS had focused primarily on emergency communications and health and welfare support. The DoD's Instruction now directs the three MARS services to provide contingency radio communications to support US government operations, Department of Defense components, and civil authorities at all levels.

"MARS units will still continue to provide health and welfare communications support to military members, civilian employees, and other designated groups when in remote or isolated areas, in contingencies, or whenever appropriate. However, MARS must also be capable of operation in radio only modes without telephone service or access to the Internet. Also, it must be sustainable on emergency power when public utility power has failed. Also, some MARS stations must be transportable for timely deployment." —*AR Newsline, 1/1/10*

Our mission was to set up communications for the operations center in order to control the air traffic in and around the city. When we arrived, there was no control system in place; several close calls between military and civilian helicopters made the success of our mission imperative. We arrived about 1:00 AM, and even though we were tired from the long flight, we managed to complete this task before the sun rose. As soon as we were up and running, we began our 12-hour shifts to monitor and assist. During our time off there was very little to do, and being a ham with a "Go-Kit" (which I had stuffed in my duffle bag), I set up my "shack" in the hallway beside my cot. My equipment consisted of a Yaesu FT-817 and a dipole taped to an A10 that was in for maintenance before the hurricane hit.

My first attempt was to try all of the repeaters that I had pre-programmed before arriving in the area. No luck, as most, if not all, had been damaged or destroyed. The one I did finally hit was deathly silent during the entire month that I was there. As for the HF bands, I have to admit that my antenna was located on a metal aircraft in an all-metal hanger about eight feet off the ground. I was lucky if I could hear down the runway, let alone anywhere else.

I did meet up with another ham who was an officer in the Louisiana National Guard. He shared with me how frustrated he was that they were denying entry into the New Orleans area to ham radio operators who had not been requested or who did not have the required training/background check. After returning to the state of Washington, I heard that this had occurred more often than not, even though amateur radio was touted for its support during Katrina. Today, five years later, there is a bill in the Senate seeking to have the Department of Homeland Security look at how amateur radio can be used to support its mission.

So here is the good and the bad. I am in total agreement that training should be required for every ham who desires to work in emergency communications at an actual disaster site. Let me be clear that this training is only required if you desire to work at the site itself. Most, if not all, organizations now require NIMS training. NIMS stands for the National Incident Management Structure, and the associated training covers all aspects of responding to an emergency. One of the most important concepts is in understanding the Incident Command Structure (ICS). In order to operate in today's ICS environment you need to know who the Incident Commander is and understand the roles of those below him or her.

Those hams who want to provide support from their home QTHs are not required to have any training, but I high-

Our communications setup when we moved to Baton Rogue just prior to Hurricane Rita hitting.

ly recommend the courses offered by the ARRL. These courses will help you understand how operations are run today during an emergency. For those who want to work at the actual site, the more training you seek, the better prepared you will be. As for background checks, each person will have to cross that bridge and make his or her own decision when he or she comes to it. I personally have no problem with it, but I know that some do.

In summary, how we respond to emergencies has changed dramatically over the years. We hams need to embrace this change rather than battle it, because change will win most every time. Look at the sidebar and you can see how the MARS mission has evolved.

I believe that as technology continues to grow, we will see VHF playing an even greater role in disaster communications of the future—higher power, more repeaters, portable repeaters, and the list goes on. Let's be prepared to be a part of the team, as every emergency gives us an opportunity to learn how to improve.

Photo of an inlet on the Slidell, Lousiana side of Lake Pontchartrain. The surge came in from the ocean, and when the levees broke in New Orleans, the water sucked all of the buildings and items right into the lake.

By Tomas Hood,* NW7US

VHF PROPAGATION

The Science of Predicting VHF-and-Above Radio Conditions

The Sun is Alive!

The last decade closed out with a welcomed sign that our nearest star was no longer inactive. From November 2009 until press time (early January 2010), sunspot activity ruled the solar disc. December was a very active month, with only 10 days without official sunspots. December 9 ended 16 days of zero spots that started at the end of moderately-active November. Sunspot region 1034 (as numbered by The National Oceanic and Atmospheric Administration, NOAA), small but belonging to the new Cycle 24, emerged near the eastern limb of the Sun. This small region resulted in an initial sunspot count on December 9 of 13. By December 12, it appeared to be fading, yet on December 13 it increased in spots with a count of 14.

Then on December 14 another new sunspot region numbered 1035 emerged, kicking the sunspot count up to 28. By December 15, its size was seven times wider than Earth! Over the next several days through December 18 this new Cycle 24 sunspot group rapidly increased in size, becoming one of the biggest yet in the new cycle. On December 16, the complex magnetic structures within this sunspot region triggered a coronal mass ejection (CME) toward Earth. This massively huge cloud of solar plasma (billions of tons!) arrived about three days later, but did not cause any geomagnetic disturbance.

Coronal mass ejections are the fuel for auroral activity, and that is welcomed activity to the VHF weak-signal DX hound. When active sunspot regions breed CMEs, the possible result is geomagnetic storms that counter any positive effect that the increased solar activity may have on radio signal propagation on the frequencies below 6 meters. At the same time, the CME unleashes a plasma cloud that rides the solar wind and then, if the unleashed ejection is directed into the orbital path of Earth, causes aurora. Auroral activity occurs at the *E*-region of the ionosphere, and "clouds" of highly-ionized clouds form that in turn may reflect radio signals in VHF and sometimes even UHF spectrum.

By December 19, the Sun kicked into high-gear with the total sunspot count climbing to 43, the highest yet in the new sunspot Cycle 24. This pushed the 10.7-cm flux up to 87 on December 17! While the increase in sunspot activity and the higher daily 10.7-cm flux (remaining in the mid-80s) are not yet high enough to energize the ionosphere for *F*-region VHF propagation, it signals an encouraging up-tick in sunspot cycle activity.

Speaking of size, the size of active sunspot regions is given as units, each unit being one millionth of the Sun's visible hemisphere (this unit does not have a specific name). The Active Region 1034 that emerged on December 9 measured ten of these units, or 10 millionths of the visible solar disc. By December 11, it grew to 20 millionths. With the new sunspot region, 1035, emerging on December 14, the total area of all active regions only totaled 30 millionths. However, 1035 quickly grew in size. By December 20, the total area of all sunspot regions equaled a huge 330 millionths of the visible Sun!

*P.O. Box 9, Stevensville, MT 59870
e-mail: <nw7us@arrl.net>

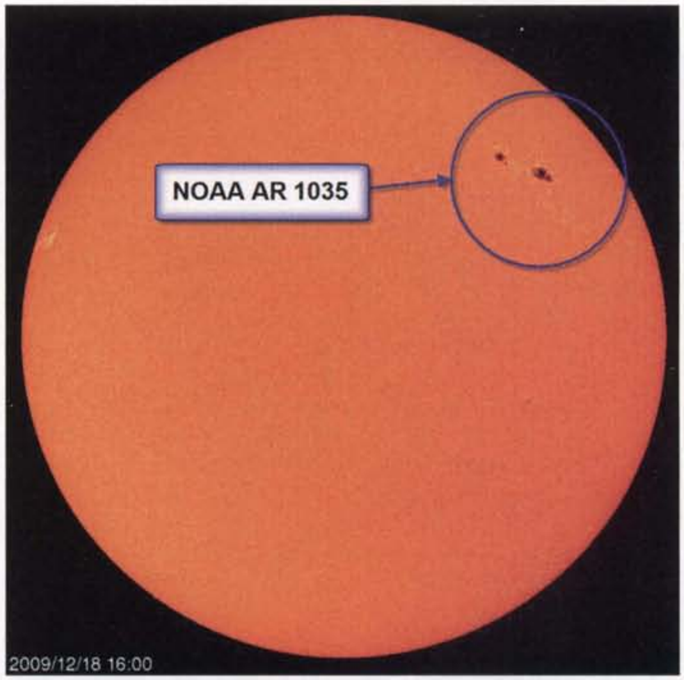


Figure 1. One of the largest active sunspot regions yet observed in the new sunspot Cycle 24, NOAA 1035, seen here in the Michelson Doppler Imager (MDI) intensitygram (IGR) on December 18, 2009. (Source: Solar and Heliospheric Observatory [SOHO])

By the New Year's Eve, three additional sunspot regions emerged—1036, 1037, and 1038. Region 1037 quickly ended, but the others continued to help keep things exciting. Additionally, Active Region 1039 emerged on December 27 and continued to rotate across the solar disc until it rotated around out of view on January 6, 2010. On January 7, region 1036 appeared to be rotating back into view! Perhaps now we can start to accept the idea that the new cycle is well under way. With that comes overall improvement on higher frequencies in the high-frequency shortwave spectrum. Soon, with this up-tick in sunspot activity the *F*-region of the ionosphere will begin to offer VHF propagation.

Propagation Outlook for February through April

Because of the nature of the Earth's orbit around our Sun, we have two seasons each year when any adverse space weather has a greater influence in causing geomagnetic disturbances: The first is known as the spring equinoctial season and the second is known as the autumnal equinoctial season. These are the two times during the course of the Earth's orbit around the Sun when the Earth is in just the right position to be most influenced by solar activity.

The spring equinoctial season peaks between March and April of each year. Because we're in the very start of solar Cycle 24, it is likely that we will have significant geomagnetic disturbances this year, triggering the sort of auroral activity known to bring about VHF activity.

What is Aurora?

Aurora is a direct result of solar plasma interacting with gasses in the upper atmosphere. Aurora occurs during geomagnetic substorms. During these substorms, solar wind plasma resulting from coronal mass ejections can rain down into the atmosphere. Gasses in the atmosphere start to glow under the impact of these particles. Different gasses give out various colors. Think of a neon sign and how the plasma inside the glass tube, when excited, glows with a bright color. These precipitating particles mostly follow the magnetic field lines that run from Earth's magnetic poles and are concentrated in circular regions around the magnetic poles called "auroral ovals." These bands expand away from the poles during magnetic storms. The stronger the storm, the greater these ovals will expand. Sometimes they grow so large that people at middle latitudes, like California, can see these "Northern Lights."

Because the Earth's magnetic dipole axis is most closely aligned with the Sun's solar wind spiral in April and October, the interaction between the solar wind and the Earth's magnetosphere is greatest during these two seasons. This is why aurora is most likely to occur and strongest during the equinoctial months. When you see the solar wind speed increase to over 500 kilometers per second, and the B_z (one of the three dimennsions of the interplanetary magnetic field) remains mostly negative (the IMF is oriented mostly southward), expect an increase in geomagnetic activity, as revealed by the planetary *K*-index (*Kp*).

This year, the spring equinoctial season will be active, with a few strong geomagnetic storms. If we do experience moderate to storm-level activity due to recurring coronal holes, look for aurora-mode propagation. The higher the *Kp*, the more likely you may see the visual aurora. However, you don't have to see them to hear their influence on propagation. Listen for stations from over the poles that sound raspy or fluttery. Look for VHF DX. Sometimes it will enhance a path at certain frequencies, while other times it will degrade the signals. Sometimes signals will fade quickly, and then come back with great strength. The reason for this is that the radio signal is being refracted off the more highly ionized areas in the *E*-region of the ionosphere that are energized by this aurora. These ionized areas ebb and flow, so the ability to refract changes, sometimes quickly. I've observed the effect of aurora and associated geomagnetic storminess even on lower HF frequencies.

Radio Aurora

If there are enough solar particles flowing down the Earth's magnetic field lines and colliding with atmospheric atoms and molecules, ionization occurs. This ionization may be sufficient to reflect VHF and lower UHF radio waves, generally between 25 and 500 MHz. This usually occurs in conjunction with visual aurora, but the mechanism is a bit different and it is possible to have one (visual or radio) without the other.

Using radio aurora, the chances of contacting stations over greater distances than would ordinarily be possible on the VHF frequencies is increased. Like its visual counterpart, radio aurora is very unpredictable. The thrill of the chase draws many VHF weak-signal DXers to working auroral DX.

Figure 2. Look at all of the activity on December 22, 2009! At the end of 2009, the sun became very active with a combined active area larger than any previous active day since the end of solar Cycle 23. The 10.7-cm flux index rose to just shy of 90 during this period. (Source: SOHO)

Figure 3. The intensitygram (MDI IGR) view of NOAA Active Region 1039 on the last day of 2009. This sunspot region did not fade away as it rotated away from view on January 6, 2010, but continued to produce minor flares. All of this activity during December, at the end of the second most "quiet" year of the solar minimum (2008 had more zero days than did 2009), indicates that the new solar cycle is alive and beginning to strengthen. (Source: SOHO)

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

The *K*-index is a good indicator of the expansion of the auroral oval and the possible intensity of the aurora. When the *K*-index is higher than 5, most readers in the northern states and in Canada can expect favorable aurora conditions. If the *K*-index reached 8 or 9, it is highly possible for radio aurora to be worked by stations as far south as California and Florida. Your magnetic latitude can be found using the map at <http://www.sec.noaa.gov/Aurora/globeNW.html>.

Meteors

While there are no major meteor showers during February and March, April has one meteor shower worthy of note. The *Lyrids* peaks on April 22 at 1700 UTC. While this shower peaks at about 18 meteors per hour, or about one per every five minutes on average, it can provide some good radio bursts. It is possible to see the hourly meteor rate (ZHR) reach as high as 90 per hour this year.

The debris expelled by comet Thatcher as it moves through its orbit causes the *Lyrids*. It is a long-period comet that visits the inner solar system every 415 years or so. Despite this long period, there is activity every year at this time, so it is theorized that the comet must have been visiting the solar system for quite a long time. Over this long period, the debris left with each pass into the inner solar system has been pretty evenly distributed along the path of its orbit.

This material isn't quite evenly distributed, however, as there have been some years with outbursts of higher than usual meteor activity. The most recent of these outbursts occurred in 1982, with others occurring in 1803, 1922, and 1945. These outbursts are unpredictable and one could even occur this year. The best time to work this shower should be from midnight to early morning.

The Solar Cycle Pulse

The observed sunspot numbers from October through December 2009 are 4.6, 4.2, and 10.6, showing a slow yet steady rise in the activity of the new sunspot cycle, Cycle 24. The smoothed sunspot counts for April through June 2009 are 2.2, 2.3, and 2.7. The smoothed numbers will likely show little improvement until the average covers the very last months of 2009, as the observed sunspot count for August 2009 is zero.

The monthly 10.7-cm (preliminary) numbers from October through December 2009 are 72.3, 73.6, and 76.8. The smoothed 10.7-cm radio flux numbers for April through June 2009 are 69.3, 69.7, and 70.2. As with the smoothed sunspot numbers, the smoothed flux numbers will show little improvement until they include the last months of 2009.

The smoothed planetary *A*-index (*Ap*) numbers from April through June 2009 are 4.3, 4.1, and 4.0. The monthly readings from October through December 2009 are 3, 3, and 1 (the most quiet this cycle). The overall geomagnetic conditions have been much quieter during the minimum period between solar Cycles 23 and 24 than the last few prior solar cycle minimums.

The monthly sunspot numbers forecast for February through April 2010 are 17, 20, and 23. The monthly 10.7 cm is predicted to be 78, 80, and 82 for the same period. That's really great news, as we'll likely see improvement in *F*-layer propagation higher and higher in the radio spectrum.

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

Feedback, Comments, Observations Solicited!

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

Until the next issue, happy weak-signal DXing.

73 de Tomas, NW7US

By Miguel Enriquez,* KD7RPP

THE VHF-PLUS CLASSROOM

Furthering Ham Radio Through Education

Elmers: A Vital Part of Ham Radio Education

Last year was a very good year for the members of the Pueblo Magnet High School Amateur Radio Club. It was a year that saw new members, new licenses, new activities, and, most importantly, new Elmers. It was also a year that culminated in the creation of a ten-year design and development program to construct and launch a CubeSat satellite for digital amateur television and audio communications.

As a mathematics teacher and ARC sponsor, finding new projects and locating the resources to complete those projects is a constant challenge. Getting the students interested in doing the projects is the easy part of this endeavor. With the help of the ARRL's Education & Technology Program, the Pueblo ARC has a "patron saint" of sorts that provides wonderful possibilities to stimulate students' imagination and creativity. Building directional antennas to use in fox-hunting radio activities required one set of skills. Building a 5-watt QRP rig and getting it to work required a higher skill set. However, designing, developing, constructing, testing, and launching a CubeSat satellite will require skills that are far beyond the present level of Pueblo ARC members.

That is where Elmers become the critical part of this success formula. Since the Pueblo ARC began making presentations to parents, teachers, administrators, and ham radio club audiences informing them of the very ambitious CubeSat satellite program, many amateur radio operators have offered their assistance. The first to step up to the plate was Mark Spencer, WA8SME. Mark is the ARRL's Education and Technology Program Coordinator. Mark's support was the first datum that suggested our ambitious project is attainable. Larry Brown, W7LB, was equally supportive and pledged whatever technical assistance he could provide. Jack McGowen, AD7NK, the newly elected president for the Green Valley Amateur Radio Club, was, and has been, equally supportive. Lloyd Miller, N7GV, also from the Green Valley Amateur Radio Club and our venerable technical problem solver, was quick to join the ranks of volunteers again.

One of the Elmers who has been supporting the Pueblo ARC for years is Ron Phillips, AE6QU, from the West Valley Amateur Radio Club in Sun City, Arizona.

These Elmers have been supporting the Pueblo ARC for years now along with Ron Phillips, AE6QU, from the West Valley Amateur Radio Club in Sun City, Arizona and Bruce Betterley, WA1BZQ, from the University of Arizona Amateur Radio Club.

Bob Frett, KE7YTF, is one of the newest Elmers to join the CubeSat satellite project. Bob was also responsible for getting his brother-in-law, William Creek, and his wife Elisha from Apache Junction, Arizona to donate an ICOM IC-718 to the Pueblo ARC. William and Elisha have not been bitten by the ham radio bug but have made their contribution to the CubeSat program because they saw the value of their investment for the students, for the school, for the ham radio community, and for the U.S. Technically, the moniker "Elmer" would normally not apply to them, but we are making an exception.

Two additional new Elmers to the Pueblo ARC are Katherine Larson, KF7GFG, and Alex Thome, KF7GFF. Katherine and Alex obtained their licenses primarily so they can support our CubeSat project. Both of these Elmers attended the ARRL Teacher Institute I taught at Pueblo Magnet High School last summer and quickly committed to our ambitious goal. The ARRL Teacher Institute is designed to provide support for teachers at all levels with the primary objective of helping teachers use electronics and robotics in the classroom to effectively promote math and science literacy. Alex is currently completing his

**c/o Pueble Magnet High School Amateur Radio Club, 3500 S. 12th Ave., Tucson, AZ 85713*
e-mail: <Miguel.Enriquez@tusd1.org>

Two new Elmers to the Pueblo ARC are Katherine Larson, KF7GFG, and Alex Thome, KF7GFF.

PhD in computational neuroscience. Katherine is a research scientist, teacher, poet, and novelist whose teaching method is as soft and loving as a mother's whisper in your ear.

Elmers become the vital part of any ham radio community because they are truly the keepers of the flame. Without them and their expertise ham radio would regress to a "dark age" period. Nowhere in the books would our club have found the solution to fixing a Drake T-4XB, but Kurt Cramer, W7QHD, knew exactly how to drop the transmitter six inches onto the table to get it working. You don't read that in the manual. His 40-plus years of enjoying the quality signal from his Drake rigs taught him that skill.

And so as the new decade begins, the Pueblo ARC students are focused on a long-term program of growth and development. As word of the CubeSat project spreads, other students want to join the Pueblo Amateur Radio Club. At a recent science night event held at Pueblo, two students and their parents attended just to inquire about getting permission to attend Pueblo High School because their middle school is not a feeder school.

I never had an Elmer, as such. However, my next-door neighbor, returning from the Air Force some 50 years ago, served as my unofficial Elmer. It was his demonstration of a CW contact with Bolivia that got me hooked. In a way, Sergeant Manuel Fierros became a better magician than Houdini when he allowed me to hear the symphony of dots and dashes via the wire-style headphones used in WW II. I still have those headphones. Until next time…

73 de Miguel, KD7RPP

By Mark Thompson, WB9QZB

DIGITAL RADIO

Digital Technology on VHF, UHF, and Microwaves

Digital Frequency Coordination

Band plans have been present on the HF, VHF, and UHF bands for many decades. They were created to ensure that various modes and band uses didn't interfere with one another. Bands are regulated by the FCC, and it mandates band frequency usage by license class and/or mode. Band usage is also stipulated by ham organizations. National organizations such as the ARRL have created voluntary band plans to specify calling frequencies for each VHF/UHF band and designate band usage for segments of each band. Band plans can vary by geographical area to meet the specific needs of that area. Statewide and regional frequency-coordination organizations were created primarily to coordinate the frequency usage of FM repeaters in an orderly manner to ensure a minimum of interference among repeaters on the same frequency. Coordination organizations typically work with organizations in nearby states and areas to minimize interference.

On the HF bands there are recommended frequencies for the use of both digital data and voice modes such as RTTY, PSK-31, and WinDRM, etc.

Some History

During the 1970s and 1980s the number of 2-meter and 70-cm FM repeaters increased dramatically. In order to accommodate the need for more frequencies, many areas changed from 30-kHz channel spacing to 15-kHz pair spacing in the 146- and 147-MHz repeater sub-bands. Fifteen-kHz spaced repeater pairs were created between the 30-kHz pairs and used inverted receiver and transmit frequencies in order to minimize interference to existing 30-kHz spaced repeaters. When the 145-MHz repeater sub-band was opened, it typically was spaced at 20 kHz. In some areas the 146- and 147-MHz repeater sub-bands were respaced to 20 kHz as well.

*P.O. Box 457, Palatine, IL 60078
e-mail: <wb9qzb@arrl.net>*

In the early 1980s, when packet radio became popular on the VHF and UHF bands, band plans had to be modified to accommodate packet radio usage. The ARRL modified its national band plan and specified frequencies for packet radio usage.

Packet radio grew dramatically from the middle 1980s through the early 1990s. Most hams who used packet first set up their station on 2 meters on the typical calling frequency, 145.01 MHz. The frequency quickly became congested to the point of becoming unusable due to slow throughput on the frequency because of repetitive packet retries. Packet radio is a half-duplex mode. If a packet transmission isn't complete, the packet TNC will transmit again until it is successful. As usage grew, there wasn't enough time available on the calling frequency to handle all of the stations. Additionally, packet radio relies on all stations on a frequency to hear one another. If a station does hear others on the frequency, its transmissions could collide with them, causing packet retry transmissions and reducing throughput even further.

One of the solutions to frequency congestion was to create LAN (Local Area Network) frequencies for separate areas in a region to improve overall throughput. LAN frequencies were also designated to specific uses such as bulletin board systems (BBS), DX PacketCluster, and Keyboard-to-Keyboard.

Packet frequencies on 2 meters typically were in the 144.91–145.09 MHz range spaced every 20 kHz, like the repeater frequencies in the 145-MHz repeater sub-band. Packet radio also often used frequencies in the non-repeater sub-band from 145.51–145.79 MHz.

In some areas packet users put full-duplex packet FM repeaters on the air on the 2-meter and 70-cm bands. The purpose was not only to extend the range of packet stations, but more importantly to dramatically improve throughput by eliminating the hidden-transmitter effect caused by packet stations on a frequency not hearing one another.

Packet users also constructed high-speed backbone links to transmit data among BBSes. The backbone link frequencies often used the same bandwidth as analog FM, but sometimes they were wider when higher data speeds were used. The network backbone links on 70 cm often needed to be coordinated in order to not cause interference to other packet users and also to not interfere with repeaters and remote links. This required coordination with repeater coordinators who worked together, but often didn't publish, the frequencies of repeater system remote links.

The designation of LAN and networking frequencies needed coordination as well. In many areas the local repeater coordinator wasn't interested in coordinating packet frequencies because they do so for "repeaters." Consequently, packet radio frequency coordination typically became the responsibility of the local packet radio club.

When packet radio use began to decline in the late 1990s, the need for coordination became less necessary. In fact, in many areas packet radio clubs membership fell dramatically and in some cases the clubs disbanded due to lack of participation and interest.

Packet radio might have become completely unused had it not been for the development of APRS (Automatic Packet Reporting System) in the late 1990s. However, in many areas there has been a resurgence of packet activity, including many newer hams who had never used packet radio before. This increased usage will ultimately require hams on a local and regional basis to again coordinate usage of frequencies on a geographical basis.

Digital Voice Modes

Within the last few years, for the first time digital voice modes have started to be used on the HF and VHF/UHF bands. On VHF and UHF digital voice modes such as APCO P25 and D-STAR are the most common modes. P25 and D-STAR can be used simplex or with repeaters. Since these digital voice modes use repeaters, they need a pair of full-duplex frequencies and consequently need coordination from a local frequency coordinator. The challenge for a frequency coordinator has been where to place these new digital repeaters.

Although current P25 repeaters require only 12.5 kHz of bandwidth for digital voice, they often are implemented in dual-mode. In dual-mode a P25 repeater can receive and transmit either analog FM or P25 digital. While this approach preserves compatibility with legacy FM users, the repeater requires the same bandwidth as a traditional analog FM frequency coordination.

However, narrow-band modes such as D-STAR are only 6.25 kHz wide. Since at least two D-STAR repeaters could be placed in the spectrum that one analog FM repeater requires, it would be wasteful to coordinate a D-STAR repeater on the center frequency of an analog FM pair.

Repeater coordinators were faced with a decision of how and where to coordinate narrow-band repeaters such as D-STAR. In some areas reallocating separate frequencies to digital-only use was considered.

In California, where all repeater frequencies are often already coordinated and frequencies are not available, some repeater owners and coordinators designated D-STAR repeaters as not actually repeaters so they could place them in the 145.5–145.8 sub-band where repeaters were not allowed by FCC regulation. Some declared that the inherent delay in all digital transmissions meant they weren't simultaneous transmissions and therefore weren't repeaters. Others called D-STAR repeaters auxiliary stations. The FCC eventually declared that digital voice repeaters were repeaters and existing FCC regulations applied to them.

The Illinois Repeater Association (IRA) took a different approach to coordinating narrow-band repeaters. Their Digital Migration Guideline plan preserves compatibility with the existing band plan while conserving spectrum. This approach allows spectrum to be reallocated to narrow-band repeaters on the 2-meter and 70-cm bands as existing analog FM pairs become available. When an analog FM pair becomes available, the IRA plan can divide the FM repeater pair into up to three narrow-band 6.25-kHz wide channels. On the 30-kHz spaced, 70-cm band two narrow-band repeaters could be placed at 6.25 kHz above and below the analog FM center frequency and potentially a third repeater on center frequency perhaps with some degree of geographic separation. Additionally, when adjacent FM frequencies become narrow-band as well an inter-channel, narrow-band frequency could potentially be established. On 20 kHz and 15 kHz 2-meter bands the narrow-band repeaters are placed 5 kHz above and below center frequency. The IRA plan has been successfully implemented over the last $2^1/2$ years in Illinois. The plan has demonstrated that an existing analog FM pair can be used for two D-STAR repeaters in the same geographical area without causing interference to adjacent FM repeaters. More information about the IRA Digital Migration Guideline can be found at: <http://www.ilra.net/Documents/The%20Digital%20Migration-IRA_R0428071.pdf>.

As analog FM repeaters and frequencies reserved for FM transition to narrow-band digital voice repeaters, there will be more repeater frequencies available in the same amount of spectrum currently used by FM repeaters. More importantly, digital-voice repeaters provide weak-signal performance enhancement over analog FM, and in the case of D-STAR provide data capabilities not available with FM.

I encourage everyone to explore the digital voice and data modes on HF and VHF/UHF, since they are the future of ham radio. 73, Mark, WB9QZB

By Rich Arland,* K7SZ

BEGINNER'S GUIDE

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

SETI, EmComm, and YO-YO 72

Hello and welcome to 2010. I trust that Santa was good to you and this new year will be an informative and fun-filled time as we explore more of VHF+. As a starter for the new year, I plan on deviating a bit from the norm and wander into an exciting aspect that couples *real* QRP (low-power signals, 5 watts and under) with VHF+, resulting in an almost surreal endeavor: Searching for Extra Terrestrial Intelligence (SETI)!

SETI-101

One of the great things about living in northeast Pennsylvania for a number of years was I was close to Dr. Paul Shuch, N6TX, better known as "Dr. SETI" *(see his column elsewhere in this issue—ed.).* Paul is the firebrand behind the SETI League (http://setileague.org/), headquartered in New Jersey. I first became acquainted with Dr. Shuch about 10 years ago when I attended a York (PA) VHF club meeting where he was the guest speaker. The topic? SETI, of course!

Both my wife, Patricia, and I were transfixed by Paul's presentation and joined The SETI League on the spot! His overall message: SETI is doable on a small budget, using cast off C-Band satellite TV dishes and some relatively inexpensive hardware, including the sound card on your computer. During his multimedia presentation, Dr. Shuch showed how easy it was to retrofit a 9- or 12-foot dish and achieve the sensitivity approaching (if not surpassing) the huge "Big Ear" radio telescope at Ohio State University. Wow! That is a lot to take in all at once!

The "WOW!" Signal

Speaking of "WOW!" the Big Ear radio telescope was the one that heard the famous "WOW!" signal in 1979. What was the "WOW!" signal? It was a series of coded observations recorded by a radio astronomer who was using the Big Ear at the time. In the margin of the printout he placed the letters "WOW!" alongside the incoming signal. Was this the first indication of extraterrestrial life? The answer is unknown. Even though radio astronomers across the world followed up on the "WOW!" signal, no other emanations from that particular portion of the sky have ever been recorded. Try as they did, no one could duplicate the signal on other radio telescopes. Some think that this was an anomaly—some glitch in the receiving or recording equipment. Others think it might have been a terrestrial source such as an artificial Earth satellite or possibly a spy aircraft. In short, no one knows for sure. The "WOW!" signal still mystifies radio astronomers to this day.

*770 William St. SE, Dacula, GA 30019
e-mail: <k7sz@arrl.net>

SETI League and You

The ultimate goal of The SETI League is to use amateur radio astronomy equipment manned by SETI League members to provide an "all-sky" search in an attempt to receive some microwave transmissions from intelligent species outside our own planet. It seems far fetched, but in reality it is a starting point that, unfortunately, has been pushed aside by mainstream science and NASA. This leaves interested amateurs in the driver's seat. With the current microwave receiving techniques coupled with re-tasked C-Band satellite TV dishes and some very sophisticated software, an individual can assemble a working radio telescope that would rival anything that could have been placed on line by universities and/or governments only 20 years ago. Now that is saying something.

The cost is quite economical, too, if I do say so myself. My 12-foot C-Band dish cost me absolutely nothing! It was free in exchange for my efforts to remove it. Thanks to Kyle Albritton, W4KDA, and his big pickup and trailer, we managed to dismount the dish from its mounting pole, load it on the trailer, and drive it about a half mile to my home. Two of my neighbors helped us man-handle the dish on and off the trailer. It now sits beside our house awaiting a new mounting system and a whole bunch of concrete. All in good time.

Receiver Considerations

Believe it or not, procuring a dish was the easy part of this SETI station. The receiver was the biggie. If you have deep pockets, a wide-band commercial receiver such as the ICOM R-5000 would be a good choice. Why? It's simple: The receiver tunes all the way up into the microwave region. This means no downconverter to worry about, and you can simply change out the LNA (low-noise amplifier) at the dish feed point with one that is cut for the hydrogen line (1420 MHz) or the hydroxyl line (1667 MHz) and run the signal directly in from the dish to the receiver. *(Note: The hydrogen line and the hydroxyl line are a band of radio frequencies between 1420 and 1667 MHz. This is a very quiet frequency spectrum where there is little noise from space. It is theorized that because of the quietness, the best possible SETI efforts can take place. The hydrogen line is the spectral line created by changes in the energy state of neutral hydrogen and occurs at a frequency of 1420.40575177 MHz. The hydroxyl absorption line is at approximately 1667 MHz.—ed.)* The output of the receiver is then routed to the station computer running the audio DSP software. Ergo, an "instant" (almost) SETI station.

If, however, you are like the majority of the rest of us, you are going to have to either make or buy an LNA with an LNB (down-converter) to place at the dish feed and run the down-converted RF signal into a VHF receiver (older 2-meter radios often are pressed into service here) and then take the audio output of the VHF receiver (henceforth referred to as a tunable IF) into your computer audio DSP software.

These extra steps escalate the overall cost of our new SETI station. However, it is an acceptable way to accomplish the end mission—to listen to the stars. Until recently, Down East Microwave, along with other gear manufacturers, has marketed LNBs that will work at the dish feed.

Unfortunately, due to the lack of demand, these are no longer offered commercially, which means that you will either have to procure a used LNB or make one from plans in various ARRL publications or from internet sites. Either method is permissible and not all that difficult.

As my SETI station takes shape I will return to this theme and give updates as to how I conquered the various obstacles to get my station on the air. Although theoretically this is a "beginners" column, most of this SETI station is composed of commercial off-the-shelf equipment that is *not* beyond the capabilities of a newcomer to the hobby to duplicate. After all, think of the the idea of engaging in the quest of a lifetime, trying to unravel one of the all-time mysteries of mankind: Are we alone in the universe? The idea that we, as radio amateurs, are able to participate in this ultimate quest is saying quite a lot about our technology and our skills.

EmComm

Emergency Communications (known also as EmComm) is of particular interest to me personally, and I feel that anyone new to the ham radio hobby needs to be thoroughly indoctrinated into the nuances of EmComm and why it is so important to the survival of our hobby. Having been involved with ham radio for nearly 50 years, I have watched our methods of communications evolve and expand into the exciting and ultra-cool systems we currently are using. When I first entered the hobby, AM (amplitude modulation) was "king" and SSB (single sideband) was just making inroads into HF communications. A few years later, AM signals were relegated to a narrow portion of the lower HF bands and SSB had come to dominate HF long-haul communications. In college we still used a lot of AM and CW on the VHF bands.

In the late 1960s the switch to FM was just starting, and to get a FM signal on 6 or 2 meters required the procurement and subsequent modification of a piece of used commercial FM gear such as a Motorola, GE, or RCA police and/or fire department radio. Once converted you had one or two channels of FM that allowed you to operate on a local repeater channel and one simplex channel (most likely the repeater output). As soon as the Japanese equipment manufacturers saw the huge potential market for 2-meter FM radios, the race was on. First with crystal-controlled gear, which was followed by synthesized gear that allowed full VHF/UHF band coverage.

Today we have excellent VHF+ FM rigs that offer built-in terminal node controllers (TNCs), Automatic Packet Reporting System (APRS) ready equipment, and now, with the advent of ICOM's D-STAR software, we have digital voice/ data systems capable of operating on VHF+, which greatly enhances our capabilities as emergency communicators.

The FCC, as part of our licensing agreement, dictates that we, as ham radio operators, be available to lend a helping hand with emergency communications during times of natural and man-made disasters. Amateur radio is one of the very few "hobbies" that allows the participant to actively support his/her local community.

Since the atrocities of September 11, 2001, EmComm has become a buzz word across the spectrum of disaster preparedness. Professional disaster-preparedness mitigators have come to rely on trained amateur radio operators to augment, and in some cases completely replace, communications systems/facilities destroyed or impaired due to a crisis situation. The key word here is "trained." The days of the ham radio operator showing up with a hand-held transceiver (HT) and a couple of battery packs to "furnish comm" are over. As the professionals within the disaster-preparedness community quickly found out, many hams did not have the training or the developed skills and discipline needed to dove-tail with the professional world.

To address those shortcomings, the ARRL, much to its credit, started offering continuing education courses in emergency communications (see <http://www.arrl.org>) with the hope that those amateur radio operators already involved with the Amateur Radio Emergency Service (ARES) and Radio Amateur Civil Emergency Service (RACES) would become involved and become fully trained EmComm volunteers.

Having taken all three levels of the ARRL's EmComm courses, I can attest to the fact that the training is comprehensive, timely, thorough, and once trained, you are recognized as an EmComm volunteer who can be counted on to work within the disaster response community. In other words, you are "validated" and have become an asset to the professional disaster mitigators.

EmComm and You

Once you understand that you *must* become trained, get busy and get the training. Our local Gwinnett County (GA) ARES unit has a pre-deployment training program that *all* ARES members must complete prior to be allowed to participate in any ARES drills/real-world disaster events. Yes, they *do* take EmComm seriously here.

YO-YO 72!

Invariably, both new and experienced EmComm personnel start putting together their "Go-Bag," or as I like to call it, "GOOD-Bag" (Get Out Of Dodge Bag). Unfortunately, all too often the Go-Bag becomes the primary focus of the EmComm volunteer's life. ARRL ARES/ RACES guidelines call for being self-sufficient for a 72-hour period, referred to as "YO-YO 72," or "You're On Your Own for 72 hours."

In reality, I prefer to provision my GOOD-Bag for a minimum of two weeks, since you *really* don't know what you might be getting into, and having the extra provisions, batteries, spare underwear, medications, bottled water, power-bar rations, etc., might mean the difference between being part of the solution to the disaster or part of the problem.

There is always the temptation to include as much radio gear as possible, along with a multitude of batteries, and everything up to and including the proverbial "kitchen sink." Resist this temptation, *please*! First of all, the chances of needing a box car full of comm gear are virtually non-existent. You will mainly be concerned with VHF/UHF comms, so stick with that. A good, multi-band HT loaded with the necessary local FM repeater/simplex frequencies along with a hand-held scanner (to cover the local police/fire/EMS frequencies, NOAA WX radio) and an AM/FM commercial receiver to listen to the local news outlets will be all you really need to take along.

The ARRL ARES/RACES guidelines present a comprehensive list of things that your Go-Bag should have in it. Among the most important is to be sure that any maintenance medications that you might be on should be procured ahead of time with the help of your primary-care physician. Ditto on eyeglasses. Compare notes with other members of your ARES/RACES members to get an idea of what they have in their Go-Bags. You'd be surprised at what you might find.

Well, that is about it for this time. I will be revisiting this topic in the next installment of this column, so be prepared. Hmm . . . that sounds like the Boy Scouts! 73, Rich, K7SZ

By Bill Brown,* WB8ELK

UP IN THE AIR

New Heights for Amateur Radio

Launches by the Space Hardware Club of UAH

The Space Hardware Club of University of Alabama, Huntsville (UAH) has been flying a number of unique high-altitude balloon experiments. The club members meet two nights each week to work on their experiments and often launch a couple of balloons each semester. One of their payloads last year consisted of human and mouse nerve cells in an environmental chamber to see the effects of a trip into the stratosphere. The cells survived! UAH also flies Balloonsats as part of the electrical engineering senior design class, but the Space Hardware Club (SHC) is unique in that students of any major can participate.

This past fall on a beautiful October day the SHC students launched a high-definition camcorder that also downlinked live video. The fast-scan amateur television (ATV) transmitter section (see photo 1) put out 3 watts on the 70-cm band into a

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

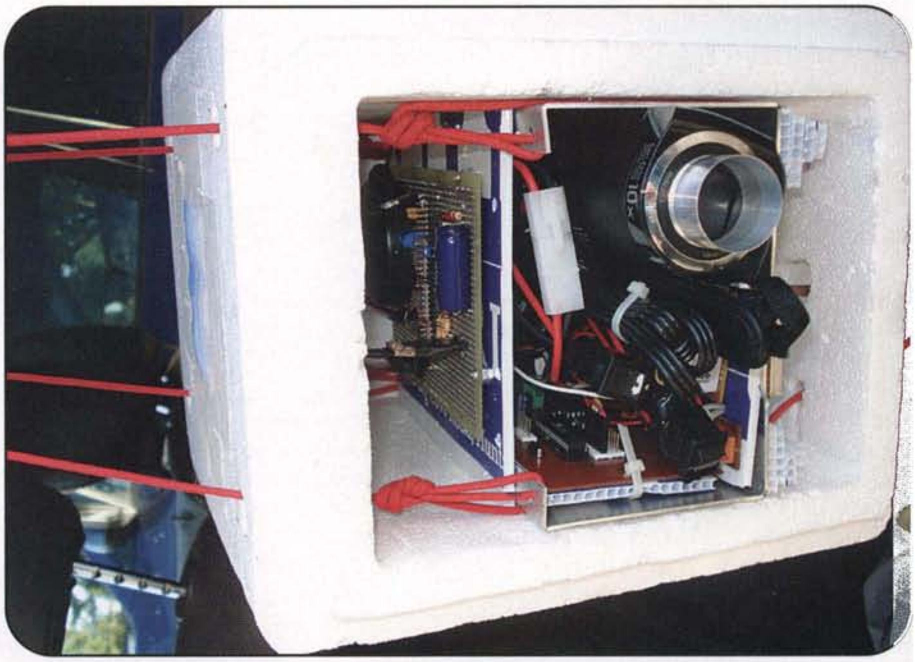


Photo 1. The Space Hardware Club's hi-definition ATVtransmitter payload. (All photos by Bill Brown, WB8ELK)

Photo 2. Club members get to wear this unique T-shirt.

Photo 3. The Space Hardware Club students prepare to launch their balloon experiments.

Photo 4. Barry Lankford, N4MSJ, sets up his portable ATV ground station.

horizontally polarized Little Wheel antenna. In addition, there were several APRS (Automatic Packet Reporting System) transmitters on 144.39 and 144.34 MHz for tracking the balloon's position during flight.

The calm winds allowed a picture-perfect liftoff (see photos 2 and 3) as the students watched their payload rise high above Huntsville, Alabama. Barry Lankford, N4MSJ, brought his portable ATV receiver and antenna to watch the video during the flight (see photo 4). In addition, the Electrical and Computer Engineering (ECE) department at UAH has allowed the Space Hardware Club to set up a great ground station in a room on the second floor that has roof access for their antenna system. The az/el rotor system combined with some custom programming of their ground-station computer allows the antenna to track the balloon by decoding the APRS downlinked position and altitude, calculating the azimuth and elevation bearings and automatically steering the antennas toward the balloon throughout the flight (photo 5).

This first flight of their ATV system had some antenna problems (the Little Wheel had been beaten up pretty badly during a number of earlier missions), so only a few minutes of live ATV signals were received. However, they did get some beautiful high-definition video recorded on the camcorder's memory card.

Jason, KG4WSV, did some repair work on the Little Wheel, and the club members flew the payload again a few weeks later from the Sparkman Middle School with excellent full-color live video received by many ATV stations across the southeast. I was able to receive that flight with nothing more than a 3-element handheld Arrow Antenna hooked up to an ICOM IC-R3 radio in TV mode throughout the majority of the flight (photo 6). Hank, W4HTB, had color video reception from over 200 miles away in Bowling Green, Kentucky and also linked his received video onto the BATC's (British Amateur Television Club) streaming video website (www. batc.tv). The balloon burst at peak altitude was quite spectacular. We could clearly hear the balloon pop and were treated to the sound of the air rushing by the payload as it started its rapid descent in the near-vacuum of the edge of space.

Photo 5. SHC students man the campus ground station.

Photo 6. Balloon ATV received by WB8ELK using an ICOM IC-R3 and handheld Arrow Antenna.

The final portion of the parachute drop back to Earth was quite exciting and a bit nerve-wracking, as the payload came down only a few hundred feet from Alabama's equivalent of the Grand Canyon (Little River Canyon State Park). Fortunately, a cliff-hanging recovery was not needed, as the payload managed to land in a tree not far from a road near the edge of the canyon.

For more info and announcements of future flights from the Space Hardware Club, visit: <http://spacehardware.uah.edu>.

73, Bill, WB8ELK

By Dr. H. Paul Shuch,* N6T

DR. SETI'S STARSHIP

Searching For The Ultimate DX

Watching Terrestrial Television at Alpha Centauri

In our last column, we explored an attempt to beam the 2008 film *The Day the Earth Stood Still* to purported science-fiction fans at Alpha Centauri, our nearest stellar neighbor. We showed through link analysis that to watch the movie they would require an antenna on the order of 3200 km in diameter – roughly the size of a continent.

Although I refuse to rule out the possibility of advanced extraterrestrial beings engineering antennas (or arrays of antennas) of continental scale, there still remains the problem of pointing those immense antennas in our direction. Recall that the beamwidth of a parabolic antenna can be estimated from its diameter and operating wavelength. For the Centaurian antenna, that half-power beamwidth is on the order of:

$$\theta = \frac{\lambda}{D} = \frac{5.0 \times 10^{-2}\ \text{m}}{3.2 \times 10^{6}\ \text{m}} = 16\ \text{nRad}$$

which is on the order of a *millionth* of a degree. One shudders to think how any civilization, no matter how advanced, could aim a whole continent to that level of accuracy, much less track a moving target from a moving object for the length of a two-hour movie. However, more significantly, one must ask: Why bother?

One would think that by comparison to the Centaurians' challenge of aiming an antenna of continental size, our problem on Earth, pointing our tiny 5.5-meter uplink antenna, would be trivial. Not so, because although our antenna's half-power beamwidth is a respectable half a degree, we are dealing with an n-body Newtonian motion problem over interstellar distances.

Consider first that we are aiming our antenna from the surface of a planet that is both spinning on its axis and orbiting its star. That star is, in turn, revolving around the center of the Milky Way galaxy, as is the Alpha Centauri system. Our movie-going audience is ostensibly situated on the surface of a planet somewhere in that triple-star system. Unless it is tidally locked (not a happy circumstance for the emergence of life), that planet is doubtless rotating on its axis, and negotiating a complex orbital dance with respect to its *three* suns. Our own motion is known, or can at least be computed. Having not yet even detected our target planet, we can only guess as to its complex path over time.

"Over time" is our key here. Remember that when we look at Alpha Centauri in the southern sky, we are seeing not where it *is*, but rather where it *was* some $4^1/_4$ years ago. Thus, when we transmit toward Alpha Centauri, our antenna must aim, and track, not where it *was* $4^1/_4$ years ago, or even where it *is* today, but rather where it *will be* $4^1/_4$ years hence.

True, our half-degree transmit beamwidth gives us some leeway. As our beam spreads out conically in interstellar space, there is a chance that we might get lucky and that part of our signal may end up intercepting its intended target. Then again, maybe not. It's not an easy matter for me, or the Deep Space Communications Network (DSCN), to calculate.

The foregoing calculations might well cast a pall over the whole SETI enterprise. How can we expect, one might wonder, to intercept incidental radiation from a distant civilization when our own broadcasts are most likely not detectable at even the nearest star, but for superhuman efforts and incredible antenna engineering?

The encouraging answer is that SETI science seeks not to watch movies (or, in fact, to demodulate intelligence of any kind) as much as to identify signals of clearly intelligent extraterrestrial origin, providing proof of existence of our cosmic companions. Let's think about how *The Day the Earth Stood Still* uplink might have provided proof of existence to our cosmic companions, over far greater distances than Alpha Centauri.

First, and most obviously, while de modulating viewable FM video require a reputed positive signal-to-noise ratio o the order of 10 dB, we can detect the pres ence of an artificial signal at unity SNR or even less. Thus, dispensing with tha assumed 10-dB detector threshold allow us to decrease our receive antenna size b a factor of three, or alternatively, t increase our detection range for the orig inally computed antenna also by a facto of three. However, it gets even better.

Significant increases in detectabilit are achieved in SETI receivers by inte grating a received signal over time. Th longer the time averaging, the more a sig nal rises out of the noise. Of course, mod ulation (that is, information content) i lost in the process, but if we are seekin proof of existence rather than video enter tainment, this is hardly a factor. In the pre sent example, by integrating our receive signal for a mere three seconds, we ad an additional 40 dB to our SNR. Thi would allow us to increase distance by factor of 100, or decrease receive anten na size by a factor of 100, or some com bination of the two.

Finally, although a 40-MHz channe allocation (34-MHz receiver bandwidth is typical for analog satellite TV, there ar many modulation modes that concentrat considerable power into a far narrowe bandwidth. Since narrowing receive bandwidth improves SNR, we migh expect to detect these narrower signal over far greater distances, or with signif icantly smaller antennas. A 500-watt car rier, for example, contained within a 10 Hz bandwidth could easily be detecte over interstellar distances by an antenn such as Arecibo in Puerto Rico, Earth' largest radio telescope, given about 10 seconds of integration time.

Given the above, one wonders ove what distance video programming fron the DSCN can realistically be receive given Earth-level technology. It turns ou that an Arecibo could recover clear vide

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

from this uplink out to a range of about 3-billion km. This figure represents the approximate distance between the Sun and Uranus at aphelion. Thus, an Arecibo Observatory on Uranus could, if properly aimed, be used to monitor Earth's satellite TV uplinks.

Bear in mind that the uplink facility used at DSCN initially was intended to relay FM video via a communications satellite parked in the Clarke orbital belt, a mere 38,000 km from Earth. This is a facility designed for relatively local communications. That it appears capable of interplanetary video relay is encouraging. It should not disappoint that its utility over interstellar distances seems suspect.

"Give me a lever long enough," wrote Archimedes more than two millennia ago, "and a fulcrum on which to place it, and I shall move the world."

"Give me an antenna large enough," wrote the Alpha Centaurians, "and a target at which to aim it, and I shall watch your world."

Their task in viewing *The Day the Earth Stood Still*, though not inconsistent with the laws of physics, is nonetheless daunting beyond belief.

73, Paul, N6TX

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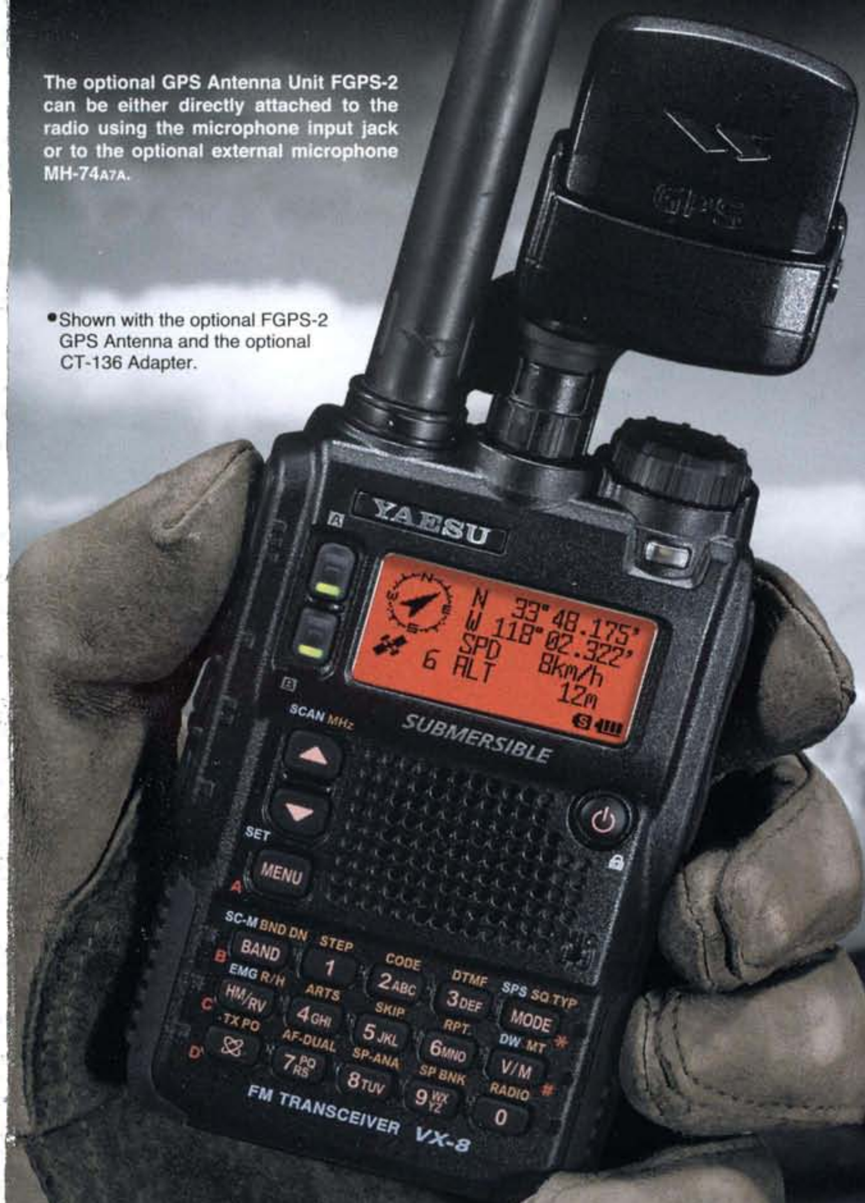

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• Shown with the optional FGPS-2 GPS Antenna and the optional CT-136 Adapter.

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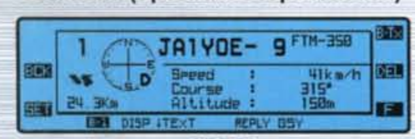
FPR-1 Monitor Unit

Screen Example

Dual Band (Spectrum Scope function)

Navigation (with GPS antenna unit attached)

Mono Band (Spectrum Scope function)



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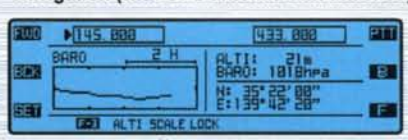

Barometer

Timer

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