SETI:
The Role of the Dedicated Amateur

Dr H. Paul Shuch, N6TX

The Search for Extra-Terrestrial Intelligence is moving forward on a number of fronts, thanks in large part to amateurs who volunteer their time and expertise.

Since its emergence as a respectable scientific discipline nearly a half century ago, the electromagnetic Search for Extra-Terrestrial Intelligence (SETI) has been dominated by three classes of practitioners: government agencies, academic institutions, and non-profit organizations surviving on a combination of private contributions and research grants. Recent technological advances have brought a new group of players into the SETI game—dedicated amateurs with a personal passion for achieving interstellar contact.

This article explores the contributions such nonprofessionals are making to SETI science, in the realms of experimental design, equipment construction, software development, direct observation, sky coverage, signal analysis and message interpretation. Like the amateur athlete competing in an Olympiad, the amateur SETIzen can expect to struggle for survival, absent commercial or institutional sponsorship. Grassroots amateur efforts can nevertheless supplement the accomplishments of the professional SETI community, bringing us all closer to the day of Contact.

The SETI Olympiad

The challenge of interstellar contact, no less elusive than the quest 50 years ago to break the four-minute mile, is demanding of human skill and perseverance. Unfortunately, success in this particular arena is also a function of one significant factor beyond human control: the very existence, in the proper timeframe, of technologically advanced extraterrestrial beings. Given that no human effort can impact this particular factor, what can we do to maximize our chances for SETI success?

For a brief time (admittedly a mere eyeblink in human history), the governments of planet Earth threw their prestige and fiscal resources at the SETI problem, sponsoring any number of scientific searches. But it is amateurs who have made, and continue to make, the most significant strides toward contact.

An amateur, as defined by science and the Olympics Committee alike, is one who strives to excel without financial compensation. The motivation of the amateur is revealed by the Latin root of the word: an amateur works for love.

Ask any contemporary SETI scientist or technologist why he or she strives against incredible odds. The answer is always the same. What modest salary he or she may draw is almost incidental. Any skilled SETIzen could always make more money by diverting the requisite effort in a different direction. It is indeed for the love of the game that the best and the brightest choose to compete in the SETI Olympiad.

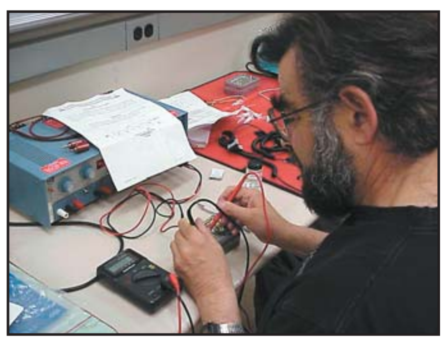
The Athletes

Not all SETI pioneers are licensed radio amateurs (though those I will discuss here are, or were). Not all of the work described here was pursued as a strictly amateur endeavor (though some of it was). What these SETI players share is the spirit of amateurism that marks their science as being of truly Olympian stature. These representative examples, by no means inclusive, show how the world's dedicated radio amateurs competed, and continue to compete, for SETI glory.

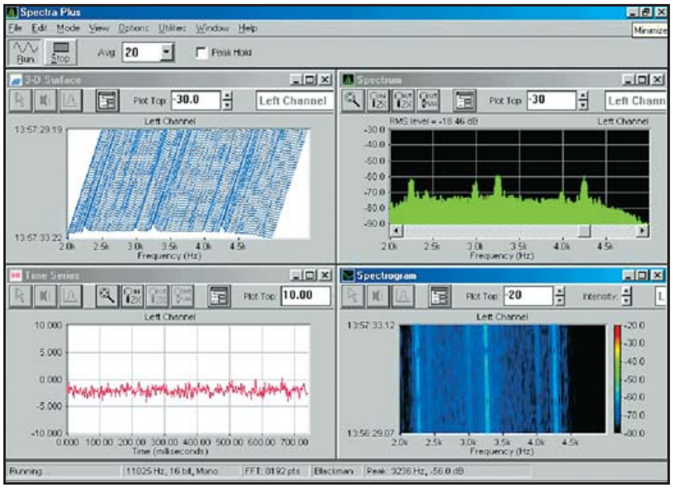
Grote Reber, W9GFZ

When the Father of the Radio Telescope (SK, December 20, 2002) built the world's first modern radio telescope in 1937, a 10-meter-diameter parabolic re-

A roomful of interested amateurs share insights and ideas at one of The SETI League's annual SETICon Technical Symposia.

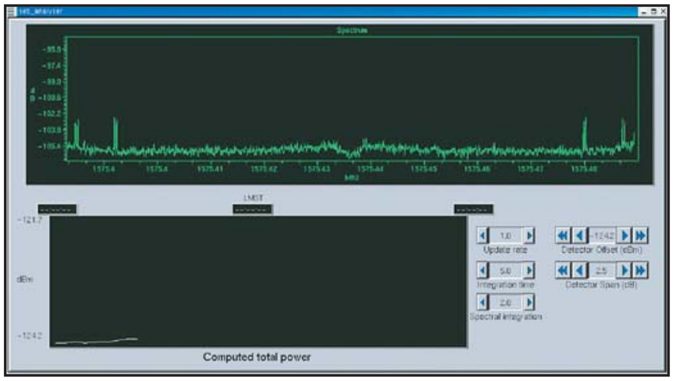


Dr Malcolm Raff, WA2UNP, assembles a low-noise microwave preamplifier at a SETI League Hardware Workshop.



SETI League members use a variety of digital signal processing software tools to examine candidate signals in the time and frequency domains.

COURTESY VE3MDL



SETI League member Marcus Leach, VE3MDL, built his own software-controlled receiver for wideband SETI scanning.

flector in the backyard of his mother's house in Wheaton, Illinois, he was working strictly as an amateur, and under the authority of his ham radio license. Grote produced the first radio map of the Milky Way Galaxy, though it took years for his amateur accomplishments to gain acceptance from the world's astrophysics professionals. His subsequent low-frequency radio astronomy research from Tasmania continued in the amateur tradition of independent research for its own sake. Never one to shy away from controversy, Reber's last published paper was titled "The Big Bang is Bunk!"

Phil Morrison, W8FIS

Undeniably one of the patriarchs of SETI, Professor Morrison had long since gone inactive on the ham bands when in 1959 he coauthored the first serious scientific SETI paper. His boyhood interest in Amateur Radio had motivated his interest in exploring the feasibility of microwaves for interstellar communication. During SETI's Golden Age he has inspired a whole generation of engineers and scientists. On a personal note, my own SETI interests were motivated by following in Phil Morrison's footsteps (albeit from a distance of 30 years). As an EE undergraduate at the Carnegie Institute of Technology, I had the privilege of operating W3NKI, the campus ham radio station he had founded three decades prior.

John Kraus, W8JK

Arguably the most creative antenna designer of his generation, Kraus (SK, July 18, 2004) is best remembered for the late Big Ear radio telescope that he designed and built at Ohio State University. Big Ear conducted the longest running continuous SETI sky survey in history. John Kraus' grad student Bob Dixon, W8ERD, succeeded him as Director of the OSU Radio Observatory. Dixon is now leading a team of dedicated amateurs in the design of the omnidirectional Argus radio telescope.

Paul Horowitz, W1HFA

Still active on the Amateur Radio bands, a passion he has pursued since childhood, Horowitz heads Harvard University's SETI efforts, and designed the Project META and BETA searches funded in part by the Planetary Society. He is the author of the world's most popular Electronics Engineering undergraduate textbook. Lately he has been turning his interests and expertise toward Optical SETI.

Kent Cullers, WA6TWX

A world-class leader in digital signal processing, Cullers is better known to the public as Kent Clark, the character based upon him in the popular film *Contact*. The first (and probably still the only) blind individual to earn a PhD in the highly visual discipline of astronomy, Kent developed the signal detection algorithms for the late NASA SETI program, and later for The SETI Institute's Project Phoenix targeted search. If he has seen farther than other men, it is because Kent Cullers stands on the shoulders of some very clever code.

Dr John Kraus, W8JK, was an inspiring teacher, prolific author, prominent antenna designer and one of the fathers of modern radio astronomy.

Seth Shostak, N6UDK

Seth's face is familiar on television, and his voice a fixture on broadcast radio, in his professional role as public programs scientist for the SETI Institute. That voice is less often heard on the ham radio bands, but it is there that Shostak first gained exposure to the technologies he routinely exploits as a senior SETI scientist. He encouraged The SETI League in the construction and testing of its W2ETI Microwave Moonbounce Calibration Beacon, and was the first radio amateur to detect its weak signals reflected off the lunar surface (albeit with the 305-meter-diameter Arecibo Radio Telescope).

Richard Factor, WA2IKL

If SETI is truly the science that refuses to die, that is due in large part to this New Jersey industrialist. An active ham since boyhood, Factor was dismayed at Congressional cancellation in 1993 of the NASA SETI program. Then, putting his money where his mouth is, he founded the nonprofit SETI League, to involve the world's radio amateurs in privatizing the search. Though not as active as he would like to be in Amateur Radio astronomy, Factor's greatest contribution has been his leadership role as SETI League president and primary source of financial support. He can claim much of the credit for the 126 Amateur Radio telescopes that SETI League members now operate all over the world.

The Organizing Committee

Founded by Richard Factor in 1994 as a response to the demise of the NASA SETI program, The SETI League, Inc is a grassroots Amateur Radio club of global scope and galactic span. It coordinates the SETI activities of 1450 experimenters in 66 countries on six continents. Its members design hardware and software for a coordinated all-sky survey, publish articles, conduct conferences, construct and operate equipment, and collectively control more radio telescopes than exist in the rest of the world, combined. Funded entirely by membership dues and individual contributions, The SETI League currently has no paid employees, with all its functions being performed by volunteers.

The SETI League's main medium of communications is its extensive Web presence (see **www.setileague.org**), along with half a dozen specialized e-mail discussion lists, whereby members can pursue a variety of collaborative projects. The organization also publishes *Contact In Context*, an on-line peer-reviewed scientific journal, and provides Webmaster services for the SETI Permanent Study Group of the International Academy of Astronautics—all on an operating budget of just a few thousand dollars per year. In addition to their scientific and engineering activities, SETI League members are involved in publicizing and popularizing SETI, having conducted hundreds of media interviews and having appeared in dozens of television documentaries.

The backbone of The SETI League is its Field Organization, a cadre of 65 volunteer Regional Coordinators around the world, who offer their expertise and assistance to SETI enthusiasts, whether SETI League members or not.

The Events

SETI amateurs are challenged by and involved in a number of technological pursuits. A brief sampling:

The Discus

The antenna of choice for amateur backyard radio astronomy is the discarded C-band home satellite TV dish. These 3 to 5-meter-diameter parabolic reflectors exhibit in excess of +30 dBi of gain in the Waterhole spectrum between 1.4 and 1.7 GHz, and provide modest resolution with their 2 to 4° beamwidths. They can generally be had for the asking in communities where TVRO technology has been replaced by digital Direct Broadcast Satellite television distribution. Several hundred Amateur Radio telescopes are already on-line or under construction around the world, using just such antennas as their basis. A suitable L-band feedhorn can be readily fabricated out of hardware store materials and tin snips by any experimenter reasonably skilled in sheetmetal working techniques.

The SETI Horn of Plenty, a waveguide horn antenna for 1.3 to 1.7 GHz designed by the author, has been duplicated by dozens of SETI League members around the world, for classroom demonstrations as well as observational radio astronomy and SETI.

Tommy Henderson, WD5AGO, shows off two horn antennas used for radio astronomy. The larger of the two (on an az-el mount) is optimized for 1.4 GHz hydrogen line observations. Tommy is holding a smaller horn for 5.7 GHz methanol line measurements.

The 21 cm Closed Circuit

Once those L-band photons falling from the sky have been captured by a suitable antenna, it remains for the dedicated amateur to amplify, filter and process them in a suitable microwave receiver. Amateur Radio astronomers have modified military and government surplus equipment, employed commercial receivers produced for the ham radio and telecommunications markets, and, more recently, designed their own dedicated SETI receivers from scratch. Every year at its SETICon Technical Symposium, The SETI League hosts a microwave circuit construction workshop, to train its members in the skills necessary to produce a workable hydrogen line receiver.

The Binathalon

The output of the typical microwave receiver is analog baseband, generally in the audio range. This signal is converted to a string of binary digits for signal analysis, often in a personal computer sound card. More advanced analog to digital conversion at a receiver's intermediate frequency stages is recently becoming a preferred method of preparing the receiver's analog output for digital signal processing (DSP). Amateur Radio astronomers are working on the next generation of DSP hardware, software and algorithms, to ferret out the hallmarks of artificiality buried in receiver and cosmic noise.

Synchronized Scanning

With over 100 Amateur Radio telescopes now engaged in a coordinated all-sky survey, it is necessary to efficiently allocate the search space among participants, in terms of sky coverage, frequency spectrum, and time. A major challenge for The SETI League has been to develop means of ensuring maximum spectral and sky coverage, with minimal overlap, constrained by the equipment capability and location of each individual participating station. Real-time coordination via the Internet turns a hundred individual instruments into a zeroth-order interferometer of impressive capabilities. Still, the challenge remains to automate the coordination process, especially as more stations are added, growing the Project Argus sky survey toward its eventual goal of 5000 participating Amateur Radio telescopes and real-time all-sky coverage.

The Broadband Jump

The typical commercial communications receiver has an instantaneous bandwidth on the order of a few kilohertz. Given the enormity of the spectral space across which valid ETI signals are likely to be dispersed, the time factor to analyze a reasonable portion of spectrum is inordinate. New receiver designs are needed, which can process and digitize hundreds of kilohertz, or preferably many megahertz, of bandwidth in real time. SETI

League members have recently been applying new components designed for the wireless telecommunications industry to the challenge of seeking out narrow-band emissions across broad chunks of the electromagnetic spectrum.

The High-Frequency Hurdles

Although there is a certain romance associated with searching for ETI across the traditional Waterhole frequencies spanning the spectral emission lines of neutral hydrogen and hydroxyl (the dissociation products of water), four decades of SETI in this portion of L-band have thus far failed to produce positive results. The higher frequency reaches of the electromagnetic spectrum are a ripe area for SETI exploration, and a number of Amateur Radio astronomers are now equipping themselves to monitor across S, C, X and Ku bands, and in some cases clear into the millimeter waves. It is axiomatic that, whereas there are interesting magic frequencies to be explored, there are no *wrong* frequencies for SETI research. The current push toward ever higher frequency coverage can be expected to continue, with Amateur Radio astronomers "searching where no man has searched before."

The 500 nm Dash

Optical SETI, though proposed as early as the 1960s, is only now beginning to be regarded as a serious and potentially productive branch of SETI science. Amateurs have pioneered the search for high-energy pulses in the visible and infrared spectra, helping that pursuit to gain legitimacy among SETI professionals. As academic institutions and governments begin to invest resources in Optical SETI, they can turn to the more experienced and numerous amateur optical astronomers for guidance.

Dual quad-helix arrays for 1296 MHz, one right-hand and the other left-hand circularly polarized, are part of The SETI League's W2ETI Moonbounce Calibration Beacon.

The Pole Vault

With hundreds of Amateur Radio telescopes at work around the world, a commonly available calibration and validation means became a necessity. Four years ago The SETI League constructed its Lunar Reflective Calibration Beacon, a continuously operated transmitter, locked to an atomic frequency standard, and driving antennas that track the moon under computer control. Microwave signals reflected off the Moon can be received by amateur and professional radio telescopes alike, any time the Moon is above the horizon at the transmit and the receive location simultaneously.

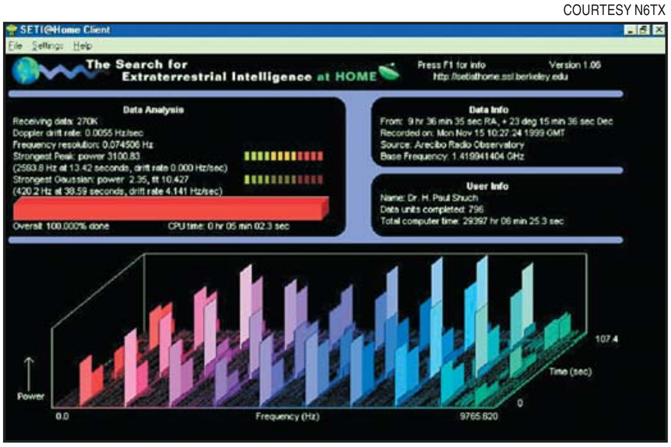
These weak but stable moonbounce signals, at a frequency adjacent to those for which most Amateur Radio telescopes normally operate, enable the experimenter to verify the proper operation of his or her equipment. To date the W2ETI beacon (identified by the assigned call sign of The SETI League's Amateur Radio club station) has been used as a test source by the Arecibo Radio Observatory, at the Bernard Lovell Telescope in Jodrell Bank, United Kingdom, and by a handful of Project Argus stations around the world. We hope it will become the calibration standard for all Amateur Radio astronomers observing in L-band.

The 5 Million CPU Relay

The SETI@home project run by the University of California, Berkeley, is undoubtedly the world's most successful distributed computing experiment, though arguably its most dubious SETI experiment. The strength of this well-known project lies in its 5 million participants, all crunching data from the SERENDIP receiver at Arecibo, the world's most sensitive radio telescope. The weakness is that all 5 million users are crunching data from the *same* sensitive radio telescope. Where is the weak link in this chain?

Nevertheless, SETI@home has done more to raise public consciousness about SETI than any other project, and SETI League members are eager and active participants. The project has demonstrated how a large-scale task can be broken down into manageable chunks, and parsed out to a cadre of participants. What remains now is to marry the distributed processing aspects of SETI@home to the distributed observing network of The SETI League's Project Argus all-sky survey. The result will be the most powerful SETI project ever, a net stretched wide to capture that elusive fish in the cosmic pond.

COURTESY N6TX



The SETI@home project run by the University of California, Berkeley, though not a SETI League initiative, has stimulated the interest of SETI supporters around the world. SETI League members are among the several million users who lend their spare computer cycles to the analysis of archival data from the Arecibo Observatory in Puerto Rico.

SETI League members gathered last year at the Starkenburg Observatory in Heppenheim, Germany, for the EuroSETI04 Conference. The SETI League has sponsored meetings around the world, to encourage collaboration and cooperation among its more than 1400 members in 66 countries.

The Uneven Parallel Bars

In 2001 the SETI Institute started the design of the One Hectare Telescope (1HT), a dedicated SETI array of unprecedented sensitivity. Later renamed the Allen Telescope Array (ATA) in honor of a major contributor, this instrument is now under construction at the University of California's Hat Creek Observatory facility, at a projected cost in the tens of millions of dollars.

At around the same time, The SETI League, Inc began work on its Very Small Array (VSA), a significantly more modest SETI array of much more limited performance, but budgeted at mere tens of thousands of dollars.[1] The ironic parallel between these two disparate projects is that, at present, each is funded at a level of about a third of its ultimate cost. Thus, the leading professional and the leading amateur SETI organization both find themselves in the position of having to expend a significant fraction of their scarce resources on fund-raising, to complete the construction of their respective next-generation SETI instruments.

The Future of the Sport

As public and private funding for SETI science continues to wane, its greatest untapped resource is the dedicated amateur. Thousands of Amateur Radio enthusiasts, and millions of personal computer users around the world, promise to the SETI enterprise more observing and analytical power than had ever been imagined in the days of government-sponsored SETI. The challenge facing us is to focus their energies and coordinate their activities in the most efficient way. This is the charter of The SETI League Inc, and the direction that other organizations will likely take to ensure the survival of SETI as a respectable science.

Conclusions

In his biography *The First Four Minutes*, Sir Roger Bannister writes that, upon completing the first four-minute mile, "pain overtook me. I felt like an exploded flashlight with no will to live." One can only speculate as to whether SETI success will be as draining. I expect elation to dominate the mood of those detecting the first valid signal, but only after the weeks or months of follow-up verification activities which responsible science demands. In the athletic Olympiad, success is immediately evident at the finish line. In the scientific arena, definitive results take a little longer.

A mere 46 days after his momentous accomplishment, Bannister's record was beaten by another distinguished amateur, his Australian rival John Landy (later the governor-general of Victoria). Since then, nearly a thousand runners have turned sub-four-minute miles. Similarly, once the first substantiated evidence of ETI is presented, we expect others to strive for still more news of our cosmic companions. Just as aviation activities did not cease once Lindbergh had flown the Atlantic, we expect that first SETI success to be only a beginning. Whether that first detection is made by an amateur or a professional, one can expect numerous amateurs to contribute to the efforts that follow.

On the 50th anniversary of his most famous run, Bannister told an interviewer, "the race taught us we could do most things we turned our minds to in later life. And it made us friends."

One can ask no more of SETI success.

[1]P. Shuch, "The Very Small Array," *QST*, Sep 2002, pp 28-30.

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Photos by the author.

Dr H. Paul Shuch, N6TX, serves as volunteer Executive Director of The SETI League, Inc. A long-term engineering professor credited with designing the first commercial home-satellite TV receiver, he is the author of more than 400 publications, has received numerous honors and awards and (as N6TX) has operated in 20 ham bands between 1.8 MHz and 24 GHz. You can reach the author c/o The SETI League Inc, PO Box 555, Little Ferry, NJ 07643; **n6tx@setileague.org**.

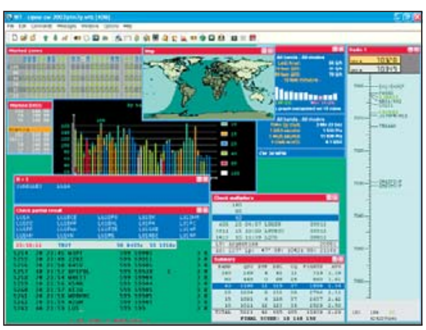
New Products

WIN-TEST CONTEST LOGGING SOFTWARE

◊ *Win-Test* is a contest logging software, developed in C++ by Olivier, F5MZN, father of *DxNet* and the *Editest DOS* contest logging program. This software, based on the K1EA's popular *CT* syntax, has been used since 2003 at the FY5KE contest site.

Win-Test requires a 166 MHz or faster Pentium based PC with 32 MB of RAM. All the 32 bit *Windows* versions are supported. *Win-Test* does not require any specific hardware, except a standard interface to generate CW.

A trial version is available at **www.win-test.com**. For full capability beyond the trial period, a registration fee is required. See the Web site for details.



QPACK LOW POWER TUNER

◊ The QPack Precision Tuner, described as a deluxe manual portable tuner, is available from Miracle Antenna. The QPack uses Miracle's own flatpak variable capacitors, said to be compact sealed and gasketed units providing high maximum capacitance and low loss. The QPack design incorporates modified link coupling designed to provide matching capabilities to 15:1 from 3.5 to 56 MHz. The Qpack Precision will feed balanced lines, coax, random wires and whips.

The unit is built into an extruded aluminum enclosure. The controls are driven by Rogan soft-touch knobs designed for a smooth, weighted feel without backlash. The tuner is rated at 30 W maximum. Price, $149.95. The tuner can be ordered from your local dealer or from Miracle Antenna. For information contact Miracle Antenna, 2705 Bates Rd #303, Montreal, QC, H3S 1B4, Canada; **www.miracleantenna.com**; tel 866-311-6511.