WINNING THE SETI OLYMPIAD: THE ROLE OF THE DEDICATED AMATEUR

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ABSTRACT
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 nonprofit 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 paper explores the contributions such non-professionals 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. This paper shows how grass-roots amateur efforts can nevertheless supplement the accomplishments of the professional SETI community, bringing us all closer to the day of contact.

KEYWORDS: SETI history, ham radio, SETI technology

INTRODUCTION

Fifty years ago, the last true amateur sports hero left his mark on history. Roger Bannister was in has final year at St. Mary's Hospital Medical School. He had finished fourth in the 1500-meter run at the 1952 Olympics in Helsinki. Undaunted, he set his sights on the elusive four-minute mile. Bannister sensed that this was his last chance; once he completed his studies, he knew, his medical career would prevent him from continuing as an amateur athlete. (In fact, he went on to distinguish himself as a prominent neurologist, but it is for his athletic accomplishment that Bannister will always be remembered.)

Working alone, without the benefit of trainer, coach, sponsorship, or steroids (the fight against the latter which he went on to lead in the 1970s), Bannister rode by rail on 6 May 1954 to Iffley Road in Oxford, where he paid his own 3-pence admission. Arriving at the minor amateur track meet after a morning of hospital rounds and a heavy English luncheon with friends, he noticed St. George's flag dipping above a nearby church, realized that the winds were shifting in his favor, and decided the time was right to go for his goal. His success is a tribute to the spirit of amateurism, in sports as well as in science.

THE SETI OLYMPIAD

The challenge of interstellar contact, no less elusive than the four-minute mile, is equally 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 SETI-zen 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, which 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 built in 1937 the world's first modern radio telescope, a ten-meter diameter parabolic reflector in the back yard of his mother's house in Wheaton IL, 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, Prof. Morrison had long since gone inactive on the ham bands when in 1959 he co-authored 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 thirty years). As an EE undergraduate at the Carnegie Institute of Technology, I had the privilege of operating W3NKI, the campus ham radio station he founded three decades prior.

John Kraus, W8JK

Arguably the most creative antenna designer of his generation, Kraus is best remembered for the late Big Ear radio telescope which he designed and built at Ohio State University. Big Ear conducted the longest running continuous SETI sky survey in history. John Kraus' graduate 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 omni-directional 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 Ph.D. 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.

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 radio 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 120+ amateur radio telescopes that SETI League members operate all over the world.

THE ORGANIZING COMMITTEE

Founded by Richard Factor (see above) in 1994 as a response to the demise of the NASA SETI program, The SETI League, Inc. is a grass-roots amateur radio club of global scope and galactic span. It coordinates the SETI activities of 1400 experimenters in 65 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 SETI 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 it extensive Web presence, along with half a dozen specialized email discussion lists, whereby members can pursue a variety of collaborative projects. The organization also publishes *Contact In Context*, an online 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 US 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 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 they themselves are 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 back-yard radio astronomy is the discarded C-band home satellite TV dish. These three to five-meter diameter parabolic reflectors exhibit in excess of +30 dBi of gain in the "waterhole" spectrum between 1.4 and 1.7 GHz, provide modest resolution with their 2 to 4 degree beamwidths, and can generally be had for the asking, in communities where TVRO technology has been replaced digital by Direct Broadcast Satellite television distribution. Several hundred amateur radio telescopes are already online 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 sheet metal working techniques.

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 receivers 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 one hundred amateur radio telescopes now engaged in a coordinated all-sky survey, it is necessary to allocate efficiently 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 5,000 participating amateur radio telescopes and real-time all-sky coverage.

The Broadband Jump

The typical commercial communications receiver has an instantaneous bandwidth of approximately 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 ca process and digitize hundreds of kilohertz, or preferably many megahertz, of bandwidth in real time. SETI League members are recently applying new components designed for the wireless telecommunications industry, to the challenge of seeking out narrowband 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 disassociation 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.

The Pole Vault

With hundreds of amateur radio telescopes at work around the world, a commonly available calibration and validation means became a necessity. Three 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 Lovel Telescope in Jodrell Bank, UK, 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 Five 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 five million participants, all crunching data from the SERENDIP receiver at Arecibo, the world's most sensitive radio telescope. The weakness is that all five 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 tasks, 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.

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. 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 fundraising, to complete the construction of their respective next-generation SETI instruments.

THE FUTURE OF THE SPORT

As public and private funding for SETI science continue 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 his famous run, "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 that 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 eve of his famous fiftieth anniversary, 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.

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