

A brief history of the search for extraterrestrial intelligence and an appraisal of the future of this endeavor

Stuart Bowyer
Professor of Astronomy (Emeritus)
Space Sciences Laboratory
University of California
Berkeley, CA 94720 USA

The idea that credible searches for Extra-Terrestrial Intelligence (ETI) could be carried out were laid out in detail in the (now classic) paper by Morrison and Cocconi (1959).¹ They suggested using the radio band for these searches. Since then radio searches have been carried out by over sixty different groups. No signals from ETIs have been identified. Most searches did not have high sensitivity and it is not surprising that ETI signals were not detected. It is important to note, however, that these efforts were instrumental in developing new technical capabilities and they helped generate wide interest in this field. In this paper I will briefly discuss the more sensitive searches that have been carried out and some of the other searches that are arguably quite innovative or have been influential in some other manner.

Ohio State University

In the early 1950s John Kraus at Ohio State built a very crude radio telescope for a search for extra terrestrial intelligence. However, he realized that this telescope had severe limitations and consequently he developed a new telescope for this search which became operational in 1961. This telescope used a very unique design which would not be recognized as a telescope by most people. It used embedded metal mesh laid on a flat ground area. A prime advantage of this design was its ease of construction and hence its low cost. In the early 1960s Bob Dixon joined Kraus and was placed in charge of the data analysis effort. Extensive observations were carried out and analyzed.

In 1977 a very odd signal was detected (dubbed the Wow! space signal). There was no obvious terrestrial explanation for this and it was widely reported in the popular press as an ETI signal. Unfortunately the group lost its National Science Foundation funding shortly thereafter. It was realized that the telescope had quite limited sensitivity and it would need to be replaced for a significant SETI program to be carried out. Lacking funding the facility was closed. Perhaps the most significant contribution of this effort was the publicity generated by the Wow! source and the raising of public awareness of SETI searches.

Suitcase SETI/SENTINAL/META/BETA

In the mid 1970s Paul Horowitz began a SETI project at Harvard University and in 1978 he carried out a very limited search at Arecibo. In 1981 he obtained funding from NASA and the Planetary Society to build a high resolution spectrometer which he dubbed Suitcase SETI. In 1982 he installed this device at Arecibo and searched for an ETI signal from 250 locations. In 1983 this instrument was mounted on Harvards 26 meter telescope at the Universitys Oak Ridge Observatory and a search (dubbed SENTINAL) was begun. Suitcase SETI and SENTINAL covered only 2 kHz bandwidth which was a severe limitation. Hence a new spectrometer was developed with a total of 8 million channels with 0.05 Hz resolution and 400 kHz of instantaneous bandwidth. This device was dubbed META (Megachannel ExtraTerrestrial Assay). Development of a spectrometer

Email: bowyer@ssl.berkeley.edu
Telephone: +1 510 642-1648

with even higher resolution and a wider band-pass was begun in 1991 and was completed in 1995. This device, dubbed BETA (Billion-channel ExtraTerrestrial Assay), was then mounted on the Oak Ridge telescope. Observations with this system were carried out until 1999 when the telescope was blown over by strong winds and was compromised. This ended the Harvard Groups radio SETI project. Perhaps the most significant result of their efforts was the development of very high resolution spectroscopy for use in SETI.

SERENDIP

At Berkeley I began a SETI project (named SERENDIP, an acronym for the Search for Extraterrestrial Radio Emissions from Nearby Developed Intelligent Populations) in 1980. Our strategy was to use data obtained in an observatory's regularly scheduled astronomical programs. Data acquired were analyzed off-line at the UC Berkeley Space Sciences Laboratory. A commensal SETI program such as this is not free to choose observing frequencies and sky coordinates. However, in view of the plethora of postulated frequency regimes for interstellar communication and the large number of potential sites for civilizations which have been suggested, this is not necessarily a disadvantage.

The SERENDIP program began with a simple set of hardware with limited capabilities. But it was begun at a time when very few searches were being attempted, and those that were being carried out were only done intermittently. We were able to obtain substantial amounts of observing time and we collected large quantities of data. Even more important was our continuing work to develop more powerful instrumentation and signal detection software. Our first instrument used data from the University of California Hat Creek Telescope. As our instrument capabilities progressed, we were fortunate in obtaining time on NRAO's 300-foot telescope at Green Bank West Virginia. We operated at this facility from 1986 until its collapse due to a structural failure in 1988. (The tabloid press attributed the collapse of this telescope to alien forces who resented the fact that they were being tracked by our instrumentation).

The combination of our SERENDIP II instrumentation with this very large telescope resulted in a very high sensitivity search. In fact, our searches have consistently been among the most sensitive in operation. In Table 1 (reprinted from Bowyer (2011)²), I provide a comparison of our search at Green Bank with other instrumentation operating at that time.

In 1991 we installed an upgraded version of our instrument at the Arecibo radio telescope in Puerto Rico. We have continued observations at this facility where our latest and most sophisticated instrument continues to obtain data.

Bologna

A group at the Institute of Radio Astronomy in Bologna, Italy led by Stelio Montebugnoli has initiated a substantial SETI effort. In this work they used the SERENDIP IV system which I arranged to have transferred to them when we removed this instrument from the Arecibo telescope for replacement with our improved SERENDIP V system. The Bologna observations began in 1998 and are continuing today. They are primarily carried out on a 32 meter dish in Medicina, Italy. This group is pioneering efforts to use the Karhunen-Loeve transform to extract signals from noise. In principle the use of this transform has substantial advantages over the use of other types of transforms. Unfortunately, this transform is extremely demanding computationally. A straightforward implementation of a system using this algorithm requires an exponential increase in computing power as the quantity of the data is increased. This is clearly untenable. The Bologna Group is having some success in overcoming this problem. A more detailed description of this search is provided in Montebugnoli (2011).³

Table 1. Summary of SETI programs, circa 1986.

	Ohio State	NASA (test MCSA)	Sentinel	Meta	Serendip II
Telescope diameter (feet)	175	84	84	84	300
System temperature (degrees K)	100	25	65	65	25
Total bandwidth (KHz)	500	74	2	420	3500
Single channel Bandwidth (Hz)	1000	.5	0.03	0.05	0.98
Channels per beam	500	74,000	65,536	8,388,608	3,571,428
Integration time (sec)	10	1000	30	20	1
Beams/hr	8	3.6	20	20	10
Fraction of time in operation (percent)	80	40	80	80	40
Relative probability of detection per unit time	0.0002	0.2	0.007	0.7	0.7

NASA Ames

Studies for a SETI program to be carried out at the NASA Ames facility began in the late 1970s. This program was initiated at a low level to examine various possible systems to carry out a SETI search. Another extremely important part of this effort was the initiation of a program for the development of data analysis systems. The development of the instrumentation went through several different configurations as technical problems were discovered in the various approaches that were investigated. In 1991 development of the instrument was begun in earnest with funding of millions of dollars per year. The program went through a number of name changes beginning when a group at NASAs JPLs facility joined the effort, and again when NASAs funding was withdrawn in 1993. Private funding was then found to support this effort and the instrumentation previously developed was placed on a number of different telescopes. It is not entirely clear when actual observations (as opposed to test trials) with this instrumentation began, but significant searches were eventually carried out. A description of this search and its capabilities when fully implemented and installed on the Allen telescope (described below) are provided by Tarter (2011).⁴

ATA

Paul Allan (the co-developer of Microsoft) funded the development of what was envisioned to be the worlds largest SETI effort dubbed the Allen Telescope Array. The facility was intended to consist of 350 radio antennas to be located at the University of Californias Hat Creek Radio Observatory. Because of a substantial number of technical difficulties in the development of this array, Allans funding was exhausted after only about twenty of these telescopes were developed to the point that they were capable of being operated as an array. The ATA was officially dedicated in late 2007 and test observations were begun. The data analysis systems developed at NASA Ames were set up to use the output from these observations. Tragically, in early 2011 NASA stopped

funding this program. New private funding was sought for this effort but none could be found. Consequently this search had to be terminated.

Other types of searches

Searching for ETI signals in other bands of the electromagnetic spectrum has been proposed. Suggestions range from a search for pulsations in the the optical flux in stars to the search for signals in the anti-neutrino flux distribution. Of all these suggestions, the only actual non-radio searches that have been carried out are searches for optical pulsations in the output of stars. While arguments can be made for these optical searches, it is my belief that these arguments are not strong. They usually require that huge increases in laser emitting technology, far beyond that envisioned in the most ambitious Star Wars laser programs, will be developed.

An adjunct suggestion to the requirement that super mega-lasers will have to be developed is the hope that very large optical mirrors will be feasible. One suggestion is that a parabolic mirror be built on the Moon using a slowly rotating solution of molten salts with an ultra thin coat of silver as the reflecting material. I will not discuss these optical projects in this paper.

A personal appraisal of the future of this endeavor

By 2010 several radio searches were underway or were close to being finalized which would have provided a huge increase in detection capabilities. In addition, a major discovery of import was the detection of a surprising number of planetary systems. This increases the potential locations for extraterrestrial intelligence. However, the systems that have been discovered show that the formation of planetary systems is complex and results in many systems that are unstable. In a worst case scenario for SETI, there will be far more stars with planetary systems but few planets with stable orbits. An additional complexity is the requirement, based on very general grounds, that water is a necessity for the development of life. But the origin of water on Earth appears to be the result of an odd set of circumstances which are not expected to occur in virtually all planet formation scenarios. Despite these uncertainties most workers in the field continue to be optimistic regarding the possibility of eventually detecting an ETI signal.

Tragically, the search which was to be carried out with the Allen Telescope at the Hat Creek observatory was canceled for funding reasons. Other searches have also been canceled. Nonetheless, work continues by groups that are developing new instrumentation and new types of data analysis software. It is expected that these efforts will ultimately result in substantially more sensitive searches.

Project Argus, a search effort coordinated by the non-profit SETI League, encourages the development of SETI searches by amateurs. These systems typically use small TV dishes. At this point the SETI League coordinates the efforts of almost 150 operational searches throughout the world. A fuller description of this effort is provided in Shuch (2011).⁵

The Berkeley SERENDIP Program continues to acquire large amounts of very sensitive data. Eric Korpela leads an effort (described in this symposium) to develop new techniques for data analysis. This work has been successful on several levels but the reduction and analysis of the ongoing data set is progressing slowly.⁶

Robert Dixon at the Ohio State Radio Observatory is developing a new type of telescope for SETI. This is a high gain, omnidirectional array. It is inherently less expensive than a dish and has no large or moving parts. It has no tight mechanical tolerances and requires no mechanical maintenance. The array itself is uniquely suited to a SETI search. The challenge in using this type of array is that it is extremely demanding of computing power. Dixon currently has developed an array with twenty four elements but there is no way to extract the signals from the data stream using current computing capabilities. The group is investigating various approaches which will reduce the computing demands of this system to a reasonable level. A more complete description of the work is provided in Dixon (2011).⁷

In conclusion, it is possible that one of the currently operating searches may detect an ETA signal. However, given the intrinsic limitations of these searches, this outcome seems unlikely. However, it is reasonable to hope that in the long term (say in 50-100 years) instrumentation and computing schemes (perhaps using some of the techniques discussed herein) will have been developed to the point that large parts of the sky can be simultaneously searched with high sensitivity and efficiency. At that point one can be reasonably optimistic that a true ETI signal will be discovered.

REFERENCES

1. Cocconi, G. and Morrison, P., "Searching for Interstellar Communications," *Nature* **184**, 844–846 (Sept. 1959).
2. Bowyer, S., "SERENDIP: The Berkeley SETI Program," in [*Searching for Extraterrestrial Intelligence: SETI Past, Present, and Future (The Frontiers Collection)*], Shuch, H. P., ed., 99–105, Springer, Heidelberg, DE (2011).
3. Montebugnoli, S., "Implementing the KLT," in [*Searching for Extraterrestrial Intelligence: SETI Past, Present, and Future (The Frontiers Collection)*], Shuch, H. P., ed., 275–284, Springer, Heidelberg, DE (2011).
4. Tarter, J., "ATA: A Cyclops for the 21st Century," in [*Searching for Extraterrestrial Intelligence: SETI Past, Present, and Future (The Frontiers Collection)*], Shuch, H. P., ed., 131–145, Springer, Heidelberg, DE (2011).
5. Shuch, H. P., "Project Argus: Pursuing Amateur All-Sky SETI," in [*Searching for Extraterrestrial Intelligence: SETI Past, Present, and Future (The Frontiers Collection)*], Shuch, H. P., ed., 201–225, Springer, Heidelberg, DE (2011).
6. Korpela, E. J., "Distributed Processing of SETI Data," in [*Searching for Extraterrestrial Intelligence: SETI Past, Present, and Future (The Frontiers Collection)*], Shuch, H. P., ed., 183–200, Springer, Heidelberg, DE (2011).
7. Dixon, R., "A Sentry on the Universe," in [*Searching for Extraterrestrial Intelligence: SETI Past, Present, and Future (The Frontiers Collection)*], Shuch, H. P., ed., 285–304, Springer, Heidelberg, DE (2011).