SETI OBSERVATIONS WORLDWIDE

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ABSTRACT: This paper reviews all recent SETI observing programs that the author is aware of from the literature and private communication. The technical parameters of all known SETI efforts are summarized in an appendix containing references whenever possible.

At the 1978 Joint Session devoted to SETI during the Montreal IAU General Assembly, Ben Zuckerman very skillfully summarized a number of recently completed observational programs aimed at searching for evidence of extraterrestrial technology. In this paper I'd like to bring you up to date on what has been going on since that time. Unfortunately, the most obvious omissions in Ben's summary and my own today were and are the projects being conducted by our Russian colleagues. Although these activities have at times been spectaculaly reported in the press, journal articles and conference proceedings are few and far between. I had hoped that this Symposium might offer us all the opportunity to learn first hand about the Soviet research, but I'm afraid you will have to be content with my own report based on what I learned during the Soviet Academy of Science sponsored meeting "SETI '81" in Tallinn, Estonia.

I routinely maintain an archive of SETI observational programs, beginning with Frank Drake's Project Ozma in 1960. This archive is reproduced as an appendix. Of the 45 entries in this archive, 25 refer to searches conducted in the last 6 years since the Montreal IAU. It is obvious that the increase in the number of search programs reflects both the growing "legitimacy" of SETI and the increased professional and public interest in this field.

It is convenient to discuss observational programs in SETI under three headings: DIRECTED, SHARED and DEDICATED. By this I mean those searches which directly control the acquisition of data (for example by pointing a telescope) as opposed to those searches which share the data acquisition process with another primary user or re-use existing data previously collected for another purpose, and as opposed to those searches which are in fact the sole function of a dedicated piece of

M. D. Papagiannis (ed.), The Search for Extraterrestrial Life: Recent Developments, 271–290.

observing equipment. Table 1 displays either the project name or principle investigator for the 25 recent search programs under the appropriate category heading. The entries in block parentheses are Russian programs which I have included even though they were conducted prior to 1978, because they were not reviewed by Ben Zuckerman, and are probably not familiar to most of the audience.

TABLE I SEARCHES SINCE 1978 IAU

DIRECTED	SHARED	DEDICATED
KNOWLES & SULLIVAN (1978)	ISRAEL & DERUITER (1975-79) ISRAEL & TARTER (1981)	OSURO (1973 -)
FREITAS & VALDES (1979) SETA (1981-82)	COHEN et al (1978)	SENTINEL (1983 -)
TARTER et al (1979-81)	COLE & EKERS (1979)	SMALL SETI OBSERVATORY (1983-)
LORD & O'DEA (1981)	SERENDIP (1976-79) SERENDIP II (1979)	AM-SETI (1983-?)
BIRAUD & TARTER (1981)	WIELEBINSKI & SEIRADAKIS (1977 -)	STEPHENS (1983-?)
SIGNAL (1981)		TROITSKIJ et al (1983-
SUITCASE SETI (1982)	WITTEBORN (1980)	
VALDES & FREITAS (1983)	MERIDIEN CENTRAL GALACTIQUE (1982 -)	[SOVIET DIPOLE NETWORK]
[MANIA]	DAMASHEK (1983)	
	GULKIS (1983 -)	

If such a table had been drawn up 6 years ago, there would have been no need for 3 columns. With the notable exception of Ohio State, all the searches that had been conducted fell into the DIRECTED category. They had been conducted by individuals with sufficient status and/or courage to formally propose the use of astronomical observatories and equipment for the purpose of doing SETI. The large number of entries under SHARED and DEDICATED (and several of the entries under DIRECTED) indicate the current willingness of both the professional and amateur communities to construct and utilize SETI-specific instrumentation. Although SETI is still acknowleged to be a long shot, and is often likened to buying a lottery ticket, the entries in the table above give clear evidence of a growing commitment to pay the purchase price for that lottery ticket, instead of waiting around hoping that a ticket will fall out of some astronomer's pocket! Although the table does not explicitly show the location of the observational activities, another difference between this table and one made six years ago would be the increased international participation in SETI. Ben Zuckerman reported on SETI observations that had been conducted in the USA, Canada and the USSR, today we can add France, The Netherlands, Germany and Australia. I believe that the multiplicity and visibility of these many observational programs have helped to establish the current climate wherein NASA can be engaged in the process of preparing to conduct the first large scale systematic SETI Program.

However, politics was not the primary goal of these observational programs, they were carried out with the expectation that they might produce some evidence of the existence of extraterrestrial technology Each entry in the table represents a particular strategy for limiting the vast multi-dimensional phase space inherent to the SETI endeavor, and defining thereby some finite and manageable subset of the search. Since precisely the same sorts of limiting choices must be made by the planners of systematic searches (if they are to be finite and manageable) there is much to be learned by considering the trade-offs accepted by the individuals performing these recent observations. If none of them has yet succeeded in their primary goal, they may yet have provided valuable lessons on how to search better.

2. Recent Searches

2.1 DIRECTED Searches

When a systematic search through the electromagnetic spectrum is impossible, some variation of the "magic frequency" game must be played. With sufficient funding and time, this may be as weak a limitation as recognizing that the microwave region of the spectrum presents the minimum background noise from natural sources of radiation and therefore may be the preferred communication channel over interstellar distances. Individual programs are generally forced to a much more limiting form of this game, and many people have expressed their views as to what is the "obvious" choice of frequency. Although most such suggestions involve the fundamental line radiation frequencies from atoms and molecules or dimensionless constants of physics, Knowles and Sullivan used VLBI taperecorder technology to provide extremely good frequency resolution at frequencies in the range of 1- 500 MHz, so that they could attempt to eavesdrop on two nearby stars, seeking the analog of our own usage of the electromagnetic spectrum for communication and defense. The tape recorder provided a 1-bit representation of the voltage out of the antenna at a sufficiently high sampling rate for a sufficiently long time, that a large Fourier transform of the bit stream could produce in post-real-time the equivalent of a 65536 channel spectrum analyser, each channel of which was about 5 Hz wide. Even though they used the large collecting area of the Arecibo Observatory, these experimenters pointed out that the analog they were seeking had to employ far greater communication power levels than is our practice, if they were to be detectable in this mode. Nevertheless this is an interesting approach to the problem. There are currently (1984) 122 stars sufficiently close to the Sun to have been able to eavesdrop on our TV transmissions and, having detected the carrier(s) (with systems more sensitive than that of Knowles and Sullivan) to respond in kind with signals that could have arrived at Earth by now.

In another series of experiments at Arecibo, which concentrated on the magic frequencies associated with HI and the hydroxyl radical, Tarter, Clark, Cuzzi, Duquet and Lesyna improved upon the 1-bit tape recording technology with the use of a 1-bit sampler specifically constructed by the observatory for this purpose. Under control of the observatory tracking computer, it was possible to sample successive frequency bands in each of two circular polarizations until a total of 4 MHz of the spectrum was observed around both the HI and OH lines. Post processing of recorded data with a CDC 7600 produced the equivalent of 3.4 million channels of spectral data for each of the 210 solar type stars observed.

In the most extreme of the limited frequency approaches pursued during the last 6 years, Horowitz, Teague, Linscott, Chen and Backus built a real time spectrum analyser with 131,072 extraordinarily narrow channels. They observed 250 solar type stars at Arecibo with "Suitcase SETI", exploring 2 KHz of the spectrum around the HI line and 4 KHz around 2 x the HI line frequency, seeking narrowband signals specifically transmitted to arrive at Earth at the exact "magic frequency". The search for ultra-narrowband signals arriving at a precisely predetermined frequency allows for the construction of an extremely sensitive detector with a high degree of built-in interference rejection out of relatively slow and cheap electronics. Shortly Paul Horowitz will tell us more about this clever detection scheme, because "Suitcase SETI" lives on as the hardworking core of the SENTINEL program at Oak Ridge. I only wish that Paul could tell us for sure that he knows which magic frequency is the right magic frequency, and that Their magicians agree!

Another real-time SETI spectrometer has been built in France and is installed on the telescope at Nancay. This device is an 8-level 1024 channel autocorrelator with variable resolution. It was constructed in such a manner as to leave the highest resolution attainable, a value to be determined by the needs of SETI observers. A value of 50 Hz has been chosen, and Biraud and Tarter have begun a series of observations centered on the 1665 and 1667 MHz main lines of the OH masers plus 2 other nearby frequencies which constitute the weighted and unweighted means of the main lines plus 1612 and 1720 MHz. This program also observes solar type stars and is intended as a compliment to earlier work at Arecibo and the NRAO 300FT, where low declination sources were not observed. The statistical analysis of the correlator spectra is designed to detect the presence of narrowband signals remaining within one observational channel during the 25 second integration time.

Lord and O'Dea chose a very different frequency for their search with the U. Mass telescope. They investigated the 115 GHz CO line frequency, which lies above the range of frequencies comprising the quiet terrestrial microwave window, but well within the freespace microwave window and near the frequency suggested by Drake and Helou as being the most efficient for space-based interstellar communication channels. They did not choose to look at nearby stars, but rather attempted to explore a well defined and "magic location" within the Milky Way Galaxy and accessible to all its inhabitants. They scanned along the north galactic rotation axis, seeking a powerful beacon established by some more advanced technology.

There is of course one unique location associated with the Milky Way Galaxy and that is its center. A number of authors have suggested that this would be the obvious choice for establishing an informational beacon. However at many wavelengths this region of space emits vast quantities of radiation, indicative of extraordinary energetic phenomena taking place within a small volume of space. Shostak and Tarter argued that one way to make a beacon visible against the background confusion of natural emission would be to make it pulse in time, perhaps as a narrowband rotating lighthouse. Further, the best way to detect it would be to use an interferometer to spatially filter out much of the extended emission from the region. In SIGNAL, the Westerbork Radio Synthesis Telescope was used to observe the galactic center at 21 cm for the four hours a day during which it was above the Dutch horizon. Signals with a repetition rate between 40 seconds and one hour and a bandwidth of less thant 3 KHz would have been detected at the 20 mJy level.

There have been several other searches of "magic locations" by Freitas and Valdes. But here the "magic" lies not in their general accessibility, throughout the galaxy, but rather in the locally determined gravitational field of the Earth-Sun-Moon system. These investigators have been looking for physical artifacts or probes placed into the most easily maintained orbit by some distant technology, which have waited patiently for the evolution of an intelligent species capable of detecting them. These observations have been done at visible wavelengths in an attempt to detect reflected sunlight from large solid bodies in the vicinity of the Earth-Moon and Earth-Sun Lagrange points. Both the Leuschner 30" telescope of the University of California Berkeley, and the 24" telescope at KPNO have been used. The most sensitive plates should have detected shiny objects a few meters or more in size.

These same investigators have also looked at nearby solar type stars, not at visible wavelengths, but rather at the 1516 MHz line associated with tritium. The observations were performed at Hat Creek Observatory and were intended to test the possibility that a stable advanced technology involved in the production of energy by nuclear fusion reactions might leak a detectable amount of tritium. Since the half-life of this isotope is so short, there is no natural astrophysical mechanism which would be expected to produce a detectable amount in the vicinity of a quiescent main sequence star.

The 6m optical telescope of the SAO at Zelenchuskaya has been equipped with a detector capable of finding very short pulses (3 x 10^{-7} sec - 300 sec) from narrowband optical lasers. Swartzman and his colleagues have used this device called MANIA to look at 21 peculiar stellar objects with purely continuous optical spectra and time variable radio emission (BL Lac's ???), under the hypothesis that these represent examples of super advanced Type III civilizations. There has been no report of searching in the vicinity of normal stars for similar emission and the current status of this work is unknown to the author.

2.2 SHARED Searches

The DIRECTED searches described above represent a significant number of telescope hours devoted to SETI. But a number of other observers have accomodated the "long shot" concept of SETI by attempting to find ways of observing that are not so costly in this particular astronomical currency. Isreal with DeRuiter and then with Tarter took advantage of the fact that Dutch astronomers at Leiden and Groningen had attempted to save all the "dirty" interferometer maps ever produced by obervers using the Westerbork Radio Synthesis Telescope. This tape archive provided a large number of unbiased pictures of the sky at the hydrogen line frequency, which could be searched for point sources of emission coincident with the positions of known stars listed in machine readable catalogs. The use of dirty maps meant that any field of view with very strong a source at the center had to be ignored because the grating response was too overwhelming, yet the remaining 130 fields provided an opportunity to investigate several hundred stellar positions. The interferometer is intrinsically immune to terrestrial interference, and so point source confusion was minimized. It is hoped that this sort of approach may eventually be implemented as a background process at the VLA, to search through all maps as they are created in the pipeline computing system.

Cohen, Malkan and Dickey also made use of stored astronomical data to search for SETI narrowband signals at frequencies associated with OH and water masers. In this case the old data were their own; surveys of a number of globular star clusters. With thousands of stars in the telescope beam at one time, these observers attempted to find signals at frequencies outside the range permitted by the velocity distributions of the masers. They were in a way testing an old suggestion from Tom Gold, that an ET civilization might well choose to take advantage of the free amplification provided by masers in space to produce a very detectable signal for anybody listening along a line of sight on the other side of a maser cloud.

Magnetic tape may someday prove to be the critical ingredient of a successful serendipitous ETI detection. As yet another example of an observer re-analysing his astronomical data to look for ETI signals, Damashek recently subjected data recorded at 390 MHz with the NRAO 300

FT (during a pulsar search program covering much of the sky) to a Walsh function analysis. The type of signal being sought was analogous to our own telemetry (bit-stream) signals. Damashek claims that the comparisons with square waves, as opposed to the traditional sine wave Fourier analysis, provides a greater sensitivity to this on-off signalling technique. The analysis of some 700 hours of telescope time is still in progress.

Bowyer and collaborators at UC Berkeley and the Jet Propulsion Lab also decided to let astronomical concerns dictate where they would look for narrowband SETI signals. Arguing that radio astronomers spend a great deal of time looking through the plane of the Galaxy, where the stars are, they built a simple automated 100 channel spectrum analyser to parasite off the astronomers data signal and search through the IF frequency band looking for and recording to tape any strong signals which occurred in only one 2.5 KHz channel. These tapes were later analysed extensively in an attempt to find patterns in terms of sky coordinates, times and various frequencies which would allow identification of the many signals encountered. The SERENDIP box was used first at the Hat Creek Observatory at 18,21 and 6 cm and later at DSS14 in the spacecraft S & X bands. A new version of this hardware has been designed and is intended for installation at Arecibo, where it will be the most sensitive. Dan Wertheimer will be describing it later on. The detective work required to deduce the nature of a detected signal, long after it has been observed, is difficult and often unsuccessful. The SERENDIP program has generated a list of sky and frequency combinations which must be reobserved because the "signal" detected had a statistically insignificant chance of being due to noise alone, and no association with other signal events allowed for its identification with a known source of interference within the observatory or on the horizon.

In their search for sharply pulsed emission from impulsive radio events or a temporally compressed ETI signal, Cole and Ekers took great pains to distinguish signals of celestial origin from terrestrial interference, by recognizing that signals travelling over interstellar distances would arrive highly dispersed. A search for exploding black holes and fine scale microstructure within a number of pulsars was conducted at 5 GHz with the Parkes telescope and a number of G & K main sequence stars were also included in the target list as part of a symbiotic observational program. As it happened, observations in the direction of a G5 star 82-Eridani produced the only non-explicable signal event during the 4 day observing run. The event lasted over 1 millisecond and had temporal structure as fine as 4 microseconds. Subsequent observations of this star have failed to reproduce the event. Par for the course in SETI work to date!

Another search for pulsed ETI signals has been conducted during a routine search for new pulsars, by Wielebinski and Seiradakis using the 100 m Effelsberg telescope at 1420 MHz. At opportune intervals in the primary search program, coordinates of solar type stars are inserted. The detection hardware, being unaware of this turn of events, would have responded to any regularly pulsed ETI signal having a period between 0.3 and 1.5 seconds, if its bandwidth were less than about 20 MHz and it were stronger than 4×10^{-23} W/m^2.

In the course of routine Infrared astronomical observations, some 20 stars have been discovered to have an excess emission in the 8.5 - 13.5 micron region of the spectrum and in addition appear to be too faint for their spectral type. Witteborn argued that this is precisely what would be the expected observational consequences of an advanced technology which chose to construct a Dyson sphere that partially enclosed the primary star. These stars were all reobserved using the 1.5 m telescope on Mount Lemon in an attempt to provide spectral detail sufficient to compare and distinguish between a Dyson sphere, a proto-planetary disk, a planetary system that did not form, and an incorrect spectral type assignment. Nothing that cannot be explained on the basis of conventional astrophysics has been claimed for these data; astro-engineering is not the only source of unusual looking stars.

Later on in this meeting, Jacques Vallee will describe a search of the galactic plane that he is conducting with Ms. Simard-Normandin using the Algonquin Radio Observatory at 10.5 GHZ. Although the primary rationale for this search is a study of the galactic magnetic field structure, the serendipitous detection of highly polarized ETI signals was specifically called out in the observing proposal.

You are all aware that radio telescopes sometimes break down and require extensive periods of repair. Although they are not then capable of carrying out their primary function (such as tracking a satellite), if the problem is mechanical and does not involve the receiver chain, the telescopes can remain sensitive to signals arriving at RF frequencies. This was recently the case with NASA's 64 m antenna in Australia, DSS-14. The antenna was stowed for 4 months while extensive repairs were made to its concrete pedestal. Gulkis, Kuiper, Olsen, Jauncey and Peters convinced NASA to leave the receivers functioning at 8 and 22 GHz and with a little help from their friends at the Planetary Society, they constructed a 256 channel spectrum analyzer. This recorded to tape, for subsequent analysis at JPL, the data available from the sky passing overhead. With the antenna stowed in the same position for days at a time, multiple samples of sky-frequency combinations were taken and this helped with the identification of real signals as opposed to interference and noise events. When the repair schedule permitted, the telescope was moved in elevation to allow another range of declinations to be scanned. Although repairs have been completed, this mode of operation is continuing whenever the telescope load is low and the antenna would normally be stowed to zenith.

2.3 DEDICATED Searches

The Ohio State University Radio Observatory is the archetype for a DEDICATED facility for SETI. Later in this program Bob Dixon will describe its technical capabilities and routine observational performance and summarize the results to date. I hope he will also find time to recount its recent dealings with land developers and its threatened conversion into a golf course. This episode provides tangible evidence of the public support for and interest in SETI, because this has been the sole preoccupation of this observatory for the past 11 years.

Also later in this program, Paul Horowitz will detail his new addition to the ranks of DEDICATED facilities for SETI. Funding for Project SENTINEL as it is known, has come from the public through the Planetary Society and is another example of just how widely appealing SETI is. As "magic frequencies" go, this system is in the Cadillac Class!

While the two operations just cited are being run by trained and disciplined professionals (with the help of some silicon associates), who can be expected to sustain a prolonged observational activity, it remains to be seen whether this is the case for a number of recent additions to the DEDICATED category. These new facilities have been constructed and are being run wholly by (we hope) dedicated amateurs. Robert Gray and several collaborators have constructed a 4 m dish and micro-computer controlled receiver system in his back yard near Chicago. (One can only wonder what Grote Reber's mother might have to say about this!) This Small SETI Observatory employs 256 channels of binwidth 40 Hz to conduct a transit sky survey at 1420.405 MHz during most evenings. Gray is a professional programmer who has created some clever software for compressing and storing the data onto floppy disks. Nevertheless, disks must be recycled and the final analysis involves human scanning and hardcopy summaries which will undoubtedly prove to be the eventual limitation to this operation in its continued efforts to conduct a sky survey and/or to provide archival materials of use to other SETI efforts. Most recently Gray has spent a lot of telescope time concentrating on a declination of $^{-}27^{\circ}$ in an attempt to reacquire the "WOW" signal of Ohio State.

Like Gray, a number of radio amateurs in the Silicon Valley have decided that the very best possible use for a home computer is as a SETI FFT spectrum analyzer. Under the banner of AMSETI, these individuals have sought advice from SETI scientists at NASA-Ames Research Center (particularly Kent Cullers) and other local experts who are sympathetic to the concept. To date these efforts have produced at least one complete system at 1420 MHz that uses GaAs FET amplifiers, and a satellite TV antenna hooked into a micro. How much systematic searching will ever get done and archived is unclear at this time. I am not a member of the Ham fraternity, and I've been given widely varying opinions by those who are as regards to the average Ham's persistence and attention span. One opportunity for this community has been pointed out by John Wolfe and others; the frequencies at or just below 1 GHz. The terrestrial microwave window is still quiet in this region, but the difficulty of installing physically large feeds on the DSN antennas, may preclude the systematic sky survey program from reaching these long wavelengths. If this particular frequency band is singled out for attack, multiplexing in time and person-power could produce a respectable sensitivity using these home-grown systems in a reasonable amount of time. Maybe I'll be able to report to you at the next Commission 51 Symposium, whether or not it has done so.

There is yet another amateur effort under way in Canada's North

West Territory. The Terrestrial Research Institute founded by Bob Stephens has acquired two large (15 m class) tropo-scatter antennas from NorthWestTel, and the 1.5 acre site on which they sit from the town of Hay River at the cost of $1.00 per year. Stephens has put together a low noise water hole receiver (uncooled GaAs FET) with 30 KHz filters at the back end to demonstrate that the signals from both antennas can be combined and a SETI sky survey could be conducted from this naturally quiet locale. That is once he eliminates the interference from his own electric razor and the passing motor boats. Stephens has solicited to raise public funds to support this effort, and currently appears to have taken up residence at the Hay River SETI site - - without phone. Thus I cannot report the current status and health of his enterprise, but I would guess that if anyone is looking for a place to put in some avocational/recreational time this summer, there might well be something for you in the Yukon.

Also in the category of "unknown status" is the Russian effort under Troitskij. At Tallinn plans to build an array of 100 1 m telescopes were reported. This would represent the first attempt to construct a system intended for the detection of narrowband signals. Previous Russian work has revolved around the detection of broad pulses at radio frequencies. A network of omni-directional dipoles was established across the Soviet Union and pulsed signals from celestial sources were sought by demanding the appropriate delays between detected events. The first of Troitskij's new dishes operating at 1420 MHz was scheduled to go into service in 1983 and the system was eventually to produce a sensitivity of 10^{-19} W/m^2, but I cannot verify that this has happened.

While this report has occupied many pages and much of your time and named a large number of individuals, I believe that it is important to stress how little has actually been done. The Cosmic Haystack is vast indeed, and we are still awaiting a suitable pitchfork with which to explore it. So far we've been poking at it with tweezers - sometimes very clever and sophisticated tweezers - but tweezers none-the-less. No wonder the going has been slow. Many people are fond of using the "absence of evidence is not evidence of absence" phrase incorrectly in support of many things. In fact they sometimes even quote it in defense of their position that the absence of evidence is evidence of absence to their special interests. We've done so little of the job (present searches not withstanding) that it is proper to say only that there is no evidence. And that lovely phrase belongs precisely where I have it - across a tee shirt that I wear jogging when back in California. It is an inspiration to me and my colleagues to get on with the task of seeking the evidence!

SUMMARY OF SETI OBSERVING PROGRAMS (JUNE 1984)

DATE	OBSERVER	SITE	INSTR. SIZE(m)	SEARCH FREQ. (MHz)	FREQ. RESOL. (Hz)	OBJECTS	FLUX LIMITS (W/m^2)	TOTAL HOURS	COMMENTS	REF.
1960	DRAKE "OZMA"	NRAO	26	1420-1420.4	100	2 STARS	4.E-22 **	400	Single channel receiver.	1.
1963	KARDASHEV & SHOLOMITSKII	CRIMEA DEEP SPACE STATION		920	10 MHz	QUASAR			Reported detection of CTA102 as possible Type III civilization.	20.
1966	KELLERMANN	CSIRO	64	MANY, BETWEEN 350 & 5000	FULL BANDWIDTH FOR EACH FEED	1 GALAXY	$\pm$ .5FU	---	No "notch" of ETI origin was detected in galaxy 1934-63.	2.
1968 & 1969	TROITSKII, GERSHTEIN, STARO-DUBTSEV, RAKHLIN	ZIMENKIE, USSR	13	926-928 & 1421-1423	13	12 STARS	2.E-21 **	11	25 Channels with F=13 Hz were spaced 4 KHz apart: coverage not continuous.	3.
1968 & ON	TROITSKII	GORKY	DIPOLE	21 cm 50 cm 1 m	---	ALL SKY SEARCH		CONT	Search over all sky visible by single dipole.	24.
1970 & ON	TROITSKII, BONDAR, STARO-DUBTSEV	GORKY, CRIMEA, MURMANSK, USSURI	DIPOLE	1863 & 927 600	---	ALL SKY SEARCH FOR SPORADIC PULSES	1.E+4 FU	700 & CONT. AT 50% TIME	Network of isotropic detectors: cross correlation from 2 or 4 sites over 8000 km.	4.
1970 TO 1972	SLYSH	NANCAY	40x240	1667	20 kHz	10 NEAREST STARS				

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1971 & 1972	VERSCHUUR "OZPA"	NRAO	91 & 43	1419.8 - 1421 & 1410-1430	490 & 6900	9 STARS	5.E-24 & 2.E-23	13	384 channel correlator on-line.	5.
1972	KARDASHEV & STEINBERG	CAUCASUS, PAMIR, KAMCHATKA, MARS PROBE		40 - 500	2 MHz	OMNI-DIRECTIONAL			"Eavesdropping" search for pulses.	
1972 TO 1976	PALMER, ZUCKERMAN "OZMA II"	NRAO	91	1413-1425 & 1420.1-1420.7	$6.4x10^4$ & 4,000	674 STARS	1.E-23 **	500	384 channel correlator on-line.	6.
1972 & ON	KARDASHEV, GINDILIS	EURASIAN NETWORK, INST. FOR COSMIC RADIATION	DIPOLE	1337-1863	---	ALL SKY SEARCH FOR SPORADIC PULSES	1.E+4 FU	---	2 or more sites operating simultaneously.	7.
1973 & ON	DIXON, EHMAN, RAUB, KRAUS	OSURO	53	1420.4 REL. TO GAL. CEN. ± 250 kHz	10 & 1 kHz	ALL SKY SEARCH	1.5E-21 **	CONT.	Receiver is tuned to hydrogen rest frequency relative to Gal. Cen. (as a function of direction).	8.
1974 TO 1976	BRIDLE, FELDMAN "QUI APPELLE?"	ARO	46	22235.08 ± 5 MHz	$3x10^4$	70 STARS	1.E-22 **	140	70 solar type stars within 45 lt yrs have been observed to date.	

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1974	WISHNIA	"COPERNICUS" SATELLITE	1	3.E9	---	3 STARS	---	---	Search for UV laser lines.	9.
1974 & ON	SHVARTSMAN "MANIA"	ZELENCHUK-SKAYA	6	5500	$\Delta\lambda \leq 10^{-5}$ Å	21 PECULIAR OBJECTS			Optical search for short pulses of length 3×10^{-7} to 300 seconds, and narrow laser lines.	21.
1975 & 1976	DRAKE, SAGAN	NAIC	305	1420 & 1667 & 2380 B = 3 MHz	1,000	4 GALAXIES	3.E-25 **	100	Search for type II civilizations in local group galaxies.	10.
1975 TO 1979	ISRAEL, DE RUITER	WRST	1500 MAX BASELINE	1415	4×10^6	50 STAR FIELDS	2.E-23 **	400	Searches of "cleaned" maps prepared for the WSRT background survey, looked for positional coincidence between residual signals and AGK2 stars.	
1976 & ON	BOWYER et al U. C. BERKELEY "SERENDIP"	HCRO	26	1410-1430 & 1653-1673	2500	ALL SKY SURVEY	5.E-22 **	---	Automated survey parasitic to radio astronomical observations.	11.

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1976	CLARK, BLACK, CUZZI, TARTER	NRAO	43	8522-8523 *	5	4 STARS	2.E-24 **	7	VLBI High speed tape recorder combined with software direct Fourier transformation to produce extreme frequency resolution (non-real time).	
1977	BLACK, CLARK, CUZZI, TARTER	NRAO	91	1665-1667 *	5	200 STARS	1.E-24 **	100	VLBI High speed tape recorder combined with software direct Fourier transformation to produce extreme frequency resolution (non-real time).	12.
1977	DRAKE, STULL	NAIC	305	1664-1668 *	0.5	6 STARS	1.E-26 **	10	High speed tape recorder combined with optical processor to produce extreme frequency resolution (non-real time).	13.
1977 & ON	WIELEBINSKI, SEIRADAKIS	MPIFR	100	1420	20,000,000	3 STARS	4.E-23	2	Candidate stars are inserted into ongoing program which searches for pulsed signals with periods of 0.3 to 1.5 sec.	

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DATE	OBSERVER	SITE	INSTR. SIZE(m)	SEARCH FREQ. (MHz)	FREQ. RESOL. (Hz)	OBJECTS	FLUX LIMITS (W/m^2)	TOTAL HOURS	COMMENTS	REF.
1978	HOROWITZ	NAIC	305	1420 +/- 500 Hz	0.015	185 STARS	8.E-28 **	80	Assumes that signal frequency was corrected at the source to arrive at rest in Heliocentric or barycentric laboratory frame.	14.
1978	COHEN, MALKAN, DICKEY	NAIC HRO CSIRO	305 36 63	1665+1667 22235.08 1612.231	9500 65000 4500	25 GLOBULAR CLUSTERS	1.8E-25 1.1E-22 1.5E-24 **	40 20 20	Passive search for Type II & III civilizations using astronomical data originally observed to detect H_2O and OH masers in globular clusters.	15.
1978	KNOWLES, SULLIVAN	NAIC	305	130-500 (SPOT) *	1	2 STARS	2.E-24 **	5	Attempted "eaves-dropping" using MKI VLBI tapes as in Black, et. al., 1977.	16.
1979	COLE, EKERS	CSIRO	64	5000 +/- 5 MHz and +/- 1 MHz	10^7 and 10^6	NEARBY F, G AND K STARS	$4x10^{-18}$ **	50	Simultaneous pulsed events in both 2 MHz and 10 MHz filters are sought in detectors having time resolution of 4 μ seconds.	17.
1979	FREITAS, VALDES	LEUSCHNER OBSERVATORY UCB	0.76	5500A°	———	STABLE "HALO ORBITS" ABOUT L4 AND L5 LIBRATION POINTS IN EARTH-MOON SYSTEM	M_V<14	30	Attempt to discover evidence of discrete objects (such as interstellar probes) in stable orbits about L4, L5 by study of 90 photographic plates.	18.

SUMMARY OF SETI OBSERVING PROGRAMS (JUNE 1984)

DATE	OBSERVER	SITE	INSTR. SIZE(m)	SEARCH FREQ. (MHz)	FREQ. RESOL. (Hz)	OBJECTS	FLUX LIMITS (W/m^2)	TOTAL HOURS	COMMENTS	REF.
1979 & ON	JPL UCB SERENDIP II	DSS 14	64	S & X BAND B = 10 MHz	19500	APPARENT POSITIONS OF NASA SPACECRAFT	8.E-24 **	400 TO DATE	Automated survey parasitic to spacecraft tracking operations using 512 channel auto-correlator and 100 channel correlator with micro-processor control.	
1979 TO 1981	TARTER, CLARK, DUQUET, LESYNA	NAIC	305	1420.4 +/- 2 MHz & 1666 +/- 2 MHz *	5 & 600	200 STARS	1.E-25 **	100	Rapid 1-bit sampler and high speed tape recorder run in parallel with 1008 channel correlator. Software direct Fourier transformation as in Black, et. al., 1977.	22.
1980	WITTEBORN	NASA-U of A MT. LEMON	1.5	8.5 μ - 13.5 μ	1 μ	20 STARS	N MAGNITUDE EXCESS $\leqslant$ 1.7	50	Search for IR excess due to Dyson spheres around solar type stars. Target stars were chosen because too faint for spectral type.	
1981	LORD, O'DEA	U.MASS	14	115000	20,000 125,000 $4x10^8$	NORTH GALACTIC ROTATION AXIS $\ell = 5° \rightarrow 90°$	1.E-21 **	50	Search for signals near J=1-0 CO line frequency from a transmitter somewhere along the Galactic rotation axis.	
1981	ISRAEL, TARTER	WRST	3000 MAX BASELINE	1420	$4x10^6$ $10x10^6$	85 STAR FIELDS	8.E-22 TO 6.E-24	600	Parasitic search similiar to Israel and De Ruiter using 'uncleaned' maps stored at Groningen and Leiden, and AGK3 catalog.	19.

SUMMARY OF SETI OBSERVING PROGRAMS (JUNE 1984)

DATE	OBSERVER	SITE	INSTR. SIZE(m)	SEARCH FREQ. (MHz)	FREQ. RESOL. (Hz)	OBJECTS	FLUX LIMITS (W/m^2)	TOTAL HOURS	COMMENTS	REF.
1981 & ON	BIRAUD, TARTER	NANCAY	40x240	1665-1667	97.5	300 STARS	1.E-23 **	80 TO DATE	8-level 1024 channel auto-correlator with stepped 1st LO to extend frequency coverage at modest resolution.	
1981	SHOSTAK, TARTER "SIGNAL"	WRST	3000 MAX BASE-LINE	1420.4 REL.TO GAL.CEN. B = 156 KHz	1200	GALACTIC CENTER	1.E-24 **	4	Use of interferometer to search for pulsed signals from Galactic Center in range of periods from 40 seconds to 2 hours.	
1981 TO 1982	VALDES, FREITAS "SETA"	KPNO	0.61	5500 Å	----	EARTH-MOON L1 thru L5 SUN-EARTH L1, L2	$10 < m_V < 19$	70	Attempt to see discrete artifacts (>few m in size) in stable orbits near Lagrange points. Studied 137 IIIaF photographic plates.	23.
1982	HOROWITZ TEAGUE LINSCOTT CHEN BACKUS	NAIC "SUITCASE SETI"	305	2840.8 B=4 KHz AND 1420.4 B=2 KHz	0.03 1-LINEAR 0.03 2-CIRCULAR	250 STARS 150 STARS	4.E-26 ** 6.E-28 **	75	Dual 64K channel real time microprocessor based spectrum analyser with video archiving and swept LO frequency to test "magic frequencies".	
1982	VALLEE, SIMARD-NORMANDIN	ARO	46	10,522	185 MHz	GALACTIC CENTER MERIDIAN	1.E-19 **	72	Search for strongly polarized signals by mapping field 1/4°x25° along ℓ=0°.	
1983	HOROWITZ "SENTINEL"	OAK RIDGE (HARVARD)	26	1420.4 AND 1665.4 AND 1667.3 AND 2840.8	0.03 DUAL CIRCULAR B= 2 KHz	SKY SURVEY	8.E-26 **	CONT	"Suitcase SETI" as the backend of automated sky survey at 4 or 5 magic frequencies over a 5 year observing period.	

SUMMARY OF SETI OBSERVING PROGRAMS (JUNE 1984)

DATE	OBSERVER	SITE	INSTR. SIZE(m)	SEARCH FREQ. (MHz)	FREQ. RESOL. (Hz)	OBJECTS	FLUX LIMITS (W/m^2)	TOTAL HOURS	COMMENTS	REF.
1983	DAMASHEK	NRAO	92	390 +/-8	$2x10^6$	SKY SURVEY (PULSARS)	1.E-28	700	16 MHz sampled at 60 HZ; 8 contiguous frequency channels. Search for single dispersed pulses and telemetry (bit-stream) signals.	
1983	VALDES, FREITAS	HCRO	26	1516 +/-2.5	4.9 KHz 76	80 STARS 12 NEARBY STARS	3.E-24 ** 2.E-25	100	Search for radioactive tritium line from nuclear fusion.	
1983 & ON	GULKIS	DSS 43	64	8 GHz AND 2380 +/- 5 MHz	40 KHz	PARTIAL SOUTHERN SKY	2.E-22 **	800 & ON	Sky survey of constant declination strips (3 from -28.9 to -34.3 by April '83) whenever antenna stowed.	25.
1983 & ON	GRAY	SMALL SETI OBS.	4	1419.5 - 1421.5	40	SKY SURVEY & -27° δ	1.E-22 **	CONT	Dedicated search system constructed by amateurs, operated during evenings.	
1983 & ON	CULLERS	AMSETI	2	~1420 & < 1000	-	-	-	CONT (>1984)	Low noise GaAS FETS & micros with sattellite TV dishes, by Silicon Valley Hams, with NASA-Ames consultation.	
1983 & ON	STEPHENS	TERRESTRIAL RESEARCH INSTITUTE @ HAY RIVER NWT		1400 - 1700	30 KHz	SKY SURVEY	-	CONT	Surplus tropo-scatter dishes used as dedicated amateur SETI observatory.	
1984 ?	TROITSKIJ	USSR	1 X 100	1420	-	STARS & SKY SURVEY	1. E-19 **	CONT	Planned array of up to 100 dishes of 1m size. ??????????????????????	

*These experiments corrected frequencies for the motion of the observed stars with respect to the Local Standard of Rest.
**Quoted sensitivities refer to signal/noise ratio = 1.

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SITE ABBREVIATIONS

NRAO	National Radio Astronomy Observatory Greenbank, West Virginia Tucson, Arizona Soccorro, New Mexico
CSIRO	Commonwealth Scientific and Industrial Research Organization Epping, New South Wales Australia
NANCAY	Observatoire de Nancay Nancay, France
OSURO	Ohio State University Radio Observatory Columbus, Ohio
ARO	Algonquin Radio Observatory Ontario, Canada
NAIC	National Astronomy and Ionospheric Center - Arecibo Observatory Arecibo, Puerto Rico
WSRT	Westerbork Synthesis Radio Telescope Westerbork, The Netherlands
HCRO	Hat Creek Radio Observatory Castel, California
MPIFR	Max Planck Institut fur Radioastronomie Effelesberg, West Germany
HRO	Haystack Radio Observatory Westford, Massachussetts
	NASA Deep Space Network
DSS 14	Goldstone, California
DSS 43	Tidbinbilla, Australia
U. MASS	Five College Radio Astronomy Observatory Amherst, Massachussetts
KPNO	Kitt Peak National Observatory Tucson, Arizona