SETI: THE MICROWAVE SEARCH PROBLEM AND THE TARGETED SEARCH APPROACH

Charles L. Seeger and John H. Wolfe
NASA Ames Research Center, M/S:229-8
MOFFETT FIELD CA 94035 USA

ABSTRACT. The targeted search component of the NASA SETI program is limited to time sharing in the usual fashion on existing large radio telescopes. Unless the consequences of this restriction are compensated by increased capability in the SETI electronic systems, an undesirable loss in sensitivity must be accepted in order to prevent a more costly and humanly unattractive lengthening of the projected five-year observing program to a duration of some decades.

1. INTRODUCTION

The term - SETI - was concocted by participants in the 1975-76 Science Workshops on Interstellar Communication, chaired by Philip Morrison, to designate a conceptual program they had outlined for a passive microwave radio search for extraterrestrial intelligence (Morrison et al., 1977). SETI was adopted as program descriptor to distinguished this program and its rationale from the older and broader subject matter known as CETI, for communication with ETI (Sagan, 1973), which requires intentional transmissions on our part. Exploring for an ET signal bearing the mark of intelligence is one thing; deciding whether and what to communicate to a detected ETI species involves a host of considerations and responsibilities not relevant to passive exploration.

The present NASA SETI R&D program is a direct development of concepts enunciated by the Morrison Workshops. The goal is to design and field-test a scaled-down, fully-functional version of the larger systems envisioned for the late '80s, in order to carry out a bimodal exploration for ETI microwave signals. In a companion paper in this volume, Oliver has sketched the overall nature of the current R&D program. For a more detailed discussion of the projected microwave observing program (MOP), see the SETI Science Working Group Report (Drake, et al., 1983).

Though the exploratory philosophy of the targeted search has hardly changed since 1971 (Oliver and Billingham, 1973), some of the search strategies continue to evolve as research, new technology, and funding permit. Since the MOP is limited to time-sharing on large radio telescopes in the usual way, certain parameters will be influenced by the

M. D. Papagiannis (ed.), The Search for Extraterrestrial Life: Recent Developments, 391–395.

https://doi.org/10.1017/S007418090014673X Published online by Cambridge University Press

characteristics of the telescopes used and by the hours per telescope-year available for SETI. In this note we illustrate how this important limitation can affect the targeted search component of the projected microwave observing program.

2. THE TARGETED SEARCH

The plan for the targeted search calls for observation of at least the 773 F-G-K dwarf stars contained in the RGO catalog (Wooley, et al., 1970). These stars are scattered over the whole sky and would be observed with telescopes in the U. S. A., Puerto Rico, and Australia. The frequency range of primary interest (in the absence of strong, prohibitive radio frequency interference, RFI) is 1200-3000 MHz. This is near the low-frequency end of the terrestrial microwave window and is believed to be the most promising band for an initial, broadband exploration. The preferred duration of an observation is at least 10^3 s per star and instantaneous frequency band. This permits exceptional sensitivity to an interesting range of signals, pulsed or continuous, drifting in frequency or not (Drake, et al., 1984). The present design for the multichannel spectrum analyzer (MCSA) and accompanying signal processor (SP) has a unit instantaneous (frequency) bandwidth (UIB) of 8 MHz in each of two orthogonal polarizations. Greater instantaneous bandwidths may be achieved by paralleling these basic modules.

3. THE OBSERVING LOAD

How one distributes observations among the available large telescopes depends on the celestial positions of the target stars and on the fractional time available to SETI at each telescope. Since sensitivity is proportional to the effective area of the telescope, one naturally wishes to use the largest available telescope to observe all the stars within its sky coverage, using smaller telescopes for the stars larger telescopes cannot observe.

No agreements have been reached with respect to SETI-time on any large radio telescopes. But it is useful to consider the implications of the observing parameters given in Section 2 and the previous paragraph. By way of example, consider the following hypothetical scenario:

Site	Location	Ant. Dia. (m)	No. of Stars
Arecibo	Puerto Rico	305	243
DSS 43	Australia	64	172
OSU	Ohio	53 (equiv.)	305
DSS 14	California	64	53
			773 Total

https://doi.org/10.1017/S007418090014673X Published online by Cambridge University Press

For simplicity, assume no telescope time is used for moving telescopes from star to star, for re-observation, for system maintenance, or to deal with RFI problems. Then we can calculate the total time required on each telescope as follows.

$$T = (\Delta\nu/nB)\left(\tau S/3.1\text{x}10^{7}\right) \text{ years} \tag{1}$$

where, $\Delta\nu$ = total bandwidth to be searched .... and assume 1800 MHz

B = unit instantaneous bandwidth " 8 MHz

n = number of unit systems in parallel

S = number of stars observed

τ = time per star and unit inst. bandwidth " 10^{3} s

Using the values on the right of the table,

$$T = 0.00726(S/n) \text{ yr} \tag{2}$$

Thus, with but one 8 MHz system (n = 1), we would need more than these times:

Arecibo	1.76 years
DSS 43	1.25 "
OSU	2.21 "
DSS 14	.38 "

At present the Kraus/Dixon telescope at OSU (Ohio State Univ. Obs.) is dedicated entirely to SETI and the staff expects to concentrate heavily, but perhaps not exclusively, on SETI for a long time. With one 8 Mhz system installed and assuming 50% observing time efficiency, it would take about 4.5 years to complete the observations assigned to OSU in our purely hypothetical example.

The availability of the Deep Space Network's 64-meter telescopes is not clear, but it seems obvious to us that there is no realistic hope of getting sufficient time on these busy facilities even over a five-year period.

There have been informal suggestions that Arecibo might be willing to share perhaps 3% of its annual observing time to SETI. At 50% observing efficiency, to carry out Arecibo's share of this scenario would take on the order of 50-years, something quite unreasonable to contemplate.

4. SOLUTIONS

There are a number of possible solutions to this important SETI problem, a problem created by what one may rightly call an extended community of variously interested parties.

Here are a few suggestions, put forward to encourage others to think about what we believe is a matter of fundamental importance to SETI -- and to our efforts to understand the origin and prevalence of life in the universe.

1. Cut the observing time per star and unit bandwidth by a factor of ten. In our example this would reduce the demand on Arecibo from 70 to 7 years. Do the same for the demand on the 64-meter telescopes, and see if it is manageable.

2. Besides trying to raise the observing time efficiency somewhat, use ten (or perhaps a few more) 8 MHz MCSA/SP UNITS in parallel at Arecibo. This would require developing a broadband feed system for Arecibo, a concern given considerable study in recent years because of its astronomical importance quite aside from SETI. A similar approach might solve the 64-meter problem. With a sufficient number of parallel units, one assembly might be usable consecutively at both 64-meter telescopes.

3. The DSN 64-meter telwescope in Spain or the Bonn 100-meter telescope might be available to lighten the demand on DSS 14.

5. CONCLUDING REMARKS

There is no rational way to estimate the intensity of the strongest ETI microwave signal, if such exists. Since the days of the Cyclops summer study it has been widely held that the strongest received ETI signals are more likely to be very weak than strong, by terrestrial standards. It has also been held that one should avoid overbuilding. Hence the approach where one builds the best possible electronic systems and uses them with existing large antennas is a logical first step. If no signal is found, then is the time to build larger collecting areas, larger by a factor of ten or so. This stepwise process could be repeated until either success occurs, or more attractive ways arise to answer the fundamental question about life, or we decide that we are an extremely rare species in the universe and lose interest in further radio exploration.

Solution 1 is most unappealing to the two authors of this note, for we believe sensitivity is crucial to this exploration. One-hundred seconds is a mighty small sampling time per star. Eventually, much more may be required. Furthermore, we would lose sensitivity to certain types of signals that may represent our best hope for discovery when using present antenna systems -- signals produced by slowly scanning beacons.

Solution 2 is more attractive. Large scale integrated (LSI) circuit technology is leaping ahead and the cost of duplicating the efficient Peterson, Kok Chen, and Linscott electronic system architecture (Peterson, et al., in this volume) has dropped to the point where instantaneous bandwidths on the order of 100 MHz are not too costly to consider.

Stretching this initial stage of SETI over decades is most unattractive to competent participants and with respect to the overall cost of the program. We hope this note will encourage discussion soon of the matters raised here

REFERENCES:

Drake, F., Wolfe, J.H., and Seeger, C.L., (Eds.), SETI Science Working Group Report. NASA Technical Paper 2244 (1983)

Morrison, P., Billingham, J., and Wolfe, J., (Eds.),The Search for Extraterrestrial Intelligence: SETI. NASA SP-419 (1977), available from Ames Research Center, M/S 229-8, Moffett Field, CA 94035, and from the Government Printing Office. Reprinted, with trivial deletions, by Dover Publications, New York (1979)

Oliver, B.M., and Billingham, J., PROJECT CYCLOPS: A Design Study of a System for Detecting Extraterrestrial Life. NASA CR 114445 revised edition 1973.

Sagan, C., (Ed.), Communication with Extraterrestrial Intelligence (CETI). MIT Press, Cambridge, Mass., (1973)

Seeger, C.L., The Recognition of Extraterrestrial Artificial Signals. Proc.I.E.E.E., 13th Annual Asilomar Conference on Circuits, Systems, and Computers, Nov. 5-7, 1979; Conference Record, IEEE Catalog Number 79CH1468-8C (1980)

Sullivan, W.T.3rd, Brown, S., and Wetherill, C., Eavesdropping: The Radio Signature of the Earth. Science, 199, 377-388, 27 Jan. (1978)

Wooley, R., Epps, E.A., Penston, M.J., and Pocock, S.B., Royal Greenwich Observatory Catalogue of Stars within 25 Parsecs of the Sun. Roy. Observ. Ann., no. 5, Herstmonceux, England, 1970