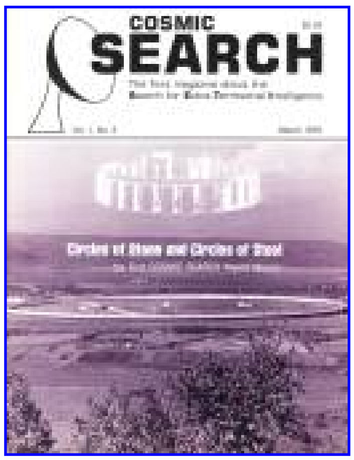
North American
AstroPhysical Observatory

North American AstroPhysical Observatory (NAAPO)



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The SEnTInel (SETI News)

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The Need for Protection of Frequencies for SETI

Contributed by Mark Stull and Charles Seeger

Over a century ago, Thomas Huxley wrote in Man's Place in Nature: "The question of questions for mankind—the problem which underlies all others, and is more deeply interesting than any other—is the ascertainment of the place which Man occupies in nature and of his relations to the universe of things. Whence has come our race; what are the limits of our power over nature and of nature's power over us; to what goal are we tending; these are the problems which present themselves anew and with undiminished interest to every man born in the world." The scientific exploration we call SETI (Search for Extra-Terrestrial Intelligence) speaks directly to this ancient question.

At present the most practical approach to SETI is to search for radio signals from other civilizations. Under these circumstances, the frequency band from 1400 to 1727 megahertz (MHz) is of unique value. Signals from other civilizations might be broadcast at any frequency, but it is within roughly this small fraction of the spectrum that we have the greatest ability to detect one. This is not a temporary technological situation. Rather, it is because this band lies in the frequency range where naturally emitted interfering cosmic background radiation (or noise) is least. A weak signal in this band might be detected while a stronger signal from the same civilization but at a frequency well outside this band might not be. Moreover, it is possible that extraterrestrial societies may deliberately choose this band for transmissions meant for detection by civilizations unknown because they, too, would realize not only that it lies in the frequency range where information transmission is most efficient, but also that it contains the prominent interstellar spectral lines of hydrogen and hydroxl, the decomposition products of water. If another water-based intelligent life form wished to call attention to itself, it seems an obvious place to advertise. Hence, this band had been dubbed "the waterhole."

By historical accident, the 1400 to 1727 MHz band is now largely free of terrestrial signals which would seriously impair SETI observations. In fact, SETI can easily share the waterhole with the many low-power earth-based transmitters currently using these frequencies, and spurious emissions from powerful transmitters outside the band may be the most annoying terrestrial sources of interference. But this happy situation is well on the way to changing drastically. There are already a few experimental satellites using the waterhole, and unless action is taken at the World Administrative Radio Conference (WARC) being held this year in Geneva, Switzerland, large numbers of satellite systems will be introduced during the eighties and thereafter. There is no necessity for the proposed, or for the existing, satellite seruices to use this band. Technically, there are other satisfactory bands. The present portions of the waterhole used for space-earth transmissions were allocated twenty years ago to possible future uses in the space service, long before such uses were defined and long before it was generally recognized that these frequencies were of unique value to SETI.

The upcoming WARC will have as its task the first complete revision in twenty years of the International Radio Regulations. These regulations are binding upon all members of the International Telecommunications Union (ITU). Whatever cooperative agreement is reached by the more than one-hundred-fifty nations which participate in the ITU, it will control worldwide spectrum usage for the remainder of this century and well beyond, because of the enormous investments involved in worldwide telecommunications systems. Thus, the 1979 WARC is an opportunity for SETI that must not be missed.

Present satellite use of the waterhole is relatively small. However, the maritime MARISAT system is slowly being brought into operation there, and the 24-satellite NAVSTAR, or GPS, system plans to use the band starting in the early eighties. Four prototype GPS satellites are already in orbit. Other major systems have also been proposed for the waterhole where, now, only a few meterorological [sic; meteorological] and other research satellites operate. The Federal Communications Commission (FCC), the civil radio spectrum authority in the United States, has tentative plans to open this band to television broadcasting. Beyond this, because of satellite economics and because of mankind's extraordinary lust for communication facilities, many other satellite systems will surely be developed. As a result, a huge investment in satellite systems will be made in the eighties and beyond, not only in the waterhole but throughout the microwave spectrum, and soon the earth will be surrounded by a brilliant man-made glare denying access to the universe from the surface of the earth over most of the microwave spectrum. This investment, perhaps as much as tens of billions of dollars, will create great economic pressure against an attempt at a subsequent WARC, to revise whatever allocations are devised in 1979. Certainly, any protection that might be given SETI in the waterhole at later WARC's would result in much greater economic dislocation.

Satellite uses of the waterhole today are few, and the design lifetime of orbiting transmitters is short (five to seven years), though construction for much longer lifetimes is planned for the eighties and thereafter. The need to replace equipment as it becomes obsolete provides an opportunity to engineer the new equipment to operate at a different frequency without incurring excessive costs. Then, too, a large fraction of present system equipment can be cheaply modified for operation in a neighboring or other appropriate band. Although SETI observations around the world are increasing in number and comprehensive programs are being planned, the level of expected activity can accommodate the present satellite transmissions in the band well into the mid-eighties and perhaps longer, if need be. Thus, if prompt action is taken now, a plan can be developed and implemented that will protect the waterhole while minimizing the impact on satellite services now in the band. Such a plan should bar new satellite systems from the waterhole and provide a timetable for those currently operational or in advanced stages of design to obtain alternate frequencies. It should be noted that this would insure compliance with United States telecommunications law which requires that, in the allocation of frequencies, public interest considerations, such as those that motivate a SETI program, prevail over economic ones.

The interest of mankind as a whole in SETI is large and growing. Countries as diverse as India, Japan, Canada, the Soviet Union, and the United States are either carrying out or considering SETI programs. The detection of the existence of another civilization in the universe would provide splendid motivation for humanity to reconsider its self-image and could provide strong impetus toward a more stable global political order. The very ideas inherent in SETI have sparked some established religious organizations to examine and expand their theologies. Moreover, for us to attempt to discover whether or not we are alone is indeed prudent, since earth has been announcing its presence strenuously for several decades through its television and radar stations. We are discoverable, and contact initiated by an extraterrestrial civilization, the presence of which had not been suspected, could be a profound surprise.

The last WARC at which there was a complete revision of the International Radio Regulations was held in 1959. Then an issue arose that was similar to that presented by SETI, but which probably lacked the broad popularity of the subject of extraterrestrial life. This was protection from interference for scattered parts of the spectrum for radio astronomy. The United States initially expressed barely nominal support, but a loose international coalition of astronomers, scientists, scholars, and others finally convinced the ITU after a modest but inspired campaign. Though somewhat embarrassed, the United States reversed its policy in mid-WARC, and has since been an effective supporter of the needs of radio astronomy. Many of the spectacular scientific achievements of radio astronomy would probably have not yet occurred, were it not for this essential protection by the nations of the world acting through the ITU. No small element in the success of the radio astronomers at the 1959 WARC was their appeal for the right of mankind to know, coupled with the obvious absence of considerations of private gain or national imperative that usually attach to demands for spectrum allocations.

SETI in the waterhole requires less protection and less total bandwidth than radio astronomy. But, like radio astronomy, without adequate international help it is more than likely that SETI at an effective level will have to be put off until it can be carried out from space sometime in the indefinite future and at great cost.

Wouldn't it be heart-lifting to see the United States, the dominant exploiter of the microwave spectrum for satellite telecommunications systems, lead the effort at the 1979 WARC to respect once again humanity's right to seek, now, its "relations to the universe of things"?

Those wishing to express their views about frequency protection for SETI should contact:

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and the Commissioners of the Federal Communications Commission:

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Life Believed to Originate in Space

Scientific theories of the origin of primitive life may be divided into two broad categories—those which say that life originated solely from combinations of elementary substances here on the earth, and those which say that some necessary substances were deposited on the earth from space. The "deposited" theory received a boost recently by Sir Fred Hoyle (well-known astronomer) and Professor Chandra Wickramasinghe of University College, Cardiff, Wales. They concluded recently that the relatively large organic molecules now known to exist in space were deposited on the earth by comets and meteors, and served as seeds for the development of life. This idea bodes well for SETI, because the seeds are everywhere in space, and would need only to encounter a planet at the appropriate time in the planet's history for life to begin.

Penzias (left) and Wilson. "A small discrepancy led them to the grandest of all possible answers."

Penzias and Wilson Receive Nobel Prize

Radioastronomers Arno Penzias, 45, and Robert Wilson, 42, have received a Nobel prize for their discovery of the 3 degree kelvin sky temperature associated with the Big Bang fireball which created the universe. Penzias and Wilson made their observations in 1965 at the Holmdel, New Jersey, site of the Bell Telephone Laboratories (BTL) where another BTL scientist, Karl G. Jansky, discovered radio waves of extraterrestrial origin in 1931.

Penzias and Wilson had measured a 3 degree excess in the temperature of their big horn antenna. They at first suspected its cause in some of the antenna's connections but finally concluded it was related to the creation of the universe. Their careful tracking down of a small discrepancy led them to the grandest of all possible answers.

Four radioastronomers are now Nobel laureates, the other two being Antony Hewish, 54, and Sir Martin Ryle, 60, of the Cambridge University, England, radio observatory — Hewish for his discovery of pulsars (see "Little Green Men, White Dwarfs and Pulsars" by Jocelyn Burnell in the January 1979 COSMIC SEARCH) and Ryle for his development of the aperture synthesis method of mapping radio sources. Hewish and Ryle received the prize in 1974; Penzias and Wilson were awarded theirs in the most recent ceremony (1978), receiving together half of the physics prize of $165,000, the other half going to the 84-year-old Russian physicist Peter Leonidovich Kapitsa for his research on materials at low temperatures.

Infinite Radio Ranges Not Possible

It is a widely accepted fact of nature that signals having a narrow bandwidth can be transmitted and received over greater distances than signals having a wide bandwidth. This leads one to the conclusion that intelligent civilizations trying to contact one another across interstellar distances by radio would use the narrowest bandwidth that they could possibly achieve. If the minimum achievable bandwidth is known, one can calculate the ranges that might be attained between two civilizations, making reasonable estimates of their transmitter powers and antenna sizes.

Heretofore it has been believed that this minimum achievable bandwidth was based primarily on the technological skills of the civilizations involved. It is technologically difficult, for example, to build receivers and transmitters that do not wander around slightly in frequency, thereby requiring the receiver bandwidth to be at least as wide as the maximum wandering width. Another technological difficulty is that of trying to compensate exactly for the Doppler frequency shifts caused by motions of both the receiver and transmitter through space. Any inexactness in compensating the Doppler shifts requires that the bandwidth be at least as wide as the resulting frequency errors. It would seem reasonable then that more and more advanced civilizations would in time be able to do better and better jobs of solving these technological problems, so that their minimum achievable bandwidths, and hence their maximum ranges should increase indefinitely, with no particular ultimate limit. The great significance of this is that all civilizations could ultimately be within range of each other.

Recently, however, Frank Drake and George Helou of the National Astronomy and Ionosphere Center (N.A.I.C.) at Cornell University have shown that there is an intrinsic property of the turbulent dust and gas between the stars that sets an absolute minimum to the achievable bandwidth.* [*N.A.I.C. Reports 75 and 76.] Although this gas is exceedingly thin, interstellar distances are so very large that a radio signal traveling through the gas is gradually split up into many separate signals, each of which arrives at the receiver at a slightly different time and frequency. This situation is analogous in its effect to long range voice communication in a giant room or mountain chasm. You hear multiple echos so closely spaced that they all blend together, making it difficult to understand what is being said. As you might expect, this effect gets worse at longer range, because there is more intervening gas. The net result of all this is that interstellar signals are going to have a bandwidth of at least 0.01 hertz from nearby stars, and 0.1 hertz from more distant ones, so there is no advantage for SETI in trying to push technology beyond that point.

A not-so-obvious property of this gas-caused minimum bandwidth is that it also depends on what frequency is used. Higher frequencies permit smaller bandwidths. If this effect is entered into calculations of the optimum frequency to use for SETI, Drake and Helou arrive at about 70 gigahertz (wavelength about 4 millimeters) which is significantly higher than that commonly advocated and searched. The earth's atmosphere makes ground based SETI programs at that frequency difficult but this obstacle can be overcome by making observations from above the atmosphere. Drake and Helou recommend that frequencies in the vicinity of 70 gigahertz be included in the list of those to be ultimately searched.

Ultra-Narrowband SETI

Soon after the lower limit to the bandwidth that can be used for SETI was calculated by Drake and Helou, Paul Horowitz of Harvard University actually used this minimum bandwidth.* [*"Science" Aug. 25, 1978.] With a bandwidth of only 0.015 hertz, he employed the 305-m diameter dish antenna at Arecibo, Puerto Rico to listen in the directions of 181 nearby stars. Each star was examined for eight minutes, searching for ultra-narrowband signals near the hydrogen line (1420 megahertz), assuming that the transmitting civilization had doppler-corrected their signals specifically for our solar system. Horowitz observed a total bandwidth of 1 kilohertz, and recorded this on magnetic tape. At a later time, the tape was played back into a computer which divided the original 1 kilohertz bandwidth up into 65,536 different channels, each 0.015 hertz wide. This is the narrowest bandwidth ever used for SETI purposes, and as a result this search is the most sensitive ever made of those stars.

No signals were detected, but Horowitz has successfully demonstrated that it is now possible for man to use the minimum useable SETI bandwidth. He also makes the point that narrow bandwidth, together with his doppler correction techniques, are an answer to part of the problem of interference from man's own transmitters. A man-made transmission can easily be distinguished from an alien signal with Horowitz's techniques, which keeps the false alarm rate within reason. Nevertheless, a man-made signal will still blind the radio telescope to alien signals that might exist at the same frequency.

A New Type Of Dish Antenna

When something has been around as long as the dish antenna, you wouldn't think there would be anything new to say about it. Not so! Sebastian Von Hoerner of the National Radio Astronomy Observatory in Green Bank, West Virginia, has come up with a method of designing dish antennas which provides greater sensitivity and less noise pickup.* [*Institute of Electrical and Electronic Engineers, Transactions on Antennas and Propagation, May 1978.] Rather than using the traditional parabolic shape for the main reflector his method uses an unusual asymmetrical shape having several different curvatures. One of the prime motivations for his design was its potential use in SETI systems.

SETI Considered Enterprising

The Rolex Company of Geneva, Switzerland, celebrated the 50th anniversary of their enterprising invention of the world's first waterproof watch case, by sponsoring a competition to pay tribute and give tangible support to the human Spirit of Enterprise. Entrants were required to submit detailed proposals and descriptions of their enterprising projects. Over 3000 applicants from around the world entered in the three categories: Applied Science and Invention, Exploration and Discovery, and the Environment. Of these, 131 were selected for special description in a book just published, entitled "In the Spirit of Enterprise" (Freeman, 1978). One of the selected projects is "Searching for Extraterrestrial Intelligence," submitted by Dr. Richard M. Arnold of the Bell Telephone Laboratories in

Columbus, Ohio. Dr. Arnold is also an active participant in the ongoing SETI program at the Ohio State University Radio Observatory. His proposal describes the current observing project, explains how it is being carried out largely by volunteers such as himself, and points out how its detection range could be substantially increased by only modest expenditure. His proposal ends with the observation—"Nothing less than the question of our place in space and time is at stake."

Navy Takes Over NRAO Interferometer

The 2700-m three-element interferometer of the National Radio Astronomy Observatory (NRAO), Green Bank, W. Va., is now being operated by the Naval Research Laboratory, Department of the Navy. From the completion of the last of the three telescopes in 1968 until September 30, 1978, the site was operated by Associated Universities, Inc., under National Science Foundation sponsorship.

The Navy Research Laboratory plans to maintain operation of the site for one year as a time-keeping instrument. A polar motion study is presently underway.

The first of three stations of the interferometer, the 85-ft. Howard Tatel telescope, was used by Frank Drake in 1960 to conduct the first SETI search, Project Ozma (see "A Reminiscence of Project Ozma," in the Jan. 1979 COSMIC SEARCH).
