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SEARCHING FOR GOOD SCIENCE: THE CANCELLATION OF NASA'S SETI PROGRAM

STEPHEN J. GARBER
NASA History Office, Code ZH, Washington, DC 20546-0001, USA

On Columbus Day, 1992, the National Aeronautics and Space Administration (NASA) formally initiated a radio astronomy program called SETI (Search for Extraterrestrial Intelligence). Less than a year later, Congress abruptly canceled the program. Why? While there was and still is a debate over the likelihood of finding intelligent extraterrestrial life, virtually all informed parties agreed that the SETI program constituted worthwhile, valid science. Yet, fervor over the federal budget deficit, lack of support from other scientists and aerospace contractors and a significant history of unfounded associations with nonscientific elements combined with bad timing in fall 1993 to make the program an easy target to eliminate. Thus SETI was a relative anomaly in terms of a small, scientifically valid program that was canceled for political expediency.

1. INTRODUCTION

Humans have always had a curiosity about whether we are unique or whether other intelligent life forms exist elsewhere in the Universe. After some preliminary ideas in the early twentieth century, scientists formulated a new approach to answering this question in 1959 by using radio astronomy to "listen" for signs of extraterrestrial intelligent life. In 1975, the National Aeronautics and Space Administration (NASA) began funding definition studies for the Search for the Extraterrestrial Intelligence (SETI) programme. After progressing at a low level of funding (cf. Appendix A) for a number of years, on Columbus Day in 1992 NASA began what was to have been a ten-year, $100 million formal SETI effort that had been renamed the High Resolution Microwave Survey (HRMS). Less than a year later, in 1993, Congress seemingly abruptly cancelled the HRMS programme, though some of the scientific efforts continued with private funding.

Why did the NASA SETI/HRMS programme, hereafter referred to simply as the SETI programme, fail? While there was, and still is, a debate over the likelihood of finding intelligent extraterrestrial life, virtually all informed parties have agreed that the SETI programme constituted worthwhile, valid science. A number of political factors, however, combined to kill the programme. Fervour over the federal budget deficit, lack of support from other scientists and aerospace contractors and a significant history of unfounded associations with nonscientific elements, combined with bad timing in fall 1993 to make the programme an easy target to eliminate. Thus, SETI was a relative anomaly in terms of a small, scientifically valid programme that was cancelled for pure political expediency.

ACRONYMS

DSN	Deep Space Network
ETI	ExtraTerrestrial Intelligence
FY	Fiscal Year
HRMS	High Resolution Microwave Survey
JPL	Jet Propulsion Laboratory
MOP	Microwave Observing Project
NAS	National Academy of Sciences
NASA	National Aeronautics and Space Administration
NSF	National Science Foundation
SETI	Search for ExtraTerrestrial Intelligence (also used to refer to NASA's SETI/HRMS program)
TOPS	Toward Other Planetary Systems

2. SEARCHING FOR SIGNALS OF EXTRATERRESTRIAL INTELLIGENCE - A BRIEF HISTORY

Even before the space age, scientists and engineers have pondered ways to answer the question, Are we alone? In the early twentieth century, radio pioneers such as Heinrich Hertz, Nikola Tesla, and Guglielmo Marconi foresaw the possibilities of using radio waves for "interplanetary communication," as it was called at the time. After observing some unusual radio signals, Marconi tried to determine whether they came from Mars, causing a considerable public stir in 1919. Elmer Sperry, head of the Sperry gyroscope company, proposed using a massive array of searchlights to send a beacon to Mars, and even Albert Einstein suggested that light rays might be an easily controllable method for extraterrestrial communication [1].

The age-old question about whether intelligent life exists beyond Earth reached a turning point in 1959. That year, Giuseppe Cocconi and Philip Morrison published a seminal paper [2] in which they suggested that the microwave portion of the electromagnetic spectrum would be ideal for communicating signals across the tremendous distances in our galaxy. A narrow-band frequency could be beamed long distances with relatively minimal power and signal interference, they theorized. Radio waves travel at the speed of light and are not absorbed by cosmic dust or clouds. Thus, if scientists tuned radio telescopes (large antennae with attached receivers) to the right portion of the spectrum, it could be possible to detect a pattern indicating extraterrestrial intelligence. Indeed, our own radio and television broadcasts had been drifting into space for a number of years. While we might pick up such unintentional extraterrestrial signals, Cocconi and Morrison primarily hoped to find a message deliberately sent by other intelligent beings.

Independently of Cocconi and Morrison, a young astronomer named Frank Drake had also been contemplating using radio astronomy as a way to search for extraterrestrial signals. He decided to test this approach by setting up some rudimentary equipment at the Green Bank Observatory in West Virginia. While listening to emissions from two nearby stars for two months in 1960 during "Project Ozma," Drake was startled when he noticed a non-random pattern that potentially indicated ETI. After checking his results, he realized that it was a terrestrial pattern, namely a secret military radar. Drake has gone on to be one of the leading figures in this field.

While radio waves in the microwave portion of the spectrum seemed to be the logical place to look for extraterrestrial signals, this still left a broad range of frequencies. Drake, as well as Cocconi and Morrison, speculated that the best area would be near the natural spectral emission of hydrogen, the most common element. Soon afterward, scientists adopted a strategy of looking in the "water hole" portion of the spectrum between the natural emission lines of hydrogen and hydroxyl (OH), components of water, since water is assumed to be essential for life [3].

In 1961, Drake gathered a small group of astronomers and various other scientists at Green Bank for probably the first serious conference on SETI. These ten attendees later called themselves members of the *"Order of the Dolphin"*, a reference to a discussion they had about the intellectual capabilities of these animals and the evolutionary likelihood of intelligent life. In trying to come up with an agenda for this meeting, Drake formulated what became known as the Drake Equation, a formula that estimates the number of potential intelligent civilizations in our galaxy. The equation reads

$$N = Rf_p n_e f f_i f_c L$$

where N is the number of detectable civilizations in space.

Variable	Definition
R	the rate of star formation
f_p	the fraction of stars that form planets
n_e	the number of planets hospitable to life
f_l	the fraction of these planets on which life actually emerges
f_i	the fraction of these planets on which intelligent life arises
f_c	the fraction of these planets with intelligent beings capable of interstellar communication
L	the length of time such a civilization remains detectable [4]

When running the numbers himself, Frank Drake calculated N to be approximately 10,000. This just considers the Milky Way Galaxy [5], one of "billions and billions" of galaxies in the universe. As later critics pointed out, scientists only have some hard data on one of these variables; all the rest continue to be just rough estimations. Nevertheless, Drake devised the equation simply as a starting point to think about searching for extraterrestrial signals.

In the late 1960s, John Billingham, who worked at the NASA's Ames Research Center, began efforts to get NASA involved in SETI. Billingham had been trained as a medical doctor and had previously done biomedical and life sciences work for NASA such as designing the liquid-cooled inner garment for the Apollo spacesuits. In 1971, Billingham and Bernard Oliver, a former vice president of research at Hewlett-Packard Corporation with a long-standing interest in SETI searches, authored a detailed NASA study [6] proposing an array of 1,000 100-meter telescope dishes that could pick up routine television and radio signals from neighbouring stars. Project Cyclops, as it was called, was never adopted, in large measure because of its tremendous $10 billion price tag. An especially unfortunate effect was that some people thought that the Cyclops report implied an "all or nothing" approach and thus SETI got nothing for several years [7].

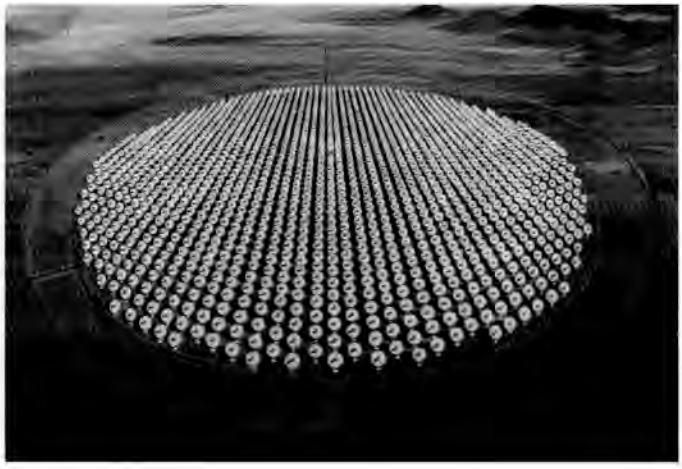

Fig. 1 Artist's rendering of the Cyclops system. Project Cyclops was a study carried out in 1971 for detecting signals from extraterrestrial intelligent life. In this artist's conception, the array of the antennas is seen as though from an aircraft flying at some distance from the site. The diameter of the whole array would have been about 16 km.

Four years after this unintended setback, NASA managers judged that the relevant science and technology was mature enough to merit additional investigation. Thus, in 1975, NASA began funding some design studies under the leadership of Philip Morrison of the Massachusetts Institute of Technology, who had co-authored the seminal *Nature* paper in 1959. The next year, managers at NASA's Ames Research Center established a SETI branch and scientists and engineers at the Jet Propulsion Laboratory (JPL) also started SETI work. Ames had experience in biomedical research while JPL had experience tracking deep space missions and could use its Deep Space Network antenna for radio astronomy.

One might trace the programme's troubles in Congress back to 1978. That year, while still receiving a relatively low level of funding (Appendix A), Senator William Proxmire bestowed one of his infamous "Golden Fleece" awards on the SETI programme, deriding it as a waste of taxpayer money. In 1981, a Proxmire amendment killed programme funding for the next year. Proxmire viewed the SETI programme as a silly search for aliens that was unlikely to yield results.

At this point, Carl Sagan, a well-known astronomer, stepped in and offered to talk to Senator Proxmire. Proxmire agreed and Sagan, who had previously dealt with him on "nuclear winter" issues, was able to convince him of the scientific merits of the programme. Proxmire agreed not to oppose SETI and Congress reinstated funding the next year, fiscal year 1983 (FY 83).

While NASA's small SETI programme was progressing throughout the 1980s, several private SETI searches were also under way. The Planetary Society, which Sagan had helped found, provided some money to two JPL researchers to conduct SETI observations at a NASA tracking station in Australia. The Society also partially funded Paul Horowitz, a Harvard University astronomer, who used some old antennae and computers to build a portable system called *"Suitcase SETI"*, which he transformed into Project Sentinel and then the Megachannel Extraterrestrial Assay. Various other projects included "Serendip" at the University of California at Berkeley and the University of Ohio's "Big Ear" programme. In 1984, the non-profit SETI Institute was founded in California.

Internationally, there was also interest in searching for ETI signals, particularly from scientists in the former Soviet Union. International conferences were held in 1971 and 1981 in Armenia and Estonia, due in part to the interest of Soviet luminaries Iosif Shklovsky and Nikolai Kardashev. In 1965, Soviet scientists had detected a signal with the apparent hallmarks of ETI but American scientists determined that it was the result of a naturally occurring phenomenon called quasars. In case they had not before, SETI scientists worldwide quickly realized the importance of double checking their results with colleagues before making any grand pronouncements [8].

In 1988, NASA Headquarters formally endorsed the SETI programme and technicians began to build the necessary hardware. Simultaneously, the Solar System Exploration Division at NASA Headquarters established a working group to form a strategy for finding other planetary systems. This led to Towards Other Planetary Systems (TOPS) workshops in 1990 and 1992.

By this time, SETI researchers had been growing anxious to begin their search, not only because the preliminary studies had taken many years but because of a technical reason: an increasingly clouded radio spectrum. New commercial communications satellites threatened to create a significant noise problem in the same part of the spectrum where SETI scientists concurred that chances were best to detect extraterrestrial signals. This cluttering was likely to worsen so there was an impetus to start full-fledged *"listening"* quickly.

While the SETI programme had always suffered from a "giggle factor" that wrongly associated it with searches for "little green men" and unidentified flying objects (UFOs), the Congressional rhetoric heated up in 1990. The Bush Administration requested $12 million for the programme in FY 91, up from $4.2 million in FY 90, to start a full-fledged Microwave Observing Project (MOP) search. Congressman Ronald Machtley (D-RI) declared "We cannot spend money on curiosity today when we have a deficit" [9]. Silvio Conte (R-MA) stated that he didn't want to spend millions of dollars to find evidence of ETI when one could spend *"75 cents to buy a tabloid* [with reports of aliens] *at the local supermarket"* [10]. Perhaps the programme was lucky to end up with $11.5 million for FY 91.

In response to continued jibes and the *"giggle factor"* associated with SETI, NASA slightly restructured the programme and prepared to start its new search, formally called the High Resolution Microwave Survey (HRMS), on 12 October, 1992, precisely 500 years after Columbus had "discovered" North America. Informed rumour had it that a key Senate staffer told NASA to rename the programme from MOP. In addition to doing so, NASA moved HRMS to its Solar System Exploration Division (previously the SETI programme had resided in the Life Sciences Division) and made it part of the TOPS programme. The House Authorizing and Appropriations Committees, along with the Senate Authorizers, tried to cancel the programme but it was saved by the Senate Appropriations Subcommittee, in part as a favour to Senator Jake Garn, who had flown on the Space Shuttle and waxed eloquently about his religious convictions in ETI [11].

Despite this shaky footing, HRMS was allocated $12 million for the next year (FY 93) as part of a ten-year, $100 million programme. The programme included two main components: the targeted search and the all-sky survey. NASA Ames managed the targeted search component, which was conducted at the over 300-meter radio telescope in Arecibo, Puerto Rico, and was meant to focus on emissions from those nearby stars that scientists viewed as most promising for ETI signals. JPL scientists managed the all-sky survey, which used its Deep Space Network dish to scan the entire Milky Way.

After almost a year of HRMS operations, the programme hit a political wall when a prominent political opponent sensed an opportune time to strike. On 22 September, 1993, Senator Richard Bryan (R-NV), a noted SETI critic, offered a last-minute amendment to kill the programme and the full Senate concurred. A House-Senate conference committee approved the Senate plan, which included $1 million for programme termination costs. Bryan issued a press release saying *"This hopefully will be the end of Martian hunting season at the taxpayer's expense"* [12]. Seemingly out of nowhere, NASA's SETI efforts were dead.

While greatly disappointed, programme personnel moved quickly and with resolve to continue SETI with private funding. Barney Oliver successfully led an active campaign to raise money from a number of wealthy Californians in Silicon Valley he knew from his days at Hewlett-Packard. A number of scientists moved over to the non-profit SETI Institute, which had acted as a NASA contractor for a number of years. The SETI Institute raised $7.5 million to cover costs of operating only a targeted search through June 1995 [13] and began the

Fig. 2 Barney Oliver speaks at ceremonies marking the formal start of the HRMS program. From left to right are John Billingham, an unidentified Puerto Rican official, Oliver, and John Rummel. This photo was taken on October 12, 1992 by Seth Shostak.

Fig. 2 HRMS observations begin on October 12, 1992. Photo by Seth Shostak.

appropriately titled *"Project Phoenix"*, which continues today. The all-sky survey, which had used NASA JPL's equipment, was discontinued, as was the ten-year HRMS plan and was replaced by the less comprehensive observations that the SETI Institute could make contingent upon the vagaries of continued private fundraising. While the cancellation of NASA's SETI programme did not end all research in this area, it significantly limited the amount of science that researchers could accomplish.

3. THE SCIENCE OF SETI

The first step in assessing scientific value is usually peer review. Do other knowledgeable scientists agree that the researchers' questions and methods of inquiry reflect proper scientific method? If so, then the results are usually accepted and further research is encouraged. NASA's SETI programme generally received high marks on this score. A 1991 National Academy of Sciences (NAS) working paper done by the Radio Astronomy Panel concluded that even though SETI was not formally a radio astronomy programme, it contained exciting, valid science. The panel therefore recommended establishing a complementary university-based research programme to help NASA develop search algorithms and signal processors [14]. Similar NAS studies in 1982 and 1972 concluded that SETI was an exciting, worthwhile scientific programme. In 1982, the journal *Science* published a petition put together by Sagan that was signed by numerous prestigious scientists, including biologists and biochemists such as Stephen Jay Gould, David Baltimore, and Linus Pauling [15].

When the discussion stayed on a serious scientific level, the SETI programme was viewed favourably in large measure because those scientists who thought about such matters had reached a strong consensus years ago about the how, where and when to search for signals. Furthermore, their reasoning was relatively transparent to scientists from other disciplines and the general public. Sagan even explained the SETI game plan to the public in an article that made the cover of *Parade* magazine [16]. SETI scientists agreed that a narrow-band signal in the radio portion of the microwave spectrum provided the most "bang for the buck" in terms of travelling furthest with a minimum of power. Narrowing searches down to the "water hole" region also made common sense. While other search methods might develop later, in the late 1980s and early 1990s, SETI scientists were especially eager to start searching in earnest because the formerly quiet microwave spectrum was quickly becoming jammed by the noise of new commercial communications satellites. In short, no major scientific organization seriously disputed SETI's scientific approach.

Still, scientific skeptics tried to play on the fact that nobody had any solid idea about what the odds were of an intelligent civilization existing elsewhere in the cosmos. Even if there was intelligent life elsewhere, what was the possibility that these beings could beam a message to us that we could pick up and understand? If we on Earth were just guessing at these probabilities or the probabilities were low, why bother looking at all? Ernst Mayr, a prominent biologist who believes that the evolution of intelligent life on Earth was the result of incredibly long odds, casts aspersions on the idea of searching for ETI signals.

Mayr has gone through the Drake Equation and assigned probabilities to conditions relating to the individual variables. He believes that only two such conditions have probable likelihoods: that extraterrestrial life is able to originate repeatedly and that other habitable planets similar to Earth exist. All the other conditions he rates as improbable, with the exception of extraterrestrial life adapting toward higher intelligence, which he rates as highly improbable. Coming from his background as a staunch supporter of Darwinian evolution, Mayr notes that life on Earth is thought to have originated 3.8 billion years ago, while intelligent life on Earth only began about half a million years ago. If the *"evolutionary soup"* was a few degrees hotter or colder at any one point, we would not be here at all, goes Mayr's argument. Even if ETI did develop, Mayr argues that a particular intelligent civilization probably would not have the ability to communicate through space. His reasoning is that over the past 10,000 years there have been at least twenty or so distinct civilizations on Earth (ancient Greeks, Mayans, Europeans, etc.) and only one of them has achieved this technological capability [17].

Put another way, Mayr has argued that since the beginning of life on Earth, approximately 50 billion species have evolved but only one has developed technology. In his Darwinian terms, "If intelligence has such high survival value, why don't we see more species develop it" [18]? Back in 1961, however, the members of the "Order of the Dolphin" concluded that intelligence did indeed have a high survival value, as shown by the intelligent behaviour of species such as dolphins [19]. While dolphins assuredly are not interested in astronomy, there is another variable, f_c, in the Drake Equation to calculate the fraction of intelligent species who develop the technological means for interstellar communication. Mayr overlooks this aspect and attacks SETI, calling it *"hopeless"*, *"a waste of time"*, and says that *"We have to deal with realities—not pipe dreams"* [20].

Fig. 3 The Arecibo telescope. This photo was taken on October 12, 1992 by Seth Shostak.

Fig. 4 One of the Deep Space Network (DSN) radio antennae used in the SETI program. The photo shows the research and development station, DSS-13, at the Goldstone Deep Space Communications Complex in Goldstone, CA on October 16, 1992. This station was the first DSN antenna to use a *"beam waveguide"* to focus and track multiple radio frequencies.

Sagan responded to these comments by allowing that while the probability of ETI may be low, he quoted his 1982 *Science* petition: "No *a priori* arguments on this subject can be compelling or should be used as a substitute for an observational programme" [21]. Sagan also attacked Mayr for effectively suggesting that *"biologists know better"*, noting that because "the relevant technologies involve the physical sciences, it is reasonable that astronomers, physicists and engineers play a leading role in SETI" [22]. Indeed, as this article points out, Sagan had a relatively unique position as an astronomer with at least some experience in biology, having served as a research assistant in the laboratory of the Nobel Prize-winning geneticist Hermann J. Muller.

Mayr turned this argument around by claiming that while common sense dictates that the existence of ETI cannot be established by *a priori* arguments, *"this does not justify SETI projects, since it can be shown that the success of an observational programme is so totally improbable that it can, for all practical purposes, be considered zero"* [23]. Similarly, in the fall of 1993, Congressional critics such as Senator Bryan noted that despite almost one full year of HRMS operation and almost two decades of a NASA programme, SETI had failed to find any "little green men." True, the HRMS operation had found no ETI signals after scanning only a small fraction of the sky but this was planned as a ten-year programme. Sagan argued that Mayr's, and hence Bryan's, line of thinking was the closed-minded equivalent of believing that the Earth is at the center of the universe. Ultimately, however, Sagan noted that arguing over the relative probability of receiving an ETI signal is fallacious - we won't know whether there are any signals until we seriously look for them [24].

Another line of thinking suggests that instead of looking for ETI signals, we might well sit back and wait for a more advanced extraterrestrial civilization to visit us directly.

After the Manhattan Project scientists had developed the atomic bomb, Enrico Fermi is reported to have said *"Where are they?"* By this, Fermi meant that surely we weren't the only ones to have developed high technology, so why hadn't other extraterrestrial civilizations left signs of their existence? Because our Sun is a medium age star, SETI researchers believe that if another ETI civilization exists, it stands a good chance of having existed for longer than we have and thus be more advanced technologically. The Fermi Paradox is partly premised on the notion that such advanced ETI civilizations would naturally expand into and colonize space [25].

Yet perhaps other civilizations would only colonize areas of space near themselves, but still very far from us. Bernard Oliver, among others, refutes Fermi's Paradox, arguing that interstellar travel would be quite difficult, even for a highly advanced civilization, because of immense power requirements [26]. Perhaps they would not colonize at all, for a variety of reasons, including the relatively young state of their technology - just as we have not colonized space yet. John Ball, an astronomer at the Massachusetts Institute of Technology, suggests another possibility, the *"zoo hypothesis"*: that alien civilizations are simply content to watch us from afar [27].

Whether or not distant civilizations could somehow travel directly to us, the efficiency of radio signals makes that form of indirect communication much more likely. Beyond listening for deliberate signals, SETI scientists could conceivably find extraterrestrial transmissions that weren't meant for us, just as our radio and television signals have been leaking into space this century. As Fermi himself realized, the Fermi Paradox may be interesting to contemplate, but it really offers no evidence one way or the other about the existence of ETI [28].

Skeptics such as James Trefil and Robert Rood, who try to calculate how long colonization of the galaxy would take, take another cut at the problem. Trefil, a physics professor at George Mason University, and Rood, an astronomy professor at the University of Virginia, analyzed the Drake Equation and calculated the chances of other life in the Galaxy at three per cent. Trefil and Rood believe that if we can almost build space colonies now, an extraterrestrial civilization would have done so long ago, due to diminishing resources and crowding on their home planet. They theorize that such colonization further and further into space would continue exponentially through the generations. Thus, in 30 million years, the whole galaxy would be colonized. Assuming the universe is billions of years old, this would be a mere blip on the cosmic timeline [29]. So, again, where are they? For the record, Sagan calculated the length of time it would take a civilization to colonize the galaxy as 5 billion years [30].

Yet even cynics such as Trefil and Rood see value in ETI searches. Trefil believes in the value of technological spin-offs while Rood heralds SETI as "a great intellectual adventure into our own origins" [31]. Former Senate staffer Kevin Kelly, a less than enthusiastic SETI programme supporter, felt strongly that the educational component alone, which could get children and their parents excited about science, virtually justified NASA's SETI programme [32]. In terms of spin-offs, the Federal Aviation Administration showed interest in adapting SETI frequency analyser technologies for air traffic control purposes while the National Security Agency was curious to learn about new techniques in eavesdropping and code-breaking [33].

While not vocal supporters of the SETI programme, many other scientists felt that a $10 million annual investment was probably worthwhile. For example, Zen Faulks, a University of Victoria biologist, argued that *"The incredible improbability of alien intelligence should be taken into account when deciding how much of our effort SETI should occupy, but I would be disheartened to see the search stopped...The fallout for all the sciences, especially the biological sciences, would be so gargantuan if we did contact an alien intelligence...that it seems foolish to abandon the entire affair"* [34].

At bottom, it could be argued that some of what scientists investigate is based on fundamental beliefs, hunches, or faith that the world works in some logical way. Deciding what is logical when we have little information may be a leap of faith. Thus, Rood has made the interesting argument that the majority of the population that believes in extraterrestrial life may do so because of a psychological need to believe this [35]. Even if true, this should in no way taint the search for ETI however, as no responsible scientist has yet claimed to find any, just that it is worth looking. Interestingly, Rood has gone on to conduct SETI research himself in the belief that, while it is unlikely that we will find ETI, it is still worth looking since theorizing can't prove or disprove their existence [36].

Moreover, SETI researchers fully comprehend and appreciate the need to double and triple check any potential signals from ETI in case a simpler phenomenon, whether terrestrial or non-terrestrial, could be the explanation. In addition to this application of the standard scientific principle of *"Occam's Razor"*, an internationally adopted "contact" protocol calls for data of a potential ETI signal to be widely publicized so that other scientists may scrutinize and validate it [37].

Even though SETI scientists are wary of publicizing a strange signal too soon for fear of *"crying wolf"*, the basic scientific logic is simple: something that can not be explained by conventional terrestrial or cosmic sources merits further investigation. As longtime SETI scientist Jill Tarter says, *"It's not a matter of being able to define what identifies intelligence. What constitutes 'credible evidence' is being unable to explain a signal — which you also can't make go away — by any known astrophysics or technology"* [38]. Again, SETI researchers have long been aware of the perils of debating their programme at the "little green men" level and have taken pains to stick to traditional scientific methods of inquiry.

In addition, many SETI researchers caution that they may not discover an ETI signal any time soon. Although those such as Drake continue to be very optimistic, simultaneously most researchers know that, by its very nature, the length of a comprehensive search is very hard to predict. While signal processing and other computer technology has continued to change rapidly, NASA's SETI programme was a classic example of basic science whose results would hopefully pay off, but when and how was anyone's guess. Programme scientists also noted that if a definitive search produced no signs of ETI, this negative result would be very

important. While HRMS certainly was not a definitive search, it was tens of thousands of times more comprehensive than any previous efforts. Yet, as Jill Tarter noted, the programme was in the unenviable position of having to petition Congress for more funding based on previous "failures" [39].

Unfortunately for SETI, even John Gibbons, President Clinton's science advisor, demonstrated a surprising misunderstanding of the nature of SETI. In February 1994, he opined, *"we've done a lot of observing and listening (for alien signals) already, and if there were anything obviously out there, I think we would have gotten some signal (by now)"* [40]. Gibbons made these comments after Congress had already cancelled funding for SETI, so it is possible he was posturing after the fact. Nevertheless, either nobody properly briefed Gibbons or he was never interested enough to learn anything about SETI.

The SETI programme thus suffered politically from the fact that it couldn't guarantee any major short term results. While basic science has often been linked with *"big science"*, ironically enough SETI was an efficient, relatively small programme in basic research that logically might have fit in well with politicians' desire to extract more *"bang for the bucks"* that were invested in it.

Indeed, it is well known that few scientists or engineers serve in Congress. One analysis of the membership of the 103rd Congress by a SETI scientist showed that it contained more former undertakers (four) than former scientists (one) or engineers (three) [41]. This one former scientist, Congressman George Brown, did call SETI *"valid science"* [42]. Yet, shouldn't science be accessible and understandable not just to scientists but to the lay community as well? If war is too important to leave to the generals in a democratic society, should science be left strictly to the scientists?

Finally, in considering the overall scientific quality of the SETI programme, it may be worth asking whether the cancellation of Congressional funding in 1993 really was a defeat for the programme. Ironically, it is possible that SETI researchers are better off under Project Phoenix without the capricious vagaries of annual Congressional appropriations and the bureaucratic government oversight. While the SETI Institute began private fundraising almost immediately after Congress terminated the NASA programme, this was not so remarkable in its broader context. Although programme people and supporters were surprised by the timing of Senator Bryan's parliamentary tactics, they were certainly aware of the programme's long history of political problems and had to have been making contingency plans. More importantly, while the targeted search has continued under Project Phoenix, the all-sky survey was cancelled.

Thus, it seems clear that the scientific scope of SETI research was compromised by the cancellation of Congressional funding in 1993. If the scientific content of the programme was valid, why then was the programme cancelled?

4. THE POLITICAL STORY BEHIND THE CONGRESSIONAL CANCELLATION

The SETI programme represents a relatively unique case study. By all accounts, it was a programme that was on budget, properly managed, scientifically valuable, and had a relatively small budget for such a science or technology project. By contrast, the Superconducting Super Collider, which Congress also cancelled at about the same time, was a multi-billion dollar programme that was controversial among physicists and suffered from significant mismanagement. While agencies such as NASA or the National Science Foundation do not always renew scientific investigators' grants, SETI was a small, but complete, research programme. So what went wrong? Why was SETI seemingly singled out in Congress?

Ironically, the first factor was SETI's small size. It only received $12.25 million annually at the height of the programme, less than 0.1% of NASA's total budget and a drop in the bucket compared to the billions of dollars for major space science or defense research and development programmes. SETI's small budget meant that few contractors were involved. Since the SETI programme people prided themselves on being self-reliant and developing much of their own hardware and software [43], there were no major engineering support contracts and no big aerospace firms to lobby Congress on the programme's behalf. While the programme might have been "lean and mean," it provided no political "pork" in the form of jobs in Congressional districts around the country.

At the same time, the SETI programme was a victim of an intensified Congressional and public fervour over the ballooning federal budget deficit. In 1993, the new Clinton Administration and Congress were taking a hard look at overall federal spending. Congress was searching for easy targets to cut. While $12 million in one year obviously would not erase the deficit, the programme's $100 million price tag over ten years sounded more like "real money," and wasteful at that, if one characterized it as searching for *"little green men"*.

Fall 1993 was also a particularly trying time for NASA, politically. That summer and fall, NASA had barely won two bruising battles over continuation of the multi-billion dollar Space Station programme and the Advanced Solid Rocket Motor programme. The Hubble Space Telescope was still suffering from its spherical aberration problem. In short, after fighting these larger battles, NASA had little political ammunition left to defend a small programme such as SETI. While top NASA officials such as Daniel Goldin, who had been the Administrator since May 1992, and Wesley Huntress, a planetary scientist who had been the Associate Administrator for Space Science for approximately six months, publicly supported SETI, it was more a question of how hard they could afford to push. One person involved in the programme believes that the SETI programme people were reluctant to call on their political friends for help and that the legislative affairs office of NASA didn't push particularly hard for SETI [44], but the main point was that fall 1993 was a bad time for SETI to ask for political help.

Another well-known problem was the *"giggle factor"*. While the SETI programme was well reviewed by scientific peers, it was easy for opponents to make jokes at the programme's expense. SETI programme people hated this, of course, but once the dialogue descended to this level, it became harder and harder for the programme to be taken seriously. In addition, the nature of the search programme

meant that no immediate definitive results were likely. Nevertheless this was another source of unwarranted criticism.

While the cancellation of Congressional funding in 1993 might have seemed abrupt, it is important to remember that SETI had suffered political difficulties for a number of years. Senator Bryan was not the first member of Congress to ridicule or try to cancel the programme: Proxmire and Conte were just a few of the others. One key Hill staffer heavily criticised the programme after the fact, calling it a very narrowly focused "rifle shot" programme that was not supported by anybody other than those elitist people who worked on it [45]. Because of other issues such as the "giggle factor" and the programme's small size, SETI had already been attacked and was weakened.

Similarly, one may wonder whether the name change from SETI to HRMS backfired politically. From most accounts, NASA management simply went along with this instruction from the Senate appropriators. Whether or not programme people believed at the time that the name change might attract additional critical attention is hard to say, but surely they were willing to put up with a new name if they got their money. Besides, if skeptical Members of Congress or others wanted to grill NASA about the programme, they could certainly ask whatever questions they wanted about SETI activities, regardless of the programme's official name. As a result, the name change is probably best seen as an indication of the programme's declining political fortunes, but not a major direct cause of its demise.

Another problem was that, by 1993, opponents such as Senator Bryan did not want to debate the programme's merits in earnest. From all indications, Bryan felt that he had all the information he needed to make a decision. SETI programme people knew that Bryan was opposed and tried repeatedly to talk with him or his staff. A decade earlier, Sagan was able to win over Proxmire but this time Bryan simply refused to meet with anyone associated with SETI. Project scientist Jill Tarter noted that she and other programme people had been working with NASA's legislative affairs office to arrange such a meeting for over a year with Bryan and Huntress, only to be caught off guard at the last minute when Bryan's office finally called and nobody from NASA was available [46]. As programme manager Gary Coulter put it, he never knew of anyone who was initially opposed to SETI, who after listening to the proponent's side of things, did not at least move to a neutral position. In other words, he felt that Congress was not "fighting fairly" [47].

SETI had still another problem beyond the halls of Congress: It was an unconventional programme that did not fit neatly into the bounds of a specific scientific discipline whose members could support it when times got tough. SETI had begun under the aegis of NASA's life sciences programme, in part because of John Billingham's interest. Once it was restarted as HRMS in 1992, it was moved to the Solar System Exploration Division, but some planetary scientists did not receive it warmly because they felt that it did not "come with its own money" in a time of tight budgets [48]. In other words, some TOPS planetary scientists did not want to be "tainted" by SETI's problems [49].

Because SETI was an exobiology [50] programme using the tools and techniques of radio astronomy, neither the biology or astronomy scientific communities fully embraced it. According to one observer, the average radio astronomer saw SETI as a distraction [51]. A 1991 decade-long survey of astronomy projects by the National Academy of Sciences called the search for ETI very exciting but cautioned that the *"speculative nature of the subject"* demanded especially innovative technology development and careful peer review [52]. While some critics singled out such language as a less than resounding endorsement, this was largely because it didn't fall naturally into the domain of the Commission members, who were mostly conventional night-time astronomers, with the notable exception of Frank Drake [53]. Perhaps unfortunately, there are few people or groups willing and able to stand up in support of basic scientific research. While one former programme official believes that there were a few such people, he also believes that they were surprised by the political tactics of Senator Bryan [54]. Overall, whether the SETI programme was managed by NASA life scientists or astronomers was less significant than the fact that neither discipline community supported it wholeheartedly. With all these factors entering into the political equation, it is not surprising that Congress cancelled funding for the SETI programme in 1993.

5. CONCLUSIONS

Recently there has been increased public interest in the possibility of extraterrestrial life. NASA's discoveries of a Martian meteorite that may contain fossils of microorganisms and of possible water on Jupiter's moon Europa, as well as the successful Mars Pathfinder mission and the movie *Contact*, have all increased excitement in space exploration. NASA has begun a new programme called Origins that aims to build on the Hubble Space Telescope's dramatic successes by building a series of even more sophisticated space observatories to search for planets beyond our solar system. The Origins programme also is to include various other means to answer fundamental questions about how the universe began and whether there is life beyond Earth. It is unlikely, however, that radio astronomy SETI efforts will be incorporated into the Origins programme in the near future.

So how is it that NASA Administrator Goldin has managed to capture the public's imagination about tiny possible Martian fossils, while the potentially much more exciting SETI programme was defeated in 1993? What are the lessons to be learned in this case?

The cancellation of Congressional funding for the SETI programme is an interesting study, in large part because it is a relatively unique story. It is unlikely that the same combination of factors that killed SETI will terminate another similar programme. At a time of budget deficit fervour, SETI was a small, efficient programme that nonetheless was easy to attack because it had few contractors and thus jobs involved. NASA had just won two bruising political battles over programmes with budgets several orders of magnitude larger than SETI's, leaving the space agency with little political capital with which to defend SETI. Because of inaccurate associations the "giggle factor" had persisted in making SETI a perennially easy political target. While SETI involved truly fundamental science, it didn't fit neatly into any existing scientific discipline and there was no strong lobbying force for basic science itself. Last, but certainly not least, its opponents rejected an honest, open discussion of SETI's merits and drawbacks.

In short, the SETI programme supporters basically did all they reasonably could to defend the programme. Hopefully, future Congressional and public debate over basic science programmes will be conducted in a more open, and thus informed, manner.

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44. Notes from telephone conversation with L. Billings, former support contractor for the SETI program at NASA Headquarters, 10 July, 1997. While SETI had a strong scientific rationale, Billings also contends that the program people were somehow reluctant to explain it, perhaps after having been unfairly associated with "little green men." See Billings conversation, 10 July, 1997 and e-mail, 21 July, 1997. Billings also wrote a chapter entitled "From the Observatory to Capitol Hill," covering the political history of SETI to 1990, in B. Bova and B. Preiss, (editors), *First Contact: The Search for Extraterrestrial Intelligence*, Plume Penguin Books, New York, 1990.
45. Kelly conversation, 2 July, 1997. Kelly also criticized the claim by SETI supporters that "if this doesn't get funded by Congress, it won't get done" as being false, since the SETI Institute was able to continue Project Phoenix with private funds. Project Phoenix, however, only continued the targeted search portion of NASA's SETI program and the all-sky survey was dropped for lack of money. Additionally, Kelly stated that doing ground-based astronomy is not part of NASA's prime mission, but even most casual observers would probably concede that looking for ETI fit into NASA's overall mission more appropriately than that of any other agency.
46. Private communication, J. Tarter, 23 July, 1997.
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51. Notes from telephone conversation with D. Smith, National Academy of Sciences, 7 July, 1997.
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53. Kelly conversation, 2 July, 1997, and Smith conversation, 7 July, 1997.
54. Letter from J. Rummel, 21 July, 1997. Rummel was the SETI program scientist at NASA Headquarters.

APPENDIX A: FUNDING HISTORY

Area	FY75	FY76	FY77	FY78	FY79	FY80	FY81	FY82	FY83	FY84
SETI Funding ($K)										
SETI Microwave Observing Project	**140.0**	**310.0**	**400.0**	**130.0**	**300.0**	**500.0**	**1895.0**	**0.0**	**1800.0**	**1500.0**
Definition/R&D	140.0	310.0	400.0	130.0	300.0	500.0	1895.0	0.0	1800.0	1500.0
Program/Project C/D	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	FY85	FY86	FY87	FY88	FY89	FY90	FY91	FY92	FY93	Totals
SETI Funding ($K)										
SETI Microwave Observing Project	**1505.0**	**1574.0**	**2175.0**	**2403.0**	**2260.0**	**4233.0**	**11500.0**	**12250.0**	**12000.0**	**56875.0**
Definition/R&D	1505.0	1574.0	2175.0	2403.0	0.0	0.0	0.0	0.0	0.0	14632.0
Program/Project C/D	0.0	0.0	0.0	0.0	2260.0	4233.0	11500.0	12250.0	12000.0	42243.0

NOTE: FY92 & FY 93 figures are for the High Resolution Microwave Survey (HRMS).
In October 1993, Congress directed NASA to discontinue the HRMS program.

Source: Jens Feeley, NASA Headquarters Office of Space Science, June 1997

APPENDIX B: CHRONOLOGY

Guglielmo Marconi observed radio signals that seemed to originate from Mars	1919
Giuseppe Cocconi and Philip Morrison published seminal *Nature* paper suggesting microwave interstellar communication	1959
Frank Drake conducted Project Ozma	1960
"Order of the Dolphin" conference (first serious SETI meeting) held	1961
Project Cyclops study by John Billingham and Bernard Oliver published	1971
NASA began funding SETI design studies under Morrison's leadership at MIT	1975
Personnel at NASA's Ames Research Center and JPL started SETI work	1976
Senator William Proxmire gave NASA's SETI program a "Golden Fleece" award	1978
Proxmire amendment killed program funding for the next year	1981
Carl Sagan convinced Proxmire of program's merits; Congress reinstated funding	FY1983
Non-profit SETI Institute founded	1984
NASA Headquarters formally endorsed SETI program; hardware construction began	1988
NASA Headquarters Solar System Exploration Division held TOPS workshops	1990, 1992
Bush Administration requested increased funding for full-fledged MOP search	1990 (FY1991)
Restructured and renamed HRMS program began	1992
Senator Richard Bryan led successful efforts to terminate program	1993
SETI Institute's Project Phoenix began	1993
