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Project Argus Progress Report: t plus Thirteen Years and Holding

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ABSTRACT

Following the cancellation in 1993 of the NASA SETI program, the grass-roots SETI League was established to help privatize SETI research. Project Argus, its principle scientific initiative, emerged as a continuation of the all-sky survey component of NASA's two-pronged Microwave Observing Project (MOP). Project Argus contemplated a global network of 5,000 small radio telescopes scattered across the surface of the Earth, providing real-time, continuous coverage of all 4 pi steradians of the celestial sphere. This paper traces the development of Project Argus, from its equipment design phase in 1995, through its launch the following year with just five operational instruments, into its growth phase reaching 144 cooperative observation posts, and beyond, to its present state of stagnation, which has resulted in far fewer participants than had initially been expected. We explore possible reasons that Project Argus' growth has fallen short of its initial, optimistic goals; examine the technology used to take us this far and that which will be required to take us farther; and discuss the kinds of meaningful scientific observations which can still be made with the global Project Argus network, a viable tool in ongoing astrophysical and SETI research even at its present level. The paper concludes with a summary of lessons learned, which can be applied to future attempts to privatize curtailed government projects.

KEYWORDS

SETI League, Project Argus, all-sky survey, radio telescope, TVRO

THE DEMISE OF NASA SETI

For a brief time, the US space agency NASA had a modestly funded but technologically ambitions SETI project under way from headquarters at the Ames Research Center, Mountain View, CA. Budgeted at $12.6 Million annually (about 5 cents per US citizen per year), NASA SETI kicked off on October 12, 1992, the 500th anniversary of Columbus' first voyage of discovery. The plan was to conduct a ten-year search. At that same time, work was underway in Texas on the 12 Billion (that's **Billion**) dollar Superconducting Supercollider (SSC), which would have been the world's largest and highest-energy particle accelerator complex.

Just one year later, in October of 1993, Congress pulled the plug on the Supercollider. Particle physics was deemed wasteful of our limited resources. And if particle physics was wasteful, the reasoning went, SETI was all the more so. We had been searching for a full year, argued Senator Richard Bryan (R - Nev.), and not one little green man had yet walked up and said 'Take me to your leader.' Which proved they do not exist.

In a single sweep of the pen, our elected leaders opted to cancel the Superconducting Supercollider, and NASA SETI as well. This makes good economic sense to some, since the cancellation of NASA SETI alone did indeed reduce the federal deficit . . . by all of 0.0006 percent!

TWO-PRONGED SEARCH

Early in SETI science's brief history, it was believed that advanced technological civilizations should be abundant throughout the cosmos. This assumption drove early experimental design, as it implied the nearest detectable civilization would be relatively nearby, and sensitive receiving equipment on Earth might well detect its electromagnetic leakage radiation. Targeting nearby sun-like stars with large radio telescopes seemed a promising strategy. More recently, an alternative viewpoint has emerged: that radio-using civilizations may be somewhat rare, and the distance to the nearest one too great to enable detection of leakage radiation. In this case, SETI success would be maximized by searching for deliberate beacons beamed our way by more distant, advanced benevolent societies. Each paradigm suggests a specific search strategy, and instrumentation.

NASA SETI had been comprised of two distinct but complimentary research elements: a targeted search of nearby sun-like stars, and an all-sky survey for interesting signals of unknown origin. The former, which involves aiming powerful radio telescopes at likely candidate stars for long periods of time, is well suited to large, steerable dishes with their narrow beamwidths and high sensitivities. If we guess right as to which stars constitute likely candidates, the thinking goes, the targeted search will provide us with the greatest likelihood of immediate success. But since only a limited number of relatively nearby candidate stars is known to us, concentrating our search in their direction may cause us to miss an equally good star of which we happen to be unaware.

An all-sky survey, on the other hand, makes no a priori assumptions as to the most likely direction to explore. The sky survey attempts to sweep out the entire sky which can be seen from a given location. No antenna tracking is required, since it is the entire sky, rather than individual stars, which we seek to scan. While targeted search antennas must be constantly moved, sky survey radio telescopes are operated in meridian transit, or drift- scan mode, in which the experimenter never needs to aim the antennas. Rather, it is the Earth's rotation which turns them.

Since large antennas have quite narrow beamwidth, they see only a small portion of the sky at a given time. To sweep out the whole sky with such large antennas would consume inordinate amounts of time. A sky survey effort, as opposed to a targeted search, would be best performed with antennas of moderate size.

Smaller antennas can see more sky within their beam patterns, but have correspondingly less gain, thus more limited range. We achieve reasonable sensitivities through digital signal processing, the application of powerful computers to sift through the cosmic static for patterns which Nature cannot produce. But the antennas need to remain fixed on their targets for a relatively long time period, as the computers average out the background noise. With large antennas, this would require active tracking as the area of interest appears to drift east to west across the sky. Fortunately, when used in meridian transit mode, small antennas, with their relatively wide beamwidths, provide us with far greater signal acquisition time than do the larger antennas typically used for targeted searches.

PRIVATIZATION

Shortly after its demise, NASA's late targeted search was resurrected by the non-profit California-based SETI Institute. This scientific organization had been the institutional home of many key players in

NASA SETI, and they set about securing private sponsorship. Their aim was to utilize the same receivers and computer analysis tools they had designed for NASA, in a private search of the thousand nearest sun-like stars. They called their search Project Phoenix, having risen from the ashes of the late NASA SETI program.

Their success in this endeavor has been an inspiration to all who advocate the privatization of science. If they are as effective at science as they are at fundraising, the SETI Institute cannot miss. Project Phoenix employs some of the world's finest radio telescopes, aiming them sequentially at promising targets from a catalog of nearby sun-like stars.

Now enter Richard Factor, a New Jersey radio amateur (WA2IKL), science buff, and industrialist of more than modest means. Factor's company, Eventide Inc., was a leader in broadcast and studio electronics, aircraft navigation equipment, and a number of other high-tech products. For years Factor had toyed with the notion of building up his own amateur SETI station, and scanning the stars for signs of life. With the termination of NASA SETI, his resolve intensified.

"I got really mad when Congress killed SETI and the Superconducting Supercollider in the same year," says Factor. The Supercollider, with a price tag of $12 billion, was well beyond his help. But SETI, he decided, could be salvaged. So he founded a non-profit, membership supported educational and scientific corporation to privatize SETI. And he hired the author, then an electronics professor in the Pennsylvania State University system, to run it. The SETI League was not his first taste of non-profit science, but it quickly became apparent that it would be the most challenging. For starters, it would be necessary to decide exactly what role a citizen's group could play in resurrecting some component of the late NASA effort.

BIRTH OF PROJECT ARGUS

The SETI League was actively attracting radio amateurs and microwave experimenters around the world, with the promise of some undefined great SETI project. And the sky survey approach seemed ideally suited to the community of amateur radio astronomers desiring to pursue SETI. So that is the aspect of SETI which Factor and his fledgling organization chose to pursue. A grass-roots effort ultimately involving thousands of amateur radio telescopes worldwide, the SETI League's Project Argus sky survey was initiated in April of 1996, with only five active stations. Within a year, the network had grown to 28 listening posts, and the League to 500 members in 26 countries.

The lofty goal of Project Argus is to provide (for the first time ever) real-time full-sky coverage, its thousands of antennas collectively looking in all directions at once, across all four pi steradians of space and time. Given the capture angle of the modest radio telescopes employed, this suggests a need for something on the order of 5,000 Project Argus stations worldwide, coordinated through the internet. Toward the end of the 20^{th} century, this goal seemed entirely feasible, and in fact by 2000, the SETI League’s membership base had grown to roughly 1500 members in over 60 countries, with over 100 stations operational.

EQUIPMENT DESIGN

The typical Project Argus station is built around the use of discarded home satellite TV dishes of three to five meters in diameter. When properly illuminated for minimum sidelobes at L-band, such antennas exhibit a 3 dB beamwidth on the order of 4 degrees. Thus, each antenna will subtend just over two milli-steradians of sky, and a properly coordinated network of 5000 such instruments is sufficient to meet the stated goal of covering the entire four pi steradian celestial sphere.

Although larger dishes would afford greater antenna gain, hence improved sensitivity and range, economic tradeoff analysis favors these more modest instruments if our goal is to achieve full sky coverage. The available receive circuitry, coupled with the specified antennas, yields a threshold sensitivity of 10^23 watts/meter^2 in the 1.3 to 1.7 GHz "water hole" spectral region. This sensitivity is on a par with that of the Ohio State University "Big Ear" radio telescope during its long-running all sky survey. Further, it is on a par with the sensitivity which was contemplated for the NASA all sky survey effort during its early planning stages.

PROJECT ARGUS LAUNCH

Project Argus was officially launched, to great fanfare, on 21 April 1996, with five participating stations in the US, Canada, and Europe. These stations were largely modeled after the prototype developed by the author in 1995. At the launch ceremony, the author delivered the following dedication speech:

“We are here to launch a new Search for Extra-Terrestrial Intelligence. We seek to determine whether humankind is alone, the sole sentient species in the vast cosmos. The late NASA SETI program, terminated by Congress two and a half years ago, involved a two-pronged approach to answering that question. A targeted search of nearby Suns was designed to offer prompt results -- if we happen to guess right as to what constitutes a suitable star. But just in case we don't, a methodical survey of the entire sky was also begun. Our SETI Institute colleagues in California have very ably resurrected the targeted search component, under the Project Phoenix banner. Today, we begin Project Argus, our continuation of the sky survey. But we are attempting something which NASA had never contemplated: real-time, all-sky coverage.

“You see, the world's giant radio telescopes, the type which NASA used, can only see about a millionth of the sky at a time. Which means if you have one turned on, tuned to exactly the right frequency, at the very instant when The Call comes in, there's still a 99.9999% chance you'll be pointed the wrong way! One possible solution is to build a million such instruments, and cover the entire sky, all at once. At maybe fifty million dollars apiece, we'd very quickly exceed the Gross Planetary Product. But small radio telescopes such as this one can see 200 times as much sky as more traditional research instruments. Only five thousand of these systems, each priced at just a few thousand dollars, can be coordinated to see in all directions at once.

“It's true that these small telescopes have limited sensitivity. Thus at this time we can only hope to capture those highly intermittent, extremely powerful radio emissions which we hypothesize might be emanating from relatively nearby technological civilizations. But our microwave and computer technologies are evolving at a dizzying pace. Within just a few years, we can envision technological advances which would allow instruments like this one to hear all the way to the edge of the Galaxy. The SETI League hopes to promote just such advances. If we do, then our mission is successful, even if we never hear a peep from the stars.

“During the last half-century, SETI has emerged out of the realm of science fiction, and into the scientific mainstream. Every month we read about the discovery of yet another planetary system in space. We are beginning to learn about how life might have developed on other worlds. And we have completed the Copernican Revolution, finally realizing that we are not the center of all creation. Yet SETI programs continue to yield negative results. We are not discouraged. Not only have we not yet scratched the surface, we haven't even felt the itch.

"We launch our search on Earth Day, and fly the Flag of Earth, because SETI is an enterprise which belongs not just to one country, government or organization, but rather to all humankind. Like Argus, the guard-beast of Greek mythology who had a hundred eyes, we seek to see in all directions at once, that we might capture those photons from distant worlds which may well be falling on our heads even as we speak. Today, Project Argus stations go on the air in Spain, Toronto, Colorado, Hawaii, and here in New Jersey. This small step for humanity represents a humble beginning for what will ultimately be a global effort. From five stations today, we can foresee 500 participants within two years, and perhaps five thousand by the year 2001. When we reach that level, there will be no direction in the sky which evades our gaze. Then we can hope to find the answer to a fundamental question which has haunted humankind since first we realized that the points of light in the night sky are other suns: Are We Alone?"

GROWTH AND STAGNATION

The above estimates proved unrealistically optimistic. Four years after the launch of Project Argus, a mere 100 stations had come online. From there, project growth leveled off, and by August 2009, total participation sits at just 144 stations in 27 countries, far short of the number necessary to achieve the stated goal of real-time full-sky coverage.

We attribute this disappointing rate of growth to five factors:

(1) *Global economic downturn* – Project Argus was initiated during a time of unsustainable economic growth, especially in the computer and technology sectors. The bursting of the "dot com bubble" at the end of the 20th Century was followed by terrorist attacks at the beginning of the 21st, warfare on several fronts, market meltdowns, and a general reduction in discretionary capital for all but the wealthiest inhabitants of Planet Earth. Since, for privatized SETI, participation is at the hobby level for most, it was one of the first expenditures curtailed by many SETI League members in a declining economy. Similarly, the modest grant funds attracted by The SETI League from industry, governments, and non-government organizations dried up as other priorities were competing for limited resources.

(2) *Lack of turn-key systems* – the earliest Project Argus stations were pieced together out of a combination of surplus and purpose-built electronics equipment, by a highly trained and talented cadre of electronics experimenters (many with lifelong backgrounds in Amateur Radio). Globally, persons with these talents and abilities number in the low thousands, and The SETI League succeeded in attracting a significant number of

them into our membership ranks early on. The explosive growth required for full-sky coverage would have had to draw from an entirely different population of enthusiasts, ones who would be depending upon off-the-shelf hardware, which we expected to become commercially available at modest cost. Unfortunately, even the hoped-for 5,000 stations did not afford the economies of scale necessary for equipment manufacturers to commit to volume production. Early on, several small companies did indeed bring antenna feeds, low noise preamplifiers, microwave receivers, downconverters, and related products to market. Within just a few years, these products were all abandoned by their manufacturers when market volume proved disappointing. At one point, the author approached the largest electronics retailer in the US, offering for their private-label production a proven turn-key system design on a royalty basis. Their (understandable) response was that, unless we anticipated a market volume of 1 million units per year, they were not interested.

(3) *Negative economies of scale* – the first Project Argus stations used for their antennas decommissioned C-band home satellite television parabolic reflectors on the order of three to five meters in diameter. As the US, Canada, Europe, and Australia made the transition to Ku-band digital satellite television in the 1990s, these antennas briefly became abundantly available at low to no cost. However, with C-band analog TVRO services now largely phased out, the primary market for these antennas disappeared. Many of the established antenna providers abandoned this product line, and today, their availability even on the retail market is limited. Thus, over time and with the success of Ku-band direct broadcast services, the cost of the required antennas has failed to decrease, and in fact has risen sharply.

(4) *No new "Contact" films* – the release in 1997 of the Warner Brothers film "Contact," based upon the science fiction novel by Carl Sagan, did much to publicize SETI, and resulted in explosive growth in public support and participation. In the months following the release of the film, SETI League membership and Project Argus participation both doubled. Unfortunately, within a year this public interest began to wane, and most of the new members acquired post-"Contact" failed to renew their memberships. Another blockbuster movie depicting SETI science in a positive light would have been beneficial, but was not forthcoming.

(5) *Computers are easier* – shortly after the launch of Project Argus, Prof. Woody Sullivan of the University of Washington presented at a Bioastronomy conference in Italy a concept for distributed processing of signals

being gathered by the UC Berkeley SERENDIP project long ongoing at the Arecibo Observatory. His proposal quickly grew into the well-known SETI@home project, which has attracted some six million participants worldwide. This experiment has proved a double-edged sword for observational SETI. On the one hand, it has raised public interest and awareness to unprecedented levels. On the other hand, it is far cheaper and easier to allow an idle home computer to crunch data than it is to build and operate an actual radio telescope. As a consequence, many potential Project Argus participants opted out, deciding instead that SETI@home participation was an acceptable contribution to SETI science. While we are delighted at the success of this UC Berkeley initiative, it is an unfortunate reality that six million participants are now analyzing data from a *single* radio telescope, operating in a *single* frequency band, which, though highly sensitive, can see only a minute fraction of the sky.

WHERE DO WE GO FROM HERE?

Since it appears unlikely that Project Argus will ever realize its full potential, or grow to meet its initial optimistic projections, one must ask what can realistically be expected for the future of this project in particular, and amateur observational SETI in general. The author suggests five guidelines for this and future SETI League initiatives:

(1) *Scale back expectations* -- it is clear that the goal of real-time all-sky coverage is unrealistic. Instead of continuing to pursue it, Project Argus participants should consider what might be accomplished with the network of stations as it now exists. 142 observatories, though far short of our initial goal, is still more operational radio telescopes than exist in the rest of the world, combined. With them, given proper coordination of declination assignments, we can create a drift-scan array which is still capable of monitoring the entire 4 pi steradians of space, for tens of minutes every day. Though not our initial goal, this scaled-back project still promises to make significant contributions to SETI science.

(2) *Do more with less* – even at its present modest level, we can expand the capabilities of our existing stations, so that they cover more search space. One promising area in which our reach has continued to expand is in the area of frequency coverage. Whereas Project Ozma, the world's first modern observational SETI experiment (circa 1960) monitored a single channel a mere 100 Hz wide, the first Project Argus stations were able to monitor about 1,000 bins of 10 Hz each, for a total spectral coverage of several kilohertz. In the dozen years since the program's inception, SETI League members have increased both the bandwidth of their receivers and the resolution of their digital signal processing algorithms. Thus, the spectral coverage of Project Argus stations is now extended from the tens of kilohertz, into the tens of Megahertz. Though this is still far

from the hundreds of Megahertz monitored in real time by the high-end, purpose-built multi-channel spectrum analyzers developed by NASA and used at The SETI Institute, Moore's Law suggests we can expect to see amateur capabilities continuing to close in on the state of the art.

(3) *Attract new constituencies* – not surprisingly, given its origins as a Ham Radio club, The SETI League early on concentrated upon attracting those radio amateurs and microwave experimenters already skilled in the arts required of SETI observers. This constituency represents an extremely limited pool of admittedly high-level talent. SETI@home has already proven that the masses are seeking an appropriate level of SETI participation. We need to explore projects that can be pursued by enthusiasts of more modest technical background, if SETI populism is to succeed.

(4) *Embrace new technologies* – the traditional SETI paradigm involves high-gain microwave antennas, sensitive receivers, and powerful digital signal processors. In nearly half a century of observation (perhaps 1,000 separate experiments conducted in dozens of countries), we have yet to detect a single clear, unambiguous signal of decidedly intelligent extraterrestrial origin. Perhaps it's time to seek a new approach to SETI. This is an area in which The SETI League's members can provide leadership, given that enthusiastic amateurs are not personally or professionally committed to maintaining the status quo.

(5) *Forego instant gratification* – we are beginning now to realize that SETI success is unlikely to come quickly or easily. We are, after all, in our technological infancy; a thorough SETI search may take generations. SETI is not a science that offers much to he or she who demands instant gratification. To date, not only have we not yet scratched the surface; we haven't even felt the itch. If we do the search, and we do it right, sometime in the distant future we will have arrived at one of two conclusions: either we are not alone in the cosmos, or we are. Either possibility boggles the imagination.