North American
AstroPhysical Observatory

NAAPO (North American AstroPhysical Observatory)

"Signals"
Volume 11 Number 5
The NAAPO Newsletter
(May 1995)

Editor:
Earl W. Phillips, Jr.
7893 Thornfield Lane
Columbus, Ohio 43235
614-764-0476

NAAPO Coordinator:
Dr. Philip E. Barnhart
Dept. of Physics/Astronomy
Otterbein College
Westerville, Ohio 43081
614-823-1516

IN THIS ISSUE:

COORDINATOR'S CORNER
Phil Barnhart

We enjoyed another pleasant Open House at the Observatory on Saturday. Pleasant weather met a fair number of visitors and the tours ran smoothly. A somewhat disappointing turnout kept some groups below the optimum numbers.

Russ Childers, recording individual radio portraits of visitors, found the eagerness to have one's microwave portrait recorded varied directly with the size of the group. Where two or three are gathered together there is hesitancy to stand in front of the receiver horns to have one's microwaves detected.

To alleviate this problem by holding up the start of a tour till 12 or more people are ready would have made an intolerable wait during the slack times of the day. We need to attract larger numbers through some more extensive publicity.

Entrance and exit polling yielded a somewhat unofficial indication that the guests found their way to the event due to the following efforts in roughly descending order:

- E-mail posting
- Radio announcements (WTVN)
- Delaware Gazette
- Tour guide family members
- Barnhart Astronomy class

It seems we are still being let down by the major news media, all of whom were sent two press releases by Bill Miller. We are apparently not engaged in enough lurid activities to warrant coverage. Perhaps some scandal surrounding the brownies for sale in the gift shop area?

During the festivities we enjoyed a visit from the manager of the Delaware Country Club golf course. Some consternation was voiced when he pulled up in his souped up golf cart with a stern look on his face. This was misinterpreted by some as a sign of aggravation over so much traffic crossing the fairways in front of golfers, or alternatively, the need to close down the driving range that lies alongside visitor parking and terminates on the ground plane.

Not to fear. It seems we now have a kindred soul in jeopardy of displacement by the new landlords, whoever they may be. Adversity does indeed create strange bed-fellows.

On another subject -- -- I was particularly pleased at the turnout of members of the RO staff and friends at the luncheon set to honor my participation over the years in the Science 2000 lecture series at Otterbein. John Kraus, Skip Lewis, Phil Shumacher and Steve Brown came to hear the lectures by Virginia Trimble and join in the eating with a number of colleagues and ex-students. It is gratifying that people would come so far to pay homage while I am still alive.

We continue to struggle under a cloud of secrecy about the future of the project at Big Ear. We feel as if the negotiations that are being carried out between the University and the landlords (both old and "new") are somehow a case of the 'blind leading the blind'. We get little information and what does come seems to be distorted, falsified or at least grossly misinterpretted. Last week, Bob Dixon managed to meet with a few of the people involved with environmental evaluation of the site and cleared up the 'mystery' of the "NASA vials". It seems some disc packs labelled 'NASA Lewis Research Center' which were never used by the RO appeared from under some of the brush in the old dump area. If only people would ask those who know the answers these matters would be cleared up in very short order. Nearly a year of working in the dark has led to much misunderstanding and grief, let alone unfounded fear.

In spite of all sorts of set-backs we continue the search, the re-survey and

development of the new generation radio telescope. Volunteers continue to contribute and spirits, though frayed, are still running high. As has happened so often in the past when difficulties have been encountered, we will overcome. We will survive!

MARS PATHFINDER PROJECT REPORT
By: Brian Muirhead, Flight System Administrator
April 24,1995

FLIGHT SYSTEM STATUS REPORT

The Mars Pathfinder Flight System Team of over 400 engineers and technicians all over the country is currently in the final stages of engineering model testing and flight hardware fabrication leading to the start of the spacecraft system-level Assembly, Test and Launch Operations (*ATLO*) phase on June 1st, 1995. This phase is coming 18 months after project start in Nov. 1994 and lasts until launch which is scheduled for December 2, 1996. Currently, the Attitude and Information Management (*AIM*) subsystem has just completed its engineering model functional and vibration tests and delivered its first full-function set of flight software operating on the approximately 20-million-instruction-per-second flight computer. The Telecommunication Subsystem has started integration and test with the flight deep space transponder, diplexer and command decoder unit. The Mechanical Integration Subsystem has started assembly of the flight cruise stage structure which will then be delivered to the Propulsion Subsystem for integration with the propulsion hardware. The lander petals, cabling and various actuators are in flight fabrication and assembly. The Power and Pyro Switching subsystem is completing assembly and testing of its electronics and the solar arrays are starting assembly. The Entry, Descent and Landing subsystem has just completed key tests to demonstrate parachute stability, rocket assisted deceleration performance and aeroshell structural integrity and is preparing for a very important airbag drop test sequence at the Plumbrook Station in Cleveland, Ohio. Overall progress is excellent, with the team feeling very excited about the progress to date, with the fruits of many hours of hard work paying off in top quality hardware/software that is coming together and starting to work as a system. The usual class of problems are occurring in this phase of a flight project such as electronic parts failures, noisy signals, test problems and delays, etc. but the team is knocking the problems down as quickly as they come up and no schedule or budget busting problems have appeared (*yet!!!??*).

GALILEO PROVIDES EVIDENCE OF ASTEROIDAL SATELLITES

Images sent back from the Galileo spacecraft provide hard evidence that asteroids can have satellites, according to a letter published in *Nature* magazine Wednesday.

Clark R. Chapman, of the *Planetary Science Institute* in Tucson, Arizona, and colleagues have studied images of the asteroid 243 Ida and found a satellite, named Dactyl, with a diameter of one mile, around it. The scientists said astronomical observations at the time a star is eclipsed by an asteroid suggested asteroids might be circled by satellites, but up to now there has been little hard evidence to back this up. They said that Dactyl physically resembles Ida and other members of the Koronis asteroid family some 280 million miles from the Sun, and may have been formed when the Koronis parent body broke up. Dactyl is slightly less red than the Ida asteroid, but the color differences are of a similar magnitude to variations among various Koronis family members, they said. They speculated that the differences could be due to slight differences in composition, or to a "space weathering" process that modifies surface colors marginally with time. The images lend weight to the view that other asteroids, particularly those that are part of asteroid families, may also possess satellites, the scientists said.

The Galileo spacecraft of the **U.S. National Aeronautics and Space Administration** (*NASA*) is headed for Jupiter, and is expected to reach the planet's atmosphere toward the end of this year. Thrusters were fired on the Jupiter-bound Galileo spacecraft April 12 to fine-tune the aim point for its atmospheric probe, which will descend into the giant planet's swirling clouds on December 7.

The probe will hit Jupiter's cloud tops at 22:04 Universal Time (*2:04 p.m. Pacific Standard Time*) at 6.57 degrees north latitude, 5 degrees west longitude; radio signals confirming the event will reach Earth 52 minutes later at 22:56 Universal Time (*2:56 p.m. PST*). The trajectory correction maneuver performed in April consisted of 64 thruster pulses, changing the spacecraft's velocity by 8 centimeters per second (*about 0.2 mph*). A final maneuver to trim the probe aim point is possible in late June, but appears unnecessary at this time. The probe will be deployed on July 13 to fly independently to its Jupiter atmospheric mission. Soon afterwards, the orbiter will be redirected with a large engine firing toward its own aim point at Jupiter that will take it on a flyby of the Jupiter's moon Io at an altitude of 1,000 kilometers (*620 miles*) some 4 hours, 18 minutes before the probe enters

Jupiter's atmosphere.

On April 18, science teams for the atmospheric probe met at **NASA's Ames Research Center** in Mountain View, Calif., responsible for developing the probe, to discuss results of the previous month's probe checkout and the recently completed ground tests ofan electric battery similar to one used to power the probe. There was unanimous agreement that the probe was in excellent health and ready for its mission.

On the ground, Galileo project teams are developing and testing the next generation of flight software, the system that will control Galileo while it is in orbit around Jupiter. This software, which includes on-board data compression and other procedures to handle data from the spacecraft's science instruments, will be loaded in Galileo's computers in March 1996.

Parts of it have already been checked out in the Galileo test bed, a simulated Galileo spacecraft put together on the ground for software testing. A block of software governing five of the scientific instruments began early in April, and runs into early May. Another software block begins in July. The spacecraft is in good health, spinning at about 3 rpm and transmitting science and engineering telemetry at 10 and 16 bits per second to ground stations of the NASA/JPL Deep Space Network. Galileo is now 664 million kilometers (*413 million miles*) from Earth after traveling a total of 3.66 billion kilometers (*2.3 billion miles*) in a looping flight path that has taken it more than twice around the Sun.

TOPEX/POSEIDON MISSION STATUS

May 1, 1995

PUBLIC INFORMATION OFFICE
JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
PASADENA, CALIF. 91109
TELEPHONE (818) 354-5011

The Earth-orbiting oceanographic TOPEX/Poseidon satellite and its sensors continue to operate as expected, and ground system computers are performing well. The satellite tape recorders have been played back and the daily science and engineering data products are being produced.

The satellite is in its 96th 10-day data collection cycle.

The science data team reports it is now processing the interim geophysical data records for cycle 95. Completed geophysical data records for cycle 92 have been shipped to the **Physical Oceanography Distributed Active Archive Center** (*PODAAC*) at **JPL** for distribution to the principal investigators.

TOPEX/Poseidon has completed more than 12,395 orbital revolutions of Earth since its launch from French Guiana on Aug. 10, 1992. The satellite orbits Earth once every 112 minutes.

ULYSSES MISSION STATUS

May 1, 1995

PUBLIC INFORMATION OFFICE
JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
PASADENA, CALIF. 91109
TELEPHONE (818) 354-5011

All spacecraft operations and science experiments continue to go well aboard the Ulysses spacecraft. Flight controllers are continuing to perform Earth-pointing maneuvers to keep the spacecraft properly oriented as its axial boom is illuminated by the Sun, causing a slight wobbling onboard the craft. This phase of the mission, when the spacecraft's boom is heated by the Sun, will continue into September.

Ulysses is 43 degrees north of the Sun's equator today, traveling at a heliocentric velocity of about 111,600 kilometers per hour (*about 70,300 miles per hour*). The spacecraft has entered the region above the magnetic current sheet, which rotates with the Sun but dips above and below the Sun's equator. When spacecraft are above the current sheet, they detect magnetic fields directed outward from the Sun. When they are below it, they observe inward directed fields. Ulysses is now beginning to observe only high-speed solar wind, which is unique to the polar regions of the Sun.

Ulysses will begin the second phase of its primary mission — to explore the northern solar pole — when it reaches 70 degrees north of the Sun's equator on June 19.

VOYAGER MISSION STATUS

May 1, 1995

PUBLIC INFORMATION OFFICE
JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
PASADENA, CALIF. 91109
TELEPHONE (818) 354-5011

Voyager 1 and 2 are healthy and are continuing to make observations of their interplanetary environment as they head out of the solar system.

Both spacecraft are using their ultraviolet spectrometers to map the heliosphere and study the incoming interstellar wind. The cosmic ray detectors are seeing the energy spectra of interstellar cosmic rays in the outer heliosphere. The magnetometer sensors are still measuring the strength and direction of the solar magnetic field. The plasma detectors looking back at the Sun record the solar wind parameters. The low-energy charged particle experiment studies the energy spectra of particles coming from the Sun.

The plasma wave instrument is studying the incoming signals from the direction of the heliosphere.

Voyager 1 is currently 8.8 billion kilometers (*5.5 billion miles*) from Earth and is traveling at a speed of 63,000 kilometers per hour (*39,100 miles per hour*). Voyager 2 is 6.8 billion kilometers (*4.2 billion miles*) from Earth and is traveling at a speed of 58,000 kilometers per hour (*36,100 miles per hour*).

The total distance Voyager 1 has traveled since its Sept. 5, 1977 launch, called the arc length, is 10,640,000,000 kilometers (*6,611,000,000 miles*). The total distance Voyager 2 has traveled since its Aug. 24, 1977 launch is 10,067,000,000 kilometers (*6,255,000,000 miles*).

PIONEER 10 & 11 STATUS
UPDATED: 5/1/95

Pioneer 10

- Distance from Earth: 9.42 billion kilometers (*5.85 billion miles*)
- Roundtrip Light Time: 17 hours, 27 minutes
- Active Instruments:
    - Plasma Analyzer
    - Charged Particle Instrument
    - Cosmic Ray Telescope
    - Geiger Tube Telescope
    - Ultraviolet Photometer

The spacecraft is healthy and continues to make observations of the interplanetary environment at the outer regions of our Solar System. As the spacecraft electrical power continues to decline, the instruments are operated according to a power-sharing schedule. Individual intruments, or groups of instruments, are turned on at a time such that the total power consumption is within the available power range.

Pioneer 11

- Distance from Earth: 6.35 billion kilometers (*4.94 billion miles*)
- Roundtrip Light Time: 11 hours, 46 minutes

The Pioneer 11 spacecraft is out of communication at this time. The Earth moved out of the spacecraft antenna beam in January 1995. A precession maneuver, needed to aim the spacecraft high gain antenna toward the Earth, could not be performed in January because the Sun was out of view of the spacecraft sun sensor. The motion of the Earth will bring the antenna beam back into view, starting on 16 May 1995, and the spacecraft will be re-acquired at that time. The available power from the Pioneer 11 spacecraft Radio-Isotope Thermoelectric Generators (*RTG*) is declining to the point where there will be insufficient power for any instrument by December 1995. Between June and August 1995, Pioneer 11 will be used as a test-bed to study its performance under sub-normal voltage conditions. Despite the strong possibility that the tests may cause the spacecraft to fail permanently, the knowledge gained will be invaluable for future operation of Pioneer 10 in late 1997 and 1998.

Project Manager: Fred Wirth (*e-mail:Fred_Wirth@qmgate.arc.nasa.gov*)

GAS FOUND BLASTING FROM PULSAR

NEW YORK (*AP*) — A jet of gas more than a million times longer than the distance between Earth and the sun is blasting away from a pulsing star, and the finding may explain why such stars move so fast, researchers say.

The star is a pulsar, an extremely dense, spinning object that sends pulses of energy toward Earth.

Pulsars move very quickly, averaging about 300 miles per second. Scientists have thought that was because of a "kick" from the explosions that create pulsars. But if other pulsars also produce these jets, that might be responsible for the stars' speed, researchers said in Thursday's issue of the journal **Nature**. And if jets propel pulsars far out of the Milky Way galaxy, the pulsars may create unexplained bursts of gamma rays that appear to come from beyond the galaxy's borders, said researcher **Hakki Ogelman** of the *University of Wisconsin in Madison*. The pulsar he and a colleague studied lies relatively close to Earth, about 1,600 light-years away in the direction of the constellation Vela. A light-year is the distance light travels in one year, about 5.88 trillion miles.

Discovery of the jet, about 20 light-years long, may answer a mystery about pulsars, Ogelman said. Their spins slow down, showing that they are losing rotational energy. Scientists have been unable to figure out where the energy is going.

Maybe most of it is going into jets, he said.

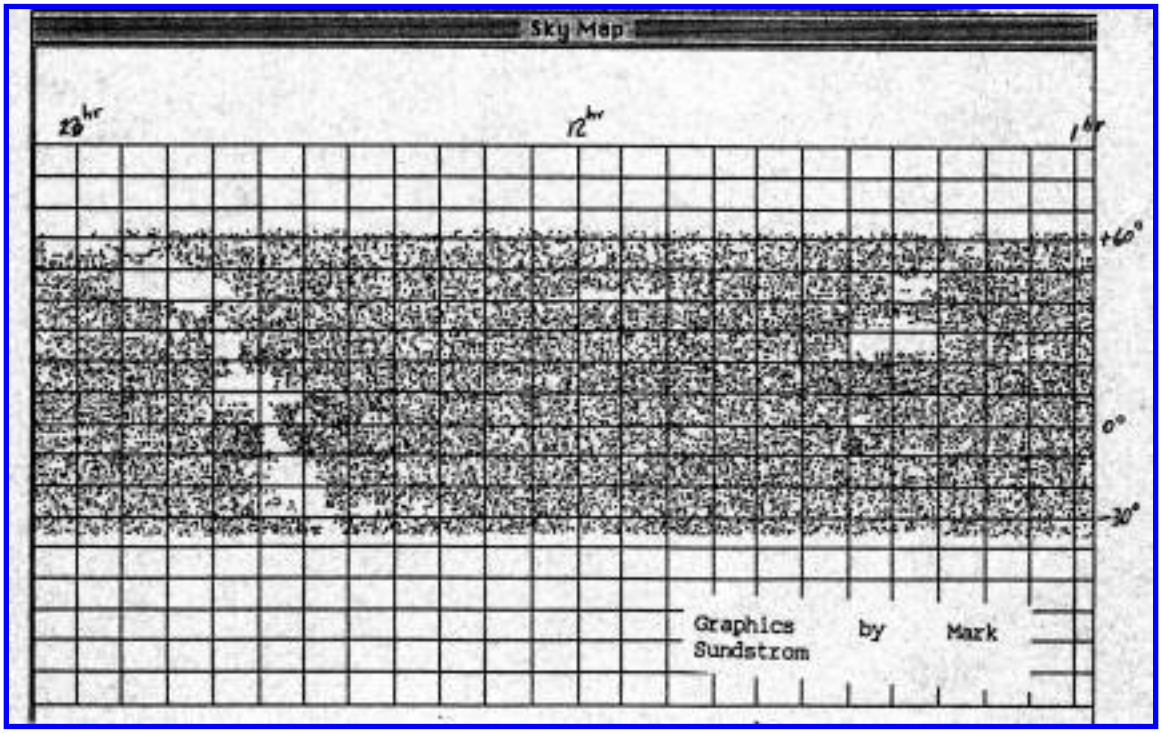
Joseph Taylor, a *Princeton University* pulsar expert, said the feature reported in the study has not been proven to be a jet. But he said the idea that jets propel pulsars is intriguing. He also said pulsars are known to be able to escape from the galaxy, regardless of whether they are pushed by jets. So they are viable candidates for causing the mysterious gamma ray bursts, he said.

Mark Sundstrom's Plot of Ohio Survey Source Positions

Mark Sundstrom has provided a plot of the Ohio Survey source positions. No attempt has been made to indicate relative intensity, just position.

Note the location of the galactic plane where sources become too crowded to be easily separated.

[Click on the image below to obtain a larger version.]



Argus — A Future SETI Telescope

New Search Can Accomplish a Great Deal ... If OSU Lets It

By Robert S. Dixon

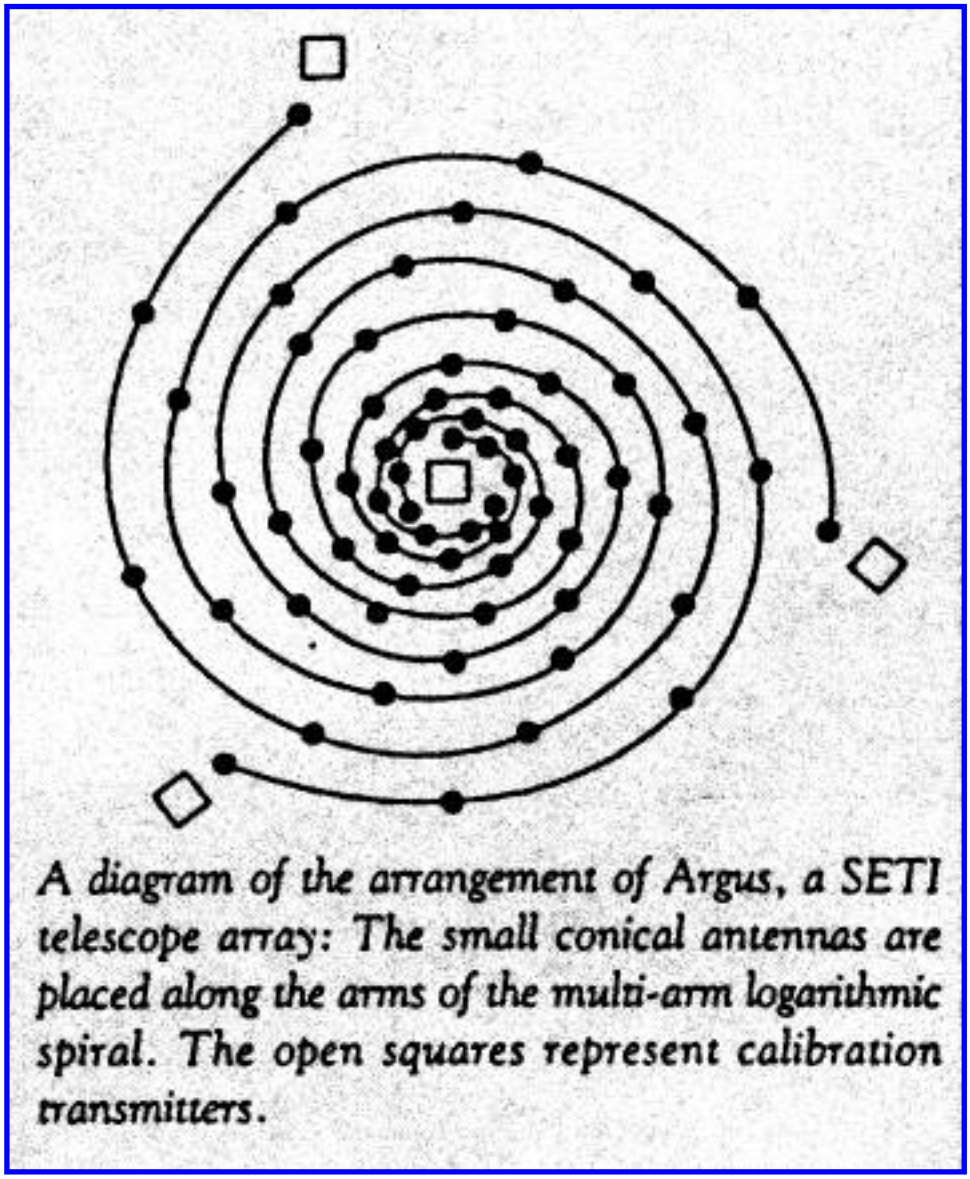
From Bioastronomy News, First Quarter 1995

The time has come to consider the next generation of radio telescopes for the search for extraterrestrial intelligence.

Until now, all SETI work has been done using radio telescopes designed for other purposes. This has significantly limited SETI efforts and precluded discovering

many types of signals. The most serious deficiency of today's telescopes is that they can only look in one narrow direction at a time, making detection of transient signals very unlikely. And these narrow-direction telescopes ignore the vast majority of energy that falls on them from outside Earth, making them very inefficient.

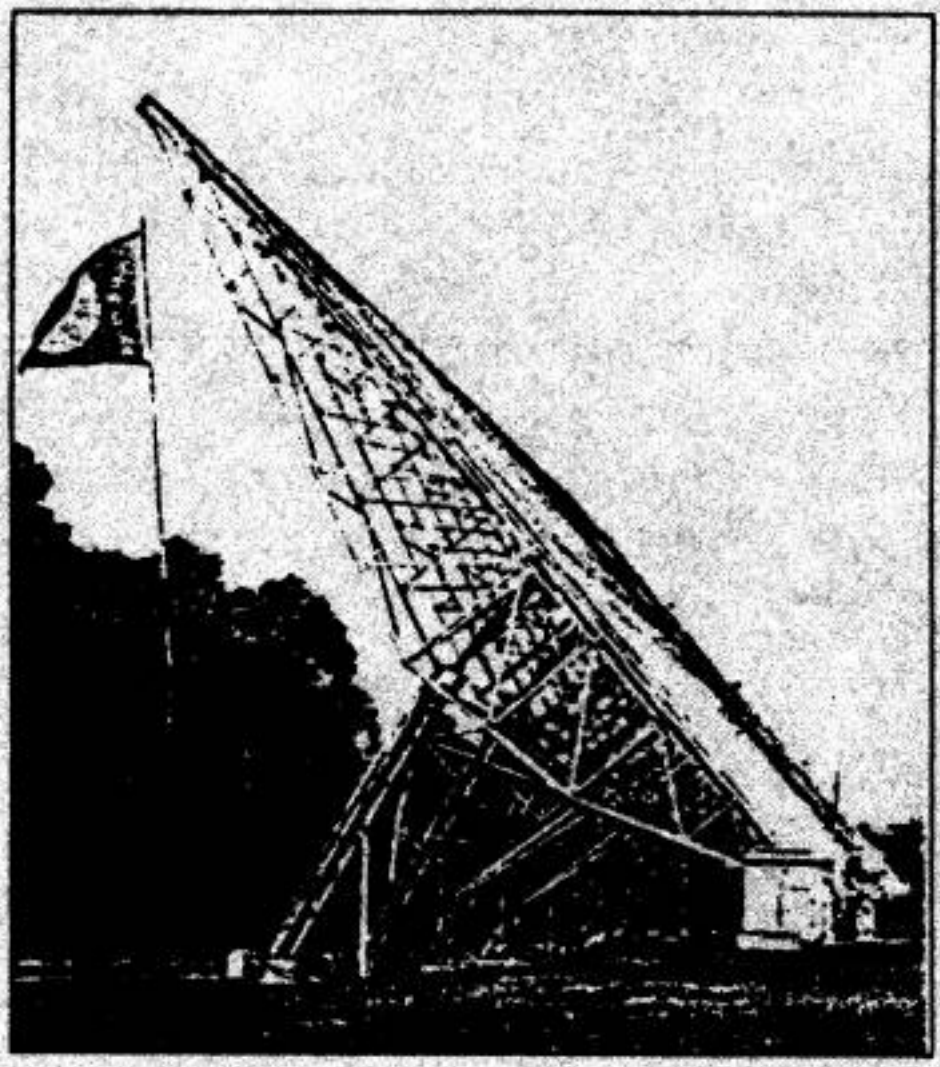
At the Ohio State University Radio Observatory a couple of years ago, we successfully constructed and operated a prototype of a system that does not have the limits of most radio telescopes. Such an array of small antennas is called Argus.



A diagram of the arrangement of Argus, a SETI telescope array: The small conical antennas are placed along the arms of the multi-arm logarithmic spiral. The open squares represent calibration transmitters.

Our prototype array consisted of only eight antennas, but a full Argus system could use thousands. In a typical Argus configuration, the antennas would be about 30 centimeters each in size and would be spread out over a field of a few hundred meters. The antennas are not dishes, but multifilar conical helices. The array is laid out along the arms of a multi-arm logarithmic spiral (See the diagram at the left. Click on it for a larger image.). Computers combine the signals from each of the elements in such a way as to create simultaneous beams looking in every direction of the sky at once. It is like having many large dish antennas all operating at the same time, pointing in different fixed directions.

Our plan has been to construct a full-scale Argus on the ground plane of our existing large radio telescope (See, at the right, the photo of the flat reflector portion of the "Big Ear" radio telescope. Click on the photo for a larger image.). However, that plan and the current telescope are now being threatened because OSU's administration may abandon the observatory. The land lease is up for renewal, and the administration is seriously considering not renewing it (See [article below] "Big Ear To Stop Listening?").



This 90-foot high flat reflector is a vital part of the Ohio State University Radio Observatory near Delaware, Ohio.

The Argus Prototype

Despite uncertainty about our project's site, the work continues. The eight-element Argus prototype operated at 162 MHz, but we are now planning a larger 64-element array for the 500 to 1,000 MHz region. We will ultimately need thousands of elements.

The computing architecture for Argus consists of one small computer (comparable to what's in your personal computer) for each element and one small computer for each beam, all joined by a network. The computational power required for an Argus array of equivalent size to a large dish is greater than can be reasonably achieved today in the microwave region. But continuing developments in computing will make this possible, and today modest arrays at lower frequencies are possible.

Argus is limited only by the available computing power, which is the best kind of limit one can have today, since computer power continues to grow.

The History of Argus

Argus is the name of the mythological guard-being that had 100 eyes and could watch all directions at once. This name has been applied to fictional SETI arrays by Arthur C. Clarke in his novel *Imperial Earth* and by Carl Sagan in his novel *Contact*. The computing revolution now snakes a real Argus array possible.

An Argus timed array provides many advantages. The array can cover all directions of the sky at once, instead of scanning one area at a time. Among the system's other advantages are arbitrarily long integration time, low sidelobes (responses to signals in other than a desired direction), detection of transient and moving sources, retroactive observations and interference rejection.

And an Argus array is ultimately less expensive than a larger telescope approach, since it takes advantage of mass production, has no large or moving parts and is essentially unaffected by gravity, sunlight or wind. The construction cost of a dish increases with time (since labor costs dominate), whereas the construction cost of an array decreases (since computing costs dominate). Hence an array eventually becomes less costly.

One fully implemented Argus array can simultaneously carry out all the observations now being done by other comparable radio telescopes, not only for SETI but for all scientific and commercial monitoring of the radio environment. We hope that we get the funding, time and space to establish such an innovative search.

Robert S. Dixon is director of the SETI research program at the Ohio State University Radio Observatory.

[***Captions:***
Diagram on the left:
"A diagram of the arrangement of Argus, a SETI telescope array: The small conical antennas are placed along the arms of the multi-arm logarithmic spiral. The open squares represent calibration transmitters."

Photo at the right:
"This 90-foot high flat reflector is a vital part of the Ohio State University Radio Observatory near Delaware, Ohio."
Note that the slant height of this flat reflector is 100 feet, not 90 feet.]

Earth-bound rules threaten quest for extraterrestrial life

From Nature, April 20, 1995

Boston. Astronomers at the Ohio State University, who have been engaged in the world's longest running search for extraterrestrial intelligence (SETI) are trying to save their radiotelescope — one of only a handful of such facilities dedicated to SETI activities — from eviction.

The threat to the university's so-called 'Big Ear' telescope comes on top the loss of its grant support from the National Aeronautics and Space Administration (NASA), whose budget for SETI was eliminated by Congress last year.

Since then, existing SETI projects have scrambled to find alternative funding sources. For the Ohio State radio survey, which began in 1972, this has been a double blow, as the 10-year lease for the Big Ear telescope — one of the largest radiotelescopes in the world — expires on 30 July. The owner of the property wants the telescope to be torn down to make room for the expansion of a golf course and the construction of new homes.

"The timing is bad, with our lease coming up for renewal shortly after the cut-off in federal funds," explains Robert Dixon, who directs the Ohio State SETI programme. "When the university asks us what [outside] grants we have, we're forced to say none." In principle — and assuming that the university continues to pay for rent, electricity and bare upkeep — the all-volunteer project would still be able to keep going without any outside funding, as it has often done in the past. But there remains a further obstacle.

A provision in the lease stipulates that the telescope must be painted. Federal lead paint laws will make this a difficult and costly job, running into $100,000 or more — an expense the university may not be willing to defray. "It's a ridiculous situation," Dixon observes. "Environmental laws, which were designed to keep small children from eating paint chips in their homes, may end up killing our telescope. It's a unique dilemma in the history of astronomy."

The Planetary Society has asked its members, and others concerned about the fate of Big Ear, to express their support by writing to the president of the university, E. Gordon Gee. Many have done so, including Carl Sagan, Arthur C. Clarke, and Paul Horowitz, a Harvard physicist.

"The Ohio State University team has been a pioneer in SETI, responsible for many innovations in radiotelescope design," says Horowitz, who heads his own Megachannel Extraterrestrial Assay (META) SETI project at Harvard. "It would be a pity for such a venerable and high-quality group to have to close its doors."

Unlike its Ohio State counterpart, the future of META is relatively secure, thanks to donations from the Planetary Society, the Bosack/Kruger Foundation and other sources. "Private funding is much more stable [than federal funding] when you can get it, because it is not subject to the whims and vagaries of Congress," Horowitz says.

His own programme has recently benefited from another windfall. Micron Tecnology Inc., the largest manufacturer of computer memory chips in the United States, has agreed to donate 3,420 megabytes of memory chips — worth over $100,000 — if Planetary Society members can match this contribution.

Once the memory chips are installed later this year, META will become BETA — for Billion Channel Extraterrestrial Assay — as its receiver will be able to analyse a quarter of a billion radio channels simultaneously.

The upgrade will lead to a thousandfold improvement in search capability, and BETA will then be able to scan more channels over a wider range of frequencies than any other SETI effort. Nevertheless, Horowitz believes that with the enormity of the challenge — sifting for evidence of an advanced civilization among 400 billion stars in the Milky Way — it is important to keep several programmes alive, especially those using different search strategies.

"SETI is seriously underfunded worldwide, given that the detection of just one signal of extraterrestrial, and artificial, origin would be the greatest discovery in the history of the human race," he says.

Robert Dixon agrees. "This is one of the most important questions that humans have sought to answer, and we've barely scratched the surface." Dixon acknowledges, however, that the task will require patience and perseverance. "We've known from the beginning that this would be a difficult problem to solve."

Steve Nadis

Big Ear To Stop Listening?

From Bioastronomy News,
First Quarter 1995

The longest-running SETI program is threatened with extinction.

The first ten years of the land lease Ohio State University's Radio Observatory — home of the telescope often referred to as "Big Ear" — ends this summer, and OSU is waffling about renewing it. Someone has told OSU President E. Gordon Gee that the telescope is obsolete and hence not worth having and that another telescope in North America does the same work. Both statements are false. Significantly, the lease requires OSU to paint the telescope, which they have not done. The least expensive estimate we have obtained for this work is $283,000, which makes OSU administration hesitate.

The landlord wants OSU out so they can build houses sometime before the next ten-year lease would expire. So they have offered a compromise of three years (maybe negotiable) and no painting. We might also be able to ask OSU administrators for alternate land or funds to move to a location where we might build an Argus array after the three or more years.

But the most critical thing is to convince the president that the program is worth saving at all. You can assist us in these arguments by contacting President Gee by phone, letter or fax. You can reach him at 205 Bricker Hall, 190 N. Oval Mall, Ohio State University, Columbus, Ohio 43210; phone (614) 292-2424; fax (614) 292-1231.

[Back to List of Issues in Volume 11] | **[Back to List of Volumes]** | **[HOME]**

E-mail Webmaster

Designed by Jerry Ehman
Last modified: March 22, 2004