Finally, a Serious Search for Intelligent Beings in Space

By Eugene F. Mallove

IN 1900, THE FRENCH Academy of Sciences offered a prize of 100,000 francs to the first person establishing communication with a world other than Mars. So certain was the existence of Martians that communicating with them seemed too easy to deserve a prize.

Scientists' view of the prospects for contacting extraterrestrials has matured enormously since that era of perceived Martian canals and presumed Martians. We are now nearly certain that there are no other technologically advanced civilizations in our solar system. Man must look to the 300 billion stars in our own Milky Way galaxy, or to the billions of galaxies beyond, if he is to contact his biological kin.

Impossible as that task may seem, optimists in the search for extraterrestrial intelligence (referred to in the world of modern astronomy as SETI) feel that a Renaissance is at hand. Listening efforts now underway or planned go technologically far beyond earlier tries. These efforts feature sophisticated yet economical microcomputer-controlled signal-processing devices coupled to radio telescopes, a system that greatly speeds up the painstaking process of scanning the heavens.

Moreover, it is no longer science fiction fantasy to think that robots — or man himself — will venture beyond the solar system in the next century to see whether nearby stars have planets hospitable to intelligent life. Manned interstellar missions, possibly propelled by light sails, fusion-driven ramjets, or antimatter rockets are now in the realm of possibility.

For the moment, however, radio telescopes provide the best hope for contacting other worlds.

Until now, the main obstacle to successful radio searches has been our inability to study, at any given instant, a large sampling of frequency channels of the most promising portion of the radio spectrum. However, new computerized signal processors allow scientists to search tens of thousands, and soon millions of channels, simultaneously and distinguish almost instantly between possible messages and other noises.

In the countryside just outside Boston, "Project Sentinel" is already working around the clock. Sponsored by the Planetary Society, a private, non-profit organization, it is the most systematic and exhaustive cosmic search yet. Paul Horowitz, a professor of physics at Harvard University who has emerged as a leader in SETI, is chiefly responsible for the technology behind the project, which accomplishes more in one minute than the first receiver constructed specifically for SETI in 1960 could have done in 1,000 years.

Meanwhile, the National Aeronautics and Space Administration, after years of neglect, is moving ahead with the largest SETI program ever. NASA's budget includes $1.5 million a year for a long-term effort. Researchers at NASA's Ames Research Laboratory, the Jet Propulsion Laboratory and Stanford University are currently building the next generation of signal analyzers and other instruments required for the search. Some listening for alien signals will be done as the equipment is tested, but the major searches may not begin until 1988.

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SETI researchers base their conviction that other civilizations exist on several factors. First is the idea that many if not most stars are circled by planets. This idea received an important boost late last year. Scientists using the Infrared Astronomical Satellite (IRAS) detected what seems to be a planetary system forming around Vega, one of the brightest stars in the sky, located 26 light years (about 150 trillion miles) from Earth. This discovery provided the first direct evidence that solid objects of substantial size exist around a star other than our sun.

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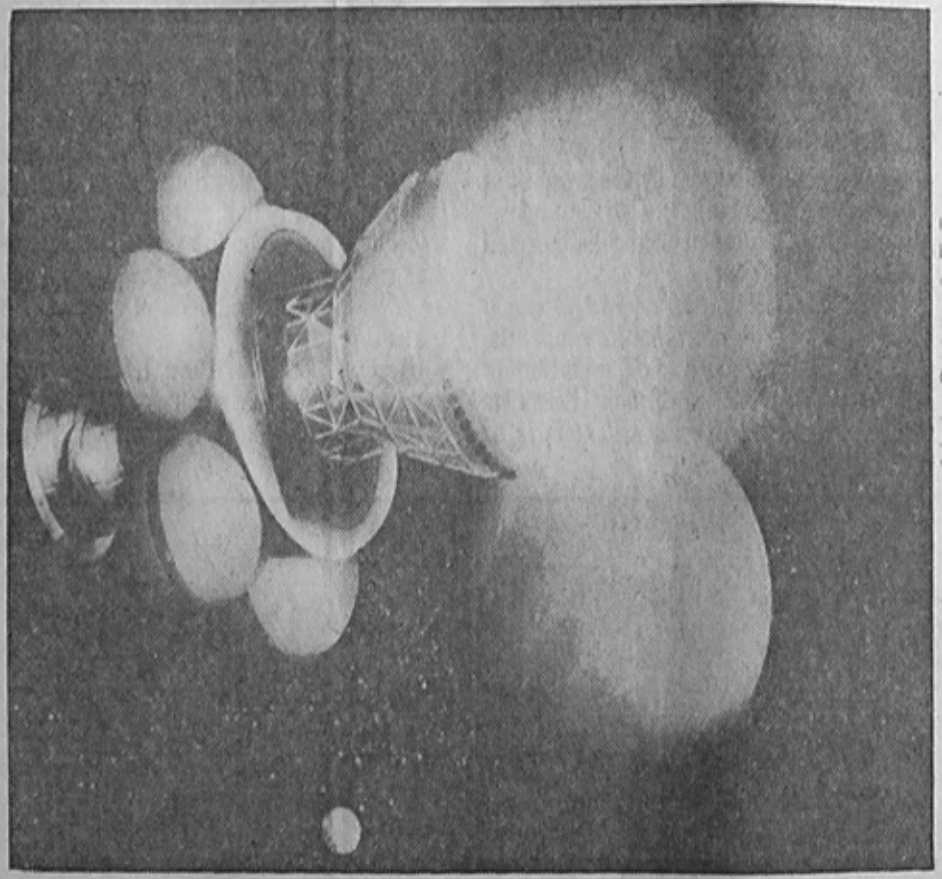

Starship Daedalus would use thermonuclear power for its flight.

Eugene Mallove, an astronautical engineer from Holliston, Mass., writes "Starbound," a syndicated column on space. This article was adapted from Technology Review magazine.

Starships to Reach Our Galactic Brethren

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Laboratory experiments have shown how easy it is for the organic building blocks of life to form. Complex organic molecules form in abundance when scientists pass ultraviolet light or electric discharges through a flask containing the simple constituents believed to have comprised the early atmosphere of Earth.

What's more, radio astronomers in the last decade have detected prodigious quantities of organic molecules in interstellar space. Everything in the universe that has a temperature emits radiation, and physicists can sort out what a molecule or material is by the radio frequency it gives off. In this way, more than three dozen different molecules have been identified, often in interstellar clouds light years across. Thus, many scientists believe that life owes even more to the workings of stars than earlier suspected. Not only have the violent deaths of stars in explosions released all the elements; these elements have organized themselves in space to form organic molecules that might have played a direct role in the evolution of life on planets.

"This means that a suitable habitat for life and a mechanism for its origin may exist near many of the billions of stars in our galaxy," says Horowitz. "Thus, the galaxy may be teeming with life and technology. But even without relying upon detailed speculation as to the probabilities of planetary formation, chemical and biological evolution, and the rise of intelligence, technology and the like, we can observe that, in all of nature's variety, there is no phenomenon that happens only once. With apparently billions of opportunities for life to arise in our galaxy alone, it would be astounding if we turned out to be the sole example of intelligent life."

we see alien visitors all around us, since interstellar travel should have been available to them for millions of years? Our own Milky Way galaxy is at least 10 billion years old. The skeptics cite calculations showing that if a single civilization set out to colonize the galaxy, even at the snail's pace of primitive interstellar craft, the entire whirlpool of stars could be inhabited in a small fraction of the galactic lifetime.

Others have imagined self-replicating "Von Neumann machines" flung into space by aliens. These artificially intelligent probes would use stellar resources to duplicate themselves exactly, with a mission to explore ever-increasing territory in the galaxy. If we see no evidence of such probes, say the critics of SETI, either the original extraterrestrials never existed or they came to grief early in their technical development. For it is mathematically difficult to believe that *all* these societies would have chosen not to come here.

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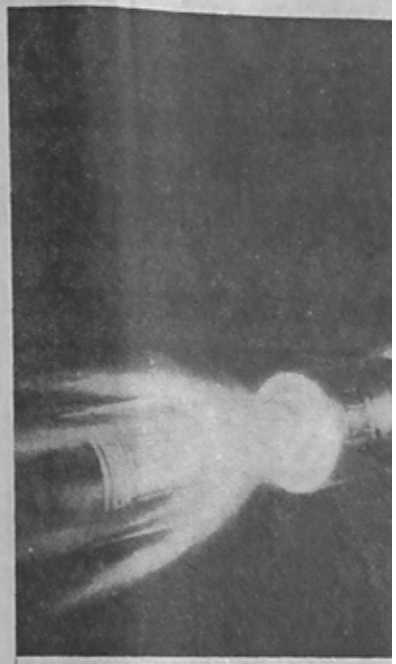
SETI researchers, however, offer a number of explanations why no one has found any concrete evidence of the existence of aliens. Perhaps such beings have tried to colonize new areas but have restricted their efforts in direction and extent. Advanced cultures might even find that, with the contentment of age, they no longer seek new physical frontiers. SETI researchers hope, of course, that these cultures have not become so introverted that they have forgotten to offer greetings to other struggling civilizations.

John Ball, a radio astronomer at Harvard University, has ventured that we earthlings may live in a cosmic "zoo," not to be violated by responsible advanced cultures, for whatever unknown reason. We might be living in



The mile-long "interstellar ramjet" for its fusion engine.

neutron stars whose existence had been predicted by physicists. But at least for a while, Bell and Hewish referred to their signals as "LGM-1," for Little Green Men.

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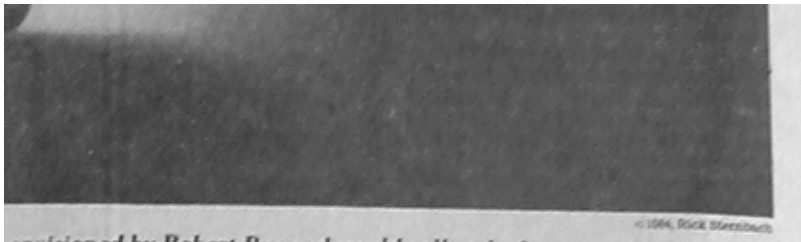
"The searches to date have been like trying to find a needle in a haystack by walking past the haystack every now and then," says Drake. Only a small fraction of the "cosmic haystack" has been surveyed.

Some of the searches targeted hundreds of specific stars in the solar neighborhood that were deemed likely to have life-bearing planets. These stars were examined extensively at many frequencies. Other searches have been "whole-sky," sweeping large areas of the heavens without focusing on specific



envisioned by Robert Bussard would collect hydrogen in deep space

look for other evidence of distant planetary cultures. For example, Princeton University physicist Freeman Dyson has suggested that cultures may have surrounded their parent star with energy-collecting structures that emit infrared signatures. Other scientists have proposed that advanced societies might deliberately seed their star with radioactive elements whose spectra would be evidence of technology.

There are also those who think beyond merely searching from Earth for messages, to the possibility of sending advanced robot spacecraft and, someday, even manned "space arks" out in the galaxy.

The Journal of the British Interplanetary Society regularly contains detailed engineering discussions of interstellar travel. Would-be galactic sailors have identified a number of possible propulsion technologies and trajecto-

speed of light after passing relatively close to the sun. Thus, small robot probes towed by light sails might reach Proxima Centauri in only 250 years. Astronomers waited nearly that long for the optical telescope, invented in 1609, to bear its spectacular modern fruit.

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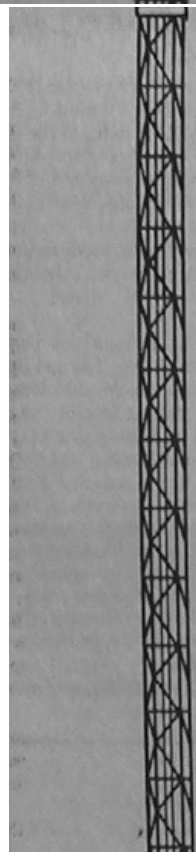
Cosmic travel may require leaps of science and technology almost beyond our imagining. But glimmerings can already be seen. For example, there is the "interstellar ramjet" proposed by Robert Bussard, president of INES-CO, a private company that conducts research on fusion power. This mile-long ship will generate a huge magnetic field to collect interstellar hydrogen to burn in its fusion engines. According to plans, the craft will collect fuel faster as it speeds up, which in turn makes the ramjet work even better.

However, there are skeptics. If life is so revalent and antique, they ask, why don't

an enviromentally protected area, much like species on Earth that are protected from hunters or tourists. But perhaps our zoo, or game preserve, is not perfectly sealed off from the outside. In that case, the aliens may allow tidbits of information-bearing radio signals to drift our way, just as humans give grizzly bears in Yellowstone Park glimmerings of their ways.

Cornell astronomy professor Frank Drake has suggested that aliens may be almost immortal, and unwilling to risk the hazards of contacting young races on distant planets. And Paul Horowitz points out that sending signals is so much more efficient than sending spaceships that aliens might simply rather communicate than commute.

But more than anything, SETI researchers maintain that our efforts to look and listen for aliens simply haven't been adequate.



In the first realistic attempt to detect extraterrestrial signals, Project Ozma in 1960, Frank Drake used an 85-foot-diameter dish at the National Radio Telescope Observatory in Green Bank, W. Va., to monitor two nearby sun-like stars, Tau Ceti and Epsilon Eridani. Scientists in several nations have since made perhaps three dozen other searches. For example, Robert Dixon of Ohio State University has for more than 10 years scanned the sky using a telescope the size of a football field.

Researchers at the Jet Propulsion Laboratory and the University of California at Berkeley have been "sneaking" observing time using antennas usually used to track interplanetary spacecraft. And in the Soviet Union, V.S. Troitsky and colleagues at the Gorky Radiophysical Institute have scanned the skies since 1970 for pulses of intelligent origin.

Although none of these projects has yielded unambiguous evidence of alien transmission, there have been some exciting moments along the way — such as signals later found to be interference from here on Earth, and a curious few that did not persist long enough to be identified. Perhaps the most famous false alarm came in 1968 in England, when Jocelyn Bell, a Cambridge University graduate student, and Antony Hewish, her professor, detected regularly spaced pulses arriving every one and one-third seconds. It turned out that they had discovered pulsars, the long-sought

nearby targets but monitoring a smaller part of the radio spectrum. The number of stars searched so far, says Carl Sagan, constitute "only a millionth of a percent of the stars in the galaxy."

The idea of monitoring radio waves rather than other regions of the electromagnetic spectrum, such as visible light, infrared or X-rays, traces back to 1959. Philip Morrison and Giuseppe Cocconi, then physicists at Cornell, contended in Nature magazine that the best listening post was the microwave region between 1,000 and 10,000 megahertz.

The galaxy is a noisy place, full of cosmic static from fast-moving charged particles in interstellar space and even echoes of the original "big bang" of creation. But this particular part of the microwave spectrum is relatively quiet, so an extraterrestrial transmitter wouldn't have to be turned up so much and could be detected more easily.

There are also several good reasons why aliens might logically choose this range to communicate. It includes the frequency (1,420 megahertz) at which radio signals are emitted by atoms of hydrogen, the most abundant element in the universe. And SETI researchers have focused on what they call "the water hole," the region nearby these hydrogen emissions, between approximately 1,400 and 1,700 megahertz. One edge of the "water hole" is the hydrogen frequency. The other is that emitted by hydroxyl, composed of one atom each of hydrogen and oxygen. Hydrogen and hydroxyl are the products formed when water decomposes — thus the nickname "the water hole" for the frequencies in between. Just as animals convene at water holes on Earth, galactic species might mingle in this region via radio waves!

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The key to Project Sentinel, and NASA's ambitious plans, is in the electronics and computerization, which permit instant analysis of huge numbers of incoming signals and filtering out of time-consuming false alarms. Sentinel's analyzer, for example, scans more than 131,000 radio channels at once and is nearly immune to man-made interference.

Though far ahead of other searches, Project Sentinal is already being improved. Researchers are modifying the analyzer so that it collects a wider band of frequencies and examines many more channels. "It will be the equivalent of listening with 8.4 million receivers at once," says Horowitz. The new system

than is the sun — a journey of 4.3 years as light flies. Today's chemically propelled spacecraft, or even nuclear rockets that might soon be possible, would take tens of thousands of years to get there.

Thus, robot probes will probably be the first interstellar emissaries. (In fact, a probe is already underway — the U.S. Pioneer 10 spacecraft crossed the outer bounds of the solar system in July 1983 while still sending back information.) In 1977, the Jet Propulsion Laboratory released its Interstellar Precursor Mission Study of a probe that could be launched by the year 2000. The 50-year scientific mission would explore intersteller space out to 1,000 times the distance from Earth to the sun. Making equipment reliable enough for such a mission would strain the limits of today's technology and require development of such items as computers that test and repair themselves.

Early interstellar missions will probably use refined versions of propulsion systems now being developed. One possibilility is the "ion-drive" engine. This engine would use electricity generated by a nuclear reactor to transform a propellant into charged particles (ions), which would then be accelerated by an electric field and rapidly expelled to provide thrust. NASA has already tested in space prototype ion-drive engines made by Hughes Aircraft Co., and in 1985 the Air Force plans to launch a satellite that will use such engines for maneuvering.

More ambitious probes driven by advanced propulsion systems might depart by the middle of the next century. In the mid-1970s, the British Interplanetary Society conducted perhaps the most detailed feasibility study of an interstellar trip. In the society's scenario, a starship, named Daedalus after the legendary inventor of Greek mythology, would make a fly-by mission to Barnard's Star, located nearly six light-years away. Daedalus would be propelled by thermonuclear "microexplosions" ignited 250 times a second by laser or electron beams. The ship would accelerate to about 12 percent the speed of light — some 36,000 kilometers per second, or more than 1,000 times faster than today's rockets. The one-way trip is scheduled to take 50 years.

'Light sails" are another possibility for starships of the 21st century. Manufactured in space, the sails will be made of thin metallic film and will be hundreds of miles across. They will tow payloads tethered to the sail by thin, ultrastrong cables. Some of the sails will be propelled by radiation from the sun — or, someday, by radiation from other stars. Other sails may be pushed out of the solar system by powerful lasers stationed in orbit around the sun.

Gregory Matloff of Pratt Institute and I have determined that a sail can be blown out of the solar system at more than 1 percent the

stantly annihilate each other, creating a flash of energy. One of the most promising rocket would use protons and antiprotons; the energetic particles generate during annihilation would be mixed with large quantities of hydrogen and funneled through a "magnetic nozzle" to create thrust. The antimatter rockets that hypothetically drives TV's Starship Enterprise may be distant, but their lower-performance cousins might well be used in the next century.

The question of human travel is always the centerpiece of starflight speculation. Some enthusiasts have analyzed the effects of the interstellar medium on vehicles moving at nearly the speed of light. The possibility of traveling at "relativistic velocities" is intriguing because of the practical benefits of "time dilation," in which time slows down as speed increases. This effect, described by Albert Einstein, would make flights of almost any distance possible within an astronaut's lifetime if — a mighty big if! — speeds over 99 percent that of light can be reached.

But if humans can't ever travel that fast, they might instead travel in multigenerational "interstellar arks." As early as 1929, British scientist John Desmond Bernal envisioned space colonies journeying through the galaxy in starships, or even in hollowed-out asteroids.

Today, the designs for space colonies promoted by Gerard O'Neill of Princeton University make interstellar arks seem more feasible. Nay-sayers scoff at the notion of colonists setting out on journeys that only their descendants will complete. But the idea of traveling for millenia may be less intimidating to people who have lived their lives, from birth, in a rotating cylinder orbiting the sun, as O'Neill has envisioned.

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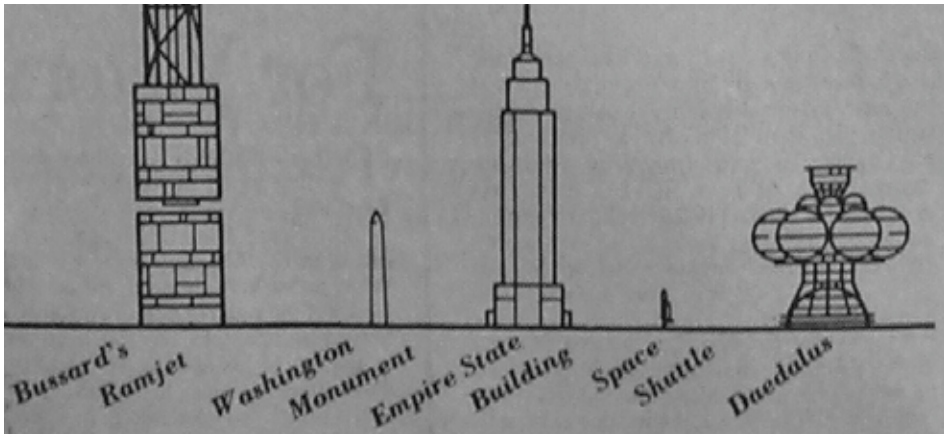
Among some SETI enthusiasts, the notion will die hard that the solar system is a province for philosopher kings who contemplate the universe but never venture beyond the planets.

If humans ever contact distant races by radio, we will achieve a precious and economical window for viewing remote star systems. But this will only increase the desire of earthlings to *meet* their cosmic neighbors firsthand.

Even if SETI is not immediately successful, the microwave search itself will yield new tools for radio astronomy. The high-speed information-handling technologies used may also find application elsewhere.

Carl Sagan has noted that the cost of SETI programs up to now, by all nations, is less than that of a single military attack helicopter. This does not seem too high a price for experiments that might revolutionize man's vision of his true place in the cosmos.



will be able to detect transmissions that are not beamed directly at the Earth. It could pick up powerful, omnidirectional beams sent by aliens.

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SETI optimists, buoyed by the prospect of persistent searches using the latest technology, feel that alien signals could be detected within the next 50 years.

If current efforts in the microwave region of the spectrum do not produce results, the search could be extended to other portions of the electromagnetic spectrum. Scientists could use larger, more sensitive antennas, or