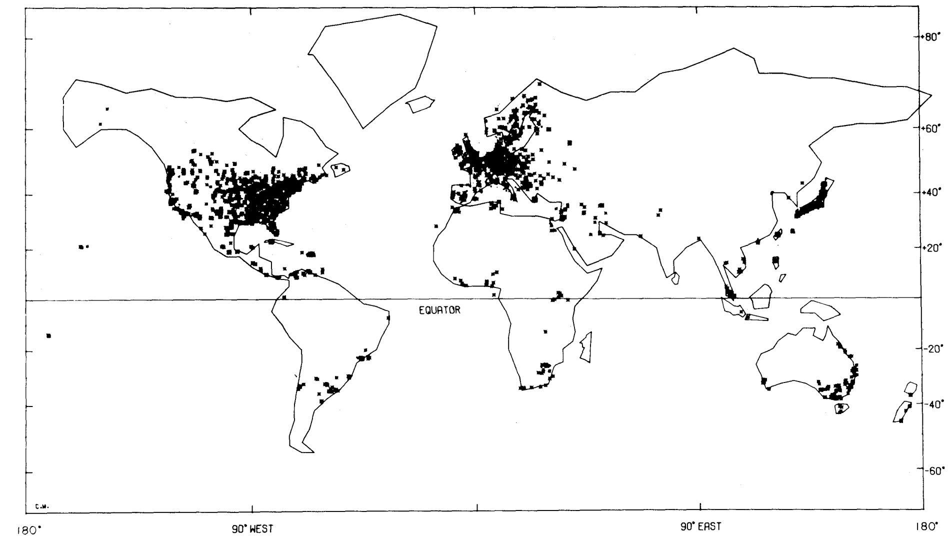
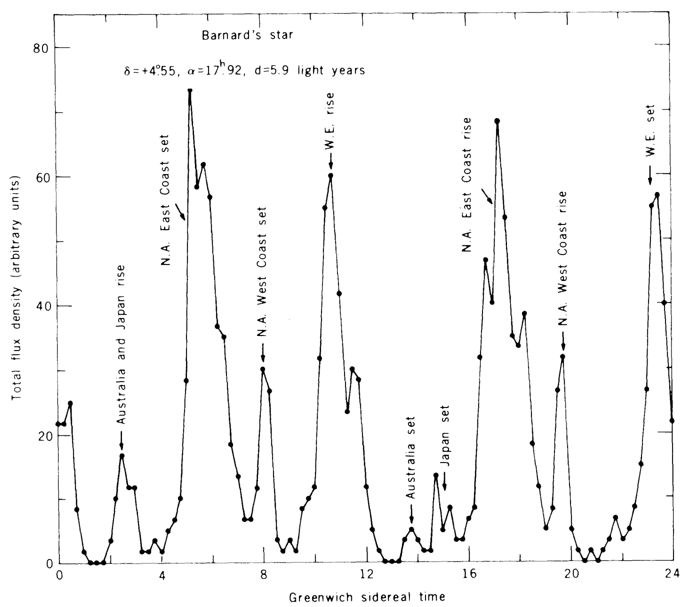
# GIVING OURSELVES AWAY

*Though there has been a dearth of deliberate attempts to signal possible extraterrestrial civilizations, earth has been broadcasting its presence for decades*




*Map (above) of television transmitters with effective radiated power of 50 kw or more shows the most conspicuous component of earth's broadcast "signature." Graph (right) shows relative flux density, summed over all TV frequencies, as it would appear over a sidereal day from the direction of Barnard's star.*

W. T. Sullivan III et al/Science

BY JONATHAN EBERHART

In the vastness of space, "handful" may be too large a term to describe the number of star systems to which earthlings have deliberately listened for possible intelligent signals. Yet the number of known earthly attempts to *send* such signals, points out Frank Drake of the National Astronomy and Ionosphere Center at Cornell University, is smaller still: one. It was beamed out on Nov. 16, 1974, at the dedication of the newly resurfaced Arecibo radiotelescope in Puerto Rico, and contained a range of information — numbers, basic elements, a human silhouette — designed to be easily reconstructed from a pattern of binary numbers (SN: 11/23/74, p. 325). Even then there were complaints that such attempts should be abandoned, for fear of "giving ourselves away."

Yet the earth is, in effect, "sending" all the time. A growing sphere of radio, television, radar and other electromagnetic signals has been radiating outward from the planet virtually since the inception of those technologies. Some, such as AM and most shortwave broadcasts, are cut off by the ionosphere (which, in fact, is often deliberately utilized for its ability to reflect certain wavelengths back to the ground). Others differ in their effective signal strengths or in the degree to which their frequencies are masked by the pervasive interstellar static known as "galactic noise." These escapees — the leakage — together give earth a unique electromagnetic signature, written across light-years of sky for any suitably equipped audience to detect.

This unintentional message has been radiating outward for a relatively short time for the distances involved. The main component — television video carrier waves — is barely 30 years old, which means that most of those signals have had a chance to travel less than 30 light-years, the radius of a sphere encompassing perhaps 400 stars. Furthermore, it is possible that future technologies (optical transmission, highly directional satellites, increased use of cable TV, etc.) could greatly modify, reduce or even effectively eliminate much of the present leakage pattern, erasing earth's inadvertent "hello."

Such a cutoff is uncertain, however, and some say unlikely. More to the point, terrestrial efforts at seeing if we have company in the cosmos have concentrated primarily on listening (including the SETI — Search for Extraterrestrial Intelligence — proposal in the FY 1979 NASA budget request) rather than on sending messages. Since it is equally possible that *They* are listening to *Us*, Woodruff T. Sullivan III of the University of Washington and two of his then-undergraduate students, Stewart Brown and Chris Wetherill, decided in 1976 to determine just what the earth's leakage signature actually is, and to figure out what intelligent extraterrestrial eavesdroppers might be able to learn from it.

Working out the signature turned out to be a formidable problem. Signals ranging from citizen's band radio to the Ballistic Missile Early Warning System radars differ not only in power and frequency, but also in a number of other characteristics. Sullivan, an assistant professor of astronomy, discovered that he had to inform himself about such broadcasting arcana as power spectra, modulation techniques and antenna patterns. Even so, the result (published in the Jan. 27 SCIENCE) is an approximation, and required a number of assumptions about both senders and eavesdroppers to keep the task within manageable bounds. Nonetheless, the picture is an enlightening one, with the potential for yielding a surprising amount of information about the earth.

Detecting the earth is basically a matter of detecting the single strongest signal, and the powerful BMEWS radars, Sullivan says, are about 100 times as detectable as the strongest U.S. TV stations (their actual power, differently modulated, is some 400,000 times as great). Each BMEWS installation continuously sweeps a large fraction of its local horizon, according to the researchers, so that by their collective output, "a large fraction of all stars are illuminated at some time." There are very few installations, however, and for security reasons they are continuously shifting their frequencies. The latter feature "would make them highly unsuitable for long-term monitoring in an effort to detect patterns in Doppler shifts," which Sullivan's group sees as essential data in deriving information about the source planet. Instead, the BMEWS output might be more likely to act as "acquisition signals," bright beacons alerting the listeners to hunt for details at weaker, but consistent frequencies.

Despite the power of the individual BMEWS transmitters, the researchers estimate that a larger *total* contribution — about 300 megawatts versus about 200 Mw for BMEWS—comes from the large number of FM radio transmittters. But TV video carrier waves, whose power is concentrated in extremely narrow frequency ranges, are far more prominent still, with an estimated total — and at consistent frequencies—of about 10 billion watts. Television thus became the focus of Sullivan's signature-analysis project.

Numerous science fiction scenarios have introduced alien visitors whose facility with terrestrial languages is credited to their "monitoring our broadcasts." The audio portion of the TV signal, however, is also FM, posing problems like those of FM radio (wide power dispersion, etc.), and the analysis by Sullivan's group indicates that even the TV pictures would be extremely difficult to receive and reconstruct.

To an observer 25 light-years away, for example, the time delays between signals received from stations 100 kilometers apart on the earth's surface (some of which will be carrying the same program) are already about 3 milliseconds, while a single line of a television picture is produced about every 0.06 second, "causing irreconcilable confusion among different stations." Also, even stations officially at the same frequency "are in fact spread over a range of a few hundred hertz or more." The result, the team calculates, is that it would take a receiver 20,000 times more sensitive (over a 5 MHz bandwidth) to yield a useful picture than simply to pick up the carrier wave. "Depending on one's opinion of the information content of television broadcasting," says Sullivan, "this calculation can be taken either as discouraging or reassuring."

Even to detect the carrier waves from 25 light-years away would require a system similar to the proposed Cyclops array of 1,000 100-meter dish antennas, the group calculates (although the BMEWS signals could be detected at about 10 times that distance). But even the carriers alone could be well worth studying.

What would the eavesdroppers detect? In their analysis, Sullivan's team discovered that 97 percent of the total TV carrier power in the spectrum is represented by about 15 percent of the transmitters, those with effective radiated power of 50 kw or more. The resulting list includes 2,191 transmitters, of which 999 are in North America, 636 in western Europe, 138 in eastern Europe, 108 in Japan, 81 in Australia and 229 in the rest of the world. ("Full information for stations in the Soviet Union and China was not available," says the team's report, "but estimates indicate that there is negligible television power in these countries.") Antenna radiation patterns also have to be considered, as do power spectra (the degree to which the output is concentrated in frequency).

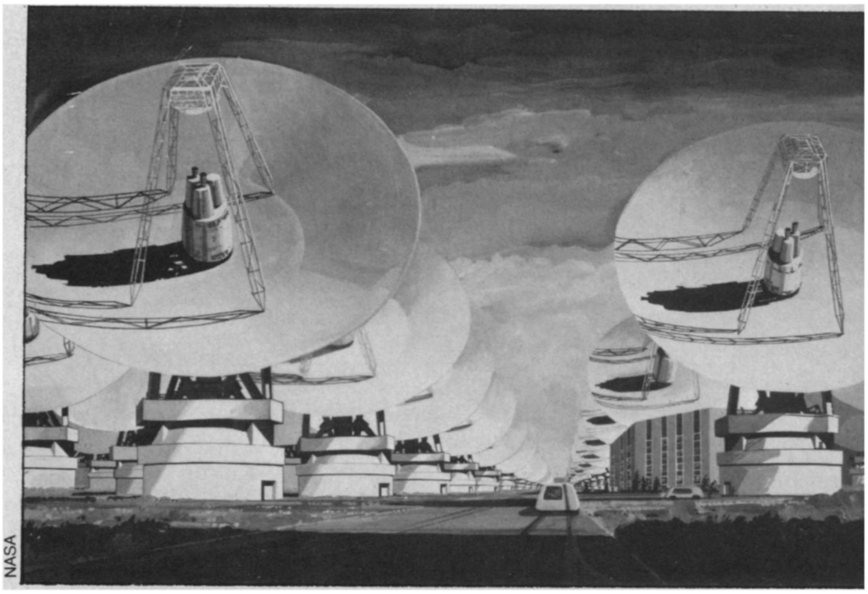
Even without decoding the program content, the eavesdropper in the vicinity of another star could detect several important effects in the signal: The earth rotates, so the signal strength increases each time a concentration of stations—such as in eastern North America or western Europe — appears around the edge of the planet. (This would be true even though Sullivan's team assumes that, projecting from current technology, the eavesdropper's antenna would be incapable of resolving the diameter of the earth, let alone specific locations on it.) Most of the stations go off the air for part of the night, so the eavesdropper could perceive some kind of apparent modulation related to the sun (which would be visible through optical telescopes), even if its cause is unknown. Because the earth also revolves around the sun, changing the plane of the day-night line as seen by the distant observer, this daily modulation would be seen as an *annual* modulation in the sidereal daily intensity curve.

The key question, perhaps, is whether the eavesdropper could identify the signal as being artificial. Even given the extremely narrow-band, linearly polarized signal with its precise patterns of frequency placement and frequency shifts, asks Sullivan, "might not one of their clever theorists be able to produce a substance that naturally emits the appropriate spectrum?" It's a tall order, but if the distant civilization has previously encountered no others, its experts will be faced with the problem of trying to rule out all natural causes first. Discovering the program content would certainly prove the point, but barring that breakthrough, Sullivan says, "it's impossible to say." Yet much could be learned, or at least inferred.

The long-period Doppler shift in the signal due to the earth's motion around the sun would strongly suggest such orbital movement. After a year of observing variations in the signal's radial velocity (due to the earth's approaching and receding from the observer's position), the eavesdropper could derive earth's orbital period, the eccentricity of the orbit, the longitude of its closest approach to the sun, and probably enough other information to find the orbit's semimajor axis, important in theorizing whether the signal source is at such a distance from its star that the temperature might tolerate life.

Other analyses would show that the source-body rotates, and reveal the inclination of its equator, allowing speculation on the nature of the seasons. Doppler-shift geometry could yield the radius of the body (even though the antenna could not resolve it), ultimately leading to a map of individual station locations that Sullivan says would be accurate to within a few kilometers. The map, with two marked concentrations, several lesser ones and vast "bare spots," might lead to the inference of geophysical, political or other boundaries, but other such "cultural deductions" are simply unknowable.

Earth's inadvertent sending, says Sullivan, should not take the place of deliberate attempts, nor of our own listening efforts. It does, in fact, provide a model for a deductive process through which earthlings, some day, may have to go. □



*The proposed "Cyclops" array of 1,000 100-meter dish antennas is the sort that an extraterrestrial listener might need to detect the radiation leakage of earth's TV carrier waves from a distance of 25 light-years.*

NASA