Voyager: A third ear in a pinch

The powerful radio emissions of Jupiter have been recognized on earth for nearly a quarter of a century. In recent years, possible signs have been detected of similar outpourings from Saturn and perhaps Uranus, and theorists think it likely that Neptune is yet another beacon in the sky. Now en route to study such emissions (among numerous other phenomena) are Voyagers 1 and 2, said to be the first U.S. spacecraft ever to carry instruments intended exclusively for planetary radio astronomy.

Both probes will fly past Jupiter next year, afterwards heading off to Saturn encounters in 1980 (Voyager 1) and 1981 (Voyager 2). If all goes well, Voyager 2 may then move off on a still more ambitious trek, bound for Uranus in 1986 and maybe even Neptune late in 1989, adding up to a record-breaking flight of a dozen years. Thus it is perhaps ironic that, with some or all of the solar system's major planetary beacons on its tentative itinerary, the success or failure of Voyager 2 could end up depending on the ability of that radio-astronomy instrument to "hear" radio signals from earth.

Last April, one of the two receivers over which Voyager 2 had been receiving its commands from the control center at Jet Propulsion Laboratory in Pasadena stopped working, apparently due to blown fuses. The other receiver has been carrying on the task — doubled or "redundant" components are common on spacecraft for just such emergencies — but it, too, has had its troubles (SN: 4/29/78, p. 279). Although these ills are not at present seen as signs of any terminal condition, Voyager engineers are concerned because the spacecraft's whole mission is still before it, and without a way to receive instructions from earth the probe would face at best a greatly restricted mission, operating on a limited batch of pre-stored commands that say essentially, "If you never hear from earth again, at least do this." At worst, the controllers at JPL would be unable to correct or compensate for some other malfunction that might leave Voyager 2 dead in space, mutely drifting through the millennia.

But Voyager 2 carries yet a third "ear": the planetary radio-astronomy instrument, or PRA. It is about as different from the regular command receivers as it could be, but it is on the spacecraft, and it is in working order. The PRA first detected Jupiter's radio output last December (three months after the spacecraft was launched), and before that it had provided the first measurements of the polarization of earth's kilometric radio "noise."

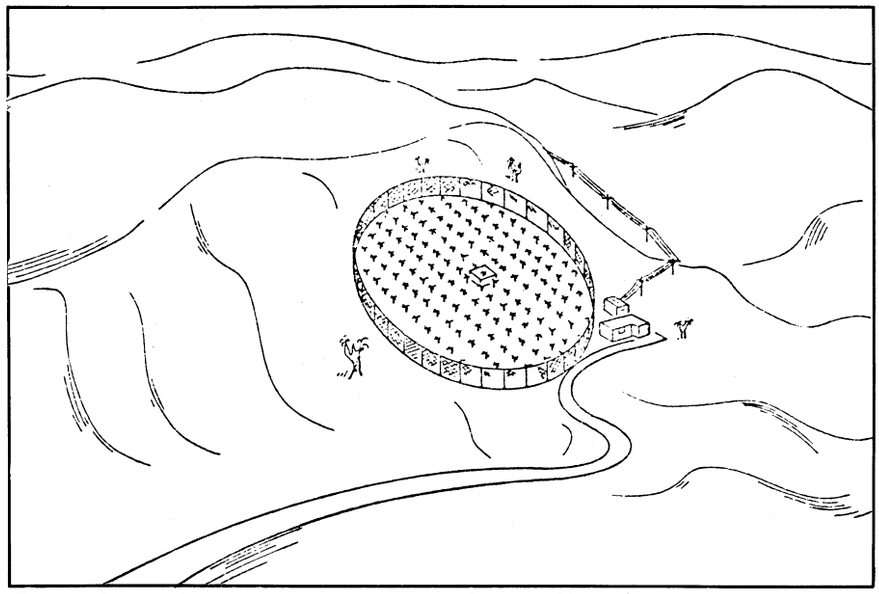
It was the PRA's chief scientist, James W. Warwick of the University of Colorado, who pointed out to Voyager project officials in 1973 (while the craft was still being designed) that the device could be used in a pinch as a "deep backup" receiver. Far more would be involved than simply throwing a switch, however, and it was not until this year, when the first regular receiver stopped working, that the Voyager office seriously began to explore the possibility.

One of the problems is frequency. The command receiver operates in the "S-band" region at 2113 megahertz, while the PRA is designed to detect Jovian emissions below 40 MHz. A more significant factor may be the difference between how the regular receiver and the PRA operate. A radio signal to Voyager gets weaker as the square of the spacecraft's distance away, but the command receiver can compensate for this effect (on the possible "bit rate" of incoming information) by narrowing its bandwidth essentially to concentrate the strength of the incoming signal. The PRA, however, covers a fixed bandwidth, with the result that, in effect, its sensitivity goes down with the *fourth* power of distance. In other words, when the spacecraft doubles its distance from earth, a given signal appears four times weaker to the command receiver, but 16 times weaker to the PRA.

The first real step at checking out the idea was taken on Sept. 13, when a signal was directly beamed to the PRA for the first time. There was no message — just the plain carrier wave, transmitted from the 46-meter Stanford radio telescope in California, and it took a week even to be sure that the spacecraft had detected it. The PRA works by scanning across a 200-kHz-wide bandwidth every thirtieth of a second, and even last December Jupiter's powerful radio output could be identified in a single scan. The Stanford signal, Warwick says, took 10,000 scans, even though it was sent by a 250,000-watt transmitter.

To use the PRA as a command receiver thus might well require building a new transmitting facility, or at least its huge antenna. "Antenna efficiency," says Warwick, "is a lot cheaper than watts," and Voyager officials are now studying the requirements for such a device. One version under consideration is a circular array more than 180 meters across, built on the ground (rather than as a movable dish) and consisting of about 1,000 individual dipole antennas phase-linked together into, effectively, a single large structure.

Existing radio telescopes are being studied as possible candidates — the above version could cost several million dollars — but, says Warwick, all so far seem to have their drawbacks. Huge Arecibo in Puerto Rico is heavily committed to other work and cannot aim as far south of the equator as Voyager 2 will go in parts of its journey. Platteville, in Colorado, transmits in too low a frequency band. The Clark Lake facility, east of San Diego, would take too much power, Warwick says, and Peru's Jicamarca cannot at present be even electronically steered to follow the spacecraft.



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Proposed ground antenna for transmitting to Voyager 2's radio-astronomy instrument.

It is possible, of course, that the whole idea will never be needed — the existing receiver may just keep plugging along. Also, the PRA could not take over the job until after next year's Jupiter encounter anyway, and Uranus and Neptune are as yet only optional targets.

There could be other uses for the ground facility, however. Besides studies of the interplanetary medium and occultation measurements of such targets as Saturn's rings (both making use of the spacecraft at the "other end"), Warwick suggests possibilities including radar studies of terrestrial winds and of the solar corona.

The fate of Voyager, however, will probably make the difference. □