Man in the Moon

By DIETRICK E. THOMSEN

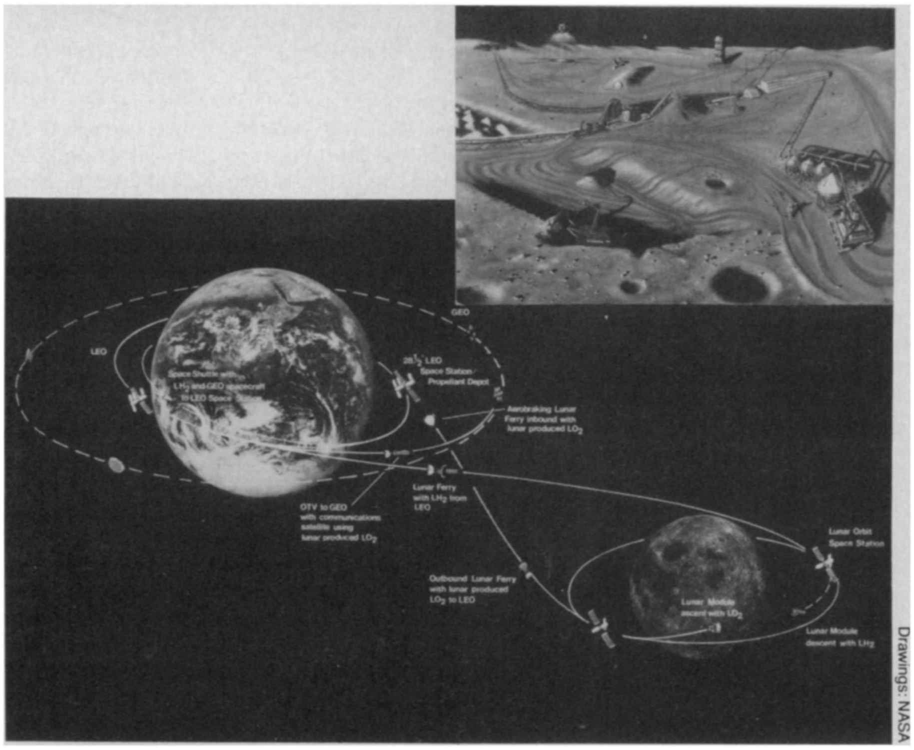
Two decades ago a major goal, if not *the* major goal, of the U.S. space program was to put a man on the moon. Since that was accomplished, manned space flight has never gone farther — or even as far again. Now there is a group of scientists (mostly astronomers) and spaceflight specialists planning for a human return in force to the moon. This time it would not be a short mission for reconnaissance or exploration, but a colony meant to last.

Jack O. Burns of the University of New Mexico in Albuquerque wonders if it is not too soon to worry about such a thing. "Will anybody pay attention?" he asks. In reply Harlan Smith, director of the University of Texas McDonald Observatory and professor at the Austin campus, points out that astronomers started talking about the Space Telescope back in 1962. The telescope is just now nearing completion, and before the Challenger explosion sent NASA's plans into disarray, it was scheduled to go into orbit later this year. Smith envisions the first lunar pioneers landing around the year 2000.

"I'm amazed at what the moon offers for astronomy," Smith told the Symposium on Astronomical Observations from a Lunar Base, which met in Houston early in January. However, astronomers do not expect their amazement alone to carry the day for a moon colony. They hope to be able to piggyback on various cultural, political and even economic impulses. Wendel Mendell of NASA's Johnson Space Center in Houston quotes Krafft Ehricke, president of Space Global Corp. in La Jolla, Calif., one of the pioneers of spaceflight: "If God had meant us to be a spacefaring race, he would have given us a moon."

Says Smith, "There's no question there are going to be human beings on the moon."

In addition to this climb-Mt.-Everest-because-it's-there attitude, proponents of a moon colony see an international manned-spaceflight race in the future. Mendell points out that the Apollo program was both begun and terminated by political motivations. "In 10 years the moon will be a policy issue," he says. Smith maintains, "We're going to see a major manned Russian push into space." There could be an economic payback as well as a political one. Mendell foresees moon mines, particularly for oxygen to be used as propellant.



Earth-moon transportation is a three-step process. Part of its freight would be liquid oxygen produced on the moon by chemically reducing ilmenite mined there and electrolytically separating the resulting water (inset).

For astronomy the moon would provide a stable platform capable of accommodating the largest equipment. This platform is virtually free of an atmosphere. It is free of the light pollution and radio interference characteristic of the earth's surface. It rotates every 28 days, and so provides a full view of the sky. Unlike equipment in near-earth orbit, instruments on the moon would never be blocked or shadowed by the earth. Every branch of astronomy has projects it would like to put into such an environment.

The lunar surface vacuum would permit diffraction-limited imagery for optical telescopes, says Smith. The sharpness of the images would be limited only by the size and curvature of the mirrors, not by atmospheric twinkling. It would make possible radioastronomy at frequencies below 40 megahertz, impossible from the earth's surface.

According to James Douglas of the University of Texas at Austin, radio waves at such low frequencies would give us new information about sources we already know emit them, such as the sun, Jupiter, Saturn, earth and the interstellar medium of our galaxy. We might also discover previously unknown objects. If we went to the far side of the moon, where the moon's bulk would shield the receiver from sources of such radiation on the earth, conditions would be so good that the equipment could be quite simple. "The receiver could be a hairpin," Douglas says.

For X-ray astronomy the lunar lack of atmosphere means that detectors can be set on the surface; it will not be necessary to put them on rockets or orbiters. This convenience combines with the virtually unlimited real estate on the moon, as Paul Gorenstein of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass., puts it. Experiments would not be limited by the apertures of instruments that can be carried on rockets and orbiters; they could be spread out over acres. Gorenstein's most specific proposal is a Large Area Modular Array of Reflectors, a matrix of telescopes to be laid out over an area 30 meters square. Such a thing would have an X-ray collecting area of up to a million square centimeters. This is 1,000 times that of AXAF, the Advanced X-ray Astrophysics Facility that NASA intends to put into orbit early in the next decade.

Smith's list of lunar advantages continues with its dark, cold sky. This facilitates observation of ultrafaint objects. (In addition, the moon's slow rotation, with its 14-day night, would enhance such observations with very long photographic exposures.) The darkness also gives spectra free of sky emissions, and it means good daytime observations.

The ultracold would particularly aid infrared observations. On the earth, infrared emissions from astronomical objects face competition from the heated air, the soil, structures, people and particularly the telescope itself. As Dan Lester of the University of Texas at Austin adds, the lunar lack of atmosphere means there would be little contamination of an infrared telescope and its sensors by freezing out of gases from the earth's extended atmosphere such as "you run into in low earth orbit." An infrared telescope on the moon could also be passively cooled, he says. It wouldn't need to be actively cooled with expensive refrigerants as on earth or in near-earth orbit. The lunar surface cools to 120 kelvins toward the end of its 14-day night.

Lester proposes for a first step an infrared survey telescope sweeping the sky as the moon rotates. It would have a mirror 1 meter across with an array of infrared sensors at its focus. Such a telescope would be very simple and could be set up and get results in the pioneering stage of a lunar colony while the colonists were still struggling to establish themselves, he says.

The moon's stability and large expanses of empty terrain are a natural combination for interferometry, a technique that puts together observations by an array of telescopes in such a way as to simulate a single telescope as large as the whole array. Interferometry reveals very fine detail about astronomical sources; the larger the array, the finer the detail.

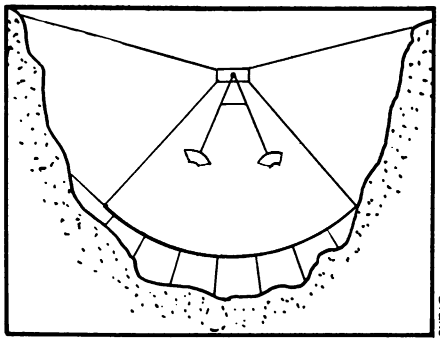
Historically interferometry has been most practiced in radioastronomy, a range of the radiation spectrum where it can be successfully done on the surface of the earth. Still, there are subtle advantages to putting a radio interferometer on the moon, says Roger Linfield of the Jet Propulsion Laboratory in Pasadena, Calif. On the earth the troposphere retards radio waves and affects the resolution of long baseline interferometers. These would be more accurate on the moon, with potential resolution down to a thousandth of second of arc.

The real advantage for radioastronomy, says Burns, is to use a radiotelescope on the moon in an interferometric array with one or more on earth, an arrangement he calls a Moon-Earth Radio Interferometer (MERI). MERI would have a resolution 10,000 times as fine as that of the Very Large Array that now stands in New Mexico. It could measure locations of radioastronomical features to an accuracy of 30 millionths of a second of arc. It could record the radio emissions of individual stars such as the sun — very difficult to do now — and see them to 300 parsecs (almost 1,000 light-years) away. It could attack a long list of astrophysical and cosmological problems.

The largest single radiotelescope on earth is the 1,000-foot-diameter dish built into a natural depression near Arecibo, Puerto Rico. Frank Drake of the University of California at Santa Cruz points out that the moon's craters would be ideal locations for similar antennas. He adds that the design of the Arecibo telescope is also very appropriate for copying on the moon.

The spherical shape of the reflecting surface at Arecibo is formed from a mesh of weighted wires. Its receiver is hung from wires draped over three pylons built on the edge of the hole. A combination of weights and cable connections holds everything in shape and in place. The weights rest on the ground, but are not attached to it. Nearly all members of the structure are in tension; only the three pylons are in compression.

The ground at Arecibo dictated this design; it won't take shear stresses. Neither will the moon's outer surface, says geologist Geoffrey J. Taylor of the University of New Mexico. The largest feasible size for such a reflector depends on how long the wires can become before they break of their own weight. On the earth this is about 5 kilometers for steel, Drake says. With the moon's lesser gravity it could be 30 km for steel and 60 to 90 km for high-specific-strength materials, he says. Observers could see a great deal of the radio universe with that.



Drake

Arecibo-type telescope in moon crater. Receiver hangs from the crater lip.

The moon seems a prime location for an optical interferometer, too. Although there are ongoing projects to produce optical interferometers of some size on the earth, optical interferometry historically has been restricted to receivers only a few meters apart. At larger distances, atmospheric twinkling effects destroy the time and phase correlations necessary for interferometry.

For the moon, Jacqueline Hewitt of Massachusetts Institute of Technology describes an interferometer made of 27 small telescopes spaced over an area 10 kilometers across. With a resolving power in the microarcsecond range, it should be able to see stars as disks — not as shimmering points of light — and to resolve features such as starspots on their surfaces. Each of the 27 elements would weigh about 530 kilograms (on earth), or half a shuttle payload. Hewitt does not foresee transportation as a problem.

Assuming that a colony for permanent human residence had been established, people would be continuously available to monitor and maintain astronomical equipment on the moon — a significant advantage over the situation of equipment in earth orbit. However, this advantage carries with it a potential disadvantage. As Smith puts it, "You are a fraction of a millimeter away from death. Anything that punctures your space suit, you've had it." It would be preferable to do as much as possible with robots.

We would go to the moon in stages. The first would be the establishment of a manned station in earth orbit. Shuttle vehicles would carry people and materials to this station. Interplanetary vehicles would then take them to a similar station orbiting the moon, and from there a suitable lander vehicle would take them to the lunar surface.

The practicality of this scheme depends on shuttle technology — as Mendell puts it, "not having to throw away your vehicle each time." The Challenger disaster has saddened the proponents of a lunar colony, but it has not seriously damped their enthusiasm, says Burns. This is a project not likely to begin for 15 to 30 years, and the Challenger explosion, though it may put off NASA's immediate plans for a year or more, is not likely to affect lunar colonization much. Burns says the only really serious hindrance would be a public backlash that might compromise the future of the whole U.S. space program, but he does not see that developing, nor do the politicians he talks to.

Politicians do have to think about money, however, and at this symposium so did Paul Keaton of Los Alamos (N.M.) National Laboratory. Keaton presents figures to show that for the last 100 years the American economy has been on a steady growth curve, with a whopping average annual growth rate of 3.2 percent. Even the Depression of the 1930s, which was so disastrous for so many, appears as no more than a small glitch on his growth curve. Expenditures for space, he says, have been a minor part of the national budget compared with welfare and entitlement programs or defense.

Keaton estimates the cost of a lunar base at $130 billion over 22 years. The manned earth-orbiting station would add another $100 billion. In comparison, the Apollo program cost $25 billion in the currency of the 1960s, or the equivalent of $80 billion in 1985. If the lunar base project should fall somewhere in the time frame 1990 to 2020, Keaton figures its cost would amount to a tenth of a percent of the gross national product, assuming his growth curve continues. He thinks the country can afford it. □