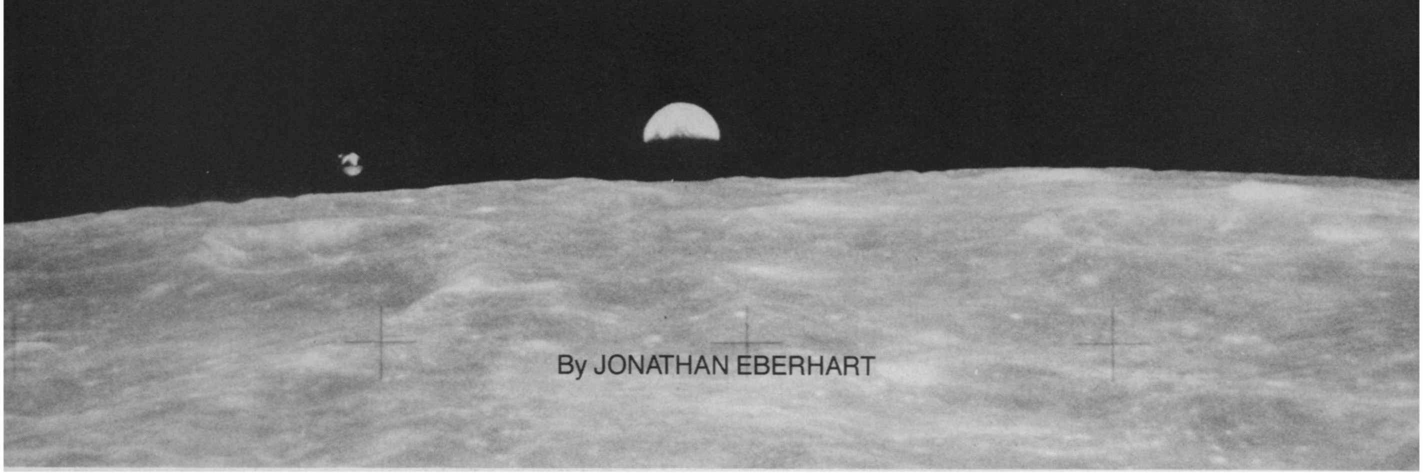
Going for the Whole Moon

The Lunar Observer would study what other spacecraft missed



By JONATHAN EBERHART

An early portrait: Earth and an Apollo command module loom over the moon's cratered horizon in this NASA photo taken from a lunar landing craft.

The stampede to the moon began in January 1959 with the Soviet Union's Luna 1 probe, which missed its objective by 6,000 kilometers. Two months later came the U.S. Pioneer 4, which passed 10 times as far away. In spite of early failures, the space race was on, and more than five dozen spacecraft have since made the trip, most of them taking pictures and a few carrying astronauts and returning with moonrocks. It might thus seem that the moon is well known by now — yet in a sense, all of these missions wore blinders.

Spacecraft photographing the moon from orbit have been able to observe only narrow strips, in large part because most orbits have been angled to pass only slightly above or below the lunar equator. Furthermore, the orbits of different spacecraft often do not overlap, so when scientists want to compare different kinds of measurements gathered during separate missions, the data often reveal little more than individual "postage stamps," marking the only spots on the surface where the various orbital paths cross.

Similarly, scientists know little about variations in the lunar gravitational field — necessary for figuring out where the moon's mass is concentrated — and about the moon's surface composition, because few spacecraft have followed orbits tilted enough to carry them over the higher latitudes near the lunar poles.

In 1974, scientists began advocating a solution to this knowledge gap, in the form of an unmanned spacecraft called the Lunar Polar Orbiter. Carrying instruments similar to those aboard the Apollo craft and other missions, it would have gone into an orbit tilted about 90° to the moon's spin axis, so that the whole lunar surface would have passed beneath it. The Apollo program had wound down by that time, however, and a polar moon-orbiter attracted little support, even when some scientists noted that this single mission could expand all the Apollo-era "postage stamps" into global maps. The Lunar Polar Orbiter lost out to a considerably more intriguing plan called the Jupiter Orbiter and Probe. The twin spacecraft, renamed Voyagers 1 and 2, took advantage of a rare alignment of the outer planets to visit Jupiter, Saturn, Uranus and Neptune during an enormously successful 12-year mission.

Now NASA wants to give the moon another look. Its 1991 budget request, now under consideration by Congress, seeks $15 million to begin developing a $500-million-plus polar orbiting mission called the Lunar Observer.

Why now? Space agency officials cite several reports in recent years — including one by then-astronaut Sally Ride and another by the National Space Commission — proposing a permanently inhabited lunar outpost and human exploration of Mars as objects for NASA's focus. In addition, President Bush included both objectives as part of a "Human Exploration Initiative" proposed last July.

Indeed, many space enthusiasts see the Lunar Observer as testing the commitment of the administration, Congress and the nation to the idea of sending humans to the moon once again. While the craft could carry out its mission without obligating the United States to an inhabited lunar installation, building such a base early in the 21st century requires something like the Lunar Observer as a preparatory step.

NASA's plans for the envisioned moon base call for building habitats and an oxygen plant as well as developing new construction technologies to use in the inhospitable lunar environment. Before any of these projects got underway, however, the Lunar Observer would lay the groundwork, providing key facts about potential sites for the outpost. NASA officials see the lunar craft as similar in design to another unmanned spacecraft called the Mars Observer, scheduled for launch in 1992.

Some Lunar Observer proponents, however, worry about whether continued scientific investigation of the moon would win enough support to get the mission started were it not for the added enticement of the more costly human visits that might follow. "The Human Exploration Initiative is what is driving this mission right now," says Douglas Nash, a development-flight project scientist for the craft at NASA's Jet Propulsion Laboratory (JPL) in Pasadena, Calif. "The assumption is that we're going to send human beings back to the moon. The odds are that except for Bush's initiative, it [the Lunar Observer] wouldn't get off the ground at this time."

Cost estimates for the mission run from $500 million to $700 million, plus the cost of launching the craft with an expendable rocket instead of the space shuttle, says Kerry Nock, the project's science-mission design manager at JPL. Nash, Nock and others express hope that the Lunar Observer will head moonward in seven or eight years in the form of two identical spacecraft, each perhaps deploying a small "subsatellite" to help with some of the planned experiments. Using two craft, Nash says, would keep the data flowing, complete the mission more quickly and allow the option of doing some things differently with the second craft.

NASA is considering various dates for starting the lunar base, and Nock says that providing engineering and environmental data in time to get it going by 2005 would require launching the Lunar Observer by 1997 or 1998. The craft would map the moon and study its surface for a full year, then continue for a second year to pare down a proposed set of potential surface sites for the outpost.

Scientists working on the Lunar Observer mission have proposed an elaborate set of instruments to study the moon's surface properties, subsurface geophysics, thin atmosphere and even its astronomical environment. So far, says Nash, these proposals form a "straw-man payload" to help planners envision the final design and to provide a basis for various scientific and engineering decisions.

Surface properties: Some researchers have speculated that ice may exist in shaded areas near the moon's poles, representing a source of water as well as of hydrogen for materials processing and other lunar-base activities. A gamma-ray spectrometer aboard the Lunar Observer would look for such ice. If any sufficient concentration of ice exists within about 1 meter of the surface, says Nash, neutrons released from the ice by gamma rays striking it should reveal the hydrogen – almost certain evidence of water-ice. The gamma-ray spectrometer would use detectors made of germanium, deemed more hydrogen-sensitive than the sodium iodide detectors used during Apollo.

The imaging system proposed for the mission would use three different cameras. One of them, for geodesy studies, would measure only the extent of high and low areas on the surface. A camera taking pictures nearly four times as sharp as those of the geodesy camera (15 meters per pixel, compared with 55) would map the moon on a global scale. The third and sharpest camera would have one clear and three color channels, which could show subtle differences in the composition of the moon's vast volcanic floodplains, or maria (SN: 3/24/90, p.191). This camera would examine possible landing sites, measuring their elevations to within 0.6 meters. At the same time, a laser altimeter would measure elevations – ups, downs and rough spots – to within 2 meters' accuracy and horizontal details to within about 50 meters.

An X-ray spectrometer would enable Earth-based scientists to determine the abundances of individual elements in the surface rock while a visible/near-infrared mapping spectrometer looks for minerals. A thermal-emission spectrometer, sensitive to emitted rather than reflected energy, would measure the spectra of rocks as they are heated by the sun. This would help with mineralogy studies by revealing what elements exist in the rocks.

Subsurface geophysics: The Lunar Observer would first go into an elliptical, pole-crossing orbit ranging from 200 to 5,000 km above the moon, then release its "subsatellite" into the same orbit to provide what scientists envision as the first definitive gravitational measurements of the lunar far side. Researchers would determine these by analyzing the wavelength changes, or Doppler shifts, in the radio signals received by the Observer from an ultrastable oscillator aboard the subsatellite. Gravity variations would move the tiny satellite up and down as it orbited the moon, prompting measurable changes in the craft's radio signals.

Eventually, ground controllers would lower the Observer to a circular orbit with an altitude of 200 km, and later 100 km, leaving the subsatellite in its highly elliptical path. The low-flying craft would shoot surface photos and obtain spectral data and more precise gravity measurements that reveal the distribution of the moon's internal mass.

"We want a very tight [gravity] mapping of the moon," says Donald Gray of JPL, who studies gravity fields.

Some gravity-field models raise questions as to whether the craft will have enough fuel to stay approximately at its assigned altitude if the lunar gravity varies too much from place to place. Current plans provide for enough fuel to allow changing the speed of each of the twin Observers by a total of 730 meters per second during the mission. But scientists are so uncertain of the moon's gravity that estimates of how much fuel the craft should carry range from "about a tenth of that number to twice that number," Gray says. "We don't have data near the poles or data for the far side."

The chosen amount of fuel will affect the cost of both the launch vehicle and the spacecraft, but Gray predicts the Lunar Observer measurements of the gravity field will be "about 10 times as good as what we've got now."

Plans call for measuring the moon's magnetic field with a magnetometer on each Lunar Observer, and possibly on the subsatellites as well. Doing the job from an Observer's circular orbit and a subsatellite's ellipse at the same time, says Nash, will allow "deep sounding" of the lunar interior to ascertain whether the moon has an iron core and to determine the core's size and shape.

In addition, an electron reflectometer on the craft would help map the magnetic field at the moon's surface – believed to be a "remnant field" left over from when the moon cooled – by measuring the number of low-energy electrons trapped in that field. The reflectometer would map electrons flashing back and forth along magnetic field lines near the surface, while the magnetometer would measure the field strength near the spacecraft.

A shallower view of the lunar interior would come from a microwave radiometer. This would measure the microwave intensity in three wavelengths between about 1 cm and 20 cm. The instrument would provide data about the physical properties of the moon's surface and near-surface layers at depths down to perhaps 10 meters.

Atmosphere: As thin as it is, the moon's atmosphere has nonetheless revealed traces of sodium and potassium, and it may include traces of other elements. Nash notes that a primary science objective of the project is to obtain baseline data on the state of the lunar atmosphere before human activities related to an inhabited outpost change it forever, causing ecological shifts that would affect the entire moon.

Lunar Observer plans include an ultraviolet spectrometer as well as ion and neutral-atom mass spectrometers for atmosphere studies. In addition, Nash says, a particularly sensitive technique would be "radio occultation" – sending radio signals close to the lunar surface on their way to Earth or the subsatellite, to see whether they are affected by passing through even faint wisps of an atmosphere.

Astronomy: Astronomers have long dreamed of constructing a huge radio telescope on the moon's far side. With the moon itself blocking off human-made and natural emissions from Earth, this could allow scientists to observe faint stellar radio sources. Such a facility might well prove the most "radio-quiet" of its kind, and one goal of the Lunar Observer planners is to check out the possibility by studying the "radio environment" in the part of the lunar sky that is never visible from Earth.

The mission is already part of NASA's planning for the future. Still unresolved, however, is whether funding for the project will survive the budget process – an uncertainty that leaves space scientists, NASA officials and others to wonder whether the whole idea of a U.S. return to the moon will in fact become reality. ☐