Asking for the Moon

With the space station still on the drawing boards, people are already urging NASA to look beyond—to a permanent lunar base

Fifteen years after Neil Armstrong and Edwin Aldrin touched down at Tranquillity Base in 1969, and 12 years after the Nixon Administration abruptly canceled the Apollo program in 1972, to a cadre of enthusiasts from the National Aeronautics and Space Administration's (NASA's) Johnson Space Center convened a symposium at the National Academy of Sciences to contemplate a return to the moon—this time to build a permanent base.*

It was an odd conference to listen to. On one hand, talking about a lunar base seems grossly premature. NASA has barely gotten started on its space station project. On the other hand, lunar bases are nothing new. Most of the arguments presented at the Academy—that we should go back to the moon to study the origin of the solar system, to build giant observatories on the far side, to exploit lunar resources, or to mount further expeditions to Mars and the asteroids—have been made many times before.

Yet the roughly 200 participants in the lunar base symposium formed a solid and responsible cross section of the space community, and they were convinced that the time had come to take the idea seriously. "We see the moon as a logical, evolutionary step," said planetary scientist Wendell M. Mendell of the Johnson Space Center, one of the organizers of the symposium. More important, he and his colleagues could point to a number of new factors in the political equation:

• A Supportive Administration. Ronald Reagan's endorsement of NASA's space station program symbolizes an increased receptiveness to this sort of thing in Washington—even at NASA headquarters, where officials have long been leery of visionary suggestions that might provoke the agency's numerous critics. In his keynote speech to the symposium, NASA administrator James M. Beggs came as close as he ever has to endorsing the lunar base idea: "I believe it likely that before the first decade of the next century is out, we will, indeed, return to the moon."

White House science adviser George A. Keyworth, II, who has long been pushing NASA to articulate goals beyond the space station, was even more emphatic. "My firm opinion is that the space program ought to be both practical *and* visionary," Keyworth told the symposium. "A lunar base is only one of the more obvious next steps."

• The Space Station. Assuming that the station goes forward as planned, it will allow the approach to the moon to be far more orderly and incremental than it was in the Apollo program. As a number of speakers pointed out, the space station itself would serve as a staging area and refueling depot. Much of the station technology, including habitation modules, power, thermal control, and communications, could be adapted to build the lunar base.

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And the "orbital transfer vehicle," a reusable spacecraft that will be developed to ferry communications satellites from the station to the 35,900-kilometer-geostationary orbit, could easily be adapted to take payloads to the moon: the fuel requirements for geostationary and lunar orbits happen to be almost identical.

The upshot is that the cost of a lunar base may not be impossibly high. The Planetary Society, a space interest group headed by Carl Sagan, and certainly no fan of the manned space program in the past, has recently estimated that an initial manned landing and reconnaissance of the moon, using space station technology, would cost $17 billion in 1984 dollars. (The Apollo program cost $75 billion.) According to the society's executive director, Louis Friedman, that figure translates into a year-by-year budget that is roughly the same as NASA's development budget for space shuttle, or its proposed budgets for space station. The lunar base could thus be phased in smoothly after the initial rounds of space station construction are completed in the 1990's.

• The International Prospect. A lunar base could have considerable symbolic and political utility if it were done internationally; Phillip M. Smith, executive officer of the Academy, pointed out a number of terrestrial precedents, including the Antarctic bases, CERN (the European Center for Particle Physics), Spacelab, and the Apollo-Soyuz Test Project.

Admittedly, the prospects for direct U.S.-Soviet cooperation on the moon (or anywhere else) are exceptionally dim at the moment, said Smith. On the other hand, a lunar base is still 15 to 20 years away and attitudes do sometimes change. (On 30 October, in fact, Reagan signed Senate Joint Resolution 236, which calls for initiating cooperative East-West ventures in space.)

More encouraging is the move toward greater scientific cooperation among the Western nations, not least because it helps spread the costs around. In June, for example, the Versailles Economic Summit identified 18 scientific areas that seemed ripe for joint ventures, including fusion, particle physics, and planetary science. Last January, Reagan explicitly invited other nations to participate in the U.S. space station; the Japanese, the Canadians, and the Europeans have responded with strong interest. By the time the lunar base is ready to go in the late 1990's, the framework for an international venture should already be in place.

Obviously, said Mendell, it is premature to talk about spending a lot of money on a lunar base project. Significant funding will not be needed until the 1990's. But what *is* needed now is a national commitment to the moon as a long-term goal. At the very least, he said, NASA should be planning the space station and the orbital transfer vehicle with the moon in mind.

At the same time, he added, the proponents have to articulate a clear rationale for the moon. His audience seemed well aware of that necessity. Most of the technical papers in the symposium were devoted to what people might do on the moon.

There is the scientific study of the

*"Lunar Bases and Space Activities of the 21st Century," 29 to 31 October, at the National Academy of Sciences.

moon itself, for example. Even after the six Apollo landings and a series of unmanned Soviet probes, its origin and evolution is as obscure as ever. Researchers are not even sure if the moon has a metallic core. The Lunar Geochemical Orbiter, scheduled for launch in 1991, will map the broad-scale surface composition. But it will need to be followed up by seismic networks, heat-flow measurements, and in situ chemical analysis.

In the same vein, the relatively pristine surface of the moon has preserved a record of early solar system. Solar wind and solar flare particles trapped in the lunar surface layer, for example, can trace changes in solar activity over the past 4 billion years.

As a platform for space astronomy, the moon offers three advantages. First, radio telescopes on the far side would be shielded from terrestrial radio emissions, which would allow for observations at the theoretical limits of sensitivity. Second, the moon provides a solid, seismically stable, high-vacuum platform for interferometric arrays; a lunar optical array, for example, might resolve astronomical details about a million times finer than those seen from the earth. Finally, the moon lies beyond the earth's radiation belts, which gives it a low-background-radiation environment for studying such things as cosmic rays, the solar wind plasma, cosmic neutrinos, and even gravitational radiation.

As a source of raw materials in space, the moon is attractive for the simple reason that lifting an object into orbit from its surface takes roughly 1/20 to 1/30 as much energy as launching it from the surface of the earth. A prime example is liquid oxygen, which will be much in demand as a propellant for hydrogen-oxygen rockets such as the Centaur upper stage or the orbital transfer vehicle. It happens that oxygen is abundant in the silicate rocks of the moon and could be extracted using readily available solar power.

In conclusion, the participants in the symposium cheerfully admitted that the whole idea of a lunar base is highly speculative—but then, how does any new idea get started? Indeed, several enthusiasts called the meeting a landmark. More realistically, however, it was a trial balloon, an attempt by lunar base proponents to get the attention of the Administration, the media, and most especially, NASA headquarters.

In that they probably succeeded. It remains to be seen if they can build a compelling political case for the moon.

—**M. Mitchell Waldrop**

Obstacles to Arms Control in Space

Continued pursuit of a comprehensive ballistic missile defense, as outlined in President Reagan's "Star Wars" plan, will bar any meaningful limitation on antisatellite weapons, according to a report prepared recently for the Arms Control and Disarmament Agency (ACDA). Conversely, the report says, a continuing effort to develop and deploy antisatellite weapons will seriously erode existing limitations on ballistic missile defenses.

The report, written under contract by William Durch, a former ACDA official who is presently a research fellow at Harvard University,* indicates that the Reagan Administration will face some difficult choices when it next confronts the Soviet Union in arms negotiations. Last summer, the Soviets indicated that one of their first priorities in any arms control talks would be to halt the testing and development of satellite killers by the United States (*Science*, 10 August, p. 601). Durch makes it clear, however, that such an agreement will be meaningless unless restrictions are also placed on the testing and development of ballistic missile defenses.

The reason, he explains, is that the technology needed for ballistic missile defense (BMD) and for an antisatellite weapon (ASAT) is similar. Under an existing BMD treaty, for example, either country can develop and deploy a limited number of weapons capable of intercepting ballistic missiles in midflight. Due to the overlap in technology, these could also be used to attack low-altitude satellites. At a recent defense conference, Major General Eugene Fox, the manager of the Army's BMD program, agreed that "without a doubt, there is a technical capability to do it." Last summer, the United States successfully tested such a weapon against a missile over the Pacific Ocean.

More sophisticated space-based BMD systems, of the type envisioned by Reagan, would "automatically" provide extensive ASAT capabilities, Durch says. The reason is that satellites, which are less numerous and travel in more or less predictable orbits at relatively low speed, will never be more challenging targets than ballistic missiles, and will therefore be vulnerable to any BMD weapons deployed within range.

Conversely, weapons designed primarily as ASAT's can also provide limited BMD capability. Fixed and mobile ground-based lasers, for example, cannot be tested in a BMD "mode," under an existing BMD treaty. However, they can be tested in an ASAT mode, and there is some overlap between the two. Such tests "could generate considerable uncertainty with respect to . . . treaty compliance," Durch writes. Similarly, a space-based system composed of multiple projectiles that home in the heat signature of satellites could "provide valuable data" for a BMD system aimed at missiles. And a space-based laser and particle beam system designed primarily to attack satellites "could be quite valuable to the design and development of space-based BMD."

Durch writes that "there is, in short, a two-way synergy . . . that could only be interrupted by prohibitions on space-testing for both." Although the report makes no explicit recommendations, Durch lists a number of reasons why such prohibitions would be sensible. One is that the United States intends to deploy a manned space station within the next decade, and to fly an increasing number of space shuttle missions, which will be vulnerable to ASAT attack. Another is that "ASAT will be a growth field for spending," with successful tests spawning a costly new competition with the Soviet Union. A third is that "it will be more difficult to roll back ASAT capabilities a decade hence." If one takes these into account, as well as what Durch describes as the minimal utility of ASAT's in a conflict with the Soviets, then the benefits of arms control seem clear, he says.

Henry Cooper, the director of ACDA's strategic programs bureau, says that he agrees with the report's conclusions about the overlap in BMD and ASAT technologies.—**R. Jeffrey Smith**

*Durch, who also worked at the Center for Naval Analyses from 1973 to 1978, is solely responsible for the study's conclusions. But he had advice from Ashton Carter, an assistant director of the Center for Science and International Affairs at Harvard University, who formerly worked at the Defense Department's systems analysis office; Donald Hafner, a former adviser to the National Security Council on ASAT matters, who now teaches at Boston College; Stephen Meyer, a political scientist at MIT who directs a working group in Soviet security studies; Paul Stares, a research fellow at the Brookings Institution; and Philip O'Neill, Jr., a lawyer in Boston.