Asking for the Moon

The moon-Mars initiative may or may not fly on Capitol Hill, but NASA wants the scientists on its side

GIVEN THE STATE of the federal deficit these days, it's still anybody's guess how Congress will react to President Bush's multibillion-dollar "Human Exploration Initiative," his proposal to send humans to the moon and Mars. Adding together existing programs related to the initiative, plus enhancements, yields a first-year budget request of some $1.3 billion in fiscal 1991.

In the meantime, however, the National Aeronautics and Space Administration (NASA) and the White House's National Space Council are making every effort to build some credibility with the proposal's second toughest audience: the scientists who remember all too clearly how huge expenses and chronic delays on an earlier human exploration initiative—the space shuttle—ended up ravaging the rest of NASA's research programs.

To that end, NASA planning has been putting heavy emphasis on such scientific goals as the construction of astronomical observatories on the moon. And perhaps more important, the agency has pledged to open up its planning process in an unprecedented way. In an effort to forestall another shuttle experience, for example, the National Academy of Sciences and the Aerospace Industries Association have been asked to review NASA's exploration plans on an ongoing basis. And to counter a widespread perception of massive bureaucratic inertia and lack of creativity at NASA, outside scientists and engineers are already being canvassed for innovations that might help space programs go far faster and more cheaply than they do now.

Those efforts at building a constituency seem to be paying off. At a recent Washington meeting of the American Astronomical Society, to take the most vivid example, an initially skeptical audience gave a hearty ovation to Vice President Dan Quayle when he outlined these measures and vowed that "the large exploration programs we are planning will not emphasize human activities at the expense of scientific excellence."

Quayle is chairman of the space council, a new 11-member policy group including such figures as the Administrator of NASA, the President's Chief of Staff, Science Adviser, and National Security Adviser, and the Secretaries of Defense, State, and the Treasury. It was the space council, in fact, that inspired the moon-Mars Initiative.

Senior astronomers, many of whom had been asked to comment on early drafts of the Vice President's speech, and who later received a background briefing from space council staffers, also voiced their support. "The Stever report has apparently had a strong influence on the thinking of the Administration," says Princeton University's Jeremiah Ostriker, referring to a 1988 report on the space program that was prepared for President-elect Bush by a national academy committee working under former presidential science adviser Guyford Stever. Ostriker, who was a member of that committee, notes that its central message was that any grand initiative to the moon or to Mars must come only in *addition* to NASA's baseline science and technology programs, not in place of them. "It seems that Quayle [and the space council] have agreed to that," he says.

Among the key safeguards of those baseline programs is the new national academy/aerospace industries review structure, which should be able to blow the whistle in a very public way if the moon-Mars initiative seems to be eating up the basic research budget. An ad hoc academy panel, also chaired by Stever, will soon be finishing up an evaluation of NASA's initial plan for the moon-Mars initiative, and NASA Administrator Richard Truly has recently sent in a formal request that the process be made permanent. The academy is expected to agree to this proposal. Its long-established Space Studies Board (formerly the Space Sciences Board) will continue critiquing NASA's baseline research and applications efforts.

Meanwhile, there is the common perception in the space community that NASA has long since become too ingrown to come up with anything new on its own. A case in point is NASA's "90-day plan," which the agency hurriedly put together during the 3 months after Bush announced the exploration initiative on 20 July last summer, and which envisioned a careful, step-by-step program of moon and Mars exploration at a cost of some $400 billion over 30 years: it was roundly criticized by the space council staff as being stodgy, slow, and unimaginative.

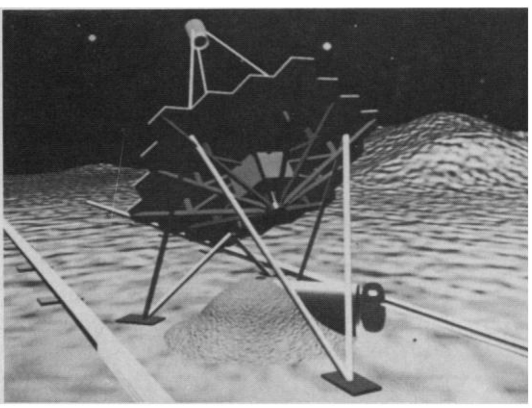
Frank Martin, head of NASA's Office of Exploration, thinks the criticism was blatantly unfair, if only because the 90-day report itself emphasized the need for innovative technology. "But we have to recognize the real world we're living in," he sighs. The perceptions are there. "You can't just step back and say that Challenger never happened."

In any case, Quayle sent Truly a letter on 19 December requesting that NASA "cast our net widely"—that the agency query academic researchers and aerospace industry engineers alike for their ideas on "different architectures, new systems concepts, promising new technologies, and innovative uses of new technologies."

The basic idea is that NASA will spend the next 2 years evaluating these new concepts. This approach recognizes the fact that Congress is highly unlikely to fund any massive new venture in the next few years—if ever. And any emphasis on "faster-cheaper-better" also looks good to the scientists, who have been increasingly frustrated by NASA science missions that take a decade or more to come to fruition. "It means that an assistant professor can get involved and not have it mean death to his career," says Ostriker.

One example of the kind of ideas that will likely be surfacing in this period is the approach recently proposed by physicist Lowell Wood and his colleagues at the Lawrence Livermore Laboratory—a group that has been preoccupied until recently with Strategic Defense Initiative research. By carrying everything into orbit using existing expendable rockets, they argue, and by assembling the interplanetary spacecraft and surface habitats out of inflatable Kevlar balloons, an expedition could be sent to Mars by the turn of the century for only $40 billion—about one-third the time and about one-tenth the cost of NASA's approach.

NASA



What would they do there? *An artist's conception of a 16-meter lunar telescope.*

This vision of inflatable spacecraft has raised some very skeptical eyebrows at NASA, where engineers wonder how long it would be until the first balloon pops. But the proposal has intrigued staffers at the space council, who see it as an "existence proof" that the NASA way is not necessarily the only way. Whether or not the balloons fly, they say, this is the kind of thinking they want NASA to pay attention to.

Of course, if Congress provides the necessary money and a manned trip to Mars proves possible, the next question is "What are they going to do when they get there?" But as it happens, one answer—building observatories on the moon—is being given serious attention by the astronomers.

"Most astronomical observations are ideally done from the moon—*if* there are no logistical constraints," says Nobel laureate physicist Robert W. Wilson of Bell Laboratories, who recently presented an analysis of the issue to a national academy survey committee studying astronomy's needs for the 1990s. That is admittedly a big If, he says. But assuming that the exploration initiative does get as far as the moon, then it would be possible to build some very interesting instruments there.

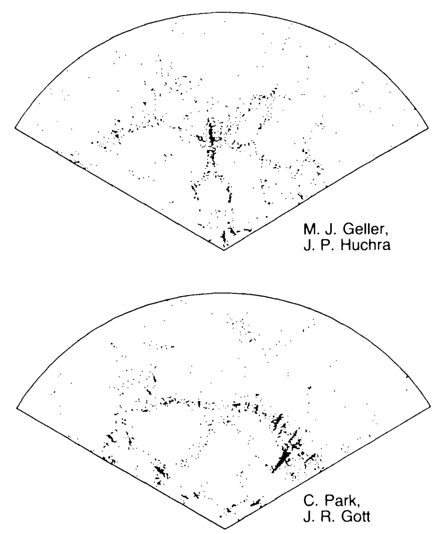
Since the moon has no air, for example, a 16-meter or 25-meter optical telescope located on the lunar surface would be just as free of atmospheric interference as the Hubble Space Telescope. But it would have ten times better resolution and would be considerably easier to keep pointed accurately than a telescope on a drifting, rapidly rotating satellite. If such a telescope were also cooled to about 100 K to maximize its infrared sensitivity—lunar dust is an excellent insulating material, and the lunar night is very cold—then it could search for Earth-like planets around other stars and could study very young and very distant galaxies in the process of formation.

Meanwhile, arrays of optical telescopes ranging across the lunar plains for dozens of kilometers could combine their light interferometrically to produce angular resolutions measured in *micro*arc seconds—good enough to make detailed maps of how matter falls into the massive black holes thought to lie in the cores of quasars and other active galaxies. Giant radio telescopes could operate free of terrestrial interference. Batteries of special-purpose telescopes could continuously monitor the whole sky at every wavelength, making sure that no supernova or other transient event would ever go unnoticed.

And so it goes. As iffy as the moon-Mars initiative still is, the academy's astronomy survey committee is taking it seriously enough to add a chapter on the subject to its final report, which is due out next year, says the committee chairman John Bahcall of the Institute for Advanced Study . The initiative, he says, "is a central and important question." ■ M. MITCHELL WALDROP

The Return of Cold Dark Matter

"The reports of my death have been greatly exaggerated," declared Mark Twain. And now the same can be said of the recently reported demise of the cold dark matter theory of galaxy formation—the proposition that a kind of invisible cosmic ectoplasm has shaped the universe through the pure force of gravity.



Two universes. *Park's simulation (bottom) produces "walls" like those seen in the real universe (top).*

Originally invoked to explain how clusters and superclusters of galaxies could have formed from the smooth soup of matter left by the Big Bang, the cold dark matter theory actually spent the better part of the 1980s being very successful. Observational evidence suggests that some kind of dark matter comprises 90 to 99% of the mass in the universe; the theory simply postulates that the stuff is a haze of slow-moving, weakly interacting elementary particles that were also produced in the Big Bang. With so much mass, moreover, the gravitational forces exerted by dark matter could have quickly pulled ordinary matter into an array of dense clumps, thus forming the galaxies and clusters we see today.

Lately, however, cold dark matter had seemed to be headed for the grave, as astronomers kept finding clusters and sheets of galaxies that seemed far too immense to have formed by gravity alone. And yet it has now been resurrected by Changbon Park, a Princeton University graduate student running the largest computer model of the cosmos ever attempted.

Using the astronomy department's new Convex minisupercomputer, Park defined a model universe some 200 million light-years on a side, or almost twice as large as in any previous simulation. Next, he filled that volume with a random distribution of 2 million mathematical particles representing cold dark matter, plus another 2 million particles representing the ordinary matter that forms visible stars and galaxies. Finally, he set them all in motion under the influence of gravity and followed their evolution from the Big Bang to the present—a period of some 13 billion years.

Park has published his results in the February issue of the *Monthly Notices of the Royal Astronomical Society*. Just as in previous, smaller simulations, the galaxies of his model universes trace out sponge-like structures of clumps and voids very much like the ones astronomers find in the real universe. Unlike previous simulations, however, Park's universes also produced huge sheets of galaxies reminiscent of the "Great Wall," one of the recent discoveries that looked fatal to the cold dark matter theory (*Science*, 17 November 1989, pp. 885, 897).

"It's nice to see that these structures *can* be formed by gravity," says Princeton astronomer J. Richard Gott, Park's thesis adviser. Otherwise, he says, cosmologists would be hard-pressed to explain how galaxies could have been pushed into structures such as the Great Wall. Previous simulations failed to show such structures because they were simply too small, he adds.

"It's very solid work," agrees Massachusetts Institute of Technology astrophysicist Edmund Bertschinger, who until recently held the record with a 2-million particle simulation. Nevertheless, he points out, Park's model is still too coarse-grained to model the formation of individual galaxies. Like everyone else in this game, Park was forced to make some questionable assumptions about how galaxies form, a flaw that still leaves room for doubt about the cold dark matter theory.

To do a proper model of galaxies as well as the large-scale structures, Bertschinger says, "you'd ideally need hundreds or thousands of times more particles." He and his colleagues hope to take a big step in that direction this year, when they will devote some 2000 hours of supercomputer time at the Cornell supercomputer center to modeling the universe with some 17 million particles. ■ M. MITCHELL WALDROP