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# **The Second Conference on Lunar Bases and Space Activities of the 21st Century**

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## **Harlan J. Smith**

1924-1991

*Advocates for lunar bases, professionals exploring the frontiers of astronomy, and enthusiasts for scientific investigation of the unknown all have lost a champion with the passing of Harlan J. Smith. As Director of McDonald Observatory for 26 years and as chairman of the Astronomy Department at the University of Texas at Austin for 15 years, Harlan's academic and scientific credentials are stellar. However, his inexhaustible energy and boundless enthusiasm for developing innovative approaches to astronomical research set him apart from the mainstream.*

*My only opportunity to work personally with Harlan came about during my studies of a permanent lunar base as a goal for the U.S. space program in the first decade of the twenty-first century. At the Johnson Space Center in the early 1980s, Mike Duke and I came to understand that any lunar base program needed a legitimate scientific component. (By the term "legitimate," we meant the program science could be advocated successfully on scientific grounds by scientists in scientific forums.) Mike formed an advisory group to help us think through the problems, and he asked Harlan to represent astronomy.*

*Harlan's reaction to the request was a healthy skepticism as to whether any large, manned space project could be seen by astronomers as a prudent investment in science. Nevertheless, he agreed to participate in order to ensure a knowledgeable representation of the views of astronomers.*

*Harlan worked with us at his usual high energy level and helped organize the Lunar Base Working Group, which met at Los Alamos in April 1984. The Report of the Working Group includes a thoughtful discussion of the advantages to making astronomical observations from the lunar surface. In particular, the seismically stable lunar surface permits optical interferometry with microarcsecond angular resolution in the observational data. Bernie Burke developed the concept of the lunar optical interferometer.*

*As Harlan began to appreciate the unique qualities of the lunar environment for high-resolution, high-sensitivity optical observations and for wide-spectrum radio observations on the radio-quiet far-side, he became not only an advocate but a champion of lunar-based astronomy.*

*Harlan was familiar with the need for persistence in advocating high-quality scientific projects. He helped organize a one-day workshop on lunar astronomy following the annual meeting of the American Astronomical Society in 1986. As I led off the meeting with a short talk on lunar base concepts, a young man in the front row asked, "If there is not going to be a lunar base for 20 years, why are we having this workshop now?" I turned to Harlan, who was sitting a few seats away, and asked when he had started talking about the Large Space Telescope (now called the Hubble). Harlan answered simply, "1962."*

*Harlan was ubiquitous and indefatigable in his advocacy. When he traveled to Moscow in late 1988, he wasted no time in bringing the Moon to Soviet scientists, most of whom had not considered a lunar base program. (In the Soviet Union, human exploration missions were discussed in the context of Mars landings within a paradigm established by Roald Sagdeev and his American colleague, Carl Sagan.)*

*In the spring of 1989, I met the Soviet planetary scientist Mikhail Marov and we discussed the relative merits of a manned lunar base and piloted missions to Mars as candidates for the next great step into space exploration. Mikhail was unfamiliar with the lunar base concepts although he knew Sagdeev's ideas well. When I saw Mikhail again at the International Space University session in Stras-*

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## Prologue

Plans for manned bases on the Moon were first conducted by professional engineering organizations in the late 1950s as part of Project Horizon, a classified study sponsored by the U.S. Department of the Army. The civilian space program began to think about such things after President Kennedy's directive to land a man on the lunar surface by the end of the decade. Within a few years, NASA was working on concepts for extended human presence on the Moon under the Apollo Applications Program, as a continuation of the Apollo initiative. Journeys to Mars were also mapped out in the EMPIRE studies funded by NASA.

Detailed plans for lunar bases were simultaneously being developed in the Soviet Union as part of their secret manned lunar program. Although details of the Soviet N-1 rocket and their lunar transportation system have been released publicly, their lunar base plans have not yet been discussed.

In 1969-70, the Nixon Administration commissioned a study of the future of the space program under the stewardship of Vice-President Agnew. The report of the Space Task Group (STG) presented a sequence of manned programs, beginning with a low Earth orbit space station and continuing on to bases on the surface of the Moon and on Mars. The plan offered three different levels of effort with schedules dependent on funding commitments. In outline, the Space Task Group Report strongly resembles the current Space Exploration Initiative.

President Nixon and his staff decided that budgetary constraints would not permit commitment to a long-range program of human exploration of the solar system. In fact, they canceled the final two missions of the ongoing Apollo program. NASA conducted the Skylab program and the Apollo-Soyuz Test Project with spare Apollo hardware, but the long-range plans of the space agency were reduced to the development of the reusable space shuttle. In the STG Report, the Earth-to-orbit cargo vehicle, which later became the shuttle, had not received major emphasis. In NASA of the 1970s, it became the center of focus in the manned program and was to have major impacts on the unmanned program also.

The 1970s also saw a sequence of presidents who did not assign a high priority to ambitious goals for the space program. The NASA administrators reflected this philosophy and concentrated on being "team players" in restricted budgetary environments. The situation can be illustrated by considering the fiscal projections published in the STG Report for their three proposed approaches to expanding human presence in space. The graph that contained the funding estimates also featured a dotted line running along the bottom part of the chart. This dotted line was included to give the reader a reference point for the funding levels reflecting a hypothetical elimination of the manned space program. Looking back on the actual NASA funding (in constant year dollars) for the decade of the 1970s, we can see that it fell approximately 20% below the hypothetical dotted line.

Struggling to keep fiscal body and soul together, NASA invested few resources in true strategic planning. The last lunar base studies of the Apollo era have publication dates of 1972 or 1973. The agency looked seriously at solar power satellites as solutions to the energy crisis and dabbled in the space colony phenomenon, but generally the organizational mind-set embraced incremental programmatic evolution rather than bold landscapes with new initiatives. The phasing out of one major engineering development program (the space shuttle) and the start-up of another (the space station) occupied all the energy of the policy process within NASA of the early 1980s.

The space shuttle was operated by the Office of the National Space Transportation System (NSTS), a designation that could encompass other elements such as a space station and orbital transfer vehicles (OTV) for launching payloads from LEO to higher orbits. At the inauguration of the Reagan Administration, configurations for a LEO space station were being explored, and the performance requirements for a future OTV were being inserted into NASA databases.

This was the state of planning that I and my colleagues found in 1981 when we set off to explore the possibility of launching a Lunar Polar Orbiter (LPO) mission on the (then) new space shuttle. As NASA scientists involved in planetary exploration, we had little familiarity with manned programs. We were interested in resuming exploration of the Moon with implementation of the rather simple LPO spacecraft that had been "under consideration" for almost 10 years.

From our point of view, the NSTS, in its configuration circa the year 2000, appeared to provide routine access to the Moon. An OTV designed to deliver a communications satellite from the space station to geostationary orbit should be able to take satellites (or even landers) to the Moon because the  $\Delta V$  (change in orbital velocity) required for both missions was essentially the same. As we pursued the matter further, we wondered whether consideration should be given to sizing the NSTS to carry humans and supporting cargo to the Moon for a lunar base.

Within NASA we encountered a number of reasons why a lunar base was a bad idea. A lunar base would be unaffordable or would compete with the space station; or Congress might scuttle the space station if it was believed to be a precursor for a lunar base. As we insisted on closer examination of an obvious extrapolation of the Space Transportation System, we became known as "lunar base advocates." We were told that advocacy of any particular objective was improper. The job of NASA planning was to produce a comprehensive list of all possible futures and study each to the same level of (superficial) detail as "options."

In 1983 we began a process to which I now refer as the legitimization of the lunar base discussion. We perceived the need to create forums wherein individuals and groups with accepted credentials could raise the relevant questions. Thereby the subject could become legitimate to evaluate within NASA. Critical steps in that process were the Report of the Lunar Base Working Group, from a workshop held at Los Alamos in April 1984, and the book *Lunar Bases and Space Activities of the 21st Century*, which recorded the proceedings of a symposium held at the National Academy of Sciences in Washington, DC, in October 1984. These meetings were conceived and organized by a small group of aerospace leaders from government, industry, and academia, who had been attracted to the lunar base as a long-term policy objective. Within NASA, funding was secured with the help of Deputy Administrator Hans Mark.

From that time forward, the planning environment evolved rapidly. A working group internal to NASA completed in 1985 a review of the technical constraints for manned Mars missions. The National Commission on Space delivered to the President in early 1986 a vision for the next 50 years. Astronaut Sally Ride led a NASA Task Group to produce the influential report, *Leadership and America's Future in Space*. NASA formed an Office of Exploration, staffed to the Administrator, in 1987. All these study groups relied heavily on technical information developed primarily at the Johnson Space Center a year or two earlier when lunar bases were not de rigeur. That work was performed on a tiny budget, but had the explicit support of Center Directors Chris Kraft and Aaron Cohen. The Second Symposium on Lunar Bases and Space Activities of the 21st Century was convened when interest in permanent presence on the Moon was growing rapidly. The Office of Exploration had become a funding source for new studies, replacing updated versions of older work. Internal funds in various organizations were being used to evaluate fresh ideas. New faces were appearing at aerospace meetings, particularly from the constructor-engineer companies, which possess unique and valuable expertise in building and operating facilities in harsh and isolated environments.

The current volume consists of a peer-reviewed selection of the papers delivered at the Second Symposium, held in Houston, Texas, on April 5-7, 1988. Compared to the 1984 symposium on lunar bases, these papers tend to go into more technical depth, reflecting a higher content of currently funded research. Participation from NASA is higher. Like the first symposium, the subject matter covers a broad range of topics, including discussions beyond the usual bounds of engineering and science. The selections are representative of the level of planning during the first year of operation of NASA's Office of Exploration.

During the preparation of this volume, many changes have occurred in what is now called the Space Exploration Initiative (SEI); and some of the assumptions in the papers here are dated. Legitimation of the lunar base concept has been completed with President Bush's sweeping vision of a return to the Moon ("... this time to stay...") followed by piloted missions to Mars. At this writing, the fate of Space Station Freedom is uncertain, and progress in planning the SEI is awaiting the report from the Synthesis Group led by General Tom Stafford. The Report of the Advisory Committee on the Future of the Space Program is being cited and debated throughout the aerospace community.

Impatient enthusiasts supporting the human exploration of the solar system despair over the current turmoil. However, we must remind ourselves of the enormous progress that has been made in creating a real dialogue within the American body politic on the promise of the space frontier. This vision of the future must not be trivialized by identifying it with any single program or mission. Our movement to the planets must be made on a broad front with the active involvement and participation from many institutions in our society and from many of the peoples of the world. No longer is it sufficient to concentrate all space activities in one organization and expect all other constituencies to support it. Yet fundamental change in the assignment of responsibility and authority is neither easy nor self-evident. We now are seeing the beginnings of change to a "new space order" that must be established before we can "boldly go where no one has gone before."

*Wendell Mendell  
Houston, Texas  
May 23, 1991*

## Acknowledgements

Providing peer review for a collection of professional papers is always a demanding task for an editor. He must find associate editors—responsible and knowledgeable volunteers each of whom is willing to take charge of six to eight manuscripts and solicit qualified referees for them. In an eclectic volume such as this one, the editorial board must span a variety of disciplines and professional communities. Every community has its own culture and standards for judging worth, and these value systems must be integrated to provide a uniform quality to the finished collection.

For this volume, I was forced to go to 17 associate editors in order to provide reasonable workloads for each one, and I am grateful to them all; but I feel particularly obligated to Gordon Woodcock, Larry Taylor, and John Alred, all of whom jumped in at crucial times.

I thank Stephanie Tindell, Sarah Enticknap, Ronna Hurd, and other members of the Publications Services Department at the Lunar and Planetary Institute for exhibiting inexhaustible patience throughout the production phase. Bill Lagle from the Lockheed Engineering Services Company was invariably eager to do whatever was asked, and I should have taken advantage of his talents more often. Mark Cintala and Sarah Enticknap deserve special acknowledgment for creating the subject index.

Finally, I must acknowledge the efforts of Mike Duke and Barney Roberts in holding the original symposium and in helping to publish this book.

*Wendell Mendell  
Houston, Texas  
February 7, 1992*