Introduction

BACKGROUND

On July 20, 1989, the President of the United States affirmed a national space policy that emphasized the expansion of human presence and activity beyond Earth orbit. His vision included completing Space Station Freedom, returning permanently to the Moon, and eventually sending humans to explore Mars. In response to the President's declaration, the National Aeronautics and Space Administration undertook a review of the main elements of such a program, characterized as the Human Exploration Initiative (HEI). The review, entitled the Report of the 90-Day Study on Human Exploration of the Moon and Mars, was based on feasibility studies that NASA had conducted in the past. The report contains five “reference approaches” that are intended as a data base for planning, or as a starting point for future discussions involving technical, budgetary, or scheduling options. The primary audience for the report was the National Space Council, headed by the Vice President of the United States.

Subsequently, the Vice President invited members of several scientific and industrial communities in the US to participate in considering the best ways to address the national HEI. On December 4, 1989, the Vice President wrote to the Chairman of the National Research Council (NRC) asking for a review of the scope and content of the NASA report including the questions of whether the “report addresses the widest possible range of technically credible approaches to meeting the President's exploration
goals," the reasonableness of NASA's technical assumptions, whether the report has overlooked possible innovative uses of existing technology or alternative ways to accomplish human space exploration, and whether the range of both desirable and enabling scientific objectives was appropriate. The committee was not asked to approve or endorse any aspect of the Human Exploration Initiative. (See Appendix A for the Vice President's request and the NRC response.)

PROCEDURE

In accordance with its practice and procedures, the NRC organized a committee of experts to prepare a report responsive to the request. The committee contains expertise ranging across many scientific and technical space disciplines. (Biographical data on committee members is found at the end of the report.) On January 4, 1990, several members, constituted as a steering committee, met in Boston to plan the undertaking. On January 17-21, 1990, the full committee and several invited technical and scientific advisors convened in Washington, D.C. The committee received a series of technical presentations on alternative mission scenarios and technical approaches from persons from private industry, universities, the Department of Defense, and national laboratories, and heard elaborations on the 90-Day Study and analyses from the NASA Administrator, several Associate Administrators, and other NASA representatives. In addition, the committee invited experts to brief them about four areas of space life sciences and also briefers to discuss the space nuclear power and propulsion programs run by NASA, the Department of Defense, and the Department of Energy. (A list of invited presenters and guests is contained in Appendix B.)

The committee considered a number of approaches to the HEI and its elements. These included the set of reference approaches addressed by NASA in its 90-Day Study and relevant programmatic information; an alternative approach called The Great Exploration, put forward by the Special Studies Program of the Lawrence Livermore National Laboratory; a concept that would utilize identical modules for a space station and the lunar and Mars missions; and several suggestions for improvement of launch and space propulsion capabilities. An extensive library was available to the committee, and key documents are listed in the bibliography.

Following two days of briefings on these matters, the committee spent two and a half days in discussion to begin preparation of the findings and conclusions in this document.
APPROACH

The committee regards the NASA 90-Day Study, currently available alternative mission scenarios, and the identified scientific and technical alternatives as starting points. It did not limit its deliberations to a review of the technical approaches in the NASA report and the alternative presentations, but extended its considerations to a number of interrelated nontechnical and institutional subjects, some of which are also addressed in the 90-Day Study.

The President's July 20 statement established a long-term objective of returning to the Moon and advancing humans to Mars. The President stated this policy in terms of an opportunity, not a race. (Excerpts from the July 20 statement and the subsequent National Space Policy document of November 2, 1989, are found in Appendix C.)

The pace at which the initiative should proceed, while clearly influenced by scientific and technical considerations, is inherently determined by social and political decision-making processes in which nontechnical constraints, such as the sustainable level of resource commitment and acceptable level of risk, are paramount. Within practical limits, technical analysts can develop alternative mission scenarios to achieve the stated goals under various sets of constraints, which provide ground rules for design. While scientists and engineers contribute to the policy debate, it is up to the political decision makers to establish the ground rules, which depend in turn on technical options.

To date the ground rules are unclear; as a consequence, technical analysts have presented mission scenarios based on differing assumptions. Many mission scenarios to establish bases on the Moon have been suggested, not only within NASA, but throughout the engineering and scientific communities of the US and the world. In its deliberations, the committee was exposed to only a few of these. Collectively, the committee is aware of many other possible scenarios, but lacked the time to examine them in detail. Some mission scenarios project a deliberate pace, extending current technology along foreseeable paths in order to minimize technical risk and maximize human safety. Other visions place higher emphasis on minimizing the time to get humans to Mars, incurring higher levels of technical and human risks. Clearly, there is need for guidance at an early date regarding the scope and pace of the early stages of the HEI.

In its reviews of alternative mission architectures and the underlying scientific and technical challenges, the committee also recognized a number of other issues inherent to achieving the President's goal. One was the challenge of educating, recruiting, training, and maintaining a technically competent work force. Another was the requirement for an appropriate
industrial infrastructure to carry out the work. Still another was the man-
agerial and administrative challenge of mounting a project of this nature,
one that will certainly take many years to accomplish and presumably will
result in a sustained program supporting the presence of humans in space.