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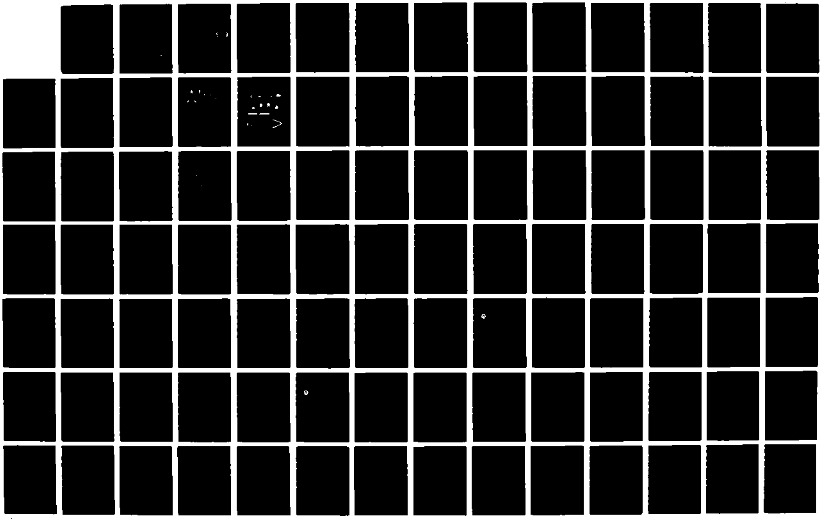

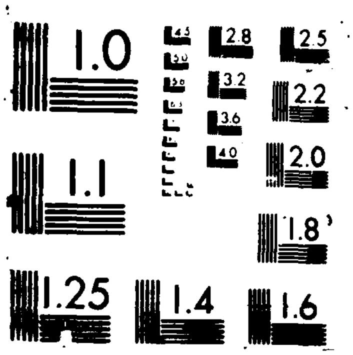
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CRITICAL ISSUES FOR ESTABLISHMENT
OF A
PERMANENTLY-OCCUPIED LUNAR BASE

THESIS

Paul C. Kent II
Captain, USAF

AFIT/GSM/LSPA/87S-13

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Wright-Patterson Air Force Base, Ohio

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THESIS

Presented to the Faculty of the School of Systems and

Logistics of the Air Force Institute of Technology

Air University

In Partial Fullfillment of the

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Master of Science in Systems Management

Paul C. Kent II

Captain, USAF

September 1987

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Abstract

Interest in a permanently-occupied Moon base has been revived as planners in the space community look beyond the space shuttle and space station toward future manned space activities. The purpose of this study was to determine the critical issues for a potential lunar outpost by polling a group of experts knowledgeable about decision-making involving the allocation of large-scale resources. The experts, who were in fact decision-makers themselves, were asked to participate in a Delphi exercise, a technique to solicit expert opinion. It is an iterative polling technique in which the group opinion is refined during successive iterations, while at the same time preserving the differing viewpoints among the group. The Delphi of this research employed two iterations, with twenty-three experts responding to the first questionnaire and eighteen experts following through on the second. The experts identified four critical issues: 1) demonstration of the value of a lunar base (e.g. cost effective lunar-based science, source of raw materials, technology spin-offs, etc.); 2) sustained political and financial support; 3) credibility of the government (i.e. NASA) in accomplishing such a large and complex program; 4) development of the military value of a lunar base. The scaled response data from the Delphi was submitted to a factor analytic study which revealed five factors: 1) government and space advocates; 2) nationalist; 3) commercial; 4) military; 5) international. Further research is indicated to refine the critical issues and factors affecting a potential lunar base program. The research also points to the necessity of informing a large and diverse group of decision-makers about the true costs and benefits of a lunar base.

CRITICAL ISSUES FOR THE ESTABLISHMENT OF A PERMANENTLY-OCCUPIED LUNAR BASE

I. Introduction

General Issue

Recorded history is filled with evidence of man's desire to explore, exploit, and settle new territory. Viewed in this context, the Moon may be considered new territory and elements of the Americ n space program, among them the Apollo Moon landings, additional evidence. Serious interest in a manned outpost on the Moon, once strong during the Apollo Program, has been revived as space planners look beyond the space shuttle and upcoming space station toward future space activities.

The National Commission on Space (23:63,140) has recommended, as one of the long-range (50 years) goals for U.S. space activity, that a permanently-occupied human outpost be established on the Moon. Reasons the Commission gives supporting such a goal include: advancing science, using lunar materials to aid development of earth orbit facilities, and taking advantage of the Moon's lower gravity to host exploration of the rest of the solar system (23:64,85,138-140). Mendell states that the term "lunar base", "...can refer to a spectrum of concepts ranging from a mannable 'line shack' to a multi-functional, self-sufficient, populous colony."(22:33) For purposes of this research, Lowman's definition will be used:

> The term "lunar base" will be used here to cover a wide range of possible programs, from small facilities for short-term occupations by a few people up to large complexes at several locations occupied semi-permanently by large staffs. It will not include large autonomous colonies on the Moon (19:35).

The scope of a lunar base project would be greater than any space project attempted so far (28). The Apollo program, from 1969 through 1972 saw eight launches which sent twenty-four astronauts as far as the Moon; twelve of whom spent less than two weeks total time on the surface (23:63). In comparison, one proposal for a lunar base in 1969 called LESA (Lunar Exploration System for Apollo) would have required eighteen Saturn V launches per year for support (14:53). Mendell acknowledges that the Moon base project will be "...of necessity a large and visible exercise..."(22:699) Sellers and Keaton (32:712) offer a conservative estimate of Moon base cost of under $100 billion spent over 25 years as compared to the Apollo program's cost of $80 billion spent over eleven years (figures in 1984 dollars). Still, that a lunar base is within the capability of the U.S. to accomplish is an assumption (whether explicit or implicit) of all literature reviewed by this researcher. Referring to lunar base studies conducted during the Apollo Program, Lowman states, "The Apollo Program ... could have led to the establishment of a permanent base on the Moon."(19:35) Hoffman and Niehoff, in a study to define a concept for a permanently manned lunar base state, "A key study assumption limits the technology used ... to that which is currently available ... or to technology that will be available in the near term..."(13:69) Koelle *et. al.* conclude, "It appears feasible to return to the lunar surface by the year 2000..."(16:254) From a financial perspective, Woodcock states, "... a permanent human presence on the Moon ... appears [to be] an achievable option within the funding scope of present civil space activities."(36:111)

Sellers and Keaton conclude "... in fact, a permanent lunar base can be financed without increasing NASA's historical budgetary allocation."(32:711) Koelle *et. al.* add, "It appears to be within the limit of available resources to have one hundred people on the Moon by the year 2010..."(16:254)

While feasibility is unquestioned, the actual prospects for a lunar base appearing before the end of the first decade of the 21st century seem far less certain. The larger question is, will it be done. As Johnson and Leonard put it, "Man has developed the capability of colonizing the Moon. Whether he will do so, and for what reasons and when, remain unanswered questions."(14:55)

Specific Problem

If the technical problems appear to be solvable, then to answer the question of whether there will be a lunar base, one must turn to non-technical areas. A fundamental question might be who is both willing and able to undertake such a large program. Space activists Stine and Pournelle, citing problems with the space shuttle and down-scoping of the space station, contend that inefficiencies in government will raise the cost of any large scale project such as a base on the Moon to the point of placing it beyond reach. They further suggest, while pointing out embryonic commercial space enterprises, that not until private industry has advanced technology so as to dramatically reduce the cost of space access will there be any hope of any organization pursuing any large scale space projects (33; 26). In another view, Hickel suggests the government must help open access to space just as early American governments subsidized railroads to "open up the country."(12:18) Likewise, Mendell states, "...private capital will not be invested in lunar development until near-term profitability is more than speculation."(22:5) If government funds are required, it might be asked which factors affect government support for space programs. Logsdon, a self-described "student of the political process" is a long time observer of the U.S. space program. He contends that the necessarily great cost of a lunar base project will require it be made a national budget priority (as were Apollo, the space shuttle, and the space station) (18:701-6). As such priorities are determined by shifting alliances in Congress (34:TV), the space experts in NASA would not be permitted to determine alone whether or not a lunar base project should be undertaken. Logsdon observes there are many factors (e.g. political and economic) which are beyond NASA's control which will influence the decision process (18:708). Logsdon uses the space shuttle program as an example of how large-scale policy choices are normally made in the United States.

> The normal process of policy-making involves a wide variety of participants; it is characterized by bargaining among players positioned within various government organizations. Individuals and groups outside government participate in this process and can be very influential, but their power lies primarily in influencing those within government who control the resources required to undertake a new course of action. ... The shuttle that President Nixon finally approved for development was dramatically different in both design and estimated cost from that which NASA had originally hoped to develop. ... The final shuttle design emerged from a process of negotiation, compromise, and conflict; it had the rationale, technical characteristics, and cost implications required to gain the support of the President and his advisors, the Department of Defense, and a majority of Congress, while still meeting most of the needs of NASA and it contractors (18:703-5).

The uncertainty associated with the decision-making process greatly complicates NASA planning. The result is a costly evolutionary process whereby planners must consider myriad alternatives in the face of incomplete information. While uncertainty in any planning process is a given, a greater or lesser degree of uncertainty for large projects could represent large deltas of expense and time. Preliminary studies which reduce the level of uncertainty may be beneficial. Logsdon points out that preliminary studies have both technical and advocacy components. He says technical studies outline what is possible and help decision-makers understand the "payoffs, the cost, and the risks associated with proposed actions..."(18:708) Another function of studies is to contribute to policy choice by "providing the basis for an extremely persuasive argument in support of a particular action."(18:708) One way these arguments might be enhanced would be to identify the critical questions to be addressed. If in so doing, the uncertainty level could be reduced, planners might be able to conduct further studies more efficiently; devote their resources to more potentially rewarding approaches. The central problem then, for this research, was to outline and rank the critical issues affecting a lunar base project; issues which must be addressed as the project is presented to the gamut of decision-makers (both formal and informal) who ultimately will decide the fate of the lunar base. Such an outline may aid NASA and other space planners as a supplement to future, more detailed studies in the on-going debate over a lunar base.

Research Objectives

The objectives of this research were to determine the critical issues affecting a potential project to establish a permanent lunar base and make a reasoned prediction of the justification for such a project.

Research Questions

The following questions were posed to meet the research objectives:

1. What are the critical issues for establishment of a lunar base?

2. What factors will most likely determine the lunar base configuration (e.g. scientific, commercial, military, political, economic, etc.)?

3. Which experts currently represent these factors?

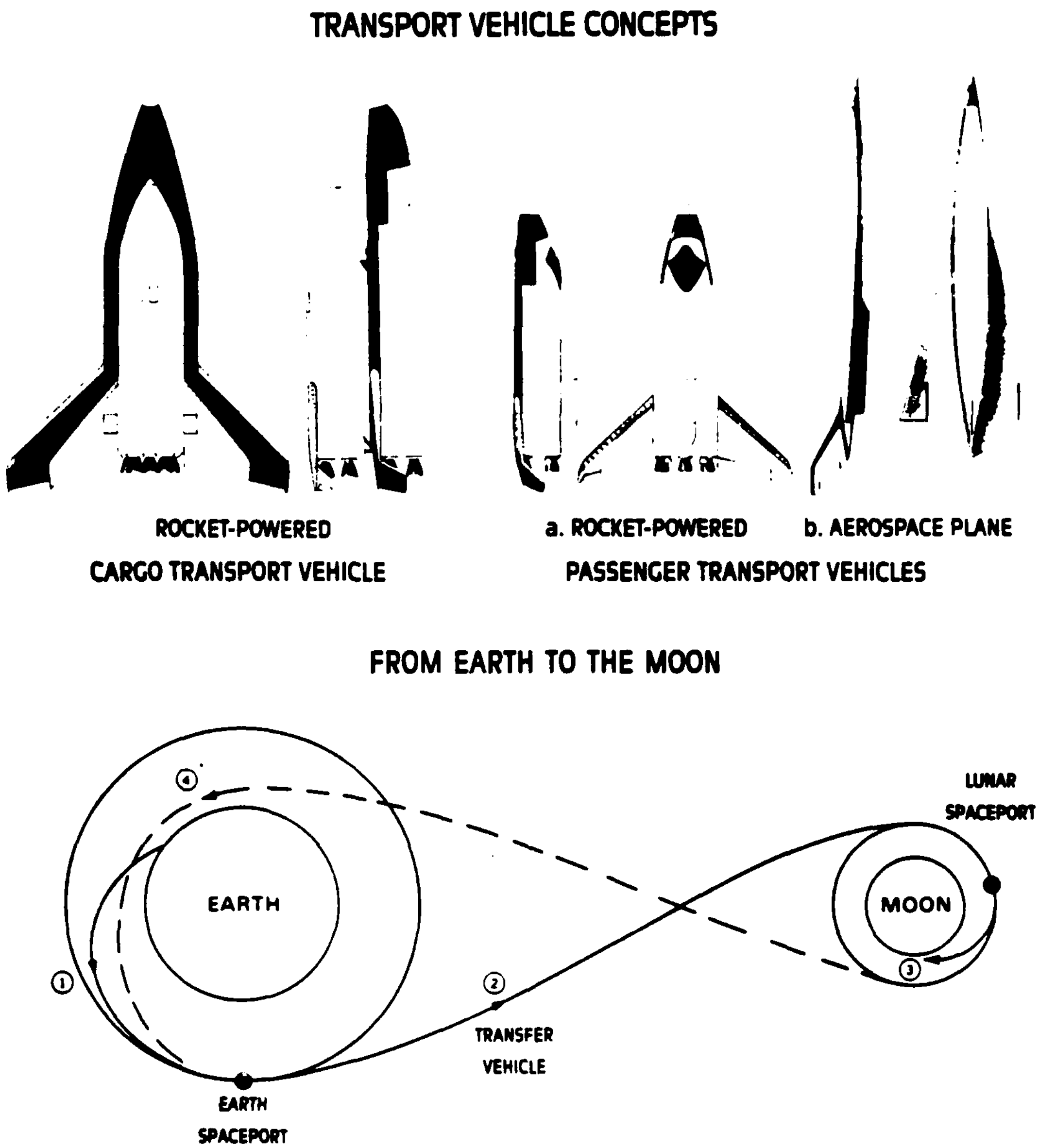
Scope

This research addressed only the issues of the initial lunar base program. Neither precursor programs (e.g. the space station) nor concurrent or follow-on activities (e.g. a manned trip to Mars) were included. Technical challenges were assumed surmountable, and so were not a focus of this research.

Background

Interest in the Moon and thoughts of living there have been part of scientific literature for well over a hundred years (8:359). Detailed planning for putting men semi-permanently on the Moon began with the Apollo Program in 1961; as soon as the technology for transporting men there was on the horizon (14:49-50). More than a dozen studies during the Apollo program considered the idea, the last being in 1972. The latter and subsequent studies to the present, resting on a firm data base from the six Apollo missions to land on the Moon, show a lunar base to be technically feasible (19:39). Technology has continued to advance since the days of Apollo, making planners ever more confident in the technical possibility of a lunar base. Some steps required for transportation are proposed or already in the planning stages. There are follow-on launch vehicles to the space shuttle for taking people, equipment, and supplies to low Earth orbit (LEO), as shown in Figure 1. The space station will be available as a transfer point. Roberts suggests the shuttle and space station can be part of a general purpose space transportation infrastructure (27:1). In addition to the shuttle and station, orbital transfer vehicles are proposed which could provide transport to the Moon (see Figure 2) (23:122-3). Designs based on space station modules could be used for the initial living quarters on the Moon. The only piece missing in the Earth-Moon link is a lunar shuttle; a technologically less challenging task than the other parts of the system. Early studies estimated that Earth-based transportation might account for two-thirds of the cost of a Moon base (27:8). Therefore, realizing savings in transportation will be critical to any fiscally conservative Moon base project.

Data from the Apollo Moon landings show there are potentially useful materials to be found there (11:438). Considerable effort is now being made to discover methods to economically recover and process lunar materials. The big near-term advantage to using lunar materials is anticipated need in LEO. There is a significant difference in transportation costs to LEO between the earth's surface and that of the Moon. The current space shuttle carries only 1.5% of its weight at liftoff as useful payload (most of the rest being the propellant needed to overcome earth's gravity). On the other hand, the Moon's lower gravity (see Figure 3) would permit a theoretical shuttle operating from the Moon to LEO to carry as much as 50% of its liftoff mass as useful cargo (7:60). Another potential reason for going to the Moon is to use it as a research base. Because the Moon is relatively free of vibration (little seismic



① THE CREW BOUND FOR THE MOON TRAVELS FROM EARTH'S SURFACE TO THE EARTH SPACEPORT IN A PASSENGER TRANSPORT VEHICLE.

② AT THE EARTH SPACEPORT THEY BOARD A TRANSFER VEHICLE TO TAKE THEM TO THE LUNAR SPACEPORT.

③ AT THE LUNAR SPACEPORT, THEY BOARD A LUNAR LANDER TO TAKE THEM TO THE SURFACE OF THE MOON.

④ ON ITS RETURN TO EARTH, THE TRANSFER VEHICLE IS AEROBRAKED IN EARTH'S ATMOSPHERE PRIOR TO ITS RENDEZVOUS WITH THE EARTH SPACEPORT.

Figure 1: Transport Vehicle Concepts
(Adapted from 23:114,139)

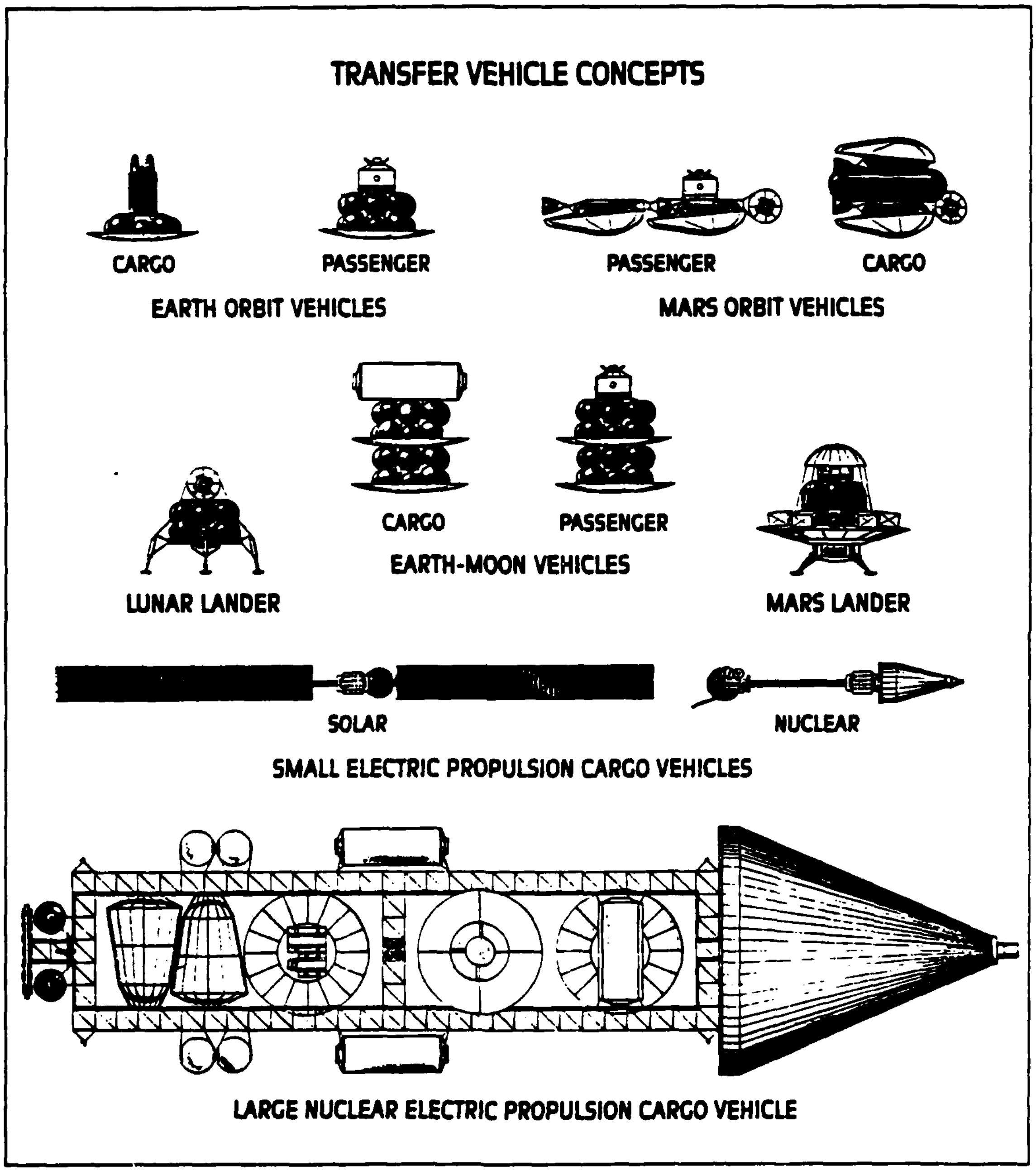


Figure 2: Transfer Vehicle Concepts
(Reprinted from 23:123)

EARTH'S GRAVITY WELL

To lift payloads in Earth's gravitational field and place them in orbit, we must expend energy. We generate it first as the energy of motion—hence the great speeds our rockets must attain. As rockets coast upward after firing, their energy of motion converts, according to Newton's laws, to the energy of height. In graphic terms, to lift a payload entirely free of Earth's gravitational clutch, we must spend as much energy as if we were to haul that payload against the full force of gravity that we feel on Earth, to a height of 4,000 miles.

To reach the nearer goal of low Earth orbit, where rockets and their payloads achieve a balancing act, skimming above Earth's atmosphere, we must spend about half as much energy—still equivalent to climbing a mountain 2,000 miles high.

Once in "free space," the region far from planets and moons, we can travel many thousands of miles at small expenditure of energy.

INNER SOLAR SYSTEM GRAVITY WELLS

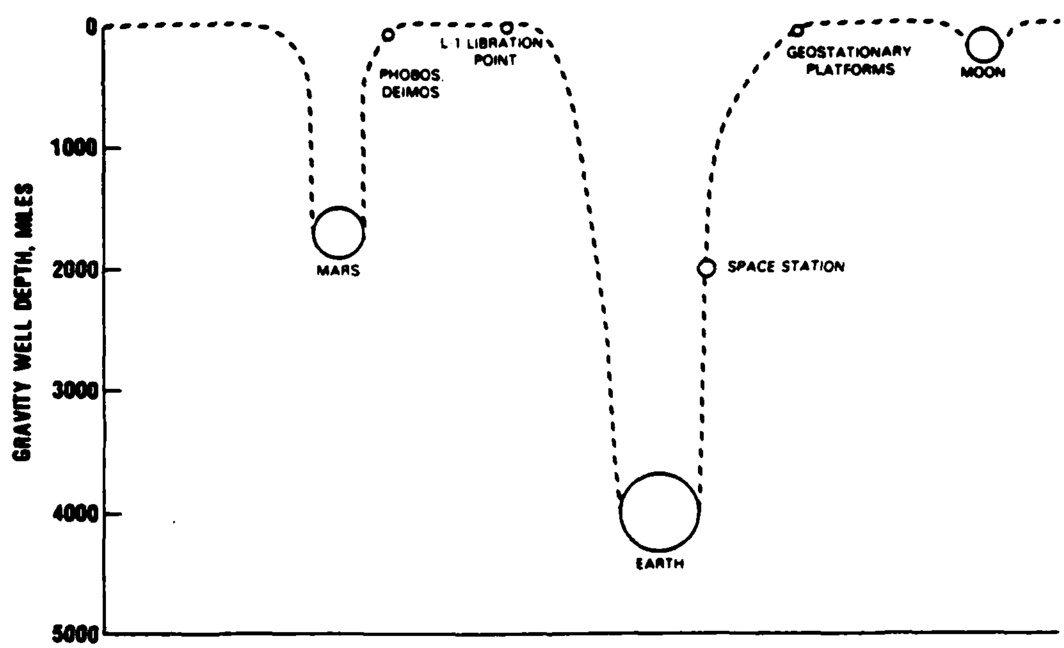


Figure 3: Gravity Wells
(Reprinted from 23:61)

activity) and obscuring atmosphere, very high resolution optical and infrared astronomy is possible. The far side of the Moon is perfectly shielded from earth's television, radio, and other electromagnetic interference, thus permitting sensitive radio astronomy.

While various groups move toward defining the technical possibilities, others are well aware that the larger challenge lies in convincing the general population that a lunar base project deserves support in the midst of the realities of budget deficits, social support, public works, defense, and the like. One study (32:715) showed that a lunar base is affordable. At its peak, the Apollo program took four percent of total federal outlays (see Figure 4). Yet even at the current level of 0.8% of federal outlays for NASA funding, a potential Moon base would require only one third of the total over fifteen years, thus allowing for continuation of NASA's other important work, without an extraordinary national commitment.

That much research into the above mentioned areas and others has been done, is evidence of considerable interest in the space community in returning to the Moon. NASA allocated $1.2 million for lunar base studies in 1987 alone (1). The literature also indicates a lunar base is clearly feasible. However, in its early development, a Moon base project (or any other large project) necessarily attracts only those people already favorably disposed towards the idea. This small group, consisting mainly of "idea people" in NASA and aerospace companies plus interested individuals in academia, finance, and law, is exploring the realm of possibilities and defining alternatives (e.g. the 72-mission data base of NASA's Roberts or comparison of strategies by Koelle *et. al.* of the Aerospace Institute in Berlin) (27:2; 16).

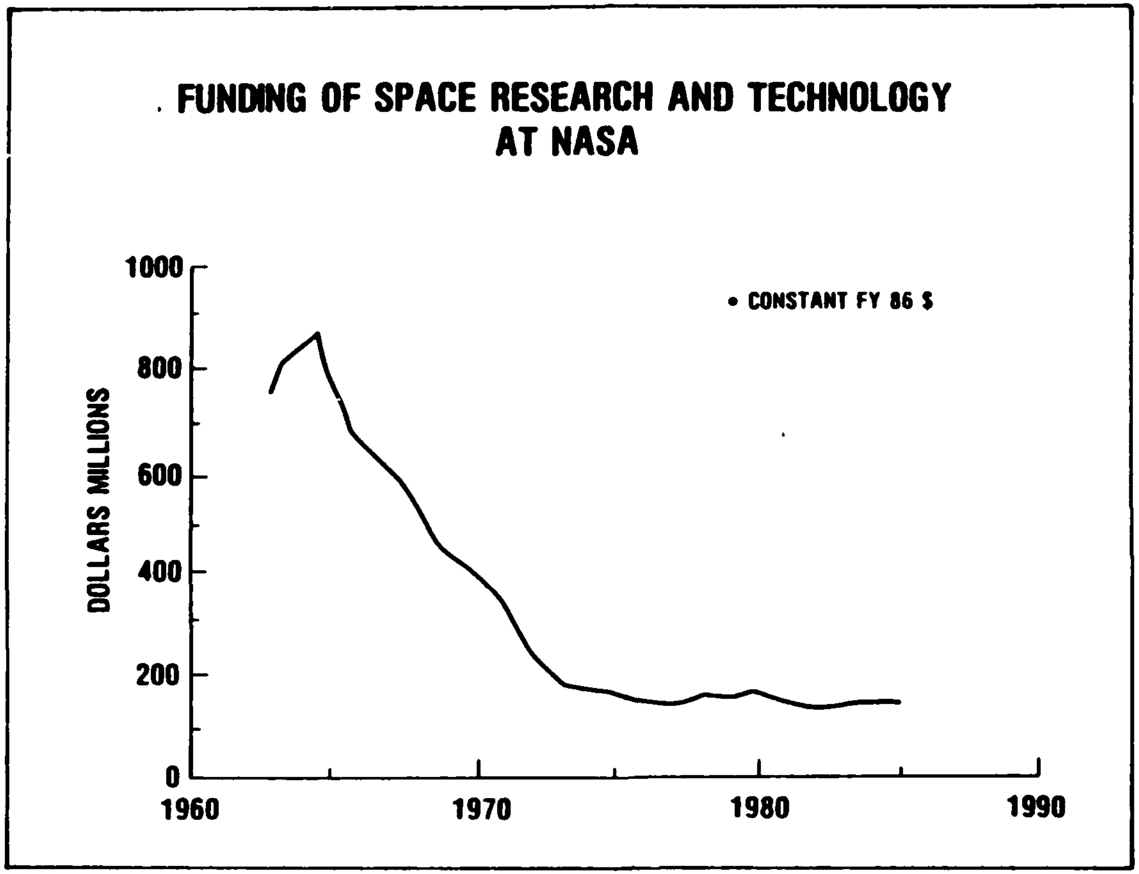


Figure 4: Federal Outlays for Space
(Reprinted from 23:97)

As stated above, the size of any potential Moon base program will be such that the proposals originated by the project proponents must at various times be judged by people outside the group of proponents. These outsiders who are in a position to support or block a potential program (as opposed to, for instance, the sometimes notable, always outspoken opponents who for all their efforts seem unable to alter the course of events) might be labeled "decision-makers". Decision-makers are typically forced to routinely make large-scale tradeoffs in their particular arenas. The collective advice of some subset of decision-makers is solicited by government and/or industry in the process of deciding whether or not to pursue a large-scale project such as a Moon base. So far, there has been little outside reflection on the activities of Moon base proponents. Even the National Commission on Space which "weighed the opinions received from citizens [and]...experts..." (23:183-4) admitted their particular perspective led them to a progressive view. Through the identification of critical issues, this research attempted to provide some feedback from decision-makers. From such a perspective, this research may be viewed as part of an iterative process whereby Moon base proponents may narrow their alternatives and focus their energies on areas most critical to influencing the project.

II. Methodology

The objective of this study was to identify the critical issues associated with the establishment of a lunar base, as an aid to planners concerned with future American initiatives in space. To achieve the research objectives, data was collected using a Delphi exercise. Some of the data collected was submitted to a factor analytic study.

Scope

The data consisted of expert opinion solicited from a pre-determined group of experts in widely varying fields representing different and relevant perspectives. All experts shared a common characteristic of being familiar with (if not directly responsible for) resource allocation to large-scale projects in government and/or industry. The criteria used to select experts and desirability of diversity of expertise were the only factors considered for data sources.

Approach

According to Brown, "We use an expert because he has at his disposal a large store of background knowledge and a cultivated sensitivity to its relevance which permeates his intuitive insight."(2:13) The use of multiple experts is based on the age-old premise that "n heads are better than one."(4:6) The most common way to take advantage of multiple experts is in a committee. Yet committees can exhibit severe drawbacks:

- The domineering personality, or outspoken individual that takes over the committee process
- The unwillingness of individuals to take a position on an issue before all the facts are in or before it is known which way the majority is headed
- The difficulty of publicly contradicting individuals in higher position
- The unwillingness to abandon a position once it is publicly taken
- The fear of bringing up an uncertain idea that might turn out to be idiotic and result in loss of face (35:86)

The need for expert opinion while addressing the above problems led to the development of the Delphi (3:3).

The Delphi

The Delphi originated in an Air Force-sponsored Rand Corporation study in the early 1950's titled "Project Delphi". That study dealt with the use of expert group opinion. By the late 1960's, use of the technique had become widespread (17:10,3). The Delphi process is "a set of procedures for eliciting and refining the opinions of a group of people."(3:1) The procedures were designed to reduce the negative aspects of committees through three characteristics: 1) anonymity; 2) controlled feedback; 3) statistical group response (3:3). Dalkey describes the importance of these characteristics. Anonymity counters the effects of a domineering personality. Anonymity is maintained by collecting separate, private answers, usually on a written questionnaire. These answers as well as all other communication among the respondents are routed through formal channels controlled by the monitor. Controlled feedback, the second characteristic, reduces "noise" or irrelevant data. The data is usually summarized and "screened" by the monitor before being presented to the respondents. A statistical group response is used to represent the group opinion and reduces group pressure toward conformity. This response is usually reported as median and inter-quartile range (IQR) for each question for which a numerical response is provided. The median divides the group response so half of the responses are above the median and half are below. Each half on either side of the median divided in half again give the inter-quartile values. These values divide the middle half of the responses from the outer quarters, hence may be called the 50% range. The median and inter-quartile ranges are the most common measures of central tendency and group dispersion respectively used in Delphi (21:21). "There is no particular attempt to arrive at unanimity among the respondents, and a spread of opinions on the final round is the normal outcome."(3:3) A concise description of the Delphi is found in Linstone and Turoff:

> The most common [form of the Delphi process] is the paper-and-pencil version... In this situation a [monitor] designs a questionnaire which is sent to a ... respondent group. After the questionnaire is returned the monitor ... summarizes the results and, based upon the results, develops a new questionnaire for the respondent group. The respondent group is usually given at least one opportunity to reevaluate its original answers based upon examination of the group response. To a degree, this form of Delphi is a combination of polling procedure and conference procedure which attempts to shift a significant portion of the effort needed for individuals to communicate from the ... respondent group to the [monitor] (17:5).

Emphasizing the last point Dalkey writes, "In general it involves much less effort for a participant to respond to a well-designed questionnaire than, for example, to participate in a conference or write a paper."(4:17)

Applications developed for the Delphi have been many and varied (15:236). The primary justification for employing a Delphi process is "when accurate information is unavailable or expensive to obtain, or evaluation models require subjective inputs to the point where they become the dominating parameters."(17:10) Linstone and Turoff state that the appropriateness of utilizing Delphi is determined not by the nature of the application, rather by the circumstances surrounding the necessary group communication. They list circumstances which may lead to employing the Delphi. Those which apply to this study:

> - The problem does not lend itself to precise analytical techniques but can benefit from subjective judgements on a collective basis
> - The individuals needed to contribute to the examination of a broad or complex problem have no history of adequate communication and may represent diverse backgrounds with respect to experience or expertise
> - More individuals are needed than can effectively interact in a face-to-face exchange
> - Time and cost make frequent group meetings infeasible
> - The heterogeneity of the participants must be preserved to assure validity of the results, i.e., avoidance of domination by quantity or by strength of personality ("bandwagon effect")(17:4)

As will be seen in "Panel Selection" below, the nature and number of experts desired for participation in this study precluded any kind of group meeting. Furthermore, the complexity and volume of the material to be considered by the group eliminated from consideration any other alternatives, such as personal or telephone interviews.

Application. This study employed a variation on the Policy Delphi. Turoff contrasts the Policy Delphi with the more conventional form.

> Delphi as it originally was introduced and practiced tended to deal with technical topics and seek a consensus among homogenous groups of experts. The Policy Delphi, on the other hand, seeks to generate the strongest opposing views on the potential resolutions of a major policy issue... Generating a consensus is not the prime objective, and the structure of the communication process as well as the choice of the respondent group may be such as to make consensus on a particular resolution very unlikely (35:84).

Turoff states that a Policy Delphi is not "a substitute for studies, analyses, staff work, or the committee." By exposing issues and evaluating policy options for their consequences and acceptability, the Delphi is a precursor for these activities (35:87). However, to accomplish a thorough evaluation is a demanding exercise. Turoff identifies six phases in the communication process:

> (1) Formulation of the issues. What is the issue that should really be under consideration? How should it be stated?
> (2) Exposing the options. Given the issue, what are the policy options available?
> (3) Determining the initial positions on the issues. Which are the ones everyone already agrees upon and which are the unimportant ones to be discarded? Which are the ones exhibiting disagreement among the respondents?
> (4) Exploring and obtaining the reasons for disagreements. What underlying assumptions, views, or facts are being used by the individuals to support their respective positions?
> (5) Evaluating the underlying reasons. How does the group view the separate arguments used to defend various positions and how do they compare to one another on a relative basis?
> (6) Reevaluating the options. Reevaluation is based upon the views of the underlying "evidence" and the assessment of its relevance to each position taken (35:88).

A thorough evaluation proceeding through all six phases was beyond the scope of this research. Jones and Twiss report there have been successful Delphi variations with more limited objectives than a full study (15:236). The research objectives, as well as time and financial limitations dictated a variation, an abbreviated Delphi to expose the critical issues which, by their identification, might aid space planners in further research.

<u>Usefulness</u>. The question of usefulness usually begins as, "How valid are Delphi results?" The assumption behind the question is that the results must be accurate to be useful. The question of accuracy is inherently difficult to answer for a Delphi for the very reasons requiring Delphi employment. Their subject matter is usually based in the future. Furthermore, Delphi results may be impossible to validate in those cases where the study served to alert managers who then took action to facilitate or prevent a particular scenario (25:174). Martino argues that usefulness is a more important measure for Delphi results than absolute accuracy. If, based on a Delphi study, a decisionmaker is able to take

action which affects the outcome of events in such a way as to invalidate the study results, yet in a way more favorable to the decisionmaker, then the study would have been highly useful (21:12-13). It is in this spirit that this research was conducted. It was hoped that the results would aid decisionmakers with respect to a lunar base.

Iterations. Different applications of the Delphi with various objectives have used different numbers of iterations of the response-feedback cycle. Martino describes a "basic method" using four rounds of questionnaires. He reports some experiments have shown that, in many cases, there is no advantage in excess of two rounds (21:27). An example of a successful Delphi exercise in two rounds was conducted by Overby (24:119). Martino goes on to say, "If time is short, and an initial list of events can be obtained by some other method, two rounds may well be sufficient to clarify the issues..."(21:27) It was determined based on a review of the literature, the nature of this study (issue exploration), and time constraints that two iterations would suffice.

The communication between panel members is central to the Delphi. Since this research employed only two rounds, thus permitting only a single opportunity for panel members to respond to group feedback, it was desired to have some evidence that the communication process was working. In a conventional Delphi, where an attempt is made to reach consensus on matters which are the subject of the Delphi, there is usually a specific measure for consensus, such as Overby's criteria of 50% or more of panel members choosing the same answer (24:80). However, as stated above, concensus is not a primary objective for a policy Delphi. Therefore, a different measure of group response was sought. The measure chosen was adopted from Scheibe, *et. al.* Scheibe presents the rationale for a different measure.

> ...considering that there is a strong natural tendency in the Delphi for opinion to centralize, resistance in the form of unconsensual distributions should be viewed with special interest.
> A measure which takes into account such variations from the norm is one that measures not consensus as such, but *stability* of the respondents' vote distribution curve over successive rounds of the Delphi (31:277).

The stability measurement is a comparison of response histograms between rounds and results in a percentage change figure for the group opinion between the rounds being compared. A histogram is a pictoral representation of the frequency distribution of data. The base axis is usually the measurement scale for the data. Extending from and normal to the base axis are lines whose lengths are proportional to the frequency count of data for each interval on the scale. If the scales for two histograms are identical, and the total number of observations is the same for both, then one histogram may be subtracted line for line from the other histogram. A third histogram results which reveals any shift in the frequency distribution between the two original histograms. Such a comparison is the basis for the stability measurement. Scheibe reports that empirical studies indicate a percent change figure of around 15% is a baseline "noise level" oscillation in the response data. Any figure above 15% is considered to represent significant movement in the group opinion (31:278). For purposes of this research, the stability measurement was used after the fact to determine if useful communication had occurred. Calculation of the stability measurement is described in Appendix C where that data is presented.

Panel Size. Dalkey conducted experiments designed to relate reliability to the Delphi expert panel size. Dalkey discusses reliability in terms of reproducibility. "It is clearly desirable for a study that another analyst using the same approach (and different experts) arrive at similar results."(4:12) Dalkey's data is reproduced in Figure 5 which shows an increase in reliability with increasing panel size. Jones and Twiss report ten to fifty experts on a panel is acceptable, with ten to fifteen normal for privately-conducted Delphis (15:229). Martino cites data which imply "that a panel of fifteen is sufficiently large to obtain a high degree of reliability."(21:49-52) It was decided for purposes of this research that fifteen experts would be the minimum panel size, with a goal of twenty.

Panel Selection. Jones and Twiss contend "the selection of the panel of experts is critical to the success of the study."(15:229) Martino is even stronger, "It cannot be emphasized too strongly that the choice of the panel is the most important decision the panel director will make, and considerable effort in making a good selection is fully justified."(21:54) Martino divides the problem of expert selection into two parts. First, by what criteria does one define an expert? Second, which experts does one choose?

On the first question, "Peer judgement is usually the best criterion for identifying an expert."(21:53) For the Policy Delphi, it is important that "informed people representative of the many sides of the issues under examination are chosen as participants."(35:88) One example of a Policy Delphi described the expertise of the panel members as, "The vast majority had titles of chief executive or director. All were considered ... to be distinguished in their field."(35:95) For this research, it was decided after consultation with Dr. Martino (20) that issues of a moon base would best be identified by experts in the tradeoffs required when limited resources must be allocated to mutually exclusive large-scale projects (i.e. similar to

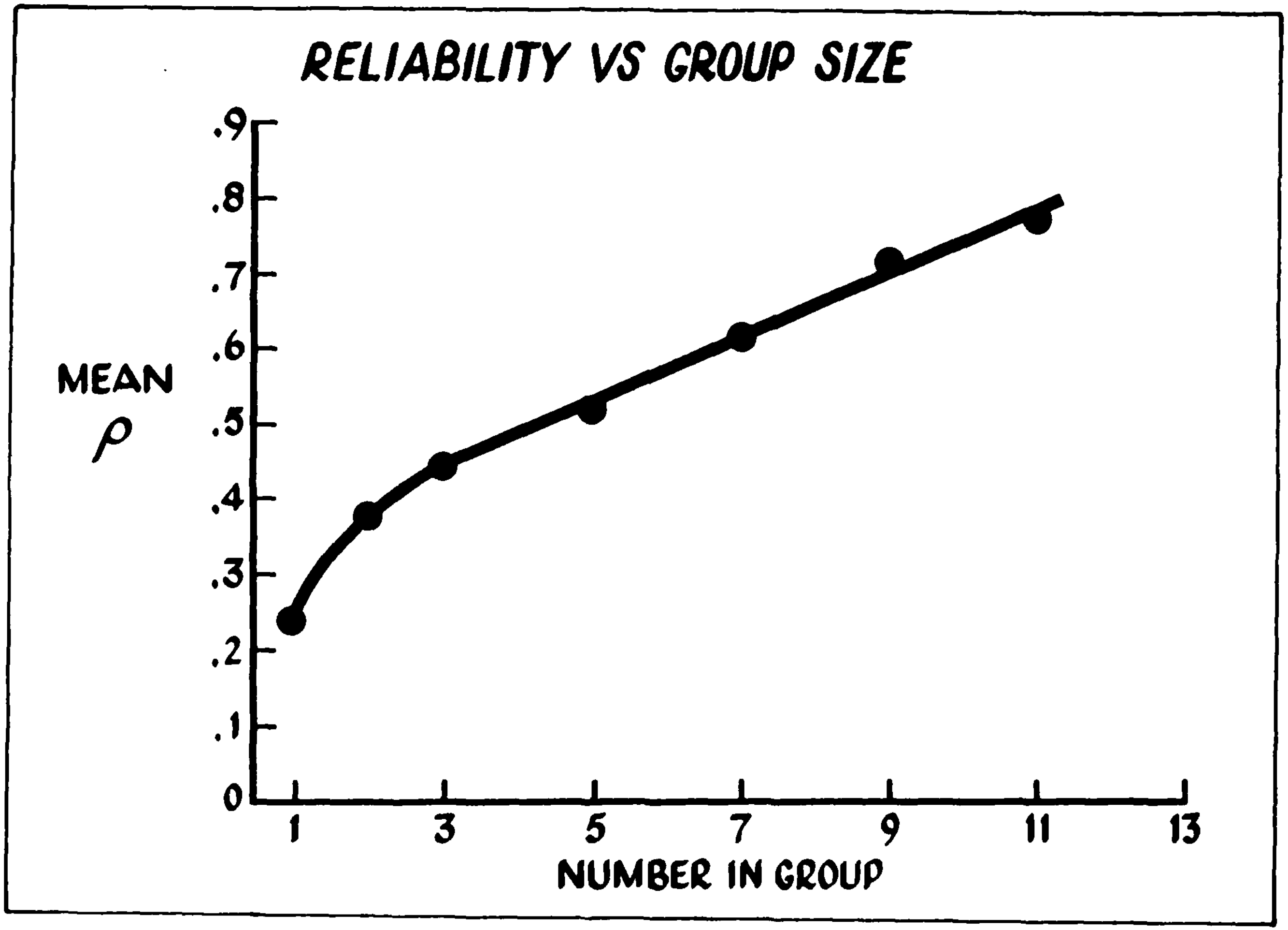


Figure 5: Delphi Reliability and Panel Size
(Reprinted from 4:13)

the decisions which must be made if a moon base is to become reality). It was then decided an expert would be a decisionmaker or someone shown to be closely associated with such decisionmaking. The degree of expertise was assumed to be related to the amount of responsibility or resources controlled or influenced by the individual in a present or previous position. In practical terms, this criteria translated into a search for people high in the management structure of large organizations. This criteria, in effect, is indirectly judgement by the prospective panel member's peers by virtue of the perceived "expertness" inherent in the person having been chosen for their particular position of responsibility.

The second part of the problem in expert selection identified by Martino is which experts, once identified, should be asked to be members of the Delphi panel. Martino suggests that the degree of expertness based on the expert selection criteria be used to prioritize the list. Martino discusses another practical problem.

> ...experts are busy people. This will be more true, the higher they are placed in the management structure. This means they may not have time to give the Delphi questionnaires adequate attention. In practice a tradeoff must usually be made between getting panelists whose organizational position gives them a sufficiently broad view, and getting panelists who will be able to spend adequate time filling out the questionnaires... The hasty opinion of a Vice President is probably not worth as much as the considered opinion of someone two or three levels below him (21:53).

To begin the actual selection process, a diversity criterion was added to the expert criterion in the search for panel members. Individuals intimately familiar with space efforts (e.g. NASA management) were included on the desired list so the views of the proponents could be offered for reaction to the other panel members. To prevent an unrepresentative agreement which might occur in a homogenous group, those directly involved in space activities were purposefully held to a minority representation on the panel. Other interest areas the panel was desired to represent were: business, finance, government, military, technology, and science.

Once the selection criteria had been determined, these were applied to the membership list of an apolitical historical organization made available to the researcher. Based on the desire to have twenty panel members, an informal survey was made of some previous Delphi exercises in an attempt to determine a reasonable response rate to be expected of the prospective panel members. A figure of fifty percent was decided upon. Given an expected half return rate, the forty top qualified people were chosen from the list. A personal appeal from the director of the organization was made by mail to the selected panel members on behalf of this study. Seven prospective panelists declined to participate in response to the initial letter. An additional six persons (four Air Force generals connected with space activities, the university professor mentioned above, and a prominent space activist known to be skeptical of government initiatives in space) were identified through other means. This brought the final total of prospective panel members to thirty-nine.

Questionnaire. As this Delphi had only two rounds, the initial questionnaire had to list an initial range of issues while allowing respondents to add to the list, as well as ask for the respondents' positions (35:88). This placed the burden on the researcher to conduct an extensive and careful literature review to identify the obvious issues prior to the questionnaire construction. From Martino's guidelines for conducting a Delphi (21:54-61), the questionnaire was designed to be easy to answer. The number of questions was held to sixteen. Much blank space was provided to encourage recording comments directly on the questionnaire. According to Turoff (35:89) rating scales were established for relative importance, desirability, and feasibility as a means of evaluating the respondents' ideas. For this study, seven point Likert scales were used. These scales are easy to construct and use (9:273-4) and so may enhance the response rate in keeping with the guidelines, above.

The questionnaire was submitted to a pretest (as recommended by Turoff) (35:93) by six individuals for evaluation of clarity, accuracy, and format. The six individuals involved in the pretest were not prospective panelists. Comments from the pretest were incorporated in the round one questionnaire.

Round One. The first round questionnaire, accompanied by a cover letter explaining the purpose of the questionnaire, a NASA letter of interest, an instruction sheet, a second copy of the questionnaire (as suggested by Turoff) (35:93), and a stamped, addressed return envelope, was sent through the U.S. mail to the thirty-nine prospective panel members. The instructions requested the questionnaire be returned within ten working days. Four weeks were allowed before the cutoff date for the first round; one week for arrival, two weeks to respond, and one week in transit on the return. In practice, three questionnaires were returned within seven days. Twenty questionnaires were returned before the cutoff date. Three questionnaires returned later were not rejected; however, their comments could not be included for reaction by the other panel members in the second round. Individual responses were tracked by assignment of a randomly generated six digit case number. The master list which matched respondents' names with the case numbers was destroyed at the conclusion of the study. The complete questionnaire is presented in Appendix A.

Round Two. The pertinent comments provided by the respondents for each question in the round one questionnaire were summarized for inclusion with the questions in the round two questionnaire. Most round one questions were repeated verbatim in the round two questionnaire. Based on different interpretations as evidenced by some comments, two questions were reworded for clarity. Median and inter-quartile values were calculated for the Likert scale responses in the round one questionnaire. Then for each question in the round two questionnaire, the median and inter-quartile range for the first round responses to that question were included. In addition, each round two questionnaire was individually marked with the values a particular respondent had indicated in the first round. This permitted each respondent to compare his or her own first round response with that of the group as a whole. The round two questionnaire was expanded to permit room for the summarized comments of the first round as well as "white space" for additional comments. The second round questionnaire was mailed with a letter thanking the panel member for his or her participation, a more extensive instruction set, and a stamped, addressed return envelope. Again, four weeks were allowed for return of the questionnaire. For those questionnaires not received after four weeks, a follow-up telephone call was made to the respondent. The complete questionnaire is presented in Appendix B.

Limitations. The Delphi technique, though widely used, has little theoretical foundation (15:240). It has a number of real and potential limitations. There is no universally accepted objective measure of an expert (30:33). An attempt was made to place at least some control on the expert selection process by submitting it to review by advisors to the researcher. Sackman states: "Delphi reports characteristically offer little or no information about panelist selection, and provide no safeguards against ... abuses."(30:33) In response to Sackman, Goldschmidt referred to a dictionnary definition of of expert, with which most researchers are comfortable. As for abuses, Goldschmidt writes, "...it is more related to ethics than to science."(10:201) This research report attempts to counter the criticism by adhering to the principle of "exposed design"; providing a complete description of expert selection, above. As stated previously, there is no independent validation of results possible. Goldschmidt, referring to the "usefulness versus accuracy" argument, states, "...the concept of prediction validity may be meaningless."(10:210) Some factors which contributed to the failure of past Delphis are:

> - Imposing monitor views and preconceptions of a problem upon the respondent group by over-specifying the structure of the Delphi and not allowing for the contribution of other perspectives related to the problem
> - Poor techniques of summarizing and presenting the group response and ensuring common interpretations of the evaluation scales utilized in the exercise
> - Ignoring and not exploring disagreements, so that discouraged dissenters drop out and an artificial consensus is generated
> - Underestimating the demanding nature of a Delphi and the fact that the respondents should be recognized as consultants and properly compensated for their time (17:6)

Every effort was made to minimize these problems through careful review, strict adherence to a rule of no monitor-originated ideas, and encouraging at every step additional comments from the respondents. Because the respondents were not compensated there may have been a temptation for some to not fully think through their responses. Conducting the Delphi with only two iterations may have limited the information obtainable.

However, two iterations was seen as a reasonable result of the tradeoff between data collection and time burden on the respondents.

Factor Analysis

Factor analysis is one of a number of multivariate techniques "for the analysis of interdependence among a set of variables."(6:20) According to Dillon and Goldstein, "Factor analysis attempts to simplify complex and diverse relationships that exist among a set of observed variables [and provide] insight into the underlying structure of the data."(6:53) Rummel states:

> Factor analysis is most familiar to researchers as an exploratory device for uncovering basic concepts. ... factor analysis may be undertaken to [determine] influences at work in a domaine. Factor analysis is a tool usable for reasoning from data to generalizations about underlying influences causing discovered patterns (29:22).

Dillon and Goldstein add: "For example, the common underlying dimension [or factor] of *social class* may account for the strong positive correlations frequently found between income, education, and occupation."(6:53) Factor analysis may be useful to glean additional information from data collected in a Delphi. An example is reported by Dalkey (5:396-8).

The basis for factor analysis is a mathematical treatment of a two dimensional numeric data matrix. Interest centers on "that part of the total variation [of the data] that a particular variable shares with the other variables constituting the set."(6:20) A discussion of the technique or its foundation is beyond the scope of this report. The result of a factor analysis is a correlation matrix of variables versus unobserved factors, where the elements in the matrix are the amount of variance in the data of each variable that is accounted for by each factor. A variable is said to load on a factor by the amount of the data element. As a rule-of-thumb, loadings greater than 0.5 are considered significant (29:378). Once significant loadings are identified, they must be interpreted. From Dillon:

> A factor is a qualitative dimension, a coordinate axis. It defines the way in which entities differ, much as the length of an object or the taste of a product defines a distinctive qualitative dimension on which objects may or may not differ. A factor does not indicate how much different various entities are, just as knowledge that an object's weight is an important physical dimension does not indicate how much heavier one object is than another. Factor analysis provides a dimensional structure for the data in the sense of indicating the important common qualities present in the data (6:60).

Since a factor is qualitative dimension, the researcher must look at the variables which load on a factor and make a judgement as to what a factor represents. As Dillon goes on to say, "...labeling the common factors is more an art than a science..."(6:94)

Though the computational aspects of factor analysis involve the complexity of matrix algebra, the technique is available to many researchers as a procedure in some computer-based statistical packages such as *BMD, SPSSX,* and *SAS.*

As factor analysis is a statistical treatment of data, two questions must be addressed. First, the measurement level of the data must be determined. Second, the given statistical treatment must be valid for the determined measurement level.

As stated above, the scales used in the questionnaires were seven-point Likert scales. According to Emory, in the strictest sense, Likert scales give only ordinal level data (9:123). That is, any given value on the scale may be said to be greater than, less than, or equal to another given value, but; if two values differ, one cannot determine quantitatively the difference. However, the more powerful statistical procedures, called parametric procedures, require interval level data. Interval level data is measured in equal units or intervals with an arbitrary origin (as in the Farenheit scale, for instance). In practice, states Emory, "...there are risks in using parametric procedures on ordinal type data but these risks are usually not great."(9:124)

As to the validity of using factor analysis with various levels of data, Rummel states:

> ...factor analysis can be applied to the data of any matrix. ...factor analysis can be meaningfully applied even to nominally scaled data, ...the lowest and least demanding rung on the measurement ladder (29:17).

Given that the Delphi is a qualitative technique, the precision of the numrical data is not critical. In addition, as stated above, factor analysis is flexible enough that it can be applied to data which is not necessarily at least interval level data. Therefore, factor analysis may be a useful supplement to a Delphi study (20).

III. Findings and Discussion

Administration

Delphi .anel Composition. Twenty-three persons responded to the round one questionnaire, providing comments to the round two questionnaire. Eighteen panelists completed the second round. The panelists represented diverse backgrounds, though all held at the time of the Delphi or previously positions of responsibility involving the allocation of large-scale resources to technical projects. Most, particularly those in NASA or holding public office, had served in more than one position of great responsibility. Included in the panel were: a current U.S. Congressman, a former U.S. Secretary of Energy, a medical venture capitalist, the CEO of an oil company, a division president of a "big three" auto company, an Air Force major general and Air Force lieutenant general, directors of several high technology companies, the CEO of an American "top ten" bank holding company, several top managers in NASA, the two highest ranking members of a "top ten" U.S. city chamber of commerce, a high-level manager in a large aerospace firm, as well as a prominent scientist associated with NASA space science projects. In the judgement of the researcher and others (20) the group's composition appeared to be sufficiently diverse to obtain a comprehensive set of opinions. However, given the lack of an accepted measure for proper panel composition, no additional attempts were made to support the adequacy of the panel selection. In addition, because of the panel's diversity combined with small size, no particular individual or group of individuals was judged representative of an occupational class. Therefore, no attempt was made to correlate questionnaire responses with the respondents' backgrounds.

Round One. As stated above, this Delphi consisted of two rounds, necessitating an initial set of issues be provided on the round one questionnaire. After an exhaustive literature review, eight main issues associated with a potential lunar base were identified: government funding, American leadership in the international arena, lunar materials, profit motive, side benefits, military involvement, international involvement, and space science. Twelve questions were formed to solicit panelists' opinions in the eight major areas. The questions were designed to stimulate thought and panelists were encouraged to expand on and add to the statements contained in the questions. In addition to these twelve questions, three more questions were included to investigate the personal views of the respondents on manned space activities in general in the short and long terms, as well as their views towards a lunar base specifically. Finally, the last question asked for issues and comments not specifically addressed in rest of the questionnaire. The round one questionnaire is presented in Appendix A.

Round Two. The second questionnaire asked basically the same questions as the first round. The summarized comments from each first round question were included below their respective questions on the second round form. In addition, a statistical summary of the group response in round one was listed with each question. Each questionnaire also had individually filled-in for each question the individual respondent's round one response for comparison to the group response. The last question in the first round was changed for round two. Instead of an open-ended request for information, a list was made of all the critical issues identified in round one. Of the twenty-five issues listed, the respondents were asked to select the ten most critical and rank order them. The round two questionnaire is presented in Appendix B.

Findings

Respondents were asked to mark a point on each scale representing their relative positions on the question asked. All questions except the last on both questionnaires used the same seven point scales. The scales were considered to be continuous. Respondents' marks were converted to numbers between one and seven inclusive, and rounded to the nearest tenth. The scaled response data from rounds one and two are presented in Table 1 and Table 2 respectively. Table 3 presents an inter-round stability measurement for each question. The stability measurement calculation was based on side-by-side comparisons of response data histograms for those respondents who answered the respective question in both rounds. Also, the respondents' summarized comments from both rounds are presented in Appendix D.

Discussion

Stability Measurement. As a measure of stability of group opinions, change percentages were calculated from only scale responses where respondents answered a given question in both rounds. Upon initial calculation of the change percentages, the resulting figures were seen to be excessive when compared to the visual differences between the histograms. It was thought the excessive variability might be attributed to the scales themselves. Review of the questionnaires indicated some respondents were not as precise as others in marking the scales (some used arrows or vertical lines whereas others used circles, "x"s, or check

Table 1
Round One Responses

	Federal	Funding	USA Leadership		Man-In-Space		Lunar	Profit		Lunar	Side	Military		Inter-	Personal
\VARIABLES	Prob	Desire	Important	Justif	General	50 Years	Materials	Desire	Feasible	Science	Benefits	Should	Will?	national	View
C															
A 342433	4	6	6	3	5	7	4.7	4	4	5	5	5.7	5	5.7	4.5
S 326725	3.2	4.5	5.5	3.2	2.3	6.3	3.2	4.7	3.2	4.5	4.5	5.8	5.7	4.5	4.5
E 267663	4	7	7	7	4	6	4	1	1	7	4	1	4		7
S 312588	3	7	6	3	5	7	3	4	4	4	3	4	5	2	5
212685	3	7	7	7	5	7	3.8	5.2	4	7	7	7	7	7	7
703716	7	7	7	7	7	7	7		1	7	7		4	2.1	6.8
152995	4	6	5	6	6	6	4	6	5	6.3	6.3	6.3	4	2.5	7
140743	5.5	6.5	5.5	5.5	3.5	5.5	4.7	5.5	6.5	5.7	5.5	4.7	6.5	4.7	6.5
125349	3	5	7	4	5	7	7	4	4	5	6	4	5	6	6
197292	4	6	4	2	1	7	7	7	7	7	7	1	1	7	7
260752	2	7	7	6	5	7	6.5	4	1	7	3	6.9	1.1	7	7
543495	3	7	7	7	5	7	4	5.5	4	7	7	7	7	7	7
106814	5	6	7	6	3	6	4	4	4	6.2	6.2	7	6	5	7
262637	4.5	5.5	6.5	6.5	4.5	5.5	5.5		5.5	6.3	5.3	4.3	4.3	5.3	5.3
483805	4	7	7	4	1	7	1	1	2	4	4	1	4	7	7
310703	3.5	1.5	5.3	4.3	1.5	3.5	1.5	6.5	4.3	3.5	6.3	3.5	3.5	1.5	3.5
239075	5	7	6	6	4	6	4	6	4	6	6	6	6	4	6
262951	4.8	6.8	7	5.5	4	5.5	5.5	1.5	1.5	6.3	2.5	1.1	1.1	5.8	7
889070	4.5	5.5	6.5	6.5	4.5	6.5	4.5	4.7	4.7	5.5	6.5	5.5	5.5	4.5	5.5
284628	7	7	7	7	5	7	5	5	5	7	7	5	7	6	7
183783	4	7	7	7	7	7	5	5	4	7	7	7	7	5	7
186924	2.5	4.5	6.5	2.5	1.5	6.5	1.5	2.5	2.5	6.5	1.5	2.5	1.5	6.5	2.5
302535	3	2.5	7	3	2	6.5	7		4	7	5	2.5	2.5		3
Median	4	6.5	7	6	4.5	6.5	4.5	4.7	4	6.3	6	4.85	5	5.3	6.8
1st Quar	3	5.5	6	3.2	2.3	6	3.8	4	2.5	5	4	2.5	3.5	4.5	5
3rd Quar	4.8	7	7	7	5	7	5.5	5.5	4.7	7	7	6.3	6	6.5	7

Table 2
Round Two Responses

\VARIABLES C	Federal Prob	Funding Desire	USA Leadership Important	Justif	Man-In-Space 50 Years	100 Years	Lunar Materials	Profit Desire	Feasible	Lunar Science	Side Benefits	Military Should	Will?	Inter-national	Personal View
A 342433	4.5	6.2	6.2	2.7	6.6	5.3	4.5	3.5	4.5	5.2	3.1	2.6	4.2	4.5	4
S 326725	3	3	6	4	6	4	4.5	5	3.5	4.5	4.5	6	6	5	5
E 267663															
S 312588	2	7	6	3	7	5	4	4	4	4	3	4	5	2.5	4
212685															
703716	7	7	7	7	7			1	1	7	7		7	2	7
152995	4.3	5.8	5.3	5.6	5.2	5.3	5	5.2	4.3	6	5.5	4	4.5	2.3	6.2
140743	5.5	6.2	5.5	5.5	5.5	3.2	4.1	5.1	5.2	5.7	5.7	4.1	5.6	4.3	5.7
125349	3	6	7	4	7	5	6	4	4	6	6	4	5	5	6
197292	5.5	5.5	5.5	1.5	6.5	6.5	4.5	5.5	5.5	5.5	5.5	1.5	1.5	6.5	6.5
260752	2	7	7	5	7	6	6	5	1	7	3.5	7	1.1	7	7
543495															
106814	4.5	7	7	6	6.2	4.7	4.7	4.2	4.2	6.2	6.2	6	5.8	5.2	6
262637	4	6	6	6	6	4	4	4	5	7	6	4	5	6	7
483805	3	7	7	4	6	2	2	1	2	4	2	1	4	7	7
310703	3.5	2.5	5.4	4.3	5.3	1.5	1.5	5.5	3.6	2.5	5.5	3.5	3.6	1.5	3.6
239075															
262951	5	7	7	6	7	6	4	2	2	6	7	4	5.5	5	7
889070	5	5	5	4	6	4	3	5	5	4	6	5	5	5	7
284628	6	7	7	7	7	6	6	6	4	7	5	7	7	7	
183783	4	5.5	5.3	5.5	5.5	5.3	4	4.8	4	6.3	6.5	6.8	7	4.5	
186924	2.5	4	5.2	2.5	5.2	2.2	2.2	2.5	2.5	5.5	2.2	2.5	4	5.8	2.8
302535															
Median	4.15	6.1	6	4.65	6.1	5	4.1	4.5	4	5.85	5.5	4	5	5	6.1
1st Quar	3	5.5	5.4	4	5.5	4	4	3.5	2.5	4.5	3.5	3.5	4	4.3	4.5
3rd Quar	5	7	7	6	7	5.3	4.7	5.1	4.5	6.3	6	6	5.8	6	7

Table 3: Inter-Round Stability

Question Variables and Percentage Change

Federal Funding:	Probability	(FEDPROB)	22%
	Desirability	(FEDDES)	22%
U.S. Leadership:	Importance	(LEADIMP)	28%
	Justification	(LEADJUST)	33%
Manned Space Activities:	50 Years	(SPA50)	28%
	100 Years	(SPA100)	59%
Lunar Materials:	Importance	(LUNMAT)	53%
Profit Motive:	Desirability	(PROFDES)	44%
	Feasibility	(PROFFEAS)	22%
Lunar Science:	Importance	(LUNSCI)	33%
Side Benefits:	Importance	(SIDEBEN)	39%
Military Involvement:	Should	(MILSHOU)	39%
	Actual	(MILWILL)	17%
International Cooperation		(INTERNAT)	22%
Personal View		(PERSON)	31%

(Stability calculations are shown in Appendix C.)

marks). Such marks resulted in some cases of responses so close in value (two tenths of a scale interval) as to be insignificantly different between rounds, yet would register as a change of opinion by that calculation. Therefore, for purposes of the change calculation only, responses were rounded to the nearest half increment before the calculation was made. The resulting figures in Table 3 thus have most of the variability associated with marking imprecision removed, and are more in line with what would be expected based on a visual comparison of the histograms (presented in Appendix C). The change percentages in Table 3 show that the group opinions were affected by feedback of the group response from round one. Only one of the fifteen questions with scaled responses showed a stable group opinion between rounds (stability was considered to be near 15% which Scheib states is the noise level associated with the scaled responses). Response to feedback is an important characteristic of the Delphi. While by itself this characteristic does not demonstrate validity of the Delphi, its presence nevertheless lends greater credibility to the exercise.

Questionnaire Topics. Each of the major topics addressed in the Delphi questionnaires is discussed in turn. Scale response distributions, characterized in the discussion below, may be evaluated visually in the histograms of Table 3. Respondents' comments, which served to qualify the scale responses, are presented in summary in Appendix D.

Personal Views. Beginning the discussion is a subjective analysis of the personal views of the respondents with the objective of discovering bias which may influence the results. There were three questions included in the questionnaire to evaluate personal views:

- Please rate your agreement with the following statement, "If mankind is to avoid the fate of all other animal species-extinction - we must become a space-faring people."
- How important is it for man to be in space during the next fifty years?
- As you look forward to early in the next century, and consider the best interests of the United States, is a lunar outpost compatible with your vision of the future?

These questions were intended to evaluate the long and short term views of the respondents about manned activities in space, and the respondents' attitudes specifically towards a lunar base, respectively. The results show the group was generally favorable towards the idea of a lunar base, but; they are not necessarily proponents. That is, even though all panel members were proponents for manned space activities in the near term (for servicing satellites and conducting research, for instance), the responses for a lunar base were much less skewed toward the positive side. Furthermore, most comments on the question of a lunar base were prefaced with "Yes, if...". The median value for the responses to the personal view question was six. When combined with the comments, however, it was apparent that few panelists were sure a lunar base project should be part of the overall plan for space activities in the near term. The question on longer term manned presence in space was poorly worded on the first questionnaire, as judged by the comments. Respondents were commenting on the threat of extinction more so than manned space activities. Said one respondent, "I can see benefits for man becoming space faring, but I see no connection between this and the notion of extinction." As a result of the comments, a more direct wording was used for this question on the second questionnaire:

> - How important is it for man to expand into space in the next hundred years and beyond? What will be different in this longer term?

The effect of the re-worded question can be seen in the high (59%) change figure for the question between rounds. The responses indicated much less certainty about manned space activities in the long term (outer bounds of 1.5-6.5 versus 5.2-7 for the near term). Several respondents indicated that if space activities were good for the next fifty years, then the next hundred years would be better. Another respondent disagreed saying it is easier to control Earth than inhabit the Moon or planets. The greater divergence of opinion for the longer term question is common in Delphi forecasts. According to Martino, this characteristic of the Delphi is evidence of an ordered process at work which gives greater confidence in Delphi exercises (21:48). Based on the comments from these three questions, it was concluded the group did not show a significant bias in favor of a lunar base and therefore could provide meaningful data.

Federal Funding. Respondents were asked to rate aspects of federal funding relative to a lunar base in the following question:

- Many of the building blocks for a lunar base system will be in place with the space station. Studies have estimated (conservatively) that a permanently-manned lunar base can be built (assuming the U.S. goes it alone and only government funds are used) over 25 years given expenditures at current levels (approximately 0.8% of the federal budget - as opposed to the 11-year Apollo program whose peak expenditures reached 4.5%) and still support other unmanned activities. Please identify the factors which will influence sustaining a federally-funded program for such a long period. Also, please assess the likelihood of sustaining such a program.

All but three respondents rated federal funding as desirable. Most respondents commented that federal funding was the only way to accomplish a lunar base, if there is to be one. One dissenter questioned the desirability in light of consistent U.S. budget deficits. The group was much less certain about the probability of sustaining federal funding over a long period. The median response was 4.15 with the IQR being 3-5. Most respondents came up with several reasons which would prevent federal funding from being sustained. Partisan politics would probably weaken overall support available to the program. Historically, the public waxes and wanes in its support for large programs. Because the space program is non-entitlement, it does not have a large and automatic constituency and is therefore more vulnerable to budget reductions in the competition for federal funds.

Leadership. This was a two part question:

- Throughout the Apollo program, the U.S. was the acknowledged world leader in space activities. How important is U.S. leadership in the space arena?
- Also, how important is the need for U.S. leadership as justification for a lunar base?

All respondents agreed that U.S. leadership in space is important, though their reasons varied from exerting influence for peace to denying adversaries a military advantage. On the second part of the question the group generally down-played the role of leadership as justification for a lunar base, with a median value of only 4.65. Most implied that as an intangible value, leadership was simply not enough to justify a program with such great size and cost as a lunar base. The idea of leadership might enhance more tangible factors (such as economic, scientific, or military benefits). One respondent suggested leadership achieved through peaceful space activities was more pronounced and cost effective than that gained through military expenditures. On the other hand, many other competing space projects (e.g. a manned trip to Mars) could also claim a leadership role.

Lunar Materials. The availability of raw materials on the Moon has been cited as a reason for developing a lunar base, hence this question:

> - A key use for the moon might be to supply lunar materials (oxygen, iron, titanium, ceramics, etc.) to processing facilities in orbit around the earth (the first stage of these facilities being represented by the upcoming space station). The chief reason for selecting lunar materials would be the cost of transport: lifting material from the earth requires approximately twenty times the energy as delivering the same material to earth orbit from the moon. How important is the availability of lunar materials in justifying a lunar base?

The response median of 4.1 and IQR of 4-4.7 showed the group as barely favorable towards lunar materials. In comments, the panel was generally skeptical about material availability as justification for a lunar base. Most cited their belief that the cost of the lunar materials would far outweigh the cost of Earth-derived materials for the foreseeable future. Several respondents thought lunar materials could be important in the long term, thus provide an additional incentive though not a primary justification.

Profit Motive. The panel was asked to comment on the role of the profit motive for a lunar base:

- How important might/should the profit motive be in establishing a lunar base?

Two scales looked at the desirability and feasibility of the profit motive. Somewhat surprisingly, given the panel's strong ties to American business, the respondents were only weakly favorable towards the desirability for the profit motive on the Moon (median response - 4.9). Like lunar materials, respondents thought the profit motive might be important in the long term. More than half of the group felt the profit motive was infeasible for establishing a lunar base, with several respondents referring to the incompatibility of a high risk, long term lunar project with the requirements of American business for relatively safe, near term return on investments.

Military Involvement. This two part question looked at attitudes and asked panelists to make a prediction.

- Military requirements for space (observation, communication, etc.) both assist and impede civilian space activities. For instance, the military may support the means for civilian access to space (e.g. the space shuttle) but also compete with the civilian sector for that same access. Please qualify the role, if any, you foresee the military should play in the development of a lunar base.
- Do you think the military will aid or impede establishment of a moon base? Under what circumstances?

The panel was clearly divided on the question of should the military be involved. The responses ended in a three-way split: for, against, and neutral. Those for military involvement thought it a prerequisite for a lunar base for reasons of the additional political and financial support. Those against simply didn't like the idea. Despite the division of attitudes, over half of the panelists predicted the military would slightly aid development of a lunar base. The firmness with which the group held this opinion is indicated by the stable 17% change between rounds for this question. Panelists generally thought military objectives in space would probably be incompatible with non-military ones, even though additional support from the military might be critical to pursuing a lunar base program.

Lunar Science. Panelists were generally favorable to space science conducted by men on the Moon when asked:

> - The moon offers many opportunities for the advancement of science, although most subjects could be studied in earth orbit as well. Some unique to the moon include ultra-powerful radio and optical telescopes free from the earth's interference, both natural and man-made. How important is scientific research in justifying a lunar base?

Only one respondent reacted negatively to this question, though most questioned the cost effectiveness of lunar-based science. Another respondent contended science was the only solid reason for advocating a lunar base at present. Several suggested science was a primary justification. Others thought that science would be better served in low Earth orbit (LEO) than on the Moon.

Side Benefits. One oft-repeated supporting point for U.S. space activities lead to this question:

> - The space program is generally recognized as benefitting people on Earth, primarily through technology spinoffs (e.g. Tang, Velcro, electronics). Please assess the importance of this factor in the support for a moon-base program.

In the first round, three fourths of the respondents were favorable to this aspect of a lunar program. All but one of those who commented, commented favorably. Yet the second round response was less favorable. While still more than half of the group were favorable towards side benefits, they were less so than before, agreeing that side benefits would accrue as a result of any large scale space activity. Therefore this factor would not by itself point to a lunar base. All respondents thought important technological side benefits would result from a lunar base.

International Participation. The group was divided on this question:

> - There have already been major examples of international cooperation in the U.S. space program (Apollo-Soyuz, the European Space Agency laboratory module flown in the space shuttle, etc.). How important will international participation be in the establishment of a moon base?

Two groups of respondents respectively opposed and supported international cooperation as justification for a lunar base. However, the remaining half of the panel was grouped around the neutral position. While most indicated that the concept is worthwhile, panelists raised objections to the effect that international participation has intrinsic costs which may not be apparent under superficial examination. Some panelists indicated international participation tended to be inherently unequal, hence unfair and undesirable. Others cited previous problems encountered with technical integration and management of international-scope programs; problems which on the scale of a lunar base program might force schedule delays and cost increases sufficient to kill the program. Other comments were along national lines: "...only if [international participation] serves [U.S.] national interests."

Critical Issues. An open-ended question was posed as the final question of the round one questionnaire. This asked respondents to review the entire questionnaire and the respondent's own comments, and list the critical issues for establishment of a lunar base. Twelve panel members provided extensive lists and comments. These were summarized in a list of twenty five issues and listed at the end of the second questionnaire. In round two, panelists were asked to choose the ten most critical issues from the list, and rank order them with one being the most critical. The purpose of the first question was to identify as many pertinate issues as possible. The purpose of the question in round two was to determine the group opinion about which issues were the most critical. In order to combine the individual panelists' rankings into a single group ranking, a simple point system was used. The ordered issues on the questionnaires were reversed scored. That is, a number one ranked issue on a questionnaire received a score of ten points. A number two-ranked issue was scored a nine and so on to the number ten-ranked issue which scored a one and all the unranked issues received no points. The scores for each issue were summed across all questionnaires. Then the issues were ranked accordingly, with the issue receiving the highest score rated the most critical. The issue point tallies are presented in Appendix E. The ordered list of the panel's top ten issues is presented in Table 4. These issues are also listed by common factor in Table 4. Eight of the top ten issues could be combined to form two major issues which the group deemed most critical to the establishment of a potential Moon base.

The first major issue combines the first, second, eighth, and tenth-ranked issues into a single factor labelled "sell/educate". That is, some combination of acceptable national goals, whether scientific, commercial, military, or otherwise, must be "sold" or demonstrated to be best achieved by the establishment of a lunar base. The demonstration or supporting data would best be economic, though other considerations which place a value on intangible qualities such as leadership or international cooperation or national security might be appealing as well.

The second major issue combines the other second (two issues tied for second) fourth, fifth, and seventh-ranked issues into a category

Table 4: Ten Critical Issues

The ten most critical issues for the establishment of a lunar base, listed in the order ranked by the Delphi Panel.

1. Demonstrations of benefits to mankind, U.S., and tax payers.

2. Development of coherent national goals which can be met most economically with a lunar base.

2. The will and money.

4. Budgetary reform in Congress to support multi-year appropriations.

5. Congressional recognition of lunar base value.

6. Government ability to organize and execute a long range program while keeping up with and using changing technology (could serve as a model to solve other long range problems).

7. Uninterrupted political and financial support.

8. Identification of "high value" science which can only be developed in the lunar environment.

9. Development of military value of lunar base.

10. Demonstration of an economically viable space station.

(Note: The two issues numbered "2." had equal point totals.)

Table 4: Ten Critical Issues (Cont'd)

First Factor: "Sell/Demonstrate"

1. Demonstrations of benefits to mankind, U.S., and tax payers.

2. Development of coherent national goals which can be met most economically with a lunar base.

8. Identification of "high value" science which can only be developed in the lunar environment.

10. Demonstration of an economically viable space station.

Second Factor: "Political"

2. The will and money.

4. Budgetary reform in Congress to support multi-year appropriations.

5. Congressional recognition of lunar base value.

7. Uninterrupted political and financial support.

Third Factor: "Credibility"

6. Government ability to organize and execute a long range program while keeping up with and using changing technology (could serve as a model to solve other long range problems).

Fourth Factor: "Military"

9. Development of military value of lunar base.

labelled "political and financial support". Comments cited the variety and variability of American politics and the large cost and long duration as factors calling into question the U.S. government's ability to sustain a lunar base program.

The third major issue was ranked sixth in the list of twenty-five (with some supporting issues not ranked in the top ten). This issue might be labelled "credibility/capability". Though virtually all respondents commented that federal funding would be essential to establishment of a lunar base, many questioned the federal government's capability to manage successfully such a large-scale, long duration task.

The fourth major issue was the development of the military value of a lunar base.

Factor Analysis. A factor analysis of the numeric scale response data was conducted to provide another perspective, descriptive in nature, on the data. This analysis was exploratory. That is, the factor analysis may reveal patterns, or the source of variability, in a data matrix such as that presented in Table 2. However, the factor analysis cannot determine the cause of the variability. For this, a completely different research design would be required, which was beyond the scope of the present effort. The factor analysis was used, however, to gather additional information from the Delphi data, information which may lead to further study. The factor analysis of the round two data was performed by the computer statistical package *SAS* at the Air Force Institute of Technology. As the computer program could not accept cases with missing values, the missing values in round two were taken to be unchanged from the panelists' first round responses. Only five data values out of 270 were estimated in this manner. From the analysis, five factors were retained for rotation. The five factors accounted for 82.6% of the variability of the data. The rotated factors are presented in Table 5. The complete printout is presented in Appendix F. The first factor might be labelled, "Space and Government Proponents." This factor loads heavily on favorable attitudes towards manned space activities and the importance of: federal funding, U.S. leadership in space, lunar materials, and lunar-based science. The second factor might be labelled, "Nationalist." This factor loads heavily on the high probability that federal funding can be sustained, importance of leadership as justification for a lunar base, importance of side benefits, a belief that the military will aid development, and a strong personal belief there should be a lunar base. The third factor might be labelled, "Commercial." This factor loads on the belief that the profit motive is both desirable and feasible for development of a lunar base. This factor also loads on the rejection of the importance of U.S. leadership. The fourth factor might be labelled, "Military." This factor loads on leadership as justification for a lunar base and on the notion that the military should be involved in a lunar base program. The fifth factor might be labelled, "International." It loads on the importance of international participation in a lunar base program as well as a favorable personal view towards a lunar base. As noted previously, factor labels are arbitrary, though the factors themselves are present in the data.

Table 5: Round Two Factor Analysis

ROTATED FACTOR PATTERN Rotation Method: VARIMAX

Question Variables vs. Factors

Question Variable		FACTOR1	FACTOR2	FACTOR3	FACTOR4	FACTOR5
Federal Probability	(FEDPROB)	0.25601	<u>0.81154</u>	0.16291	-0.26130	0.06977
Funding: Desirability	(FEDDES)	<u>0.62057</u>	0.19843	-0.36496	-0.12313	0.39341
U.S. Importance	(LEADIMP)	<u>0.54363</u>	0.02559	<u>-0.66664</u>	0.11113	0.24987
Leadership: Justification	(LEADJUST)	0.10505	<u>0.72851</u>	-0.32310	<u>0.49655</u>	0.16177
Manned Space 50 Years	(SPA50)	<u>0.85807</u>	-0.08195	-0.29443	-0.02440	0.06743
Activities: 100 Years	(SPA100)	<u>0.90336</u>	0.19391	0.15660	0.09466	0.10594
Lunar Materials: Importance	(LUNMAT)	<u>0.84951</u>	0.25977	-0.04268	0.29345	0.03687
Profit Desirability	(PROFDES)	0.02404	-0.09727	<u>0.83324</u>	0.46540	0.00673
Motive: Feasibility	(PROFFEAS)	-0.10922	0.13761	<u>0.85214</u>	-0.15015	0.01571
Lunar Science: Importance	(LUNSCI)	<u>0.54042</u>	0.35233	-0.10371	0.27416	0.44891
Side Benefits: Importance	(SIDEBEN)	0.19350	<u>0.81103</u>	0.24560	0.14626	-0.05912
Military Should	(MILSHOU)	0.21169	0.19310	0.08816	<u>0.92307</u>	0.07595
Involvement: Actual	(MILWILL)	-0.05955	<u>0.70701</u>	-0.20903	0.29978	-0.20095
International Cooperation	(INTERNAT)	0.08056	-0.30636	-0.00919	0.02791	<u>0.88870</u>
Personal View	(PERSON)	0.32580	<u>0.50923</u>	-0.06085	0.09253	<u>0.64535</u>

(Significant factor loadings are underlined.)

IV. Conclusion

Interest in establishing a permanently-manned outpost on the Moon, once strong during the Apollo Program, has been revived as space planners have begun to look beyond the space shuttle and upcoming space station in efforts to chart a course for future manned space activities. An exhaustive review of the literature left little doubt, that given sufficient time and money, a lunar base is technically feasible. After all, twelve men have walked on the Moon. The larger question appears to be one of building the support necessary to achieve such a program. This research was directed at making a small but definitive step towards answering that larger question.

The objectives of this research were to identify factors which may affect a potential Moon base program, identify experts which represent those factors, and identify the most critical issues for establishment of a Moon base.

Given that accomplishing any large scale program involves tradeoffs and compromises necessitated by limited resources, individuals in business, government, and academia with expertise in allocating resources on a relatively large scale, were invited to participate in a Delphi exercise. The Delphi is a set of procedures for soliciting group opinion. Experience with the Delphi indicates that with a group as small as fifteen sufficiently expert individuals, a group opinion can be recorded with a high degree of confidence that the same opinion would have been achieved with any comparable group. The literature also shows that group opinion arrived at through a Delphi can be very useful to decision makers.

The experts concluded that four issues were most critical for a potential lunar base program:

1. The experts agree that federal financial support will be requisite to a lunar base. A critical issue is how political, hence financial, support can be developed and maintained over a long period (10-20 years).

2. In today's environment of fiscal constraint, a program must have clear benefits to tax-payers and the economy alike. The economic benefits would be most persuasive, though there may be a combination approach which addresses science, commercial interests, international cooperation, military requirements, and national leadership.

3. The experts questioned the ability of the government to effectively and efficiently manage a large scale, long duration program such as a lunar base, qualities deemed essential to a program's success.

4. Development of the military value of a lunar base could also be critical to its becoming reality.

In addition to the issues identified directly through the Delphi, the experts' data was submitted to a factor analysis to describe factors present in the expert group opinion which might permit insight into the factors which may influence a potential lunar base program. The analysis revealed five factors:

1. Space and Government Advocacy - support for manned space activities in general together with conviction in the positive value of lunar materials and lunar science as justification for a lunar base.

2. Nationalist - a combination of belief that federal support can be maintained, partially through military spending, belief in the importance of U.S. leadership as well as the importance of benefits from technology spinoffs as justification for a lunar base.

3. Commercial - belief that there's money to be made in space and on the Moon; leadership is not important.

4. Military - belief that U.S. leadership is good justification for pursuing a lunar base and the military should be involved.

5. International - belief in the importance of international participation and cooperation along with a favorable personal view towards a lunar base.

The research data appears to signal a fundamental shift in attitudes regarding manned space exploration. From the perceived humiliation of the Sputnik launch through the triumph of six Moon landings, intangibles such as leadership and science were sufficient to maintain considerable support for the manned space program. Yet, for a lunar base, the Delphi panel was strong in its expression of the need for the program to have demonstrable, cost effective benefits; in effect to be self-supporting or nearly so. This sentiment appeared to have been reinforced by the perception that a lunar base is not part of any long range U.S. strategy. Therefore, a lunar base would be seen as a stand-alone program competing with other space and Earth-based programs as opposed to complementing other programs and supporting an overall framework of well-considered goals and objectives in space. Though efforts have been made in the space community in the mid-1980s to formulate goals and a long range strategy for space exploration, the results of these efforts were not manifest in panelists' attitudes. The sentiment for a cost effective lunar base may have been further reinforced by the destruction of the Challenger. In a situation analogous to interest rates being directly related to the perceived level of risk in an investment, corresponding to the increased perception of risk following the accident may have been an increase in the return required from the investment in a lunar base.

The sense of competition with the U.S.S.R. was quite evident in the panelists' comments. Though panelists generally doubted the ability of the U.S. political system to sustain support for a lunar base, they thought Soviet action could galvanize support. Likewise, though most panelists emphasized the need for tangible benefits, for many panelists a response to a military threat carried equal weight as tangible benefits in justifying a lunar base. Almost half of the panelists either stated or implied that a lunar base viewed as responding to an overt challenge from the U.S.S.R. would have vastly improved chances of being established. Given that the respondents also generally thought military and civilian goals on the Moon would conflict, the frequent mention of the potential military value of a lunar base would indicate that space access was not necessarily inherently desirable, but desirable so as to not be ceded by default to the major U.S. rival.

Recommendations

The research has identified critical issues which are broad. Additional research is needed to refine these issues. During the on-going refinement process, plans for addressing the issues may be formed. Additional research is also needed to further explore the factors which may influence the decision process for a lunar base program. A different methodology with an expanded data base could validate the existence of the factors, and with an appropriate research design investigate the source of the factors and relative their strengths. The latter research would complement plan formulation for addressing critical issues. For lunar base proponents, the research points to the importance of educating a broad cross section of the American population about the true costs and benefits of a lunar base. Though the research was not designed to correlate responses with respondents' backgrounds or occupations, an informal review of the data did not indicate any such correlation. If there is in fact such a lack of correlation, this would complicate efforts of those who would attempt to target specific groups of decision-makers to inform them about a lunar base. Every opportunity then should be taken to see that responsibly prepared information receives the widest possible dissemination. Such a formidable task is all the more reason for NASA to make a long term commitment to a pervasive program to enhance the perceived benefits of a lunar base.

Appendix A:

Round One Questionnaire Package

DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY
AIR FORCE INSTITUTE OF TECHNOLOGY
WRIGHT-PATTERSON AIR FORCE BASE OH 45433-6583

27 April 1987

The final report of the National Commission on Space (February 28, 1986) contained recommendations for a unified strategy for U.S. activities in space for the next fifty years. One specific proposal is to establish a permanently-occupied lunar outpost. Since this effort will necessarily be a national commitment, NASA planning must reflect national priorities for the purpose and missions of the lunar stations.

To aid NASA planning (see NASA communication, attached), I wish to informally predict the mission of the first moon base by polling the more important influences (e.g. economic, scientific, and political), of which you represent an important view. I therefore respectfully request you participate in this preliminary research.

Your participation will be limited to responding to this initial questionnaire and a single follow-up questionnaire four to six weeks from now. Both questionnaires are designed to be answered in less than 30 minutes. There will be no requests for personal or proprietary data. All responses will be completely confidential and anonymous. The research is being conducted as part of my masters degree program at the U.S. Air Force Institute of Technology. The findings will be published as a Masters thesis. For any questions, please phone me day or night, at 513-253-5286. I thank you very much for your consideration.

PAUL C. KENT II, Capt, USAF

3 Atch
1. NASA ltr, 15 Apr 87
2. Questionnaire (two copies)
3. Pre-stamped, pre-addressed, return envelope

Instructions for Questionnaire

1. Please fill out the questionnaire in the manner most convenient to you (pen, pencil, type-written).

2. Most of the questions ask for comment. The comment is needed to clarify your position relative to the other respondents to this questionnaire. The answers to all the questionnaires will be pooled to come up with a range of views. The second (and final) questionnaire to which I will ask you to respond, will essentially be asking for your comment on the pooled views.

3. The last page of the questionnaire is provided for any additional comments you may have.

4. Please remember all responses are completely confidential and anonymous and will be destroyed upon conclusion of this research in August, 1987.

5. Two copies of the questionnaire have been provided. One is for your records. Please return one in the attached pre-addressed, pre-stamped return envelope within ten working days.

I THANK YOU FOR YOUR PARTICIPATION

Many of the building blocks for a lunar base system will be in place with the space station. Studies have estimated (conservatively) that a permanently-manned lunar base can be built (assuming the U.S. goes it alone and only government funds are used) over 25 years given expenditures at current levels (approximately 0.8% of the federal budget-as opposed to the 11-year Apollo program whose peak expenditures reached 4.5%). Please identify the factors which will influence sustaining a federally-funded program for such a long period. Also, please assess, on the scale below, the likelihood of sustaining such a program.

unlikely			50/50 chance			highly likely

Is federal funding desirable ?

undesirable			neutral			very desirable

Throughout the Apollo program, the U.S. was the acknowledged world leader in space activities. How important is U.S. leadership in the space arena?

insignificant | moderate | very important

Also, how important is the need for U.S. leadership as justification for a lunar base?

insignificant | moderate | very important

Please rate your agreement with the following statement, "If mankind is to avoid the fate of all other animal species - extinction - we must become a space-faring people."

disagree ... neutral ... agree

How important is it for man to be in space during the next fifty years? Please comment.

insignificant ... moderate ... very important

A key use for the moon might be to supply lunar materials (oxygen, iron, titanium, ceramics, etc.) to processing facilities in orbit around the earth (the first stage of these facilities being represented by the upcoming space station). The chief reason for selecting lunar materials would be the cost of transport: lifting material from the earth requires approximately twenty times the energy as delivering the same material to earth orbit from the moon. How important is the availability of lunar materials in justifying a lunar base?

insignificant | moderate | very important

Also, how important might/should the profit motive be in establishing a lunar base? Please comment.

undesirable | neutral | very desirable

infeasible | unknown | feasible

The moon offers many opportunities for the advancement of science, although most subjects could be studied in earth orbit as well. Some unique to the moon include ultra-powerful radio and optical telescopes free from the earth's interference, both natural and man-made. How important is scientific research in justifying a lunar base?

insignificant moderate very important

The space program is generally recognized as benefitting people on Earth, primarily through technology spinoffs (e.g. Tang, Velcro, electronics). Please assess the importance of this factor in the support for a moon-base program.

insignificant moderate very important

Military requirements for space (observation, communication, etc.) both assist and impede civilian space activities. For instance, the military may support the means for civilian access to space (e.g. the space shuttle) but also compete with the civilian sector for that same access. Please qualify the role, if any, you foresee the military should play in the development of a lunar base.

insignificant — moderate — very important

Do you think the military will aid or impede establishment of a moon base? Under what circumstances?

impede — neutral — aid

There have already been major examples of international cooperation in the U.S. space program (Apollo-Soyuz, the European Space Agency laboratory module flown in the space shuttle, etc.). How important will international participation be in the establishment of a moon base? Please comment.

insignificant — moderate — very important

As you look forward to early in the next century, and consider the best interests of the United States, is a lunar outpost compatible with your vision of the future?

no — possibly — yes

I have mentioned some of the issues associated with a moon base. There are undoubtedly others which a review of the questionnaire and your responses may bring to mind. Please identify the most critical issues for the potential moon base. Then, please number the issues in order, with number one being the most important. Please add any qualifying remarks you feel necessary.

ADDITIONAL COMMENTS:

Appendix B:

Round Two Questionnaire Package

DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY
AIR FORCE INSTITUTE OF TECHNOLOGY
WRIGHT-PATTERSON AIR FORCE BASE OH 45433-6583

24 June 1987

[address]

Dear [panel member]

I thank you very much for responding to the first questionnaire.

As promised, enclosed is the second (and final) questionnaire. This is the most critical step in the Delphi process (more about this on the Instructions page).

Your participation will end with the return of this questionnaire. As before, all responses are confidential and anonymous. For any questions you may have, please feel free to call me day or night, at 513-253-5286. Again, I thank you for your consideration.

PAUL C. KENT II, Capt, USAF

Enclosures:
1. Instructions
2. Questionnaire
3. Pre-stamped, pre-addressed, return envelope

Instructions for Questionnaire

Background. The Delphi is an exercise in expert group opinion. As with any expert group endeavor, one would expect and hope the end results to total greater than the sum of the individual parts. Historically (last 25 years or so) the Delphi has met these high expectations. The process itself is an iterative one; this one being limited to two iterations, or rounds. In the first round, you provided your expert opinion on the set of questions presented in the first questionnaire. In the second round, you will again be presented basically the same questions. Only this time, there are two additions. First, as research director, I have summarized the comments for each question and included them in the second questionnaire. Second, with each question I have also included summary statistics for the first round responses; showing the median, 50% range about the median, plus your original response for comparison. This summarized feedback is the mechanism of managed group interaction which is characteristic of the Delphi.

Instructions.

1. Please fill out the questionnaire in the manner most convenient to you (pen, pencil, type-written).

2. As you read each question, please consider their accompanying comments. You are asked to reconsider your position based on the new information. Please note, however, the intent of the new information is to provide you with different perspectives on the questions, not necessarily to encourage you to change your responses.

3. The rating scales may be marked anywhere along their range, from 1 to 7 inclusive.

4. Most questions ask for comment. Comments greatly enhance the research. If your response to a question on this questionnaire is outside the 50% range, it is probably because you benefit from experience not available to the other experts. Please support your position. Also, even if your response is within the 50% range, and you have a particular insight to offer, please express it.

5. The last page of the questionnaire is provided for any additional comments you may have.

6. Please remember all responses are completely confidential and anonymous and will be destroyed upon conclusion of this research in August, 1987.

7. Please return the completed questionnaire in the enclosed pre-addressed, pre-stamped return envelope within ten working days.

I THANK YOU FOR YOUR PARTICIPATION

Many of the building blocks for a lunar base system will be in place with the space station. Studies have estimated (conservatively) that a permanently-manned lunar base can be built (assuming the U.S. goes it alone and only government funds are used) over 25 years given expenditures at current levels (approximately 0.8% of the federal budget-as opposed to the 11-year Apollo program whose peak expenditures reached 4.5%) and still support other unmanned activities. Please identify the factors which will influence sustaining a federally-funded program for such a long period. Also, please assess, on the scale below, the likelihood of sustaining such a program.

Previous round median: 4 *50% range: 3.1 - 4.9* *Your response:*

Comments:

Broad public support will be difficult to maintain because: great project cost and competition for federal dollars; budget deficit; resistance in Congress to multi-year funding commitments; NASA image.

Support may be enhanced by: project's relation to defense; relation to economy; nationally distributed contracting companies; technology stimulus to U.S. competitiveness; scientific advancement; national pride.

NASA reorganization will be required to focus energy on lunar base and limited additional projects.

Sustained, competitive salaries will be required for scientists.

unlikely 50/50 chance highly likely

Is federal funding desirable ?

Previous round median: 6.65 50% range: 5.75 - 7 Your response:

Comments:

Private funding is unlikely because: the project is too big; there's no immediate return-on-investment; the liability and risk are too great.

Yes, a moon base would be analogous to Antarctica in many respects.

The budget deficit is too great to permit federal funding.

undesirable neutral very desirable

Throughout the Apollo program, the U.S. was the acknowledged world leader in space activities. How important is U.S. leadership in the space arena?

Previous round median: 6.75 50% range: 5.75 - 7 Your response:

Comments:

Important for national morale, esteem, and image.

Public knows U.S. can excel and cost is acceptable.

Though reductive, the world sees the leader in space as the leader in technology, which is where the U.S. wants to be.

Leadership will continue to provide scientific and economic opportunities.

Leadership in space is worth countless tanks, bombs, and divisions; helps maintain respect.

insignificant   moderate   very important

Also, how important is the need for U.S. leadership as justification for a lunar base?

Previous round median: 6   50% range: 4 - 6.75   Your response:

Comments:

Must be related to tangible goals (e.g. economic strength), not just impressing other nations (manned presence alone is insufficient).

Appeals to leadership can sustain a program only so far.

A lunar base may be a good economic investment in the long run.

Other projects (e.g. trip to Mars) may be better suited for leadership image.

Especially important if tied to defense.

insignificant   moderate   very important

How important will American manned space activities be during the next fifty years? Please comment.

Previous round median: 6.75 50% range: 6 - 7 Your response:

Comments:

Men must go into space and apply previously developed tools and data in order for the exponential growth rate in learning to continue.

It is militarily imperative to go into space to make sure the "high ground" is not used against the U.S.

Required in order to compete successfully internationally.

Academic, since men will be in space - but will they be American?

insignificant moderate very important

How important is it for man to expand into space in the next hundred years and beyond? What will be different in this longer term?

Previous round median: 4.5 *50% range: 3.25 - 5* *Your response:*

Comments:

A broader understanding of the universe may make life and survival of mankind easier and perhaps extend man's existence.

Since men are there already, men must continue to be in space to see that it remains peaceful.

It is easier to control earth than to inhabit the moon or planets.

insignificant moderate very important

A key use for the moon might be to supply lunar materials (oxygen, iron, titanium, ceramics, etc.) to processing facilities in orbit around the earth (the first stage of these facilities being represented by the upcoming space station). The chief reason for selecting lunar materials would be the cost of transport: lifting material from the earth requires approximately twenty times the energy as delivering the same material to earth orbit from the moon. How important is the availability of lunar materials in justifying a lunar base?

Previous round median: 4.25 50% range: 3.9 - 5.5 Your response:

Comments:

May be important, but must be linked to some higher goals.

A real possibility given advances in mass-driver technology.

Raw material in bulk will not be required in low earth orbit for the foreseeable future thereby negating any advantage of lunar materials over earth-derived ones.

Possibly important in the long term.

insignificant moderate very important

Also, how important might/should the profit motive be in establishing a lunar base? Please comment.

Desirability -
Previous round median: 4.7 50% range: 4 - 5.5 Your response:

Feasibility -
Previous round median: 4 50% range: 2.6 - 4.85 Your response:

Comments:

No more motive on moon than at Antarctica - too expensive for a company.

A broader view (than just income vs. expenses) would look at the improved ability to compete in global markets as a result of the cumulative effect of the stimulus of involvement in a lunar base project.

Profits reflect benefits to people. At this point it is difficult to see how people would benefit from a moon base.

Given certain conditions space activities can be commercially successful and private investment can be an important addition to federal funds.

Desirable but not essential. The moon's other potential uses ("safety haven", fuel storage, stable base for manufacturing or experiments) may justify going without demonstrating direct profitability.

Though all previous space programs have resulted in advances that have become profit-making ventures, the profit issue is unknown and unpredictable, thus is not a good basis for supporting decisions.

undesirable neutral very desirable

infeasible unknown feasible

The moon offers many opportunities for the advancement of science, although most subjects could be studied in earth orbit as well. Some unique to the moon include ultra-powerful radio and optical telescopes free from the earth's interference, both natural and man-made. How important is scientific research in justifying a lunar base?

Previous round median: 6.52 *50% range: 5 - 7* *Your response:*

Comments:

Moderate if lunar base supports longer-term deep-space ventures.

Scientific research is very important, but should be done on the moon only if it makes economic sense.

One of the primary justifications.

Only moderate since only few areas in science would be better served on the moon than in earth orbit (e.g. the space station).

insignificant moderate very important

The space program is generally recognized as benefitting people on Earth, primarily through technology spinoffs (e.g. Tang, Velcro, electronics). Please assess the importance of this factor in the support for a moon-base program.

Previous round median: 6 *50% range: 4.25 - 6.75* *Your response:*

Comments:

Since spin-offs may be expected to continue to appear as a result of activities in low earth orbit and unmanned research, this factor will not be widely supported.

This is probably the most important factor over the long term (30-40 years).

This factor is important if "spin-offs" are viewed as "payoffs" resulting from $ billions in space investments.

Important since technology breakthroughs cannot be anticipated and may be broader than projected (not just space items that become house-hold belongings).

Historically big challenges produce benefits - the moon project should as well.

insignificant moderate very important

Military requirements for space (observation, communication, etc.) both assist and impede civilian space activities. For instance, the military may support the means for civilian access to space (e.g. the space shuttle) but also compete with the civilian sector for that same access. Please qualify the role, if any, you foresee the military should play in the development of a lunar base.

Previous round median: 5 50% range: 3.5 - 6.3 Your response:

Comments:

Communications, surveillance, and "safe haven" operations may be swing factors in a lunar base decision.

Only if a lunar base is a more economical means to an end rather than an end in itself.

The moon should not be militarized. Besides, it's not a good military site.

In international and moral terms, the U.S. gains a great deal by its high-profile civilian, peaceful activities in space.

The "military" has always played a role in major technical breakthroughs. The military will have a need for a lunar base should one exist, but the military would never participate in development. The military's problem is that they are constipated with cost-benefit studies. This military use of space technology is short-sighted. Military leaders think that surveillance and communications are it. Ivan will bury them by the year 2000 with a mix of manned and unmanned technology.

A broad constituency including the military will be required for long term program political and financial support.

Military benefits of a lunar location should be utilized.

As with Antarctica, the military may be involved - but under no pretense of occupying territory.

insignificant moderate very important

Do you think the military will aid or impede establishment of a moon base? Under what circumstances?

Previous round median: 5 *50% range: 4 - 6* *Your response:*

Comments:

DoD money can only help by augmenting NASA's budget for underpinning technologies.

Will aid if a moon base has a nationally-accepted strategic aim.

Military need (if real) will far outweigh pleas of scientists.

Military will either aid or impede depending on whether or not its own plans include the need for a lunar base.

The military has neither the vision nor wisdom to recognize the need for military men in space for the foreseeable future.

Military will aid the program if the DoD is included in initial plans, roles and mission definition, and opportunities provided by a lunar facility.

Though the moon may be the "high ground" for some, earth orbit is really the "high ground" and there is no short term defense role for a lunar base.

Military will aid if perceived as a requirement in order to be competitive with the Soviets.

Military involvement would be counter-productive.

impede neutral aid

There have already been major examples of international cooperation in the U.S. space program (Apollo-Soyuz, the European Space Agency laboratory module flown in the space shuttle, etc.). How important will international participation be in the establishment of a moon base? Please comment.

Previous round median: 5.3 *50% range: 4 - 7* *Your response:*

Comments:

Will spread burden of tremendous cost (which U.S. probably could/would not handle alone).

Hardly worth the added complication of program management for a joint venture.

In any joint venture, the U.S. would bear the lion's share of expenses while other countries would attempt to share equally in the returns. It would probably be better for the U.S. to "go it alone", sharing only what is expedient to do so.

If both international brain and economic power could be harnessed, cooperation would be good.

The size of a lunar base project would necessitate international cooperation.

Would reinforce long term cooperative relationships.

Could be a political advantage.

The U.S. track record for international cooperation in space is poor and needs improvement.

insignificant moderate very important

As you look forward to early in the next century, and consider the best interests of the United States, is a lunar outpost compatible with your vision of the future?

Previous round median: 6.9 *50% range: 5.4 - 7* *Your response:*

Comments:

Yes, if economically justifiable.

Yes, if contributes positively to geo-political stability.

Yes, if in support of broader objectives in space travel and command.

The moon base is inevitable. Earlier is better than later. Furthermore, the U.S. would be better off taking the lead rather than watching others.

no possibly yes

[NOTE: Though lengthy, this final question is particularly important.]

Listed below are some of the issues associated with a moon base. There are undoubtedly others which a review of the questionnaire and your responses may bring to mind. Please choose the ten most critical issues for the potential moon base. Then, please number your chosen issues in order, with number one being the most important. Please add any issues and qualifying remarks you feel necessary.

Comments:

___ "Missing" technologies (those required for a moon base but not yet mastered) should be developed now so as to not delay the project.

___ Development of coherent national goals which can be met most economically with a lunar base.

___ Need to inhabit the moon (and rest of solar system).

___ Need to stimulate economy through federal expenditures on technology.

___ Government ability to organize and execute a long range program while keeping up with and using changing technology (could serve as a model to solve other long range problems).

___ Demonstration of an economically viable space station.

___ Development of lower-cost boost vehicles (e.g. cargo-only).

___ Budgetary reform in Congress to support multi-year appropriations.

___ Infighting in the science community may hurt chances for development.

___ In view of shuttle, Atlas, Titan, and Delta launch failures in 1986, a long series of lesser scope successes will be required before the White House/OMB, the Congress, and public will become aggressive enough to approve a lunar base.

[CONTINUED ON NEXT PAGE]

___ Demonstrations of benefits to mankind, U.S., and tax payers.

___ Private enterprise involvement (inherently better at meeting schedule, holding down cost, achieving technical performance goals for large projects than the government).

___ Uninterrupted political and financial support.

___ Effective public relations: benefits derived from on-going program and broad application of scientific breakthroughs.

___ Personnel physical health requirements in remote and hostile environments.

___ Problems/opportunities associated with internationally compatible hardware, software, communications, and docking systems.

___ Long term storage of consumables.

___ Congressional recognition of lunar base value.

___ Development of military value of lunar base.

___ Critical shortages of essential materials on earth.

___ Identification of "high value" science which can only be developed in the lunar environment.

___ Identification of critical support activities required for special missions (e.g. a manned Mars flight).

___ Significant advances in automation and robotics.

___ National budget matters which will very likely induce strong opposition to such an ambitious and costly program.

___ The will and money. The U.S. has dropped into a mode of conservatism in space, to the point that the U.S. grouped everything into the shuttle basket, in order to guarantee success of that program. When the shuttle failed, it let everyone down. It seems likely that the shuttle will never perform as advertised and will be lucky to get twelve launches a year for a few years, then it will be stopped and replaced by another transportation system.

The lunar base and manned reconnaissance of Mars are equally attractive. The U.S. must be reestablished as the leader in space and only a bold mission will do this. Space stations are ho-hum - the Soviets are doing it already.

A meaningful lunar base demands a strong scientific backing, which will only come if it is in the individual scientist's own interest or if the lunar base is the only game in town. However, the U.S. must support related space science during the long development period or people will leave this field and not be replaced. All this means money, certainly more than NASA now receives.

ADDITIONAL COMMENTS:

Appendix C: Comparative Histograms and Stabilities

(See Notes below for explanations.)

Probability of Sustained Federal Funding

Round 1	Round 2	Change %			
N = 18 Median = 4	N = 18 Median = 4.15				
Quartiles = 3.2, 4.8	Quartiles = 3, 5				
1 :	1 :	1:			
2 : 05	2 : 005	2: 1			
3 : 0005	3 : 0005	3:			
4 : 0000055	4 : 00555	4: 4	8	4	22%
5 : 005	5 : 0055	5: 1			
6 :	6 : 0	6: 1			
7 : 00	7 : 0	7: 1			

Desirability of Federal Funding

Round 1	Round 2	Change %			
N = 18 Median = 6	N = 18 Median = 6.1				
Quartiles = 5.5, 7	Quartiles = 5.5, 7				
1 : 5	1 :	1: 1			
2 :	2 : 5	2: 1			
3 :	3 : 0	3: 1			
4 : 55	4 : 0	4: 3	8	4	22%
5 : 055	5 : 055	5:			
6 : 00005	6 : 00000	6: 2			
7 : 0000000	7 : 0000000	7:			

Round 1		Round 2		Change %		

Importance of Leadership

N = 18 Median = 6.5		N = 18 Median = 6				
Quartiles = 5.5, 7		Quartiles = 5.4, 7				
1 :		1 :		1:		
2 :		2 :		2:		
3 :		3 :		3:		
4 :	0	4 :		4:	1	10 5 28%
5 :	0555	5 :	0055555	5:	3	
6 :	00555	6 :	0000	6:	5	
7 :	00000000	7 :	0000000	7:	1	

Leadership as Justification for a Lunar Base

N = 18 Median = 5.5		N = 18 Median = 4.65				
Quartiles = 3.2, 6.5		Quartiles = 4, 6				
1 :		1 :	5	1:	1	
2 :	05	2 :	55	2:	2	
3 :	000	3 :	0	3:	2	
4 :	005	4 :	00005	4:	2	12 6 33%
5 :	55	5 :	0555	5:	2	
6 :	00055	6 :	000	6:	2	
7 :	000	7 :	00	7:	1	

Importance of Manned Space Activities in 50 Years

N = 18 Median = 6.75		N = 18 Median = 6.1				
Quartiles = 6, 7		Quartiles = 5.5, 7				
1 :		1 :		1.		
2 :		2 :		2:		
3 :	5	3 :		3:	1	
4 :		4 :		4:		10 5 28%
5 :	555	5 :	00555	5:	2	
6 :	00555	6 :	0000055	6:	4	
7 :	000000000	7 :	000000	7:	3	

Importance of Man-in-Space Beyond 50 Years

N = 17 Median = 4.5		N = 17 Median = 5				
Quartiles = 2.3, 5		Quartiles = 4, 5.3				
1 :	0055	1 :	5	1:	3	
2 :	5	2 :	00	2:	3	
3 :	05	3 :	0	3:	1	
4 :	055	4 :	0005	4:	3	20 10 59%
5 :	00000	5 :	00555	5:	6	
6 :	0	6 :	0005	6:	1	
7 :	0	7 :		7:	1	

Round 1	Round 2	Change %

Importance of Lunar Materials

Round 1	Round 2
N = 17 Median = 4.7	N = 17 Median = 4.1
Quartiles = 3.2, 5.5	Quartiles = 4, 4.7

1 :	055	1 :	5	1:	2			
2 :		2 :	00	2:	2			
3 :	00	3 :	0	3:	1			
4 :	00555	4 :	000005555	4:	4	18	9	53%
5 :	0055	5 :	0	5:	3			
6 :	5	6 :	000	6:	4			
7 :	00	7 :		7:	2			

Desirability of the Profit Motive for a Lunar Base

Round 1	Round 2
N = 16 Median = 4.35	N = 16 Median = 4.9
Quartiles = 4, 5.25	Quartiles = 3.75, 5.15

1 :	05	1 :	0	1:	1			
2 :	5	2 :	05	2:	1			
3 :		3 :	5	3:	1			
4 :	0000055	4 :	000	4:	4	14	7	44%
5 :	005	5 :	00000055	5:	5			
6 :	05	6 :	0	6:	1			
7 :	0	7 :		7:	1			

Feasibility of the Profit Motive for a Lunar Base

Round 1	Round 2
N = 18 Median = 4	N = 18 Median = 4
Quartiles = 2.5, 5	Quartiles = 2.5, 4.5

1 :	005	1 :	00	1:	1			
2 :	05	2 :	005	2:	1			
3 :	0	3 :	55	3:	3			
4 :	0000055	4 :	0000055	4:		8	4	22%
5 :	005	5 :	0005	5:	1			
6 :	5	6 :		6:	1			
7 :	0	7 :		7:	1			

Importance of Lunar Science

Round 1	Round 2
N = 18 Median = 6.25	N = 18 Median = 5.85
Quartiles = 5, 7	Quartiles = 4.5, 6.3

1 :		1 :		1:		
2 :		2 :	5	2:	1	
3 :	5	3 :		3:	1	
4 :	005	4 :	0005	4:	1	[illegible]
5 :	0055	5 :	0555	5:	2	
6 :	05555	6 :	00005	6:	6	
7 :	00000	7 :	0000	7:	1	

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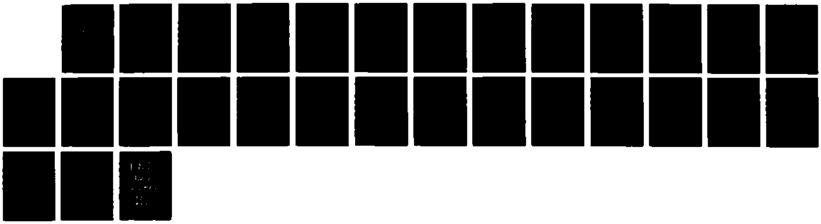
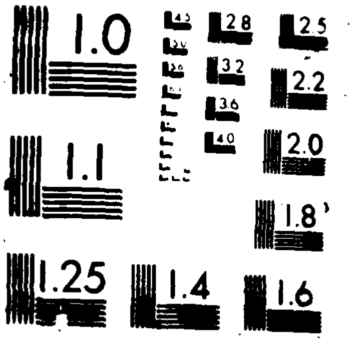



1.0
2.8
2.5
3.2
2.2
3.6
4.0
2.0
1.1
1.8
1.25
1.4
1.6

Round 1 | Round 2 | Change %

Importance of Technology Spin-Offs

Round 1	Round 2	Change			
N = 18 Median = 5.75	N = 18 Median = 5.5				
Quartiles = 4, 6.5	Quartiles = 3.5, 6				
1 : 5	1 :	1: 1			
2 : 5	2 : 00	2: 3			
3 : 00	3 : 005	3: 1			
4 : 05	4 : 5	4: 1	14	7	39%
5 : 055	5 : 05555	5: 2			
6 : 00555	6 : 00005	6: 4			
7 : 0000	7 : 00	7: 2			

Role Military Should Play in Lunar Base Development

Round 1	Round 2	Change			
N = 17 Median = 4.7	N = 17 Median = 4				
Quartiles = 3.5, 5.8	Quartiles = 3.5, 6				
1 : 000	1 : 05	1: 3			
2 : 5	2 : 55	2: 1			
3 : 5	3 : 5	3:			
4 : 0055	4 : 000000	4: 6	14	7	39%
5 : 055	5 : 0	5: 2			
6 : 05	6 : 00	6: 2			
7 : 000	7 : 000	7:			

Role Military Will Play in Lunar Base Development

Round 1	Round 2	Change			
N = 18 Median = 4.65	N = 18 Median = 5				
Quartiles = 3.5, 5.7	Quartiles = 4, 5.8				
1 : 0005	1 : 05	1: 2			
2 :	2 :	2:			
3 : 5	3 : 5	3:			
4 : 0005	4 : 0005	4:	6	3	17%
5 : 00055	5 : 000055	5: 1			
6 : 05	6 : 00	6: 2			
7 : 00	7 : 000	7: 1			

Importance of International Participation

Round 1	Round 2	Change			
N = 18 Median = 5.15	N = 18 Median = 5				
Quartiles = 4.5, 6	Quartiles = 4.3, 6				
1 : 5	1 : 5	1:			
2 : 005	2 : 055	2: 2			
3 :	3 :	3:			
4 : 555	4 : 555	4:	8	4	22%
5 : 0055	5 : 00000	5: 5			
6 : 0005	6 : 005	6: 1			
7 : 000	7 : 000	7:			

Round 1		Round 2		Change %			
Personal View Towards a Lunar Base							
N = 16 Median = 6.25		N = 16 Median = 6.1					
Quartiles = 4.75, 7		Quartiles = 4.5, 7					
1 :		1 :		1:			
2 :	5	2 :		2:	1		
3 :	5	3 :	05	3:	1		
4 :	55	4 :	00	4:	4	10 5	31%
5 :	055	5 :	05	5:	1		
6 :	05	6 :	0005	6:	2		
7 :	0000000	7 :	000000	7:	1		

NOTES:

1. The statistical response given for each question is calculated from the actual responses, not the rounded responses shown in the histograms.

2. Under the "Change %" column:

   - There is a scale beside which is the absolute difference between the number of responses in round one and round two for each point on the scale (in half point increments). For example, in "Personal View" above, the scale point "4" contains two 4.5 responses in round one and two 4.0 responses in round two. This respresents a difference of four person-changes. That is, between rounds one and two, two 4.5 values were removed while two 4.0 values were added for an absolute difference of four.

   - The first figure to the right of each scale is the total difference, or person-changes, between round one and round two for that question.

   - Since one person changing a response between rounds is recorded as removing a response from one point on the scale and adding a response to another point on the scale, two changes are counted for each response changed. Therefore, net person-changes are calculated by dividing total person-changes by two. This is the second figure to the right of each scale.

   - Change % is calculated by dividing net person-changes by the number of respondents (N) for each question.

Appendix D:

Summarized Delphi Comments

(Includes both Delphi rounds.)

What is the probability federal funding for a lunar base program can be sustained to see the program through to completion?

- Broad public support will be difficult to maintain because: great project cost and competition for federal dollars; budget deficit; resistance in Congress to multi-year funding commitments; NASA image.

- Support may be enhanced by: project's relation to defense; relation to economy; nationally distributed contracting companies; technology stimulus to U.S. competitiveness; scientific advancement; national pride.

- NASA reorganization will be required to focus energy on lunar base and limited additional projects.

- Sustained, competitive salaries will be required for scientists.

- Competition for immediate, on-going benefits will determine what the masses vote for. How can a minority female on welfare with five children and no husband benefit from a lunar program? The same question applies to senior citizens.

- Our system is better geared for the 100 meter dash than the 5,000 meter run.

- A program which is mandated by Congress will have a greater prospect for support than a program which is supported along party lines.

- The high visibility of such a "non-entitlement program" makes it a ripe "target" for deficit reduction measures.

- Intangibles. A dramatic Soviet accomplishment or undertaking in this area could serve to galvanize public/political support for such a program.

- It will not be done in the short term because greater returns can be realized in LEO and GEO. It is inevitable in the long run however, because technological advances will permit a lunar base be accomplished in a much shorter time span than is now possible.

- Shuttle and space station and other budget demands will overwhelm any major new program starts for the foreseeable future.

- Unlikely because of lack of national resolve.

- Russia's current lead with their space station will stimulate U.S. competitiveness.

Is federal funding desirable?

- Private funding is unlikely because: the project is too big; there's no immediate return-on-investment; the liability and risk are too great.

- Yes, a moon base would be analogous to Antarctica in many respects.

- The budget deficit is too great to permit federal funding.

- Federal contributions could come in the form of making space station and other program technologies available to underwrite the effort.

- It is the only way it could be done in the foreseeable future. There is too much risk for industry at this time.

- Federal funding could encourage lunar base development in the same way the Federal Housing Authority aided the housing industry.

How important is U.S. leadership in the space arena?

- Important for national morale, esteem, and image.

- Public knows U.S. can excel and cost is acceptable.

- Though reductive, the world sees the leader in space as the leader in technology, which is where the U.S. wants to be.

- Leadership will continue to provide scientific and economic opportunities.

- Leadership in space is worth countless tanks, bombs, and divisions; helps maintain respect.

- Space will continue to be a high leverage medium in the future. U.S. national security and commercial interests will be tied directly to our access to and freedom of action in space. The importance of our leadership in space is, in many ways, analogous to importance of leadership in other areas of international competition.

- One might consider the impact of the U.S. losing its unquestionable lead in the automotive industry -- or the real and present danger of losing either the military or commercial lead in space.

- It is very important that the U.S. stay ahead of potential enemies. If anybody does it, it must be the U.S.

How significant is U.S. leadership as justification for a lunar base?

- Must be related to tangible goals (e.g. economic strength), not just impressing other nations (manned presence alone is insufficient).

- Appeals to leadership can sustain a program only so far.

- A lunar base may be a good economic investment in the long run.

- Other projects (e.g. trip to Mars) may be better suited for leadership image.

- Especially important if tied to defense.

- Only if it is the most economical means to attain some other critical goals.

- Insignificant because a good working member of a group can be just as effective as a leader if the project is sound.

How important will American manned space activities be during the next fifty years?

- Men must go into space and apply previously developed tools and data in order for the exponential growth rate in learning to continue.

- It is militarily imperative to go into space to make sure the "high ground" is not used against the U.S.

- Required in order to compete successfully internationally.

- Academic, since men will be in space - but will they be American?

- As important as the "age of discovery" was to Earth in the 15th century.

- Looking at a 50 year period in the future, one only needs to look backward to where we were in technology fifty years ago. It is extremely important but we must be smart in the way we do it.

- I think we can learn a great deal by reviewing the history of sea exploration. We will extract resources from space. But we won't necessarily live there. We could live in the ocean, but why? Still, we must travel through and explore space with people.

- The economies of space will have as great an effect on our living standards as the oil and autos have had.

How important is it for man to expand into space in the next hundred years and beyond? What will be different in this longer term?

- A broader understanding of the universe may make life and survival of mankind easier and perhaps extend man's existence.

- Since men are there already, men must continue to be in space to see that it remains peaceful.

- It is easier to control earth than to inhabit the moon or planets.

- No one can look ahead 100 years!

How important are lunar materials for justifying a lunar base?

- May be important, but must be linked to some higher goals.

- A real possibility given advances in mass-driver technology.

- Raw material in bulk will not be required in low earth orbit for the foreseeable future thereby negating any advantage of lunar materials over earth-derived ones.

- Possibly important in the long term.

- The justification for using lunar materials needs to be tied to specific projects.

- Could be an added incentive for a lunar base, but not the prime reason.

How important might/should the profit motive be in establishing a lunar base?

- No more motive on moon than at Antarctica - too expensive for a company.

- A broader view (than just income vs. expenses) would look at the improved ability to compete in global markets as a result of the cumulative effect of the stimulus of involvement in a lunar base project.

- Profits reflect benefits to people. At this point it is difficult to see how people would benefit from a moon base.

- Given certain conditions space activities can be commercially successful and private investment can be an important addition to federal funds.

- Desirable but not essential. The moon's other potential uses ("safety haven", fuel storage, stable base for manufacturing or experiments) may justify going without demonstrating direct profitability.

- Though all previous space programs have resulted in advances that have become profit-making ventures, the profit issue is unknown and unpredictable, thus is not a good basis for supporting decisions.

- Establishing a lunar base for profit-oriented enterprises only would likely narrow public support for this effort. That would make it imperative for the commercial sector to be able to fund the initiative.

- Any program to be sustained must have a positive economic base.

- Such an investment has to be viewed as a long-range R&D effort, with any pay-off coming many years down the road. This has to be a faith investment in the future, like education. It can't be tied to an immediate profit motive or return.

How important is scientific research in justifying a lunar base?

- Moderate if lunar base supports longer-term deep-space ventures.

- Scientific research is very important, but should be done on the moon only if it makes economic sense.

- One of the primary justifications.

- Only moderate since only few areas in science would be better served on the moon than in earth orbit (e.g. the space station).

- Other than commercial or national security reasons, which are not currently defined nor understood, there does not appear to be any other reason for going.

Please assess the importance of technological spin-offs in the support for a moon-base program.

- Since spin-offs may be expected to continue to appear as a result of activities in low earth orbit and unmanned research, this factor will not be widely supported.

- This is probably the most important factor over the long term (30-40 years).

- This factor is important if "spin-offs" are viewed as "payoffs" resulting from $ billions in space investments.

- Important since technology breakthroughs cannot be anticipated and may be broader than projected (not just space items that become house-hold belongings).

- Historically big challenges produce benefits - the moon project should as well.

- We need to have faith in our discovery efforts. No one knows what our research work will yield. In 1929, President Hoover commissioned a group of sociologists and scientists to look ahead and predict what breakthroughs would be made in the next 15 years. Their voluminous report, delivered in 1933, totally missed predicting nuclear power, jet propulsion, and antibiotics.

- Important, but should not be over-played. Spin-offs will be recognized, but can't be promised on a monthly basis. Some will take years.

- When I worked at the Delco Electronics Division, we manufactured all of the Apollo inertial guidance and navigation systems. This technology was applied to inertial navigation systems for jetliners. Today, this inertial navigation system, called Carousel IV, is flying on 72 of the world's airlines, and with the U.S. Air Force, Navy, and Army.

Please qualify the role, if any, you foresee the military should play in the development of a lunar base.

- Communications, surveillance, and "safe haven" operations may be swing factors in a lunar base decision.

- Only if a lunar base is a more economical means to an end rather than an end in itself.

- The moon should not be militarized. Besides, it's not a good military site.

- In international and moral terms, the U.S. gains a great deal by its high-profile civilian, peaceful activities in space.

- The "military" has always played a role in major technical breakthroughs. The military will have a need for a lunar base should one exist, but the military would never participate in development. The military's problem is that they are constipated with cost-benefit studies. This military use of space technology is short-sighted. Military leaders think that surveillance and communications are it. Ivan will bury them by the year 2000 with a mix of manned and unmanned technology.

- A broad constituency including the military will be required for long term program political and financial support.

- Military benefits of a lunar location should be utilized.

- As with Antarctica, the military may be involved - but under no pretense of occupying territory.

- The military should be involved only to the extent that a lunar base program is tied to national security interests. A scientific or commercial program probably does not warrant military involvement.

- The military should be in a position to take advantage of lunar base activities if national security interests require it; initially the primary thrust should be civilian in nature.

Do you think the military *will* aid or impede establishment of a moon base?

- DoD money can only help by augmenting NASA's budget for underpinning technologies.

- Will aid if a moon base has a nationally-accepted strategic aim.

- Military need (if real) will far outweigh pleas of scientists.

- Military will either aid or impede depending on whether or not its own plans include the need for a lunar base.

- The military has neither the vision nor wisdom to recognize the need for military men in space for the foreseeable future.

- Military will aid the program if the DoD is included in initial plans, roles and mission definition, and opportunities provided by a lunar facility.

- Though the moon may be the "high ground" for some, earth orbit is really the "high ground" and there is no short term defense role for a lunar base.

- Military will aid if perceived as a requirement in order to be competitive with the Soviets.

- Military involvement would be counter-productive.

- Military aid could be crucial but militarization will preclude international commercialization of the Moon.

- The military will be a help. They understand the advantage of leading-edge R&D.

How important will international participation be in the establishment of a moon base?

- Will spread burden of tremendous cost (which U.S. probably could/would not handle alone).

- Hardly worth the added complication of program management for a joint venture.

- In any joint venture, the U.S. would bear the lion's share of expenses while other countries would attempt to share equally in the returns. It would probably be better for the U.S. to "go it alone", sharing only what is expedient to do so.

- If both international brain and economic power could be harnessed, cooperation would be good.

- The size of a lunar base project would necessitate international cooperation.

- Would reinforce long term cooperative relationships.

- Could be a political advantage.

- The U.S. track record for international cooperation in space is poor and needs improvement.

- If the purpose is to maintain U.S. leadership in space or if it is tied to national security activities, then international participation would not likely serve our interests.

Should there be a lunar base?

- Yes, if economically justifiable.

- Yes, if contributes positively to geo-political stability.

- Yes, if in support of broader objectives in space travel and command.

- The moon base is inevitable. Earlier is better than later. Furthermore, the U.S. would be better off taking the lead rather than watching others.

- I believe we should focus on exploiting both manned and unmanned presence in near space as opposed to a lunar outpost.

- What we learn from STS, the space station, the National Aerospace Plane, as well as other programs during the next couple of decades will give us a clearer view of a lunar outpost's utility.

- Yes. It is crucial evidence of our positive view for the future.

- There are probably more important things to do on Earth.

- We can't afford not to be there. We can't abdicate the Moon and its "stepping stone" position to the Russians.

Appendix E:

Critical Issue Ranking Tabulation

Below are the issues as listed in the Round Two questionnaire. Above each issue is the ranking point tabulation for all respondents, as well the overall ranking for those issues ranked in the top ten. Ranking points were assiged on the basis that an issue ranked number one by a respondent received the maximum ten points, whereas the number ten ranked issue received one point, and unranked issues received no points. Points were then totalled for each issue for all respondents, and issues were ranked with the issue receiving the most total points being ranked number one.

36 = 2 4 4 10 1 8 2 5

___ "Missing" technologies (those required for a moon base but not yet mastered) should be developed now so as to not delay the project.

2ND 89 = 10 3 3 3 6 6 9 5 7 7 10 8 9 3

___ Development of coherent national goals which can be met most economically with a lunar base.

22 = 4 2 1 3 10 2

___ Need to inhabit the moon (and rest of solar system).

38 = 9 7 1 7 9 5

___ Need to stimulate economy through federal expenditures on technology.

6TH 68 = 10 8 1 7 3 5 8 6 5 7 8

___ Government ability to organize and execute a long range program while keeping up with and using changing technology (could serve as a model to solve other long range problems).

10TH 41 = 10 6 8 5 6 2 4

___ Demonstration of an economically viable space station.

26 = 6 9 5 2 4

___ Development of lower-cost boost vehicles (e.g. cargo-only).

4TH 81 = 9 7 6 5 5 6 6 6 1 3 6 6 7 8

___ Budgetary reform in Congress to support multi-year appropriations.

4

___ Infighting in the science community may hurt chances for development.

20 = 8 1 2 4 5

___ In view of shuttle, Atlas, Titan, and Delta launch failures in 1986, a long series of lesser scope successes will be required before the White House/OMB, the Congress, and public will become aggressive enough to approve a lunar base.

1ST 98 = 2 4 5 10 10 1 3 7 7 8 10 4 9 2 3 7 6

___ Demonstrations of benefits to mankind, U.S., and tax payers.

29 = 5 9 8 1 5 1

___ Private enterprise involvement (inherently better at meeting schedule, holding down cost, achieving technical performance goals for large projects than the government).

7TH 63 = 7 4 6 8 2 7 9 9 5 6

___ Uninterrupted political and financial support.

28 = 8 8 4 7 4

___ Effective public relations: benefits derived from on-going program and broad application of scientific breakthroughs.

3

___ Personnel physical health requirements in remote and hostile environments.

4 2

___ Problems/opportunities associated with internationally compatible hardware, software, communications, and docking systems.

___ Long term storage of consumables.

5TH 77 = 6 7 9 3 9 6 8 7 3 10 9

___ Congressional recognition of lunar base value.

9TH 44 = 7 8 2 5 9 6 4 2 1

___ Development of military value of lunar base.

11 = 5 2 2 1 1

___ Critical shortages of essential materials on earth.

8TH 62 = 5 7 6 9 3 4 8 10 10

___ Identification of "high value" science which can only be developed in the lunar environment.

3 2 4

___ Identification of critical support activities required for special missions (e.g. a manned Mars flight).

3 9 3

___ Significant advances in automation and robotics.

25 = 4 10 1 1 2 1 2 4

___ National budget matters which will very likely induce strong opposition to such an ambitious and costly program.

2ND 86 = 1 8 9 1 10 10 10 10 10 8 9

___ The will and money. The U.S. has dropped into a mode of conservatism in space, to the point that the U.S. grouped everything into the shuttle basket, in order to guarantee success of that program. When the shuttle failed, it let everyone down. It seems likely that the shuttle will never perform as advertised and will be lucky to get twelve launches a year for a few years, then it will be stopped and replaced by another transportation system.

The lunar base and manned reconnaissance of Mars are equally attractive. The U.S. must be reestablished as the leader in space and only a bold mission will do this. Space stations are ho-hum - the Soviets are doing it already.

A meaningful lunar base demands a strong scientific backing, which will only come if it is in the individual scientist's own interest or if the lunar base is the only game in town. However, the U.S. must support related space science during the long development period or people will leave this field and not be replaced. All this means money, certainly more than NASA now receives.

Appendix F:

Round Two Complete Factor Analysis Printout

1 SAS 21:46 FRIDAY, AUGUST 21, 1987 1

OBS	CASE	FEDPROB	FEDDES	LEADIMP	LEADJUST	SPA50	SPA100	LUNMAT	PROFDES	PROFFEAS	LUNSCI	SIDEBEN	MILSHOU	MILWILL	INTERNAT	PERSON
1	342433	4.5	6.2	6.2	2.7	6.6	5.3	4.5	3.5	4.5	5.2	3.1	2.6	4.2	4.5	4.0
2	326725	3.0	3.0	6.0	4.0	6.0	4.0	4.5	5.0	3.5	4.5	4.5	6.0	6.0	5.0	5.0
3	312588	2.0	7.0	6.0	3.0	7.0	5.0	4.0	4.0	4.0	4.0	3.0	4.0	5.0	2.5	4.0
4	703716	7.0	7.0	7.0	7.0	7.0	6.0	7.0	1.0	1.0	7.0	7.0	4.0	7.0	2.0	7.0
5	152995	4.3	5.8	5.3	5.6	5.2	5.3	5.0	5.2	4.3	6.0	5.5	4.0	4.5	2.3	6.2
6	140743	5.5	6.2	5.5	5.5	5.5	3.2	4.1	5.1	5.2	5.7	5.7	4.1	5.6	4.3	5.7
7	125349	3.0	6.0	7.0	4.0	7.0	5.0	6.0	4.0	4.0	6.0	6.0	4.0	5.0	5.0	6.0
8	197292	5.5	5.5	5.5	1.5	6.5	6.5	4.5	5.5	5.5	5.5	5.5	1.5	1.5	6.5	6.5
9	260752	2.0	7.0	7.0	5.0	7.0	6.0	6.0	5.0	1.0	7.0	3.5	7.0	1.1	7.0	7.0
10	106814	4.5	7.0	7.0	6.0	6.2	4.7	4.7	4.2	4.2	6.2	6.2	6.0	5.8	5.2	6.0
11	262637	4.0	6.0	6.0	6.0	6.0	4.0	4.0	4.0	5.0	7.0	6.0	4.0	5.0	6.0	7.0
12	483805	3.0	7.0	7.0	4.0	6.0	2.0	2.0	1.0	2.0	4.0	2.0	1.0	4.0	7.0	7.0
13	310703	3.5	2.5	5.4	4.3	5.3	1.5	1.5	5.5	3.6	2.5	5.5	3.5	3.6	1.5	3.6
[illegible]	262951	5.0	7.0	7.0	6.0	7.0	6.0	4.0	2.0	2.0	6.0	7.0	4.0	5.5	5.0	7.0
15	889070	5.0	5.0	5.0	4.0	6.0	4.0	3.0	5.0	5.0	4.0	6.0	5.0	5.0	5.0	7.0
16	284628	6.0	7.0	7.0	7.0	7.0	6.0	6.0	6.0	4.0	7.0	5.0	7.0	7.0	7.0	7.0
17	183783	4.0	5.5	5.3	5.5	5.5	5.3	4.0	4.8	4.0	6.3	6.5	6.8	7.0	4.5	7.0
18	186924	2.5	4.0	5.2	2.5	5.2	2.2	2.2	2.5	2.5	5.5	2.2	2.5	4.0	5.8	2.8

MEANS AND STANDARD DEVIATIONS FROM 18 OBSERVATIONS

	FEDPROB	FEDDES	LEADIMP	LEADJUST
MEAN	4.12778	5.81667	6.13333	4.64444
STD DEV	1.3995	1.39884	0.774597	1.56927

	SPA50	SPA100	LUNMAT	PROFDES
MEAN	6.22222	4.55556	4.27778	4.07222
STD DEV	0.687327	1.50263	1.46229	1.51921

	PROFFEAS	LUNSCI	SIDEBEN	MILSHOU
MEAN	3.62778	5.52222	5.01111	4.27778
STD DEV	1.37704	1.27766	1.58815	1.76853

	MILWILL	INTERNAT	PERSON
MEAN	4.82222	4.78333	5.87778
STD DEV	1.6448	1.72976	1.3956

CORRELATIONS

	FEDPROB	FEDDES	LEADIMP	LEADJUST	SPA50	SPA100	LUNMAT	PROFDES
FEDPROB	1.00000	0.24824	0.05878	0.45393	0.13447	0.38076	0.36249	-0.01539
FEDDES	0.24824	1.00000	0.64169	0.38311	0.62181	0.55476	0.52156	-0.33442
LEADIMP	0.05878	0.64169	1.00000	0.41343	0.74653	0.34855	0.52314	-0.42356
LEADJUST	0.45393	0.38311	0.41343	1.00000	0.10919	0.21941	0.43521	-0.05102
SPA50	0.13447	0.62181	0.74653	0.10919	1.00000	0.67479	0.63905	-0.20049
SPA100	0.38076	0.55476	0.34855	0.21941	0.67479	1.00000	0.81175	0.13368
LUNMAT	0.36249	0.52156	0.52314	0.43521	0.63905	0.81175	1.00000	0.08047
PROFDES	-0.01539	-0.33442	-0.42356	-0.05102	-0.20049	0.13368	0.08047	1.00000
PROFFEAS	0.19218	-0.20150	-0.54743	-0.25240	-0.29715	-0.01728	-0.14983	0.62855
LUNSCI	0.34868	0.56786	0.40873	0.55544	0.33968	0.64060	0.74773	-0.05391
SIDEBEN	0.63583	0.04625	0.01116	0.57688	0.06443	0.37809	0.35954	0.18153
MILSHOU	0.01334	0.07744	0.16289	0.57858	0.15964	0.35554	0.45540	0.47813
MILWILL	0.41932	0.11565	0.12497	0.60922	0.00630	0.05992	0.21666	-0.14828
INTERNAT	-0.11449	0.25368	0.30381	-0.10958	0.21902	0.10448	0.02938	0.02153
PERSON	0.44095	0.54678	0.37836	0.56989	0.32311	0.48898	0.44075	-0.03277

	PROFFEAS	LUNSCI	SIDEBEN	MILSHOU	MILWILL	INTERNAT	PERSON
FEDPROB	0.19218	0.34868	0.63583	0.01334	0.41932	-0.11449	0.44095
FEDDES	-0.20150	0.56786	0.04625	0.07744	0.11565	0.25368	0.54678
LEADIMP	-0.54743	0.40873	0.01116	0.16289	0.12497	0.30381	0.37836
LEADJUST	-0.25240	0.55544	0.57688	0.57858	0.60922	-0.10958	0.56989
SPA50	-0.29715	0.33968	0.06443	0.15964	0.00630	0.21902	0.32311
SPA100	-0.01728	0.64060	0.37809	0.35554	0.05992	0.10448	0.48898
LUNMAT	-0.14983	0.74773	0.35954	0.45540	0.21666	0.02938	0.44075
PROFDES	0.62855	-0.05391	0.18153	0.47813	-0.14828	0.02153	-0.03277
PROFFEAS	1.00000	-0.15952	0.21127	-0.06326	0.05581	-0.02128	-0.09516
LUNSCI	-0.15952	1.00000	0.34050	0.40270	0.20829	0.33900	0.53406
SIDEBEN	0.21127	0.34050	1.00000	0.34503	0.43654	-0.29114	0.51021
MILSHOU	-0.06326	0.40270	0.34503	1.00000	0.39471	0.06756	0.30818
MILWILL	0.05581	0.20829	0.43654	0.39471	1.00000	-0.27195	0.16244
INTERNAT	-0.02128	0.33900	-0.29114	0.06756	-0.27195	1.00000	0.37241
PERSON	-0.09516	0.53406	0.51021	0.30818	0.16244	0.37241	1.00000

INITIAL FACTOR METHOD: PRINCIPAL COMPONENTS

PRIOR COMMUNALITY ESTIMATES: ONE

EIGENVALUES OF THE CORRELATION MATRIX: TOTAL = 15
AVERAGE = 1

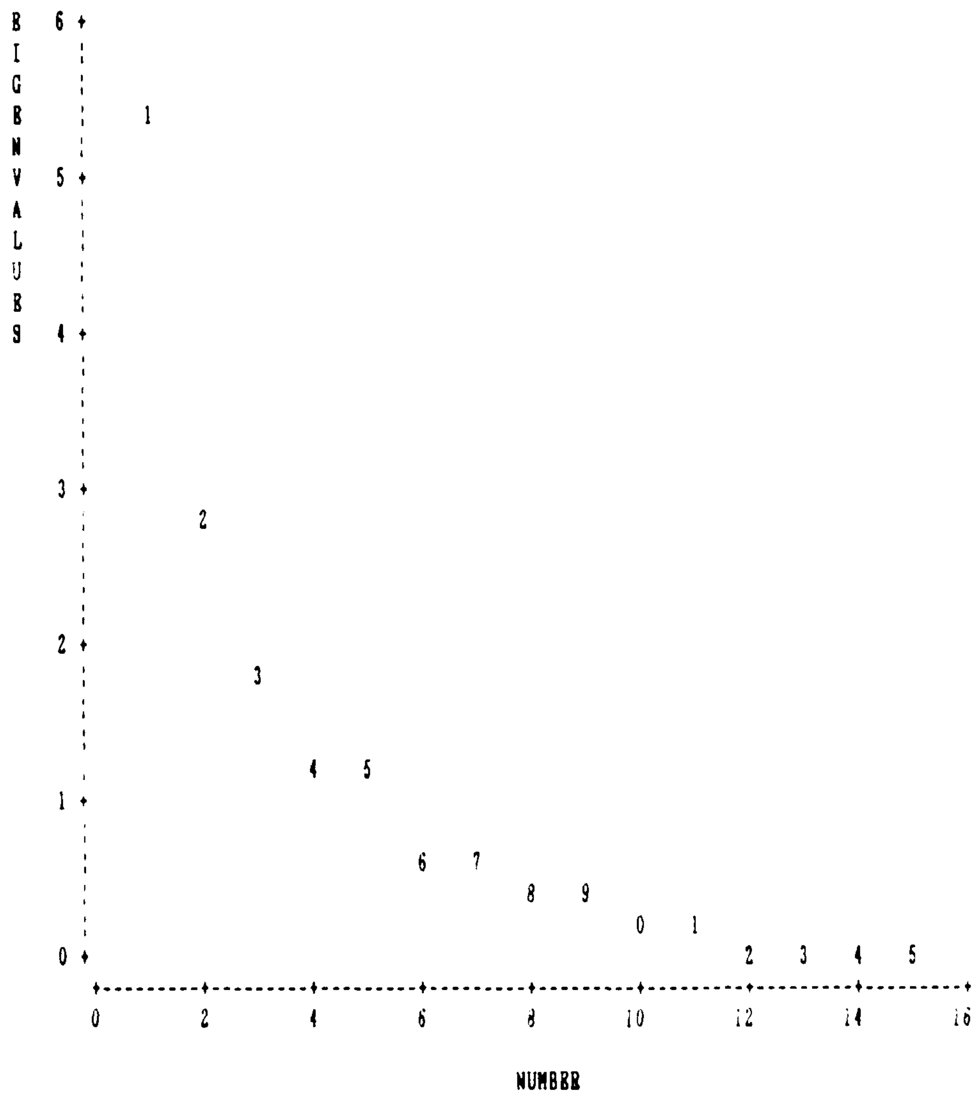
	1	2	3	4	5	6	7	8
EIGENVALUE	5.420282	2.734279	1.811771	1.295733	1.130361	0.670101	0.594374	0.437084
DIFFERENCE	2.686003	0.922508	0.516039	0.165371	0.460260	0.075728	0.157290	0.111240
PROPORTION	0.3614	0.1823	0.1208	0.0864	0.0754	0.0447	0.0396	0.0291
CUMULATIVE	0.3614	0.5436	0.6644	0.7508	0.8262	0.8708	0.9105	0.9396

	9	10	11	12	13	14	15
EIGENVALUE	0.325843	0.273168	0.158982	0.069500	0.053151	0.021080	0.004290
DIFFERENCE	0.052675	0.114186	0.089482	0.016350	0.032071	0.016790	
PROPORTION	0.0217	0.0182	0.0106	0.0046	0.0035	0.0014	0.0003
CUMULATIVE	0.9613	0.9795	0.9901	0.9948	0.9983	0.9997	1.0000

5 FACTORS WILL BE RETAINED BY THE MINEIGEN CRITERION

INITIAL FACTOR METHOD: PRINCIPAL COMPONENTS

SCREE PLOT OF EIGENVALUES



INITIAL FACTOR METHOD: PRINCIPAL COMPONENTS

FACTOR PATTERN

	FACTOR1	FACTOR2	FACTOR3	FACTOR4	FACTOR5
FEDPROB	0.51056	0.45257	-0.19114	0.55562	0.11440
FEDDES	0.72425	-0.38733	0.01235	0.21188	0.08947
LEADIMP	0.67126	-0.56385	-0.16465	-0.13393	-0.04246
LEADJUST	0.70688	0.33546	-0.41987	-0.30312	0.19624
SPA50	0.65937	-0.46616	0.18220	0.12139	-0.36720
SPA100	0.76709	0.00968	0.40522	0.20684	-0.32072
LUNMAT	0.84141	0.01324	0.21422	-0.01272	-0.35248
PROFDES	-0.10823	0.60513	0.69070	-0.24396	-0.08058
PROFFEAS	-0.24899	0.60580	0.46849	0.35134	0.08879
LUNSCI	0.80469	0.00191	0.15549	-0.06140	0.16779
SIDEBEN	0.51343	0.67437	-0.15462	0.19528	0.00000
MILSHOU	0.49733	0.38900	0.18537	-0.71315	-0.07805
MILWILL	0.38529	0.46004	-0.54651	-0.13459	-0.02166
INTERNAT	0.18760	-0.41795	0.49487	-0.11037	0.65118
PERSON	0.73335	0.07619	0.07628	0.10431	0.48363

VARIANCE EXPLAINED BY EACH FACTOR

FACTOR1	FACTOR2	FACTOR3	FACTOR4	FACTOR5
5.420282	2.734279	1.811771	1.295733	1.130361

FINAL COMMUNALITY ESTIMATES: TOTAL = 12.392426

FEDPROB	FEDDES	LEADIMP	LEADJUST	SPA50	SPA100	LUNMAT	PROFDES
0.923821	0.727615	0.815377	0.918891	0.834838	0.898374	0.878435	0.920975

PROFFEAS	LUNSCI	SIDEBEN	MILSHOU	MILWILL	INTERNAT	PERSON
0.779794	0.703631	0.780424	0.947706	0.677353	0.890991	0.794202

ROTATION METHOD: VARIMAX

ORTHOGONAL TRANSFORMATION MATRIX

	1	2	3	4	5
1	0.71732	0.50995	-0.24163	0.26509	0.31105
2	-0.23764	0.62291	0.63783	0.30418	-0.23697
3	0.37839	-0.48580	0.69130	0.12015	0.35846
4	0.22520	0.27663	0.23768	-0.90329	-0.01842
5	-0.48486	0.19850	-0.02020	-0.08269	0.84750

ROTATED FACTOR PATTERN

	FACTOR1	FACTOR2	FACTOR3	FACTOR4	FACTOR5
FEDPROB	0.25601	0.81154	0.16291	-0.26130	0.06977
FEDDES	0.62057	0.19843	-0.36496	-0.12313	0.39341
LEADIMP	0.54363	0.02559	-0.66664	0.11113	0.24987
LEADJUST	0.10505	0.72851	-0.32310	0.49655	0.16177
SPA50	0.85807	-0.08195	-0.29443	-0.02440	0.06743
SPA100	0.90336	0.19391	0.15660	0.09466	0.10594
LUNMAT	0.84951	0.25977	-0.04268	0.29345	0.03687
PROFDES	0.02404	-0.09727	0.83324	0.46540	0.00673
PROFFEAS	-0.10922	0.13761	0.85214	-0.15015	0.01571
LUNSCI	0.54042	0.35233	-0.10371	0.27416	0.44891
SIDEBEN	0.19350	0.81103	0.24560	0.14626	-0.05912
MILSHOU	0.21169	0.19310	0.08816	0.92307	0.07595
MILWILL	-0.05955	0.70701	-0.20903	0.29978	-0.20095
INTERNAT	0.08056	-0.30636	-0.00919	0.02791	0.88870
PERSON	0.32580	0.50923	-0.06085	0.09253	0.64535

VARIANCE EXPLAINED BY EACH FACTOR

FACTOR1	FACTOR2	FACTOR3	FACTOR4	FACTOR5
3.534239	3.041787	2.368317	1.724993	1.723090

FINAL COMMUNALITY ESTIMATES: TOTAL = 12.392426

FEDPROB	FEDDES	LEADIMP	LEADJUST	SPA50	SPA100	LUNMAT	PROFDES
0.823821	0.727615	0.815377	0.918891	0.834838	0.898374	0.878435	0.920975

PROFFEAS	LUNSCI	SIDEBEN	MILSHOU	MILWILL	INTERNAT	PERSON
0.779794	0.703631	0.780424	0.947706	0.677353	0.890991	0.794202

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Interest in a permanently-occupied Moon base has been revived as planners inthe space community look beyond the space shuttle and space station toward future manned space activities. The purpose of this study was to determine the critical issues for a potential lunar outpost by polling a group of experts knowledgeable about decision-making involving the allocation of large-scale resources. The experts, who were in fact decision-makers themselves, were asked to participate in a Delphi exercise, a technique to solicit expert opinion. It is an iterative polling technique in which group opinion is refined during successive iterations, while at the same time preserving the differing viewpoints among the group. The Delphi of this research employed two iterations, with twenty-three experts responding to the first questionnaire and eighteen experts following through on the second. The experts identified four critical issues in order: 1) demonstration of the value of a lunar base (e.g. cost effective lunar-based science, source of raw materials, technology spin-offs, etc.); 2) sustained political and firancial support; 3) credibility of the government (i.e. NASA) in accomplishing such a large and complex program; 4)development of the military value of a lunar base. The scaled response data from the Delphi was submitted to a factor analytic study which revealed five factors: 1) government and space advocates; 2) nationalist; 3) commercial; 4) military; 5) international. Further research is indicated to refine the critical issues and factors affecting a potential lunar base program. The research also points to the necessity of informing a large and diverse group of decision-makers about the true costs and benefits of a lunar base.

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