THE POST–APOLLO SPACE PROGRAM: DIRECTIONS FOR THE FUTURE

SPACE TASK GROUP REPORT TO THE PRESIDENT

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Conclusions and Recommendations

The Space Task Group in its study of future directions in space, with recognition of the many achievements culminating in the successful flight of Apollo 11, views these achievements as only a beginning to the long-term exploration and use of space by man. We see a major role for this Nation in proceeding from the initial opening of this frontier to its exploitation for the benefit of mankind, and ultimately to the opening of new regions of space to access by man.

We have found increasing interest in the exploitation of our demonstrated space expertise and technology for the direct benefit of mankind in such areas as earth resources, communications, navigation, national security, science and technology, and international participation. We have concluded that the space program for the future must include increased emphasis upon space applications.

We have also found strong and wide-spread personal identification with the manned flight program, and with the outstanding men who have participated as astronauts in this program. We have concluded that a forward-looking space program for the future for this Nation should include continuation of manned space flight activity. Space will continue to provide new challenges to satisfy the innate desire of man to explore the limits of his reach.

We have surveyed the important national resource of skilled program managers, scientists, engineers, and workmen who have contributed so much to the success the space program has enjoyed. This resource together with industrial capabilities, government, and private facilities and growing expertise in space operations are the foundation upon which we can build.

We have found that this broad foundation has provided us with a wide variety of new and challenging opportunities from which to select our future directions. We have concluded that the Nation should seize these new opportunities, particularly to advance science and engineering, international relations, and enhance the prospects for peace.

We have found questions about national priorities, about the expense of manned flight operations, about new goals in space which could be interpreted as a "crash program." Principal concern in this area relates to decisions about a manned mission to Mars. We conclude that NASA has the demonstrated organizational competence and technology base, by virtue of the Apollo success and other achievements, to carry out a successful program to land man on Mars within 15 years. There are a number of precursor activities necessary before such a mission can be attempted. These activities can proceed without developments specific to a Manned Mars Mission - but for optimum benefit should be carried out with the Mars mission in mind. We conclude that a manned Mars mission should be accepted as a long-range goal for the space program. Acceptance of this goal would not give the manned Mars mission overriding priority relative to other program objectives, since options for decision on its specific date are inherent in a balanced program. Continuity of other unmanned exploration and applications efforts during periods of unusual budget constraints should be supported in all future plans.

We believe the Nation's future space program possesses potential for the following significant returns:

- new operational space applications to improve the quality of life on Earth.
- non-provocative enhancement of our national security
- scientific and technological returns from space investments of the past decade and expansion of our understanding of the universe
- low-cost, flexible, long-lived, highly reliable, operational space systems with a high degree of commonality and reusability
- international involvement and participation on a broad basis

Therefore, we recommend -

That this Nation accept the basic goal of a balanced manned and unmanned space program conducted for the benefit of all mankind.

To achieve this goal, the United States should emphasize the following program objectives:

- increase utilization of space capabilities for services to man, through an expanded space applications program

- enhance the defense posture of the United States and thereby support the broader objective of peace and security for the world through a program which exploits space techniques for accomplishment of military missions

- increase man's knowledge of the universe by conduct of a continuing strong program of lunar and planetary exploration, astronomy, physics, the earth and life sciences

- develop new systems and technology for space operations with emphasis upon the critical factors of: (1) commonality, (2) reusability, and (3) economy, through a program directed initially toward development of a new space transportation capability and space station modules which utilize this new capability

- promote a sense of world community through a program which provides opportunity for broad international participation and cooperation

As a focus for the development of new capability, we recommend the United States accept the long-range option or goal of manned planetary exploration with a manned Mars mission before the end of this century as the first target.

In proceeding towards this goal, three phases of activities can be identified:

- initially, activity should concentrate upon the dual theme of exploitation of existing capability and development of new capability, maintaining program balance within available resources.

- second, an operational phase in which new capability and new systems would be utilized in earth-moon space with groups of men living and working in this environment for extended periods of time. Continued exploitation of science and applications would be emphasized, making greater use of man or man-attendance as a result of anticipated lowered costs for these operations.

- finally, manned exploration missions out of earth-moon space, building upon the experience of the earlier two phases.

Schedule and budgetary implications associated with these three phases are subject to Presidential choice and decision at this time with detailed program elements to be determined in a normal annual budget and program review process. Should it be decided to develop concurrently the space transportation system and the modular space station, a rise of annual expenditures to approximately $6 billion in 1976 is required. A lower level of approximately $4-5 billion could be met if the space station and the transportation system were developed in series rather than in parallel.

For the Department of Defense, the space activities should be subject to continuing review relative to the Nation's needs for national security. Such review and decision processes are well established. However, the planned expansion of the DoD space technology effort and its documented interest in the Space Transportation System demands continued authoritative coordination through the Aeronautics and Astronautics Coordinating Board to assure that the national interests are met.

The Space Task Group has had the opportunity to review the national space program at a particularly significant point in its evolution. We believe that the new directions we have identified can be both exciting and rewarding for this Nation. The environment in which the space program is viewed is a vibrant, changing one and the new opportunities that tomorrow will bring cannot be predicted with certainty. Our planning for the future should recognize this rapidly changing nature of opportunities in space.

We recommend that the National Aeronautics and Space Council be utilized as a mechanism for continuing reassessment of the character and pace of the space program.

SPACE TASK GROUP REPORT

THE POST-APOLLO SPACE PROGRAM: DIRECTIONS FOR THE FUTURE

I. INTRODUCTION

With the successful flight of Apollo 11, man took his first step on a heavenly body beyond his own planet. As we look into the distant future it seems clear that this is a milestone - a beginning - and not an end to the exploration and use of space.

Success of the Apollo program has been the capstone to a series of significant accomplishments for the United States in space in a broad spectrum of manned and unmanned exploration missions and in the application of space techniques for the benefit of man. In the short span of twelve years man has suddenly opened an entirely new dimension for his activity.

In addition, the national space program has made significant contributions to our national security, has been a political instrument of international value, has produced new science and technology, and has given us not only a national pride of accomplishment, but has offered a challenge and example for other national endeavors.

The Nation now has the demonstrated capability to move on to new goals and new achievements in space in all of the areas pioneered during the decade of the sixties. In each area of space exploration what seemed impossible yesterday has become today's accomplishment. Our horizons and our competence have expended to the point that we can consider unmanned missions to any region in our solar system; manned bases in earth orbit, lunar orbit or on the surface of the Moon; manned missions to Mars; space transportation systems that carry their payloads into orbit and then return and land as a conventional jet aircraft; reusable nuclear-powered rockets for space operations; remotely controlled roving science vehicles on the Moon or on Mars; and application of space capability to a variety of services of benefit to man here on earth.

Our opportunities are great and we have a broad spectrum of choices available to us. It remains only to chart the course and to set the pace of progress in this new dimension for man.

The Space Task Group, established under the chairmanship and direction of the Vice President (Appendices A and B), has examined the spectrum of new opportunities available in space, values and benefits from space activities, costs and resource implications of future options, and international aspects of the space program. A great wealth of data has been made available to the Task Group, including reports from the National Aeronautics and Space Administration and the Department of Defense reflecting very extensive planning and review activities, a detailed report from the President's Science Advisory Committee, views from

members of Congress, the National Academy of Sciences Space Science Board, and the American Institute of Aeronautics and Astronautics. In addition, a series of individual reports from a special group of distinguished citizens who were asked for their personal recommendations on the future course of the space program were of considerable value to the Task Group.

This broad range of material was considered and evaluated as part of the Task Group deliberations. This report presents in summary form the views of the Space Task Group on the Nation's future directions in space.

II. BACKGROUND

Twelve years ago, when the first artificial Earth satellite was placed into orbit, most of the world's population was surprised and stunned by an achievement so new and foreign to human experience. Today people of all nations are familiar with satellites, orbits, the concept of zero 'g', manned operations in space, and a host of other aspects characteristic of this new age - the age of space exploration.

The United States has carried out a diversified program during these early years in space, requiring innovation in many fields of science, technology, and the human and social sciences. The Nation's effort has been interdisciplinary, drawing successfully upon a synergistic combination of human knowledge, management experience, and production know-how to bring this National to a position of leadership in space.

Space activities have become a part of our national agenda.

We now have the benefit of twelve years of space activity and our leadership position as background for our examination of future directions in space.

National Priorities

By its very nature, the exploration and exploitation of space is a costly undertaking and must compete for funds with other national or individual enterprises. Now that the national goal of manned lunar landing has been achieved, discussion of future space goals has produced increasing pressures for reexamination of, and possible changes in, our national priorities.

Many believe that funds spent for the space program contribute less to our national economic growth and social well-being than funds allocated for other programs such as health, education, urban affairs, or revenue sharing. Others believe that funds spent for space exploration will ultimately return great economic and social benefits not now foreseen. These divergent views will persist and must be recognized in making decisions on future space activities.

The Space Task Group has not attempted to reconcile these differences. Neither have we attempted to classify the space program in a heirarchy of national priorities. The Space Task Group has identified major technical and scientific challenges in space in the belief that returns will accrue to the society that takes up those challenges.

Values and Benefits

The magnitude of predicted great economic and social benefits from space activities cannot be precisely determined. Nevertheless, there should be a recognition that significant direct benefits have been realized as a result of space investments, particularly from applications programs, as a long-term result of space science activities, DOD space activities, and advancing technology. These direct benefits are only part of the total set of benefits from the space program, many of which are very difficult to quantify and therefore are not often given adequate consideration when costs and benefits from space activities are weighed or assessed in relation to other national programs.

Benefits accrue in each of the following areas:

economic – directly through applications of space systems to services for man, and indirectly through potential for increased productivity resulting from advancing technology; improvements in reliability, quality control techniques, application of solid state electronics, and computer technology resulting from demands of space systems; advances in understanding and use of exotic new materials and devices with broad applicability; refinement of systems engineering and management techniques for extremely complex developments.

national security - directly through DOD space activities, and indirectly through enhancement of the national spirit and self-esteem; reinforcement of the image of the United States as a leader in advanced technology; strengthening of our international posture through demonstration that a free and democratic society can achieve a challenging, technologically sophisticated, long-term objective; maintenance of a broad base of highly skilled aerospace workers applicable to defense needs; and advancement of technology that may have relevance to defense use.

science - directly through support for ground and space research programs, indirectly through ability to open to observation new portions of the electromagnetic spectrum; opportunity to search for life on other planets, to make measurements in situ at the planets or in other regions of space, and to utilize the unique environment of space (high vacuum, zero 'g') for experimental programs in the life sciences, physical sciences and engineering.

exploration – the opening of new opportunities to investigate and acquire knowledge about man's environment - which now has expanded to include not only the Earth, but potentially the entire solar system.

social – providing educational services through enhanced communications which enable improved treatment of social problems.

international relations – providing opportunities for cooperation; the identification of foreign interests with U.S. space objectives and programs, and their results.

What is the value to be placed upon these benefits, and how should the space program be constituted to provide the greatest return in each of these areas for a selected level of public investment?

The answers to these questions cannot be stated in absolute terms - there is no dollar value associated with national self-esteem or with many of the other benefits listed above, and there is no fixed program of missions without which these benefits will not accrue. As with many programs, there is, however, a lower limit of activity below which the viability of the program is threatened and a reasonable upper limit which is imposed by technological capability and rate of growth of the program.

These limits are a key consideration in the options discussed later in this report.

National Resource

In the eleven years since its creation, NASA has provided the Nation with a broad capability for a wide variety of space activity, and has successfully completed a series of challenging tasks culminating in the first manned lunar landing. These accomplishments have involved rapid increases to peak annual expenditures of almost $6 billion and a peak civil service and contractor work force of 420,000 people. Expenditures for NASA have subsequently dropped over the last three years from this peak to the present level of about $4 billion and supporting manpower has dropped to about 190,000 people.

In addition to NASA space activity, the DOD has developed and operated space systems satisfying unique military requirements. Spending for military space grew rapidly in the early sixties and has increased gradually during the past few years to approximately $2 billion per year.

The Nation's space program has fostered the growth of a valuable reservoir of highly trained, competent engineers, managers, skilled workmen and scientists within government, industry and universities. The climactic achievenment of Apollo 11 is tribute to their capability.

This resource together with supporting facilities, technology and organizational entities capable of complex management tasks grew and matured during the 1960's largely in response to the stimulation of Apollo, and if it is to be maintained, needs a new focus for its future.

Manned Space Flight

There has been universal personal identification with the astronauts and a high degree of interest in manned space activities which reached a peak both nationally and internationally with Apollo. The manned flight program permits vicarious participation by the man-in-the-street in exciting, challenging, and dangerous activity. Sustained high interest, judged in the light of current experience, however, is related to availability of new tasks and new mission activity - new challenges for man in space. The presence of man in space, in addition to its effect upon public interest in space activity, can also contribute to mission success by enabling man to exercise his unique capabilities, and thereby enhance mission reliability, flexibility, ability to react to unpredicted conditions, and potential for exploration.

While accomplishments related to man in space have prompted the greatest acclaim for our Nation's space activities, there has been increasing public reaction over the large investments required to conduct the manned flight program. Scientists have been particularly vocal about these high costs and problems encountered in performing science experiments as part of Apollo, a highly engineering oriented program in its early phases.

Much of the negative reaction to manned space flight, therefore, will diminish if costs for placing and maintaining man in space are reduced and opportunities for challenging new missions with greater emphasis upon science return are provided.

Science and Applications

Although high public interest has resided with manned space flight, the Nation has also enjoyed a successful and highly productive science and applications program.

The list of major achievements in space science is great, ranging from our first exploratory orbital flights resulting in discoveries about the Earth and its environment to the most recent Mariner missions to the vicinity of Mars producing new data about our neighbor planet.

Both optical and radio astronomy have been stimulated by the opening of new regions of the electromagnetic spectrum and new fields of interest have been uncovered - notably in the high energy X-ray and gamma-ray regions. Astronomy is advancing rapidly at present, partly with the aid of observations from space, and a deeper understanding of the nature and structure of the universe is emerging. In planetary exploration, we have a unique opportunity to pursue a number of the major questions man has asked about his relation to the universe. What is the history of the formation and evolution of the solar system? Are there clues to the origin of life? Does life exist elsewhere in the solar system?

In the life sciences, questions about the effect of zero 'g' upon living systems, demands of long-duration space flight upon our understanding of man and his interaction or response to his environment, both physiologically and psychologically, promise new insights into the understanding of complex living systems.

These are only a few of the disciplines that have profited from the program of research in space. Space science is not divorced from science on the ground, but is rather an extension of science which builds and depends vitally upon a strong ground-based foundation.

Building upon the basic science on the ground and in space, and upon the growing capability in the design, construction and launch of satellites, the United States pioneered in the development of space applications - notably communications, meteorology and navigation. Operational systems have been placed into service in each of these areas, and the potential for the future appears bright - not only in these areas but also in new fields such as earth resource surveying and oceanography.

International Aspects

Achievement of the Apollo goal resulted in a new feeling of "oneness" among men everywhere. It inspired a common sense of victory that can provide the basis for new initiatives for international cooperation.

The U.S. and the USSR have widely been portrayed as in a "race to the Moon" or as vying over leadership in space. In a sense, this has been an accurate reflection of one of the several strong motivations for U.S. space program decisions over the previous decade.

Now with the successes of Apollo, of the Mariner 6 and 7 Mars flybys, of communications and meteorology applications, the U.S. is at the peak of its prestige and accomplishments in space. For the short term, the race with the Soviets has been won. In reaching our present position, one of the great strengths of the U.S. space program has been its open nature, and the broad front of solid achievement in science and applications that has accompanied the highly successful manned flight program.

The attitude of the American people has gradually been changing and public frustration over Soviet accomplishments in space, an important force in support of the Nation's acceptance of the lunar landing in 1961, is not now present. Today, new Soviet achievements are not likely to have the effect of those in the past. Nevertheless, the Soviets have continued development of capability for future achievements and dramatic missions of high political impact are possible. There is no sign of retrenchment or withdrawal by the Soviets from the public arena of space activity despite launch vehicle and spacecraft failures and the pre-emptive effect of Apollo 11.

The landing on the Moon has captured the imagination of the world. It is now abundantly clear to the man in the street, as well as to the political leaders of the world, that mankind now has at his service a new technological capability, an important characteristic of which is that its applicability transcends national boundaries. If we retain the identification of the world with our space program, we have an opportunity for significant political effects on nations and peoples and on their relationships to each other, which in the long run may be quite profound.

III. GOALS AND OBJECTIVES

Goals

An important aspect in both popular acceptance of the space program and in the spirit, dedication and performance of those who are directly involved in space activity is the conviction that such activity is worthwhile and contributes to the quality of life on Earth.

Public support for the space program can be related to understanding of the values derived from space activity and to understanding and acceptance of long-term goals and objectives which establish the framework for the program.

In the National Aeronautics and Space Act of 1958, the Congress declared "...it is the policy of the United States that activities in space should be devoted to peaceful purposes for the benefit of all mankind." This policy statement, which served effectively as a guide to the first decade in space, must now be translated into clearly enunciated new long-range goals and program objectives for the post-Apollo space program.

We view the challenge of setting new goals, of providing a focus for our future space activities, of expanding the limits of man's reach and thereby demonstrating America's leadership in scientific and technological undertakings while maintaining the confidence of the people in the strength and purpose of our Nation, as the key to continued space leadership by the United States.

Facing this challenge, some would urge that our efforts should be restricted to exploitation of existing capability, pointing out, quite correctly, that exciting and challenging missions remain to be accomplished which can utilize the existing base. But such a course would risk loss of the foundation for future achievements - a foundation which depends largely on providing a new capability which challenges our technology.

One of the values of the lunar landing goal was that it carried a definite time for its accomplishment, which stressed our technology and served as basis for planning and for budget support. It was a national commitment, a demonstration of the will and determination of the American people and of our technological competence at a time when these attributes were being questioned by many.

The need for an expression of our strength and determination as a Nation has changed considerably since that time. Today the need is for guidance - for direction - to set before the people a vision of where we are going.

Such a vision for the future should have a number of important qualities:

- it should have substantive values that are easily characterized and understood
- it should have a long-term goal, a beacon, an aim for our activities to act as a guide to both short-term and longer range decisions
- it should be sufficiently long-range to ensure that adequate opportunity exists for solid progress in a step-by-step fashion towards that long-term goal yet sufficiently within reach that each step draws measurably closer to that goal
- it should be challenging both for man's spirit of adventure and of exploration and for man's technological capability
- it should foster the simultaneous utilization of space capabilities for the welfare, security, and enlightenment of all people.

The Space Task Group has concluded that a balanced space program that exploits the great potential for automated and remotely-controlled spacecraft and at the same time maintains a vigorous manned flight program, can provide such a vision.

This balanced program would be based upon a framework in which the United States would:

- Accept, for the long term, the challenge of exploring the solar system, using both manned and unmanned expeditions.
- Develop an integrated and efficient space capability that will make Earth-Moon space easily and economically accessible for manned and unmanned systems.
- Maintain a steady return on space investments in applications, science, and technology.
- Use our space capability not only to extend the benefits of space to the rest of the world, but also to increase direct participation by the world community in both manned and unmanned exploration and use of space.

The balanced program for the future envisioned by the Task Group would possess several important characteristics:

flexibility. The ability to see clearly the opportunities that lie ahead in this new field is limited at best. Some opportunities will fade as we approach them while others, not even discernible at this time, will blossom to the first magnitude. This program will permit the course and time scale to be flexible, to adjust to variations in funding, to shifting national and international conditions, while preserving a guidepost for the future.

challenge. The space program has flourished under a set of goals that has demanded the highest standards of performance, and an incentive for excellence that has become characteristic of our space efforts. A balanced program of both challenging near-term objectives and long-range goals will enhance and preserve these attributes in the future.

opportunity. The Nation has in being significant capability for space activity. Abundant opportunities exist for further exploitation of this capability. A balanced program will permit adequate attention to applications and science while also creating new opportunities through development of new capability

In its deliberations, the Space Task Group considerd a number of challenging new mission goals which were judged both technically feasible and achievable within a reasonable time, including establishment of a lunar orbit or surface base, a large 50-100 man earth-orbiting space base, and manned exploration of the planets. The Space Task Group believes that manned exploration of the planets is the most challenging and most comprehensive of the many long-range goals available to the Nation at this time, with manned exploration of Mars as the next step toward this goal. Manned planetary exploration would be a goal, not an immediate program commitment; it would constitute an understanding that within the context of a balanced space program, we will plan and move forward as a Nation towards the objective of a manned Mars landing before the end of this century. Mars is chosen because it is most earth-like, is in fairly close proximity to the Earth, and has the highest probability of supporting extraterrestrial life of all of the other planets in the solar system.

What are the implications of accepting this long-range goal or option on the character of the space program in the immediate future?

In a technical sense, the selection of manned exploration of the planets as a long-term option for the United States space program would act to focus a wide range of precursor activities and would be reflected in many decisions, large and small, where potential future applicability to long-lived manned planetary systems design will have relevance. In a broader sense such a selection would tend to reinforce and reaffirm the basic commitment to a long-term continued leadership position by the United States in space.

The Space Task Group sees acceptance of the long-term goal of manned planetary exploration as an important part of the future agenda for this Nation in space. The time for decisions on the development of equipment peculiar to manned mission to Mars will depend upon the level of support, in a budget sense, that is committed to the space program.

NASA has outlined plans that would include a manned Mars mission in 1981 with the development decision on a Mars Excursion Module in FY 1974, if the Nation were to accept this commitment. Such a program would result in maximum stimulation of our technology and creation of new capability. There are many precursor activities that will be required before a manned Mars mission is attempted, such as detailed study of biomedical aspects, both physiological and psychological, of flights lasting 500-600 days, unmanned reconnaissance of the planets, creation of highly reliable life support systems, power supplies, and propulsion capability adequate for the rigors of such a voyage and reliable enough to support man. Decision to proceed with a 1981 mission would require early attention to these precursor activities.

While launch of a manned Mars exploration mission appears achievable as early as 1981, it can also be accomplished at any one of the roughly biennial launch opportunities following this date, provided essential precursor activities have been carried out.

Thus, the understanding that we are ultimately going to explore the planets with man provides a shaping function for the post-Apollo space program. However, in a balanced program containing other goals and objectives, this focus should not assume over-riding priority and cause sacrifice of other important activity in times of severe budget constraints. Flexibility in program content and options for decision on the specific date for a manned Mars mission are inherent in this understanding.

The Space Task Group, in response to the President's request for a "Coordinated program and budget proposal," has therefore chosen this balanced program as that plan best calculated to meet the Nation's needs for direction of its future space activity. In reaching this conclusion we have considered international and domestic influences, weighed and placed in perspective science and engineering development, exploration and application of space, manned and unmanned approaches to space missions, and have appraised interagency influences. Discussion of the principal objectives which describe this balanced program follows.

Program Objectives

Elements of the balanced program recommended by the Space Task Group can be identified within the following set of program objectives which define major emphases for future space activity:

- Application of space technology to the direct benefit of mankind
- Operation of military space systems to enhance national defense
- Exploration of the solar system and beyond
- Development of new capabilities for operating in space
- International participation and cooperation

1. Application of space technology to the direct benefit of mankind.

Focus: To increase utilization of space capabilities for services to man.

Programs directed toward the application of the Nation's space capabilities to a wide range of services, such as air and ocean traffic control, world-wide navigation systems, environmental monitoring and prediction (weather, pollution), earth resource survey (crops, water resources, geological structures, oceanography) and communications have great potential for improving the quality of life on this planet Earth. Significant direct economic and social benefits from such applications have been forecast. Major contributions to management of domestic problems and greater opportunities for international cooperation could result from an expanded space applications program.

2. Operation of military space systems to enhance national defense .

Focus: Enhance the defense posture of the United States and thereby support the broader objective of peace and security for the world.

The Department of Defense is presently using space capabilities in the support of communications, weather forecasting, navigation, surveillance and mapping, and for other functions. Such space activity has been not an end in itself, but a means for accomplishing functions in support of existing forces and missions. Military uses of space have proven effective and space systems are now contenders for specific applications and missions. Each military space mission should continue to be decided on a case-by-case basis in competition with ground, sea, and airborne systems and should reflect priority given to national defense with consideration of arms limitation agreements, and other U. S. policy reactions. Exploitation of the unique characteristics of space systems by the Department of Defense can provide increased confidence in the ability of this Nation to defend itself from any aggressor and assurance that space will be used for peaceful purposes by all nations.

3. Exploration of the solar system and beyond.

Focus: Increase man's knowledge of the universe.

Exploration of the solar system and observations beyond the solar system should be important continuing broad objectives of the Nation's space program. Many unanswered scientific questions remain about the planets, the interplanetary medium, the sun - both as a type of star and as a source of the earth's energy - and about a variety of celestial objects, such as pulsars, quasars, X-ray and gamma ray sources. Both ground-and space-based experiments and observational programs will contribute to the quest for answers to these questions. Space platforms provide several unique advantages - such as ability to observe across the range of wavelengths of the electromagnetic spectrum (rather than only through specific atmospheric "windows," which is the case from the ground); freedom from local environmental conditions; potential for continuous observations (no day-night cycle); ability to approach, orbit and land on extraterrestrial bodies - and also disadvantages - high cost, inaccessibility for easy repair and servicing, and long lead times for experiment modification. For these reasons a careful balance between investments in space and ground experiments should be maintained.

The major elements of such a program should be:

- Planetary Exploration - Unmanned planetary exploration missions continuing throughout the decade, both for science returns and, in the case of Mars and Venus, as precursors to later manned missions. The program should include progressively more sophisticated missions to the near planets as well as multiple-planet flyby missions to the outer planets taking advantage of the favorable relative positions of the outer planets in the late 1970's. Early missions to the asteroid belt and to the vicinity of a comet should be planned.

- Astronomy, Physics, the Earth and Life Sciences - In each of these disciplines, extension of existing or planned unmanned programs promises continued high science return. There are additional significant opportunities for experiments in connection with manned Earth orbital programs which should be exploited. Work in astronomy, physics and the life sciences, as well as work in the earth sciences and remote sensing, will form an essential part of the foundation for future applications benefits and will contribute to the broadening horizons of man as he acquires knowledge not only of his own planet but also about the rest of the universe.

- Lunar Exploration - Apollo-type manned missions to continue exploration of the Moon should proceed. The launch rate should permit maximum responsiveness to new discoveries while maintaining mission safety and efficient utilization of support personnel. Early upgrading of lunar exploration capability beyond the basic Apollo level including enhanced mobility capability, and lunar rovers, is important to safe and efficient realization of significant returns over the longer term. An orbiting lunar station, followed by a surface-base, building upon Earth orbital space station and space transportation system developments, could be deployed as early as the latter half of the decade. Extension of manned lunar activity beyond upgraded Apollo capability should include consideration of these options.

4. Development of new capabilities for operating in space.

Focus: Develop new systems for space operations with emphasis upon the critical factors of: (1) commonality, (2) reusability, and (3) economy.

Exploration and exploitation of space is costly with our current generation of expendable launch vehicles and spacecraft systems. This is particularly true for the manned flight program. Recovery and launch costs will become an even more significant factor when multiple re-visit and re-supply missions to an Earth orbiting space station are contemplated. Future developments should emphasize:

- Commonality - the use of a few major systems for a wide variety of missions.

- Reusability - the use of the same system over a long period for a number of missions.

- Economy - for example, the reduction in the number of "throw away" elements in any mission; the reduction in the number of new developments required; the development of new program principles that capitalize on such capabilities as man-tending of space facilities; and the commitment to simplification of space hardware.

An integrated set of major new elements which satisfy these criteria are:

a. A space station module that would be the basic element of future manned activities in Earth orbit, of continued manned exploration of the Moon, and of manned expeditions to the planets. The space station will be a permanent structure, operating continuously to support 6-12 occupants who could be replaced at regular intervals. Initially, the space station would be in a low altitude, inclined orbit; later stations would be established in polar and synchronous orbits. The same space station module would also provide a permanent manned station in lunar orbit from which expeditions could be sent to the surface.

By joining together space station modules, a space base could be created. Occupied by 50-100 men, this base would be a laboratory in space where a broad range of physical and biological experiments would be performed.

Finally, the space station module would be the prototype of a mission module for manned expeditions to the planets.

Such an array of space station modules would be designed to utilize the space transportation system described below.

b. A space transportation system that will:

- Provide a major improvement over the present way of doing business in terms of cost and operational capability.

- Carry passengers, supplies, rocket fuel, other spacecraft, equipment, or additional rocket stages to and from orbit on a routine aircraft-like basis.

- Be directed toward supporting a spectrum of both DoD and NASA missions.

Although the concept of such a space transportation capability is not new, advances in rocket engine technology, additional experience in design for reentry conditions, and improved guidance, navigation and automated check-out systems now permit initiation of an experimental effort for a Space Transportation System with technical, operational, and economic characteristics satisfying the needs of both NASA and DoD. An orderly, phased, step-by-step development program could then be implemented including as potential components:

- A reusable chemically fueled shuttle operating between the surface of the Earth and low-earth orbit in an airline-type mode.

- A chemically fueled reusable space tug or vehicle for moving men and equipment to different earth orbits. This same tug could also be used as a transfer vehicle between the lunar-orbit base and the lunar surface.

- A reusable nuclear stage for transporting men, spacecraft and supplies between Earth orbit and lunar orbit and between low Earth orbit and geosynchronous orbit and for other deep space activities. The NERVA nuclear engine development program, presently underway and included in all of the options discussed later, provides the basis for this stage and represents a major advance in propulsion capability.

c. Advanced Technology Development - In addition to the major vehicle developments listed above, a continuing program of investigation and exploration of new technology that can serve as the foundation for next generation systems is an essential component of the DoD, NASA, and other agency programs. A broad and aggressive program to advance our capabilities to operate in space during the next decade and to set the stage for the decade to follow is needed.

We foresee future requirements for larger and more efficient power supplies utilizing a range of energy sources, particularly nuclear systems, for continuing propulsion system improvements - both in performance and reliability, for improved understanding of the complex interface between man and machine, for advances in technology and systems design that result in lower cost development of new spacecraft, and for achievement of new levels of reliability. In the advanced technology program, we should emphasize biomedical research, space power and propulsion technology, both nuclear and non-nuclear, remotely controlled teleoperators, data management, multi-spectral sensors, communication and navigation technology, and experimental evaluation and demonstration of new concepts.

5. International participation and cooperation.

Focus: To promote a sense of world community; to optimize international scientific, technical, and economic participation; to apply space technology to mankind's needs; and to share the benefit and cost of space research and exploration.

To these ends, our international interests will be served best by (1) projects which afford maximum opportunities for direct foreign participation, (2) projects which yield economic and social benefits for other countries as well as ourselves, and (3) activities in which further international agreement and coordination might usefully be employed.

The past decade has demonstrated that programs like Project Apollo are virtually unrivalled in their capacity to catch the world's imagination and interest, win extensive admiration and respect for American achievements, and generate a common human experience. The decade has demonstrated also that effective ways can be found to share the practical benefits of space with people everywhere, as in space meteorology and communications. Modest but significant levels of direct participation in space flight research and exploration have also been successfully achieved through cooperative projects. Future program plans must seek to continue and substantially extend this experience.

We should also devote special effort to meliorate, between the space powers and others, the increasing gap in technological capability and the gap in awareness and understanding of new opportunities and responsibilities evolving in the space age.

If international participation and cooperation are to be expanded in an important way, there will have to be (1) a substantial raising of sights, interest and investment in space activity by the other nations able to do so in order to establish a base for major contributions by them; and (2) creation of attractive international institutional arrangements to take full advantage of new technologies and new applications for peoples in developing as well as advanced countries.

The most dramatic form of foreign participation in our program will be the inclusion of foreign astronauts. This should be approached in the context of substantive foreign contributions to the programs involved.

The form of cooperation most sought after by advanced countries will be technical assistance to enable them to develop their own capabilities. We should move toward a liberalization of our policies affecting cooperation in space activities, should stand ready to provide launch services and share technology wherever possible, and should make arrangements to involve foreign experts in the detailed definition of future United States space programs and in the conceptual and design studies required to achieve them. We should consider three further steps:

- The establishment of an international arrangement through which countries may be assured of launch services without being solely and directly dependent upon the United States.

- A division of labor between ourselves and other advanced countries or regional space organizations permitting assumptions of primary or joint responsibility for certain scientific or applications tasks in space.

- International sponsorship and support for planetary exploration such as that which was associated with the International Geophysical Year.

The developing countries will be most attracted to (1) applications of space technology which serve their economic and social needs, and (2) the development of international institutional arrangements in which they can participate along with the advanced countries. Some examples are:

- Environmental studies and earth resource surveying via satellites;
- Direct broadcast via satellites of TV instructional and educational programs;
- Expanding arrangements to acquire and use meteorological data;
- Training opportunities in space applications and space-related disciplines.

To the extent that future practical space applications are achieved, there should be no significant technical obstacles to ensuring the sharing of benefits on a global basis. There will, however, be economic and political issues which require recognition and effective anticipation.

In the case of the USSR, experience over the past ten years makes clear that the central problem in developing space cooperation is political rather than technical or economic. Numerous specific technical opportunities for cooperation with the Soviet Union have been identified and are available. Indeed, many of them have been put to the Soviet Union in various forms through the years with little success. For example, we could formulate a series of graduated steps leading toward major cooperation. They would range from full and frank exchange of detailed space project results, at the lowest level, to prearranged complementary activities at the next level (e.g., mutual support of tracking requirements, coordinated satellite missions for specific tasks in space), and ultimately to fully integrated projects in which subsystems could be provided by each side to carry out a total space mission of agreed character. The following possibilities merit serious consideration:

- In space research -- earth orbital investigation of atmospheric dynamics and Earth's magnetic field; astronomical observations from earth satellites or lunar stations; satellite observation of solar phenomena, and lunar and planetary exploration.
- In practical applications -- coordination of a continuing network of satellites to provide data for world-wide weather prediction and early warning of natural disasters; the development of capabilities for earth resource surveying via satellites.
- In manned flight -- bio-medical research, space rescue, coordination of experiments and flight parameters for Earth orbiting space stations, lunar exploration, and exchange of astronauts.
- In tracking -- to supplement each other's networks.

In view of the heavy commitment of the Soviets, planetary exploration appears to offer unusual opportunities for complementary activities.

IV. PROGRAM AND BUDGET OPTIONS

The Space Task Group was asked to provide "definitive recommendation on the direction the U. S. space program should take in the post-Apollo period," through preparation of a "coordinated program and budget proposal." In the Section "Goals and Objectives," the Space Task Group has outlined the elements of this coordinated program.

We have also pointed out that there are upper and lower bounds to the funding which will support a viable, productive and well disciplined program. Between these bounds there are many options both in program content and in total funding required. In this section we will explore the range of these options and their resource implications.

Clearly, there are a number of factors outside the space program and the intrinsic merit of its goals and objectives that must be considered in determining the allocation of resources to the program. Demands of other domestic programs, international conditions, and state of economic health of our Nation are only a few of the major influences upon the specific budget for space in a given fiscal year.

Despite the highly variable nature of these influences, which produces a corresponding increasing uncertainty in projections of resource availability, it is important for planning purposes to look into the future and forecast the general nature of funding required to support decisions on content and pace of the program. Two basic questions arise. Is the Nation to exploit its existing capabilities, to expand those capabilities or reduce its participation in space activity? Is funding for space generally to remain at present levels, to increase dramatically or to decrease significantly below present levels?

We stand at a crossroads, with many sets of missions and new developments open to us and with three main avenues for funding to pursue these opportunities.

To assist in answering these questions and to provide a basis for Task Group analyses, NASA and DOD were each requested to prepare a set of alternative proposals or options that would cover a range of future resource levels and be consistent with the goals and objectives recommended by the Task Group.

NASA Options

The range of resource levels considered by the Task Group for NASA is shown in Figure 1.

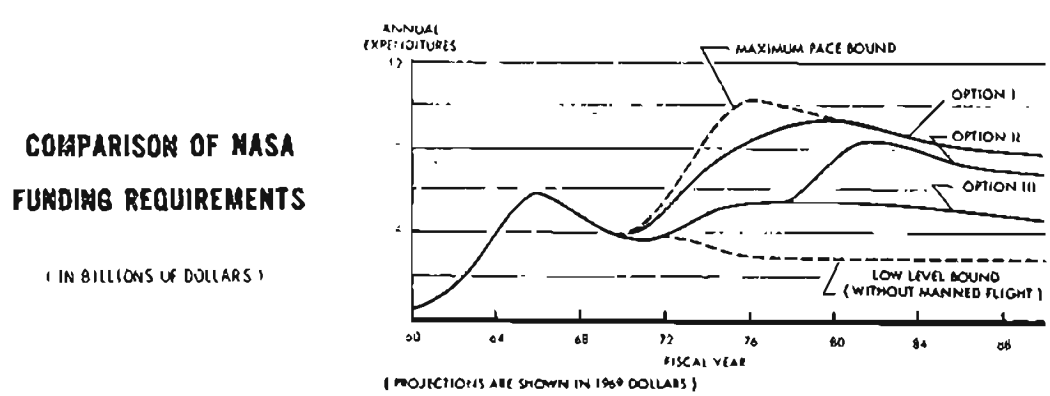


Figure 1

These include: (1) an upper bound, defined by a program conducted at a maximum pace - limited, not by funds, but by technology; (2) options I, II, and III which illustrate programs consistent with the Task Group recommendations, but conducted under varying degrees of funding restraints; and (3) a low level program constructed with an increased unmanned science and applications effort consistent with the Task Group recommendations but, because of the significantly lower budget levels, without a manned flight program after completion of Apollo and Apollo Applications.

A comparison of the timing of major mission accomplishments under the various programs is indicated in Table 1.

COMPARITIVE PROGRAM ACCOMPLISHMENTS

MILESTONES	MAXIMUM PACE	PROGRAM I	II, III	LOW LEVEL
MANNED SYSTEMS				
Space Station (Earth Orbit)	1975	1976	1977	-
50-Man Space Base (Earth Orbit)	1980	1980	1984	-
100-Man Space Base (Earth Orbit)	1985	1985	1989	-
Lunar Orbiting Station	1976	1978	1981	-
Lunar Surface Base	1978	1980	1983	-
Initial Mars Expedition	1981	1983	II - 1986 III - Open	-
Space Transportation System				
Earth-to-Orbit	1975	1976	1977	-
Nuclear Orbit Transfer Stage	1978	1978	1981	-
Space Tug	1976	1978	1981	-
Scientific				
Large Orbiting Observatory	1979	1979	1980	-
High Energy Astron. Capability	1973	1973	1981	1973
Out-of-Ecliptic Survey	1975	1975	1978	1975
Mars-High Resolution Mapping	1977	1977	1981	1977
Venus-Atmospheric Probes	1976	1976	Mid-80's	1976
Multiple Outer Planet "Tours"	1977-79	1977-79	1977-79	1977-79
Asteroid Belt Survey	1975	1975	1981	1975
Applications				
Earliest Oper. Earth Resource System	1975	1975	1976	1975
Demonstration of Direct Broadcast	1978	1978	Mid-80's	1978
Demonstration of Navigation Traffic Control	1973	1974	1976	1974

Table 1

Although the program represented by the upper bound appears technically achievable, would provide maximum stimulation to our over-all capabilities, and is fully consistent with the Task Group recommendations, it represents an initial rate of growth of resources which cannot be realized because such budgetary requirements would substantially exceed predicted funding capabilities. This has therefore been rejected by the Space Task Group, and is presented only to demonstrate the upper bound of technological achievement.

We have therefore developed a set of options which falls within these limits to illustrate programs conducted at budget levels which appear possible during the next decade.

Option I is illustrative of a decision to increase funding dramatically and results in early accomplishment of the major manned and unmanned mission opportunities, including launch of a manned mission to Mars in the mid-1980's, establishment of an orbiting lunar station, a 50 man earth-orbit space base and a lunar surface base. Funding would rise from the present $4 billion level to $8-10 billion in 1980. Decision to proceed with development of the space station, earth-to-orbit shuttle and the space tug would be required in FY 1971. Firm decisions

on other major systems or missions would not be needed until later years; for example, a decision to develop the Mars excursion module for an initial manned Mars expedition would not be required before FY 1974.

Options II and III illustrate a decision to maintain funding initially at recent levels and then gradually increasing. These options are identical with the exception that Option II includes a later decision to launch a manned planetary mission in 1986 and in Option III this decision is deferred. Both options demonstrate the effect of simultaneous development of the Space Transportation System and earth orbital space station module, each of which is expected to require peak expenditure rates of the order of $1 billion per year, and both options include a substantial increase in unmanned science and applications from present levels but less than that in Option I. Maintaining the unmanned program at the Option I levels would require several hundred million dollars in additional funding. Decision to develop both space station and earth-to-orbit shuttle would be in about FY 1972, resulting in initial availability of these systems in 1977. Similarly, other major milestones would occur later, with decision on the Mars Excursion Module estimated for FY 1978. Funding for both options would remain approximately level at $4 billion for the next two fiscal years and then would rise to a peak of $5.7 billion in 1976 - this increase reflecting simultaneous peak resource requirements of space station and space shuttle developments. If these developments were conducted in series, lower funding levels ($4-5 billion) could be achieved. Option II would have a later peak of nearly $8 billion in the early 1980's resulting from the manned Mars landing program.

Details of funding requirements for each of the program options are shown in Figure 2 through 4 and Table 2.

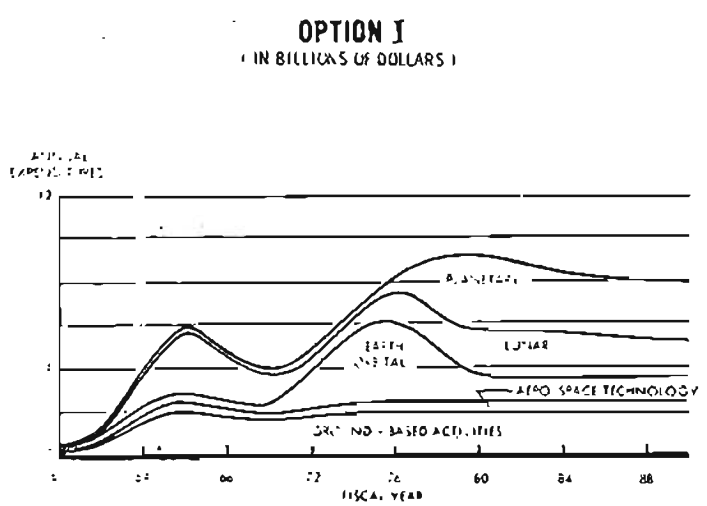


Figure 2

OPTION II

(IN BILLIONS OF DOLLARS)

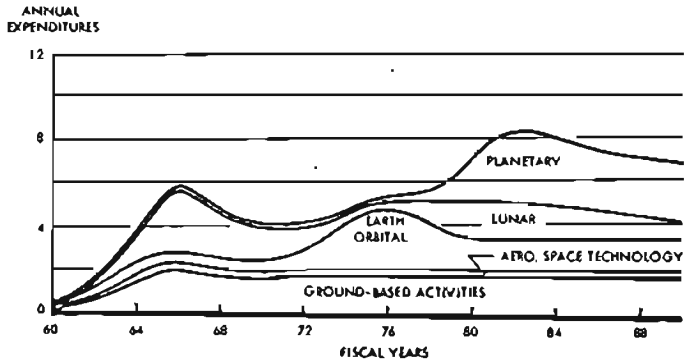


Figure 3

OPTION III

(IN BILLIONS OF DOLLARS)

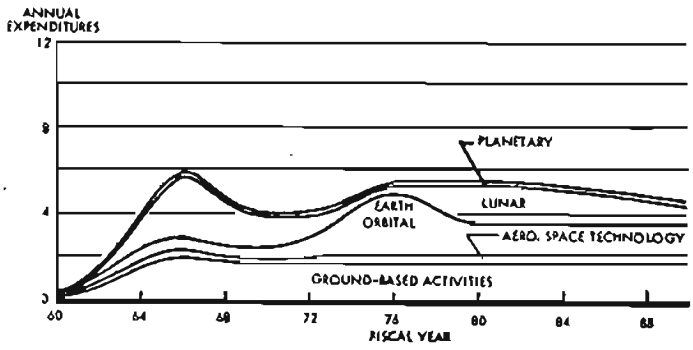


Figure 4

FUNDING FOR NASA PROGRAM

OPTIONS I, II, AND III

TOTAL EXPENDITURES (MILLIONS OF DOLLARS)

	FY 70	71	72	73	74	75	76	77	78	79	80
OPTION I	3900	4250	4850	5850	6800	7700	8250	8750	9100	9350	9400
OPTION II	3900	3950	4050	4250	5000	5450	5500	5500	5650	6600	7650
OPTION III	3900	3950	4050	4250	5000	5450	5500	5500	5500	5500	5500

(PROJECTIONS IN 1969 DOLLARS)

Table 2

The lower bound chosen by the Space Task Group illustrates a program conducted at significantly reduced funding levels. It is our judgment that, in order to achieve these significantly reduced NASA budgets, it would be necessary to reduce manned space flight operations below a viable minimum level. Therefore, this program has been constructed assuming a hiatus in manned flight following completion of Apollo applications and follow-on Apollo lunar missions. It thus sacrifices, for the period of such reduced budgets, program objectives relating to development of new capability, and the contribution of continuing manned space flight to several of the other program objectives recommended by the Task Group. It does, however, include a vigorous and expanded unmanned program of solar system exploration, astronomy, space applications for the benefit of man and potential for international cooperation. Funding for such a program would reduce gradually to a sustaining level of $2-3 billion depending upon the depth of change assumed for the supporting NASA facilities and manpower base.

The Space Task Group is convinced that a decision to phase out manned space flight operations, although painful, is the only way to achieve significant reductions in NASA budgets over the long term. At any level of mission activity, a continuing program of manned space flight, following use of launch vehicles and spacecraft purchased as part of Apollo, would require continued production of hardware, continued operation of extensive test, launch support and mission control facilities, and the maintenance of highly skilled teams of engineers, technicians, managers, and support personnel. Stretch-out of mission or production schedules, which can initially reduce total annual costs, would result in higher unit costs. More importantly, very low-level operations are highly wasteful of the skilled manpower required to carry out these operations and would risk deterioration of safety and reliability throughout the manned program. At some low level of activity, the viability of the program is in question. It is our belief that the interests of this Nation would not be served by a manned space flight program conducted at such levels.

DOD Options

A similar set of DOD Options, A through C, was constructed to illustrate three basically different levels of military space activity.

Three options are presented, not only to provide funding and program options, but also to characterize the band of choices within which a rational program of military space activities will evolve. Options A and C are considered to be the upper and lower boundaries of probable military space activity, with Option B being an example of an intermediate level.

Option A presumes a future in which the threat to national security could evolve in an increasingly hostile manner, thereby leading to increased priorities for national defense and military space activities. This option also provides for contingency efforts designed to accommodate a high degree of uncertainty in future international conditions. Cost effectiveness, technology availability, growth rate of resource application, and national policy constraints were considered in establishing this upper option for a full military space capability.

Option B includes those efforts necessary to counter the known and generally accepted projections of the threat. In addition, it provides limited developmental activities toward those capabilities needed if the threat increases. Option B is a prototype program which recognizes the need to minimize cost increases over the next few years, but reflects the expectation that military space activity will increase to provide the necessary support to our military forces and posture. This option is consistent with national and DOD policies and with Force Structure planning.

Option C is directly responsive to current national economic constraints, and assumes that a lessening of world tensions will result in reduced emphasis on national defense. It, therefore, includes a lower level of system deployment than the other two options. It still includes, however, the technology and support effort necessary for contingency planning, together with those programs now considered to be reasonable and predictable requirements. Option C is the lower boundary of military space activity that will meet existing national defense needs, although implied in this option is a higher degree of risk than that inherent in Options A and B.

Annual resource requirements for the DOD options are shown in Figure 5.

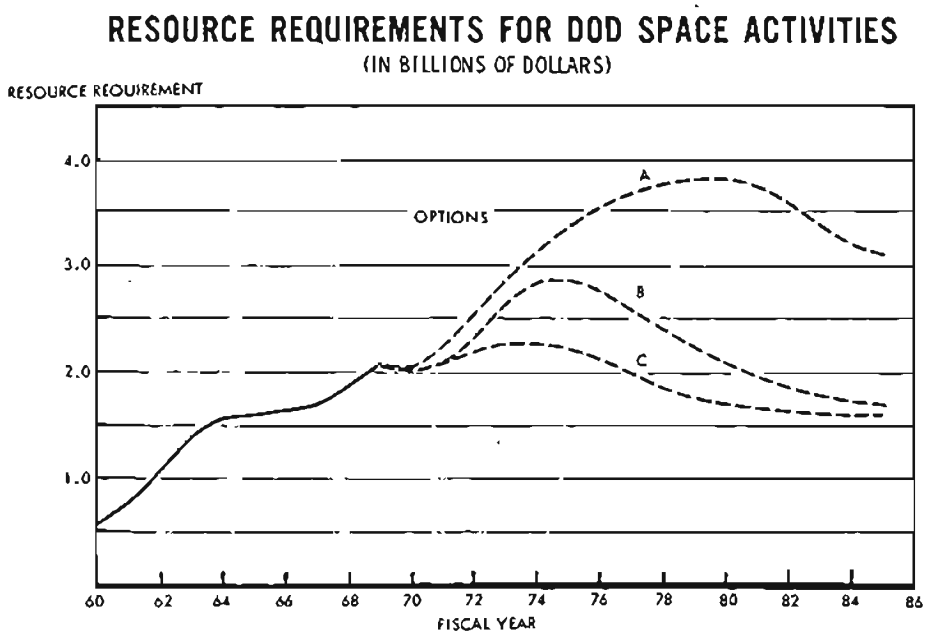


Figure 5

Program Flexibility

In the options submitted by NASA and DOD, resource requirements have been projected which represent a large number of decisions to be made in sequence over a number of years. Thus, the resource projections represent the upper envelope or sum of funds required to support these decisions. Many of these decisions are relatively independent - that is, an earth orbit space station module can be developed independently, without commitment to placing such a station in orbit around the moon, or sending such a module on a mission to Mars. In both of these examples, however, development of the space station module would

be the normal first step in achieving the lunar orbit station or Mars mission capability. An example of the set of major program elements and hence decision points inherent in the options described, based upon NASA Option II, is included as Figure 6. A diversity of specific programs with varying emphasis can be constructed by delaying or shifting initiation of funding for these major elements relative to other new developments.

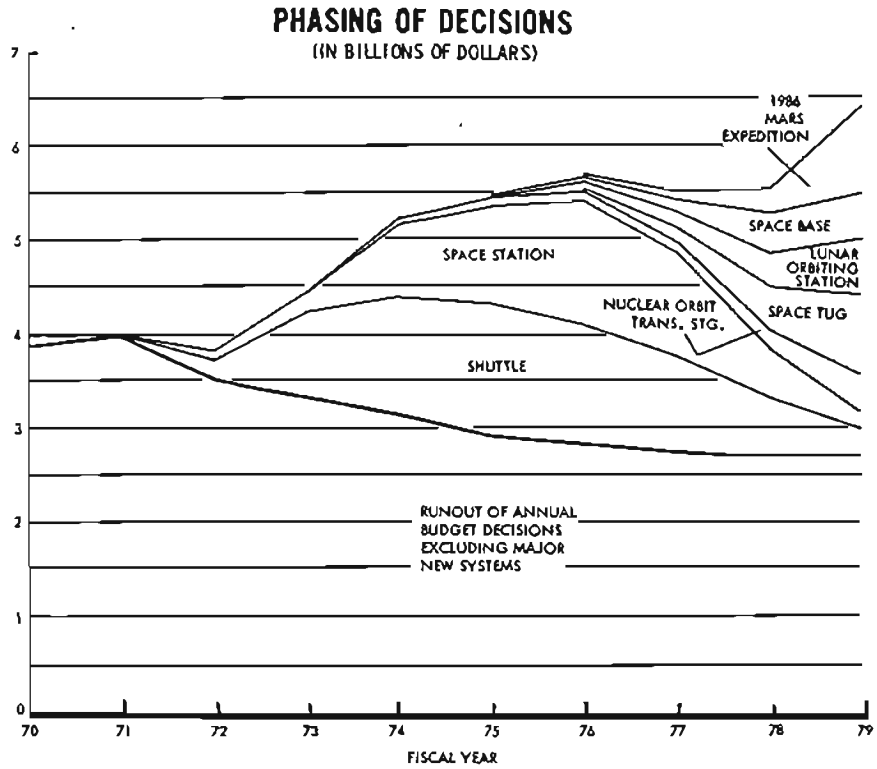


Figure 6

There is, therefore, a great amount of flexibility inherent in each of these options and adjustments to funding constraints may be made on a yearly basis as part of the normal budget process. Of course, once initiated, a specific major system development profits from continuity in funding - stretchout or major fluctuations in funding for a particular project generally increase the total costs associated with it.

The levels of activity for the NASA and the DOD programs are essentially independent, that is, selection of Options I or II for NASA could be consistent with an Option A, B, or C level of activity for DOD, since the DOD space activity will continue to be responsive to national defense needs and will be determined on a case-by-case basis under the budget and program established annually for the Defense Department. It is important, however, that continued coordination of the NASA and DOD programs and the effect of each agency's activity on a common industrial and facility base receive authoritative attention.

THE WHITE HOUSE

WASHINGTON

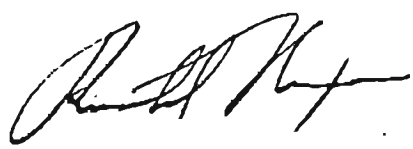
February 13, 1969

MEMORANDUM FOR

The Vice President
The Secretary of Defense
The Acting Administrator, National Aeronautics and Space Administration
The Science Adviser

It is necessary for me to have in the near future definitive recommendation on the direction which the U. S. space program should take in the post-Apollo period. I, therefore, ask the Secretary of Defense, the Acting Administrator of NASA, and the Science Adviser each to develop proposed plans and to meet together as a task group, with the Vice President in the chair, to prepare for me a coordinated program and budget proposal. In developing your proposed plans, you may wish to seek advice from the scientific, engineering, and industrial communities, from The Congress and the public. You will wish also to consult the Department of State (on international implications and cooperation) and other interested agencies, as appropriate, such as the Departments of Interior, Commerce, and Agriculture; the Atomic Energy Commission, and the National Science Foundation. I am asking the Science Adviser also to serve as staff officer for this task group and as coordinator of the staff studies.

I would like to receive the coordinated proposal by September 1, 1969.



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