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GRADUATE PROGRAM IN SCIENCE TECHNOLOGY AND PUBLIC POLICY

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2. SPACE STATIONS:

A POLICY HISTORY

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I, of course, am solely responsible for the interpretations and conclusions in this report. My findings do not necessarily represent the views of George Washington University or NASA.

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CHAPTER I

EARLY SPACE STATION PLANS

Almost from the first time humans thought about leaving the surface of this planet, one theme has been the creation of some form of human outpost in space. In fiction, and during this century in increasingly specific engineering detail, the space station concept has been extensively discussed. In one of the two major space-faring nations, the Soviet Union, a fairly rudimentary but still very capable space station program, centered on the Salyut spacecraft, has been ongoing since 1971. In the other space power, the United States, the desirability of developing some kind of permanent manned presence in space is now under consideration, as it has been on several occasions over the past twenty-five years. This report contains a "policy history" of those past occasions; the emphasis is thus thus on the political process, both within NASA and external to it, through which space station proposals were assessed during the 1959-1980 period. There is little attention given to the development of space station designs per se, or to other technical aspects of the space station concept such as, for example, debates over the need for artificial gravity or over the appropriate source of in-orbit power.

A. Pre-History: Space Stations of the Imagination[1/]

Perhaps the first detailed plan for a space station was contained in an 1869 Atlantic Monthly article by Edward Everett Hale, "The Brick Moon." Hale proposed a 60-meter-diameter satellite, made of bricks and housing a crew of 37. From a 6000 km orbit, the brick moon would serve as a navigational aid for ships; communications were by Morse code, with signals created by the station's occupants jumping up and down on the satellite's exterior surface!

Space pioneers Konstantin Tsiolkovsky and Herman Oberth both gave some attention to building orbital stations. Tsiolkovsky discussed the idea as early as 1911, and in 1923 wrote of staying "at a distance of 2000-3000 versts [a Russian unit of distance equal to 0.6629 miles] from the Earth, as its Moon. Little by little appear colonies with supplements, materials, machines, and structures brought from Earth." In his 1923 book The Rocket into Interplanetary Space, Oberth first described an orbiting manned satellite as a "space station," and proposed that it could be used as an Earth observation site, world communications link, weather satellite, or as an orbital refueling station for outward-bound space vehicles.

Others in Europe wrote of stations during the twenties and thirties, and their ideas were quite familiar to the team of German rocket scientists led by Wernher von Braun when it began operation in the United States after World War II. Some form of large space platform was a central part of von Braun's thinking throughout the 1950s, and his ideas got wide publicity in a Collier's magazine special section of March 22, 1952 titled "Man Will Conquer Space Soon." Von Braun's contribution to the magazine was an article called "Crossing the Last Frontier," in which he claimed that "scientists and engineers now know how to build a station in space that would circle the earth, 1,075 miles up. . . . If we do it, we can not only preserve the peace but we can take a long step toward uniting mankind." Von Braun's plan called for a triple-decked, 250-foot wide, wheel-shaped station in polar orbit (See Figure 1) which would be a "superb observation post" and from which "a trip to the moon itself will

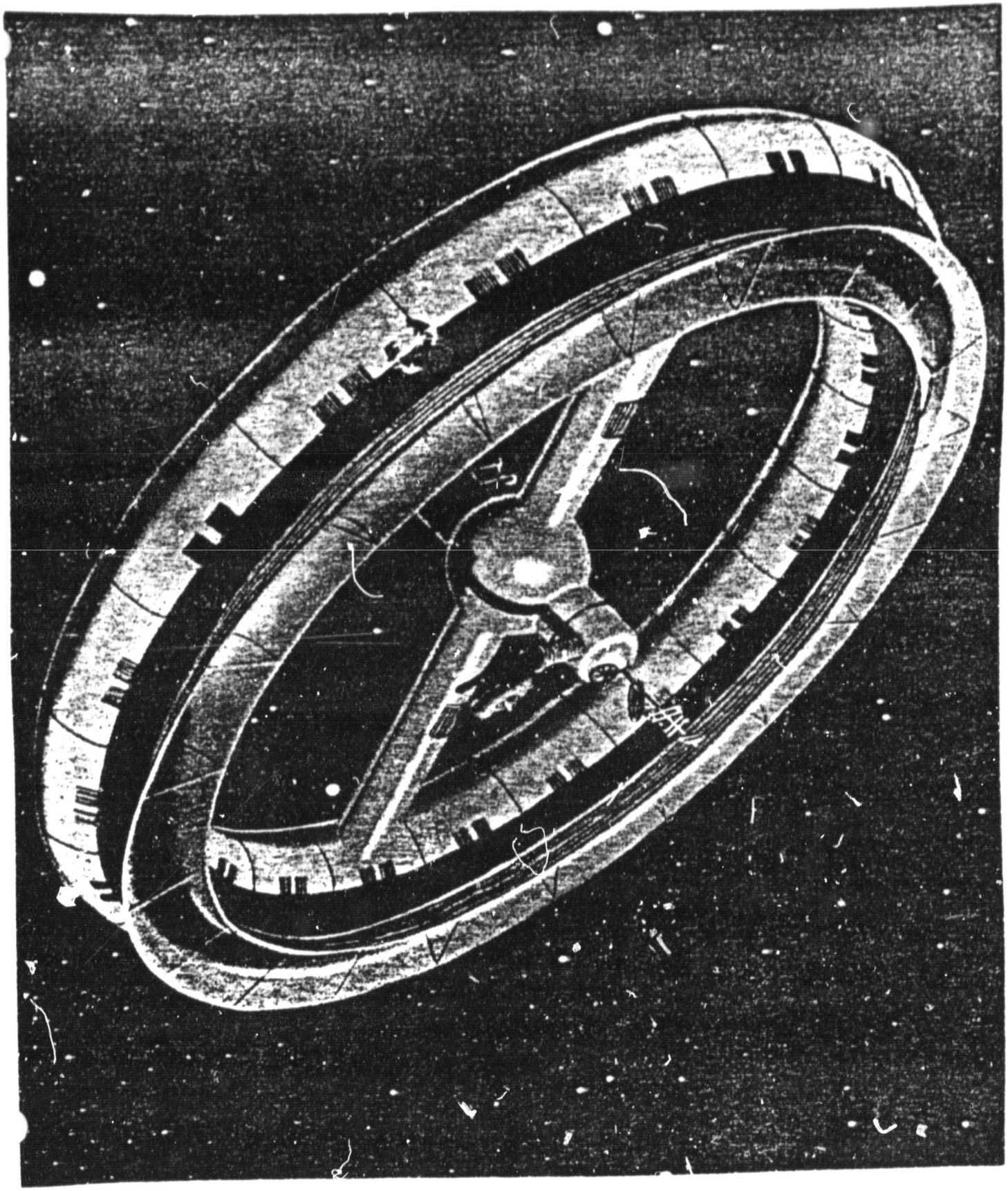

Figure 1. VON BRAUN STATION CONCEPT

be just a step." The main station would be accompanied by a free-flying unmanned but man-tended astronomical observatory.

Von Braun noted that the station would not be alone in space; "there will nearly always be one or two rocket ships unloading supplies near to the station." "Space taxis" or "shuttle-craft," as von Braun described them, would ferry both men and materials from the rocket ships to the station itself.

Von Braun noted a number of uses for a space station:

-- "a springboard for exploration of the solar system"

-- "a watchdog of the peace"

-- a meteorological observation post

-- a navigation aid for ships and airplanes

-- "a terribly effective atomic bomb carrier."[2/]

This detailed description was only one of the many concepts developed in the years after World War II prior to the 1957 launch of Sputnik and the formal beginning of the Space Age; even before the United States had an official space program, most of the possible uses of a space station had been identified by visionaries who dreamed of space travel. The past twenty-five years, in this country at least, have been spent in debating whether to translate some form of that vision into reality.

B. The Earliest Years: Planning a Post-Mercury Space Program[3/]

Even before it opened its doors for business on October 1, 1958, NASA had been assigned the responsibility for manned space flight and had developed Project Mercury as the initial manned activity. The NASA leadership set as a high priority task developing a long-range plan for the agency's first decade. A space station was a leading candidate for a post-Mercury goal. The House Space Committee in early 1959 concluded

that stations were the logical follow-on to Mercury, and von Braun (then still working for the Army) presented a similar view in his briefings to NASA. At this time, the German rocket team had developed an elaborate scheme, called Project Horizon, for Army utilization of space, including military outposts on the lunar surface.

In the first half of 1959, NASA created a Research Steering Committee on Manned Space Flight, chaired by Harry Goett. At the first meeting of this committee members placed a space station ahead of a lunar expedition in a list of logical post-Mercury steps. In subsequent meetings, the debate centered on the research values, especially with respect to biomedical studies, of a station versus the excitement of a lunar landing goal. While some members of the committee argued that "the ultimate objective of space exploration is manned travel to and from other planets," the Langley representative argued for an interim step, since "in true space flight man and the vehicle are going to be subjected to the space environment for extended periods of time and there will undoubtedly be space rendezvous requirements. All of these aspects need extensive study. . . . the best means would be with a true orbiting space laboratory that is manned and that can have a crew and equipment change."[4/] Ultimately, the Goett committee recommended that a lunar landing be established as NASA's long-range goal, on the grounds that it was a true "end-objective" requiring no justification in terms of some larger goals to which it contributed.

These recommendations were not immediately accepted. In 1960, Robert Gilruth told a space station symposium that "it appears that the multi-manned earth satellites are achievable . . ., while such programs as manned lunar landing and return should not be directly pursued at this time."

At an August 1960 industry briefing on NASA's future plans, George Low presented a scheme in which a manned lunar landing and creation of a space station were given equal treatment as long range goals of the NASA program; Low told the conference that "in this decade, therefore, our present planning calls for the development and demonstration of an advanced manned spacecraft with sufficient flexibility to be capable of both circumlunar flight and useful earth orbital missions. In the long range, this spacecraft should lead toward manned landings on the moon and planets, and toward a permanent manned space station."[5/] Low also announced the name of the advanced spacecraft program, aimed both at the moon and at space stations; it was to be called "Project Apollo."

All of the debate was effectively terminated by John F. Kennedy's May 1961 announcement that "I believe we should go to the moon."[6/] As NASA planners accepted Kennedy's challenge and chose lunar-orbit rendezvous as the approach to accomplishing a lunar landing mission before 1970, any chance of developing a space station in the 1960s disappeared. The rest of the decade was spent studying the concept, with the anticipation that it would be the logical post-Apollo program.

C. Space Station Plans During the 1960s

Throughout the sixties, there were almost always funds available for engineering and design studies of future concepts. These studies were conducted both within NASA and by the various aerospace contractors (particularly those without a major role in Apollo), and they resulted in the examination of a wide variety of concepts, ranging from inflatable balloon-like structures, through the use of refurbished rocket stages, to very large stations requring the use of Saturn V boosters to put them in

orbit. Three NASA field centers, the Manned Spacecraft Center in Texas, the Marshall Space Flight Center in Alabama, and the Langley Research Center in Virginia, managed these in-house and contractor studies, and they were coordinated by the Advanced Missions Office of the Office of Manned Space Flight at NASA Headquarters in Washington.

These studies and the various concepts which evolved from them will not be reviewed in detail in this report, since the focus here is on the policymaking process rather than on the development of specific technological proposals.[6/] Rather, the interaction between the study process and periods at which NASA leadership gave serious thought to proposing post-Apollo space goals and space programs to the President and Congress will be the focus of attention.

1. Advanced Planning, 1962-1968 Some attention to the technical planning effort is needed, however, to get a sense of what concepts were being most actively explored. While the manned flight centers at Houston and Hunstville were focussing almost their total energies on getting Apollo started in the early 1960s,* the Langley Research Center was giving substantial attention to the theoretical and engineering aspects of space station design. These efforts dated from at least mid-1959, and by 1962 enough work had been done to form the basis for a space station symposium.[7/] Langley researchers noted that "a large manned orbiting space station may have many uses or objectives." Among these objects they listed:

*Even so, both Houston and Hunstville had space station study efforts underway; in particular, Houston was studying a large (24-person) space station launched by a Saturn V. (See reference 6.) The studies directed by Langley have been chosen for review because they were more fully developed than those directed by the other two centers.

1. Learning to live in space
   a. artificial-gravity experiments
   b. zero-gravity experiments
   c. systems research and development
2. Applications research
   a. communications experiments
   b. earth observation
3. Launch platform experiments
4. Scientific research

With respect to launch platform experiments, Langley suggested that "the space station with its crew of trained astronauts and technicians should be a suitable facility for learning some of the fundamental operations necessary for launching space missions from orbit. The new technologies required for rendezvous, assembly, orbital countdown, replacement of defective parts, and orbital launch can be determined."[8/]

Among the various space station studies carried out by Langley contractors during the first half of the 1960s, perhaps the most detailed was that of a Manned Orbital Research Laboratory (MORL) conducted by Douglas Aircraft from 1963 to 1966. Douglas had had some prior interest in space stations; in 1960 it had built a full-scale mockup of a four-person astronomical space observatory as the central theme of an "ideal home exhibition" held in London. This station was to be constructed inside the fuel tank of a second-stage booster, a Douglas idea which ultimately found use in the Skylab program over a decade later.[9/]

In this study, a baseline technical concept for a Manned Orbital Research Laboratory (MORL) was established first, then the "utilization potential" of such a station examined, i.e., design preceded requirements. When the original design was compared to various requirements, it was inadequate, and a larger station in a different orbit evolved as the final result of the study effort. The study found that the highest utilization potential came from "key engineering and scientific research studies augmented by specific experiments directed toward potential Earth-centered applications."

As the study effort proceeded, the MORL got steadily more complex and bigger, as there were no criteria established to limit the addition of new experimental requirements. Table 1 illustrates the growth and changes as the concept evolved.

The MORL requirements study examined:

1. earth-centered applications
2. national defense
3. support of future space flights
4. the space sciences

From this analysis, the study predicated the need for "hundreds of thousands of manhours" in orbit to carry out all useful applications; this implied a long-range requirement for "near permanent operations and support of probably several space stations." The study also noted, foreshadowing a future issue, that "the limiting factor on the number of such stations, and the crew size of each station, appears to be the cost of logistic support." Figure 2 is the final MORL concept; although basically a zero-gravity station, the station had an on-board centrifuge for re-entry simulation, testing of physical condition, and physical therapy if zero-gravity conditions were debilitating for the crew.[10/]

2. Management Attention to a Space Station. By early 1963, NASA Associate Administrator and General Manager Robert Seamans called for study of an Earth Orbiting Laboratory (EOL) from "an overall NASA point of view." Such study was needed, said Seamans, since an EOL had been studied and discussed "by several government agencies and contractors"* and

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* Though it is not discussed in detail in this report, during this period the Department of Defense was exploring the potential of manned flight for national security missions. Some of this study effort was conducted jointly with NASA, but most was not; one focus of the effort was the military potential of a space station. In 1963, the Air Force's Manned Orbiting Laboratory (MOL) program was approved as an initial step in examining ways in which human crews could be used to enhance national security operations in orbit. The MOL program was cancelled in 1969.

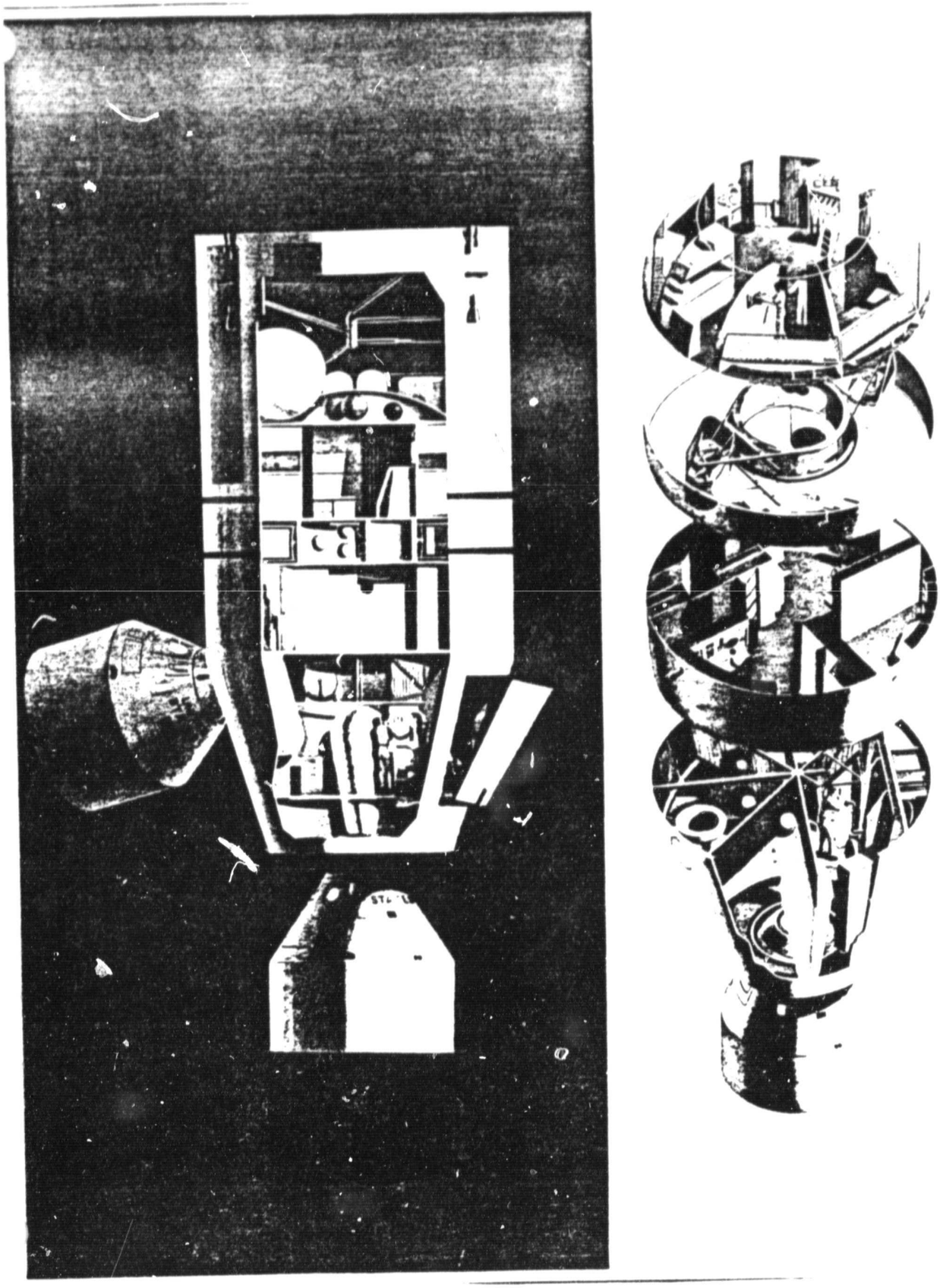

Figure 2. MANNED ORBITAL RESEARCH LABORATORY CONCEPT

	Sept. 1963	Nov. 1964	Feb. 1966
Manhours of experiments	9670	19,500	53,000
Crew size	4	6	9
Program duration	1 year	2-5 years	5 years
Orbit	28.72 degrees 200 n.mi.	28.72 degrees 200 n.mi.	50 degrees 164 n.mi.
Launch date	1968	1970	1972
Cost ($ million) w/o operations	$1050	$1566	$1939

Source: Douglas Missile and Space System Division, "Report on the Development of the Manned Orbital Research Laboratory (MORL) System Utilization Potential," SM-48822, January 1966, p. 14.

TABLE 1. MORL Concept Evolution

because NASA and DOD "are now supporting a number of additional advanced studies." Seamans' reference to DOD was significant; NASA and DOD were locked in a controversy over control of post-Apollo manned flight efforts. NASA's management, anticipated Seamans, would "be faced with the decision to initiate hardware development" in 1964. Seamans ordered an agency-wide, 4-6 week high-priority study which would examine EOL proposals in terms of, among other factors:

a. Defense Department interest
b. International factors
c. Other government agency interest 11/

Throughout this study and other attempts to define a space station program in the 1963-1966 period, there was a continuing tension between those designing the station itself (primarily associated with the Office of Manned Space Flight, its field centers, and associate contractors) and those interested in the experiments and other uses of such a facility (primarily the Offices of Space Science and Applications and the Office of Advanced Research and Technology). For example, one OART staffer complained in 1963 that "the fact that OMSF is supplying funds for MORL . . . does not change the fact that in doing so they are in a supporting role to the experimental purpose of the MORL. That experimental purpose should carry a heavy stick in the determination of how the research program will be accomplished." 12/

Later in 1963, the Director of OART asked field center assistance in defining "more clearly the potential usefulness of such a laboratory as a platform for scientific and technological research in space." He noted that "a view has prevailed to date, based primarily on intuitive judgment [emphasis added], that this research function (exclusive of biotechnology and human factors research) constitutes one of the more important long-range justifications" for a space station. It was essential, he argued

to make "a correct decision as to whether and why a MOL [manned orbital laboratory]* project should be undertaken."[13/] By 1964, the definition of uses for a space station had broadened enough to lead the director of the OMSF Advanced Manned Mission Office to suggest that it was "both timely and necessary to pursue . . . broadly beneficial uses of space stations with the departments and agencies that will capitalize and exploit these broader uses" and that an interagency "applications working group" be established for this purpose. Such interagency involvement, he noted, "can result in a higher level of knowledgable support to NASA for implementation of a national multi-purpose space station program."[14/]

Neither 1964 nor 1965 were propitious years for proposing major new starts in the national space program. In 1964 a careful in-house examination of NASA's future options had recommended that NASA defer "large new missions for further study and analysis."[15/] However, there was concern within NASA about maintaining an adequate work load as the development phase of the Apollo neared completion for both NASA centers and NASA contractors, and an evolutionary approach from Apollo to more advanced missions appeared more likely to meet this need, given the low probability of a major new start on post-Apollo programs.

A 1963 change in test philosophy made by OMSF head George Mueller made it it likely that there would be surplus Apollo command and service modules and lunar modules and Saturn boosters available which could be used for earth orbital missions. As an interim measure to keep NASA's manned spaceflight centers busy and in order to utilize the surplus Apollo hardware, in 1965 NASA formally initiated an Apollo Applications Program (AAP). In a sense, AAP became not only a bridging program between Apollo and whatever new program would follow it, but also a reason for deferring space station approval until results from the central AAP project (later called Skylab) were in.

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* This is not a reference to the Air Force's MOL program.

With the Apollo Applications Program underway and Apollo itself pushing toward an initial lunar landing in 1968 or 1969, by mid-1966 NASA top-level management recognized that it was "timely that we update our studies of a permanent manned station." This agency-wide study was to be divided into two parts; one effort would focus on system design, the other on the "need for, the requirements of, and the constraints on a space station" to support a number of objectives:

1. Astronomy with large optical and radio telescopes
2. Geographical studies with emphasis on earth resources
3. Meteorological sensor development
4. Biological research
5. Aeromedical research and development
6. General laboratory research and development in advanced technology
7. Flight operations development directed toward more efficient resupply, service, and orbital operations
8. Long duration flight leading to a future missions capability of manned flight to the planets

The study charter emphasized that "it is still a question whether a permanent space station is the best approach to achieving the envisioned mission objectives," and called for a review of both advantages and disadvantages of a station as the means for accomplishing them. Finally, the study charter indicated that the request for such a study "is in no way an indication of an agency decision to proceed with or propose a manned space station; it is very important that this point be clearly understood by all concerned with the study and by those with whom it is discussed."[16/]

The continuing tension between those establishing requirements for a station and those proceeding with its design surfaced again during this

study. One participant noted that "the problems engendered by the requirements not being available to the design people before embarking on the design were very evident. Acceleration of the former and delay of the latter would be very beneficial." This individual compared the space station to another mission concept then under active evaluation within NASA, a manned Mars fly by, and concluded that "of these two, the space station is the more significant and useful, the more within our technical grasp, and is a necessary precursor to any manned planetary or other future manned space program."[17/]

The requirements segment of the 1966 space station study was directed by Charles Donlan; the design segment, by E.Z. Gray. It was the Donlan group in which the conflicts between various experimental objectives and design requirements were assessed. The Donlan study found that "the most difficult problem to resolve is the matter of artificial gravity. If artificial gravity becomes a firm requirement for crew comfort," it noted, "its implementation can have a very large impact on space station design" since "zero gravity is a mandatory requirement for major portions of the experiment programs." Other conflicts included those between astronomical observations and earth observations, which are "obviously in conflict in both direction and stabilization modes." The conclusion of this assessment was that "the manned space station concept emerges as an unparallelled opportunity for learning how to exploit the features of space," and that "the prime justification for a manned station [is] associated with the potential the station offers for undertaking broad-based research and development programs in science and technology addressed to all the space objectives of the United States." The group considered both a single station in which there would be an attempt to integrate various conflicting experiments by

sequential scheduling, and a concept of splitting the station into several components, each optimized for a particular set of activities. The study concluded that "a minimum station that would appear to satisfy much of the program needs would operate in 200-mile orbit at an inclination of 50°, be capable of operating for a 5-year period, continuously or intermittently, and large enough to house a staff of from 8 to 12 people."[18/]

3. Attempts to Gain Approval for Space Station Program Based on the 1966 space station study and the lead time required to get a space station program defined and implemented, NASA leadership in the fall of 1966 decided to go ahead with what the Donlan Committee had defined as a minimum space station program, and requested $100 million in the FY 1967 budget for detailed definition (Phase B) studies. The Bureau of the Budget totally rejected this request, allocating no funds specifically for space station work,[19/] and throughout 1967 and 1968 preliminary studies continued mainly inside NASA, but at a low level of funding.

As the first successful lunar landing mission approached and as the funding peak of the by now much-reduced Apollo Applications Program also was imminent, in the fall of 1968 NASA requested $60 million to initiate a space station effort. Once again, this request was denied. NASA approached the beginning of 1969 in some disarray:

-- James Webb had resigned in the fall of 1968, and the Acting Administrator, Thomas Paine, was new to the agency

-- Richard Nixon had been elected President, and his position on space policy was far from clear

-- NASA had settled on the space station as its post-Apollo program objective, but to date had had no success in getting Presidential or Congressional support for such an initiative

NASA took bold action in the early months of 1969 to attempt to change this situation; that effort will be described in the following section.

CHAPTER II

SPACE STATION HOPES PEAK: 1969-1972

A. An Unsuccessful Space Station Initiative

Throughout 1967 and 1968, NASA used the limited resources available to it for advanced mission studies to continue "Phase A" preliminary conceptual space station studies, with the hope that during 1969 NASA could initiate two "Phase B" detailed design studies during 1969. The anticipation was that the results of those studies would provide the basis for an agency and national decision to develop a space station. The following section describes the evolution, implementation, and termination of those those Phase B studies. However, even before NASA opened bidding on these design study efforts, its Acting Administrator, Thomas Paine, made a bold attempt to gain the support of newly-inaugurated President Richard Nixon for an immediate commitment in principle to the space station as the centerpiece of the post-Apollo space program. This attempt was unsuccessful, and in the process NASA may well have lost some of its credit with the new President and his associates. The history of this "Paine initiative" is recounted below.

1. The Situation Facing NASA Even at the peak of its success, with the spectacular Apollo 8 mission at Christmas 1968 and virtual certainty that the first lunar landing would come during 1969, NASA faced a highly uncertain future as that year began. In October 1968, in submitting the proposed NASA budget for Fiscal Year 1970, which contained substantial increases in funds and new program starts, including a space station, Acting Administrator Paine had argued that

> it is impossible to justify a rational national policy in which the United States, having invested so much in the first ten years to develop and demonstrate a capability to conduct significant operations in space, turns its back in the second decade on what it can accomplish. 1/

Paine's argument was not convincing; President Johnson and his Bureau of the Budget (BOB) reduced the NASA budget request, and explicity deferred decisions on new programs for the incoming Nixon Administration. A Bureau of the Budget issue paper prepared for the new administration summarized the situation:

> FY 1970 and FY 1971 are critical decision years for the civilian space program, because the attainment of the manned lunar landing goal is now imminent, and the lead time for achievement of major new goals in space is long. . . . Chief among [NASA's budget issues] is whether there should be a program of manned space flight after the first lunar landing, and if so, what the nature and rate of activity of that program should be. Large reductions in NASA FY 1970 outlays cannot be made without assuming that the long-term policy of the Administration will be to minimize or even eliminate manned space flight activity for a period of at least 5 years.

The Bureau of the Budget listed arguments for and against major reductions in the NASA budget

> For: The principal argument for exercising some of the reduction options/alternatives is to reduce government spending on space, turning the funds to other uses in the public or private sector. If outlay reductions become mandatory in the space program, manned space flight activities are the only contributors to major savings.
>
> Against: The major arguments against exercising the option are...abandonment of expensive inventories and local economic disorientation. In addition, the following arguments can be made for continued manned space flight: the large investment in a transportation system argues for some lunar exploration; technological advancement and competition with the U.S.S.R.; the claimed need for continuity as a major contributor to reliability and safety; and possible national security implications of an unspecified nature.

The political implications of major cuts in the NASA budget were also projected:

Congressional Committees: The Space Committees support the program with individual members particularly interested in specific areas of space. Congress, generally speaking, votes both ways on the space program. However, there is no consistent organization opposition bloc. There has been less Congressional support in the 1968-1969 appropriation cycles than in previous years.

Aerospace Industry: It can be anticipated that the major aerospace contractors and the Congressmen with major plants in their districts will oppose strongly any cutback in the program which forces contract terminations. 2/

2. Paine Decides to Ask for the Moon (and a Space Station Too) When the Nixon Administration took office on January 20, 1969, space was not high on its list of concerns. Thomas Paine continued as Acting Administrator, and there was no indication from the White House whether he would be given the job permanently or whether Nixon would appoint his own person to head NASA.

It is standard procedure for a new administration to conduct an early review of the outgoing government's just-submitted budget. President Nixon and Bureau of the Budget Director Robert Mayo asked for such a reappraisal on January 23, with the guidance to agencies that they should attempt to reduce the budget submitted by a Democratic President. Paine and his closest advisers decided to take an opposite tack. Paine's predecessor, James Webb, was extremely cautious about proposing new large programs that would be politically difficult to support; Paine had no such inhibitions. He was an aggressive leader and believed strongly in the importance of the NASA program, and he thought that the momentum of the Apollo 8 success was great enough to gain Presidential support for major new initiatives. Thus he decided to ask the Bureau of the Budget to increase substantially the FY 1970 NASA budget. In justifying this requested increase, Paine argued that "critical program and funding decisions were specifically deferred

to President Nixon's Administration and must now be made." Paine asked for budget increases in three areas:

1. lunar missions with enhanced scientific value
2. resumed production of the Saturn V launch vehicle
3. space station studies and long leadtime development of space station subsystem items. 3/

In an unusual move for an agency leader in a new administration, much less one serving in an acting capacity, Paine also appealed directly to the President in support of the manned space flight program. He argued that "positive and timely action must be taken by your Administration now to prevent the nation's programs in manned space flight from slowing to a halt in 1972" and suggested that "the nation should . . . focus our manned space flight program for the next decade on the development and operation of a permanent space station -- a National Research Center in earth orbit -- accessible at reasonable cost to experts in many disciplines who can conduct investigations and operations in space which cannot be effectively carried out on earth." Paine told the President that he had "a unique opportunity for leadership that will clearly identify your Administration with the establishment of the nation's major goals in space flight for the next decade" and that "the case that a space station should be a major future U.S. goal is now strong enough to justify at least a general statement on your part that this will be one of our goals."

Paine described NASA's space station concept for the President in some detail:

> -- The space station...should become a central point for many activities in space, and would be designed to carry on these activities in an effective and economic manner. It would be located in the most advantageous position to conduct investigations and operations in the space environment, many im-

portant aspects of which cannot be duplicated in an earth-based environment. The best place to study space is in space. We have in mind a system consisting of general and special-purpose modules with a low-cost logistic support system that will permit ready access and return by many users and their equipment and supplies. The space station would not be launched as a single unit, but would evolve over a period of years by adding to a core new modules as they are required and developed. One of the key objectives is to develop the system in cooperation with the Department of Defense so that it can be adaptable for future military research as well as for a variety of non-military scientific, engineering, and other applications purposes.

There are many potential valuable uses of such a space station, and new ones will be found as experts in many fields become familiar with the possibilities and are able to visit and actually use it. However, we believe strongly that the justification for proceeding now with this major project as a national goal does not, and should not be made to depend on the specific contributions that can be foreseen today in particular scientific fields like astronomy or high energy physics, in particular economic applications, such as earth resources surveys, or in specific defense needs. Rather, the justification for the space station is that it is clearly the next major evolutionary step in man's experimentation, conquest, and use of space. The development of man's capability to live and work economically and effectively in space for long periods of time is an essential prerequisite not only for operations in earth orbit, but for long stay times on the moon and, in the distant future, manned travel to the planets. It is for these reasons that I believe that space station development should become one of your Administration's principal working goals for the nation over the next decade. 4/

Given the existence of the STG, Paine had to justify his request for an early Presidential commitment to a space station. One argument he used was the "distinct possibility" that the Soviet Union would launch a space station prior to the time the STG was to report its findings, and "that would take the edge off your announcement of a similar U.S. objective in the fall." By making such requests to the President, Tomas Paine was short-cutting both the normal budget process and a specific planning process for space which had just been established. His approach was a high-stakes gamble, and, unfortunately from NASA's point of view, one which he lost.

3. NASA's Proposals Reviewed Paine asked for a March 31 Presidential decision on future manned space flight issues. He did this even though he knew that, on February 13, the President had established an ad-hoc blue-ribbon Space Task Group (STG) and had asked that group for "definitive recommendations on the direction which the U.S. space program should take in the post-Apollo period," with a September 1 reporting date. By asking the President to decide on the future of manned space flight in advance of the planning process which was being established for precisely that purpose, Paine was trying to use the success of the Apollo 8 mission and the desire on the part of any new administration to take some early and popular policy initiatives as counters to a process which he was not sure would be favorable to NASA. During the transition period after the November 1968 election, President-elect Nixon had established a Space Task Force chaired by Nobelist Charles Townes of Berkeley (also a close adviser to NASA's manned space flight program). That Task Force had told the President "we do not recommend a commitment now to a large space station, extensive development of 'low-cost boosters,' or a manned planetary expedition." The Task Force did believe that "study of the possible purposes and design of such a station should be continued," but that the concept was on "doubtful ground. It is much too ambitious to be consistent with the present clear needs for continued exploration of man's continued usefulness in space."[5/]

The Townes report was an extensive discussion of the many decisions that had to be made by the new administration in order to define its space policy, and was a key factor in the early White House decision to commission a special study of space policy. In its original conception, this study was to have been directed by the new Presidential Science

Adviser, Lee DuBridge, former President of the California Institute of Technology. DuBridge was on record as skeptical of the value of large manned space programs, and this reflected the general orientation of the President's Science Advisory Committee (PSAC). NASA objected strenuously to a DuBridge-led study, on the grounds that its outcome would be prejudged. This objection was sustained by the White House, and Vice-President Spiro Agnew was given the Chairmanship of the Space Task Group, with the NASA Administrator, the President's Science Adviser, and the Secretary of Defense (who was represented by the Secretary of the Air Force) as members, and representatives of the Department of State, Atomic Energy Commission, and Bureau of the Budget as observers. The Space Task Group was the forum within which a future space policy was intensively debated during the summer of 1969,[6/] but its first task was to consider NASA's proposed to make its future actions essentially irrelevant.

The Bureau of the Budget was more than mildly annoyed by the NASA request for quick policy and budgetary decisions. On March 3, the BOB Director wrote the President about the proposed budget increases, noting that

> No reductions in other space program areas have been offered as offsets against these increases.
>
> Our first look at the agency recommendations that we have received in response to our request shows many more increases than decreases. In total these requests, if granted, would make precarious if not impossible the attainment of the surplus forecast by the previous Administration, which already depends on the extension of the surtax and the enactment of controversial legislation which may not be attained. And I know that your conviction is that our fiscal policy must be addressed to the attainment of a budget surplus as an essential response to today's inflationary environment and the uncertainties surrounding our commitment in Vietnam.

> In this combination of circumstances, I recommend:
>
> - That you make no statements endorsing future space objectives until your interagency task group has made its recommendations and I have had an opportunity to review them and advise you within the total budget context. 7/

On the same day, he told NASA that "I am not prepared at this time to recommend to the President approval of your requested budget increase." 8/

Thomas Paine had been selected by President Nixon to be permanent NASA Administrator on March 5, but the selection had not been accompanied by any indication of a positive Presidential response to Paine's initiative. In fact on March 7, President Nixon responded to Paine's February 26 memorandum and in essence told NASA that its attempts to get an early space station commitment were unlikely to succeed

> Thank you for your thoughtful memorandum on February 26 on problems and opportunities in manned space flight. I recognize the significance of the issues you raise, and agree that they merit serious and careful consideration.
>
> In accordance with my instructions, the Budget Director is engaged in a Government-wide effort to determine where near-term budget reductions can be made in order to provide for future programs within the limits of our overall fiscal policies. He will review your 1970 budget request in that context.
>
> On February 13, I established a task group, of which you are a member, to consider future plans for the space program. I hope that the task group will devote its primary attention to a thorough examination of the major alternatives for the next decade in space, their expected accomplishments, and their costs. 9/

In preparing for Space Task Group consideration of the Paine initiative, the positions of the various participants on a large space station, and the factors influencing their positions, became evident.

The BOB objective was to "head off any play by NASA to get a budget amendment now" since "this is bad budget strategy, probably unworkable as

far as Congress is concerned, and impossible to obtain without committing the President to support the long-range objectives." The BOB staff listed and evaluated four alternatives with respect to the space station and provided arguments for and against those options. Table 2 presents the "pros" and "cons" for each of the following alternatives:

1. endorse now, fund now - "high risk decision at this point in time even if President wants to go ahead. Gives most of the control levers away to NASA and Congress."

2. endorse now, fund later - "a possible course if President believes that at some time in his Administration we will want to start a large space station development. Gives opportunity to share publicly in lunar landing excitement."

3. fund now but don't endorse - "probably unworkable - either NASA won't get funds past Congress, and Administration will experience a 'defeat' or Congress will appropriate funds and attempt to hold Administration to going all the way."

4. postpone decision on endorsement and on funding - "keeps most management and funding control levers in President's hands. Passes up an opportunity to make the most political capital from excitement surrounding MLL [manned lunar landing]." 10/

The President's Science Adviser asked the PSAC Space Science and Technology Panel to assist him in evaluating the Paine initiative. The Panel met with NASA officials, and advised Dr. DuBridge that there was "no great urgency" related to the issues Paine had raised and, "from a programmatic standpoint, the arguments in favor of early action appear very weak." 11/

The space station did gain some support from the Department of State, which saw "a close relationship between our space program and foreign policy objectives. Thus, an ongoing, challenging and successful space program is important from the viewpoint of these objectives -- particularly

Case 1--Endorse now, Fund now

Pro	Con
1. Strongest positive support for President, clearly identifying him as moving force behind space station--as Kennedy and LBJ are identified with manned lunar landing.	1. Strong identification may not be favorable if: --Congress doesn't support --Public loses interest or uses as a bad example of putting big technology ahead of people-oriented programs in competition for Federal support.
2. Moves toward earliest realization of space station.	2. Puts strain on 1970 budget. 3. Significantly reduces budget flexibility in 1971-76 period.
3. Best chance to compete with any large space station efforts of U.S.S.R. should they occur.	4. May, by reaction of aroused interest groups and Congress, freeze into a Presidential commitment to a specific schedule and to significantly increased future budgets.
4. Give NASA a focus for manned space flight development and technology after the manned lunar landing and AAP.	5. Must be done without clear view of: --Specific anticipated outputs --Configuration/Launch Vehicle requirements --Relationship to DOD requirements and programs --Relationship to NASA unmanned program --Costs--which could vary from $5 B to $50 B depending on configuration and program duration.

Case 2--Endorse now, Fund later

Pro	Con
1. Implies less Presidential commitment than case 1.	1. Implies less Presidential commitment than case 1. 2. Implies 6 mos.-1 year delay in first flight. 3. Increases odds by 6 mos.-1 year that the U.S.S.R. may put a space station in orbit before we do.
2. Reduces 71-76 budget flexibility less than funding now.	4. Reduces 71-76 budget flexibility somewhat (but less than funding now). 5. Could still freeze into a commitment by reaction of interest groups and Congress.

TABLE 2. Bureau of the Budget Space Station Options: Early 1969

TABLE 2, continued

Pro	Con
	6. Congressional reaction could result in appropriation of space station funds even though they were not specifically requested.
3. Gives NASA general idea of favorable Presidential support for continued MSF development technology efforts after first MLL and AAP.	7. May raise credibility questions since real commitment is funding commitment.
4. Buys time to consider before presentation to Congress, in context of total space program objectives --Specific anticipated outputs --Configurations --Launch vehicle requirements --Relationship to DOD requirements and programs --Relationship to NASA unmanned programs --Costs	
5. Avoids strain on 1970 budget	

Case 3--Fund now but don't endorse

Pro	Con
1. Implies less commitment than case 1.	1. Because of timing of special announcement, and of upward budget amendment, can be interpreted as just as strong a commitment as case 1.
2. Has all other advantages of case 1.	2. Has all disadvantages of case 1 except for #1.

Case 4--Postpone decision on endorsement and on funding

Pro	Con
1. Avoids any implication of Presidential commitment.	1. Avoids any implication of Presidential commitment.
	2. Runs some risk that Congress will take initiative and advocate go-ahead.
2. Preserves budget flexibility in 1971-76 time period.	3. Clearly postpones first flight by 6 mos.-1 year.
3. Buys time to consider before presentation to Congress	4. Leaves NASA without clear focus for MSF development-technology after MLL and AAP.

TABLE 2, continued

Pro	Con
--Specific objectives and outputs --Configurations --Launch vehicle requirements --Relationship to DOD programs and requirements --Relationship to NASA unmanned programs --Costs	5. Misses possible best political timing--anticipated wave of enthusiasm surrounding MLL--to get new space projects approved by Congress.
4. Avoids strain on 1970 budget.	

Source: Bureau of the Budget Briefing Memorandum on "President's Task Group on Space...Meeting No. 1," March 6, 1969.

larly one designed and funded to afford increasing opportunities for international cooperation." The State Department believed that there were "greater international values in a space station and reusable logistics vehicle than in . . . lunar exploration," and that "our choices should not be unduly influenced by our estimate of Soviet choices, nor do we need to prejudice deliberate consideration our space goals in order to pre-empt Soviet activities. Our capability is now well understood both by the Soviets and by most other countries. Foreign countries will focus less on the competition between ourselves and the Soviets than on the relevance of space activities to their own interests and needs."[12/]

The Department of Defense position was that DOD "does not have or anticipate projects which require a space station as defined by NASA. DOD has great interest in the development of a lower cost transportation system suitable for their uses as well as for NASA's."[13/]

The report of the Space Task Group staff directors was a rejection of that part of the Paine initiative which asked for an early space station commitment:

> The majority of the Committee members . . . did not support the request for additional FY70 funding to enable more rapid progress toward the launch of a space station in the mid 1970's. This view does not represent an unfavorable judgment on the question of adopting the space station as a major new goal of our space program, but rather results from a desire not to imply prejudgment of the eventual result of the STG review. The case for urgency was unconvincing, and it appears that no important options would be foreclosed by deferring action. [14/]

Paine met with several of the other members of the STG to lobby against the staff directors' report, but was unable to sway their views, and on March 22 the STG accepted the report's recommendation. Even at that meeting, Paine was still arguing that "to put it bluntly, the U.S. manned flight

program is going out of business, unless some decisions and steps are taken to keep it going."

4. Implications of Space Task Group Recommendations The attempt by NASA to get early commitment to a space station has been reviewed in some detail because its resolution foreshadowed much of what happened in the following one and one half years as NASA strugged to gain support for space station development as its major post-Apollo program objective. Throughout the Space Task Group review and the White House consideration of the STG report, NASA argued that the space station, and not the space shuttle concept which was evolving from the station's logistic vehicle, should be the Agency's top priority program. In the summer of 1969, NASA let two Phase B study contracts for space station design, and in its 1970 Congressional testimony the station was presented as the centerpiece of the Agency's programs, with the shuttle justified primarily as its logistics vehicle. Throughout 1970, NASA continued technical studies and user-oriented activities to promote the station concept. However, by the middle of that year, it was clear that, in the eyes of the space subgovernment outside of NASA, the shuttle program was a more attractive investment than was the station, and by the end of the year, the station had been dropped back to conceptual study status. NASA had built up a great deal of momentum behind the space station concept through the 1960s, but when it came time for the country to decide, through the policymaking process, whether the station was a "good buy," the response was negative. The reasons for this negative assessment were already clear for NASA to see by March 1969, but it took over a year for NASA's leadership to recognize the situation and to steer the Agency away from the station and behind the shuttle. That process is described in the following section.

B. Space Station Studies Go to Phase B (and Then Nowhere)

While at the policy level NASA's hope for an early Nixon commitment to the space station was being dampened, at the engineering level the momentum behind the program was building. After conducting preliminary Phase A studies, primarily in-house, during 1967 and 1968, NASA was prepared in early 1969 to involve the aerospace industry in defining the program through two Phase B studies. NASA's hopes were that these program definition studies would provide the technical basis for a start on space station development within a year or two. These studies were initiated in September 1969, and extended over most of the next two years. But events at the policy level, described in the following section, made it increasingly unlikely that the space station program would ever proceed beyond the Phase B stage, at least in the 1970's. The writing was already on the wall by the time the "Paine initiative" was rejected in March 1969, but during the rest of 1969 and 1970 it became much clearer. Finally, NASA could no longer avoid reality, and by early 1971 the space shuttle, not the station, was identified as the agency's top priority. Just as the Apollo Applications Program had been a "better buy" for the country in the mid-1960's, so the shuttle was perceived by policymakers in the early 1970's. But the failure of the space station program to gain approval was not due to a lack of effort; the Phase B study process was the focus for that effort.

1. Defining the Preferred Concept and Its Rationale One problem, perhaps the key one, was that NASA found it quite difficult to tell both prospective contractors and the political leadership what kind of station, for what purposes, it wanted to develop. This was so even though NASA had been studying space station concepts throughout the 1960's. Figure 3 summarizes the status of the space station program as 1969 began. The basic requirements

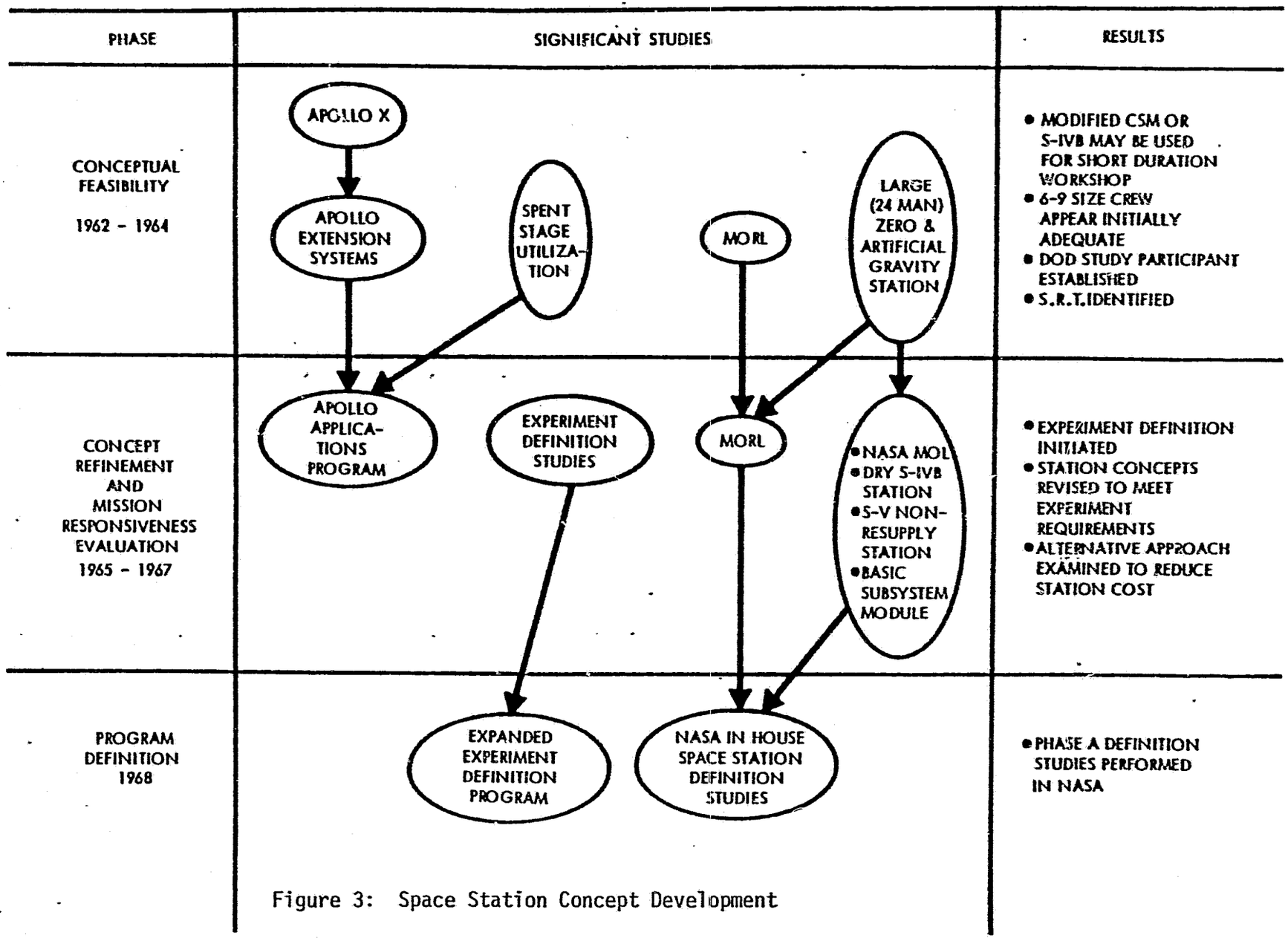

Figure 3: Space Station Concept Development

which had emerged from the study effort were:

1. qualification of man and systems for long-duration earth orbit flight;

2. demonstration of man's ability and functional usefulness in performing engineering and scientific experiments;

3. periodic rotation of the crews and resupply of the space station.

The average crew size for this station was planned to be six to nine persons, with a two-year orbital lifetime design goal.[15/] An Apollo command and service module launched by a Saturn IB booster was to be the logistics vehicle for the station; the station itself was to be launched on a Saturn V booster.

Incorporating these requirements into an agreed-upon statement of work for the Phase B studies proved difficult. Some sense of the flux in the process can be gathered from this excerpt from a January 18 letter from OMSF official Charles Matthews to MSC Director Robert Gilruth:

> You have received a letter dated January 14, 1969 from Dr. Paine requesting personal review and advice on the Statement of Work, Space Station Program Definition, Phase B. The letter was in the context of a January 2, 1969 draft of this statement of work. Since then, the document has undergone further review and editing incorporating changes resulting from comments by Dr. Paine and many other key NASA personnel. A seventh draft dated January 17, is hereby forwarded to you for use in the review cycle requested by Dr. Paine.

The questions which were posed to Gilruth and other center directors were rather fundamental:

1. Are the goals, objectives, and uses of the Space Station Program stated adequately?

2. Does the Statement of Work imply a sufficiently forward looking approach?

3. Is there proper emphasis on low cost operations, particularly with respect to logistics transportation?

...

8. Is the Space Station approach as to size, flexibility, operating mode (zero "g" and artificial "g," for example, and safety stated properly? 16/

Apparently, what was going on at this point was that Thomas Paine, bullish after Apollo 8, was pushing for a more exciting space station concept than that emerging from NASA's in-house planning process; Paine wanted to see what the various center directors thought, and for that purpose convened a January 27, 1969 meeting.

That meeting dramatized the lack of agreement on basic parameters of the space station program. Langley Director Ed Cortright commented:

o Subjects requiring more attention:

- USAF and other security applications
- planetary option

o Problems:

- 1975 launch date would preclude major technological advances
- too much Phase A work left undone
- unrelated to future major space base

o NASA top management must agree on general approach (selection of missions, artificial gravity, timing, goals)

o Give MSFC the space station job, with MSC and other cooperating

o Get with Air Force now

Abe Silverstein, Director of the Lewis Research Center, commented that "NASA is asking (in mushy language) for something we should know ourselves before going out. . . . This program must be saleable in terms people can understand. . . . Low cost in orbit and space station capability cannot be achieved by finding a series of 'blue book' industry studies; that only loses us a year and several million dollars."

Wernher von Braun of MSFC struck a theme that Paine found quite attractive:

> NASA should now tell the contractors what we want in the long run, what we foresee as the ultimate--the long-range--the dream--station program. NASA should spell out the sciences, technology, applications, missions and research desired. Then NASA should define a 1975 station as a core facility in orbit from which the ultimate "space campus" or "space base" can grow in an efficient orderly evolution through 1985.

Finally, MSC Director Robert Gilruth told Paine: "This work statement doesn't set NASA's sights high enough for the future. We should now be looking at a step more comparable in challenge to that of Apollo after Mercury. The space station size should be modular and based on our Saturn V lift capability into 200-mile orbit. Three launches would give us one million pounds in orbit, including spent stages. That is the number we should be planning for the core size."[17/]

The character of the space station was described by one of those most directly involved in its definition as "quite similar to that of a research center here on earth" and as "a centralized and sustained base of support and a focus for the conduct of many eandeavors in space."[18/] However, this rationale for the station did not command universal support, even within NASA. One of NASA's top scientists commented that "considerable attention is being given...to the search for meaningful experiments to be conducted in a manned orbiting space station, but at present greater scientific pressures exist to extend the use of small, special purpose satellites toward achieving current goals and objectives, and much work must be done before clear and meaningful scientific objectives for a space station can be generated."[19/] Administrator Paine, in explaining the value of the station to President Nixon in February, said "we believe strongly that the justification for proceeding now with this major project...does not, and should not be made to depend on the specific contributions that can be foreseen today.... Rather, the justification for the space station

is that it is clearly the next major evolutionary step in man's experimentation, conquest, and use of space."[20] And George Mueller, NASA's top manned space flight official, listed a variety of justifications for the space station in March 1969 Congressional testimony (see Table 3).

Out of this lack of consensus within NASA came a rapid change from the January concept of a space station program; Paine had heard, and agreed with, the advice of his center directors that NASA should be bolder in its plans. In February, Aviation Week reported that "all previous concepts have been retired from active competition in favor of a large station," with the focus on "a 100-man earth-orbiting station with a multiplicity of capabilities" and the "launch of the first module of the large space station, with perhaps as many as 12 men, by 1975." Top NASA officials were reported to have rejected earlier space station plans as "too conservative."[21]

The new guidelines for the space station were developed in the weeks following the January 27 meeting under the direction of Charles Matthews, Deputy Associate Administrator of Manned Space Flight at NASA Headquarters, with participation by staffers from OMSF, MSC, MSFC, and LRC. The center representatives were still in significant disagreement. The MSC representative noted that "crew sizes smaller than 20 men represent sorties into space as opposed to what Gilruth would like to see as an agency goal, namely, establishing an earth-like environment in space." The MSFC representatives "didn't agree that the 1975 module had to be designed for artificial 'g' or had to be a part of the 'ultimate' Space Station," and felt that OMSF was "getting away from what Dr. von Braun wants...(6 to 9 men, etc.)." One of the headquarters participants "didn't agree at all that there is going to be a 100-man type Space Station," particularly "if very low cost transportation is feasible and available."[22]

TABLE 3

RATIONALE FOR SPACE STATION - EARLY 1969

* Continued Development of National Capability
  - Next logical and necessary step
  - Major reduction in cost of space operations

* International Recognition of U.S. Space Capability
  - Visible sign of space capability
  - First international men in space
  - Preempt the Russian challenge

* Broad Support of Space Science
  - Oceanography, atmospheric science, meteorology, geophysics
  - Bioscience and biomedical laboratories
  - Solar and stellar astronomical observatories

* Potential Exploitation of Space
  - Advanced earth resources research, agriculture, fisheries, hydrology, forestry, minerals
  - Materials processing - crystals - composites
  - Base for building large structures
  - Research in communications and traffic control

* Experience in Space Operations
  - Support and maintenance of unmanned satellites
  - Long duration
  - Modification - repair and maintenance of instruments and equipment

* Development of the Equipment Required for the Operational Use of Space by Other Agencies

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Source: Testimony by Dr. George Mueller, Associate Administrator for Manned Space Flight to House Committee on Science & Astronautics, March 12, 1969. Published in 1970 NASA Authorization, Hearings, Part 2, p. 284.

By February 19, NASA Headquarters had decided that "the definition study will concentrate on a Space Station Module applicable to the concept of a much larger space station but with independent capability for application and experiment activities with a 12-man crew starting in 1975."[23/] A three day meeting later in the month further refined NASA's conception of the Space Station program which was to have four major elements:

1. a large Space Base with artificial gravity capability and composed of modules launched by a two-stage version of the Saturn V;

2. a smaller Space Station which is the first element of the Space Base;

3. an Intermediate Logistics System that would be new, based on a Gemini capsule, available at the first launch of the Space Station, and would be launched on either a Tital IIIM or modified Saturn V vehicle;

4. an Advanced Logistics System which would be a low cost reusable shuttle.

In a little less than two months, NASA had done an almost complete redefinition of its plans for earth orbital manned flight. Rather than an evolutionary six to nine person space station serviced by existing launcher systems, slightly modified, NASA was now ready to announce its plans for an extremely ambitious program, with four new starts in the period of just a few years. All of this came at a time when, at the policy and budgetary level, NASA's request for start-up money on such an accelerated program was being firmly rejected. Nevertheless, NASA was now ready to add two contractors to the team planning the Space Station program.

2. Phase B Competition NASA issued a Statement of Work for the Phase B Space Station Program Definition on April 19. Prospective contractors were ready; they had been following the rapidly expanding character of the program closely and were "already forming teams in anticipation" of the Phase B competition.[24/]

The Work Statement described the space station as "a centralized and general purpose laboratory in Earth orbit for the conduct and support of scientific and technological experiments, for beneficial applications, and for the further development of space exploration capability" and noted that the work requested would include "the Space Base but will focus on the mid-1970s Space Station as the initial but evolutionary step toward the Space Base." The objectives of the space station program were stated as:

a. Conduct beneficial space applications programs, scientific investigations and technological and engineering experiments.

b. Demonstrate the practicality of establishing, operating and maintaining long duration manned orbitan stations.

c. Utilize Earth orbital manned flights for test and development of equipment and operational techniques applicable to lunar and planetary exploration.

d. Extend technology and develop space systems and subsystems required to increase useful life by at least several orders of magnitude.

e. Develop new operational techniques and equipment which can demonstrate substantial reductions in unit operating costs.

f. Extend the present knowledge of the long term biomedical and behavioral characteristics of man in space.

The initial space station was to have a crew of 12, and normally to operate in a zero gravity mode, but there would be during the early weeks of its mission an assessment of the effects of artificial gravity; a counterweight would be tethered to the station and the configuration spun to provide the gravitational effect. The station was to be 33 feet in diameter and was normally to operate in a 270 nautical mile, 55° orbit, but also be capable of operating in polar and slightly retrograde orbits. Figure 4 is an illustration of the station concept as it appeared in mid-1969.

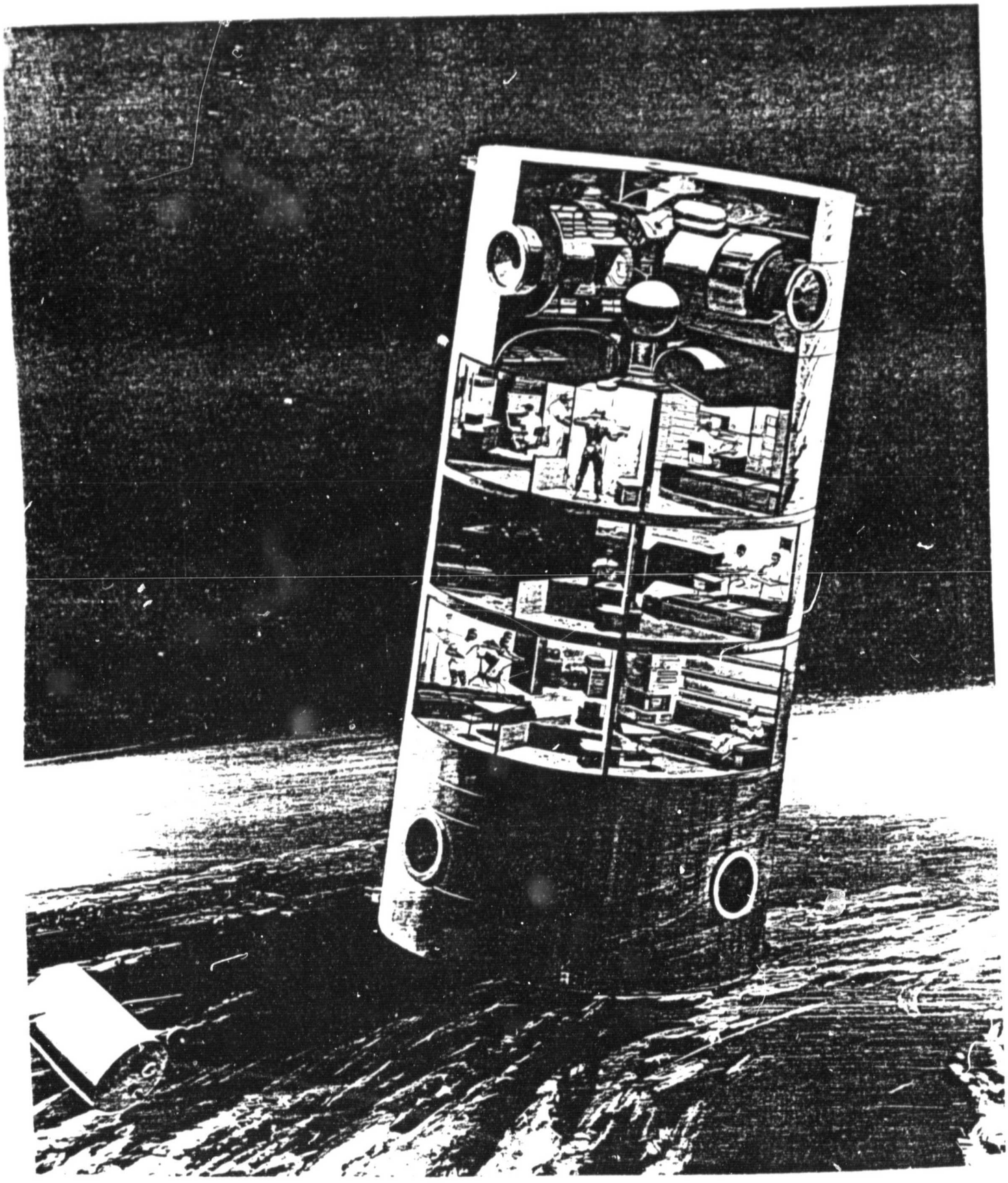

Figure 4. Saturn V-Launched Space Station Concept

The Work Statement noted that "the logistic resupply system for the Space Station and Space Base has not yet been selected." Hope was held out that the Advanced Logistics System (shuttle) would be available for the first station launch in 1975.[25/]

There were to be two parallel Phase B contracts of $2.9 million each, one managed by MSC, the other by MSFC; NASA Headquarters would organize a Space Station Task Force to coordinate the study efforts.* The effort was to be divided among four study areas:

- o conceptual definition of space base - 15%
- o definition of space station - 60%
- o definition of an initial logistic system - 15%
- o develop interface requirements for an advanced logistic system - 10%*

The Statement of Work contained a "candidate experiment program" for the space station, but this was "a summary of an illustrative program...to assure the system has the inherent capabilities to support those specific experiments and other experiments not yet identified."[25/]

Shortly after the original proposals in response to the April 1 statement of work were received by NASA, a new requirement was added to the Phase B effort. Not only was the space station to be designed so it could be the core around which a space base could be developed; the station module would also be the core of a spacecraft designed for a manned trip to Mars. This requirement came out of the policy debates described in Section II.C below, and was a reflection of the high hopes for all of NASA's future

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*The advanced logistic system was the subject of a parallel study effort which ultimately led to the definition of the earth-to-low-orbit space shuttle.

manned programs which were pervasive in the immediate aftermath of the first lunar landing.

3. Phase B Contracts Let; Studies Begin Three aerospace firms, North American Rockwell, McDonnell Douglas, and Grumman Aircraft, submitted proposals to NASA in response to the Phase B Statement of Work, and July 22, NASA awarded Phase B contracts of $2.9 million each to North American and McDonnell Douglas. The studies were to run for 11 months beginning in September; MSC would manage the North American effort, and MSFC, the McDonnell Douglas study. Each contractor during the course of the study would invest significant amounts of its own funds to supplement the NASA contract, in the hope that it would ultimately be chosen to develop the space station. Each prime contractor was backed up by one or two major subcontractors and a number of other subcontractors (see Figure 5). In all, an impressive industrial effort was mobilized in support of the space station Phase B studies.

Both centers organized in-house space station task groups to manage the contractor and parallel in-house studies; overall coordination and control of the studies was provided by an OMSF Space Station Steering Group and Space Station Task Force, and an independent Space Station Review Group oversaw the technical content of the study effort. Quarterly reviews of the study effort were conducted by top NASA management and others outside NASA interested in the space station; representatives of other countries were invited to participate in several of these reviews, with the hope that non-U.S. firms could participate in the station development effort.

One source of continuing tension during the course of the Phase B studies was the difficulty of integrating station design and the candidate

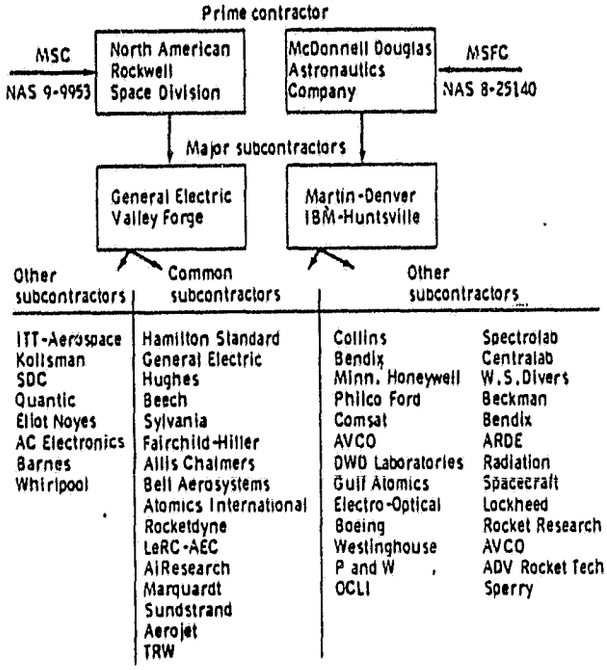

Figure 5. PHASE B CONTRACTORS AND SUBCONTRACTORS

experiments proposed for the station. These studies were compiled into a thick document known universally as the "Blue Book." One participant in the study later noted that "the candidate experiments compiled in the NASA Blue Book are too costly to be considered as a whole, are somewhat duplicated..., have not been verified as the true experiment goals...."[27/]

4. Study Effort Redirected Throughout the first half of 1970, the space station studies gathered momentum, aimed toward July completion and a subsequent NASA request to begin station development in late 1971. For reasons discussed in Section II.C, in effect the decision that there would be no space station had already been made, although this was not apparent to those intensely involved in the Phase B effort.

The Phase B studies were extended for six months on June 30; by this time, the planning date for the first station launch had slipped to 1977. The cost of the program was now estimated at $8-15 billion, including both development costs and 10 years of on-orbit operations; this estimate did not include the cost of the space shuttle program. It was reported that "an overriding desire on the part of the United States to internationalize the 12-man space station...has eliminated any possibility of Department of Defense participation in the program."[28/] In addition to the technical design activities, NASA was undertaking a Phase B effort to define experiment modules to be added to the core station and planning a year-long study to involve potential users, both domestic and international, in the program as it was developing. A user's symposium to kick off this effort was scheduled for September 1970, and both study contractors were building full-scale mockups of the 33-foot station.

Each contractor had come up with a station concept which had met the requirements of the Phase B Statement of Work, but there were a number of

differences between their two concepts in areas such as power supply for the station (solar or isotope generator), environmental control and life support systems, extent of artificial "g," and experiment priorities. NASA concluded in July 1970 that it could prepare a Phase C/D Statement of Work on the basis of the Phase B study results already available, but that was not to happen.

On July 29, 1970, Charles Matthews ordered MSC and MSFC to terminate the on-going Phase B activity and to redefine the effort in a fundamental way. NASA leadership had become convinced that the Saturn V program, which had been in terminal condition for almost two years, was finally dead, i.e., there would be no booster capable of launching a 33-foot station. The only launch vehicle available for use in putting the space station into orbit would be the space shuttle, with its 15-foot by 60-foot payload bay. What had started out as the supply vehicle for the station was now its key to survival.

That it might be necessary to go to a shuttle-sized space station had been becoming more evident in the months preceding July. The feasibility of such an approach had been suggested by studies conducted by the Aerospace Corporation. NASA, while recognizing that it might have to go to a shuttle-launched station because of the unavailability of Saturn V, wanted to make sure such a station had comparable capability (12-person crew, 10-year lifetime, multidisciplinary R&D facility), since "the development of an in-orbit research facility is the central focus of our current studies and this capability will be rapidly lost with any reduction in crew and vehicle size, vehicle life, and in the general purpose laboratory and data-processing equipment planned to be on-board."[29/]

On May 4 NASA Headquarters told MSC and MSFC to anticipate paying some

attention to shuttle-launched stations, and then on July 29 directed the centers to reorient their study efforts totally in this direction.

Over the next several months, NASA and its contractors did some interim work on modular space station concepts, and NASA issued a Statement of Work for a Phase B effort on the modular station on November 16. By then NASA had given up on attempting, in the initial version of a modular station, to preserve the same capability as the 33-foot station. The Statement of Work said

> The modular station shall consist of individually launched modules assembled in orbit and capable of operating at altitudes of 445 to 500 kilometers (240 to 270 nautical miles) in an inclination of 55 degrees. The Initial Space Station shall be sized to accommodate a crew of six with the first module launch scheduled for January 1978. This Initial Station shall also have the potential of growth to a configuration whose capability is equivalent to that of the 12-man, 33-foot diameter station defined in the original Phase B effort. The basic program approach of a more evolutionary type of station capability should provide a reduction in early funding requirements. The buildup to this full capability should be complete by 1984 with operations extending through 1989. 30/

It took some doing to skew the study effort toward components of 14-foot diameter; one study contractor commented that "people who were eager to fly in a 33-foot station found the prospect of long stays in the 14-foot station not very attractive." But NASA did issue Phase B extension contracts for a modular space station study effort to extend through most of 1971, and North American Rockwell and McDonnell Douglas went to work on the new concept. Figure 6 is a representative concept for the modular space station.

5. Phase B Studies "Fade Away" By the time they began their studies, however, the likelihood that they would lead to an early commitment to station development was already vanishingly small. NASA had suffered a number

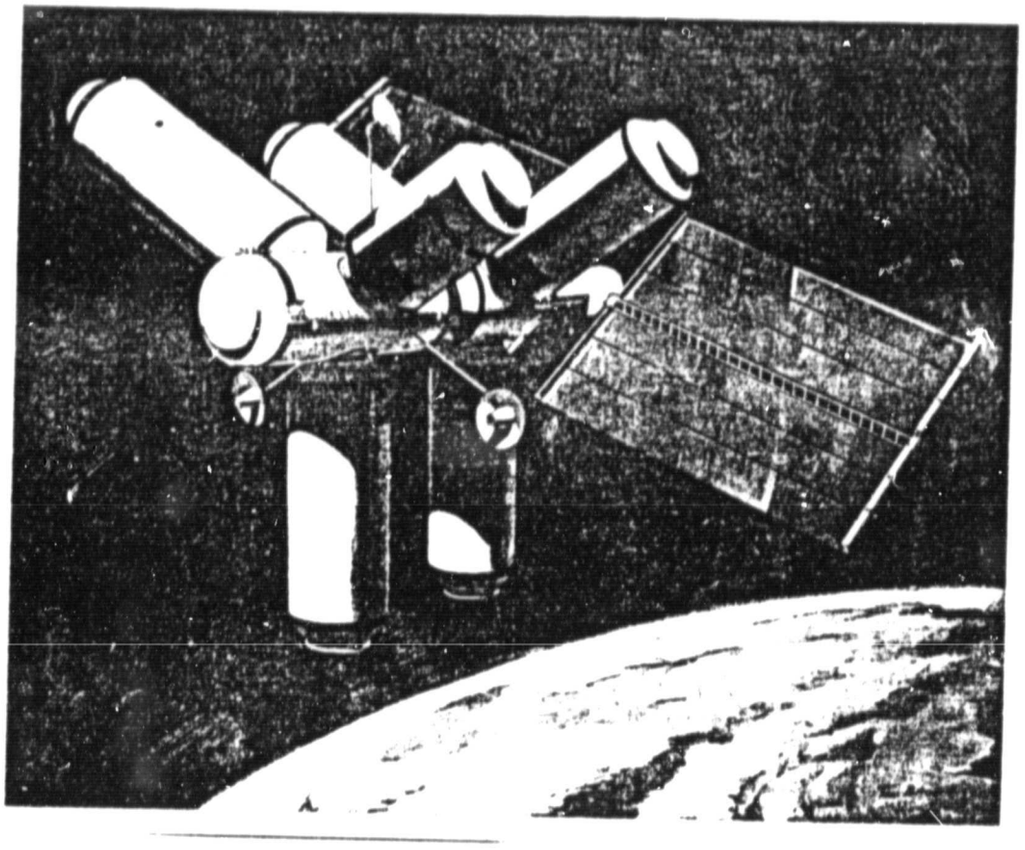

Figure 6. SHUTTLE-LAUNCHED MODULAR SPACE STATION CONCEPT

of shocks in late 1969 and through 1970 in its attempts to get an ambitious post-Apollo program approved, and by the summer of 1970 it was becoming quite clear to NASA leaders that only one big program had any chance of Presidential and Congressional approval, and that it was not the space station program. From its start as the "advanced logistics system" for the station and space base, the space shuttle had garnered the interest of the Air Force and many within NASA, and in the summer of 1970 the agency leadership grudgingly decided to make the shuttle its top priority program. Thomas Paine had announced his resignation, and the station thus lost a supporter at the top; this may have made the shift to the shuttle easier.

In September 1970, NASA was simultaneously:

- conducting public meetings to inform potential users of the characteristics and potentials of a 33-foot space station
- developing plans for the study of a modular, shuttle-launched station because the 33-foot concept was dead, and
- preparing a budget request in which space shuttle development was given priority, and the space station dropped from separate program status to an advanced mission study.

Station studies continued through 1970, 1971, and 1972, with the final in-house studies being focused on a single research applications module (RAM) carried into orbit by a shuttle.* This was all that remained of what, only a few years earlier, had been plans for truly large facilities in earth orbit. As a final indication of this reality, on November 29, 1972 the Space Station Task Force was abolished, then immediately reincarnated as the Sortie Lab Task Force. NASA was able to gain approval for shuttle development in early 1972, and that task occupied the agency's energies

throughout the decade. Until the Shuttle was ready, the dream of permanent human facilities in space would have to wait.

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*This concept led to the ESA-developed Spacelab.

C. NASA's Post-Apollo Ambitions Dashed[31/]

While the space station Phase B effort was proceeding apace at the technical planning level, at the policy level NASA from 1969 through the end of 1971 was trying to get White House (particularly) and Congressional support for an increasingly less ambitious post-Apollo program. The initial forum for this attempt was the Space Task Group, discussed in Section II.A above. After its early rejection of NASA's space station initiative, the STG turned to the task of preparing recommendations on future space policy and programs for President Nixon.

The image of the Apollo commitment as a model for future space goals colored Space Task Group discussions from the start. At an early STG meeting, NASA's Administrator, Thomas Paine, argued the need for a "new banner to be hoisted" around which competent and motivated engineers, scientists, and managers could rally, as they had around the Apollo goal. Vice-President Agnew, reacting to Paine's point, raised for the first time in the STG context the question that would influence much of the group's debates: Where was the Apollo of the 1970's? Could it be, asked Agnew, that the United States should undertake a manned mission to Mars?

When Agnew first read the staff proposals for STG consideration, he reportedly was disappointed because none contained the strong and dramatic theme he thought was required for the national space effort. On July 16, 1969, as he joined thousands at Kennedy Space Center to watch the lift-off of the Apollo 11 mission, Agnew "went public." In interviews at the launch site Agnew said that it was his "individual feeling that we should articulate a simple, ambitious, optimistic goal of a manned flight to Mars by the end of this century." After lift-off, Agnew told the launch team that he "bit the bullet...today as far as Mars is concerned."

Agnew's statement at Cape Kennedy was not a spontaneous reaction to the excitement of the occasion; it had been planned in advance. It reflected Agnew's willingness to lend support to an ambitious and bold space program, if only NASA would propose it. This willingness matched the predispositions of NASA head Paine, himself disappointed at the lack of excitement and purpose he was getting from the organization's planning machinery. Spurred on by Agnew's private and public support, Paine decided that NASA should also "bite the bullet" and move aggressively to identify an early manned Mars mission as the central focus for its future plans. In order to do this, he ordered NASA planners explicitly to incorporate a manned Mars mission during the 1980's into NASA's overall plans. This was the source of an early modification to the Phase B study requirements described in Section II.B.3 above.

There were several reasons for switching to the Mars emphasis as a central theme in NASA planning. Perhaps most influential was the early STG rejection of a space station commitment based on the "logical next step rationale." By justifying a space station as a necessary precursor to manned Mars missions in the eighties, Paine hoped to provide a convincing rationale for the station's urgency. Not only space stations, but also the newly-proposed space shuttle, the development of nuclear rocket engines, and the retention of the large Saturn V as a booster were required if an early manned Mars landing were to be approved as a national goal.

Between March and August 1969, as the Apollo program and other ongoing NASA missions achieved spectacular successes and public interest in space was at a peak, as the Vice President continued to ask for an "Apollo for the seventies," as a key segment of NASA, its manned flight organization, coalesced behind an aggressive plan of new activities for the

next decade, and as NASA head Thomas Paine became more and more bullish about the need for bold new initiatives as a way of keeping the nation's civilian space program vigorous and his agency's momentum large as Apollo came to an end, NASA plans had gotten increasingly ambitious. (See Table 4 for a sense of the program alternatives NASA was suggesting to the STG.) Now, by asking for "commitment in principle" to the most ambitious plan his advisers had conceived, Paine presented a challenge to the other STG members and to others interested in the future of the space program. He told the nation that NASA was ready to begin a program that would send men to Mars at the earliest feasible time, and he asked the nation's leadership whether they were willing to support such a bold enterprise. The answer was not long in coming, and it was a resounding "No."

The results of NASA's attempt to mobilize support behind the manned Mars objective, were, from the Agency's perspective, little short of disastrous. What NASA discovered was just how limited the support for major new space initiatives was. The final STG report, submitted to the President in mid-September, did suggest that "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." This goal, said the report, would act as "a shaping function for the post-Apollo space program." Beyond its general statements, the report recommended no commitment to any particular program option or even any specific project on a particular time table.

Even this "muted Martian manifesto" had no standing with the White House. Although the STG finished its work with its submission to the President, more than six months passed before Nixon made any formal reaction to the Group's recommendation, and that reaction was noncommittal.

TABLE 4

Alternative NASA Programs Presented to Space Task Group in August 1969

	Program A	Program B	Program C
12-man Space Station	1975	1976	1977
Shuttle	1975	1976	1977
50-man Space Base	1980	1980	1984
100-man Space Base	1985	1985	1990
Lunar Orbit Base	1976	1978	1981
Lunar Surface Base	1978	1980	1983
First Manned Mars Expedition	1981	1983	1986

In the interim, the processes of public policymaking operated on the space program to shape it to the short and longer-term requirements of what the White House perceived as the budgetary and political interests of the nation. When NASA tried to use the STG report as the basis for justifying its 1971 budget request, it found that the report's recommendations carried little weight either in the Bureau of the Budget or, particularly, the White House. While the President personally apparently remained a space buff, his advisers were quite skeptical of the political benefits of major new activites in space; their reading of public opinion was that society had little interest in future space spectaculars. This skepticism, combined with stringent budgetary constraints, resulted in a budget for NASA in fiscal 1971 that was far below NASA's most pessimistic expectations. NASA, still not reconciled to the notion that space had little political support, "fought a retreating action through the entire budget process," being "beaten back but fighting lustily at every turn of the road," according to Administrator Paine.

It was in this context that, during the first half of 1970, it became clear to NASA leadership that NASA would not get approval to develop simultaneously both a space station and the space shuttle. In a March 1970 statement, President Nixon provided only a very guarded endorsement of future space activites, and he gave what priority was granted to the space shuttle. Congress during the 1970 debate over NASA's budget expressed a high degree of skepticism about ambitious new goals in space. The linkages among the shuttle program, development of a space station, and a manned Mars expedition came under particular attack, and attempts to delete funds for station and shuttle studies were made in both the House and the Senate. As the preceding section described, at the technical level NASA was still acting in mid-1970 as if space station approval were

possible. However, NASA's policy leadership grudgingly read the writing (which was in capital letters) on the wall, and in putting together the next agency budget request in September 1970 decided to make the shuttle the top priority NASA program for the 1970s and to give up attempts to gain approval to develop a space station until after the shuttle program was well underway.

Using the budget process, the political leadership of the country had applied its concept of national interest and national priorities to the space program; through that process, the technological aspirations of NASA were put under firm political control. What happened to NASA's space station plans is best viewed, not in terms of NASA "winning" or "losing," but in terms of what happens when an agency's aspirations are significantly at variance with what political leaders judge to be both in the long-term interests of the nation and politically feasible. This experience might be quite relevant to current attempts by NASA to gain support for a space station program.

CHAPTER III
EPILOGUE: THE SPACE STATION BECOMES A CONSTRUCTION SHACK

A. Introduction

During 1973, NASA carried out a "quasi-space station" effort, Skylab. Skylab was not a true space station, as defined in this report, because the modified Saturn upper stage used to house the orbital facility was not equipped for resupply of key expendable items, and thus the facility could not be used over a multi-year period. The orbital workshop was launched in May 1973, and during the year three three-person crews occupied Skylab for periods of 28, 59, and finally 87 days. The results of the Skylab program provided a major stimulus to NASA's once again beginning to examine the space station concept in the mid-1970s.

Other influences in this direction included the need to begin to identify potential "post-shuttle" programs and new requirements for manned space operations emerging from a number of study efforts being carried out by NASA in the 1974-1975 time frame. In order to build a plausible rationale for once again proposing a space station as an element of NASA's program, it would be necessary to identify some high priority missions which could not be accomplished using the space shuttle, with its 7-30 day orbital staytime, its Spacelab facility for manned experimental activities, and its significant capability for lifting large and/or heavy cargoes to low-earth orbit. Studies which established requirements for large structures in both low-earth and geosynchronous orbit, structures which could only be constructed in space, seemed to provide the needed rationale, and space construction became a major theme in space station studies during the 1975-1980 period.

This chapter briefly traces the evolution of NASA's thinking on space stations during the 1975-80 period, as this new rationale for a permanent manned orbital facility was developed and elaborated.

B. Development of the "Construction Shack" Concept

The first NASA foray into a new station effort was a 1975 study of "Manned Orbital Systems Concepts" carried out by McDonnell Douglas Astronautics under the technical direction of the Marshall Space Flight Center. This study "examined the requirements for ... a cost-effective orbital facility concept capable of supporting extended manned operations in Earth orbit beyond those visualized for the 7- to 30-day Shuttle/Spacelab system." Study guidelines included use of available hardware developed for the Skylab, Spacelab, and Shuttle programs "insofar as practical" and an initial operational capability in late 1984.

The context for the MOSC study included a growing concern about the Earth's resource limitations, population growth, and environmental stresses, driven by the widely publicized "limits to growth" debate of the early 1970s. The study noted that "the planning and development of future space programs cannot be done in isolation from the many critical problems facing the peoples of the world during the coming decades" and that "there will continue to be many conflicting and competing demands for resources in the years ahead." This context skewed the emphasis in establishing missions for the facility to "the research and applications areas that are directly related to current world needs."

Though oriented more directly than past station concepts to high priority global problems, the MOSC study still emphasized the "science and applications research facility" rationale; although such activities as assembly of large structures and operating space manufacturing facilities were examined during the study, the emphasis was on a facility which would "enable the scientific community to pursue programs directly related to the improvement of life on Earth." The final MOSC configuration called for a four-man modularized facility; the manned module would be based on the Spacelab design, and Spacelab pallets would also be used to support unpressurized payloads. Figure 7 shows the MOSC configuration. Total program costs for development and operation of the initial MOSC facility were estimated to be $1.2 billion.[1]

Rather than attempt to gain approval to take the MOSC effort to a Phase B stage, NASA in the fall of 1975 decided to conduct two parallel space station systems analyses in which the emphasis was shifted from research in orbit to space construction. In explaining its study plans, NASA noted:

> Earlier space station studies emphasized the "Laboratory in Orbit" concept. Emphasis is now being placed on a Space Station as an "Operational Base" which not only involves a laboratory but also such uses as: (a) an assembly, maintenance, and logistics base for conducting manned operations involving antennas, mirrors, solar collectors, transmitters; (b) for conducting launch and retrieval operations for orbit-to-orbit and Earth-departure vehicles which may require assembly or propellant transfer in orbit; (c) for conducting retrieval, maintenance and redeployment operations for automated satellites; (d) for managing clusters of spacecraft and space systems as a central base for support for common services...
>
> Orbital location studies will emphasize the possible exploitation of geosynchronous orbit, as well as low inclination and polar low earth orbit...Current planning is directed toward a space station new start in FY 1979.[2]

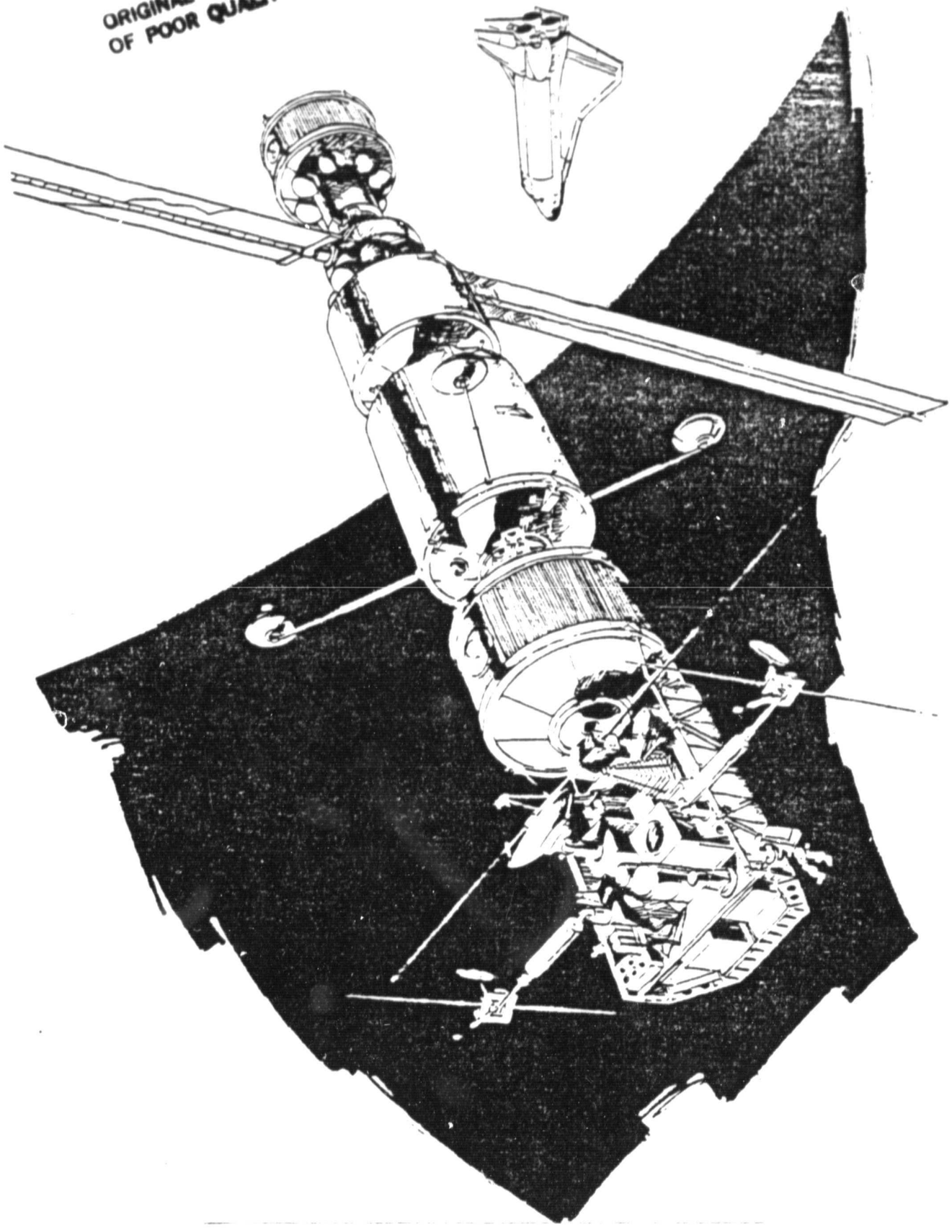

Figure 7. MANNED ORBITAL SYSTEMS CONCEPT

There were a number of reasons for NASA's switch in emphasis in space station justification. There was no evidence that the scientific community was any more supportive of a manned orbital laboratory concept in 1975 than it had been in 1970; prior attempts to justify a space station on its use as a space-based R&D facility had not been successful. More positively, the mid-70s saw a number of studies of the potentials of space operations for addressing problems on earth.

The most broadly-conceived of these studies was undertaken by a NASA study group which was asked by NASA Administrator James Fletcher in 1974 to provide an "Outlook for Space" -- "to identify and examine the various possibilities for the civil space program over the next twenty-five years." The study group concluded that "the great challenges facing the physical needs of humanity are principally the results of the continuing struggle to improve the quality of life. Particularly critical is the need to improve food production and distribution, to develop new energy sources, to meet new challenges to the environment, and to predict and deal with natural and man-made disasters. In each of these areas, we found that significant contributions can be made by a carefully-developed space program." The NASA report recognized that "future space programs must provide a service to the public." In responding to the "Outlook for Space" report, James Fletcher set as a primary NASA goal "accelerating the development of economic and efficient space services for society," such as "resources management, environmental understanding, and commercial returns from the unique contributions of space."[3]

The "Outlook for Space" report was not directly or strongly supportive of the need for a space station. It did conclude, however, that:

> Most of these activities might well be supported by the Shuttle system, together with associate space laboratories and free-flyers. There are more far-reaching objectives, however, which will require human activities in space transcending those supportable by current Shuttle flight plans, such as the construction of satellite power stations or the establishment of a permanent lunar base. It is difficult at this time to assert that either of these activities, or others like them - space manufacturing, space colonies - will be undertaken within the next 25 years. Nevertheless as we looked at the future of space, particularly at those more creative programs directed toward major exploitation of the opportunities which space provides, we inevitably found man to be an integral part of the system. If the United States is to be in a position to take advantage of these potential benefits then it would seem necessary that we develop the capability to operate a permanent manned facility in space in which human crews could operate for extended periods of time. The space facility would be constantly available, although crews would, of course, be periodically exchanged.
>
> The creation of such a permanent space facility seemed to us to be the most useful way to continue the advancement of manned-flight technology. With the Shuttle system giving us comparatively low-cost access to space on the one hand, and the economics which could be realized from the use of the permanent space facility on the other hand, the construction of a permanent space station appears to be the next logical step for the manned flight program - not as an objective in itself, but rather for its technological support of a number of other objectives which can benefit from our growing knowledge of how humans can work in space and to provide a foundation for the future.[4]

In addition to the "Outlook for Space" study, in the mid-1970s a number of even more visionary efforts were identifying challenging future space goals. One notion which received wide public attention, but had a relatively modest influence on NASA's internal planning activities, was the proposal by Princeton Professor Gerard O'Neill that primarily in response to the Earth's resource limitations work begin on developing very large human habitats in space -- space colonies. A concept which was quite attractive to NASA's engineers was developed by Peter Glaser of Arthur D. Little, Inc.; this was the proposal that large solar arrays in geosynchronous orbit could provide a

source or continuous energy on earth. The solar power satellite (SPS) idea was given a great deal of technical attention by NASA during 1975 and 1976, until NASA was forced by the Office of Management and Budget to turn over lead responsibility for SPS to the Energy Research and Development Administration (soon to become part of the Department of Energy).

Developing a SPS would require extensive on-orbit manned operations and the capability for assembling very large structures in space. Similar construction requirements were derived from less grand schemes involving large antennas in space for communications use and scientific investigations.

By the end of 1975, NASA had developed a plausible argument that space construction might be a major requirement of its programs during the 1980s, and wanted to explore the role of manned orbital facilities in carrying out these construction efforts. In December 1975 the agency issued a request for proposals for a "Space Station Systems Analysis Study"; the study effort was to be focussed around the use of a space station to "serve a wide range of operational base and space laboratory activities," such as using the station "as a test facility and construction base to support manufacturing, fabrication and assembly of various sizes of space structures."[5] Aviation Week reported that the station studies reflected NASA's "belief that a large permanent U.S. facility in space is the logical follow-on to develoment of the space shuttle".[6]

Two parallel study contracts for the Space Station Systems Analysis Studies (SSSAS) were let by NASA in April 1976; one went to McDonnell-Douglas, which would work under the direction of Johnson Space Center, and the other other went to Grumman Aerospace, which would work with Marshall Space Flight

Center. The studies were budgeted at $700,000 each and were scheduled for an 18-month duration.

The McDonnell-Douglas SSSAS study focussed on four objectives which offered "the promise of: serving important needs of man on earth; advancing U.S. preeminence in science and technology; and ultimately generating an economic return on investment, essential if permanent government support is to be avoided." These objectives were:

1. a satellite power system;
2. providing earth services for resource management and communications; the major projects here were 30-meter and 100-meter radiometers;
3. processing materials in space for commercial users; and
4. furthering scientific research.

The study identified a "common point of departure" for meeting these objectives, which was "the basic requirement for construction facilities in orbit." Such facilities would involve: crane operations, capabilities for fabrication and assembly of structures, manned extra-vehicular activity, and long duration (approximately 90 days per crew) human presence. These capabilities could best be provided, the study concluded, by a manned "construction shack" as part of the space construction base; this manned element would be the last addition of an evolutionary build-up from sortie flights, through a shuttle-tended unmanned construction base, to a permanently manned orbital facility. The cost of having a fully capable station in orbit by 1988, and of the associated missions which the construction base would perform, was estimated to be $2.4 billion.[7]

The Grumman SSSAS reached similar conclusions. It too focussed on missions related to solar power satellites, space manufacturing, and scientific experimentation, and also on a large-antenna public service platform, and found that a continuously-manned space construction base was an integral element of the capabilities needed to perform these missions; such a base, Grumman estimated, could be in operation by early 1986. The study found that "space solar power emerged as the most compelling mission with the greatest impact on the program. Space manufacturing, public service communications and earth observation, and the solar terrestrial observation missions fit well within the solar power development needs for large energy power supply, long duration manned presence in space and an in-space construction facility..."[8]

One finding of the SSAS studies was that scientific efforts could "go along for the ride" on space stations capable of supporting construction, materials processing, and power generation objectives. One aerospace publication reported that:

> The space base concept is one whose time seems to be coming rather quickly. Until recently, space stations have been thought of mainly as..."the traditional laboratory in the sky." Some observers were surprised when construction, materials processing and power were given roughly equal status with science...Now, the balance has shifted further... space construction work as the "prime focus" of the studies.[9]

When NASA began its SSSAS effort in late 1975, its hope had been to use the Phase A study results as the basis for a Phase B space station "new start" in fiscal 1979, i.e., sometime after October 1978. However, NASA was unable to get the approval of the Office of Management and Budget (OMB) to proceed on

a schedule which would have made such a new start possible. For one thing, much of NASA's justification was based on using a space station during the development of a solar power satellite, and OMB was strongly opposed to the SPS concept and had taken it away from NASA planners. Both the outgoing Ford Administration and the incoming Carter Administration rejected a NASA request for $15 million for space station studies in the FY 1978 budget[10] (In FY 1977, the budget requested for all advanced systems studies had been $13 million.) This rejection, moreover, was quite emphatic; NASA was told that OMB was very unlikely to consider any substantial funding for the space station until the space shuttle program was clearly a success. At this time (1977) the Shuttle program was experiencing technical difficulties and cost and schedule overruns, and the White House was giving serious consideration to major changes (including possible termination) in the program. This was hardly a congenial context for NASA to propose a major follow-on program. Recognizing that NASA was not going to be able to start on a major space station effort anytime soon, by the spring of 1977 NASA officials were suggesting that "the (Shuttle) orbiter is a significant space station in itself," and were looking towards ways to enhance shuttle capability to perform many of the missions that the SSSAS studies had assigned to a space station[11]

C. Johnson Invents the Space Operations Center

Rather than being the year in which significant momentum behind a space station program was developed, 1978 turned out to be a year in which there was essentially no space station activity *per se*. The SSSAS studies had identified, as important steps in extending the capabilities of the space

shuttle, the development of an in-orbit power supply and of shuttle-tended unmanned orbital platforms for various science and applications payloads. Both Johnson Space Center and Marshall Space Flight Center were studying orbital power supplies during 1978; the Johnson Space Center concept was called a power extension platform (PEP), while Marshall Space Flight Center was examining a 25 kW power platform. Marshall also initiated studies of an unmanned Science and Applications Space Platform (SASP), and most of the MSFC study activities during the 1978-1980 period were devoted to these two program concepts. (During 1981 and 1981, MSFC contracted with McDonnell Douglas to study an evolutionary program through which an unmanned platform such as the one defined in the SASP study could grow into a manned platform, and, i.e., a space station, perhaps one along the lines that McDonnell Douglas had earlier defined in the 1975 Manned Orbital Systems Concept study.)

While Marshall's emphasis was on an evolutionary approach to space platforms, theleadership of the Johnson Space Center had, by early 1979, decided that the center's efforts should refocus on a major space station effort. Aviation Week reported JSC was "concerned about this lack of continuing assessment for permanently manned U.S. facilities" and was "mindful of the growing soviet capability in this area."[12] Another factor influencing JSC thinging was "a need for a real goal to maintain the dedication of present participants in the space program and the interest and enthusiasm of young people in space technology in order to motivate their pursuing engineering and science careers."[13]

Based on these considerations, JSC during 1979 conducted an in-house study of a concept identified as a Space Operations Center (SOC).

This study was based on two assumptions: "that the next 10 to 20 years will include requirements for large, complex space systems" and "that geosynchronous orbit is clearly a primary operational area in space in the coming decades." If these assumptions were valid, JSC argued, then "the space construction and servicing of these future systems will be more effective with a permanent, manned operations center in space."

The primary objectives of the SOC were identified as:

o The construction, checkout, and transfer to operational orbit of large, complex space systems.

o On-orbit assembly, launch, recovery, and servicing of manned and unmanned spacecraft.

o Further development of the capability for permanent manned operations in space with reduced dependence on Earth for control and resupply.

The SOC study noted that this list of objectives:

> noticeably does not include onboard science and applications objectives, although the free-flying satellites which would be serviced would include mostly those of this genre. The primary implication of this omission is that experiment and applications requirements will not be design drivers; the SOC will be "optimized" to support the operational functions of the objectives. However, experiments or applications which can tolerate the operational parameters of the SOC can be operated onboard, or an entire dedicated module could be attached to an available berthing port.

The study developed a concept of a self-contained, continuously- manned orbital facility built from several shuttle-launched modules. (Figure 8) The initial SOC crew would be 4-8 people. In addition to a core facility, the full capability SOC would require a construction facility and a flight support facility. (Figure 9) The costs of this fully-capable SOC were estimated at $2.7 billion, with the total facility in place 9-10 years after program initiation.[14]

Johnson Space Center briefed interested parties on SOC at the end of November 1979, in anticipation of initiating a contractor study of the concept during 1980. One account of this briefing suggested that the "space station may be ready for a comeback."[15] Perhaps more realistic, however, were these sentences, prominently displayed at the start of the report of the Space Operations Center study:

> It should be noted that there are no NASA plans at present to implement such a concept. The study reported herein and currently planned follow-on studies are intended to explore the concept and develop material for consideration in future planning.[16]

D. Conclusion

It should be evident from the whole of this report that there can be no obvious cut-off point for an account of the development of the space station concept; this report arbitrarily breaks the story at the end of 1979. In the three years since the SOC concept was first publicized at the end of 1979, NASA has become engaged in an agency-wide effort to define a space station program which will represent an attractive investment opportunity to the nation's leaders. This effort is drawing upon the over two decades of NASA space station planning described in this report in the context of the success of the space shuttle, increasing commercial and national security interest in space activities, and NASA's need to define its post-shuttle directions. Perhaps this time around, the space station will indeed be accepted as the "logical next step" in evolving U.S. capabilities to operate in space. If this is the case, then the years of effort described in this report will have been justified.

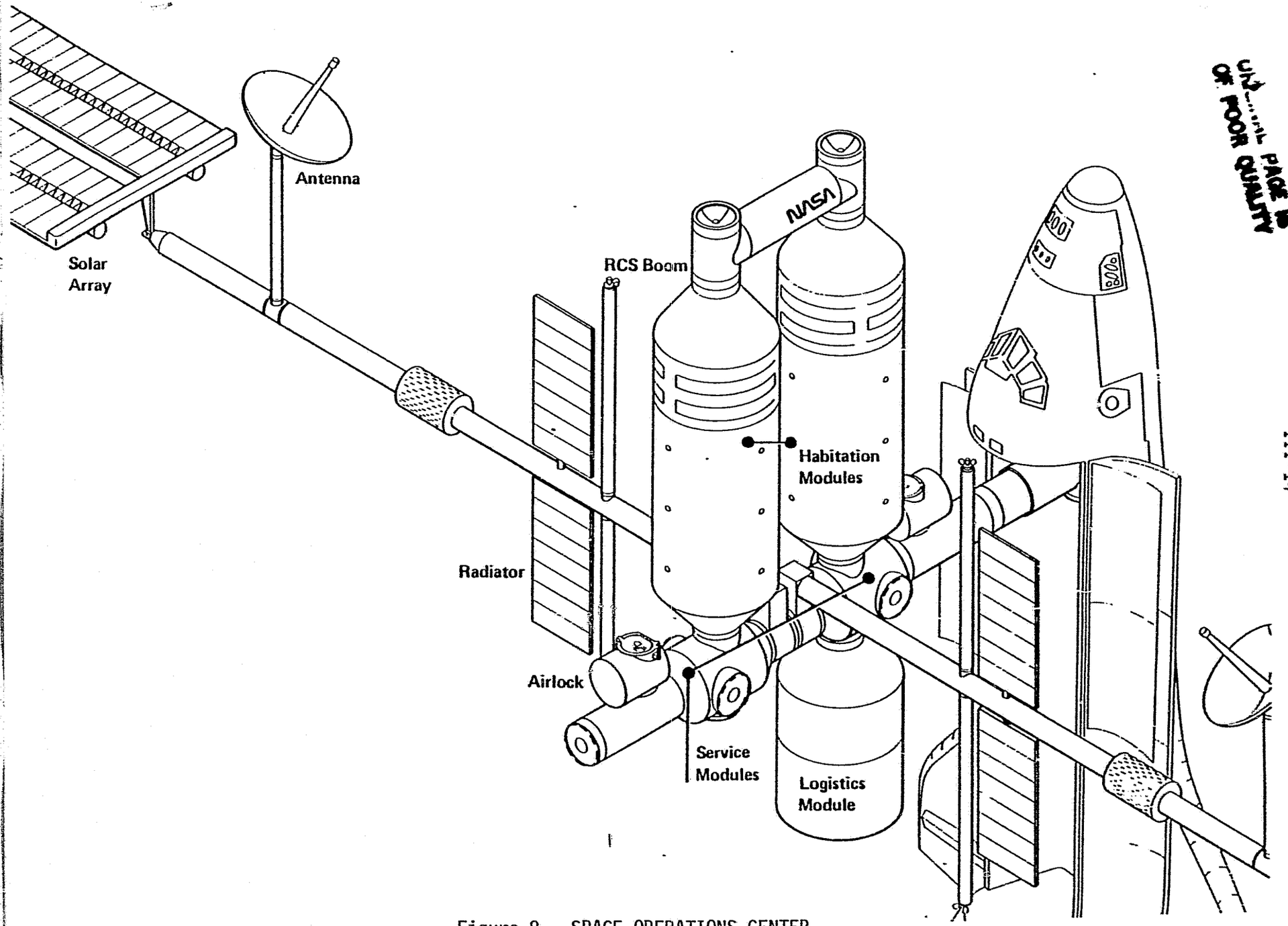

Figure 8. SPACE OPERATIONS CENTER

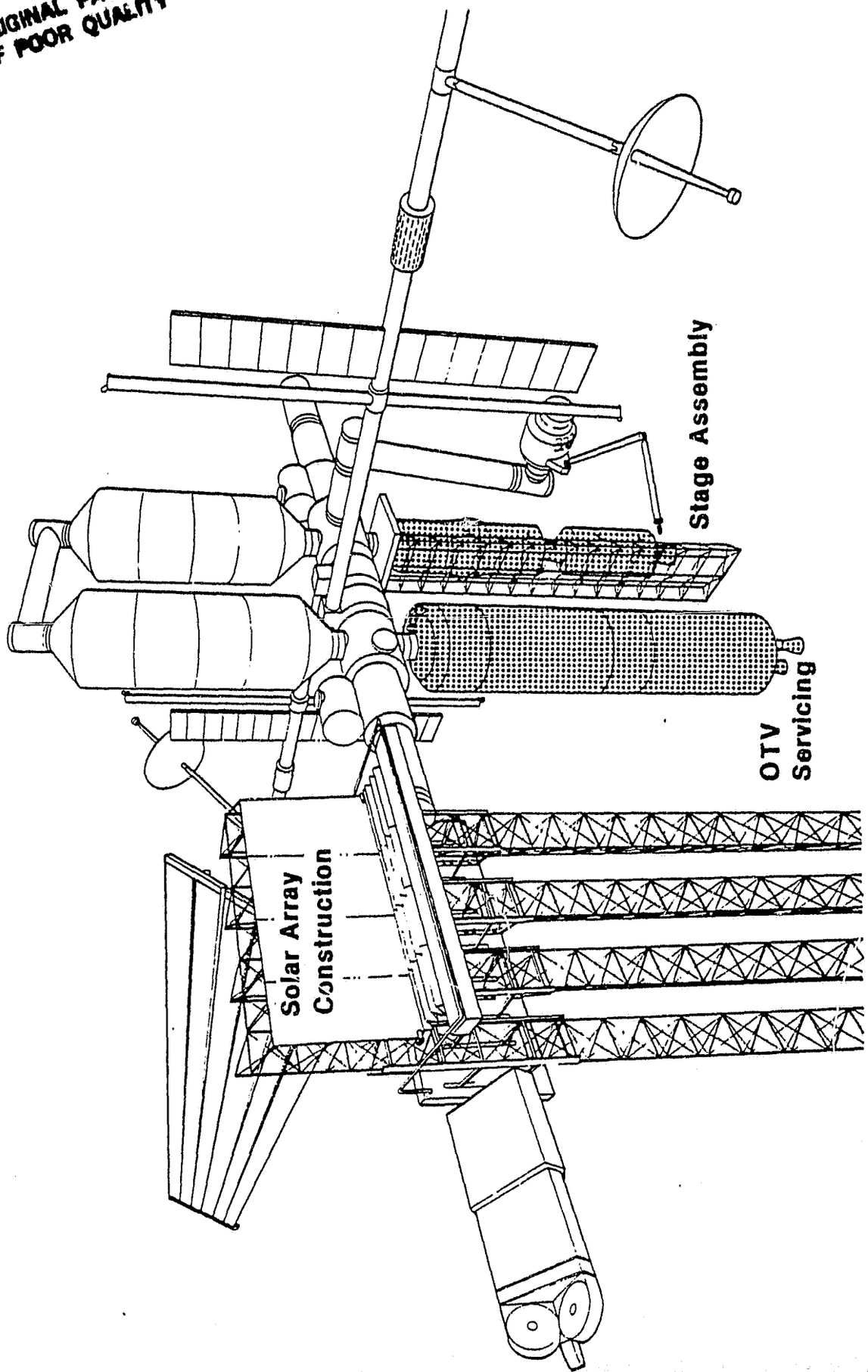

Figure 9. SOC WITH CONSTRUCTION AND FLIGHT SUPPORT FACILITIES

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Chapter I

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