Appendix B

THE EVOLUTION OF CIVILIAN IN-SPACE INFRASTRUCTURE, I. E., "SPACE STATION," CONCEPTS IN THE UNITED STATES*

Introduction

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 development of some kind of permanent presence i n space to support space activities i n an efficient and effective manner, is now u rider way.

This appendix reviews those past occasions, with particular attention to the rationales offered at various times for space infrastructure development and to the differing concepts which have been proposed. History can cast a useful perspective on current policy alternatives, which, after all, reflect the continuation of a long-running debate over the justification for infrastructure of various characteristics, size, and cost. By sketching the earlier points in the history of the U.S. space program at which a "space station" has come under serious consideration as a major project, only to be rejected in favor of some other alternative, it may be possible to identify what is now different, and what is not, that might now lead to a more favorable evaluation of various proposals.

Earliest Space Infrastructure (i e., "Space Station" Concepts)[1]

The first proposals for "space stations" conceptually akin to modern schemes appeared in the late nineteenth century. Konstantin E. Tsiolkovsky's Dreams ***of Earth and Sky and the Effects of Universal Gravity*** (1895) and Kurd Lasswitz's ***On Two Planets (1897)*** set the tone by picturing "space stations" as stepping stones for trips by people to the planets, especially Mars. Like these earliest contributions, succeeding proposals included fiction and nonfiction, humanism and science, practicality and fancy. They were sparked by an unbridled enthusiasm for spaceflight and a firm belief that exploration of the planets was human destiny. Most were informed enough to realize that direct ascent from Earth to interplanetary space was not technical y attractive. "Space stations" were way stations, logistics depots on the way to the planets.

Tsiolkovsky in 1923 wrote of a station placed "at a distance of 2,000 to 3,000 versts (a Russian unit of distance equal to 0.6629 mile) from the Earth, as (an artificial) Moon. Little by little appear colonies with supplements, materials, machines, and structures brought from Earth." In his 1923 book, ***The Rocket Into Interplanetary Space,*** space pioneer Herman 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 orbital refueling station for outward-bound space vehicles.

The early proposals resulted in more words than hardware. The only group of "space station" advocates to make progress toward realizing their dreams were the members of the German Rocket Society, among whom the "space station" concept became common currency.[2] But even they could only muddle along on rocket research with the limited private funds at their disposal until military support prompted by the approach of World War II brought on the financing necessary for research and development that would lead to spaceflight. Wernher von Braun and his associates built the v-2 rocket for the Wehrmacht in order, they said later, to achieve their real goal—the development of spaceflight. Whatever their motives, after the war they brought to the United States the most advanced rocket technology in the world and schemes for "space station" and interplanetary flight that had been sparked and nurtured by the romantic enthusiasm of the first half of the 20th century.

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*This paper was prepared for OTA by John Logsdon, based in part on original material by Alex Roland,

[1]Much **of this section is based on papers by Frederick** 1. **Ordway,** III, **"The History,** Evolution, **and Benefits of the Space Station Concept, " presented to the** XIII International Congress of the History of Science, August 1971; and Leonard David, "Space Stations of the Imagination," ***AIAA*** *Student Journal* vol ***20, No, 4,*** **winter 1982/1 983.**

[2]**Barton** C. **Hacker, "And Rest As On a Natural Station: From Space** Station **to Orbital Operations in Space-Travel Thought, 1985-1951 ," unpublished paper, NASA History** Office **Archives (hereafter NHOA), Washington, DC,** p **9.**

In the United States in the years immediately following World War II, both scientists and military leaders recognized that the ability to launch payloads into orbit would have important implications for their particular fields of activity. In considering the various uses to which space might be put, several lines of development emerged. First, to the concept of "space stations" with human crews as stepping stones to the planets was added the less dramatic but more realizable concept of relatively small Earth satellites, not to send men to other celestial bodies but to perform practical, Earth-oriented tasks in orbit: communication, scientific research, reconnaissance, etc. j

Second, further consideration led some to conclude that bases in orbit were "not necessary for most activities envisioned there: rendezvous of the rockets and satellites themselves is sufficient to most purposes. "[4] But this perspective and its appearance in the literature did nothing to deter a third line of development: the elaboration of earlier concepts of "space stations, " perpetuated in this era most spectacularly by Wernher von Braun's concept of a toroidal "space station. " Von Braun's ideas received wide publicity in a Col*lier's* magazine special titled "Man Will Conquer Space Soon." Von Braun 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, 25-ft-wide, wheel-shaped station in polar orbit which would be a "superb observation post" and from which "a trip to the Moon itself will be just a step." The main element of space infrastructure would be accompanied by another: a free-flying observatory that would be tended by a crew.

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 people and materials from the rocket ships to the station itself.

Von Braun noted a number of uses for a "space stat ion":

- "a springboard for exploration of the solar system";
- "a watchdog of the peace";
- a meteorological observation post;
- a navigation aid for ships and airplanes; and
- "a terribly effective atomic bomb carrier. "

This detailed description was only one of the many concepts developed in the years after World War II but prior to the 1957 launch of Sputnik and the formal beginning of the Space Age.[6] Even before the United States had an official civilian space program, most of the possible uses of a "space **station" had** been identified by visionaries who dreamed of space travel,[7]

The Response to Sputnik, 1957-61[8]

Sputnik changed the context for U.S. space activities. In spite of President Eisenhower's attempts to avoid it, a space race with the Russians was on. All kinds of proposals that would have been laughed from the stage in earlier years were put forward in deadly earnest. Many at home and abroad perceived the United States as having fallen behind the Soviet Union at least in this sophisticated technology, and nothing but a crash program would do.

Having people in space is the most complicated and the most dramatic of space activities, and it quickly became the focus of the competition. News that the Soviets were considering a "space station" of the von Braun variety fanned the enthusiasm in the United States for a like undertaking and underlined the military overtones of the space race.[9] As one observer put it, "the rapid and timely completion of the Military Space Station will do much to bring about space ***supremacy*** (italics added) for America and lay the scientific foundation for the aerospace power of the future."[10]

But this was not to be. In spite of all that the military had done to pioneer research in spaceflight, President Eisenhower opted for a civilian space agency, the

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[3] R. Cargill Hall, "Early US. Satellite Proposals," *Technology and Culture,* vol. 4, 1963, pp. 41 O-434; and Arthur Clarke, "Extraterrestrial Relays: Can Rocket Stations Give Worldwide Coverage?" *Wireless Wodd,* October 1945, pp 305-308.

[4] Harry E. Ross, "Orbital Bases, " *Journal of the British Interplanetary Society, vol. 9,* 1949, pp. 1 -19; Kenneth W. Gatland, "Rockets in Circular Orbit, " *Journal of the British Interplanetary Society, vol. 9, 1949,* pp. *52-59.*

[5] Wernher von Braun, "Crossing the Last Frontier, " *Collier's,* Mar, 22, 1952, pp. 25-29, 72-74.

[6] The detailed description in the von Braun article should not be confused with a detailed design. For two early detailed designs, see: 1) "Assembly of a Multi-Manned Satellite, " Lockheed Missile and Space Division, LMSD 48347, Dec. 18, 1958 (available in the archives of the National Air and Space Museum of the Smithsonian Institution); and 2) "A Modular Concept for a Multi-Manned Space Station, " in the IAS *Proceedings of the Manned Space Stat/on Symposium,* Apr. 20-22, 1960, pp. 37-72.

[7] See, for example, the IAS report, op. cit.

[8] This history is recounted in John M. Logsdon, *The Decision to Go to the Moon Project Apollo and the National Interest* (Cambridge, MA: MIT Press, 197o), ch. 2; and W. David Compton and Charles D. Benson, *Living and Working in Space: The History of Skylab* (Washington, DC: National Aeronautics and Space Administration, 1983), SP-4208, ch. 1.

[9] "Soviet Scientist Sees Need for Manned Station in Space, " *Aero/Space Engineering, vol.* 17, September 1958, p. 27.

[10] Lowell B. Smith, "The Military Test Space Stat Ion," *Aero/Space Engineering, vol.* 19, May 1960, p. 19.

National Aeronautics and Space Administration (NASA), and entrusted it with a manned mission. And that mission would be a modest one, at least at the start. Project Mercury would demonstrate that a person could fly in space; until then there would be no talk of "space stations" and manned flight to the Moon and planets.[11]

However, as the new space agency began operations, NASA leadership set the development of a long-range plan for the agency's first decade as a high-priority task. 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 i n 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 question of whether a "space station's" value for scientific research, especially in the biomedical area, outweighed 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 representative of one center argued for an interim step, since "in true spaceflight 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. " [12] 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. For example, 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 a permanent manned "space station. "[13] Low also announced the name of the advanced spacecraft program, then aimed both at the Moon and at "space stations"; it was to be called "Project Apollo."

The Apollo Anomaly

Once again, however, external events intervened to upset the orderly course of events envisioned by those planning the country's future in space. President Kennedy came into office in 1961 committed to reassert America's vitality and resolve in the war of nerves with the Soviet Union. When, in April 1961, the Russians tested the United States once again by launching the first man into space, Kennedy ended his early indecisiveness on the space program and in 1961 committed the country to the race to the Moon. This decision, the most momentous in the history of the American space program, was made for reasons of prestige and politics.[14] It determined the future of NASA and its programs more thoroughly than any other decision before or since. That influence operated on two levels.

First, and perhaps most importantly in the long run, the style and public perception of the Apollo commitment made it something of a model for all future space proposals. President Kennedy made the decision quickly but not precipitously. He consulted his staff and NASA and chose the Moon landing as the most dramatic and most feasible of the suggestions for demonstrating U.S. ability to best the Soviet Union in high-technology competition. He presented the idea in a speech before an unusual joint session of Congress, in which the new President outlined his plans for fulfilling his campaign promises of getting the United States moving again.

"Now is the time," said Kennedy, "to take longer strides—time for a great new American enterprise—time for this nation to take a clearly leading role in space achievement, which in many ways may hold the key to our future on Earth. "[15] In a moving and uncompromising challenge, the President called on ***Con-***

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[11] Loyal s Swenson, jr., James M, G rimwood, and Charles C. Alexander, *This New Ocean **A History of Project Mercury,*** **NASA** SP-4201 **(Washington,** DC:National **Aeronautics and Space** Administration, **1966).**

[12] Bruce Loft **I n,** as quoted in the Minutes of **the Research** Steering Committee **on Manned** Flight, **meeting** of **May 25-26, 1959** (NHOA)

[13] George Low, "Manned Space Flight," in NASA, ***NASA** -Industry **Program** Plans **Conference,*** July **1960, p. 80,** (NHOA).

[14] Logsdon, op. **cit.,** chs. **3-5, recounts the history of the** decision to begin **the Apollo program and analyzes the motives** which **led to that** decision

[15] Ibid **, p. 128**

gress and the public to commit itself to a $25-billion[16] undertaking in space for largely intangible goals of prestige and competition. Congress and the public agreed, launching NASA on its most famous and formative enterprise and creating an indelible image of how to launch a major project in space. Only slowly, if at all, would NASA administrators and other space advocates come to realize that the Apollo commitment was a political anomaly defying duplication.

The Apollo decision also ensured that in accomplishing the lunar landing objective the United States would develop a large, but specialized, space capability, and that manned spaceflight would come to dominate all other kinds for at least a decade. And it ensured, especially after it was complemented by the lunar-orbital rendezvous decision, that the "space station" concept would recede into the background for the duration of the race to the Moon. The Moon mission would proceed on its journey directly from Earth orbit–simply because that was the quickest way to go (though not necessarily the best for long-term development) and the Saturn V launch vehicle (originally designed for other purposes) would permit it.

In this hothouse atmosphere, Project Mercury and Project Gemini became demonstration programs for Apollo. Many of the tasks that had to be accomplished in order for Apollo to succeed were also on the agenda for "space station" research. Mercury, for example, demonstrated that a person could survive the weightlessness and radiation of space. Gemini demonstrated that rendezvous, docking, and extravehicular activity were feasible. The last of these was always more important to "space station" plans than to Apollo. Both projects demonstrated, at least to some, that a human being was a crucial component of the spacecraft's capability, performing such functions as piloting, observing, and photographing; and piloting especially was contrasted with the comparatively primitive, ground-controlled capsules of the Russians in which the cosmonaut was simply a passenger. '

Notwithstanding these positive steps on the road to a total manned spaceflight capability, Apollo was to prove a programmatic deadend for NASA. Many in NASA understood all along that the lunar rendezvous approach to accomplishing the objective was a technical anomaly and they never gave up their notion of a more logical approach to human exploitation of space, i.e., a "space station. " For this reason, while Apollo was at the center of public attention during the 1960s, studies of "space station" concepts proceeded throughout the decade.

"Space Station" Plans During the 1960s

During the 1960s, "space station" studies were conducted both within NASA and by the various aerospace contractors (particularly those without a major role in Apollo). They resulted in examination of a wide variety of concepts, ranging from inflatable balloon-like structures, through the use of refurbished rocket stages, to very large stations requiring 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.[18]

While the manned flight centers at Houston and Huntsville were focusing almost their total energies on getting Apollo started in the early 1960s,'9 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.[20] Langley researchers noted that "a large manned orbiting 'space station' may have many uses or objectives." Among these objectives they listed:

1. learning to live in space;
   - artificial-gravity experiments,
   - zero-gravity experiments, and
   - systems research and development,
2. applications research;
   - communications experiments,
   - earth observations,
3. launch platform experiments; and
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**

[16] Then—some $60 bill ton today.

[17] Swenson, et al., Op. cit.; Barton C. Hacker and James M. Grimwood, *On the Shoulders of Titans: A History of Project Gemini,* NASA SP-4203 (Washington, DC: National Aeronautics and Space Administration, 1977).

[18] Studies during the 1960s at the Langley Research Center, the Manned Spacecraft Center, and the Marshall Space Flight Center are summarized in Langley Research Center, *Compilation of Papers Presented at the Space Station Technology Symposium,* Feb. 11-13, 1969 (NHOA).

[19] Evenso, both Houston and Huntsville had "space station' study efforts under way; in particular, Houston was studying a large (24-person) "space station" to be launched by a Saturn V. The studies directed by Langley have been chosen for review because they were more fully developed than those directed by the two other centers.

[20] The early Langley studies are summarized in Langley Research Center, *A Report on the Research and Technological Problems of Manned Rotating Spacecraft,* NASA Technical Note D-1 504, August 1962 (NHOA).

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. [21]

Among 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.[22]

In this study, a baseline technical concept for an MORL was established first, then the "utilization potential" of such a station was 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 proceeded, the MORL got steadily more sophisticated and bigger, as there were no criteria established to limit the addition of new experimental requirements.

The MORL requirements study examined:

- Earth-centered applications;
- national defense;
- support of future space flights; and,
- the space sciences.

From this analysis, the study predicted the need for "hundreds of thousands of man-hours" 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. " The final MORL concept, although basically a zero-gravity station, had an onboard centrifuge for reentry simulation, testing of physical condition, and physical therapy if zero-gravity conditions were debilitating for the crew.[23]

By early 1963, NASA Associate Administrator and General Manager Robert Sea mans 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" [24] and 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 to 6 week high-priority study which would examine EOL proposals in terms of, among other factors:

1. Defense Department interest,
2. international factors, and
3. other government agency interest. [25]

Throughout this study and other attempts to define a "space station" program in the 1963-66 period, there was a continuing tension between those designing the station itself (primarily associated with the Office of Manned Space Flight (OMSF), its field centers and associate contractors) and those interested in the experiments and other uses of such a facility (primarily the Office of Space Science and Applications and the Office of Advanced Research and Technology (OART)). 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. "[26]

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

[21] Ibid

[22] George V Butler, "**space** Stations, **1959** To?" in B. J. Bluth **and S R.** McNeal *Update* ***on*** *Space*, **vol 1 (Granada Hills, CA National Behavior** Systems, **1981** J, **p 8**

[23] Douglas **Missile and Space Systems** Division, **Douglas Aircraft CO., " Report on the Development** of **the Manned** Orbital **Research Laboratory** (MORL) **System Utilization Potential, "** Report SM-48822, **January 1966.**

[24] Though it is **not** discussed in detail **in this report,** duri **ng 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 the ways** in **wh ich human crews cou ld be used to enhance national security operations** in **orbit The** MOL was canceled in 1969

[25] Memorandum from NASA Associate Administrator, "Space Task Team for Manned Earth Orbiting Laboratory Study," Mar. 28, 1963 (NHOA).

"Memorandum from Chief, Manned Systems Integration, to Director, Office of Advanced Research and Technology, " SEB for the Manned Orbital Research Laboratory, May 16, 1963 (N HOA).

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that "a view has prevailed to date, based **primarily on intuitive judgment** [emphasis added here], 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 MORL project should be undertaken."**[27]

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 knowledgeable support to **NASA for implementation of a national multipurpose 'space station' program."**[28]

Beginnings of Post-Apollo Planning[29]

Under pressure from the White House and Congress, NASA began looking beyond the Apollo project in 1964 and 1965. In 1964, an in-house examination of NASA's future options had recommended that NASA defer "large new missions for further study and analysis. "3° However, there was concern within NASA about maintaining an adequate workload for both NASA centers and NASA contractors, as the development phase of Apollo neared completion, and an evolutionary approach from Apollo to more advanced activities appeared more likely to meet this need, **given the low probability of a major new start on post-Apollo programs.**

The nature of NASA's long-range planning during this period turned on the style and personality of the Administrator, James E. Webb. A lawyer and businessman who had served President Harry Truman as Director of the Bureau of the Budget (BOB) and as Under **Secretary** of **State,** Webb combined an ebullient and dynamic personality with a keen political sense and long familiarity with the ways of Washington. He believed in long-range planning, but he eschewed long-range plans, which he felt excessively tied the hands of the Administrator. He wanted to be prepared for the future, but he did not want to commit himself or NASA prematurely to another project as large as Apollo.

Webb adopted two approaches to post-Apollo planning. First he characterized and rationalized Apollo as the development of a ***capability*** in space, not an end in itself. Once the Moon landing was accomplished, NASA would be able to convert the resources and experience of the Apollo program to other purposes through a program called Apollo Applications. Second, he used his fine political sense to ensure that NASA adjusted its ambitions in space to suit the climate of opinion in Washington and throughout the Nation. As the war in Vietnam and the domestic unrest of the late 1960s compounded NASA's problems in getting congressional attention and appropriations, NASA gradually modified its internal plans and proposals. The agency took more clearly the line that Webb stressed throughout his tenure: NASA **must have a balanced program in which manned spaceflight played a role along with space science, applications, and aeronautical research.**

NASA spoke more often in the mid-to-late 1960s of practical, Earth-oriented space activities, which would exploit the gains already made and provide taxpayers with tangible returns on their investment in space, And, increasingly, NASA came to look on the "space station" as the logical next step that would at once exploit the Apollo team and its achievements and still respond to political pressure for a measured and pragmatic space program .[31]

The public debate in the late 1960s on the future of the space program introduced many of the concepts about the "space station" that still surround this proposal–some inherited from the Apollo experience, others developed to address the criticisms of that program. First, NASA sought, in conjunction with its plans for a "space station," to define an undertaking large enough to focus the agency's future activities, as Apol-10 had focused them in the 1960s. Occasionally, it was suggested that a manned Mars mission would provide the ideal focus,[32] but the "space station" could per-

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[27] Memorandum from Director, Office of Advanced Research and Technology, "Request for Assistance in Defining the Scientific and Technological Research Potential of a Manned Orbital Laboratory, " Oct. 31, 1963, NHOA. This is not a reference to the **Air Force's MOL Program.**

[28] Memorandum from Director, Advanced Manned Missions Program, "1 ncreased Participation of Potential User Agencies in Development of Broadly Beneficial Utilizations of Manned Orbiting Space Station, " July 15, 1964 (N HOA).

[29] See Arnold Levine, ***Managing NASA in the Apollo Era,*** NASA Sp-4012 (Washington, DC: National Aeronautics and Space Administration, 1983), chapters 2 and 9 and James Webb's foreword, for a full account of post-Apollo planning.

[30] The report was called "Summary Report, Future Programs Task Group, " and was printed in U .S. Senate, Committee on Aeronautical and Space Sciences, ***Hearings, NASA Authorization for Fiscal Year 1966,*** 89th Congress, 1st sess., 1965, pt. 3, pp. 1027-1102.

[31] See, for example, Webb's testimony i n U.S. Congress, Senate Committee on Aeronautical and Space Sciences, ***National Space Goals for the Post-Apollo Period,*** Hearings, 89th Cong., 1st sess., Aug. 23-25, 1965.

[32] Webb for example, stressed the importantance of focus in a letter to President Johnson, Feb. 16, 1965, published in U.S. Congress, Senate Committee on Aeronautics and Space Sciences, ***NASA Authorization for Fiscal Year 1966,*** op. cit., p. 1028,

form the same function, even while providing a logical step toward Mars. The "space station" had the added advantage of seeming more practical and Earth-oriented. Second, NASA stressed the flexibility of the "space station" concept and a station's ability to perform a variety of functions ranging from Earth-oriented applications and scientific research to staging platforms for manned missions to the planets. George E. Mueller, NASA's Associate Administrator for Manned Flight, emphasized the economic benefits of "space stations" i n such areas as applications, weather, communications, research, and national security. [33]

NASA advocacy of "space stations" also argued that the country should see that the Apollo team and hardware were held together and exploited, should maintain manned spaceflight in addition to unmanned missions, and should sustain the Nation's preeminence in space in flight operations, science, and technology lest the Soviets win the long-term space race by default.[34] Occasionally, NASA invoked national security as a rationale for the "space station, " but in the 1960s, at least, this brought the agency into apparent conflict with the Air Force's Manned Orbiting Laboratory, a conflict Webb tried to avoid, at least in public. [35]

The theme that NASA employed most relentlessly was that the "space station" was the logical next step in the development of America's capability in space. George Mueller was especially emphatic. Speaking of practical applications, he testified:

> **The major steps that are involved . . . are, first of all, the development of an orbital "space station, " and along with that is a** need **for a logistics system to pro-**vide support for an orbital "space station. " That combination then leads to the development of what might be called an application center, and if you will, that is probably going to turn out to be a relatively large orbital station which will have in it the sensors that are required .36

Continuing this hypothetical progression of Earth-oriented, practical "space stations, " Mueller added that,

> . . . having utilized this orbital station for a number of years, there is another major step forward in going to a research complex which might be the large orbiting research laboratory and coming from that research complex, then, would come the second generation of application centers, and here they would be more specialized and there would be more of them.

This envisaged a time well into the future where man is really operating on a continuing basis in space . . . . Mueller also proposed that:

> we can go in the direction of exploiting our lunar capability as it developed in the basic Apollo program and will be developed further if the Apollo Applications Program is carried out. Or we can go in the direction of increased emphasis on Earth orbit applications . . . . We can go from Apollo applications through the development of an orbital "space station, " and then on to the near planet flyby systems and follow a logical path which then goes to planetary exploration.

For all the purposes a "space station" might serve, from the purely practical to the widely visionary, it was always cast in this period as the logical next step in developing space capability. NASA instituted an Apollo Applications Program, but this was an interim move towards what the agency really sought: a major political commitment to make the next step another large one.

In 1967 and 1968 this campaign suffered major reversals which had permanent impact on the course of events. The Apollo 204 fire in January 1967, which killed three astronauts during preflight testing at Cape Kennedy, set the Apollo landing back a number of months, and cast the first serious doubt on NASA's ability to meet its Apollo goal. The accident also focused congressional attention on NASA and consumed some of the agency's political credit on the Hill. Perhaps more damaging in the long run was the resignation of James Webb in the closing weeks of the 1968 presidential election campaign. Leaving the agency without the major commitment to a post-Apol-10 program he had sought, Webb took with him an irreplaceable sense of political pragmatism that the agency would sorely miss.

As the first successful lunar landing mission approached, in the fall of 1968 NASA requested $60 million to initiate a "space station" effort. 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.

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[33] Mueller's **testimony** is in U.S **Congress, Senate** Committee on Aeronautical **and Space Sciences, *National Space Goals for the Post-Apollo Period,*** op **Clt** , p. 103

[34] U .S Congress, Senate Com mittee on Aeronautical and Space Sciences, *National Space* God/s *for* ***the Post-Apollo Period,*** op. Cit., p. **338,**

[35] Webb told Congress the MOL **"represents** an added nationa l space Capa bility rather than a competitive one. " Ibid , p, 341. See also the testimony of Harold Brown, Director of Defense Research and Engineering, esp p. 336

[36] This and the followi **ng** two q uotations are from ibid , pp. **49, 62, and 64**

Post-Apollo Planning Under Thomas Paine

A **research engineer before joining NASA** as Deputy Administrator in January 1968, Thomas O. Paine became Acting Administrator following Webb's resignation in October. Nominated NASA Administrator by President Nixon in March 1969, Paine was confirmed by the Senate the same month, beginning the shortest term—less than 20 months—of any NASA head.

Paine was a swashbuckler,[37] an out-and-out space enthusiast, critical of the caution and circumspection of his predecessor and determined to inaugurate the second decade of space with a major, national, Apollo-like commitment. As he wrote to the President's science advisor after being confirmed as NASA Administrator:

> We have been frustrated too long by a negativism that says hold back, be cautious, take no risks, do less than you are capable of doing. I submit that no perceptive student of the history of social progress doubts that we will establish a large laboratory in Earth orbit, that we will provide a practical system for the frequent transfer of men and supplies to and from such a laboratory, that we will continue to send men to the Moon, and that eventually we will send men to the planets. If this is true, now is the time to say so . . . .We in **NASA are fully conscious of practical limitations . . . .In** the light of these considerations, we can be sensible and moderate about our requests for resources—but we *must know where we are going. 38*

Initial Proposals

This philosophy led Paine, at the start of the Nixon administration, to take steps unusually bold for an acting agency head. In February 1969, Paine 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."[39]

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.[40] 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 circumlunar mission and the desire on the part of any new administration to take some early and popular initiatives as counters to a process which he was not sure would be favorable to NASA.

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 was concerned, and impossible to obtain without committing the President to support the long-range objectives. "[41]

The President's Science Adviser, Lee DuBridge, asked the Space Science and Technology Panel[42] 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. "[43]

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[37] Homer Newell, ***Beyond the Atmosphere: Early Years*** *of Space Science* **NASA SP-421 1 (Washington, DC:** National **Aeronautics and Space** Administration, **1980),** p. **288.**

[38] Quoted in **Levine, op. cit.,** pp. **258-259.**

[39] Memorandum **from Thomas Paine to the President, "Problems and** Opportunities **in Manned Space Flight," Feb. 26, 1969.**

@The STG **was chaired by Vice-President Spiro T. Agnew and had as members NASA, the president's Science Adviser, and the Department of Defense, The Bureau of the Budget, Department of State, and Atomic Energy** Commission **had observer status.**

41 Brief in **Memorandum prepared by the Bureau of the Budget,** Economics, **Science, and Technology Division, "President's Task Group on Space** Meeting **No, 1," Mar. 6, 1969.**

[42] A **subgroup of the president's Science Advisory** Committee (PSAC).

[43] Ibid

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 one designed and funded to afford increasing opportunities for international cooperation.

The State Department believed that there were "greater international values i n 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 of our space goals in order to preempt 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[44]

The Department of Defense (DOD) 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."[45]

The report of the STG staff directors was a rejection of that part of the Paine initiative which asked for 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-1970s. 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 .46

This 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 1 ½ years as NASA struggled to gain support for a "space station" development as its major post-Apollo program objective, Throughout the STG 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 its origin solely as 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,

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.

Detailed Station Planning

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 2 years. But events at the policy level made it increasingly unlikely that the "space station" program would ever proceed beyond the Phase B stage, at least in the 1970s.

The handwriting 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 late 1970 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-1960s, so the Shuttle was perceived by policy makers in the early 1970s, But the failure of the "space station" program to gain approval was not because of a lack of effort; the Phase B study process was the focus for that effort.

DEFINING THE PREFERRED CONCEPT AND ITS RATIONALE

One problem, perhaps the key one, was that NASA found it quite difficult to tell both prospective contrac-

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[44] R F Packard, "Department of State observations, " draft, Mar. 13, 1969.
[45] Milton Rosen **(NASA staffer** for STG), "Memorandum **for the Record, " Mar 13, 1969 (N** HOA).
[46] " Report of the space **Task Group Staff** Di rector's Committee on NASA'S Request **for Amendments to** the **NASA** fiscal **year 1970 Budget," Mar.** 14, 1969, p 4

tors 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 1960s. The basic requirements which had emerged from the study effort were:

1. qualification of people and systems for long-duration Earth orbit flight;
2. demonstration of man's ability and functional usefulness in performing engineering and scientific experiments; and,
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 2-year orbital lifetime design goal.[47] An Apollo command and service module launched by a Saturn 1B booster was to be the logistics vehicle for the station; the station itself was to be launched on a Saturn V booster.

When Thomas Paine was exposed in January 1969 to this staff thinking, he found it too modest. His center directors agreed. For example, Wernher von Braun told Paine that:

> **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.**

MSC Director Robert Gilruth told Paine:

> **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.[48]

Out of this lack of consensus within NASA came a rapid change from the January concept of a "space station." 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. "[49]

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. so

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-l970s Space Station as the initial but evolutionary step toward the Space Base. " The objectives of the "space station" program were stated as:

- Conduct beneficial space applications programs, scientific investigation and technological engineering experiments.
- Demonstrate the practicality of establishing, operating, and maintaining long-duration manned orbital stations.
- Utilize Earth-orbital manned flights for test and development of equipment and operational techniques applicable to lunar and planetary exploration.
- Extend technology and develop space systems and subsystems required to increase useful life by at least several orders of magnitude.
- Develop new operational techniques and equipment which can demonstrate substantial reductions in unit operating costs.
- 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 would normally operate in a zero gravity mode, but during the early weeks of its operation there would be 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 ft 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, [51]

Shortly after the original proposals in response to the 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 that it could be the core around which a space base could be de-

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[47] William Normyle, **"Alternatives Open on Post-Apollo, "** *Aviation* ***Week and Space Technology,*** **Jan, 13, 1969,** p. **16.**

[48] Thomas Paine's **notes from meeting on space stations,** Jan. 27, 1969 **(NHOA).**

[49] William Normyle, **"NASA Aims at 100-Man Station, "** ***Aviation Week and Space Technology,*** **Feb. 24, 1969,** p. **16.**

[50] William Normyle, **"Large Station May Emerge as 'Unwritten' U.S. Goal,"** *Aviation* ***Week and Space Technology,*** **Mar, 10, 1969, p. 104.**

[51] NASA, 'Statement of Work: Space **station Program Definition (Phase B), " Apr. 14,** 1969.

veloped; 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 the section in this report, "NASA's Post-Apollo Ambitions Dashed," and was a reflection of the high hopes for all of NASA's future manned programs which were pervasive in the immediate aftermath of the first lunar landing.

PHASE B STUDIES

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 on July 22, 1969, NASA awarded Phase B contracts of $2.9 million each to North American Rockwell and McDonnell Douglas. The studies were to run for 11 months beginning in September; MSC would manage the North American Rockwell effort, and MSFC, the McDonnell Douglas study.

A continuing problem during the course of the Phase B studies was the difficulty of integrating station design and the candidate experiments 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 . . , ."[52]

The Phase B studies were extended for 6 months on June 30, 1970; 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 billion to $15 billion, including both development costs and 10 years of on-orbit operations; this estimate did not include the cost of a 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."[53]

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-ft station. However, beneath this growing momentum was an uncertain base of political support.

On July 29, 1970, Charles Mathews, NASA's Deputy Associate Administrator of Manned Space Flight, ordered MSC and MSFC to terminate the continuing Phase B activity and to redefine the effort in a fundamental way. On the basis of congressional action, NASA leadership had become convinced that the Saturn V program, which had been in terminal condition for almost 2 years, was finally dead, i.e., there would be no booster capable of launching a 33-ft station. The only launch vehicle available for use in putting the "space station" into orbit would now be the space Shuttle, with its planned 15-ft by 60-ft payload bay. What had started out as the supply vehicle for the station was to be its key to survival.

It took some doing to skew the study effort toward components with diameters able to fit into the Shuttle payload bay; one study contractor commented that "people who were eager to fly in a 33-ft station found the prospect of long stays in the 14-ft 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.

By the time the studies were begun, however, the likelihood that they would lead to an early commitment to station development was already vanishingly small. NASA had suffered a number of defeats 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 in mid-1970, and the station thus lost a supporter at the top; this may have made the shift to the Shuttle easier.

Station studies continued through 1970, 1971, and 1972, with the final in-house studies focused on a single research applications module (RAM) to be carried into orbit by a Shuttle.[54] 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 Sta-

[52] Jack C. Heberlig, "The Management Approach to the NASA Space Station Definition Studies of the Manned Spacecraft Center, " NASA Technical Memorandum X-58090, June 1972, p. 30,

[53] *Space Business Daily,* July 27, 1970.

[54] This ultimately became the basis for the Spacelab developed by the European Space Agency,

tion 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. However, preserving a large payload bay as an essential element of the Shuttle, NASA was able to maintain the possibility of returning to the station concept, thereby keeping its dream alive.

NASA's Post-Apollo Ambitions Dashed[55]

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. 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 STG 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 which would influence much of the group's debates: Where was the Apollo of the 1970s? 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 liftoff 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 liftoff, 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 administrator, 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 1980s into NASA's overall plans. This was the source of the early modification to the Phase B study requirements described previously.

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 i n the 1980s, NASA hoped to provide a convincing rationale for the station's urgency. Not only "space stations" but 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 NASA's manned flight organization coalesced behind an aggressive plan of new activities for the next decade, 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.

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 people 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 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, sub-

[55] This account is adapted from John M. Logsdon, "The Policy Process and Large-Scale Space Efforts," *Space Humanization Series, vol.* 1, 1979, pp. 65-80.

mitted to the President i n 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 program. " Beyond its general statements, the report recommended no commitment to any particular program option or even any specific project on a particular timetable.

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 then 6 months passed before Nixon made any formal reaction to the Group's recommendation, and that reaction was noncommittal. 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 payoffs from major new activities in space; their reading of public opinion was that American 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 activities, and what priority was granted he gave to the space Shuttle. During the 1970 debate over NASA's budget, Congress expressed a high degree of skepticism about ambitious new goals in space. The linkages among the Shuttle program, development of a "space stat ion," and a manned Mars expedition came under particular attack, and threatening but unsuccessful 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 handwriting (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 under way. **It took another 1 ½ years of conflict-filled negotiations with the White** House and Congress before NASA was able to gain their endorsements of the space Shuttle in 1972.

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 though perhaps too short-term 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 the kind of "space station" program that it desires.

Skylab: An Interim "Space Station"[56]

The only remainder of the Apollo Applications Program, begun with high hopes in 1966, Skylab was a S-IVB third stage of the Saturn V launch vehicle, outfitted as a workshop to be visited by three successive crews after being launched into low Earth orbit. The mission could hardly have gotten off to a worse start. During launch of the Skylab workshop in May 1973, the meteor/thermal control shade tore loose from the spacecraft and seriously damaged a solar cell panel needed to produce power on the vehicle. The first crew to visit Skylab managed to jury-rig a parasol to replace the shade and to salvage the one solar panel that was not lost in launch. This proved enough to save the mission and to allow virtually the full run of experiments that had been planned for the three crews that visited the laboratory in 1973 and 1974, turning potential disaster into another virtuoso display of NASA resourcefulness and skill.

Skylab provided grist for everyone's mill. "Space station" advocates praised the demonstration of man's long-term survivability in space–84 days for the third

[56] For a full account of the Skylab project, see W. David Compton and Charles D Benson, *Living and Work/rig in Space. the History of Spacelab* NASA SP-4208 (Washington, DC: **National Aeronautics and Space** Administration, **1983).**

crew—and the rich variety of scientific and applications tasks of which he had proved himself capable–ranging from Earth observation and photography to manning the solar telescope, conducting physiological experiments, and even carrying on space processing. Especially did they fasten on the role of human beings as the flexible, opportunistic component in the "space station" that had saved the mission with emergency repairs no machine could have made. Without people, claimed the advocates, Skylab would have failed.[57]

Without people, claimed the critics, Skylab would not have been necessary. Many who questioned the wisdom of manned space flight, especially scientists, even while they conceded the impressiveness of the Apollo achievement and appreciated how their own programs had ridden on its coattails, came to wonder if the whole undertaking involving people was worth the candle. With money drying up and many scientific missions promised for the final flights of Apollo being canceled with those flights, the relative economy and efficiency of unmanned, automated missions looked more attractive in contrast.[58]

Whatever the eventual evaluation of Skylab, it was interpreted by NASA's manned space flight managers as legitimizing renewed study of the "space station" concept. Those studies, carried out during the 1974-80 period, have laid the base for current discussions of whether it is finally time to move ahead with the acquisition of in-space infrastructure, of what character and magnitude, to be obtained by when, and to be operated, used, and paid for by whom.

Recent In-Space Infrastructure (i.e. "Space Station") Studies

In addition to the impetus to reexamine the "space station" concept which came from the success of the Skylab project, other influences in the same direction included the need to begin to identify potential "post-Shuttle" programs and new requirements for using men and women **in space operations emerging from a number of study efforts being carried out by NASA in the 1974-75 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 activities which could not be accomplished using the space Shuttle, with its 7 to 20 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 (LEO). Studies which established requirements for large structures in both LEO 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 infrastructure studies during the 1975-80 period.

The first NASA foray into a new station study effort was a 1975 study of a "Manned orbital Systems Concept" (MOSC) 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 (IOC) 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 activities to be conducted with the support of in-space infrastructure 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. Total program costs for development and operation of the initial MOSC facility were estimated to be $1.2 billion.[59]

[57] See, for example, John H. Disher, "Next Steps in Space Transportation, *Astronaut/es and Aeronautics,* January 1978, p. 26,

[58] Newell, op. cit., pp. 290-295.

[59] McDonnell Douglas Astronautics, *Manned Orbital System Concepts Study,* Book I-Executive Summary, Sept. 30, 1975, pp. iii, 1-2, 30, 36.

Rather than attempt to gain approval to take the MOSC effort to a Phase B stage, in the Fall of 1975 NASA decided to conduct further studies 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 fiscal year 1979.[60]

There were a number of reasons for NASA's switch i n 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" by 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 in 1974 by NASA Administrator James Fletcher (who had become Administrator in April 1971) 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 manmade 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. "[61]

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 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 economies 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.[62]

Once again, NASA saw the justification for a "space station" primarily as "the next logical step" in exploiting people's ability to work in space.

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 develop-

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[60] U S Senate, Committee on Aeronautical and Space Sciences, ***NASA Authorization for FY 1977,*** Hearings, p. 1046

[61] *Outlook for Space: A Synopsis* (Wash ington, DC: National Aeronautics and Space Adm in istration, January 1976), pp. iv, V, 5-7

[62] Ibid., pp 55-56

ing very large human habitats in space—space colonies.[63]

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 large source of 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 an SPS would require extensive use of on-orbit work crews in order to assemble and test 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 an argument that space construction might be a major requirement of its programs during the 1980s, and wanted to explore the role of in-space infrastructure utilizing work crews in carrying out these construction efforts. In December 1975, the agency issued a request for proposals for a "Space Station Systems Analysis Study" (SSSAS); the study effort was to be focused 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, "[64]

One finding of the system analysis studies was that scientific efforts could "go along for the ride" on ''space stations" capable of supporting construction, materials processing, and power generation objectives. An 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 to . . . space construction work as the 'prime focus' of the studies.[65]

When NASA began this study 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 to proceed on a schedule which would have made such a new start possible. 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 toward ways to enhance Shuttle capability to perform many of the missions that the SSSAS studies had assigned to a "space station. "[66]

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 system analysis 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 (JSC) and Marshall Space Flight Center (MSFC) were studying orbital** power supplies during 1978; the Johnson Space Center concept was called a power extension platform, 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 1978-80 period were devoted to these two program concepts. ***(During*** 1980 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, i.e., a "space station, " perhaps 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, by early 1979 the leadership of JSC had 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. [67]' Another factor influencing JSC thinking 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."[68]

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[63]Gerard K. O'Neill, "The Colonization of Space,' *Physics Today,* September 1974.

[64]NASA Press Release, "NASA Seeks Proposals for Space Station Studies, " Dec. 11, 1975.

[65]" Operational Base Concepts Gain in Space Station Studies, " ***Aerospace Daily,*** **Sept. 13, 1976,** p. **54.**

[66]*Aviation Week* ***and Space Technology,*** **Mar. 16, 1979, P. 49.**

[67]Ibid.

[68]NASA, **Lyndon B. Johnson Space Center,** ***Space Operations Center: A Concept Analysis, Nov. 29, 1979,*** **pp. 1-1, 1-2.**

Based on these considerations, during 1979 JSC 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 wil l be more effective with a permanent, manned operations center in space. "**

The primary objectives of the SOC were identified as:

- **construction, checkout, and transfer to operational orbit of large, complex space systems;**
- **on-orbit assembly, launch, recovery, and servic**ing of manned and unmanned spacecraft; and,
- further development of the capability for perma**nent manned operations** in space wiith 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 mission is that experiment and applications requirements will not be design drivers; the SOC will be "optimized" to support the operational functions of these 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 occupied orbital facility built from several Shuttle-launched modules. The initial SOC crew would be 4 to 8 people. **In addition to a core facility, the full-capability SOC would require a construction facility and flight support facility.** The costs of this fully capable SOC were estimated at $2,7 billion, with the total facility in place 9 to 10 years after program initiation. [69]

The 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."[70]

The following year would see a new administration take office and a new NASA Administrator appointed. The concept of in-space infrastructure would be looked at afresh.

[69] Ibid., pp 1.8, 1-13, 1- 19, 1 -24

[70] David Dooling, "Space Statlon May Be Ready for a Comeback, " *Huntsville Times*, Dec 9, 1979, p 4

Conclusions

It should be evident that there is no obvious cutoff point for an account of the development of the "space station" concept. Today's planning and proposals are a continuation of an evolution which has roots in the earliest years of this century and which has proceeded i n sporadic bursts of intensity over the past quarter-century. It is possible, however, to reflect on past experience in the context of the current situation. Such reflection reveals two levels of concrete justification which have been offered i n support of in-space infrastructure—i. e., "space station, " acquisition.

One set of justifications ties the need for a permanent human presence in orbit to a particular image of the future objectives of the civilian space program. According to this line of reasoning, a "space station" can be seen as:

1. a necessary way station in preparing for people exploring the solar system; or
2. an extremely valuable "national laboratory in orbit" for carrying out many of the research and development activities related to a balanced and diverse civilian space program with both scientific and application objectives; or
3. a centralized operations base from which the routine exploitation of, particularly the commercial exploitation of, both LEO and geosynchronous orbits can most effectively proceed.

In all of these justifications, in-space infrastructure is explicitly a **means** to achieving or facilitating a particular set of space policy objectives, and a decision to develop it would be tied to the more fundamental decision that those objectives were of sufficient priority to justify the investments required to achieve them, including the necessary infrastructure itself. Historically, what has happened at past occasions for decision on the course of the American space program is that other goals than those which would have required a "space station" were given preference:

1. In 1961, President Kennedy sought a dramatic space achievement in which the United States could best the Soviet Union. The choice of a lunar-landing objective and of the lunar-orbital rendezvous approach to achieving it as the response to Kennedy's need meant bypassing the development of Earth-orbital capabilities including "space stations. "
2. In 1969-71, President Nixon sought to reduce the priority and budget allocation of the space program after Apollo while still developing some new technology, maintaining a manned space flight element, and creating more balance among various program objectives. Within the scope of what he was willing to approve, there was insuf-

ficient activity to justify developing a major orbital laboratory, and the space Shuttle was selected as an alternative (and in NASA's mind, an interim) step until the level of space activity would become high enough to require such a facility.

From the perspective of overall policy objectives, then, the fact that a "space station" has been rejected as a part of the space program in the past can be interpreted primarily as a function of the particular stage i n the program's evolution at the time that its acquisition was proposed. Such rejections are best understood as national leaders saying "not yet" or "not under the current conditions, " rather than an outright "no." The issue then becomes whether the overall character and desired objectives of the Nation's space program for the rest of this century are now of a scope to justify acquiring in-space infrastructure as a means to achieve them.

Related to this point is an observation which springs clearly from this historical record: that the concept "space station" can be used to describe very different hardware configurations and technical capabilities, ranging from the von Braun toroidal concept of the 1950s, through the 50 to 100 person space base proposed by NASA in 1969 and the "construction shack" concept of the mid-197os, to recent proposals for a small and evolutionary station based on an unmanned platform. Historically, then, the term "space station" is extremely elastic, and an informed evaluation of a particular proposal must ask "what kind of 'space station, ' for what purposes, at what cost?" In this sense, the past history of the proposal is not particularly relevant to the current situation.

At another level of justification, the need for a permanent human outpost in orbit has been consistently seen by those with a broad perspective on future space activities as a necessary step in development of a capability to explore and exploit outer space, if that exploration and exploitation is to be pursued aggressively. Thomas Paine made this argument to Richard Nixon in 1969:

> **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 resource 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.**[71]

[71] Memorandum from Thomas Paine to the President, Feb. 24, 1969.

Current NASA Administrator James Beggs has made much the same point, saying that "a 'space station' is the logical next step in the history of our manned space systems. It will build on the achievements of the Mercury, Gemini, Apollo, and Shuttle programs. "[72]

This argument decouples station justification from any particular set of missions and suggests that a "space station" is a valuable, logical, and/or necessary step in developing the capability to pursue **any** future objectives in space. The underlying assumption is that the United States will want to pursue an active space program and that a "space station" is required to do so. This line of argument is frequently combined with assertions of the need for leadership or preeminence in space as a source of national pride and prestige and as a counter to the military and/or economic threats coming from other spacefaring nations.

This theme has consistently been put forth over the past two decades by advocates of a "space station." In the past, it seems as if they were "ahead of the curve' '—i.e.,., that in objective terms the U.S. space program had not yet developed to a point where the argument that a permanent manned outpost was indeed the logical next step in an aggressive space enterprise was plausible to those outside the space community.

The same argument is being put forth today; the question is whether it is any more plausible in 1984, as the U.S. space programs enters its second quarter-century, than it has been previously. Given the capability for easy access to orbit provided by the space Shuttle, it may be that having the ability to stay in orbit for extended periods for experiments or operations is now in fact a "next logical step." Or it may be that the program has not yet evolved, and is not evolving toward the kind of active future, in which the creation of permanent human presence in orbit is justified.

This historical review suggests that space advocates will continue to press their vision of the way to go about opening the space frontier and that a "space station" will continue to be an integral part of that vision. It is up to others in leadership positions to decide whether the vision of space held by those who are the heirs of Tsiolkovsky, Oberth, von Braun, and many others who have worked on the space program in this country is one which the United States will now embrace.

[72] James M. Beggs, "Securing Our Leadership in Space," *Astronautics and Aeronautics,* September 1982,