CHAPTER II

Chapter II

# THE CONGRESS AND THE PUBLIC DIALOGUE*

## 1964 - 1968

Three major periods of decision on U.S. space policy and NASA funding were evident during the five years of the Administration of Lyndon B. Johnson:

-- Early in 1964 (in his Budget Message for FY 1965), the new President asked continued strong backing for the space pre-eminence objective and for the Apollo program with its rapid development of manned space flight capability to be demonstrated through a manned lunar landing and return before the end of the decade. Congress agreed and raised the NASA appropriation by $150 million above the level of the previous year; and NASA programs built up a momentum that was to be a major factor in helping to carry them through to completion in this decade.

-- In 1967, President Johnson sought Congressional approval for continuing the production and use of the Saturn-Apollo space system and for such important new programs for the next decade as Voyager, Apollo Applications, and the NERVA nuclear rocket engine development program. He received only a limited and uncertain response.

-- And by 1968, the failure to start new long-lead-time projects and limitations on NASA funding

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*This chapter was written by Manning Williams.

placed NASA in the position of emphasizing the completion of current programs for the Sixties and striving to find some way not to face an almost complete cessation of flight missions in the Seventies. This led NASA Administrator James E. Webb to emphasize in his Congressional appearances that the United States would have to settle for second place in space for years to come and to point out that the failure to exercise the options available in previous years meant the lay-off of thousands of space workers as projects were completed. This stimulated renewed debate on what NASA's major activities and level of effort should be in the decade ahead.

This chapter focuses first upon the central decisions related to Presidential policies and Congressional actions during the five years 1964 through 1968 (fiscal years 1965 through 1969). It then discusses briefly some of the major issues in the public dialogue on these decisions and on the goals and level of effort they established for NASA space programs.*

## 1964 -- THE ISSUE OF PRE-EMINENCE

President Johnson was quick to publicly re-affirm the space policies he had helped to shape as Senator and Vice President. At the same time he was increasingly subject to pressures to reduce space expenditures. In his first State of the Union Message, he said: " . . . we must assure our pre-eminence in the peaceful exploration of outer space, focusing on an expedition to the moon in this decade -- in cooperation with other powers if possible, alone if necessary."

And he backed his stand for American space pre-eminence and for the Apollo program in his Budget Message:[1]

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*The impact of Congressional funding on the pace of the priority lunar landing program, and on the balance and content of the other portions of NASA's overall program, is detailed in Chapter III, IV, and VI. See Volume II, Appendix B-II-1 for an essay on the "Budgetary Process in NASA."

Our plan to place a man on the moon in this decade remains unchanged. It is an ambitious and important goal. In addition to providing great scientific benefits, it will demonstrate that our capability in space is second to no other nation's. However, it is clear that no matter how brilliant our scientists and engineers, how farsighted our planners and managers, or how frugal our administrators and contracting personnel, we cannot reach this goal without sufficient funds. There is no second-class ticket to space.

Appropriations enacted for 1964 for the National Aeronautics and Space Administration were $600 million below the amount requested. As a result, major development programs leading to the manned lunar landing have fallen behind schedule. Careful replanning of the entire program, including a reduction in the number of test flights, will offset some of this delay. Even so, more funds are needed in 1964, and I am therefore recommending a supplemental appropriation of $141 million for this year.

For 1965, I am requesting appropriations of $5.3 billion, $63 million above the 1964 amount, including the proposed supplemental appropriation. The 1964 and 1965 recommendations represent the minimum amount needed to achieve our goals in space . . .

Further on in the budget, this statement of basic policy was made:[2]

The programs of the National Aeronautics and Space Administration are designed to maintain American supremacy in space and to demonstrate this supremacy by achieving a manned landing on the moon in this decade. Besides manned space flight these programs include the exploration of space by unmanned spacecraft; the development of satellite technology for meteorological, communications, and other applications; and the advancement of basic research and technological development on which both our aeronautical and space efforts depend.

It was thus made clear in President Johnson's first budget that he would support a broad and balanced NASA effort.

NASA Administrator James E. Webb opened the FY 1965 budget hearings before the House Committee on Science and Astronautics on February 4, 1964, with a comprehensive statement on the importance of the space effort and its many benefits.[3] One portion of his statement is quoted here in full because it represents the Johnson Administration's first major presentation of its answers to many of the important questions raised in the space debate in previous years:*

> In the tight budget situation faced by the President for fiscal year 1965, it was necessary to stress with him and the Bureau of the Budget that unless the full $5.3 billion authorization requested for fiscal year 1965 and the supplemental appropriation of $141 million requested for fiscal year 1964 are approved, the manned space flight program will encounter further delays. It will then not be possible to achieve the national goal of exploring the moon with men within this decade.
>
> There may be some inclination to assume that the adjustment of our program to the reductions imposed for fiscal year 1964 indicates that this will likewise be possible in the event of reductions in the request which is before you at this time. I cannot emphasize too strongly that this is not the case.
>
> In adjusting our program to compensate for the reduction made in the appropriation for fiscal year 1964, we have already sacrificed the margins and early target dates which were needed, and which in reality are still needed, in our effort to achieve the goals which have been set for us. In fact, Mr. Chairman, we are not able to maintain a reasonably balanced program, and accommodate the entire reduction, with any strong assurance that we can meet the 1970 lunar target date. The best we can say is that we have a "fighting chance."

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*It explained also for the layman, and perhaps for future historians, why there is a great need for continuity in support and for a feeling of assurance of such support on the part of project personnel. It made the point that there is an optimum pace at which large space flight programs like Apollo should be run for efficiency and economy.

And that was the purpose of the President in sending this budget to Congress, to give us this "fighting chance."*

To sum up our situation in a sentence, if we do not receive the funds which the President has requested, there is nothing left to sacrifice except the national goal itself.

I have placed a great deal of emphasis, in these remarks, upon this national goal of lunar exploration in this decade, because that is the objective which President Kennedy, with the approval of the Congress, set before this agency, and which we have been striving to achieve. I will not, however, urge your support for this authorization request, or for the supplemental appropriation, simply because the funds are necessary if the Nation is to do what it has told the world it would do.

I am well aware that there are those who ask, "What is magic about the 1970 target date?" or "What will be lost if the lunar landing slips into the next decade?"

It is not possible to assert here today that we must reach the moon by 1970 in order to beat the Russians there. I do not know, nor can anyone in this room know, what the Soviets can or will do. Neither, however, and for the same reason, can I say that it is not necessary to do so, if Americans are to be the first to explore our nearest neighbor in space and to achieve the world leadership in space that the Russians captured in 1957.

What can be said, however, is that the 1970 date was selected, after careful study, because it appeared to be the date by which we could reach the moon with reasonable assurance that we would be first, and in the process could develop the scientific knowledge, technical knowledge, industrial base, engineering and launch installations, and worldwide tracking and control networks.*

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*Emphasis added.

There has developed no later evidence to indicate that this decision, recommended by President Kennedy and approved by the Congress, was unsound.

Mr. Chairman and members of the committee, President Johnson has made cuts in what we should have to do this job with reasonable margin, but he has sent up to you enough to avoid, I believe, fulfillment of the prediction attributed to Dr. Edward Teller some years ago, when he was asked what we would find on the moon, and he replied, "Russians."

However, whether it is agreed or not that international considerations and national security factors require that we hold to the present pace of the space program, the fact is that prudence and economy will be served.* Even if economy alone were to be the guiding consideration in the evaluation of the NASA request for fiscal year 1965, the cost of establishing and maintaining superiority in space will be less if we maintain the pace, the momentum,* which the supplemental appropriation and this authorization request will provide.

You will recall that at the time the Congress was considering President Kennedy's recommendation that we drive toward a lunar landing by 1970, NASA officials reported to you that the cost would probably run from $20 to $40 billion. Despite the difficulties which have been experienced, we can still put two American explorers on the moon in this decade, and we can do it within the lower of those two figures -- for less than $20 billion.

But, Mr. Chairman, I am prepared to say that, if the program is further curtailed, if the momentum is lost, if the Apollo program is stretched into the next decade, the cost will not be under $20 billion, but will be several billion more. The ultimate cost will increase for each year in which achievement of our goal is delayed.

The Office of Manned Space Flight has made a careful study of the effects of a stretched-out lunar program, and prepared cost estimates involving the extension of

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*Emphasis added.

the landing date for a period of up to six years. Dr. Mueller will go into this in more detail, but I would like to summarize the results.

This study indicates that the cost of the lunar exploration would increase by approximately $1 billion for each year that the landing is delayed. A three-year delay would cost $3 billion, a six-year delay $6 billion, with no corresponding improvement in the benefits obtained.

This increased expense arises because the cost of a major research and development program is roughly the sum of three factors: (1) A constant factor that designates work that must be done and facilities that must be constructed, regardless of the pace at which the program is conducted, and with most of this going to pay the people in contractor plants working on the program; (2) an operating burden, which covers costs that must be incurred at a relatively fixed level while the program is underway, and therefore accumulate in almost direct proportion to the time required for completion of the program; and (3) a timesaving factor, which includes funds expended for such purposes as overtime, parallel paths of development, the purchase of hardware and facilities beyond those which would be required for a slower paced program, and the provision of duplicate personnel complements for launch preparations and associated efforts.

A minimum-cost program is one in which the amounts expended on operating burdens and time-saving factors are relatively in balance, and that is the case with our program as it was presented last year. <u>The stretch-out to the very last of this decade, which is the basis of the 1965 budget, involves some increase in costs over the level which could have been attained</u>.* But we have not planned, either for 1964 or 1965, premium overtime and inefficient multishift operations in order to save time. Neither, however, have we been forced to establish a pace so slow that the operating burden absorbs an exorbitant share of the total expenditure.

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*Emphasis added.

If the lunar landing date is delayed further, the operating burden will begin to consume an unreasonable share of the funds provided. The costs to which I refer include the support of thousands of skilled engineers, scientists, and technicians who must be on hand to support the flight and ground test activity that continues throughout the total development program, whether the ground tests are on three- or six-month centers.

This includes the propulsion, electronics, structures, thermodynamics, astrodynamics, guidance, control and launch specialists, and the supporting technicians, to name but a few, as well as the clerical and management staffs required by each industrial contractor to do business.

Let me repeat, this cost base exists whether we are flying once in three months or once in six months.* As a result, the cost associated with each event in the program increases as the program is delayed. For this reason, if economy is to be the watchword, and if we are to meet the stated national goal of lunar exploration within this decade both the supplemental appropriation and this authorization are required.

Many of the basic questions that arose each year as NASA gave testimony before the Congress were also typically illustrated in the follow-on dialogue between NASA witnesses and members of the House Appropriation Subcommittee on April 7, 1964. The committee members were interested in learning how important NASA thought it was that the lunar landing take place in this decade, because this did impose a very real limit on their willingness to cut back the program. Great interest was shown by the committee, too, in the goals and pace of the Russian space program.[4]

NASA's appropriation for FY 1965 was $5.25 billion, including a $72.5 million appropriation under the FY 1964 authorization. This was $195 million less than President Johnson had asked, but $150 million more than NASA had received the year before.

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*Emphasis added.

This Congressional action was considered an important turning point. When the President signed the Appropriations Act on August 30, 1964, Administrator Webb issued a statement "in response to queries" concerning the effect the appropriation would have on NASA programs.[5] The statement summed up NASA's position and rationale after two crucial years of national debate and decisive Congressional action:

> The appropriation for FY 1965 of $5.250 billion for NASA is further Congressional recognition of the vital importance to this nation and the free world of the increased aeronautical and space efforts which have gone forward under three administrations. This program can give this nation pre-eminence in space and continue its aeronautical superiority.
>
> The Congress understands this. Its support has been bipartisan every year since it was started.
>
> This appropriation comes six years after NASA was established and at the midpoint of the 10-year, $35-billion program which was adopted in 1961 to challenge the then clearly dangerous Russian lead in space. NASA will utilize these funds to maintain the basic momentum and direction of the program as presented to Congress but will make a number of adjustments to meet the Congressional reduction of $195 million, to effect those specific changes directed by Congress, and to take advantage of experience gained from operations conducted during the nine months since the budget was submitted.
>
> Although these adjustments will affect launch schedules and program milestones, Dr. Dryden, Dr. Seamans, and I are convinced that it is best to make a maximum effort to gain operational leadership in manned space flight and that the manned lunar landing should continue to be targeted within this decade.* This will stretch NASA and its contractors to the limit, but we have advised the President that we are not at this time willing to give up this goal which is so challenging and which is so important as a focus for the efforts we must continue to make in all our programs.* In this decision we are taking the most effective steps we can to make sure we are not again set back by some new breakthrough such as Sputnik or Vostok

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*Emphasis added.

arising from the continued very active space program of the Russians.

In space, the obstacles are great and the lead times long. Time lost cannot be made up. The target date is only five years away. Our assurance that it can be met is less than under President Johnson's budget, but we still hope that with hard work, dedication, continued successes, and continued support we can meet it. We are going to make a hard try.

This decision does not involve the transfer to manned space flight of funds from space science and applications programs or advanced research and technology programs. These programs will require some adjustments, but will not be drastically reduced as would be necessary if funds were reprogrammed to benefit manned space flight . . .

In close association with the aeronautical and space committees of Congress, all programs will be kept under constant review to take advantage of every development and every means to maintain the momentum and progress toward pre-eminence in space.

Literally, the "last word" on the FY 1965 budget by NASA stresses "pre-eminence in space" as the national goal.

TABLE II-1

Comparative Analysis of Budget Requests
Versus Appropriations FY 1960-1969 (In Millions)

| Fiscal Year | Budget Request | Appro-priated | Difference |
|---|---|---|---|
| | | 38.5* | |
| 1960 Eisenhower | 508.3 | 481.5 | - 23.2 |
| 1961 Eisenhower | 964.6 | 964.0 | - .6 |
| 1962 Eisenhower | (1,109.6) | | |
| 1962 Kennedy | (830.7) | | |
| Subtotal 1962 | 1,940.3 | 1,825.3 | - 115.0 |
| 1963 Kennedy | 3,787.3 | 3,674.1 | - 113.2 |
| 1964 Kennedy | 5,712.0 | 5,100.0 | - 612.0 |
| 1964 Johnson (supplemental) | 141.0 | 72.0 | - 68.5 |
| 1965 Johnson | 5,304.0 | 5,177.5 | - 126.5 |
| 1966 Johnson | 5,260.0 | 5,175.0 | - 85.0 |
| 1967 Johnson | 5,012.0 | 4,968.0 | - 44.0 |
| 1968 Johnson | 5,100.0 | 4,588.9 | - 511.1 |
| 1969 Johnson | 4,370.4 | 3,995.3 | - 375.1 |

*Includes supplementals of $16.7 million (R&D) and $21.8 million (CoF) against FY 1959 authorization.

## 1965 -- PRE-EMINENCE AND THE ISSUE OF FOLLOW ON PROGRAMS

The issue of pre-eminence and the NASA way of working toward it through scientific understanding of the environment and the development of technology, with each new mission started in time to dovetail in with completed missions, came sharply into focus in January of 1965. President Johnson had been in office only a little more than two months when he signed a letter addressed to NASA Administrator Webb which had been prepared originally for President Kennedy and which asked for a review of possible space objectives beyond those already approved. The Administrator made an interim reply in May 1964. In February 1965, he transmitted to the President a copy of the Summary Report of the Future Programs Task Group of NASA, recommending that it should be made public to facilitate a national debate on what the United States should do in space after the Apollo manned lunar landing was accomplished.[6] No new programs for NASA were mentioned in the President's Budget Message delivered to the Congress on January 25, 1965, but in the budget itself a start on two programs was recommended:[7]

> Through prudent management and the termination of premature or non-essential projects, it is now possible to maintain the momentum of our ongoing programs and to start important new projects without a further significant increase in new obligational authority for 1966.
>
> Funds are provided in 1966 for studies and selected technological developments which will prepare the way for a future decision on possible uses of the Apollo spacecraft and Saturn launch vehicles other than those specifically required for the manned lunar landing.
>
> Funds are included in this budget to initiate development of the Voyager, a major new unmanned spacecraft designed to explore the planet Mars. This spacecraft will be 10 to 15 times as large as the Mariner 4 which is currently in transit to Mars. Its ultimate mission will be to place on the Martian surface an instrument package capable of determining and reporting to earth whether there is life on the planet. This program has been selected for initiation in 1966 because it is considered to be one of the most important scientific missions to be undertaken in space and must be timed for the most

favorable flight conditions. It is planned to take advantage of the opportunity that will occur in 1971.

At the NASA budget briefing, NASA Associate Administrator Seamans explained that about $45 million was being requested for work on the Apollo extension systems under the regular item in the Apollo budget called Apollo Mission Support.[8] Seamans said none of this money would be used for flight hardware, but only for design and feasibility studies and the building of experimental prototypes.[9]

In the FY 1966 budget briefing at NASA, Seamans described the studies being funded for the Apollo extension project and said the main question was, What are we going to do with the manned space flight capability we are building up in the current Saturn/Apollo program? He said that was a question that "we have been addressing ourselves to for the past year as part of a special study for the President."[10]

During the question and answer part of the budget briefing, a reporter asked: "Aren't you saying, Dr. Seamans, that to all actual intents and purposes, at this point we don't have any dramatic program going on beyond the manned lunar program?" And Seamans answered:[11]

> No, I wouldn't agree with that. It is our belief that the extended Apollo program permitting flights in earth orbit, circular orbits of various sorts up to polar orbits, flights in synchronous orbit, flights extending out to four to six weeks or perhaps even more, will be very dramatic indeed.
>
> Also circumlunar flights, say in polar orbit about the moon, taking photographs of the entire lunar surface, missions that could involve stay times on the moon of up to one to two weeks, all have great possibility and offer great interest scientifically.

Funding requested for Voyager in FY 1966 was the substantial sum of $43 million (compared with $7.75 million transferred to Voyager from Mariner and used for preliminary studies in FY 1965 and no funding at all in FY 1964).

The House and Senate space committee reports (No. 273 and No. 188, respectively) on the NASA authorization bill for FY 1966 accepted the new Programs.[12]

The NASA authorization and appropriation bills for FY 1966 were little changed in Congress. The President had requested $5.26 billion, the authorization was $5.19 billion, and the appropriation $5.175 billion.

During floor debate in the Senate, Senator William Proxmire's annual proposed amendment to reduce NASA appropriations, by five percent on this occasion, was defeated on a roll call vote, 16 to 61.[13]

In the NASA Operating Plan for FY 1966, Voyager was provided $17 million and the Apollo extension systems $51 million.[14]

## 1966 -- NEW PROGRAMS DEFERRED

Despite much discussion during 1965 on the need to start new programs, President Johnson did not consider 1966 the year for commitments to new space programs.

For the first time since the beginning of the "space age" after Sputnik, space was not mentioned in the President's State of the Union Message to the Congress. The emphasis in 1966 was on carrying out "Great Society" programs.

In his Budget Message for FY 1967, President Johnson said he was asking for $163 million less for NASA in new obligational authority than for the current year; that NASA expenditures would decline by $300 million; and that this level would "sustain our progress in space exploration and continue the advancement of science and technology."[15] This budget called for the first decline in annual expenditures for NASA since it had been established in 1958.

No mention of new programs was made in the Budget Message or the budget, except for the notice that a Mariner mission (instead of a Voyager test flight) would be flown to Mars in 1969 to "obtain additional vital information for development of the much larger Voyager spacecraft looking toward a landing on Mars in the 1970's."[16] The Voyager flight to Mars in 1971, called for in the FY 1966 budget, was not included and, while funds were provided, they were at too low a level to permit NASA to move toward a definite flight date.

At the NASA budget briefing, Seamans mentioned three guidelines that had been considered in putting this budget together. These were:

> First, we wanted to put together a budget that would maintain the momentum of our major on-going programs directed at key manned space flight and scientific goals. Particularly we wanted to maintain the opportunity to land men on the moon and return them in this decade.
>
> The second guideline is to carry out work which will provide options for future major projects which will enable us to make positive achievements in space science and exploration and to deny to the Soviets the opportunity of pre-empting leadership in the future . . .
>
> A third guideline relates to the fact that we face an uncertain, but certainly a difficult, situation in Vietnam which we can anticipate lasting for an indefinite period. We also have increased commitments for improving health and education and relieving poverty at home. These and other factors have, of necessity, and properly, led to an extremely stringent budget for NASA in FY 1967.

In answer to a question, Seamans said NASA had reviewed with the Bureau of the Budget various funding levels for FY 1967 ranging from $4.8 billion to $5.8 billion. NASA recommended the $5.8 billion level, he said, but did consider that the level called for in the President's request ($5.012 billion) would assure "a good space program that kept most of the important on-going objectives."

Dropping to the $5.012 billion level, he said,[17] had caused the Voyager program to be cut back, so there could be no Mars mission in 1971; and the Apollo Applications program (as the Apollo extension systems was now being called) would remain in the definition phase. Also, the Advanced Orbiting Solar Observatory would be dropped.*

Seamans was asked if he considered Apollo Applications "a Congressionally-approved" program, or whether he thought it still had to cross that barrier. He answered that it had been

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*See Chapter IV.

made clear the year before that NASA was not asking for authority to proceed with the flight program; NASA had recommended a definition phase, and Congress approved that; and in FY 1967 the definition phase would be continued for another year.

Seamans explained that definition included not just paper work, but the breadboarding of equipment "so that you really know what it is you are going to fly." This does cost money, he said, but it saves money to define things that well before you go ahead with the flight program.

The FY 1967 budget request included about $100 million for Apollo Applications from various accounts, including $42 million under the Apollo line item, Seamans said, and NASA would have preferred to have double this amount.

Administrator Webb told the House space committee in his statement on the NASA FY 1967 authorization bill that the country was approaching another crossroads, like the crossroads of 1961 when the Apollo lunar landing goal was set. "Major new decisions for the future, and with implications more far-reaching than any this committee and NASA have faced together in the past, must soon be made." The FY 1967 budget, he said, "reflects the President's determination to hold open for another year the major decisions on future programs -- decisions on whether to make use of the space operational systems, space know-how, and facilities we have worked so hard to build up, or to begin their liquidation."[18]

Webb also stressed Soviet advances during the past year: "It will require a strong and increasing effort initiated no later than FY 1968 and vigorously pushed in the years after the United States has achieved a manned lunar landing to prevent them from forging ahead as the unchallenged leader in space."

The confident talk of pre-eminence in space as a national goal which had marked NASA statements during the years following 1961 was now missing. At this juncture, Webb said for the first time that he thought the Russians would be able to put up payloads as big as or bigger than the Saturn V could at about the same time that the Saturn V would become operational: "I cannot forecast exactly what they will do with this capability, but they can do anything we can do and we have not closed the gap."[19]

The House Committee report on the authorization bill for FY 1967 gave a rather strong endorsement to the Voyager program, and increased the amount requested by NASA for FY 1967 from $10 million to $32 million, which the Committee thought was the minimum currently needed for the preliminary work that would assure an effective and economical long-term Mars-lander program.[20]

The Senate Committee report, however, did not concur in this addition for Voyager. Indeed, the Senate report ended with this sentence: "Your committee believes that NASA should make every effort to get planetary information by less expensive means before embarking on an unmanned spacecraft as sophisticated as Voyager."[21] It was this attitude that eventually prevailed.

Congress authorized $5,000,419,000 and appropriated $4,968,000,000 for NASA for FY 1967, compared with the President's request of $5,012,000,000. (The appropriation for research and development was less than $2 million below the President's request.)

The NASA Operating Plan for FY 1967 submitted to Congress on January 23, 1967, shows a total of $80 million devoted to Apollo Applications in FY 1967, including preliminary design, long lead-time procurements, and work on the experiments to be performed.[22] About $100 million had been requested.

The FY 1967 Operating Plan also gave $10 million to Voyager, as had been requested in the President's budget.

Thus, 1966 was a year of deferred decisions, but the options to proceed in 1967 were held open.

## 1967 -- NEW PROGRAMS URGED IN PRESIDENT'S BUDGET

Early in 1967, President Johnson made the first firm recommendations of his Administration for the authorization of important new space programs for the 1970's. Indeed, he said, "we have no alternative unless we wish to abandon the manned space capability we have created."[23]

In the budget request for NASA for FY 1968, $454.7 million was included for the Apollo Applications program and $71.5 million for the Voyager program (which as then defined would use the Saturn V launch vehicle to send large orbiters and landers to Mars in 1973 and 1975). And, in a budget amendment sent to Congress on February 28, 1967, the President asked for $50 million additional for NASA (and $41 million for AEC) to begin development of the NERVA II nuclear rocket engine.[24]

The President's total budget request for NASA for FY 1968 was $5.1 billion -- which was $88 million more than he had requested for FY 1967 and $132 million more than Congress had appropriated to NASA for FY 1967. Each of the new programs would require significant long-term effort and funding over a period of years -- Apollo Applications at least $4 billion, Voyager more than $2 billion through 1975, NERVA II about $2 billion up to the point of a flight test.[25]

To continue on-going programs and start the new ones would require a total NASA appropriation level of slightly more than $5 billion a year at least through FY 1970, Deputy Administrator Seamans estimated.[26] The Apollo Applications program as described in the FY 1968 budget called for continuing production and launch of Saturn I-B's and Saturn V's at the rate of four each per year, with appropriate payloads. (Earlier the budget requests had been based on six each per year.)[27] Apollo Applications flights were scheduled to use the Saturn I-B and to begin in the middle half of 1968 (at the time the main line Apollo program was still in full swing). This was on the assumption that Saturn I-B launch vehicles and Apollo spacecraft not needed in the Apollo program would be available then.

Plans for the Apollo Applications program (AAP) were both ambitious and exciting, but they had been treated in a rather routine manner at the NASA budget briefing on January 21, 1967. A special Apollo Applications briefing, therefore, was called at NASA Headquarters on January 26, 1967. Background material on the AAP program was distributed, slides were shown, and the Associate Administrator for Manned Space Flight, George Mueller, answered questions at length.[28]

The Apollo Applications story as outlined at this briefing was not destined to get the consideration it deserved. The mood of optimism which had prevailed at the briefing was not soon to return. On the next day, Friday, January 27, the tragic Apollow fire took the lives of three astronauts -- Grissom, White, and Chaffee.

Despite the Apollo fire and its repercussions, reviewed later in this chapter, the Apollo program for FY 1968 was reduced only about one percent in the authorization and less than 2 percent in the appropriation.[29] The total NASA authorization for FY 1968, however, was $511 million less than the President had requested. It was a cut of slightly more than 10 percent.

A pivotal factor in the final outcome was President Johnson's statement issued when he signed the NASA authorization bill on August 21, 1967. In this statement President Johnson noted that the House Appropriations Committee had recommended a reduction of $517 million in his request for NASA, and stated that he would not oppose such a cut.[30] The President pointed out that conditions had greatly changed since he submitted his budget request in January. He noted that the Federal deficit for the fiscal year might run as high as $29 billion, instead of the $8.1 billion estimated in January. Hard choices had to be made, he said, and the test was "to distinguish between the necessary and the desirable." The President stressed that these reductions did not indicate a lack of confidence in the space venture or a lessening of resolve to maintain a strong program of space exploration, science, and technology.

The President said he fully shared in this finding from the House Appropriations Committee Report:

> The Committee is impressed by the knowledge and dedication of the officials administering this program. The United States has made great strides in space exploration. We have come from behind in less than ten years and have overcome deficiencies in both military and non-military space programs. We have launched 16 manned flights, and all have been successful. NASA has launched more than 200 unmanned flights and achieved dramatic break-throughs otherwise since Congress declared that we should undertake a broad and expansive space program. The fact that there has been one tragedy to date should not deter the United States from moving forward and making further advancements. Even with budgetary stringencies facing us, this Nation must move forward in space exploration.

Congressional discussion of the NASA 1968 budget and NASA's response is found in the printed record of the hearings before the Senate Appropriations Subcommittee.[31]

Action on the FY 1968 budget request enabled the top-priority Apollo program to proceed. Despite the delays caused by the Apollo fire and technological difficulties, the manned lunar landing before the end of 1969 still looked feasible.[32] But the important new programs which the President had requested in his budget in January had to be drastically revised or eliminated:[33]

-- The Apollo Applications program had been accepted as a major new program with its place as a line item in the FY 1968 Authorization Act; but it appeared that the amount of activity planned in the program would have to be greatly reduced (2 Saturn I-B and 2 Saturn V flights per year instead of four each, with the first flights delayed until after the lunar landing). The NASA Operating Plan for FY 1968 provided $251 million for Apollo Applications, compared with the budget request for $454.7 million.

-- The Voyager program was eliminated; the 1971 Mariner mission to Mars was not authorized; and the only approved planetary mission on NASA's agenda at the end of 1967 was a Mariner fly-by of Mars in 1969.

-- The future of the NERVA nuclear rocket engine development program was in doubt, but NASA sought to save it by switching from NERVA II to the less powerful and less expensive NERVA I.

-- Congress had authorized none of the $5 million requested for advanced mission studies (for manned flight beyond Apollo Applications).

## 1968 -- NASA CAUGHT IN THE FISCAL CRUNCH

NASA moved into 1968 with scaled down plans and substantial hopes for launching its lower cost new programs; but the fiscal crunch that developed between the President and the Congress was to be even more severe than before. The results were funding that permitted the Apollo program to move ahead after the period of hesitation following the Apollo 4 fire but also a sharp curtailment in institutional support for Apollo and a postponement of new programs. This precipitated an atmosphere of uncertainty about the future of the space effort after Apollo.

President Johnson's budget request for NASA for FY 1969 was $4.37 billion, the lowest since President Kennedy's request for $3.7 billion for FY 1963. It was $730 million less than the FY 1968 request and $219 million less than Congress had appropriated for FY 1968. Still, Congress reduced this request by $375 million in its appropriations actions.

In his FY 1969 Budget Message (delivered January 29, 1968), the President gave this brief review of space policy:[34]

> This Nation's leadership in advanced technology was challenged 10 years ago by Sputnik and again seven years ago by the first Soviet manned flight. We responded to these challenges with energy and imagination. We decided to create a national capability to operate in space. We established as a principal goal the development of launch vehicles and spacecraft large enough to transport men to the moon. We joined the strengths of our universities, industry, and government to accomplish this goal, to expand our knowledge of space, and to attain a leading position in aeronautics and space technology.

The President asked for $439.6 million for the Apollo Applications program, $38 million for Mars missions in 1971 and 1973 (with no attempt to revive the much more expensive Voyager program) and $41 million for the NERVA nuclear rocket engine development program (scaled down from NERVA II to NERVA I). The President replied to recent criticism of the lagging NASA planetary program by saying:

> We will not abandon the field of planetary exploration. I am recommending development of a new spacecraft for launch in 1973 to orbit and land on Mars. This new Mars mission will cost much less than half the Voyager program included in last year's budget. Although the scientific result of this new mission will be less than that of the Voyager, it will still provide extremely valuable data and serve as a building block for planetary exploration systems of the future.

The House space committee cut $153 million from the authorization request, and the House cut another $186 million. The Senate space committee cut the request by $220 million, and the Senate cut another $137 million. The House accepted the lower Senate figure, so the authorization came out at $4.013 billion. The appropriation was $3.995 billion. All in all, Congress cut the President's request for NASA for FY 1969 by 8.3 percent.

The Congressional Record for May 2, 1968, devoted 67 consecutive pages to the House floor debate on the NASA authorization bill. Most of the speakers were in favor of the bill, making this a useful summary of the reasons advanced in Congress over the years for an active NASA space program. Very little of the Congressional debate in 1968 involved direct attacks on the Apollo program or the lunar landing goal. Opposition was aimed primarily at the new programs urged by the President.

The authorization for Apollo was only $14 million off the $2.039 billion requested. The authorization for Apollo Applications was $253.2 million, compared with a request of $439.6 million. The authorizations for Mars missions in 1971 and 1973 and for the NERVA program were faily close to the request.

NASA announced an interim operating plan on August 8, 1968, which included drastic cutbacks in plans for all new programs, and explained in its news release:[35]

> The interim plan reflects Congressional reductions of $362* million in NASA's appropriation requests for FY 1969. It also takes into account the possibility that NASA may be required to make further reductions under the Revenue and Expenditure Control Act of 1968. If the interim plan were maintained throughout the year, about $3.85 billion of new obligational authority would be used (compared with the appropriation of $3.995 billion).

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*Final action on the appropriation bill changed this to $375 million.

Under the interim plan, work on the Apollo program, on aeronautics, and on Space Applications* will proceed at the levels authorized by Congress. Activities in many other areas have had to be curtailed, certain projects reduced in scope and other work deferred to future years. The principal adjustments embodied in the interim plan:

NASA civil service personnel will be reduced by more than 1,600 and contractor support effort at NASA installations by more than 2,000. The interim plan contemplates adjustments between appropriation accounts to prevent substantially larger personnel reductions which would place in jeopardy the conduct of the Apollo and other current programs.

The Apollo Applications Program (AAP) will be funded at about $140 million, a reduction of about $300 million from the 1969 Budget request. As previously announced, production of Saturn IB launch vehicles will be terminated after Vehicle No. 214. (The first 12 Saturn IB vehicles, through No. 212, were procured for the Apollo program.)

Saturn V production will not be continued after the first 15 launch vehicles (which were procured for the Apollo program). The AAP flight program will be delayed and limited in scope to one Saturn I Workshop and one Apollo Telescope Mount with a back up for each. Work toward post-Apollo lunar exploration and toward the Earth-orbiting Saturn V Workshop will be limited to studies.

The plan for a Mars 1973 mission is being revised to conform to sharply reduced funding in FY 1969. The instrumentation to be landed on Mars and the scientific return will be substantially less than in the program presented in the FY 1969 budget.

In the nuclear propulsion program, development of the flight weight NERVA engine will not begin in FY 1969 but a cadre of design and development personnel will be retained,

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*Space Applications as used here refers to NASA work on unmanned applications satellites such as Nimbus and ATS, and should not be confused with the Apollo Applications program for manned space flight.

thus preserving an option to initiate development of the flight weight engine in FY 1970. Advanced technology work will be continued and testing of one experimental engine will be completed.

As indicated in the interim operating plan for FY 1969, work on the earth-orbiting Saturn V Workshop would be limited to studies. Earlier in the year, NASA Administrator Webb had stressed the potential value of the Saturn V Workshop for both scientific and military purposes. He described it as a kind of space shelter, "something like an Antarctic base" which could be used for any national purpose and which could be developed without trying to anticipate in advance all the possible uses it would have.[36] The Saturn V Workshop would provide a whole range of new capabilities for manned space flight operations that the Manned Orbital Laboratory (MOL) of the Department of Defense, viewed by some as a competing program, would not have. Webb said he saw no reason why two Saturn V Workshops could not be put into orbit, thus keeping the important civilian and military space uses separated.[37]

The question of whether the potential of a Saturn V Orbital Workshop could be convincingly demonstrated and eventually put to use by both NASA and the military was to remain one of the most important space questions still unanswered during the last year of the Johnson Administration. America's space program for the 1960's would undoubtedly have much greater meaning if the vast potential of the Saturn V and the Apollo space vehicles could be used after the lunar landing as an interim step leading to large orbiting space stations serving important national purposes.

## THE PUBLIC DIALOGUE ON NASA

The NASA funding process was reviewed in the earlier part of this chapter in terms of what President Johnson asked for NASA in his budget each year and what the Congress provided. Its results were seen to be a level of support to which NASA could adapt and carry forward the national space program planned for the decade of the 1960's, but a failure to achieve support for programs for the future. This decision-making process took place in and was a part of a far-ranging, widely participated-in debate on current and future NASA programs.

During the Johnson Administration this public dialogue proceeded generally along the lines that emerged after the appearance of Sputnik in 1957, Vostok I in April 1961, and President Kennedy's recommendation of the Apollo program in May 1961. Attention usually focused on one of these issues or areas of discussion:[38]

-- Were the original reasons for launching a major national space effort still valid? Were they properly understood by the public? Were the benefits commensurate with cost?

-- How important was the space competition with the Soviet Union? Should the United States continue to make a serious effort to be pre-eminent in space exploration and use? What programs and what schedules would be required?

-- Had it been wise to concentrate on the Apollo program and the manned lunar landing goal? Was NASA's effort properly balanced?

-- Were the country's defense needs in space and related technology being adequately met? Were NASA and DOD working together where appropriate to avoid duplication of effort?

-- Was NASA planning for the future effective in identifying and meeting national needs in space? Was the national decision-making process functioning properly?

-- How good was NASA's management? Who or what was to blame for the Apollo fire? Was NASA keeping Congress adequately informed on real and potential problems? What was the fire's impact on public support for current and future programs?

-- Was there a decrease in public support for the space program from 1964 to 1968? Would NASA programs have -- or deserve -- the same high priorities in the future they had had in the past?

These questions were all closely interrelated, and they will be discussed briefly with emphasis on how they may have affected Congressional and public support for NASA plans and programs during the Johnson Administration. It should also be noted that the running public discussion on controversial aspects of the NASA program was only a small part of the total coverage given to NASA activities by the news media and other channels of public and technical information. On the whole, news coverage of NASA was favorable, extensive, and highly competent; and both news treatment and editorials on many occasions reflected pride and enthusiasm of the American public for the achievements of the nation's space team.

In all mass media and many specialized publications, what NASA was doing, or planned to do, was certainly well covered. Getting at, and getting across, the "Why's" of the space effort was a much more difficult assignment for the press and other media. For NASA, the White House, and the Congress there were many problems. How well the job was done, how it might have been done better (not for stating NASA's case but for correctly identifying national interests in a major investment in space) is an important question in a democratic society in competition with a quite different society.

## Re-Examining the National Interests

Debate on the validity of the reasons for a major U.S. effort to explore and use space during the past decade would have been facilitated, and a great deal of public confusion eliminated, if there had been more widespread acceptance of the fact that there were indeed a number of important reasons, and that all of them had to be taken collectively into account in any rational attempt to weigh the costs of the space program against the returns from it.[39] Formal attempts to identify and articulate the principal reasons or motivations for a strong national space effort had been made by President Eisenhower's Science Advisory Committee in 1958, and by the Ad Hoc Committee on Space appointed by Presient-elect Kennedy in 1960. The two lists were quite similar.*

It is a long step in national decision-making, however, from a catalog of reasons for a strong national space program to a determination of what to do and how much to do. Operating

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*See Chapter I.

with essentially the same published set of motivations the Kennedy Administration saw an urgent need for a determined drive for space pre-eminence, the Eisenhower Administration had not.

The reasons that have been advanced for a strong national space program may be restated briefly from the perspective of 1968 in a way that helps highlight the issue of pre-eminence in the debate on U.S. space policy, past and future:

1. National Security: U.S. leadership in space exploration and use and in the development of all important aspects of space science and technology is essential for national strength and security and to help keep space accessible, peaceful, and of maximum benefit to all nations. Practically every scientific and engineering discipline must be pushed to the limit to achieve success in space.

2. World Influence: U.S. space leadership increases American prestige abroad, strengthens its influence in world affairs, and enhances its ability to advance the interests of a democratic society in open competition with communism. At the same time, space leadership enables the United States to deny to the Soviet Union the propaganda, political, economic, and military advantages that flow from space superiority and thereby increases the likelihood of U.S.-Soviet cooperation in space in the future in ways that could reduce international tension and perhaps lessen the threat of global war.

3. Pride: The American people have made clear their desire to play a leading role in this exciting new field of human endeavor and their dislike for being in second place behind the Soviet Union. They welcome this opportunity to participate in one of mankind's greatest adventures and to carry on the pioneering traditions of their nation.

4. Other Calculated Benefits: In our national space program we are also seeking a number of other benefits of great importance which are clearly recognized and which we are willing to make a substantial investment to obtain. These benefits which we are now actively seeking include improvements in education; new ways to conduct research and development; new scientific knowledge about the Earth, the solar system, and the universe; the new technology necessary to explore and use space effectively and to maintain our position of space leadership;

and the direct practical benefits which come from the use of space satellites, such as weather, communications, and navigational satellites, and possible earth resources survey satellites.

5. Coincidental Benefits: The challenging national effort to explore and use space is stimulating and strengthening American society in many ways and yielding many valuable benefits over and above those it is primarily intended to produce. It is helping to pay for itself by increasing the ability of our society to meet the complex problems of today's world. No attempt is made to list these benefits here. A good example, however, is the contribution NASA is making to the nation's knowledge of how large research and development programs can be effectively managed and national resources in government, industry, and the universities mobilized to solve complex problems of modern society.*

The first three reasons, if valid as stated, in whole or in part, suggest that the U.S. effort in space must be geared to achieving and maintaining pre-eminence, or at least parity, with the Soviet Union.

The fourth reason, that of calculated benefits, allows for a clearer appraisal of what the space program produces in relation to its cost. It does not require any finite level of investment, except as may be necessary to carry out projects efficiently over a number of years.

The various coincidental benefits of the space program could, in the eyes of many people, help offset its cost to a considerable extent and possibly repay the investment many times over.

For whatever reasons, it is clear enough that the Kennedy space policy, from May 25, 1961, onward, was to drive for U.S. pre-eminence in space in the decade of the Sixties.

And President Johnson was quick to re-affirm this policy in his first State of the Union Message in January 1964, in what must be one of the most succinct and least ambiguous policy directives ever made:[40]

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*See also Chapter VII.

. . . we must assure our pre-eminence in the peaceful exploration of outer space, focusing on an expedition to the moon in this decade -- in cooperation with other powers if possible, alone if necessary.

The Kennedy-Johnson drive for space pre-eminence had many prominent and vocal critics. Most of the criticism was directed, however, not at the policy itself, but at the principal program designed to achieve pre-eminence -- the Apollo program and its lunar landing schedule. Some critics thought such competition between nations was undignified, or incompatible with the scientific approach, or too "cold warish." Others thought that seeking pre-eminence let the Russians call the tune and put too much emphasis on spectacular achievements (i.e., "stunts"). Still others objected primarily to the high costs. Some were loath to talk about pre-eminence until they were more sure of actually achieving it. And others seized on every fancied opportunity to claim that the Soviet Union had dropped out in the so-called "race to the moon."*

Some of the steam went out of the drive for pre-eminence during the years of the Johnson Administration as NASA eminently succeeded with the Gemini programs, the Department of Defense got the Manned Orbiting Laboratory underway, and NASA began flying the giant Saturn V booster and the Apollo spacecraft before the Soviet Union had demonstrated a match for either one.** Stress on pre-eminence also became a delicate issue when it became evident that the lowered level of effort established by Congress and accepted by the President in 1967 and 1968 would not be enough to match Soviet achievements in the years ahead.

Nevertheless, the national effort carried out to achieve space pre-eminence, based primarily on the motivations of national security, scientific advance, practical applications, national prestige, and personal pride, stood up under constant attack from 1961 through 1968, but only in support of the NASA programs laid out and underway. Most of these would be completed in this decade. The validity of the underlying motivations for the U.S. space effort was called into question in 1967 and 1968 when

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*See the analysis in Chapter I on the 1963 debate.

**"Space Cartoons, 1963-68," contained in Volume II, Appendix B-VII, provides a graphic chronology for assessing the space dialogue.

Congressional support for new programs for the Seventies (Apollo Applications, Voyager, and NERVA) were not judged necessary to compete effectively with the Soviet Union.

In September 1968, Administrator Webb's retirement and the Soviet success in recovering Zond 5 in the Indian Ocean after a flight around the moon -- a spectacular demonstration of a growing large capability -- touched off renewed public discussion, which now continues, of basic space policies of the United States. The Washington Post, for example, said the American people would have to decide on how important it was to try to compete effectively with the Russians:[41]

> . . . the next Administration owes the public a full re-evaluation of the space program after the moon flights. There is a substantial argument that this nation's destiny is to be the first in space and that we should push beyond the moon to explore the planets with all reasonable speed. There is also a substantial argument that too much needs to be done here on earth to invest in space exploration the money and manpower a real effort requires. If the national decision is to follow the latter course, we should face up to the fact that the Russians may always get there first and stop thinking in terms of a race. If the decision is to proceed with a major space effort, there should be no confusion about what it will cost or where it will lead. Only then will we be able to take the setbacks and the eventual successes in stride.

Webb had suggested the need in 1965 for a thorough national debate to determine post-Apollo programs, but it had not materialized in any clear-cut, coherent form.[42]

Perhaps it was too much to expect that a great debate would take place in a democratic society at the proper time and in a rational way merely because there was a need to re-examine and re-assess national policy. Perhaps it would take another Soviet technological surprise like Sputnik had been in its time.*

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*Both major condidates for the Presidency in 1968 urged a policy of space leadership for the United States.

A leading NASA scientist, Robert Jastrow, in the course of a review of Arthur Clarke's book, The Promise of Space, said:[43]

> Clarke describes the chronology of the Apollo decision as "politics and astronautics combined" and writes, "The verdict of history may well be that the United States made the correct decision even if from dubious motives." Elsewhere, Clarke refers to the moon -- and in this I think he is right -- as a "treasure house of knowledge." In the combination of these remarks he seems to betray a point of view that the primary purpose of the space program is, or should be, the exploitation of its scientific potential and the search for knowledge in the space around the earth and on the other bodies of the solar system.
>
> My own view is that he is mistaken. Spacecraft have yielded important scientific discoveries, and my work is concerned entirely with this part of the space program, but it seems clear to me that the preservation of national security, and not scientific research per se, was the motivation for the Kennedy proposal. Kennedy acted out of a deep gut instinct, shared by the Congress and the American people, that the United States had been presented with a major challenge to which it must respond effectively or pay a heavy penalty. . . .

As to the future, Jastrow argued that spacecraft now on the drawing boards and awaiting funding promise a "dollars-and-cents return in increased productivity in the United States so great that the question is not, can we afford a space program? but, can we afford to be without one?"

> The facts leading to this conclusion are in Clarke's book, although his own conclusion is different, for, as befits a man of extraordinary prescience, he keeps his eye on the horizon. To Clarke, it is "the universe -- or nothing. . . . If we fail to meet (the challenge of the great spaces between the worlds), the story of our race will be drawing to its close. Humanity will have turned its back upon the still untrodden heights and will be descending the long slope that stretches, across a thousand million years of time, down to the shores of the primeval sea."

In the scheme of space program motivations previously outlined, the rescue of humanity from this fate would have to be included under the category of coincidental benefits, at least for the time being.

## Appraising the Soviet Competition

Throughout the five years 1964-68, NASA Administrator Webb continued to stress that the Soviet Union was pressing forward with a broad-based and vigorous space program.[44]

On April 7, 1964, Webb told the House Appropriations Subcommittee:[45]

> We have, in short, emerged from a period in which we were far behind the Russians and did everything we could and regretted our inability to do more. We are still behind in manned space flight, but we now have a very large capability and have achieved sufficient momentum to move ahead of them in the 1965-67 time period. However, there are still many unknowns; the competition is still vigorous and could again become a danger to our position; and we are therefore increasingly confronted with hard decisions in the selection of programs which should be undertaken.

Webb cited the Soviet ability to put payloads of 15,000 pounds in earth orbit, and said there was some evidence that they were proceeding with the development of larger launch vehicles and payloads, but that it was too early to say for sure.

On April 5, 1965, Webb told the House Appropriations Subcommittee that the Russians were still ahead in booster capability available for manned space flight and would be until the Saturn I-B was operational. "It may be," Webb said, "they will match us even in the Saturn I-B."

"The Russians," Webb said, "look to space for a very major breakthrough that will effect their power position in the world and their ability to push communism as a dominant method of organization. . . . If they had a free field and we were not pushing forward ourselves, their opportunity to present themselves as the wave of the future would be very much enhanced."[46]

When Webb appeared before the House Committee on Science and Astronautics on March 10, 1966, he read a statement, which was not in his prepared text but which he had written in the committee room:[47]

> The massive Soviet commitment to a rapid buildup and a long-term program underlines the importance they attach to advancing their space capabilities. It will require a strong and increasing effort initiated no later than Fiscal Year 1968 and vigorously pushed into the years after the United States has achieved a manned lunar landing to prevent them from forging ahead as the unchallenged leader in space.
>
> The program we began presenting to you in 1961 and have elaborated in each succeeding year was intended to meet fierce competition and to end up ahead. . . .
>
> The competition is still fierce and we are not yet able to feel assurance that we will end up ahead in the option areas where the Russians are developing their strongest potential.

Six weeks later, on May 19, 1966, before the Senate Appropriations Subcommittee, Webb announced for the first time that, in his opinion, the Russians would soon have the ability "to put up bigger payloads than we can put up with the Saturn V or certainly in that category." Webb said the Russians were now building "very large equipment" and were moving faster than he thought they would or could a year ago.[48]

Webb repeated his warning in more definite terms when he testified before the Senate Appropriations Subcommittee over a year later on July 26, 1967:

> In my view they are preparing to launch a booster with an appropriately large payload that will be larger than the Saturn V and that will give them the image and capability for the next several years of being ahead of the U.S. program."[49]

In later testimony before the House Space Committee on February 7, 1968, he estimated that in 1968, or shortly thereafter, the Russians would have available a launch vehicle with more than 10 million pounds thrust, or one and one half times the thrust of the Saturn V. He said he expected the Russians to use this new launch vehicle for their manned lunar landing mission.[50]

Webb also gave a written answer to a question on the relative status and progress of the U.S. and Soviet space programs. In summarizing his answer he said:[51]

> In terms of scientific advances and in applications of space systems to economic use, such as meteorological and communications systems, our program has achieved a more advanced state than theirs. But in terms of capability to use large launch vehicles and in the rate of advance toward future greater capabilities (emphasis added), they are and will remain ahead at the 1969 budget level which we are presenting.* The hard fact we now face is, that just as we have begun to catch up in large-scale booster operations -- as shown by the flights of Apollo 4 and 5 -- we are sharply reducing our program while they continue to advance.**

Webb also discussed the Soviet space program at the press briefing at the White House on September 16, 1968, when he announced his intention to retire on October 7, 1968.*** Asked if he was satisfied with the program "as it stands now," Webb said:

> I am not satisfied with the program. I am not satisfied that we as a nation have not been able to go forward to achieve a first position in space.
>
> What this really means is we are going to be in a second position for some time to come. . . .

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*Because of cuts in the FY 1969 budget, NASA's operating level was, of course, further scaled down from the level Webb was discussing here.

**Apollo 4 was the first flight demonstration of the Saturn V launch vehicle.

***See Volume II, Appendix B-VIII; also in letter to the Presient on the same subject, October 2, 1968, in Appendix B-II.

As the U.S.S.R. proceeds to fly and remains in the number one position, we will have the capability to start new programs as the need is clearly indicated.

At the White House briefing, Webb was also asked whether there had been a time when he thought parity with the Russians had been reached. He answered:

I thought we had reached parity with the Russians about two or two and one-half years ago in every field except the flight of the large boosters and the large spacecraft. They have been ahead of us in this field all the time and I have said so in every presentation of the budget to the Congress and for the last four years I have stated that while we have developed options, each of those four budgets would not close that gap with the big spacecraft.

What I pointed out was that they had been flying 10,000 and 15,000-pound spacecraft and recovering them at will. The Gemini is only 7,000 pounds. We have had two (unmanned) flights with the Apollo on the Saturn V. But we were just coming into that area of matching them with these flights.

So we have not been ahead of them or equal to them in the big boosters and the big spacecraft at any time. The 12 Saturns a year would have brought us there I think without any doubt.* If we could have done that in late '67 or early '68, I think we would have forged ahead. But they are still moving at the rate that they have built up to, in fact, increasing it.

So while we are reducing down to a half to two-thirds of our previous program, they are still increasing. . . .

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*Webb's remarks at this press conference were extemporaneous. To express his intended meaning more precisely, this sentence should have read: Flying six Saturn V rockets and six Saturn I-B rockets per year with appropriate payloads, as NASA originally proposed, would have brought us there I think without any doubt.

Asked where the United States stood in comparison with the Soviet Union at the time of his departure, Webb said: "We are not conducting the program at a level that will bring parity." Asked whether the United States had fallen "dangerously" behind the Soviet Union, Webb answered:

> I am not going to use an adjective like that. What I said is that under the President's leadership facing all the problems we have funded the flights in a conservative way that were required to meet our commitments, the flights we have committed ourselves to, and that this will give us experience, Saturn V and Apollo experience, out to the moon. It will give us up to 6,000 hours of flight experience.
>
> This gives a capability to do what we have to do in the future. Any danger to the United States that would come from the Russian program would be visible in time to use this capability to start out. But they are going to have the reality and the image of being out in front for a number of years to come. How dangerous that is you will have to judge yourself.

At this point a newsman said: "You seem to be saying that they have topped the Saturn V, which they haven't." Webb replied: "I have been testifying for three years in the Congress that they were building a booster bigger than the Saturn V and they will be flying it soon."

Webb's final public warning as Administrator on the likelihood of American failure in the drive for space pre-eminence was given in his Diebold Lecture at Harvard University on September 30, 1968. It was also his sharpest and most detailed warning.*

It should be emphasized here that the warnings which Webb gave dealt primarily with the high sustained level of effort in the Soviet space program and the <u>future capabilities</u> that were being developed but not yet revealed publicly. In advising President Johnson on what the United States needed to do to gain and maintain pre-eminence in space exploration and use, Webb stressed that a comparison of current <u>demonstrated</u> space

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*Text in Volume II, Appendix B-VI-3.

capabilities told only part of the story, and that it was necessary to keep attention focused on the Soviet rate of advance and what the Soviet Union would soon be able to do in space, particularly in the early years of the next decade when the U.S. would have very few missions. Webb felt that too much emphasis on current demonstrated capabilities, rather than the rate of build-up for the future in the case of the Soviet Union and the rate of decline in resources in the case of the United States, would tend to lull the American public into a sense of false security in so far as U.S. chances for continued space leadership were concerned.

A brief review of these Soviet achievements will show the broad scope and sustained effort of the Soviet space program in the years 1964 through 1968.* It will also show that, although the Soviet Union did achieve some brilliant successes in space during these years, it still did nothing that aroused and disturbed the American people in the way the first Sputniks and the first Soviet manned flights had done. This was because demonstrated Soviet achievements in these years were matched or exceeded by U.S. achievements; and because U.S. capabilities being built up in the Apollo program were well known to the American public, but Soviet preparations for the future, except for Webb's repeated warnings to Congress, were not appreciated.**

Voskhod I carried three men into space for 24 hours in October 1964; Voskhod II, launched in March 1965, was equipped with an airlock which permitted Cosmonaut Leonov to carry out the first extravehicular activity in space. The two Voskhod flights did appear to take some of the competitive lustre off the first manned Gemini flights, which did not begin until March 1965. It was apparent, however, that the Voskhod spacecraft was not really a second generation manned spacecraft, but was little more than the original Vostok spacecraft modified to carry three persons under crowded conditions in the first flight, and to carry two persons and permit extravehicular activity in the second flight.

The first Soviet communications satellite, Molniya (Lightning), was not orbited until April 1965. The spacecraft

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*Through October 31, 1968.

**Discussion of the Soviet space program is from unclassified sources.

had an apogee of 21,250 nautical miles and perigee of 258, which meant that it was available at high altitudes over the Soviet Union for long periods of time. Seven additional Molniya communication satellites have since been launched.* They are used to relay television programs between Moscow and the Soviet Far East and between Moscow and Paris. The Molniya orbit has for the Soviet Union many of the advantages of synchronous orbit, and permits use of a heavier payload. The Soviet Union has, however, not yet put a satellite into synchronous orbit.*

The Proton I satellite, launched in July 1965, weighed 27,000 pounds and was put in orbit by a "new powerful rocket," the Soviet Union announced. It was called "a scientific space station" and carried heavy instruments to study energetic particles in space. Two additional Proton satellites of similar weight were launched later, and the new Soviet rocket became known as the Proton launch vehicle.

Proton I set a new record for weight of payload in orbit. With expected improvements, the Proton launch vehicle would be able to orbit payloads of 40 or 50 thousand pounds, and perhaps more if high energy upper stages were used.[52] However, through October 1968, the Soviet Union had not announced orbiting a payload heavier than Proton I.

The first operational flight of the U.S. Saturn I-B rocket, capable of putting 38,000 pounds of payload into earth orbit, did not come until the Apollo 7 manned flight in October 1968. The first operational use of the Saturn V rocket, capable of putting 285,000 pounds into earth orbit, took place in the Apollo 8 mission in December 1968.

In February 1966, the unmanned Soviet spacecraft Luna IX made the first successful landing of instruments on the moon, and in March Luna X became the first spacecraft in lunar orbit. These achievements demonstrated the strong Soviet determination to proceed with lunar exploration, and were regarded as sound preparation for later manned flights as well as a brilliant demonstration of Soviet mastery of more and more difficult space-related techniques and technology. The American public was impressed but not alarmed, because the NASA Surveyor and Lunar Orbiter programs soon demonstrated an equally or more advanced

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*Through October 31, 1968.

technology and apparently produced better pictures and more useful new information.

In October 1967, the Soviet spacecraft Venera IV injected an instrumented capsule into the atmosphere of Venus, the first Soviet success, after many attempts, to get back useful information from the planets. There was no evidence, however, that the capsule had survived a landing on the surface of Venus, and some doubt as to its altitude when the readings from its instruments ceased.

NASA's first attempt to land instruments on the planets was not scheduled until the Mars mission of 1973.* But NASA's Mariner V had apparently matched Venera IV in return of scientific information; and Mariner IV's television pictures of Mars in 1965 remained the outstanding technological and scientific achievement in planetary exploration, at least through 1968.

The last successful Soviet manned space flight, prior to the Soyuz III flight in October 1968, was the Voskhod II flight in March 1965. This was followed by ten successful manned missions in the NASA Gemini program. The Soyuz I mission, apparently intended as the forerunner of major new advances in Soviet manned space flight, was made on April 23, 1967, about three months after the Apollo fire. Soyuz I ended in disaster, and the single occupant, Vladimir Komarov, was killed, the first known fatality in space flight.

In October of 1967 and April of 1968 the Soviet Union carried out automatic rendezvous and docking maneuvers of unmanned spacecraft. The American public was not alarmed by this development in Soviet space technology, impressive as it was. NASA had demonstrated the ability to rendezvous and dock manned spacecraft in the Gemini program and would develop these proven techniques still further in the Apollo program. Also, frequent indications that the Soviet Union might soon orbit large space stations did not arouse any noticeable concern in the United States.

Thus, during the crucial years of national decision on post-Apollo programs in 1966 through 1968, the stimulus of publicly demonstrated superior Soviet performance was missing.

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*According to plans as of September 1968.

In a sense, public support for the U.S. objective of attaining and maintaining space pre-eminence was being eroded by NASA's successes. National pride in current achievements which compared favorably with what the Soviets were currently demonstrating tended to dull the sense of urgency for starting the new long-range programs which alone could assure that the Soviet Union would not have an impressive monopoly on significant pioneering space achievements three, five, or 10 years into the future. It was natural enough that many advocates of the NASA space program would wish to emphasize current evidence of the greatly improved U.S. position in space competition with the Soviet Union; it was Administrator Webb's difficult assignment to emphasize Soviet preparations for more advanced space achievements to alert the Congress and the American public to the fact that today's euphoria could evaporate quickly unless steps were soon taken to match the new capabilities for tomorrow's missions being created in secrecy in the Soviet Union.

The flight of the unmanned Soviet spacecraft Zond 5 around the moon and back to earth in mid-September 1968, and its recovery by a Soviet task force from the Indian Ocean, was hailed around the world as a significant step forward on the way to the moon. Some American commentators were quick to speculate that the Soviets were now ahead in the race to the moon, and that a Soviet manned flight around the moon might take place soon. An editorial in Pravda on September 24 pulled out all the stops in portraying Zond 5 as a great triumph of communism: "Since the time 11 years ago when the earth's first artificial satellite was launched, our Motherland has not yielded its foremost position in the exploration and conquest of space."*

In October 1968 both NASA and the Soviet Union resumed manned space flights after a long interruption. It was the general view in the United States after the Apollo 7 and the Soyuz III missions that the Apollo flight had been more impressive and that the Apollo spacecraft was more advanced than the Soyuz. Again the need was underscored for emphasizing to the American public and their leaders that current success was only part of the space competition story, and that the more accurate

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*The Soviet Union no doubt found Zond 5 useful in helping to divert world attention from the occupation of Czechoslovakia at the time with Soviet troops.

measure of space leadership at the end of 1968 was which country was preparing most effectively for the use of new generations of boosters and spacecraft that would soon appear and the use of new important advances in space capabilities that could be made and exploited in the decade of the Seventies.

## Apollo as the Focus of Debate

Public discussion of national purpose in the NASA space effort generally centered on the Apollo program and its manned lunar landing goal. Apollo became a classic example of an on-going national effort supported by the Administration and a majority in Congress, but subject to continual criticism and opposition from a number of influential newspapers, commentators, and legislators. Moves to make a significant cut in the Apollo program, tantamount to a reversal of national policy, mustered around 30 votes in the Senate year after year.

Debate on the Apollo program was related to the following:

- More than half of all NASA appropriations from FY 1962 through FY 1969 were for Apollo.
- It was considered motivated principally by the U.S. desire for leadership in the space competition with the Soviet Union.
- It did have some of the aspects of a race to the moon, even though it was much more than that; and its broad role in rapidly developing U.S. capabilities for space missions in earth orbit and the whole area of space between earth and the moon was often not fully brought out in public debate.
- It was viewed in various quarters as drawing off funds from more important scientific missions or more urgent military efforts in space.
- It required a long period of heavy expenditures involving proven, but not new technology.

-- It called for large investments over many years before its success could be demonstrated or exploited. (One reason why the Apollo program was chosen in 1961 as the most ambitious U.S. space project for the decade was the thought that the U.S. industrial system could out-perform that of the Soviet Union on such a large-scale and difficult undertaking.)

-- And because of high development and operating costs right up to the end of the program, it tended to hold back the start of new programs.

Some of the alleged weaknesses or most criticized aspects of the Apollo program were also its strong points:

-- The political and emotional commitment to Apollo probably saved it from bogging down or being dragged out indefinitely.

-- It gave the necessary focus to the U.S. drive for the rapid development of competence in the use of large boosters and in manned space flight.

-- Because of its dramatic objective and its schedule, it helped force the rapid development of capabilities for unamnned space exploration in the Ranger, Surveyor, Lunar Orbiter, and other programs.

-- Apollo also had the virtue of requiring collateral studies of the sun to provide ways of forcasting and averting possible dangers to astronauts and equipment from solar radiation on journeys to the moon and back. This in turn helped to give greater coherence and sense of purpose to NASA's space science effort.

-- Apollo established a high level of effort in manned space flight for the decade of the Sixties; it is probable that this also caused the level of effort in the space science field to be raised rather than restricted.

The role and level of support of the Apollo program during the Administrations of Kennedy and Johnson will undoubtedly be a subject of further study and analysis by historians not only for its immediate contribution to U.S. progress in science and technology, but also as a precedent for other needed efforts to rapidly advance nonmilitary science and technology in a democratic society.[54]

At this time, late 1968, a heavy share of history's judgment on the Kennedy and Johnson Administrations, and on Lyndon B. Johnson's personal leadership in charting the U.S. course in space, and the place of NASA still rests upon the success or failure of the Apollo missions scheduled for 1969. What the Russians can achieve in the same period will also be a major factor in measuring the success of the U.S. drive for space pre-eminence in the decade of the Sixties.

There is, of course, no answer today on the question whether NASA space effort was properly balanced during the Kennedy and Johnson Administrations. The best way of attempting an answer might be to ask whether any important area of space activity or of space opportunity had been neglected in such a way as to harm the security and prestige of the United States or to inhibit or seriously delay future U.S. advances in space exploration and use.

The answer, so far as could be told by the end of October 1968, was that the United States had indeed made creditable progress in all the identified areas of promise in space and appeared to be in a reasonably viable position to move forward effectively in whatever direction the national interest would require in the future.

## NASA and DOD

The bulk of NASA - DOD cooperative activities take place through the Aeronautics and Astronautics Coordinating Board and its many panels. However, in many important areas specific agreements covering NASA - DOD relations have been negotiated and signed. One of the most significant of these agreements between Administrator Webb and Secretary McNamara concerned plans for a possible large earth-orbiting space station. This agreement was signed on September 16, 1963, near the end of the Kennedy Administration. The President's Report for 1963 said of it:

> As pointed out in the agreement, since a large orbital space station would be a major technical and

financial undertaking, the requirements of all government agencies should, insofar as practicable, be met in a single national program.

Both NASA and DOD will continue advanced and exploratory studies to develop data on agency requirements, possible new design concepts, feasibility, and costs. These studies are to be coordinated through the Aeronautics and Astronautics Coordinating Board (a joint NASA - DOD group) which will evaluate the various advanced space station concepts. Acting upon the evaluations of the AACB, and in the light of experience gained in Gemini, MOL, and Apollo, the Secretary of Defense and the Administrator of NASA will, at an appropriate time in the future, address a joint recommendation as to whether to proceed with a new national program in this area.

The significance of this agreement was that it was designed to keep the inter-agency competition to design and manage such an important and challenging program from getting out of hand. Neither the Defense Department's Manned Orbiting Laboratory (MOL) nor NASA's Saturn I Workshop and Saturn V Workshop (under the Apollo Applications program) was to be considered a "space station" under the terms of the agreement. Webb has suggested on several occasions, however, that the Department of Defense might consider using a Saturn V Workshop as a follow on to its MOL program.[55]

A major change in the military approach to the possible uses of manned space flight came on December 10, 1963, when Secretary of Defense McNamara announced that the current X-20 or Dyna-Soar program would be cancelled and the the Air Force would proceed instead on the Manned Orbiting Laboratory (MOL) program. NASA and DOD worked together in defining the MOL program which makes use of the Gemini spacecraft, and NASA concurred in the DOD decision to go ahead with it.

The MOL remained in what was called the pre-program definition phase during 1964. On August 25, 1965, President Johnson announced at a press conference, after discussion with Vice President Hubert H. Humphrey and members of the Space Council, that he was instructing the Department of Defense to proceed immediately with the development of MOL, with the first manned flights scheduled for 1968. The President made an especial effort at this press conference to stress the peaceful aims of the United States in space and the desire for cooperation with the Soviet Union. He also announced that he was asking Webb to invite the Soviet Academy of Sciences to send a "very high level representative" to observe the next Gemini launch, an invitation that was not accepted.[56]

In his public statements, Administrator Webb stoutly defended the White House decision to proceed with MOL, and denied suggestions that there would be wasteful duplication between MOL and the Saturn I and Saturn V Workshops in the Apollo Applications program. His statements on this subject were ususally in the form of answers to questions at press conferences or during Congressional hearings. A more comprehensive answer can be found in the record of the Senate hearings on the NASA appropriation for FY 1969.[57] Debate on possible duplication between MOL and NASA Workshops continued into the fall of 1968, and it was expected that the question would be an important one during Congressional consideration of the FY 1970 budget.[58]

NASA and DOD were also endeavoring in the fall of 1968 to determine future national needs in the field of new large launch vehicles. One possibility under consideration was the development of a simpler and less-costly vehicle than the Saturn V with the capability to put about 100,000 pounds into earth orbit.[59] In aeronautics, NASA continued to serve certain DOD needs while Air Force laboratories assisted NASA importantly.

The exchange of key personnel between NASA and the military services, generally to the benefit of NASA, was also an important factor in improving NASA - DOD cooperation. Such exchanges helped to create a climate of mutual confidence that broad national needs for new technology, new resources, and advanced operating experience were being met in NASA programs. The Air Force made available and NASA approved Lt. Gen. Samuel C. Phillips, USAF, as director of the NASA Apollo program in 1964. This was an outstanding example of the AF - NASA cooperation. Phillips is an active duty Air Force officer and is on assignment to NASA. He had been director of the highly successful Minuteman program from 1959 to 1963.

NASA Planning for the Seventies

Planning the major new NASA programs for the Seventies was not an enviable assignment. To an observer on the periphery of the process it looked like pretty grim work. A number of reasons why this was so can be suggested. NASA was preoccupied during the early years of the Johnson Administration with carrying out the firm programs of the Sixties. So was the Congress. Public discussion of ambitious new programs, however, served to stiffen Congressional opposition to funding the current effort.

Many exciting possibilities were explored; and the more options the new technology made feasible, the more difficult it became to choose among them and make long-range commitments to a given course. Planning disciplines at NASA became more rigorous, and phased program planning procedures were adopted as dollar constraints heightened. Any significant new program for the Seventies was certain to be expensive, and substantial costs would have to begin while Apollo and other current programs were in full swing (the assumption being, of course, that a long gap in flight activity in the early Seventies would be unacceptable to the country).

Despite the rising costs of the Viet Nam war and other pressing fiscal problems, President Johnson did not seem to lose his belief in the need for a strong NASA program in the Seventies; but he felt obliged to put off decisions on starting new NASA programs as long as he could.

A very important strategy decision was reached not to set another spectacular, long-range goal, such as Apollo had been, but to stress intermediate steps and delay commitments on the more challenging long-range goals. This approach left the future options open, but it also left more uncertainty about what the direction of the intermediate steps should be or what their urgency was. A decision on manned exploration of the planets, for example, would have given the NERVA II nuclear rocket engine development an immediate priority. This approach helped keep down public criticism of the space program during difficult times, but it also tended to keep down whatever public enthusiasm might have been generated by a challenging, new long-range goal.[60]

The major new programs chosen for the Seventies -- Voyager, Apollo Applications, and NERVA -- were at first proposed to Congress on a tentative basis, with some funding for long-lead time items, but without the requirement for a commitment. Consequently, they were left dangling for several years. When the President finally called for a commitment to all three in his Budget for FY 1968, and a subsequent amendment, for NASA planners it was a high achievement. But there was little time for public enthusiasm to be manifest. The President's Budget was delivered to Congress on January 24, 1967, and the tragic Apollo fire occurred three days later.

NASA planners got little help, as has been noted, from the Soviet space program, which attracted little public attention and stirred no alarm from 1965 up to the flight of Zond 5 in September 1968. So far as the American public was concerned the spur of visible Soviet competition was largely lacking during the critical years for new program planning. The warnings of Administrator Webb on what the Soviet Union would be able to do were often dismissed as "cry wolf" scare tactics to help get the NASA budgets through Congress.[61] The future will serve as the judge in this matter.

NASA did receive substantial help from the scientific community in planning programs for the Seventies; but these recommendations represented a somewhat one-sided view of what the purpose of the space missions was to be. Even at NASA, the Future Programs Task Group did not list space leadership as one of the 10 NASA objectives in its Summary Report of January 1965.[62]

Since the rationale behind the new programs did not seem to require any set level of accomplishment or any urgent schedule, Congress gave them the salami treatment and cut them back slice by slice.

As Congressional familiarity with space possibilities grew, and NASA's image of unprecedented success suffered as a result of the Apollo fire, Congress entered into the planning activities more actively than ever before, and numerous suggestions for alternatives to NASA's proposals were made in 1967 and 1968 to expand the public dialogue.[63]

NASA in mid-1968 looked forward to the time when Apollo manned flights would begin and public enthusiasm for space activities might be expected to rise again. In the meanwhile, it took a strong measure of dedication at NASA -- or at least thick skins -- to keep thinking of the nation's future in space while commentary like one in Newsweek appeared in the popular press:[64]

> . . . the U.S. space program is in decline. The Viet Nam war and the desperate conditions of the nation's poor and its cities -- which make space flight seem, in comparison, like an embarrassing national self-indulgence -- have combined to drag down a program where the sky was no longer the limit.

Within NASA, however, planning for the Seventies was nonetheless attacked with new zeal in preparation for the change in Administrations, the impending completion of current programs, and the need for a "new look" at where NASA was headed in connection with President Johnson's FY 1970 budget.

During Senate hearings on the NASA appropriation for FY 1969, Administrator Webb was asked to give the committee the benefit of the agency's recent post-Apollo planning.* His answer, in part:[65]

> NASA is now concentrating its effort on the development of a major improvement in its planning organization and methodology. The purpose is to assure that all meaningful program alternatives are properly evaluated and that the near-term as well as the long-term implications of program decisions are clearly identified and fully understood. The basic planning machinery has been set in motion and at this time the individual Working Groups examining the various elements of the NASA program are preparing their analyses of the major options in aeronautics and space exploration, with emphasis on those decisions which would need to be made this year. The product of this work will not be available until the time of the FY 1970 Budget decisions.

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*Dr. Homer E. Newell, Associate Administrator of NASA since October 1, 1967, was assigned special responsibilities in the planning area.

## Confidence in NASA Management

NASA's reputation for effective management has been considered an important factor in obtaining from Congress the funding required for America's drive for space leadership. Moreover, NASA's demonstration of management of large research and development programs was an important benefit to the nation derived from its investment in the space effort.[66] Early in the space program, when experience was limited and checkout equipment and procedures relatively crude, launch failures were accepted as an unavoidable part of the process. Later, as spacecraft and launch vehicles became much more expensive and computerized checkout procedures more highly developed, the expectations of initial success in new projects and the penalties for failure became much greater. This was especially true of manned space flights, starting with Mercury when a man's life was at stake.

Prior to the Apollo fire in January of 1967, NASA had scored many important successes in increasingly difficult missions which established a reputation of management skill, built up confidence and good will in Congress, and seemed to enhance American prestige around the world.

The Centaur rocket, which had drawn much criticism, had its first successful flight test in November 1963 and went on to perform flawlessly in sending seven Surveyors to the moon. It was an impressive record for an advanced rocket making the first use of liquid hydrogen as a super-fuel in space and a triumph for rigorous management after early failures.

Ranger VII got U.S. lunar exploration into a success groove in July 1964 after a number of earlier disappointments. In 1966, after many troubles in the development stage, the first Surveyor spacecraft sent to the moon landed successfully and was soon followed by Lunar Orbiter, also successful on its first flight.

All ten of the manned Gemini flights in 1965 and 1966 were completed with many triumphs, no serious accidents, and a number of confidence-building episodes in which high competence and response to challenge were demonstrated in space and on the ground.

Six Saturn I flights and 3 Saturn I-B flights were completed up through 1966 without a failure -- for a unique record in the development of a powerful new launch vehicle.

In addition to these successes in space and at the moon, NASA had compiled an impressive record in holding Apollo costs near the bottom of the $20 to $40 billion range in the 1961 estimates and in overcoming delays that might have been expected from the budget limits imposed by Congress in 1963.[67] The Apollo fire on January 27, 1967, in which three astronauts lost their lives, came as a particularly severe shock to NASA's top management because it was recognized and acknowledged that management shortcomings were inevitably involved.[68]

In the aftermath of the fire, NASA top management faced an even greater challenge than any it had ever known before. Despite the shock, grief, chagrin, and bitter regrets which Webb and his associates felt, there was a sudden added burden of work and responsibility on them. The cause of the accident had to be learned and made known, the necessary corrections gotten underway, and a program of great national importance protected against unfair criticism, paralysis, and collapse.

Not only the Apollo program was at stake. The accident came only a few days after President Johnson in his Budget for FY 1968 had asked Congress for heavy commitments to new space programs for the decade of the Seventies, including a strong Apollo Applications program of manned space flight to begin in 1968.

Foremost among the gruelling tasks of NASA top management immediately after the accident was re-gaining the confidence of Congress, and of the public. NASA management was supported in this respect by the very forthright and detailed report prepared by the Apollo 204 Review Board, headed by Floyd L. Thompson; and the interim reports on the Review Board's work prepared by Robert C. Seamans, Jr., Deputy Administrator of NASA, which were submitted to Administrator Webb and also made available to Congress and the press.

Lenghty and detailed hearings on the accident itself, the Review Board's findings, and NASA's proposed actions to prevent a recurrence were held by the Senate Committee on Aeronautical and Space Sciences and by the Subcommittee on NASA Oversight of the House Committee of Science and Astronautics.

Webb appeared before the Senate Committee on February 27, April 17, and May 9, 1967, and before the House Subcommittee on April 10 and May 10.[69]

It was inevitable that the hearings would be unpleasant and embarrassing for NASA; but on the whole they gave NASA a sympathetic forum in which to explain how a tragedy had come about, and show how it would serve to correct deficiencies. The Review Board's findings explained in full detail what had happended; the hearings went further in helping the Congress and the public to understand shortcomings which on the basis of hindsight after the accident had seemed incredible.

The Senate Committee published a report on the accident dated January 30, 1968, which gave a clear statement of the unanimous views of the Committee and its recommendations, plus the additional (and more critical) views of three of its members.* Significantly, the first of the Committee recommendations was that NASA continue to move the Apollo program forward to achieve its goal.[70] An important question debated in the hearings was whether the fast-paced Apollo schedule and its lunar landing goal by the end of the decade might have been underlying causes of the accident. Although there were many critics who seemed to want to believe this, no conclusive evidence was brought out by either the Review Board or the Congressional hearings that the accident was caused, directly or indirectly, by undue haste.[71]

In its recommendations, the Senate Committee report stressed the desirability of continuing to try to hold to the established goal:

> While this goal has attracted a great deal of attention in terms of national prestige, as a pacesetter for the program, and as a rallying point for the people on the program, its true significance is seldom mentioned. The target date was and still is essential to efficient management of the program. It is essential to the planning process and to maintaining a vigorous and competent organization. Any program and particularly the largest and most complex

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*The House Sub-Committee did not publish a report summarizing its findings.

research and development program ever undertaken by man -- the Apollo program -- must have scheduled goals. The schedule is an essential and significant management tool -- without it the program would require more and more time and more and more money.

NASA officials also pointed out that any responsible executive would have been aware that a tragic accident in the Apollo program would be the most time-consuming and costly thing that could happen. It was axiomatic that the more demanding the schedule, the more careful the design and workmanship would have to be to avoid delays and possible failure. And it did not necessarily follow that a slow-paced manufacturing operation is certain to be more efficient and error-free than one under pressure. The contrary might just as well be true.

A serious issue that arose during the hearings was whether NASA had kept the Congressional committees adequately informed about shortcomings in performance by the contractor building the Apollo spacecraft (North American Aviation) many months before the fire. The issue focused at first on whether Webb and other NASA officials had been "evasive" in not acknowledging the existence of a set of documents (that came to be known as the Phillips report) criticizing the contractor's work on the Apollo spacecraft; and then on Webb's refusal to give the committees for use in open session and to disseminate to the press and public copies of the documents because such disclosures might be harmful to effective working relationships between NASA and its contractors. The issue became a tense and emotional one, inflamed by newspaper headlines. A somewhat similar issue arose on the question whether Webb had deliberately misinformed committee members on the circumstances surrounding the award of the Apollo spacecraft contract to North American Aviation in the first place.[72] These side issues tended to obscure the fact that the tragic story of the Apollo 204 accident was being frankly told by NASA and the Review Board; and the equally significant fact that NASA's managerial skill was being exercised in strong fashion to overcome earlier shortcomings and get Apollo back on the track.

It was recognized at NASA that recovery from the damage done to its reputation with the public and its standing in Congress could come only after a series of successful manned flights in the Apollo spacecraft.

New Decisions Needed

As James E. Webb's nearly eight years as NASA Administrator drew to a close, he had some interesting comments on pre-eminence as a national goal and the level of public support for NASA:*

> These reductions in the level of research and development work in the fields of aeronautics and space will have many serious effects on the U.S. position in science and technology, and in time on our status and prospects as a great power. But the ones to which we are adapting this year are only the most recent in a series of cutbacks that constitute in total what may be called a national decision. This decision has been in the making since 1964. It is that the United States will not at this time take the steps necessary to use the trained manpower and capital plant which we have built up to continue the advances of recent years in the scientific and engineering fields essential for success in space and aeronautics.
>
> Looked at in another way, the decision means that the United States is not pursuing, for the time being at least, its goal of 'pre-eminence in space.' The U.S.S.R. is quite evidently stepping up its efforts at the same time that we are curtailing our own. At the time that our production of the large Saturn boosters grinds to a halt, the Soviets will be bringing on stream their large new booster. While our plans for a Saturn V orbiting workshop remain on ice, the Soviets will be able to proceed with their long-heralded, multi-manned and multi-purpose space station. At present levels, the launching of planetary probes and deep space exploration in the early 1970's will be left to the almost exclusive domain of the U.S.S.R. The U.S. is accepting for a long time, perhaps for the indefinite future, both the advantage of expenditure reduction and the disadvantage of a second-rate position in space. In aeronautical research and development the situation is not the same, but is still a cause for serious concern.

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*From Diebold lecture at Harvard University, September 30, 1968. For full text, see Volume II, Appendix B-VI.

While I would be remiss if I did not thus emphasize the consequences that will flow from recent decisions, I recognize that the totality of the problems our nation faces reaches far beyond NASA. As responsible government officials, we in NASA accept the result of our nation's decision-making process. We know that our immediate job is to achieve success in the missions started in past years and now nearing completion. We accept the necessity of adjusting our organization, programs, contracts, university grants, and facilities to meet the reductions that have been decided on. In the process, we will do all we can to maintain a firm foundation on which we can build in the future.

As I say this, let me make very clear that NASA is still in business; and it will stay in business. We view what is happening not as a defeat but as a challenge of the times and we are moving to meet this challenge by assuring continuity in our senior management group and continuing a hard-hitting, technically sound program aimed at keeping open a wide range of options for use when the nation decides to resume its advance as a spacefaring nation. We are making the necessary adjustments now and we are also preparing a base for the nation's longer term requirements.

In connection with conditions essential to continuity, I should stress that the events of the past few months, while they have led to reduced levels of support, have nevertheless shown that there exists throughout the country a strong continuing core of support for research and development in both space and aeronautics. When one considers the whole array of problems now facing the Congress and the nation, and the fact that all national programs, needs, and priorities are being adjusted, it must be taken as significant that both the legislative and executive branches are standing firm at a four billion dollar level for the 1969 NASA budget. I think this shows a recognition of the need to continue a major effort in aeronautics and space.

Also, among thoughtful people in the country at large, I do not find a decline in public support for the space program. Rather, many feel we are in a period in which attention has been focused on other serious needs and

> problems. The problems of how we stand in the world, including our position in Southeast Asia, and the problems faced by the cities have been with us for many years. But it was not until these approached major points of crisis that demands were made for major commitments of resources extending over a long period of years. We in NASA saw much the same thing happen with Sputnik and with Gagarin. This phenomenon has been called 'decision by crisis.' The result is that many people who in the years following 1961 ascribed to space needs a special, top priority status are now realizing, as the national leadership in the space program has understood all along, that the space program must be regarded as only one of a number of essential activities of high priority to which the country must devote substantial resources. In my opinion, what may appear to some to be a decline in public support is not a changed attitude toward space, but a reflection of a new awareness of other high priority problems and requirements.

In Webb's view the Nation was fast approaching another period of crisis in its space policy, and some very hard new decisions on the priority and level of effort of NASA acitivities would have to be made.* The continued public support Webb spoke of, and the Congressional decision to hold space appropriations near the $4 billion level for FY 1969, were both bound up with the wisdom of completing current programs. But the hard, unsolved problems concerned policies, priorities, and programs for the future. And for them there was as yet no answer. The Johnson Administration had wrestled mightily with the problem of renewing America's commitment to space for another decade. The ground was well plowed, but a new Administration would have to undertake the planting.

## The Uncertain Future

The central story of NASA funding from 1958 to 1961 to 1968 and its relation to national policy and the pressures of public opinion raises two key questions for the attention of future historians.

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*See also Administrator's letter to the President, October 2, 1968, in Volume II, Appendix B-II.

Could large space programs be successfully funded to completion over a number of years without prior commitment to demanding goals and schedules or prior commitment to an annual budget level -- or both?

Is the United States likely in the foreseeable future to make such commitments (and therefore substantial investments in space exploration and space technology advances) without the stimulus of international competition and without serious intent to carry out a national policy of gaining and maintaining space pre-eminence?

During the Johnson years the stimulus of the Russian competition in space had been less apparent and the responsive desire for U.S. "pre-eminence" had grown less clear. But the ongoing drive to build American space capabilities rapidly in the Saturn/Apollo program, focused on the lunar landing goal, called for annual levels of spending that had to be met (or repudiated, in an abrupt reversal of national policy); and they were met.

The future, as seen from the fall of 1968, appeared much less clear for NASA:

-- The national commitment to the Saturn/Apollo program would soon run out with the accomplishment of the lunar landing goal.

-- Congress had indicated it did not want to make or imply any commitment to large-scale exploration of the planets, manned or unmanned.

-- The commitment to the future continuous use of the capabilities built up in the Saturn/Apollo program was still tenuous.

-- The conviction that the United States would need nuclear-powered rockets by 1980 was not yet firm.

-- The proposal advanced by NASA that a Saturn V Workshop (as the interim step to a large manned space station in earth orbit) should be an important part of the Apollo Applications program had not caught on in Congress as a major goal, and was hardly known to the public at large.

-- And the Administrator, in announcing his retirement, took the position that America's drive for space pre-eminence in the Sixties had not fully succeeded; that, in the future, the Soviet Union would "have the reality and the image of being out in front" for a number of years to come; and that a new national decision was needed on whether Soviet "pre-eminence in space" was something Americans were willing to accept.

## NOTES TO CHAPTER II

1. <u>The U. S. Budget, 1965</u>, p. 22.

2. <u>Ibid</u>., p. 88.

3. House Committee on Science and Astronautics, <u>1965 NASA Authorization</u>, Part 1, pp. 5-14. Session of February 4, 1964.

4. House Committee on Appropriations, Subcommittee, <u>Independent Offices Appropriations for 1965</u>, Part 2, pp. 921-1022, especially pp. 934-964.

5. NASA News Release No. 64-221.

6. The Summary Report and related letters are reproduced in Senate Committee on Aeronautical and Space Sciences, <u>NASA Authorization for Fiscal Year 1966</u>, Part 3, pp. 1016-1102. In the main, the NASA <u>Summary Report</u> outlined the various options available, and suggested that a national decision would be required to provide adequate funding for any of the costly ventures.

7. <u>The Budget</u>, 1966, pp. 87-88.

8. Transcript of NASA Budget Briefing, January 23, 1965, p. 28.

9. <u>Ibid</u>.

10. Transcript of NASA Budget Briefing, January 23, 1966, p. 8.

11. <u>Ibid</u>., pp. 20-21.

12. The House Committee on Science and Astronautics and the Senate Committee on Aeronautical and Space Sciences each produce a report on the annual NASA authorization bill, presenting the committee's recommendations to the House or Senate and other comments. These committees are usually referred to as the "space" committees for convenience, or as the legislative committees, to distinguish

them from the appropriations committees. Each of these Committees are deserving of separate histories to document their contributions to the history of NASA. Such separate histories cannot be recounted here.

13. Congressional Record, Vol. III, Part 12, p. 16515.

14. Background material distributed at NASA budget briefing on January 21, 1967, includes "operating plan" figures for FY 1966 and FY 1967 as well as budget request figures for FY 1968.

15. The Budget, 1967, pp. 16, 22.

16. Ibid., p. 92.

17. Transcript of NASA Budget Briefing, January 22, 1966, pp. 20 and 23.

18. House, 1967 NASA Authorization, pp. 2, 5.

19. Ibid., p. 24.

20. House Committee on Science and Astronautics, Report No. 1441, pp. 101-2.

21. Senate Committee on Aeronautical and Space Sciences, Report No. 1184, pp. 31-32.

22. Webb letter to President of Senate (and Speaker of the House) dated January 23, 1967.

23. The Budget, 1968, p. 21.

24. Ibid., pp. 94-95; Weekly Compilation of Presidential Documents, Vol. 3, No. 9, pp. 334-5.

25. Robert C. Seamans, NASA Associate Administrator, told the Senate space committee in 1965 that "a program to build upon the existing Saturn and Apollo capability can be expected, depending upon the rate of flight activity and operations and the extent of scientific instrumentation and flight hardware modifications, to be comparable in annual costs to the present level of Apollo funding," or more than $2½ billion per year; see National Space Goals for Post-Apollo Period, p. 343.

Also, George Mueller, NASA Associate Administrator for Manned Space Flight, said at the NASA budget briefing on January 27, 1968, that runout cost of the Apollo Applications program at reduced levels then planned would be between $4 and $6 billion depending on final definition of the Saturn V Orbiting Workshop. See page 45 of transcript.

For estimates of cost of Voyager and NERVA, see NASA budget briefing, January 21, 1967, pp. 45 and 49 of the transcript.

26. Transcript of NASA Budget Briefing, January 21, 1967, p. 38.

27. George Mueller, NASA Associate Administrator for Manned Space Flight, told the Senate Committee on Aeronautical and Space Sciences on August 23, 1965, that six Saturn I-B flights and six Saturn V flights per year, with eight of the twelve manned, represented optimum utilization of facilities, personnel, and resources. See National Space Goals for the Post-Apollo Period, p. 70.

28. NASA News Release No. 67-11 and transcript of Apollo Applications briefing held at NASA Headquarters January 26, 1967. A good description of the proposed new Apollo Applications and Voyager programs will be found in the hearings on the FY 1968 NASA authorization or in Report No. 338 of the House Committee on Science and Astronautics or Report No. 353 of the Senate Committee on Aeronautical and Space Sciences.

29. See Committee Reports No. 338 and 353 mentioned immediately above.

30. Weekly Compilation of Presidential Documents, Vol. 3, No. 34, p. 1193.

31. Senate hearings, National Aeronautics and Space Administration Appropriations, 1968, 209 pages.

32. Dr. George Mueller, NASA Associate Administrator for Manned Space Flight, said at NASA budget briefing on January 29, 1968, he believed there was a "reasonable chance" of carrying out the lunar landing mission in 1969. See page 43 of transcript. Webb had said at Senate Committee on Aeronautical and Space Sciences hearing on November 8, 1967, that it was possible that the lunar landing could take place in 1969, but "more likely" that it would take place on one of the flights scheduled for 1970. See NASA's Proposed Operating Plan for Fiscal Year 1968, p. 8.

33. See NASA's Proposed Operating Plan for Fiscal Year 1968, the printed record of hearings held by Senate Committee on Aeronautical and Space Sciences on November 8, 1967.

34. The Budget, 1969, pp. 28-29.

35. NASA News Release No. 68-141.

36. NASA budget briefing held January 29, 1968, p. 58 of transcript.

37. Ibid.

38. To the extent that opinions may be expressed in this chapter, they are those of the author. Their purpose is to identify questions that may helpfully interest the future historian, rather than to present a NASA view (if there is one) or definitive answer.

39. For a comprehensive study of motivations for the U. S. space effort see Vernon Van Dyke, Pride and Power: The Rationale of the Space Program (Urbana, University of Illinois Press, 1964). Other selected references: a) "Introduction to Outer Space," an explanatory statement prepared by the President's Science Advisory Committee and released by the White House March 26, 1958; b) Report to the President-Elect of the Ad Hoc Committee on Space (Jerome B. Wiesner, Chairman), released to press January 12, 1961; c) Lyndon B. Johnson, "Why Go to the Moon," Aerospace magazine, September-October 1963; d) Hubert H. Humphrey, "Space Exploration: A Higher Vision," remarks at Collier Trophy presentation ceremony, May 7, 1968. Published as pamphlet by Aerospace Industries Association of America, Inc., 1725 De Sales Street, NW, Washington, D.C., 20036; e) Letter of Secretary of State Dean Rusk to Senator Robert S. Kerr, dated June 14, 1961, discussing importance of the "prestige" motivation and opportunities for international cooperation; f) James E. Webb, interview, "Why Spend $20 Billion to Go to the Moon?," U. S. News & World Report, July 3, 1961; g) Webb, "America's Role in Space Today," N. Y. Times, October 8, 1961; h) Webb, keynote address, Third National Conference on Peaceful Uses of Space, Chicago, May 6, 1963; i) Webb, address at Second National Flight Forum Symposium, Hartford, Conn., May 15, 1963; j) Webb, statement on policy in address at Brigham Young University, Provo, Utah, March 25, 1964: "I believe our national space policy as it now stands can be summed up very briefly but fairly in this three-part statement: We seek (1) to obtain for the American people at reasonable cost the benefits to be

won from space exploration and space use and from rapid progress in space science and space technology; (2) to achieve and maintain pre-eminence for the United States in all major areas of space activity; and (3) in so far as possible to use our growing space power to encourage international cooperation in space, reduce tensions, and benefit mankind"; k) Webb, "Power and Prestige in Space," article for Associated Press, Washington Sunday Star, April 24, 1966. Also issued by Office of Public Affairs, NASA, in Speaking of Space and Aeronautics series, Vol. II, No. 4; l) Webb, statement for Senate Committee on Aeronautics and Space Sciences (in answer to question about diverting funds from space program to "some of the pressing problems we have here on the ground"), NASA Authorization for Fiscal Year 1967, pages 62-63; m) Frederick Seitz, President of the National Academy of Sciences, "Science and the Space Program," Science, June 24, 1966, pp. 1719-1721; n) Theodore C. Sorenson, Kennedy, (New York, Harper & Row, 1965), pp. 523-29; o) Lloyd V. Berkner, The Scientific Age, (New Haven, Yale University Press, 1964), pp. 18, 20-22.

40. See also President Johnson's Letter of Transmittal, Report to the Congress, U. S. Aeronautics and Space Activities, 1963: "(The year 1963 was) a period of searching evaluation of the national space program -- an evaluation which resulted in broad acceptance of the policy of our attaining and maintaining space leadership, with due regard for our national security."

41. Washington Post editorial, September 24, 1968. Also see vigorous statements by Webb in Diebold Lecture at Harvard University, September 30, 1968 (in Appendix B-VII), and Wernher von Braun in U. S. News and World Report, October 14, 1968. A different viewpoint was the editorial in the Sunday Star (Washington), September 22, 1968.

42. Webb, in letter to President dated February 16, 1965, recommended that the Summary Report of the NASA Future Programs Task Group be made public: "More than in most areas, major decisions on space require a broad consensus. During the next several years it is likely that the selection of major new space missions will be the subject of serious study and debate by many individuals and agencies in public and private walks of life. For these reasons, it may be desirable at an appropriate time to make the attached report generally available." Letter and Summary Report reproduced in record of Senate hearings, NASA Authorization for Fiscal Year 1966, Part 3.

43. Review in "Book World," The Washington Post, June 30, 1968.

44. See also "Review of the Soviet Space Program," a report of the House Committee on Science and Astronautics, prepared by Dr. Charles S. Sheldon II, which covers the Soviet space effort, with comparative U. S. data, from 1957 up through November 5, 1967. Available from Superintendent of Documents, U. S. Government Printing Office.

Webb faced a continuing dilemma in his comparison of Soviet and U. S. space efforts. Webb would have preferred to hail the success of the NASA program in achieving space pre-eminence, particularly during the Gemini flights (when the United States went far ahead of the Soviet Union in demonstrated capabilities for manned space flight). But Webb also had the responsibility of keeping the President, the Congress, and the country from being lulled by these significant, but possibly quite temporary, victories in the space competition. Thus he felt compelled to draw upon his knowledge of Soviet activities and Soviet potential based on classified reports and to stress the more rapid "rate of advance" of the Soviets toward "future greater capabilities."

45. House hearings, Independent Offices Appropriations for 1965, Part 2, p. 850.

46. House hearings, Independent Offices Appropriations for 1966, Part 2, p. 850.

47. House hearings, 1967 NASA Authorization, Part 1, p. 5.

48. Senate hearings, Independent Offices Appropriations for Fiscal Year 1967, Part 1, pp. 875-6.

49. Senate hearings, NASA Appropriations for Fiscal Year 1968, p. 70.

50. House hearings, 1969 NASA Authorization, Part 1, p. 98.

51. Ibid., pp. 98-99.

52. See 44., pp. 8-9.

53. Ibid., p. 73.

54. In the third of three lectures presented in the McKinsey Foundation Lecture Series at the Graduate School of Business, Columbia University, on May 16, 1968, Webb said:

If instead of a manned exploration of the moon, President Kennedy had chosen as the nation's goal the building of a large earth orbiting space station, we could have adjusted the size of that station downward should there be a shortfall in booster thrust. If we had had to make one or more such adjustments, we would have been subjected internally and externally to all kinds of questions and pressures relating to whether the goal of pre-eminence in space was actually being met. We would have faced a particularly difficult kind of credibility gap in an endeaver whose real purpose was to build a national capability to operate in space and to develop a variety of options, any of which could be utilized by the nation in the event of future need. But the goal chosen by President Kennedy, manned exploration of the moon, required a full and complete success in the development of a booster large enough to do the entire job as well as the spacecraft and operational know-how to send the men out and bring them back. Even a small shortfall in booster performance could only spell failure to meet the goal. There could be no yielding to temptations to downgrade the objective when difficulties in meeting it arose.

Many otherwise thoughtful observers have failed to recognize this important characteristic of the 1961 space decisions and have also failed to recognize that the capability to land men on the moon imposes the requirement to develop and use energy up to ninety-eight percent of the total required to do any other job in space. The same booster that can take men to the moon and bring them back can put the same class payload into synchronous orbit around the earth -- a particularly difficult but important capability which this nation now has and very likely would not have if any goal short of the moon had been selected in 1961.

The lunar landing goal required us to accept elements of technical uncertainty, but it also gave us assurance that its achievement would eliminate uncertainty as to our national space capability.

55. See, for example, transcript of NASA FY 1969 Budget Briefing (held January 27, 1968), p. 58.

56. Public Papers of the Presidents, Lyndon B. Johnson, 1965, Book II, pp. 917.

57. Senate hearings, Independent Offices and Department of Housing and Urban Development Appropriations for Fiscal Year 1969, Part 1, pp. 1098-1100.

58. For example, Business Week, September 14, 1968, has article entitled: "Can the U. S. Merge Its Two Space Rivals?"

59. See 57., p. 1005; also, transcript of Webb address at American Astronautical Society Symposium in Denver, Colorado, July 15, 1968, pp. 12-13; also Jacob E. Smart, "The NASA-Military Partnership," Air Force and Space Digest, October 1968.

60. Webb submitted the Summary Report of the Future Programs Task Group to the President with a covering letter dated February 16, 1965. In his letter, Webb said two new objectives for the years just ahead appeared to stand out above other possibilities. Both, he said, "appear to be within the framework of feasible resource levels for fiscal year 1967 and following years."

The first objective was to be the exploration of Mars through the use of large unmanned soft-landing spacecraft; the second objective was to be "a systematic program extending over several years to capitalize on the availability of the Saturn boosters and the Apollo-LEM manned space flight system for a wide variety of worthwhile scientific and technical missions in near-earth and synchronous orbits, in lunar orbit, and on the lunar surface." The first was, of course, what came to be known as the Voyager program, and the second the Apollo Applications program.

In his letter to the President, Webb also said the longer-range missions for the 1970's and 1980's "offering greatest promise" were systematic lunar exploration, large orbiting space stations, and manned exploration of Mars.

When Webb appeared before the Senate Committee on Aeronautical and Space Sciences on August 23, 1965, he was still more definite about not recommending long-range goals or commitments at that time. "In my view," Webb said, "what is necessary now is not a firm decision to undertake specific large new projects, but continued support and funding of the already ongoing scientific and technological efforts, and a rapid assimilation into the stream of our national policymaking of the opportunities and benefits that can be derived from the Gemini, Apollo, (unmanned) Orbiting Observatories, Nimbus, and other programs." See Senate hearings, National Space Goals for the Post-Apollo Period, p. 5.

The Senate Committee on Aeronautical and Space Sciences, in its report on the NASA authorization bill for FY 1966 (Senate Report No. 188), commented on NASA's Summary Report as follows:

> The committee found this report to be somewhat obsolete and to contain less information than expected in terms of future planning information. The report contains a useful summary of current programs and presents some future alternatives, but it does not contain important information required to make an informed decision of what our post-Apollo space program should be. For example:
>
> 1. Alternatives are presented, but no criteria are given as to how a selection would be made.
> 2. No cost information is given.
> 3. There is no indication of the other resources that would be required to accomplish the various alternatives such as manpower, facilities, materials, and management.
> 4. There is no indication of when the decisions should be made.
> 5. There is only brief mention in Mr. Webb's letter of military considerations and coordination with the Department of Defense.
> 6. There is little or no discussion of foreign programs or about how they might affect U. S. post-Apollo programs.
>
> . . . Your committee feels strongly that because of the long leadtimes required, and in order to avoid an embarrassing and costly hiatus after Apollo in the utilization of our vast space capability, that some firm decisions must be made soon regarding post-Apollo projects.

The Summary Report obviously was not what the Committee wanted; it was intended to be only a broad statement of the various directions in which the NASA programs of the future could go. But the Senate Committee report overlooked the fact that Administrator Webb had gone far beyond the Summary Report in his letter of February 16, 1965, transmitting it to the President and had in fact indicated with some precision what he thought the next steps beyond Apollo should be, and why.

In opening the hearings on NASA's Post-Apollo goals (August 23, 24, and 25, 1965), Senator Anderson pointed out the significance of the lunar landing goal:

> In 1961, as the importance of a more vigorous national space program became more apparent, President Kennedy and the Congress gave the space effort a new framework in which to operate: the mission of landing men on the moon and returning them safely to earth within this decade.
>
> The committee is satisfied that the progress during the ensuing four years has more than justified the 1961 decision. We are well on our way to becoming the world's leading space-faring nation -- second to none in our ability to use space for man's benefit and for the Nation's security and welfare.

Senator Anderson also outlined what he hoped the hearings would accomplish:

> During these three days of hearings we want to explore alternative goals for the national space program for the near future -- to 1975 -- and for the more distant future -- 1985 and beyond.
>
> We want to discuss the comparative merits of manned and unmanned missions to achieve these goals.
>
> We must have some discussion of the money, time, and technology that will be needed to accomplish these alternatives.
>
> And we want to learn more of the definition and role of Apollo Extension Systems and the DOD-MOL in the national space program.
>
> My interest is heightened by stories that our next important goal is a manned flight to Mars, with preliminary unmanned flights. Once we embark on that program we may be looking at the expenditure of $60 billion, and I think the people of America want to be sure that it is a program they want to undertake before such a costly project gets underway.

Therefore, I would hope that these hearings would indicate the steps we should take before we commit ourselves to subsequent expenditures.

61. For example, see article on Webb's impending retirement in Newsweek, September 30, 1968.

62. The Summary Report of NASA's Future Programs Task Group is the one official planning document of its kind made public by NASA in the period 1964-68.

An interesting variation on the Summary Report was the presentation of five program alternatives for the NASA manned space flight effort after Apollo and Apollo Applications, made by Dr. George E. Mueller, Associate Administrator, Office of Manned Space Flight, NASA. Dr. Mueller's alternatives were described to the Senate Committee on Aeronautical and Space Sciences on August 23, 1965, and are explained in the record of the hearings, National Space Goals for the Post-Apollo Period, beginning on page 49. The first three alternatives would emphasize extensive earth orbital activities to get maximum economic benefits; or extensive lunar operations; or early planetary landings. The fourth alternative would stress all three in a maximum effort to assure U. S. pre-eminence in manned space flight in earth orbit, at the moon, and on the planets. The fifth alternative would call for a balanced effort in all three areas, but at less cost and with a slower schedule than the fourth alternative. The Apollo Applications program was presented as a logical first step to any of the five alternatives.

A staff study, entitled Future National Space Objectives, was prepared for the Subcommittee on NASA Oversight of the House Committee on Science and Astronautics. It was completed in July, 1966.

Numerous studies of possible future missions were contracted for by NASA and frequently were reported on in the news media. Sometimes these accounts failed to make clear to the reader the difference between such studies and approved NASA plans.

The following recommendations concerning future NASA programs came from the science community and were made public:

a) Statement by the Space Science Board of the National Academy of Sciences on "National Goals in Space," dated October 28, 1964.
b) Report by the Space Science Board of the National Academy of Sciences on the Summer Study at Woods Hole, Mass., in 1965 entitled: "Space Research: Directions for the Future," in three parts.

c) Report on NASA 1965 Summer Conference on Lunar Exploration and Science, Falmouth, Mass., July 19-31, 1965. NASA publication SP-88.

d) Report by the President's Science Advisory Committee entitled "The Space Program in the Post-Apollo Period," submitted to the President February 11, 1967. A summary of the recommendations is given in the Weekly Compilation of Presidential Documents, Vol. 3, No. 7., pp. 236-38.

e) Report of a Study by the Space Science Board of the National Academy of Sciences entitled "Planetary Exploration 1968-1975," released August 15, 1968.

f) "The 1967 Interim Report of the Summer Study on Space Applications" was submitted to NASA by the National Academy of Sciences on November 29, 1967. The study continued through the summer of 1968.

63. For example, see comments of House Committee on Science and Astronautics on Astronomical and Geophysical Observatories in Report No. 338 on NASA Authorization for FY 1968; or comments of Senate Committee on Aeronautical and Space Sciences on the Voyager program in Report No. 353 on NASA Authorization for FY 1968.

64. See Note 62.

65. Senate Hearings, Independent Offices and Department of Housing and Urban Development Appropriations for Fiscal Year 1969, Part 1, pp. 1091-2.

66. For example, Webb wrote in his letter to President Johnson of May 20, 1964:

> While some of the specific technical and scientific advances resulting from space activity are more immediately obvious, many see its greatest impact in the more fundamental improvements in man's ability to conduct research. These include the new ways in which large-scale organized efforts are managed; the encouragement of multidisciplinary effort not only among the scientific disciplines, but involving science and engineering; the new techniques and tools for the conduct of research; and the manner in which these are applied to the solution of age-old scientific and technical problems.

Text of letter in Senate hearings, NASA Authorization for Fiscal Year 1966, pp. 1017-1027.
Also, Webb said in his John Diebold Lecture on Technical Change and Management at the Harvard University Graduate School of Business Administration on September 30, 1968:

> I believe what we have done in space measures up in importance to any of the other great national accomplishments of our history. The space story, however, has another significance. There is, as suggested earlier, the matter of how as well as what. The way in which we have built up our space capabilities and what we have learned in the process about the requirements for success in such long-scale endeavors, and how well we adapt to the conditions of today may constitute as important a contribution to our nation -- to its ability to move forward into the future -- as the space capabilities themselves.

67. NASA's original estimate of the cost of the Apollo program, including the lunar landing, was between $20 billion and $40 billion. (See interview with Webb in U. S. News & World Report, July 3, 1961.) In February, 1968, the total costs of the Apollo program were conservatively estimated at $23.869 billion. This would include 12 Saturn I-B and 15 Saturn V launch vehicles, some of which probably will be available for the Apollo Applications program. For further explanation of this cost estimate see Senate hearings, NASA Authorization for Fiscal Year 1969, Part I, pp. 50-51. The cost estimate was up $700 million from the estimate made in May 1967, three months after the Apollo 204 accident.

68. In a lecture on "Executive Performance and Its Evaluation" at Columbia University on May 16, 1968 (see 54. above), Webb said:

> We all know that even top level executives have to conform to "checks and balances" that are required throughout an organization. They must make formal reports; provide information about activities and operations on a regularized basis; conform to established reviewing and clearance procedures; share in various group activities; submit to internal audits; and in a public endeavor subject themselves and their operations to procedures required by the Bureau of the Budget, the Civil Service Commission, the General Accounting Office, Congressional committees, special data collection agencies, and inter-agency coordinating groups. In the fast-moving areas requiring

real-time decision making, as in the case of an abort action, if a spacecraft fails to achieve orbital speed, we in NASA combine much of this "check and balance" concept into what we call "over-the-shoulder supervision." However, it is more than that. It is a kind of participation and collaborative judgment-forming process with up to four levels of hierarchical authority involved, frequently in a simultaneous effort to draw valid conclusions from a large body of complex incoming information.

I have known executives who chafe at these kinds of requirements on grounds that they represent "red tape," take too much of their time, and "dilute" their capacity to make the "main effort." I have also noted Behavioralist studies that show middle executives generally anxious to be relieved of "red tape" controls, requirements for reports, and other such things in order to concentrate full time on "constructive" elements of their jobs, and on which they expect to be primarily judged. The large complex endeavor cannot allow the executive such freedom and personal choice as to which parts of the job he will not be bothered with. Activities that may seem to one person as routine are as essential to his effectiveness as many other more appealing activities. As much as anything else, work habits on ordinary day-to-day matters frequently make or break an endeavor.

A harsh case in point, as seen by hindsight, was the tragic fire at Cape Kennedy in January 1967. Within our feed-back system and at several executive levels certain trouble signals for the Apollo capsule development and test effort began to appear. But none of these was so strong as to be singled out and acted upon vigorously as it should have been. Everyone felt sure our research and development system and that tried by our contractors had solved worse problems before. No need was felt to feed these into the mainstream of Agency decision making in such a way that corrective measures would be insured. Many actions were being taken every day in the steady stream of decisions and problem-solving required for a complex development project and the nature or severity of these signals did not seem very different from the others flowing in the system. Our project managers had almost always handled such matters in the past. The result was a great failure, and a very costly failure. Its origins lay not in the lack of creativeness or brilliant insight on the part of our engineers, project managers, and executives, or in an inability on their part to do all of the things required for success. The shortfall was in the area of management supervision and insistence of the full dedication of all of them to making every part of the prescribed system work, with exceptions fully evaluated, approved, and put into effect in the prescribed ways.

In delivering this lecture Webb used the last paragraph quoted above, but deleted it from the lecture as subsequently published.

69. These appearances by Webb were in addition to his regular testimony before four committees on the NASA authorization and appropriation bills. The record of the Senate hearings, entitled Apollo Accident, is in eight parts. Part 8 is a report from NASA, submitted January 8, 1968, on actions taken in response to the recommendations made by the Apollo 204 Review Board. Testimony before the Committee is in the first six parts.

The record of the House hearings is in three volumes. Volume II, which has three parts, reproduces the formal accident investigation report of the Review Board. Testimony before the Subcommittee is all in Volume I.

70. Senate Report No. 956, Apollo 204 Accident.

71. The following exchange is from Senate hearings, Apollo Accident, Part 3, p. 194:

Senator (Margaret Chase) Smith: Dr. Thompson, the Board's report points out some serious deficiencies relating to design, workmanship, quality control, and failure to complete required engineering changes. In your opinion, are these deficiencies attributable in some measure to the tight schedules used for the program in order to assure a manned lunar landing in this decade?

Dr. Thompson: (Floyd L. Thompson, Chairman of the Apollo 204 Review Board): I cannot identify anything of that sort. A program of this kind has to have a very hard drive. It has to have built-in urgency in order to keep all the people properly motivated.

The thing that we directed our attention to was the other side of this tremendous project, that is, the orderliness that is required to see those things that may be overlooked if there just is not sufficient attention paid to them.

I cannot conceive of a program of this nature that would offer a tradeoff between haste and the other orderly side of it. They have to be matched. You could not tell people to slow down because we are just going too fast here. I say you have just got to put the hard drive in both sides of this picture from where I sit.

Senator Smith: Doctor, if the hard drive that you refer to is not responsible for these irregularities and deficiencies, then what would in your opinion, be the primary or underlying reason for such errors of omission and commission discussed in the Board's report?

Dr. Thompson: Well, I just think somehow or other they have not quite found out how to put all that order in. It is a very demanding task. This is a tremendously big program involving hundreds of thousands of people. Even the test itself, just the head count for the test itself showed 959 people on duty doing various tasks at that time. The organization of all that effort is a difficult management task but I do not see why it cannot be accomplished. I think that an overview of it, as we have done, will identify areas that will provide a useful guide to improvements that ought to be made.

72. At the hearing before the Senate Space Committee on April 17, 1967, Mr. Webb had been asked by Senator Smith if North American Aviation was "the first choice of the Source Evaluation Board" to build the Apollo Spacecraft. Webb replied "Yes. It was the recommended company," and went on to describe the "unanimous recommendation" to him by Drs. Gilruth, Dryden, and Seamans that North American be selected for this work. At the May 9 hearing, Senator Smith indicated that the Martin Company had been rated higher by the Source Evaluation Board. Webb explained that his answer to her question on April 17 had been in connection with North American as the first choice of NASA's source selection officials, not the Source Evaluation Board who he stated had rated North American second to Martin in the total numerical score. (See Chapter VI for a description of the relationship of the Source Evaluation Boards and the NASA officials who make the selections of major contractors.)

It is not feasible in these notes to indicate the precise points in the testimony where other controversial issues are discussed. As is usual in Congressional hearings, such issues are brought up by one committee member after the other and thus appear throughout the record mixed in with many unrelated questions.

Moreover, it is advisable that anyone interested in forming an opinion on the hearings themselves, the various issues brought up, and the quality and objectivity of the news reporting at the time study carefully the complete record.

CHAPTER III

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# MANNED SPACE FLIGHT 1964 -- 1968*

## INTRODUCTION

All but the initial manned space flight accomplishments lay ahead at the time Lyndon B. Johnson took office as President of the United States; however, both the Gemini and Apollo Programs were evidencing considerable progress. Gemini spacecraft and launch vehicles were in final assembly and test and the flight phase was rapidly approaching. The system elements of Apollo had been defined and were under development.

The nation was preparing for aggressive pursuit of major capabilities in manned space flight. A series of more complex and challenging manned space flights were to be carried out in earth orbit during the Gemini Program. In Apollo, the effort was concentrated on one of the most difficult and far reaching exploratory ventures in history, the journey by three Apollo astronauts to the moon and back. This chapter is devoted to a history of manned space flight in these very significant years, 1964 - 1968.

Prior to the period under consideration, an initial series of manned space explorations in earth orbit had been completed by both the Russians and the Americans. The accomplishments of these programs had created worldwide interest and enthusiasm. Many of the fears about the ability of man to survive and function effectively in this new environment, space, had given way before new knowledge. The people of our country were caught up in the spirit of progress.

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*This chapter was prepared under the direction of Mr. Charles W. Mathews, based in large part on material prepared by William D. Putnam.

In this climate, two new manned space flight programs had begun, Gemini and Apollo. Apollo is the ambitious long-term effort to develop the capability to carry out manned operations in space leading to a position of leadership in space for the United States. The national goal stated by President Kennedy to land men on the lunar surface and return them safely to earth within the decade provided the focus for this undertaking. Gemini was a shorter term program designed to gain a substantial amount of general space flight experience as well as to accomplish and demonstrate a number of specific functions critical to the Apollo mission.

The initiation of the Gemini Program was timed to take advantage of the knowledge gained in the nation's first series of manned space flights -- Mercury. The Mercury Program successfully demonstrated manned orbital flight, but perhaps more important, provided extensive information on how to build and fly spacecraft for the more complex missions that were yet to come. Drawing on this experience, Gemini was able to produce for its time a small but highly flexible space vehicle of considerable operational capability. These characteristics enabled a rapid expansion of our flight horizons.

The most significant achievements of Gemini involved precision maneuvering in orbit and during reentry, and a major extension of the duration of manned space flights. Also of great general interest were the investigations of the operations of an astronaut outside the confines of his spacecraft.

All of these exercises have contributed greatly to expanding activities in space that are now underway or forthcoming. In Apollo, the program to land men on the lunar surface, the crews must be transported roughly 230,000 miles to the moon and then back to earth. This trip will take a week or more. The Apollo spacecraft must perform a rendezvous, not near the earth, but out at lunar distances in order for this mission to be successful. On the moon, the astronauts must leave their spacecraft and, in their pressure suits, step out onto the lunar surface to conduct scientific exploration. The fact that all of these things were demonstrated and investigated in a number of the Gemini missions greatly aided the development of the more difficult missions about to be undertaken in the Apollo Program.

Perhaps the most significant aspect of the Gemini Program was the manner in which the astronauts contributed to the success of each of ten manned missions. In the flying of the spacecraft, in the management of the systems, in the overcoming of problems, and in the attainment of important scientific and technological information, their presence greatly enhanced the success of the program. They were backed up by a large and dedicated team of people on the ground who designed, developed, and checked out the vehicles and controlled the flights which provided nearly 2,000 hours of manned space flight experience.

As already stated, by 1964 the specifics of how the Apollo lunar mission was to be accomplished had been defined. It would involve rendezvous and docking of two spacecraft while in lunar orbit utilizing a special purpose spacecraft, the lunar module, to accomplish the descent to and return from the lunar surface. All major elements of Apollo spacecraft were well into development, including the lunar module, the command module, and the service module.

Perhaps even more significant was the development of the giant boosters for this mission, the Saturn IB and the Saturn V. In the case of the Saturn V with its ability to carry payloads of nearly 150 tons into earth orbit, and 50 tons to lunar distances, a capability adequately meeting the requirements of the Apollo lunar mission was being evolved.

In addition to the flight equipments, many of the facets of support to manned space exploration were coming into being. The Manned Spacecraft Center at Houston, an outstanding complex of facilities, laboratories, and offices was just being occupied. A number of new checkout facilities at the Kennedy Space Center in Florida were about ready to support Gemini; many other government and industrial facilities were in being, supporting the development programs.

This was the position of our manned space flight endeavors in the beginning of 1964. Now what were the expectations for accomplishment in the next four years?

In Gemini, the completion of the flight program was planned to occur early in 1967. During this program a large number of significant space accomplishments were achieved. They included: (1) The first rendezvous in orbit of one spacecraft with another and the docking of two spacecraft together. The docking operation allowed the use of the large propulsion system of the target vehicle to carry men to heights above the earth that had not previously been available, thereby providing an ability to view and photograph the earth over extensive areas; (2) A series of progressively longer flights, ultimately achieving two weeks duration in orbit, a duration that has yet to be exceeded as of this writing; (3) Precision landings utilizing maneuvering control either by the astronaut or by autopilot during the high speed reentry; (4) Operations of an astronaut in space outside the confines of his spacecraft protected by his pressurized space suit. These extravehicular activities did in fact reveal significant difficulties. Treating these directly through improved hardware, and indirectly by augmenting crew training, successful operations were eventually conducted; (5) Utilization of the astronauts as scientific experimenters while in orbit to accomplish such things as large scale color photographs of the earth's surface, medical, scientific and technological experiments.

The Gemini Program was successfully completed in November 1966, several months ahead of the scheduled 1967 milestone. With the exception of land landing demonstrations, all of the objectives were met and the flexibility of the operation enabled many variations in these objectives to be investigated. Although land landing was not included in the program because of development difficulties with the paraglider system, maneuvering during reentry to obtain precise landing point control was demonstrated on each of the last seven flights. Many activities were included which were not contained in original plans. The nearly 2,000 manhours of space flight experience, obtained by 18 astronauts, surpassed by a wide margin the 507 hours of experience obtained by the Russians.

The plan for the Apollo Program during this period was to proceed through the unmanned development flights toward manned flights in a timely manner to meet the objectives of a manned lunar landing prior to 1970. By October 1968, the terminal point of this chapter, the Apollo unmanned development flights had been completed and the manned flight buildup to the ultimate mission -- the lunar landing -- had been initiated with the flight of Apollo 7.

Prior to October 1968, six unmanned Apollo flights had been accomplished, four with the Saturn IB vehicle and two with the Saturn V moon rocket. These flights followed the 10 successful launches of the earlier Saturn I rocket, supporting the development of the larger Saturn IB and, in turn, the largest vehicle yet flown, the Saturn V.

The first three unmanned Apollo flights were early tests of the Apollo spacecraft and the Saturn IB rocket, conducted in 1965 and 1966. The Apollo 4 mission in November 1967 was one of the most historic events in the U.S. space program, a completely successful flight demonstrating the integrity of the Saturn V vehicle and the Apollo spacecraft, and the correctness of the design and development decisions leading to its creation. Every record in rocketry was extended with the launch of Saturn V.

In January 1968, a Saturn IB was employed in the launch of the Apollo lunar module, first flight of the spacecraft that will carry men to the surface of the moon. In April 1968, a second Saturn V was flown, in further tests of the large vehicle.

Meanwhile, the government-industry-university team which had been created to provide the U.S. capability in space had developed the teams, hardware and facilities for the conduct of Apollo lunar missions.

NASA marshalled large segments of the nation's resources and applied them to an endeavor which is essentially peaceful in nature and of a magnitude virtually unequalled outside of wartime efforts. A national challenge was met with a truly national response. Three sectors, government, industry and universities, were combined into a large coordinated and unified national capability. This was done in a way which recognized the importance of preserving the individual characteristics and goals of strong existing institutions of our society while at the same time moving swiftly to meet program objectives.

At the peak of the Apollo production program over 400,000 people, a large proportion of whom were scientists and engineers, were participating throughout all the States of the Union. About 20,000 industrial firms and 200 universities took part. NASA's capital plant, or facilities base, including an impressive array of unique structures and equipments, has been expanded from a value of less than $1 billion to more than $4 billion. These facts once again demonstrated that the United States can work effectively toward a great national goal without a militarily oriented impetus.

## GEMINI DEVELOPMENT AND OPERATIONS 1964-1966.

In December 1961, the decision had been taken to extend the manned space flight operations beyond Project Mercury, to provide an interim program before the flights of Apollo could begin. In January of 1962, this program, utilizing a two-man spacecraft, was officially named Gemini, after the third constellation of the zodiac with twin stars Castor and Pollux.

Gemini was to be a logical follow-on program after Mercury, minimizing time and expense, designed to subject two men and the necessary supporting equipment to long duration flights to accumulate the experience and knowledge necessary for trips to the moon and beyond. The accumulation of information and experience with regard to weightlessness and the physiological reaction of crew members to long duration missions would establish the physiological knowledge necessary for planning missions in Apollo and later programs.[1]

A second specific objective was to achieve rendezvous and docking with another orbiting vehicle and maneuver the combined spacecraft, using the propulsion system of the "target" vehicle. Rendezvous and docking were key elements of the lunar orbit rendezvous mission mode to be followed in the Apollo Program. Experience with this technique and equipment would be necessary for Apollo.

Experiments were planned with astronauts leaving the spacecraft while in orbit to determine their ability to perform useful tasks. This extravehicular activity was a technique projected for advanced missions, assembling structures and repairing equipment in space, as well as operations outside the Apollo spacecraft on the lunar surface.

Another objective of the program was to perfect methods of controlled reentry and landing at pre-selected sites. This would be necessary for return from the Apollo lunar landing mission.

Another objective originally planned, to develop an increased capability for land landing, could not be phased into the Gemini Program; Gemini did, however, contribute much to the knowledge required for this activity.

The Gemini spacecraft was planned to be, in many ways, a two-man orbiting laboratory to increase knowledge and experience in the space flight environment by several orders of magnitude. Time in space and room within the spacecraft would be provided for conducting a variety of experiments and observations during the course of the program.

## Gemini Flight Program

While the Gemini Program would be an advancement in manned space flight in general, it had to be executed in time to support Apollo. As much of the specific technology from Mercury as was feasible was used. The basic aerodynamic shape of the Mercury capsule, enlarged to accommodate a crew of two, was retained for the control module; however, the usable volume was greatly increased by adding an adapter section at the aft end of the spacecraft which carried most of the expendable supplies, the main electrical power plant, and the propulsion system for maneuvering in orbit.

Major changes in design from the Mercury Program placed increased emphasis on the role of the crew, based on the confidence acquired in Mercury. Mercury was designed for automatic control and sequencing with backup provisions for pilot control; Gemini was designed from the beginning to be controlled by the astronauts, with ground control as the backup.

A number of advanced systems were developed for the Gemini spacecraft that had not been part of Mercury. Among these were high performance thrusters, fuel cells to serve as a power source, an active cooling system utilizing a space radiator, and integrated guidance utilizing a general purpose digital computer. Gemini also employed rocket propelled ejection seats as the means for escape from a major launch vehicle malfunction, although there was no occasion for their use during the flight program.

The system concepts and the basic technical approach to the Gemini development proved very sound in terms of the objectives to be met, but the magnitude of the development effort proved greater than anticipated. Prior to 1964, some adjustment in the program costs and schedules was made with the expectation that the first manned flight would be accomplished in October of 1964. At the beginning of that year, a number of problems continued to exist, primarily associated with the new system developments. Securing an adequate life time for the new pulse operating thrusters was difficult, and they were unavailable for the early Gemini flights, being phased in later for the rendezvous missions. The development of a fuel cell electrical power system with a life sufficient to support the 8 and 14-day Gemini missions also was a problem, requiring a significant advance in the state of the art. Development was completed in time for the long duration missions, although conventional battery systems had to be substituted in the early Gemini missions. Qualification of the ejection seats was a very strenuous effort because of the wide range of conditions under which they had to operate reliably. These seats had to propel the astronauts a substantial distance away from the launch pad in event of a vehicle failure producing a detonation and the ensuing fire ball. At the same time, the seats and personnel parachutes had to operate at high dynamic pressures and at very high altitudes during the actual launch. Similar problem areas existed in other test and qualification activities, and as a result, considerable effort was placed upon planning to assure adequate readiness for the first manned flight.

A new test philosophy was evolved for the Gemini spacecraft. Initially, the Gemini managers had planned to conduct very extensive checkouts of the spacecraft in a hangar complex at Cape Kennedy, after delivery from the manufacturer's plant, as in the Mercury Program. Later, it was felt that the program could be greatly expedited by delivering the spacecraft to the launch center in a highly flight ready condition, so that after pyrotechnic loading and parachute installation, the spacecraft could be moved directly to the launch pad.

This philosophy was adopted for the second Gemini flight, GT-II. Major elements of the launch team were sent from Cape Kennedy to the manufacturer's plant in St. Louis in order to directly participate in spacecraft checkout. This approach did produce some delay in the delivery of the first two spacecraft, but greatly expedited checkout at Cape Kennedy and the ability to cycle from one flight to the next with the result that the overall program proceeded at a more rapid pace than originally planned. The plant checkout not only increased the flight readiness of the spacecraft prior to delivery, but also served to develop the confidence of the launch team in what was being done at the plant. The first manned launch took place in March of 1965.

Many areas of development were obviated by selecting the two-stage Titan II rocket, developed and tested by the Air Force as a ballistic missile system, for the Gemini launch vehicle. While the basic design of the vehicle was not altered, making the Titan II ready for manned Gemini flights was nevertheless an extensive development effort.[2]

Two aspects were involved. The first was to achieve very high reliability for Titan II, assuring a high probability of success in each Gemini launch. The other aspect was in "man-rating" the basically excellent Titan missile. To maximize crew safety during launch, a malfunction detection system designed to detect critical failure conditions in the launch vehicle was added. This system actually interrupted the launch sequence if a failure was detected prior to launch release, and during the flight phase it provided displays to the astronauts so that escape action could be initiated in the event of a serious malfunction. Also incorporated into the Titan II was a redundant flight control and guidance system. The system was designed to automatically switch from the primary system to the backup system when certain classes of failures were detected. Many other redundant features were incorporated such as in the electrical power supply and distribution systems.

Of serious concern in converting the missile to the Gemini launch vehicle had been the "Pogo" effect, a longitudinal oscillation, evident in the flight test program of the Titan II missile. A special modification was tested to reduce this oscillation load to the "man-rated" level. Three Titan II test flights performed within the "g" load limits prior to the first flight of the Gemini launch vehicle.

Late in 1963, the first Gemini launch vehicle had begun a lengthy series of prelaunch ground tests at Cape Kennedy. The first Gemini launch, on April 8, 1964, was successful in placing the spent second stage of the launch vehicle and the attached spacecraft into orbit, demonstrating the overall capabilities of the launch vehicle and the structural integrity of the spacecraft in the launch environment. No separation or recovery was planned. This successful mission paved the way for the second and last unmanned flight test, a suborbital flight to demonstrate the readiness of all the spacecraft subsystems and the reentry heat protection capability. Scheduled for the third quarter of 1964, Gemini II fell victim to a series of delays, including a lightning strike, two hurricanes, and an engine shutdown on the launch pad during the first launch attempt in December of 1964. A rapid analysis of the failure and corrective action enabled the launch to take place on January 19, 1965. The successful 19-minute flight qualified the total spacecraft as an integrated system for manned flight.[3]

The final Gemini flight qualification was a short duration manned flight of three orbits duration (Gemini III). This mission involved the first maneuvers of a spacecraft while in orbit and was accomplished with near perfect system operation.

Gemini III was the first of ten manned missions carried out over a period of twenty months and enabled a rapid movement into the operational mission phase of the program.*

## Long Duration Flight

The long duration objectives were achieved with success in three missions of four, eight, and 14 days. These were the flights of Gemini IV (June 3-7), Gemini V (August 21-29), and Gemini VII (December 4-18) during 1965. The second of these, Gemini V in August, established a new manned space flight record of 190 hours, 55 minutes, surpassing the Soviet record of 119 hours, 6 minutes, set by Vostok 5 in 1963. Gemini VII's 14-day mission subsequently raised this record to 330 hours, 35 minutes. Both Gemini V and Gemini VII utilized fuel cells for generation of electrical power. This was the first application of the fuel cell principle to power generation. It was also the first time cryogenic (liquid) hydrogen and oxygen were stored aboard a space vehicle over long periods of time. The loss of a heater in the cyrogenic hydrogen tank on Gemini V resulted in very low supply pressure to the fuel cells and necessitated operation in a low power mode over most of the mission; however, the fuel cells continued to perform quite well under this "off nominal" condition.

Medical evaluation of astronauts after these flights revealed no serious effects from their lengthy exposure to weightlessness, although some evidence of effects such as cardiovascular deconditioning has existed on all flights. A definite pattern of adaptation to weightlessness was detected on Gemini VII when post flight data on cardiovascular deconditioning showed a leveling trend when compared to flights of shorter duration. The relatively small physiological changes were similar to those obtained from experiments with physical immobilization. High heart rates were observed under high stress conditions during liftoff, extravehicular activities, and other critical mission phases; but, again, this condition is similar to those experienced in stressful activities on the ground. To this date, no Gemini pilot has felt any permanent after effects from his space flight.

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*A flight-by-flight summary of the Gemini Program may be found in Appendix B-III.

By the end of the Gemini Program, Mercury and Gemini space flights had provided approximately 2,000 manhours of weightless exposure for evaluating results against predicted physiological effects of the space flight environment. The environmental hazards and effects on man appear to be of far less magnitude than originally anticipated. No abnormal psychological reactions were observed and no vestibular disturbances related to flight occurred. Although much remains to be learned, it has been shown that if man is properly supported, he can remain in space for 14 days and probably for a considerably longer time with no untoward effects.[4]

## Rendezvous and Docking

The maneuvering capability necessary for rendezvous and docking in space was demonstrated on the first manned Gemini flight, Gemini III (March 23, 1965), when spacecraft propulsion, guidance, and control systems were exercised by changing both orbital path and phase. Attempts to station keep (fly formation) with the second stage of the launch vehicle during the Gemini IV mission were a failure because of the techniques used, but this experience did allow the adjustment of procedures to facilitate such operations on subsequent flights. After midcourse maneuvers were practiced during the Gemini V mission, as well as validation of radar and rendezvous display operations, the first attempt at rendezvous and docking between the Gemini spacecraft and the unmanned Agena target vehicle took place on the Gemini VI mission.

The target vehicle, which was launched first, failed to achieve orbit on October 25, 1965 because of a propulsion system failure. While corrective action was taking place for subsequent missions, an alternate plan was developed to work around the schedule complications created by this failure. The plan called for removing the Gemini VI launch vehicle and spacecraft from the launch pad and placing them in storage, maximizing their mated integrity. The Gemini VII booster and spacecraft would then be erected and made ready for the scheduled 14-day endurance mission as quickly as possible. The Gemini VII spacecraft would serve as the target vehicle while on its 14-day mission. Gemini VI would be launched a few days later and conduct rendezvous operations, even though docking would not be possible. On October 28, 1965, only three days after the aborted attempt, NASA Administrator James E. Webb recommended this course of action to the President; the President approved the plan, and it was announced at the Texas White House.[5]

After the Gemini VII launch on December 4, 1965, and an unsuccessful launch attempt of Gemini VI on December 12, Gemini VI was successfully launched on the rendezvous mission on December 15. In addition to the basic technical sophistication in accomplishing the first space rendezvous, this mission also demonstrated a high degree of launch and preflight operational proficiency in carrying out this complex mission. On the fourth orbit of Gemini VI, command pilot Walter Schirra maneuvered to within 50 feet of Gemini VII. In the course of sustained station keeping and formation flying maneuvers, Gemini VI flew to within one foot of Gemini VII.

Rendezvous and docking with an Agena Target Vehicle was accomplished on the Gemini VIII flight (March 16, 1966). The docking maneuver, achieved for the first time, was completely successful. This mission was terminated shortly after the docking, however, because of a spacecraft malfunction involving attitude control which sent the spacecraft into uncontrolled spinning at an increasing rate. Timely corrective action by the astronauts under very difficult circumstances, in combination with the backup capabilities intrinsic in the spacecraft design, enabled the condition to be stabilized. The flight controllers on the ground then set up a contingency recovery in the Western Pacific and the landing was made within sight of a recovery aircraft diverted to the scene.

Three different types of rendezvous maneuvers were investigated during the Gemini IX flight (June 3-6, 1966). An Augmented Target Docking Adapter was used as the target for this flight in place of the Agena Target Vehicle. Docking could not be performed, however, because the launch shroud covering the docking collar had failed to jettison.

One of the most significant rendezvous maneuvers carried out on Gemini IX was a simulation of the future rendezvous between a lunar module and a command module in lunar orbit. The maneuver successfully performed by Gemini IX would be required during an Apollo lunar mission if a decision were made not to continue with a lunar landing after the lunar module had descended toward the moon.

The third area of the rendezvous and docking objectives, large maneuvers while docked through the use of the Agena's primary propulsion system, was accomplished on the Gemini X flight (July 18-21, 1966). During this mission, rendezvous was first made with the Agena X target vehicle launched one orbit before the manned spacecraft. After docking with Agena X, the combined Gemini/Agena vehicle was maneuvered to a higher orbit with an apogee of 476 miles, the highest man had yet ventured into space.

This orbital change was the first in a series of orbital maneuvers using the Agena X propulsion system, in preparation for rendezvous with another orbiting vehicle. The second rendezvous target was the derelict Agena vehicle which had remained in orbit since the Gemini VIII mission four months earlier. Terminal rendezvous of Gemini X with Agena VIII using purely optical techniques was successfully accomplished after the Gemini spacecraft had separated from Agena X. This operation was the first to demonstrate the practicality of visiting a passive satellite for purposes of inspection and repair.

Gemini XI (September 12-15, 1966) for the first time completed a rendezvous with its target vehicle during its first revolution of the flight, using onboard guidance information exclusively. This rendezvous was most efficient in terms of time, looking to future applications where timeliness may be a factor in rendezvous. Later in the mission a second maneuver, called a coincident orbit rendezvous, was performed. This type of rendezvous was most efficient in conserving fuel, but required significant tracking time. It can find later application on missions where maximum fuel efficiency is required.

During the Gemini XI mission, docking was practiced twice by each crew man. The docket spacecraft combination was flown to new altitude (853 miles) and speed (17,943 miles per hour) records for manned space flight.

Gemini XII (November 11-15, 1966), achieved rendezvous and docking on the third orbit. A total of 10 rendezvous operations were conducted furing the Gemini Program, demonstrating that rendezvous is operationally feasible with either an active or passive target. Accumulated crew experience in rendezvous and docking operations, and tracking and control experience, provided a new confidence level for prescribing this technique in future manned space flight missions.[6]

## Extravehicular Activity

During the first long duration mission, Gemini IV (June 3-7, 1965), pilot Edward White demonstrated the feasibility of astronaut activity outside the spacecraft. In this first U.S. extravehicular activity (EVA), White stayed outside the spacecraft for 23 minutes, maneuvering himself about, taking pictures, and making observations of equipment. During the early portion of the EVA, he used a hand-held maneuvering unit which provided propulsion by emitting jets of oxygen. Astronaut White was restrained by a 25-foot tether to which was attached an umbilical hose system supplying breathing oxygen. A chest pack which maintained his suit pressure contained an emergency supply of oxygen. White wore a special protective suit and a protective helmet visor for the mission. Because no major work tasks were involved, the EVA operation appeared to be quite easy, a conclusion not borne out in later flights. The astronauts did experience an extremely heavy work load during egress in closing a balky spacecraft hatch. This problem was corrected on subsequent missions.

An expanded extravehicular mission was included in the Gemini IX flight (June 3-6, 1966), during which Eugene Cernan worked outside the spacecraft for over two hours. Astronaut Cernan accomplished work tasks over all areas of the spacecraft from the nose to inside the aft adapter section under both day and night conditions. A more ambitious demonstration of extravehicular mobility, using an Astronaut Maneuvering Unit, was cancelled when the moisture overload inside Cernan's suit caused his visor to fog. The overload was created by Cernan's unexpected exertion in preparing to don the 166-pound maneuvering unit.

On the Gemini X flight (July 18-21, 1966), pilot Michael Collins performed two extravehicular maneuvers. During his first exposure to space outside the cabin, Collins stood up in the open hatch of the spacecraft for nearly 45 minutes taking photographs and making observations. Later in the flight, during rendezvous with the Agena vehicle which remained in orbit after the Gemini VIII mission, he left the cabin, and with Astronaut John Young station keeping on the Agena, he maneuvered in space for 55 minutes with a hand-held maneuvering unit. Using a 50-foot tether and umbilical, and the hand-held maneuvering unit, Collins "translated" over to the derelict Agena and retrieved a micrometeoroid experiment which had been in space for four months.

When the extravehicular activity of pilot Richard Gordon was terminated early due to excessive fatigue after 33 minutes during Gemini XI (September 12-15, 1966), new restraining devices, training, and conditioning techniques were developed for the last Gemini flight. Unexpected difficulties with work outside the spacecraft had identified this as a problem needing more investigation. Specific routine tasks were established for Gemini XII extravehicular activity, to obtain some standard measurements of their difficulty. Several new body restraints and hand holds for maintaining body position were added to evaluate them as devices to reduce the work load on this mission, and training in water tanks under neutral buoyancy conditions was initiated. Three separate EVA operations were conducted during this mission in which 5 1/2 hours of EVA time were accumulated. On the second day of the mission, pilot Edwin Aldrin conducted a two hour and six minute test of the techniques and equipment developed. Following a schedule allowing for frequent rest periods, he completed 19 tasks, demonstrating that useful extravehicular work was feasible with careful planning, sufficient training and conditioning, and adequate restraint devices.[7]

## Reentry Control

On the last seven Gemini flights, control of the landing point was obtained by using the aerodynamic lift of the spacecraft as it reentered the atmosphere. An inertial guidance system provided the input data, an onboard computer solved the necessary guidance equations and the crew controlled or monitored the trajectory, guiding the spacecraft toward a preselected target. In *Gemini VI* through *X*, this procedure was controlled by the crew; on *Gemini XI* and *XII* an automatic system fired the attitude control system thrusters in response to guidance system commands. Average navigation accuracy of the guidance system for all seven flights was 2.2 nautical miles. The most accurate touchdown was made by *Gemini IX*, less than half a mile from the aiming point. The last five missions all landed within 3 1/2 miles of the aiming point.[8]

## Experiments

Advanced techniques and equipment in the Gemini Program made possible a large number of scientific and technological experiments on the 10 manned Gemini flights. A total of 52 separate experiments were flown in the program, many of them repeated on several flights, producing 111 experiments in flight. Of these, 90 returned useful information to the experimenter. The experiments ranged from specific physiological measurement of the crew to precise measurement of the space environment to technological developments proving out new equipment and techniques for space flight.

Of the 52 experiments flown, 17 were classified as scientific, 27 technological, and eight medical. Some of the nation's leading scientists participated as principal investigators in Gemini scientific experiments.* The scientific experiment program was interdisciplinary in character and comprised investigations in the fields of astronomy, biology, geology, meteorology and physics. Over half the experiments used photographic techniques, with the investigators taking advantage of the flight crew to guide and select the targets, returning the film for permanent record. A photograph frequently clarified data which otherwise were ambiguous.

Approximately 1,400 of the color photographs obtained were useful for geology, geography, oceanography, hydrology, aprology and agronomy. For example, one photograph of the Near East taken on Gemini XII appears to have considerable potential value in the study of the continental drift theory. Proponents of this theory consider that the Red Sea, which structurally is a large down-dropped block, represents incipient continental drift; that is, the Arabian Peninsula is considered to be drifting away and rotating from Africa.

Specific geological knowledge was acquired from photographs taken during Gemini IV, revealing new characteristics of a volcanic field in Mexico and a fault area in the Lower California peninsula only recently discovered. Similarly, the synoptic weather photography experiment produced color photographs of storm patterns and cloud cover from relatively low orbital altitudes. These pictures have been very helpful in interpreting results obtained from unmanned meteorological satellites.[9]

## Flight and Ground Crew Proficiency

The mission control and operations concepts established for Project Mercury, and refined during the Gemini Program, are being developed further for the Apollo missions. A world-wide network of tracking stations, first established to gather data on Mercury spacecraft and pilots, was expanded and refined for Gemini flight control and monitoring and is now being augmented for Apollo missions.

Gemini rendezvous and docking maneuvers, multiple vehicle missions, and long duration flights required a ground control system capable of processing and reacting to a vast amount of

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*Tables showing experiments, experimenters, and results can be found in Appendix B-III.

complex data in real-time. A new control facility was established to support not only the Gemini Program, but future space flight programs as well. The new Mission Control Center was located at the Manned Spacecraft Center where the crews, both flight control and astronauts, were stationed and the detailed mission planning was done.

This new facility was designed to direct and control Gemini flights through the Manned Space Flight Network, the world-wide communications, tracking, and telemetry network. This network of stations had proved its operational capability through the Mercury flights. The network was modified to have the capability to track two vehicles simultaneously and to provide dual command data to the spacecraft computers. Information generated during a typical Gemini mission was over 40 times the amount handled during the most complex Mercury flight. Carefully coordinated planning was done in building up to support Gemini, so that all changes would also contribute to the Apollo requirements.

Support facilities performed well in response to the Gemini requirements, including such severe tests as the Gemini VIII emergency landing and the short turn-around time of the Gemini VII/VI missions. As the flights progressed, a nucleus of qualified control personnel was greatly expanded. Techniques evolved during Gemini have resulted in flight plans providing maximum mission achievement with minimum use of consumables and optimum crew activity. Development of satisfactory work-rest cycles for astronauts and use of simultaneous sleep periods are examples of learning carried forward to Apollo planning.

Valuable flight crew experience from Gemini includes both preflight preparation for missions and the reservoir of actual flight time. Adequate crew preparation can now be assured in all areas. High fidelity mission simulators are proving very useful in training both flight and ground crews as a functional team, capable of dealing with problems as they arise. The accumulated total of 1,940 man-hours of space flight time, distributed among 16 astronauts, qualified Gemini pilots for long duration flights and complex rendezvous operations.[10]

## Department of Defense Support

Support provided by the Department of Defense throughout the Gemini Program was of such importance that it deserves specific mention. The launch vehicles for both the manned spacecraft and the rendezvous target vehicle were rockets developed and tested by the Air Force as ballistic missiles. Extensive adaptation of the Titan II missile was necessary to convert it into a man-rated booster for the Gemini spacecraft, and this development and procurement program was conducted by the Air Force Space Systems Division. Atlas launch vehicles and Agena spacecraft modified to the Gemini Target Vehicle configuration were also supplied to NASA through Air Force Space Systems Division. The launch operations functions, both for the manned spacecraft and the target vehicles, were provided by the Air Force's 6555th Aerospace Test Wing at Capt Kennedy. Range support was provided by the Air Force Eastern Test Range.[11]

Worldwide capabilities of the Department of Defense were utilized extensively in recovery operations and tracking and communications support. All of these activities in support of Gemini were conducted through the agency of a special Department of Defense Representative with authority to communicate with any element of the Department and speak with the voice of the Secretary of Defense concerning operational support needs as presented by NASA. Some measure of the scope of this cooperation, in executing the Gemini Program as a national effort, can be seen through the total cost figures for the support arrangements.

A total of $540,912,300 was expended through this channel, $455,139,900 reimbursed by NASA and $85,772,400 absorbed by the Department of Defense. Measured by the total number of personnel involved, the department's support for manned flights ranged from a high of 11,301 people on the Gemini IX mission to a low of 9,054 for Gemini XI. Recovery forces deployed 27 ships for the Gemini III mission, and this number was gradually reduced over life of the flight program to 12 for Gemini XII.[12]

## Gemini Program Management

As is characteristic of most advanced research and development programs, early cost and schedule estimates for Gemini proved to be excessively optimistic as the program and the flight vehicles became defined in more detail. By late 1963, however, program managers were able to establish a schedule which called for the final flight, Gemini XII, early in 1967. During the next three years, careful planning, intense top management attention, and hard work, on the part of the entire Gemini team produced a phenomenon rather unusual for an advanced research and development program -- a schedule which had moved ahead rather than back.

Gemini XII flew in November 1966 rather than early 1967, completing the program at least two months earlier than anticipated three years earlier. One of the most important results of this development was that total program costs to completion were estimated at $1,350 billion in Fiscal Year 1964 and actually totaled out at approximately $1,290 billion.[13]

## APOLLO DEVELOPMENT, MANUFACTURE, ASSEMBLY, AND TEST 1964-1966

During the years 1964, 1965 and 1966, steps were taken to bring to maturity the manufacturing, test, and launch facilities for the Apollo lunar mission. Near the end of this period a very heavy activity was underway on the production and checkout of launch vehicle stages and spacecraft modules.

Schedule plans and cost estimates for the manned lunar landing program, established in March of 1964, were subject to much strain and stress throughout the 1964-1966 period. In spite of some minor alterations, however, these plans and estimates formed the framework within which the Apollo Program proceeded. Under this plan, fifteen Saturn V vehicles and their associated spacecraft would be flown before 1970 to achieve a high degree of assurance that the lunar landing could be accomplished by that time.

The first major Apollo schedule adjustment took place late in 1964 as part of the decision that the Agency budget should be limited to the $5.25 billion level supported by the Congress for Fiscal Year 1965. The Apollo flight program was realigned so that the last two of fifteen Saturn V flights would occur in 1970 rather than in 1969. The timing of earlier flights was maintained, and a "reasonable opportunity" remained for accomplishing the lunar landing before the last two of the fifteen Saturn V flights, thus still within the decade.[14]

The schedule stretchout made necessary by this lower level of annual funding for the Agency ultimately resulted in a somewhat higher estimate for the Apollo Program cost as well as the total manned lunar landing costs. The manned lunar landing cost estimates include the Apollo Program as well as the total cost of operations of the three Manned Space Flight Centers, building, equipping and operation of the Tracking and Data Network and the construction of all Manned Space Flight facilities including the Manned Spacecraft Center, Kennedy Space Center, and supporting manufacturing and test facilities. In March 1964, the Manned Lunar Landing costs were estimated at $19.5 billion assuming a NASA budget level of $5-1/2 to $6 billion and that there would be a timely follow-on program to utilize and share the cost of the facilities and capabilities brought into being. In March of 1966, as a result of the reduced funding levels and the necessary schedule stretchouts, a new estimate to completion was made totaling slightly under $23 billion. This estimate was made on a more conservative basis and assumed that there would be no follow-on program in the period after the lunar landings to use the Apollo-Saturn system capability created. Nevertheless, the program proceeded through these three years with adequate progress and a good degree of stability. New approaches were also defined, such as the "all up" concept of flight testing with the expectation of expediting the flight program and holding cost levels in later years.[15]

Launch Vehicle Development and Test -- 1964-1966

During 1964 and 1965 the Saturn I flight program was completed with six launches of the two-stage vehicle. The Saturn I was the first of three major steps in the development of a large launch vehicle capability for the nation and for the lunar program. Following four launches of the first stage completed in early 1963, the ten successful launches in ten attempts comprised an unprecedented accomplishment in large rocket development managed by the Marshall Space Flight Center. The clustered engine principle of the booster stage, a technique central to the design of both the Saturn IB and Saturn V launch vehicles, was proved.

The further extension of technology essential to operation of high energy upper stages, using liquid hydrogen for fuel and liquid oxygen as oxidizer, was developed and tested, as was the guidance system, improved versions of which would fly on both Saturn IB and Saturn V.

The SA-5 mission on January 29, 1964, was the fifth flight of the Saturn I first stage, but the first launch of the complete two stage vehicle, and the first orbital flight in the program. A historic milestone in American large booster development was reached as 37,700 pounds were placed into earth orbit. The first stage was powered by eight engines producing a total thrust of 1.5 million pounds. Flight of the second stage, with six liquid oxygen-liquid hydrogen engines producing a total 90,000 pounds of thrust, established another landmark.

On May 28, the flight of SA-6 carried boilerplate Apollo command and service modules (of non-production construction, but duplicating the mass and external characteristics of the real spacecraft) into orbit, demonstrating the compatibility of the Apollo spacecraft with the launch vehicle and also testing the jettison sequence of the launch escape system. The "engine-out" capability designed into the booster, and checked out in 1963 on the SA-4 flight, was graphically demonstrated once again when one of the H-1 engines shut down prematurely. Longer burning of the remaining seven engines and appropriate course corrections by the guidance system compensated for the loss and put the payload into the planned orbital path.

Postflight reviews established that the first six flights had completed all Saturn I development and qualification testing in a program which had planned ten flights for this purpose. The remaining four flights were then considered operational missions. SA-7, the first operational mission, was successfully launched on September 18, 1964, to test the boilerplate Apollo spacecraft through launch and in orbit.

The last three Saturn I flights took advantage of the vehicle's operational status to place into orbit Meteoroid Technology Satellites named Pegasus after the winged horse of Greek mythology because the satellite had two large "wings" or panels to detect meteoroid impacts. In addition to the basic scientific value of such data, knowledge of the density and frequency of such impacts was crucial to the design of spacecraft structures for the manned space flight program. On each of the last three Saturn I flights (SA-9, February 16; SA-8, May 25; and SA-10, July 30, 1965), Pegasus satellites were placed into orbit, and after unfolding of their "wings," were monitored by telemetered signals transmitted from the spacecraft. Each flight also orbited Apollo boilerplate spacecraft with sophisticated telemetry to return detailed data on launch vehicle and spacecraft performance. The Saturn I program also accomplished a transfer of launch vehicle development and production responsibility to the industry. The last two launch vehicles of the Saturn I series were built entirely by private industry, whereas previous first stages had been assembled at the Marshall Space Flight Center.

While the flight activity of the Saturn I was underway, the development and ground test of Saturn IB and Saturn V components progressed toward flight test. The Saturn IB launch vehicle was a more advanced version of the Saturn I. The Saturn IB first stage was powered by eight, H-1 engines, as was Saturn I, but each engine was uprated to 200,000 pounds of thrust, producing a combined first stage thrust of 1.6 million pounds. A new second stage, with one J-2 engine, was fueled by liquid hydrogen and produced 200,000 pounds of thrust. It would also be the third stage for the Saturn V and considerable flight experience was obtained through flights of the Saturn IB. During 1964, fabrication of both stages began and the preflight rating tests of the J-2 engine were completed.

Saturn V component developments during 1964 included completion of initial designs for the three stages, assembly of a full scale mockup at the Michoud assembly plant, and overcoming problems with combustion instability to complete flight rating tests on the F-1 engine (1.5 million pounds thrust) for Saturn V's first stage. Two major achievements were realized during the year in development of the Saturn V second stage with five J-2 engines. In September, the 33-foot diameter common bulkhead was completed and on November 9 the engines were fired as an integral part of the stage for the first time.

During 1965, marks of progress in the Saturn IB program included formal qualification of the uprated H-1 engine for the first stage, and acceptance testing of the first stage. By December both stages were mated with the spacecraft and the first Saturn IB was ready for launch in early 1966. Meanwhile, in the Saturn V program, all three stages of the launch vehicle were static fired during the year in full duration runs. A critical test was passed on August 5, when the first full duration firing of the 7.5 million pound thrust first stage was conducted.

Although the Saturn V second stage completed a substantial portion of its ground testing during the year and the common bulkhead was structurally certified, a test stage failure at the Mississippi Test Facility and other difficulties developed which caused delivery of the first flight article to fall far enough behind schedule to become the pacing item in the Saturn V development program.

In 1966, acceptance testing was completed on the first three flight units of the Saturn V first stage and the first complete Saturn V flight vehicle was being assembled in the Vehicle Assembly Building at NASA's Kennedy Space Center. The test program was drastically rescheduled to complete necessary testing with the remaining second stage test hardware. Meanwhile, embrittlement cracks were found in second stage liquid hydrogen tanks and leaks appeared in the liquid oxygen tanks, requiring repair, reinforcement, and application of sealant in early flight stages after careful review and inspection.

The Apollo-Saturn IB flight program got underway with three successful missions during 1966. These flights accomplished their individual objectives by testing the spacecraft heat shield integrity and subsystems performance, and added confidence in the second stage of the Saturn IB (as previously mentioned, also the third stage of the Apollo-Saturn V lunar launch vehicle). The first critical test of the all-up flight test philosophy came on February 26, 1966, when the first Saturn IB and Apollo spacecraft combination was launched with all systems operating. Successful suborbital flight and recovery of the unmanned spacecraft was a major event in the early flight phase of the lunar landing program.

On July 5, 1966, a second Saturn IB flight placed the second stage, the instrument unit, and a nose cone into a 117-mile circular orbit. This 58,500 pound satellite, including 19,000 pounds of liquid hydrogen, was the heaviest American satellite to that date. Principal objective of this flight was to qualify the Saturn IB second stage as the third stage for the Apollo lunar mission by testing and observing the behavior and control of liquid hydrogen in orbit. The restart capability of the stage, a needed capability for lunar missions, was demonstrated and behavior of the liquid hydrogen was observed in real time through use of an onboard television camera.

A second suborbital flight to test the Apollo spacecraft and qualify the command module for manned flight was successfully conducted on August 25, 1966. On this flight from Cape Kennedy to recovery in the Pacific, the service propulsion engine was fired four times, demonstrating the multiple restart capability critical to the lunar mission, and the command module heat shield was tested at high heat loads through a long, shallow entry profile. The speed at reentry of 24,530 mph was the highest experienced to that time. As a result of the success of this series of flights, the first manned flight of an Apollo spacecraft was planned for early in 1967.[16]

## Apollo Spacecraft Development and Test - 1964-1966

The Apollo spacecraft is comprised of three major modules: the command module, service module, and lunar module. The command module provides the main living quarters and control stations. Its familiar squat cone shape serves as the crew compartment for the launch, the flight into lunar orbit, and the return flight from lunar orbit. It is the only module that reenters the earth's atmosphere. A two-stage lunar module is the vehicle in which two crewmen will leave lunar orbit, land on the moon's surface, and return to rendezvous and dock with the command and service modules in lunar orbit. The service module carries the fuel cells to generate the necessary electrical power for the spacecraft, oxygen for the life support system, other equipments and expendables, and houses the rocket propulsion systems for attitude control, velocity corrections on the way to the moon, deceleration into lunar orbit, and boost from lunar orbit for the return to earth.

The work on the command and service modules had preceded that on the lunar module by a year or more. As the design of the lunar module became better defined, and as early testing commenced on the command module, certain additional requirements became evident that called for the Block II version of the command and service modules.

During 1964, design and development progressed through freezing the design of the Block II spacecraft to be used in lunar missions, while the manufacture of the first orbital flight test spacecraft (Block I) was underway. Four boilerplate spacecraft were flown during the year. The launch escape and parachute recovery systems were tested successfully in two different critical phases of the planned flight profile.

Lunar module design in 1964 progressed to the stage where a full scale detailed mockup was fabricated and available for inspection and design engineering use in October. Component development tests for the service module propulsion engine were completed in preparation for complete service module system testing to begin at the White Sands Testing Facility. Fuel cell design verification tests were completed and fuel cell modules were successfully tested while connected in parallel.[17]

Extensive ground testing of major spacecraft components was the primary activity in 1965, with the critical firing sequences of the service module propulsion system begun in February and continuing throughout the year in preparation for the first flight test of the command and service modules in early 1966.

In 1965, boilerplate spacecraft were aboard the last three Saturn I launches which also placed Pegasus spacecraft in orbit. The launch escape system was qualified early in 1966. By August 1965, fabrication of the more advanced Block II command and service modules had begun. The first flight spacecraft was delivered to the Cape in October and mated with its Saturn IB launch vehicle in December. Extensive component test for the lunar module was conducted in 1965, with test articles undergoing detailed evaluation. The descent engine was tested in contractor facilities during 1965, in preparation for compatibility testing at White Sands in 1966.[18]

Then, in 1966, with two unmanned suborbital flights aboard Saturn IB launch vehicles, the performance of the command and service modules was successfully verified under actual flight conditions. The heat shield design was qualified, subsystems performance checked out, and the Block I spacecraft was cleared for manned orbital flight on the next mission, scheduled for early 1967. At that time, it was planned to accomplish two manned flights using the Block I spacecraft for astronaut familiarization and validation. As for the lunar module, careful weight control was necessary to keep it below the maximum weight allowance. Also, engine combustion problems developed which were not entirely unexpected since injector design had been more of an art than a science from the beginning of liquid rocket engineering.[19]

## THE APOLLO 204 ACCIDENT

At the beginning of 1967 the Gemini Program had been successfully completed and, after a series of delays, the first manned Apollo flight aboard Saturn IB number 204 was about ready for launch. Three flights of the launch vehicle in 1966 had qualified the entire space vehicle for manned flight.[20]

On January 27, 1967, a tragic accident took the lives of the three-man Apollo crew during a ground test on the launch pad at Cape Kennedy. Astronauts Virgil I. Girssom, Edward H. White II, and Roger B. Chaffee died inside the spacecraft within seconds after a fire broke out and spread rapidly, precipitating unconsciousness and death from inhalation of toxic gases. Investigation to determine the cause of the accident began immediately. On January 28, a review board was appointed -- under the chairmanship of Dr. Floyd L. Thompson -- to establish the cause, direct further investigations as necessary, report its findings to the NASA Administrator, consider the impact on other Apollo activities, develop recommendations for corrective action, and document its findings in a final report.[21] Although it was not possible to determine in definitive fashion the exact ignition source, the rapid spread of the fire and the material consumed established that very unusual and special precautions had to be taken to avoid fires in the pure oxygen environment of the spacecraft. The basic approach taken was to attempt to select materials that would not sustain combustion under these conditions and to demonstrate this capability by full scale flammability tests in boilerplate spacecraft. Because many materials which are fireproof in air burn readily in pure oxygen, many cases existed where new materials had to be developed.

Other changes were made such as a redesign of the spacecraft hatch to provide for more rapid egress capability. In fact, during the period wherein fire related modifications were incorporated, the entire spacecraft design was reviewed in detail. Additional testing was accomplished and although no major changes to systems approach were made, many specific improvements were made. A similar series of reviews and rework activities were implemented on the lunar module.

NASA officials reported at a Senate hearing on February 27, 1967, on efforts already underway to follow the investigating board's preliminary recommendations.

The redesign, test, and full qualification of these changes took many months and had the practical effect of delaying the first manned Apollo launch for at least 18 months.

On May 9, 1967, NASA's top Apollo Program officials appeared before the Senate Space Committee and presented the revised program planning. Block I spacecraft would be flown only on the unmanned qualification flights of the Saturn V and manned flights would be accomplished with Block II spacecraft, with all the design changes incorporated and qualified. The first manned flight would take place on a Saturn IB launch vehicle in 1968. Depending on when a man-rated Saturn V was available, this first Apollo manned flight could be followed by the first manned Saturn V flight. If Saturn V was not ready in time for this plan, alternate missions would be flown using dual flights of Saturn IB vehicles. This schedule would allow Saturn V flights before the end of 1969, slipping two more -- now a total of four -- into 1970.

By the time of the authorization hearings for the Fiscal Year 1969 budget, held in February 1968, the flight schedule planning had been adjusted further to the funding levels established in 1968 and anticipated for 1969. The revised schedule called for only a total of nine Saturn V launches before the end of 1969 and the end of the program had slipped into 1971. With "reasonable success" it was anticipated that the lunar landing could still be accomplished within nine Saturn V flights. Stretching the program into 1971 and procuring four additional command modules had raised the total run-out cost estimate, still assuming no costs absorbed by a follow-on program, to approximately $24 billion as of mid-1968.[22]

While the manned spacecraft modifications were being incorporated, the Apollo Program moved forward in an unmanned flight test phase. Three unmanned flights were accomplished between November 1967 and April 1968. The first of these, Apollo 4, marked the passage of a monumental milestone, not only in the Apollo Program, but in the history of rocket development. This was the first flight of the Saturn V launch vehicle, placing the Apollo spacecraft and third stage into parking orbit. The weight in orbit totaled 278,699 pounds. After two revolutions, the third stage restarted, as it would on a lunar mission, and placed the command and service modules in a high apogee trajectory. A first burn of the spacecraft's service propulsion system raised the apogee to 9,767 nautical miles; then a second burn on the way down accelerated the command module to a reentry speed of 24,911 miles per hour, demonstrating for the first time the effectiveness of the heat shield at lunar reentry speed. In this first test of the launch vehicle with all stages and all systems operating, the performance of both the launch vehicle and the spacecraft was virtually flawless, establishing a significant landmark for the Apollo Program.[23]

Apollo 5, launched January 22, 1968, was an unmanned flight of the lunar module on its first flight test, aboard a Saturn IB launch vehicle. The lunar module was successfully placed into earth orbit. The flight emphasized propulsion testing and both the ascent and descent engines were fired. The lunar module was the last major piece of Apollo hardware to be flight tested; Apollo 5 was a successful mission.[24]

The second flight of the Apollo-Saturn V vehicle took place on April 4, 1968, the Apollo 6 mission. First stage operation was nominal, but before the second stage had finished thrusting, problems began to develop. Two of the second stage's five engines shut down prematurely, but the planned burning time of the remaining three was extended to compensate as was the burn of the third stage. The third stage and command and service modules achieved an adequate orbit, but later in the mission, the third stage engine did not reignite as planned. An alternate mission was flown, using the service propulsion system to attain the high apogee planned to produce a high speed reentry of the command module.

Postflight analyses teams went to work and with swift and thorough detective work, using temperature distributions and other data transmitted to the ground during the flight, were able to pinpoint the engine system failures to small oxidizer lines in the engine start system. The failures were verified by testing which proved that the line behavior was different in the hard vacuum of space compared to previous tests in vacuum chambers on the ground.[25]

Perhaps even more significant, the postflight analyses revealed a high level of longitudinal vibration (Pogo effect) during the flight of the first stage. This vibration transmitted unacceptable "g" loads to the spacecraft portion of the vehicle. A team was organized from many agencies and elements of industry to solve this problem, using experience obtained from previous programs such as Gemini. In rapid order, comprehensive analyses and tests were implemented on a large scale to establish the nature of the corrective action. A high level of confidence was obtained in the design changes recommended, and by mid-1968, a decision to man the next Saturn V flight was reached, pending the successful flight of the first manned spacecraft on the Saturn IB. The engine and stage modifications were successfully tested on Saturn V number 506 at the Mississippi Test Facility and incorporated in the next flight vehicle (Saturn V number 503) at the Kennedy Space Center.

## Astronaut Selection and Training - 1964-1968

Through the end of 1967 NASA had selected a total of 66 astronaut candidates, and, in the summer of 1968, 52 were still active in the manned space flight program. Eight deaths, none in the course of an actual space flight, and six resignations were the attrition over the nine years since the original seven Mercury astronauts were named in 1959.*

The major innovation in astronaut recruiting in the 1964-1968 period was the scientist-astronaut program initiated in 1964. NASA asked the National Academy of Sciences to assist in establishing criteria for scientists in medical, engineering, or scientific specialties who could be selected for flight training

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*See Appendix B-III for list of all astronauts and biographical sketches.

and astronaut duties. The National Academy of Sciences recommended 16 outstanding candidates to NASA. NASA's Office of Manned Space Flight and Manned Spacecraft Center announced the selection of six scientist-astronauts to join the training program. Crew performance in the Gemini Program was accumulating conclusive evidence that the crewman would plan an indispensable role in the exploration of space as observer, investigator, and pilot. A second selection of eleven scientist-astronauts was made on August 4, 1967.[26, 27, 28, 29, 30]

In addition to searching for and selecting scientifically trained candidates for astronaut duty, NASA had increasingly stressed scientific training for astronauts already in the program in an attempt to make them more effective investigators, especially on the lunar surface. Thus, both classroom and field work in geology, mineralogy, petrology, and related subjects have been added to crew training.[31]

Thus, in astronaut training and in many other areas, the space program has established a precedent for bringing various disciplines together. An unusual feature of astronaut participation in space flight is that more often than not complex missions have been undertaken by crew members as a first time exposure to the space environment. This approach has placed stringent requirements on ground simulation and other forms of training.

## MANNED SPACE FLIGHT FACILITIES

By 1968, the Saturn V Launch Complex 39 at Cape Kennedy had been proved through two launches; a second launch pad, additional assembly facilities and launch umbilical towers were nearing completion. Value of the investment at the Kennedy Space Center, as of June 1967, was $945.3 million. At the Manned Spacecraft Center in Houston, Texas, investment at the same date totaled $317.5 million. This included a number of large vacuum chambers, the newly completed Lunar Receiving Laboratory, as well as the Mission Control Center and extensive crew training facilities and simulators. The Marshall Space Flight Center in Huntsville, Alabama, comprised facilities in which $312.4 million had been invested. Included were diversified facilities for development, manufacturing research, and test of large rocket components and stages. The Michoud Assembly Facility at New Orleans, Louisiana, represented an investment, with all facilities operational, of $142.4 million as of the end of fiscal year 1967. At the same time, investment at the Mississippi Test Facility totaled $234.0 million with all major construction completed. Other locations supporting the manned space flight program, including government-owned, contractor-operated manufacturing and test locations, all operational, represented $325.7 million in investment. The total investment in manned space flight facilities, as of June 30, 1967, had reached $2,277,175,000, representing a significant national capability to perform the necessary manufacture, test, checkout, launch, and control for extensive manned space flight operations.[32]

## Manned Space Flight Network Development - 1964-1968

One of the major national assets created in the conduct of the space program is the tracking, communication, and command and control network, built and operated to satisfy the requirements for manned space flights. Originally created for the Mercury Program, and expanded for Gemini, the Manned Space Flight Network had been undergoing augmentation to support Apollo missions since 1961. A summary sketch of the network's development to full operational capability provides some measure of the scope and significance of this portion of the national space program.[33]

The Manned Space Flight Network for Gemini evolved from the original tracking and data acquisition facilities developed to support Mercury. During Mercury the network consisted of eighteen stations, including two ships.

Efficient performance of the network in support of Mercury flights, and the confidence acquired in that program permitted a reduction in the number of network stations for Gemini. As configured for this second manned space flight program, the Manned Space Flight Network consisted of twelve stations. These included seven primary land stations, three secondary land stations, and two instrumentation ships. By the end of 1963, the primary land stations and the instrumentation ships were being modified by addition of digital command and more up to date telemetry, computer and communications equipment for Gemini, while network modifications for support of the Apollo Program were concurrently in the final planning stages.

During 1964 the network easily supported one unmanned Gemini mission and three Saturn I flights.

Planned augmentation to support Apollo lunar operations included provision of new stations collocated with Deep Space Network Stations at Goldstone, California; Madrid, Spain; and Canberra, Australia. These stations were planned to include 85-foot parabolic dish antennas, unified S-band receiving, transmitting and ranging systems, and highly automated data handling and processing equipment.

The unified S-band (USB) system, a major technological advance in network capability, was developed by the Jet Propulsion Laboratory for use in Surveyor, Lunar Orbiter, and Mariner missions. Gemini used separate antennas for tracking, telemetry, command, and voice communications with the spacecraft. Apollo support, with the unified S-band system, makes it possible to provide all these functions (plus television and other special uses) using only one antenna at each station. In addition, use of the unified S-band system and 85-foot antennas would extend the communications and data acquisition range of the network to lunar distance and extend the network's traking range capability from 4,000 miles to more than a million miles.

Five instrumentation ships, equipped with systems similar to those at the land stations, were planned for use where land stations were not feasible.

These Apollo changes were a major undertaking, estimated to require 3 1/2 years to complete. Contracts were awarded by late 1964 for long lead time items.

Beginning with the unmanned Gemini II flight on January 19, 1965, the network successfully supported all Gemini missions with no significant ground system failures. The new unified S-band systems were used, during Gemini, for test evaluation purposes only. Three stations were deactivated following the last Gemini mission in November 1966.

Congressional approval of two stations and eight instrumented jet aircraft for Apollo support was granted in the Fiscal Year 1966 program, and the necessary contracts were awarded in late 1965.

During 1965 and 1966, while Gemini was flying, the network building for Apollo proceeded concurrently. In August 1966, support of the Apollo-Saturn 202 flight, the first mission to carry the Apollo spacecraft unified S-band system, validated network operations.

For the complex Apollo flight missions, real time operational control was to be maintained in the Mission Control Center-Houston. Studies conducted with the National Communications System established that the requirements could not be met by conventional systems alone, but use of communications satellites would be an answer.

NASA asked the Communications Satellite Corporation to determine whether it could meet the specified communications requirements. The proposed service was found acceptable, and the contract with Communications Satellite Corporation formed the hard core upon which the corporation based its INTELSAT system. Spurred by the early NASA need date, the corporation was able to accelerate its plans and put international commercial communications satellites in service approximately two years ahead of the planned date.

By April, 1967, the critical Manned Space Flight Network stations were utilizing communications satellites which had enough excess capacity to provide service as commercial carriers.

During 1967, the Apollo augmentation was completed and the network successfully supported the first Spollo-Saturn V mission (Apollo 4) in November, as well as the flight that followed in 1968.

## INTERNATIONAL RELATIONS

The fact that this nation and others are operating in space has provided a great opportunity for re-examination by nations of their national interests and the achievement of broad measures of international agreement and understanding. The Outer Space Treaty of 1967 is a good example of the realization by many nations that the relatively untraveled environments of outer space and celestial bodies should remain available for the benefit of all mankind, and that the conduct of activities in outer space and on celestial bodies should be subject to an international code.

The area of disarmament,Article 4 of the Outer Space Treaty, reflects an agreement to bar orbiting weapons of mass destruction from outer space or from celestial bodies or space stations. As of October 8, 1968, 89 states have signed the Outer Space Treaty, 31 states ratified it and seven states acceded to it. The recent Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Space Objects is another example. As of October 8, the Agreement has been signed by 74 states and ratified by two states. States with widely divergent political, social, economic and legal systems and philosophies have proved their ability to come together and achieve mutual understanding. The agreements and the support obtained from foreign countries in the implementation and operation of stations of the Manned Space Flight Network on foreign lands is another area where the working-together of nations has been most gratifying. These endeavors, plus actual foreign participation in space experiments, open the way to better relationships between nations.

## POST-APOLLO MANNED SPACE FLIGHT 1965-1968

Progressively detailed studies made over a period of several years have produced information necessary for post-Apollo mission planning. The broad questions concerning future goals in space exploration were posed by President Johnson in a letter to Administrator Webb on January 30, 1964. Discussions leading to the decisions on the Fiscal Year 1965 budget had brought to the surface a problem endemic to any research and development oriented activity -- the difficulty of justifying advanced hardware development programs not identified with specific missions. Why should a larger rocket, or a more sophisticated spacecraft be developed if there is no specific mission for which they must be used? The President asked Mr. Webb to review future plans for space exploration". . .with the object of relating hardware and development programs to prospective missions."*[34]

From this presidential request to NASA to propose specific advanced missions grew the post-Apollo manned space flight proposals eventually known as the Apollo Applications Program.

A report by NASA's Future Programs Task Group in February 1965 dealt with all areas of NASA's responsibility, aeronautics and unmanned space flight as well as manned space flight. For future manned operations, the report identified a first phase based on making the most effective use of launch vehicles and spacecraft developed in the Apollo lunar landing program. Projecting a capacity to launch six Saturn IB and six Saturn V vehicles annually, with eight manned spacecraft provided, the report envisioned a broad spectrum of missions and identified the necessary changes to Apollo hardware which would make these activities possible.[35]

Seen as an interim program for the immediate post-Apollo period, this recommendation was appropriately named "Apollo Extension Systems" when presented to the Congress in the Fiscal Year 1965 authorization hearings. Extended earth orbital operations could be performed by increasing the supply of oxygen and other consumables, to make missions of a month or longer possible. Various experiments would be housed in a modified lunar module and a special section of the service module. Lunar surface exploration missions were projected by landing an unmanned lunar module to serve as a shelter on the moon with additional life support provisions. Extended lunar orbital flights, to survey and map the lunar surface, and earth orbital operations anticipating eventual space stations were projected. The only approval requested at this time, however, was for Apollo mission support funds to conduct design studies and find some very long lead time components.[36]

By the late summer of 1965, planning for application of the Apollo capability to future manned missions had advanced to

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*For discussion of the broader Congressional and public dialogue which ensued over the future of specific programs, see Chapter II.

the point of considering approximately 150 scientific experiments as candidate possibilities for manned flight. The scientific community had been consulted extensively. A summer conference of the National Academy of Sciences at Woods Hole devoted a portion of its time to defining the role of manned space flight in carrying out space science. Studies had been accomplished by universities and non-profit research institutions, the NASA Science and Technology Advisory Committee was providing continuing review and guidance, and a Space Medicine Advisory Group had been established to aid in defining medical experiments for manned space flight.

In hearings before the Senate Committee on Aeronautical and Space Sciences in August 1965, NASA presented the details of advanced manned space flight proposals now being called "Apollo Applications." Proposed schedules were shown indicating that mid-1968 was the earliest possible date for applications flights. A broad spectrum of possibilities was outlined, demonstrating the results of the program definition work which had been accomplished to that time. Program alternatives, in broad terms, were presented for consideration, recognizing that what was to be emphasized in future programs and at what level of effort they would be pursued was a subject for a national decision.[37]

During the Fiscal Year 1967 authorization hearings, NASA presented more details of the planning and program definition process. Since program definition was projected to extend until the end of 1967, the decision on commitment of large sums of money was deferred until the next budget year (Fiscal Year 1968). NASA spokesmen identified this as the crucial year, if there was not to be a hiatus in manned space flight operations. In the broad context, this procedure was viewed as holding open the option to proceed with further programs beyond Apollo. In 1966 it was already becoming a matter of intense concern that production lines for boosters and spacecraft would be shut down, the skilled teams of scientists and engineers in government and industry would begin to break up, and facilities were destined for "mothballing" if a decision to proceed were not reached soon.[38]

The Fiscal Year 1968 budget cycle was the long anticipated time of decision for the Apollo Applications Program. A relatively ambitious program at a funding level of $626.7 million was proposed by NASA to the Bureau of the Budget, the President's budget requested $454.7 million, Congress appropriated $315.5 million, and the NASA operating plan -- adjusting for a total agency budget reduction of $500 million -- allocated $253.2 million. During the course of the year 1967, the Apollo Applications Program was thus reduced from a $626.7 million proposal to a $253.2 million program.[39]

An overall summary of the changes to the proposed program resulting from the combined budgets for Fiscal Years 1968 and 1969 may provide a useful overview of the status of the program in mid-1968. Further adjustments to an even smaller budget will have to be made as a result of actions on the Fiscal Year 1969 budget.

Successive reprogramming actions, in response to this series of decisions, have stretched out hardware delivery schedules and tentative flight dates, with various missions cancelled or deferred. The original concept of using the capability to produce and launch six Saturn IB's, six Saturn V's and eight spacecraft per year was reduced to four, four and seven, respectively, in the program presented in early 1967. By mid-1968 this had been reduced to a commitment to buy only two additional Saturn IB launch vehicles over and above the vehicles being procured for the Apollo Program.

The flight to provide an embryonic laboratory in earth orbit, the Saturn I Workshop, was delayed until 1971. Launch of the Apollo Telescope Mount, to provide a manned telescope outside the earth's atmosphere for extensive study of the sun, was also deferred to 1971. Plans for an early mission to carry experiments concerned with earth resources, second Saturn I Workshop in earth orbit with revisit and reuse flights, and a second Apollo Telescope Mount were cancelled.[40]

Since adjustments to this tentative program were still being made in the summer of 1968 in response to further reductions in the Fiscal Year 1969 budget request, the precise content of the Apollo Applications Program was not yet established. The tentative nature of future manned programs was described by President Johnson on December 12, 1967, at New Orleans, Louisiana:

> "So we will advance in space to the extent that our our people and their representatives are prepared for us to advance and are prepared to pay the cost of that advance . . ."[41]

The basic theme of the Johnson years in a broader sense is discerned in his presidential report to Congress on aeronautics and space, of January 1965, when he said:

> "We expect to explore the moon, not just visit it or photograph it. We plan to explore and chart planets as well. We shall expand our earth laboratories into space laboratories and extend our national strength into the space dimension."[42]

## A BROADER PERSPECTIVE

This country's advancement into outer space represents a logical progression of the technologies which grew out of the challenge to creativity by the Second World War, the last previous event to harness this nation's energies as space exploration has since done. The space effort has stimulated and advanced the developments of World War II in the areas of synthetic materials; nuclear energy; rocket propulsion; microwave technology; computers and electronics; and the management techniques which enable this country to control large scale national efforts.

It was the vision of Lyndon B. Johnson and of those who worked with him to draft the National Aeronautics and Space Act that the space program would become a balanced, broad-guaged effort inspiring man to his best forward-looking efforts.

Underlying all of the accomplishments which were produced to support Apollo are significant technological advances, in and out of government, to develop new materials, devise new structures and building the comples electronic, mechanical and chemical systems and equipments of high reliability for the extremes of service imposed by aircraft and space vehicles. This new technology, in composite, brought with it revolutionary change in the way of making and testing things, not only for space systems, but for innumerable non-space services, processes and materials.

The supervisors in government, the doers in industry, and the thinkers in the universities are working together in order to accomplish very difficult technical and management jobs. This precedent, as well as some of the actual working relationship which have developed, may be drawn upon for attacking, upon the basis of the mobilization of our total national competency, large-scale problems which require the teamwork of the government supervisor, the industry doer, and the thinker. A number of our universities are now richer national resources because of the multidisciplinary studies which NASA encouraged and funded. In these space-related studies at least some of the traditional barriers to thinking across the lines of academic specialties have been broken down.

The space effort can be viewed as a movement of man to satisfy his intellectual appetite for discovering, understanding, and controlling the elements of his total environment, including himself. The ability to fly men in outer space not only allows the learning of new facts, but also of seeing the world and ourselves from a new perspective.

## NOTES TO CHAPTER III

1. Background on Mercury and the early Gemini Program will be found in Chapter I. Also see Swenson, Grimwood, and Alexander, This New Ocean for a detailed historical account of Mercury. For a detailed account of Gemini technology and operations, see James M. Grimwood and Barton C. Hacker, Gemini Technology and Operations, a Chronology (hereafter cited Gemini Chronology), now in publication as NASA SP-4002. A full history of the Gemini Program is now in preparation as part of the NASA Historical Program.

An excellent summary of the contractor's effort in the Gemini spacecraft program is NASA Contractor Report CR-1106, Project Gemini, A Technical Summary, by P. W. Malik and G. A. Souris, June 1968, available from the Clearinghouse for Federal Scientific and Technical Information.

2. Gemini Mid Program Conference, NASA SP-121, 1966; Gemini Chronology.

3. Gemini Chronology; A good account of each flight is in the Post Flight reports of the NASA Headquarters Mission Operations Reports series. See the Appendix for a table of details on each Gemini flight.

4. Gemini Summary Conference, p. 197.

5. A & A 1965, p. 493; Gemini Chronology; interview, George E. Mueller by W. D. Putnam, October 4, 1966, in NASA Historical Archives.

6. Details of rendezvous, docking and post-docking operations may be found in Gemini Summary Conference, pp. 7-64.

7. Extravehicular activity planning, training, equipment development, and mission results are discussed in detail in Gemini Summary Conference, pp. 67-146, and further elaborated in Summary of Gemini Extravehicular Activity, NASA SP-149, 1967.

8. See Gemini Summary Conference, p. 159.

9. Gemini Summary Conference, pp. 221-317, Especially the striking photographs with analysis by R. W. Underwood, on pp. 231-290. Also see NASA SP-129, Earth Photographs from Gemini III, IV and V, 1967; SP-171, Earth Photogrpahs from Gemini VI through XII, 1968; and SP-168, Exploring Space With a Camera, 1968.

10. See Gemini Mid Program Conference, pp. 153-232; and Gemini Summary Conference, pp. 321-336.

11. Department of Defense support for Gemini is summarized in Summary Report, DOD Support of Project Gemini, January 1963-November 1966, submitted to the Secretary of Defense by Lt. Gen. L. I. Davis, USAF, DOD Manager, Manned Space Flight support Operations. Launch systems research and development and launch operations activity are detailed in Gemini Program, Launch Systems Final Report, Aerospace Corporation Report No. TOR-1001 (2126-80)-3, January 1967; Launch Operations Techniques, Manned Space Flight, prepared by Gemini Launch Vehicle Division, 6555th Aerospace Test Wing, Space Systems Division, Air Force Systems Command, 22 December 1966; and Howard T. Harris, Gemini Launch Vehicle Chronology, 1961-1965, AFSC Historical Publication Series 66-22-1, June 1966.

12. Summary Report, DOD Support of Project Gemini, January 1963-November 1966.

13. House FY 1965 Authorization; House FY 1968 Authorization.

14. NASA Twelfth Semiannual Report, p. 28; House FY 1966 Authorization, Part I, pp. 8, 46; see Chapter II for discussion of the Fiscal Year 1966 budgetary process.

15. Senate FY 1967 Authorization, pp. 8-9; Memo, Willis H. Shapley, Associate Deputy Administrator, NASA, for Heads of Headquarters and Program Offices, subj: Statement on Cost of the Manned Lunar Landing Program, March 10, 1965; NASA Release 66-295.

16. A good short summary of the Saturn I program is found in the brochure "Saturn I Summary," published at the George C. Marshall Space Flight Center, NASA, February 15, 1966. Detailed accounts of each mission are found in NASA Headquarters' Mission Operations Reports series, one for each flight. Even more detail on all three Saturn research and development programs (Saturn I, Saturn IB, and Saturn V) can be found in the series of Marshall Space Flight Center Historical Monographs titled History of the George C. Marshall Space Flight Center, published for six-month intervals. The account of the Saturn program in this section is based, in part, on all of these sources.

Useful in tracing developments in the overall Apollo Program are the annual Administrator's Program Review documents, the Apollo Program Monthly Status Reports, the Apollo Weekly Program Status Reports, and the Manned Space Flight Monthly Report to the Administrator, which includes the most significant program developments. These should be useful to future historians in that they provide contemporary accounts of developments which will indicate to future readers the relative importance attributed to specific events by the immediate program managers.

17. House FY 1966 Authorization, part 2, pp. 77-88; Report to the Congress from the President of the United States, United States Aeronautics and Space Activities, 1964, (hereafter cited President's Report, 1964, etc.) pp. 12-13; NASA Eleventh Semi-annual Report, p. 37; NASA Twelfth Semiannual Report, pp. 31-33 .

18. NASA Release 65-348; A & A 1966, pp. 21, 33; House FY 1967 Authorization, Part 2, pp. 104-118; President's Report, 1965, p. 16; NASA Thirteenth Semiannual Report, pp. 27, 28.

19. President's Report, 1966, pp. 14-17; House FY 1968 Authorization, Part 2, pp. 100-105.

20. President's Report 1966, pp. 14-15.

21. A vast literature has been produced as a result of the public interest in the Apollo 204 accident, the exhaustive report of the review board, and investigation into the accident by both the Senate Committee on Aeronautical and Space Sciences and the House Committee on Science and Astronautics.

The first official reports on the accident investigation were made by memoranda from Robert C. Seamans, Jr., NASA's Deputy Administrator, to James E. Webb, Administrator. These reports, dated February 3, February 14, and February 25, 1968, were made public by NASA as they were received by Mr. Webb. On February 7, the Senate Committee on Aeronautical and Space Sciences held a hearing in executive session, released the record on February 11, then held another hearing on February 27, 1967.

Report of the Apollo 204 Review Board to the Administrator, NASA, with a transmittal letter from the board chairman dated April 5, was delivered simultaneously to Mr. Webb, Congressional Committee members, and the press on Sunday, April 9, 1967. This report contains an exhaustive description of all the board's activities, ending with conclusions and recommendations. It was printed for sale by the Superintendent of Documents, U.S. Government Printing Office, and is further reprinted completely in the Investigation into the Apollo 204 Accident, Hearings, before the Subcommittee on NASA Oversight of the Committee on Science and Astronautics, U.S. House of Representatives, Ninetieth Congress. When combined with the published record of hearings in both houses of the Congress, this is an exhaustive account of the accident, its investigation, and the aftermath. Future historians will want to begin with a careful reading of this record.

22. House FY 1969 Authorization, Part 2, pp. 291-293.

23. Apollo 4 Post Mission Operations Report; President's Report 1967, pp. 11-12.

24. Apollo 5 Post Mission Operations Report; Release 68-19.

25. Apollo 6 Post Mission Operations Report.

26. A & A, 1965, p. 423; A & A, 1966, p. 127; NASA Astronauts, EP-34, NASA, Washington, October 1967.

27. NASA Release 64-248.

28. NASA Release 65-212; letter, Frederick Seitz, President, National Academy of Sciences, to H.L. Dryden, Deputy Administrator, NASA, May 19, 1965.

29. NASA Release 65-212; see the following section of this chapter for the astronauts' accomplishments in the Gemini Program.

30. A & A, 1966, p. 302; NASA Release 67-21.

31. President's Report, 1964; NASA Astronauts, EP-34; NASA Eleventh Semiannual Report, pp. 48-49.

32. House FY 1969 Authorization, Part 2, pp. 5-7, 321.

33. This summary account of the Manned Space Flight Network development is based on material provided by the Office of Tracking and Data Acquisition at NASA Headquarters. Yearly summaries of development and status can be found in the authorization hearings, with most detail being available in the House restimony. See, specifically, for this period; House Authorization Hearings for Fiscal years 1967, 1968, and 1969, where the Office of Tracking and Data Acquisition testimony is made before the Subcommittee on Advanced Research and Technology. An interesting overview of the international relations aspects of building and operating the worldwide tracking and communication

network may be found in a paper for the U.N. Conference on Peaceful Uses of Outer Space in Vienna, Austria, August 1968, by Gerald M. Truszynski, NASA's Associate Administrator for Tracking and Data Acquisition. Also see W.R. Corliss, The Evolution of the Manned Space Flight Network Through Gemini, Goddard Space Flight Center Historical Note #5, April 1968.

34. Letter, President Johnson to Webb, January 30, 1967. This letter, Mr. Webb's interim reply of May 20, 1964, Webb's letter of February 16, 1965, transmitting his report to the President, and a letter from Webb to the chairmen of authorization committees of both houses of Congress dated April 2, 1965, are all printed as enclosures to the Summary Report, Future Programs Task Group, by the House Committee on Science and Astronautics, April 1965.

35. Summary Report, Future Programs Task Group, pp. 49-59.

36. House FY 1966 Authorization, Part 2, pp. 135-142.

37. National Space Goals for the Post-Apollo Period, Hearings before the Senate Aeronautics and Space Sciences Committee, August 23, 24, 25, 1965, pp. 77-104.

38. House FY 1967 Authorization, part 2, pp. 1195-1205, pp. 163-184.

39. House FY 1969 Authorization, part 2, p. 206; NASA's Proposed Operating Plan for FY 1968, Hearing before the Senate Committee on Aeronautical and Space Sciences, November 8, 1967, pp. 8-9; Senate Hearings, NASA Appropriation for FY 1968, Hearings before the Subcommittee of the Committee on Appropriations of the U.S. Senate, pp. 144-145.

40. House FY 1969 Authorization, part 2, pp. 206-207.

41. Text, Office of the White House Press Secretary, Remarks of the President at Michoud Space Assembly Facility, Michoud, Louisiana, December 12, 1967.

42. President's Report, 1965.