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 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.*

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*This chapter prepared by Manning Williams.

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 expendition 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]

> 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.
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> 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.
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> 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]

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

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

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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.

**Emphasis added.

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, <u>and in the process could develop the scientific knowledge, technical knowledge, industrial base, engineering and launch installations, and worldwide tracking and control networks</u>.* 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, <u>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</u>.* Even if economy alone were to be the guiding consideration in the evaluation of the NASA request for fiscal year 1965, <u>the cost of establishing and maintaining superiority in space will be less if we maintain the pace, the momentum</u>,* which the supplemental appropriation and this authorization request will provide.

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*Emphasis added.

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 the landing date for a period of up to 6 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 3-year delay would cost $3 billion, a 6-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 blance,and that is the case with our program as it was presented last year. <u>The stretchout to the very last of this decase, 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 technicans 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 3- or 6-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 3 months or once in 6 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.

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:

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*Emphasis added.

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, <u>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</u>.* This will stretch NASA and its contractors to the limit, but <u>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</u>.* 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 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.

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*Emphasis added.

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

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TABLE II-1

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

Fiscal Year	Budget Request	Appro-priated	Difference
1960 Eisenhower	508.3	38.5* 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 pre-mature 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.*

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*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. 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.[8]

*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 or 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 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.

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*See Chapter IV.

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 Apollo 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 give this brief review of space policy:[34]

> This Nation's leadership in advanced technology was challenged 10 years ago by Sputnik and again 7 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 fairly 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).
>
> 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:

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

** 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.

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, 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 doing all they could to avoid wasteful 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 acitivities 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 President-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 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 to pre-eminence in the debate on U.S. space policy, past and future:

1. National Security: Because practically every scientific and engineering discipline must be pushed to the limit to achieve success, 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.

* See Chapter I.

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 possibly 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."*

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

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 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.

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

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.*

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?"

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

> 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 <u>rate of advance toward future greater capabilities</u> (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 <u>Apollo 4</u> and <u>5</u> -- 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.....
>
> 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

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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.

**<u>Apollo 4</u> was the first flight demonstration of the Saturn V launch vehicle.

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

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 .....

Asked where the United States stood in comparision 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

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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.

> 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 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 <u>demonstrated</u> 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.***

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

**Through October 31, 1968.

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

Voskhod I carried three men into space for 24 hours in October 1964; Voskhod II, launched in March 1965, was equipped with an air-lock which permitted Cosmonaut Leonov to carry out the first extra-vehicular 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 space-craft, 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 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, was scheduled for 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

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*Through October 31, 1968.

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 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. 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

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*According to plans as of September 1968.

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 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.

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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.

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 unmanned 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 forecasting 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 reasonable viable position to move forward effectively in whatever direction the national interest would require in the future.

(Additional material for this chapter will be submitted later.)

NOTES TO CHAPTER II

1. The U. S. Budget, 1965, p. 22.

2. Ibid., p. 88.

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

4. House Committee on Appropriations, Subcommittee, Independent Offices Appropriations for 1965, 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, NASA Authorization for Fiscal Year 1966, Part 3, pp. 1016-1102. In the main, the NASA Summary Report 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. The Budget, 1966, pp. 87-88.

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

9. Deleted.

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

11. Ibid., 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 cannot be done in this project.

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's 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 of large launch vehicles). 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 endeavor 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.

CHAPTER III

Chapter III

MANNED SPACE FLIGHT*

1964-1968

By the end of 1963, seven months had passed since the last flight of Project Mercury, the first United States manned space flight program. Manned Gemini flights were two years in the future and the Apollo program was still in the detailed design and development test phase. Although Americans and Russians had each flown on six space flights, two of the United States' flights had been sub-orbital tests. The Soviets had twice flown dual missions, with two manned spacecraft in orbit at the same time. The longest American flight had been Gordon Cooper's 21 revolution, 34 hour and 20 minute, final mission in the Mercury program, while the Soviets had flown missions of increasing length, from Vostok I's hour and 48 minutes, to Vostok V's 119 hours and 6 minutes in June 1963.[1]

American effort in space, and specifically in manned space flight, was building to a highly visible element of national capability in the world context, as was to become evident during the years 1964-1968. The first stage of the Saturn I booster, a cluster of rocket engines producing 1.5 million pounds of thrust, had been flown in four flight tests by the end of 1963. Before the end of 1967, six more flights of that booster with an added second stage, three flights of the complete two stage Saturn IB vehicle, and the first flight of the complete three stage Saturn V launch vehicle with first stage thrust of 7.5 million pounds, provided dramatic evidence of growing large space booster capabilities.

By the end of 1966 the United States had established a leading role in manned space flight operations, having conducted a total of 16 manned space flights, 14 of these orbital, with a total of 19 different crewmen, seven of whom had pariticipated in two flights. The comparable Soviet totals, meanwhile, had reached 8 manned flights, all orbital; with 11 different crewmen; and a cumulative total manhours in space of 507 hours 9 minutes, as compared to the United States' 1,993 hours 36 minutes.[2]

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*This chapter was prepared by William D. Putnam.

The difference here was the Gemini flight program of 1965-1966 with 10 two-pilot flights of the manned spacecraft in 20 months, conducting rendezvous and docking operations, post-docking maneuvers, activities of astronauts outside the spacecraft, controlled reentry experiments, and many scientific and technological experiments in the space flight environment. Meanwhile, the three-man Soviet flight of Voshkod I in 1964 was followed by the two-man Voshkod II in March of 1965, featuring the world's first "walk in space" by Alekesi Leonov. A two year hiatus then ensued in Soviet manned flights before the Soyuz I on April 23, 1967, which ended with the tragic death of cosmonaut Vladimir Komarov.* Meanwhile, the U.S. Apollo program had been set back about two years by the Apollo 204 fire.

The United States' standing in the space flight "box score", well publicized in the world press, was the result of massive effort by hundreds of thousands of people over a period of several years. A summary account of that activity is the objective of this chapter. Chronologically organized, it first establishes the specific program orientation of Apollo in early 1964, then traces major events through three years of relative stability until the end of 1966. Next, a summary of the Gemini program from 1964 through 1966 is presented. Accomplishments against established objectives are stressed so the position of Gemini in the total manned space flight effort may be understood.

A following section deals with the dramatic effect of the Apollo 204 accident of January 27, 1967, then traces progress to date in the revised program through the major milestones achieved in 1967 and 1968. And finally, a brief discussion of the origins, successive readjustments, and contemporary status of the Apollo Applications Program is presented. An epilogue is planned for the final version of this report, to cover the first manned Apollo flight, anticipated in the fall of 1968.

Historians attempting to appreciate the manned space flight program development efforts in a larger context should be alerted to the peculiarities of the chronological relationship between the Mercury, Gemini, and Apollo programs. Although the manned flight portions of the three programs fall into three neatly separated periods (Mercury 1961-1963, Gemini 1965-1966,

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*The first known casualty in space flight.

Apollo 1968-   ) the conceptual, design, research, and development phases are not so neatly separated.* The Mercury program, which had its origins in early study effort by both the Air Force and NACA, was begun in 1958 with the limited objective of placing a man in earth orbital flight, observing his reactions, and recovering both man and spacecraft. It followed that the designed capabilities of that system, severely limited in spacecraft weight by available booster thrust, were amenable to little expansion or elaboration.

In terms of concept and design, the next step in manned spacecraft was Apollo. Constrained by anticipated booster lifting capabilities, the unknowns of the cislunar space travel environment, and, after May 1961, a definite time limitation, the Apollo spacecraft design competition was begun in 1960 and the command and service module configuration selected late in 1961. At this time, the total United States' space flight experience consisted of two 15 minute sub-orbital flights by Alan Shepard and Gus Grissom. The very long lead-times associated with the fabrication, test, and launch facilities which had to be built, and development of the booster rocket (all dependent to a significant degree on the spacecraft design) made it imperative to initiate work on the basic design of Apollo spacecraft many years before the first manned flight.

Gemini, begun after Apollo, had the advantage of systems in a more advanced state of development in many ways, than Apollo. Many of the lessons learned from the Mercury research, development, and flight program were directly incorporated into the Gemini design, as will be seen later in this chapter. Since Gemini was designed for earth orbital operating and reentry conditions, it afforded somewhat larger design margins than Apollo, designed for the environment out to 250,000 miles from earth, and reentry at much greater speeds.

These important time-related qualifications to the superficial appearance of a neatly compartmented chronological sequence of manned space flight programs must be kept in mind if one is to appreciate the complex interrelationship between the three programs. Whereas both Mercury and Gemini made extensive use of existing hardware and facilities, the entire Apollo system, from spacecraft and boosters through manufacturing, test, and launch facilities, was designed from its

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*Another interesting historical note is that each of the three manned space flight programs were destined to accomplish its flight objectives in the presidential administration subsequent to the one in which it was planned and initially funded. Thus, Mercury was begun in the Eisenhower administration to be flown under Kennedy; Gemini begun under Kennedy and flown under Johnson; and Apollo begun under Kennedy-Johnson to be flown out under President Johnson's successor.

beginning in 1961 to establish a national capability to conduct manned space flights to the lunar distance and demonstrate that capability by landing man on the moon and returning him safely to earth.

APOLLO MOVES TO DEVELOPMENT AND OPERATIONS PHASE OCTOBER 1963 - MARCH 1964

Although some modifications would be necessary to make the theory fit actual events, it may be useful to consider the evolution of the Apollo program within the framework of a process called "Phased Project Planning." This process divides the conduct of a research and development program into four successive phases, with intensive review and analysis at the conclusion of each phase. Based on this review, the decision is then made to proceed to the next phase with the program modified to the extent revealed necessary by the analysis.

The period from NASA's creation in 1958 until the endorsement of President Kennedy's lunar landing proposal by the Congress in 1961 could be seen as the first phase of the Apollo program. This phase consists of initial studies and research and engineering efforts in support of those studies, establishing the technological feasibility of a manned lunar landing program, leading to the decision to commitment.

Within this framework, the second phase of the Apollo program comprised detailed study, analysis, and preliminary design to identify the specific means of reaching the established goal from the alternatives available. This phase could be said to have ended in November 1962 with award of the development contract for the last major Apollo component, the lunar module. Lasting approximately 18 months, this phase included selection of major test and manufacturing sites, establishing the configuration of the Saturn V launch vehicle, and selecting the lunar orbit rendezvous mode for accomplishing the lunar landing mission.*

The third phase of Apollo was further definition, including detailed design of critical systems and subsystems to provide reasonable assurance that detailed schedule and cost estimates for achieving the program goals could be made. Apollo essentially reached the end of this phase in March 1964. Definition had then reached the point where quantities, schedules, and costs to achieve the lunar landing goal could be estimated in detail. At this time a program supporting reasonable confidence of success was projected in NASA's presentation to the Congress.[3]

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*An account of these phases of the program may be found in Chapter I.

This period of transition, the conclusion of phase three and the decisions concerning how to proceed into the fourth phase of final design, development, fabrication, test and operations was a crucial time in the Apollo program. By the late summer of 1963, several major developments had converged to produce conditions creating a definite program reorientation.

First, and acting as a major forcing factor in the process, the Administration's budget request for NASA had been sharply reduced by Congressional action as the space program became the subject of extensive debate. On January 17, 1963, President Kennedy transmitted his Fiscal Year 1964 budget request to Congress, including $5.712 billion for NASA.* This budget anticipated the first year of massive research and development expenditures for Apollo, reflecting the industrial manpower buildup then underway. In the authorization bill signed by the President on September 6, the total had been reduced to $5.35 billion (a compromise figure between the $5.2 initially passed by the House of Representatives and the $5.5 passed by the Senate) and even further cuts were anticipated in the appropriations cycle. By the time the final appropriations bill for Fiscal Year 1964 was signed into law by President Johnson on December 19, 1963, NASA's total had been reduced to $5.1 billion and many readjustments had already been made in the program.[4]

A second major development, concurrent with the overall agency funding crisis, was that detailed designs of most major systems were becoming available, providing more refined cost and schedule predictions. Analyses of these projections revealed that stretchout of the program to reduce contemporary funding levels would result in a significant increase in total program cost.[5]

At the same time significant agency reorganization was being accomplished and new management personnel were introduced. Effective September 3, 1963, Dr. George E. Mueller, a Vice-President of Space Technology Laboratories, became the Deputy Associate Administrator of NASA for Manned Space Flight. His arrival was followed by the announcement in October of a program reorganization and other procedural changes.[6]**

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*See Chapter II.

**See Chapter I for Mueller's selection, and Chapter VI for the total agency reorganization. One of Mueller's early recruits was Brigadier General Samuel C. Phillips, who had been in charge of the Air Force's Minuteman system program office. Phillips was named Director of the Apollo Program in October 1964, after serving as Mueller's deputy in that position since January of 1964.

From these developments, a series of decisions were taken establishing the organizational, funding, and schedule baseline for completion of the program. The central decision affecting the scheduling of hardware production and test was announced on October 30, 1963 -- adoption of "all-up" flight testing for Apollo-Saturn space vehicles. This meant that each flight of the Saturn IB and Saturn V launch vehicle systems would be scheduled with complete space vehicles, using live stages and essentially complete spacecraft. Earlier Air Force success with the Minuteman flight test program utilizing the all-up concept, four consecutive successful launches of the Saturn I first stage, and the necessity to shorten some of the lengthy procedures involved in the step-by-step test approach, all contributed to the decision.[7]

All-up flight testing promised several advantages; first, a large amount of data on all space vehicle systems could be acquired with each flight, providing early information needed for final design. Second, advantage could be taken of successful test flights. In a step-by-step flight program, where several flights of each component were scheduled before the next was added, a completely successful flight could often not be followed by a rapid step to the next, more complex, combination because the flight hardware would not yet be available. If the flight tests were planned under the all-up concept, the components would be ready to move on to the next phase of the test program. This technique put heavy emphasis on exhaustive ground testing done in sequence, one component at a time, then in combination, until complete flight systems were ground tested as a unit.

A third important advantage of this new approach to flight testing in the Apollo program was that it could shorten the schedule and reduce the projected total cost of the program. A move in this direction was made imperative by the budget reduction of $612 million for fiscal year 1964, unless the remainer of the NASA space program was to be virtually eliminated. A somewhat higher risk of failure on any specific flight, due to the inclusion of more unknowns; and a resultant reduction in the margin for error built into the program at the time of initial planning were the cost of this adjustment.[8]

The interrelated schedule decisions called for elimination of four manned flights which had been planned using Saturn I launch vehicles, halting the Saturn I program at the end of 10 unmanned flights, and moving more rapidly to the Saturn IB which would be capable of putting the entire Apollo spacecraft assembly into earth orbit. Since the Saturn IB second stage would later be utilized as the Saturn V third stage, this made possible early flight testing of all but the first two stages of the total lunar landing vehicle. This decision had the effect of postponing the first manned flight in the Apollo spacecraft for nine months beyond the schedule then in effect. Confidence that the spacecraft would be thoroughly tested and ready for flight by that time, and that when manned Apollo flights began sufficient hardware would be available to capitalize on successful missions, was increased.[9]

Another major change was made at this time in the management structure of the manned space flight program, in conjunction with the agency-wide reorganization effective November 1, 1963. By the end of 1963, some 14,000 government employees at NASA headquarters and in the three manned space flight centers were responsible for managing the efforts of approximately 200,000 people in the contractor structure. To maintain effective control of an effort of such vast scope and geographical dispersion, Apollo management structure was strengthened by establishing a discrete program office in the Headquarters Office of Manned Space Flight as well as at Manned Spacecraft Center, Marshall Space Flight Center, and the Launch Operations Center (renamed the Kennedy Space Center on November 24, 1963).

The underlying principle of the new program office organization was maximum delegation of responsibility and authority to the operating offices at the field centers. Thus the program office in Washington was responsible for total program management including performance, cost, schedule, test, and assurance of flight safety. The Apollo program office at Headquarters was organized into five functional directorates: program control, systems engineering, test, reliability and quality, and flight operations. Each of the program offices at the field centers was a duplicate of this arrangement. Through this alignment, communication was facilitated between the Apollo program director and each of his functional directors on one hand and their counterparts in the field on the other. Directives would flow through line channels, but detailed program communication channels would be through functional counterparts.[10]

Under this new organization, the specific function of the field center directors, in regard to the Apollo program, was somewhat altered. The center director was now responsible for providing the broad base of technical support necessary for executing the program offices' detailed design and contractor supervision responsibilities. To provide overall policy guidance and review program progress and performance, a Program Management Council was formed, consisting of the Associate Administrator for Manned Space Flight and the Directors of the three field centers. This group became comparable to a board of directors, responsible for ensuring that adequate resources were available for the successful conduct of the program and that policy, schedule, and performance goals were being met.

Another management addition made at this time proved to be a vital feature in direction of the Apollo program, as was its counterpart for the Gemini program. This was the NASA-Industry Apollo Executives Group, which held its first meeting on October 24, 1963. Since the activity of industry formed the bulk of the program, the success of Apollo depended heavily on the role played by corporate management. To facilitate effective communication and rapport between corporate and government management, the group comprised top executives of all major contractors in the Apollo program, the NASA Associate Administrator for Manned Space Flight, and the three field center directors. This group was scheduled to meet periodically at both contractor and NASA facilities to hear status briefings and consider major problems affecting the progress of the program.[11]

Based on these schedule determinations and management alterations, the Apollo program was realigned within a cost, schedule, and management framework which was to hold relatively constant from the time it was defined through the succeeding three years. Late in 1963, work was underway to establish the program detail for Congressional testimony in early 1964 supporting the Fiscal Year 1965 budget request. Revised schedules were presented, beginning in February, to the authorization committees of both houses of Congress; and the point of definition was in March, when specific cost estimates were provided for this program.[12]

The total Apollo program thus established called for flying 12 Saturn IB and 15 Saturn V launch vehicles, with the associated Apollo spacecraft systems, before the end of the decade to provide reasonable assurance of achieving the manned lunar landing and return. Under the all-up test concept, the first Saturn IB launch would take place in 1966 and the first manned Saturn IB would be launched in 1967. The first Saturn V launch was scheduled for later in 1967, and the first manned Saturn V flight for 1968, leading to the first manned lunar landing before the decade was out. The total cost estimate for this revised program, including Apollo research and development, construction of facilities, tracking and data acquisition, and operational costs, was established in March 1964 at $19.5 billion.[13]

Alterations made necessary in the total program had narrowed the scope of the Apollo effort, focusing it more exclusively on achieving the manned lunar landing goal. With better defined requirements and detailed design knowledge, and under pressure of budget reductions, assurance of reaching the goal had been increased. However, most of the margin, the hedge against unforeseen problems, had been removed.[14]

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

Cost and schedule estimates for the manned lunar landing program, established in March of 1964, were subject to much strain and stress for nearly three years until the end of 1966. In spite of some relatively minor alterations, however, these estimates formed the framework within which the Apollo program proceeded. These were three years during which the manufacturing, test, and launch facilities, as well as the flight hardware for the lunar mission, were brought to maturity. After a brief account of the schedule adjustments in this period, major developments will be outlined by discussing launch vehicle development, spacecraft development and test, the Manned Space Flight Network development, and astronaut selection and training.

The first schedule adjustment took place late in 1964 as part of the Administration's decision that the agency budget should be limited to the $5.25 billion level supported by the Congress in Fiscal Year 1965. The Apollo flight program was slipped so that the last two of 15 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 earlier than the last of the 15 Saturn V flights, thus still within the decade.[15]

In March, 1966 an upward revision was made in the total Apollo program cost estimate of March, 1964. Using the same criteria applied two years earlier, no follow-on program was assumed and all expenses charged to Apollo, the estimate to completion rose from $19.5 billion to a new total of $22.718 billion. This increase was attributed to the schedule stretch-out made necessary by the reduced agency funding approved by Congress in the intervening budgets. This level was somewhat more austere than NASA's 1964 assumptions, which had anticipated a build up more rapid than possible within the dollar levels actually appropriated.

A further schedule adjustment was made in late 1966, after development problems with both the Apollo spacecraft environmental control system and the second stage of the Saturn V launch vehicle. The effect of this adjustment, announced on November 17, 1966, was to cancel the second manned flight on Saturn IB, scheduled in the second quarter of 1967 as essentially a repeat of its immediate predecessor, and move that launch vehicle behind the scheduled unmanned flight to qualify the lunar module. Instead of two manned flights of the command and service modules, followed by an unmanned lunar module test, the lunar module qualification would come second; then two Saturn IB's would be launched on successive days, the first carrying a manned command and service module and the second and unmanned lunar module. Rendezvous, docking, and crew transfer would be carried out in earth orbit, checking out the lunar module for manned operations. These dual flights would continue, amassing experience in earth orbital operations with the Apollo spacecraft, until the Saturn V launch vehicle was ready for manned flight.[16]

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. Following four launches of the first stage completed in early 1963, the 10 successful launches in 10 attempts comprised an unprecedented program in large rocket development managed by the Marshall Space Flight Center under the direction of Wernher von Braun. A number of important development objectives were achieved in the course of this program. First of these was proving out the clustered engine principle of the booster stage, a technique central to the design of both the more powerful Saturn IB and Saturn V launch vehicles.

A second important objective was to develop and test the technology essential to operation of high-energy upper stages, using liquid hydrogen for fuel and liquid oxygen as oxidizer. This technology formed the basis for design of the Saturn IB second stage and the Saturn V second and third stages. A third major objective was development and test of the guidance system, improved versions of which would fly on both Saturn IB and Saturn V.

Thus Saturn I was the first step in a three-step process establishing a large space booster capability for the United States. In addition to these basic objectives, several operational missions were flown which reaped additional benefits in the total manned space flight effort. A brief summary of the final six flights of Saturn I will point up these accomplishments.[17]

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. An 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 (a dummy contruction duplicating the mass and external characteristics of the real spacecraft) into orbit, demonstrating the compatibility of the Apollo spacecraft with the launch vehicle while also testing jettison of the launch escape system as it would occur on a successful mission. The "engine-out" capability designed into the booster, and checked out in 1963 on the SA-4 flight, was demonstrated 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 these six flights had completed all Saturn I development and qualification testing in a program which had planned 10 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 were of crucial importance for the manned space flight program, defining the penetration hazard of meteoroids in the earth orbital environment. 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 unfolding of the "wings" was monitored by television 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 last two launch vehicles comprised two stages each, both built by private industry.* All previous first stages had been assembled at the Marshall Space Flight Center.

While the Saturn I flight program neared completion, development and ground test of Saturn IB and Saturn V components progressed toward flight test. The Saturn IB first stage was powered by eight H-1 engines, as was Saturn I, with each engine uprated to 200,000 pounds of thrust, making 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. During 1964, fabrication of both stages began and the preflight rating tests of the J-2 engine were completed by November. Saturn V component developments during 1964 included completion of initial designs for the three stages in May, assembly of a full scale mockup at the Michoud assembly plant in June, and overcoming problems with combustion instability to complete flight-rating tests on the F-1 engine for Saturn V's first stage. Two major achievements were reailized during the year in development of the Saturn V second stage with five J-2 engines. During September, the 33-foot diameter common bulkhead was completed and on November 9 an engine was 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,

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*First stage by Chrysler Corp. Second stage by Douglas Aircraft Co.

completed on April 13. After the second stage passed acceptance firing on August 8, both stages arrived at Cape Kennedy in September. By December they were mated with the spacecraft and the first Saturn IB was ready for launch in early 1966. 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 failed under an overload causing extensive damage to the test stand at the contractor's plant and loss of the stage. This difficulty, added to the welding and bonding problems already encountered with this stage, 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 stack, however, consisted of the first stage, a spacer in lieu of a second stage, the third stage, and the instrument unit. In May 1966 another test model of the second stage was destroyed when the liquid hydrogen tank was accidentally overpressurized with gaseous helium during a leak test at the Mississippi Test Facility. The test program was drastically rescheduled to complete necessary testing with the remaining hardware. Meanwhile, 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 inspection.

The Apollo-Saturn IB flight program got underway with three successful missions during the year. These flights accomplished their individual objectives by testing the spacecraft heatshield integrity and subsystems performance, and added confidence in the second stage of the Saturn IB, also the third stage of the Apollo-Saturn V lunar launch vehicle. The first critical test of the all-up flight test philosphy adopted in 1963, came on February 26, 1966 when the first Saturn IB and Apollo spacecraft combination was launched with all systems operating. Successful completion of this unmanned suborbital test flight was a major event in the lunar landing program. After the first stage performed according to plan the second stage ignited and burned for over seven minutes in its first flight test, placing the command and service modules into a trajectory with a 300 mile apogee. After separation from the second stage, the service module propulsion system fired twice, driving the command module back into the atmosphere at a speed producing a surface heat of 4,000°F., approximating the anticipated lunar return temperature of 4,500°F.

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 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 was demonstrated and behavior of the liquid hydrogen observed in real time through 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 heatshield was tested at high heat loads through a long, shallow reentry profile. The stage was now set for the first manned Apollo flight, scheduled for early 1967.

Apollo Spacecraft Development and Test - 1964-1966

Apollo spacecraft include the command module, service module, and lunar module. The command module is the three-man capsule in the familiar squat cone shape which serves as the passenger compartment for launch, the flight into lunar orbit, the return flight from lunar orbit, and reentry into 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. After the two astronauts, with their lunar samples, return to the command module, the lunar module will be left in orbit around the moon. The service module carries the fuel cells to generate the necessary electrical power for the spacecraft; oxygen for the life support system; and the rocket propulsion unit for velocity corrections on the way to the moon, deceleration into lunar orbit, and boost from lunar orbit for the return to earth.

During 1964, design and development of the command module progressed through freezing the design of the Block II spacecraft -- to be used in lunar missions -- to manufacture of the first orbital flight test model. Four boilerplate spacecraft were flown during the year, two on Saturn I flights into orbit from Cape Kennedy and the other two launched by Little Joe II boosters at the White Sands Test Facility. These latter flights were conducted to test the launch escape system, the tractor rocket assembly atop the command module which would pull the spacecraft out of danger if a mission were aborted during the boost phase of the flight. Little

Joe II flights at White Sands on May 13 and December 8, 1964, tested the launch escape and parachute recovery systems in two different critical phases of the planned boost flight profile and in each case, the boilerplate spacecraft was recovered without substantial damage.

Lunar module design in 1964 progressed to the stage where a full-scale metal 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 White Sands. Fuel cell design verification tests were completed and fuel cell modules were successfully tested while connected in parallel.[18]

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 at White Sands. Many engine starts, restarts, and runs with various fuel to oxidizer ratios, temperature environments, and firing lengths were conducted throughout the year in preparation for the first flight test of the command and service modules in early 1966.

In February, May, and July, 1965, boilerplate spacecraft were aboard the last three Saturn I launches which also placed Pegasus spacecraft in orbit. On May 19 a scheduled test of the launch escape system at White Sands was aborted when the Little Joe II launch vehicle failed in flight, creating an unplanned emergency test for the escape and recovery systems. They performed as designed, returning the boilerplate spacecraft safely through a parachute landing. A pad abort test of the system on June 29 preceded the last Little Joe II flight, qualifying the launch escape system on January 20, 1966.

Early in 1964 design of Block II model command and service modules was begun. The "block" technique was used to incorporate alterations necessary for docking with the lunar module and crew transfer between modules, since the intial design had been based on mission modes where no lunar module would have been used. Other design improvements and weight saving changes were also introduced at this point, making it a "block" change rather than incorporating individual changes piecemeal. By August 1965, fabrication of the first 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. Meanwhile, 1965 was a year of extensive component test for the lunar module, with test articles undergoing detailed evaluation. The descent engine development program passed a milestone on January 26, 1965, when TRW Systems Group was selected to continue development, winning over a parallel design effort conducted by the Rocketdyne Division of North

American. The engine was tested in contractor facilities during 1965, in preparation for compatibility testing at White Sands in 1966.[19]

In two suborbital flights aboard Saturn IB launch vehicles in February and August of 1966, performance of the command and service modules was tested under actual flight conditions. The heatshield 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. During 1966 the peak effort was reached in testing and qualification of the lunar module as exercise of tight weight control was necessary to keep the spacecraft below the maximum weight allowance. After the descent engine experienced excessive erosion of the ablative throat during test firings, changes in injector design were made which alleviated the problem. Injector problems also appeared in the ascent engine test program when both combustion instability and throat erosion turned up. Although these problems required further redesign and repeated test rescheduling, they were not entirely unexpected since injector design had been more of an art than a science from the beginning of liquid rocket engineering.[20]

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 has built to the requirements for supporting Apollo missions since 1961. A summary sketch of the network's development to full operational capability should provide some measure of the scope and significance of this portion of the national space program.[21]

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: (1) Cape Kennedy (formerly Cape Canaveral); (2) Grand Bahama Island; (3) Grand Turk Island; (4) Bermuda; (5) Grand Canary Island; (6) Kano, Nigeria; (7) Zanzibar; (8) Muchea, Australia; (9) Woomera, Australia; (10) Canton Island; (11) Hawaii; (12) Pt. Arguello, California; (13) Guaymas, Mexico; (14) White Sands Missile Range, New Mexico; (15) Corpus Christi, Texas; (16) Eglin Air Force Base, Florida; and two ships, (17) Rose Knot, and (18) Coastal Sentry.

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: Cape Kennedy (including the three down-range stations of the Air Force Eastern Test Range); Bermuda; Carnarvon, Australia; Canary Island; Guaymas, Mexico; Hawaii; and Corpus Christi, Texas; three secondary land stations: Canton Island; Kano, Nigeria; and Zanzibar; and two instrumentation ships: the Rose Knot and the Coastal Sentry. By the end of 1963, the primary land stations and the instrumentation ships were being modified by addition of digital command and telemetry equipment for Gemini while network modifications for support of the Apollo program were concurrently in the final planning stages.

Political events in Zanzibar forced closing of that station in January 1964 and activities provided by that station were transferred to a proposed new station at Tananarive, Malagasy Republic. During the year, modifications for support of the Gemini manned rendezvous missions were completed and the network successfully supported one unmanned Gemini mission and three Saturn I flights.

Planned augmentation of the network to support Apollo included provision of new stations collocated with Deep Space Network Stations at Goldstone, California; Madrid, Spain; and Canberra, Australia, for support of the lunar operational phases of the Apollo missions. 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. It was necessary, for Gemini, to use 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 tracking range capability from 4,000 miles to more than a million miles.

The new unified S-band system was also planned for the primary Gemini stations at Bermuda, Carnarvon, Guaymas, Hawaii, and Corpus Christi, in addition to use at Guam, Ascension Island, Antigua, and Kennedy Space Center. These stations, equipped with 30-foot parabolic antennas, would support the launch and orbital phases of Apollo missions and the early translunar phase of lunar missions until the spacecraft altitude reached the level where it could be covered by the 85-foot antenna stations.

Five instrumentation ships, equipped with systems similar to those at the land stations, were planned for use in providing coverage in areas where land stations were not feasible. These ships provided coverage of the initial portion of the translunar trajectory, the "post-injection" period, and spacecraft reentry at the end of the Apollo mission.

These Apollo changes were a major undertaking, estimated to require 3½ years to complete. Contracts were awarded by late 1964 for long lead-time items including production of the unified S-band systems, construction of the station at Ascension, and modification of five existing ships.

Beginning with the unmanned Gemini II flight on January 19, 1965, the network successfully supported all Gemini missions with no significant ground system failures. This record of successful performance was essential to the operational success of the program. The new unified S-band systems were used, during Gemini, for test evaluation purposes only. The Kano, Nigeria, and Canton Island Stations, not planned for use in Apollo, were deactivated following the last Gemini mission in November 1966. The Rose Knot and Coastal Sentry were retained to support the early, unmanned Apollo/ Saturn V Flights scheduled for 1967.

Early in 1964, a review of Apollo mission requirements established the need for an additional unified S-band station immediately down-range from Cape Kennedy to provide coverage in the event of a launch phase abort, for a station at Canary Island, and for eight jet aircraft to provide supplemental coverage of the critical translunar injection phase. Congressional approval of these projects 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 buildup for Apollo proceeded concurrently. The stations at Guam, Carnarvon, Bermuda, Merritt Island, Hawaii, Guaymas, Corpus Christi, and Ascension were completed and fully equipped by the end of 1966. In August, support of the Apollo-Saturn 202 flight, the first mission to carry the Apollo spacecraft unified S-band system, validated network operations. The first Apollo instrumented ship, the USNA Vanguard, was completed during the year and the first Apollo Range Instrumented Aircraft was delivered.

For the complex Apollo flight missions, real time operational control was to be maintained in the Mission Control Center-Houston, in contrast to Mercury and Gemini, where some control was exercised by remote site controllers due to communications limitations. That is, not enough data could be transmitted to the Mission Control Center in real time, in usable form, on which to base these critical control decisions. Planned Apollo stations did not have the requisite communications capability. 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.

In June 1965, through the National Communications System, 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 a hard core requirement upon which the corporation based its INTELSAT system. With this request for service in hand, and spurred by the early NASA need date, the corporation was able to accelerate its plans and put commercial communications satellites in service approximately two years ahead of the planned date. This has been an important aspect of the lead in practical communications satellites established by the United States in the international arena. 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. In addition, this development, underwritten by the Apollo requirement, resulted in significant reductions in the cost of all types of communication services for the Government and the public.

During 1967, the Apollo augumentation was completed and the network successfully supported the first Apollo/Saturn V mission (Apollo 4) in November. The Manned Space Flight Network now included the following stations, ships and aircraft:

Stations

- Merritt Island, Florida
- Grand Bahama Island
- Bermuda
- Antigua Island
- Ascension Island
- Grand Canary Island
- Madrid, Spain
- Carnarvon, Australia
- Canberra, Australia
- Guam
- Kauai, Hawaii
- Guaymas, Mexico
- Goldstone, California
- Corpus Christi, Texas

Ships

- USNS _Mercury_
- USNA _Redstone_
- USNS _Watertown_
- USNA _Huntsville_

Aircraft

8 Apollo Range Instrumentation Aircraft

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 and six resignations were the attrition over the nine years since the original seven Mercury astronauts were named in 1959.*

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

In the 1964-1968 period, 19 pilot-astronauts and 17 scientist-astronauts were addded to the potential flight crew complement. Recruiting for pilot-astronauts began in September 1965 and followed the established pattern of physical requirements and jet pilot experience as prerequisites to consideration. Out of 351 applications received, 159 met the basic requirements and, on April 4, 1966, 19 were chosen to enter training.[22]

The major innovation in astronaut recruiting in this period was the scientist-astronaut program initiated in 1964. In April of that year, NASA asked the National Academy of Sciences to assist in establishing criteria for scientists in medical, engineering, or scientific specialities who could be selected for flight training and astronaut duties. The Academy's Space Science Board organized a committee to develop the criteria in cooperation with NASA's Office of Space Science and Applications. On October 19 the recruiting announcement was issued, stating the broad limits within which applicants would be qualified; not more than 34 years old, a United States citizen, no taller than six feet, with a Bachelors degree and a Doctorate in the natural sciences, medicine, or engineering, or the equivalent in experience.[23]

Although a large number of responses to the announcement were received, it became clear that many of the respondents interpreted the "equivalent" experience to a doctorate in science quite liberally and only a small percentage were judged truly qualified under the criteria announced. After applications were officially closed at the end of 1964, the Space Science Board's committee met in March and considered the 410 applications which had passed initial NASA screening for age, height, and vision. Of these 410 fewer than 150 were actually considered qualified, in terms of the recruiting announcement, by the committee. In recommending the 16 outstanding candidates to NASA, the National Academy of Sciences suggested ways in which more qualified people might be attracted in the next recruiting attempt.[24]

NASA's Office of Manned Space Flight and Manned Spacecraft Center officials were responsible for the rest of the selection process, and announced on June 28, 1965 the selection of six scientist-astronauts to join the training program. Three physicists, two physicians, and one geologist thus became trainees for future voyages of exploration. Two of the six were already qualified jet pilots and the other four would begin flight training before returing to the Manned Spacecraft Center for further astronaut training. While these scientists entered as astronauts, crew performance in the Gemini program was accumulating conclusive evidence, if any were needed, that the crewman would play an indispensable role in the exploration of space as observer, investigator, and pilot.[25]

A second selection of scientist-astronauts was made on August 4, 1967, following a joint NASA-National Academy of Sciences announcement in September 1966. Under similar criteria, but with the opportunity publicized through the Academy's channels in addition to the public release, 923 applications were received, 69 nominees submitted to NASA in March by the Academy, and 11 selected in August.[26]

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 as explorers, especially on the lunar surface. Thus, both classroom and field work in geology, mineralogy, petrology, and related subjects were added to crew training in simulation devices, conditioning in centrifuges, and flight training in the lunar landing research vehicle.[27]

GEMINI DEVELOPMENT AND OPERATIONS 1964-1966

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

The basis for the Gemini program was a series of primary objectives. It 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 and accumulating the experience and knowledge necessary for trips to the moon and beyond. The accumulation of information and experience with the effects of weightlessness and physiological reaction of crew members during long duration missions would establish the medical knowledge necessary for confidence in planning missions in Apollo and later programs.[28]

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 not only for Apollo, but for many advanced missions as then conceived.

In addition, experiments were planned with astronauts leaving the spacecraft in orbit to determine their ability to perform useful tasks. This extravehicular activity was another technique projected for more 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 perfecting methods of controlled reentry and landing at pre-selected sites. This would be necessary for return from the Apollo lunar landing mission.

The Gemini spacecraft was planned to be, in many ways, a two-man orbiting laboratory by means of which knowledge of and experience in the space flight environment would be increased 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.

A most important overall objective of the Gemini program was accumulation of experience by both flight and ground crews in planning and execution of flight missions. Confidence in these abilities, based on experience, would be a vital ingredient to the more complex missions of manned space exploration. Included under this objective was expansion and refinement of the manned space flight network of tracking and communications stations, activation and exercise of the mission control center complex, and further refinement of the cooperative arrangements with the Department of Defense.[29]

Department of Defense Support

Support provided by the Department of Defense throughout the Gemini program was of such importance that it deserves specific elaboration. 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 with systems engineering and technical direction provided by the Aerospace Corporation. Atlas launch vehicles and Agena spacecraft modified to the Gemini Target Vehicle configuration were also supplied to NASA through Air Force management channels. All launch operations functions, both for the manned spacecraft and the target vehicles, were provided by the Air Force's 6555th Aerospace Test Wing at Cape Kennedy. Range support was provided by the Air Force Eastern Test Range.[30]

In addition, the existing world-wide 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 to the department. 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. Launch vehicle acquisition and launch operations, costing $200,114,100 and $235,235,000 respectively, made up the bulk of the direct dollar expense. Range operations costs ran to $42,487,800, of which $22,794,000 -- over half -- was paid by the Defense Department. The most striking example of direct support was in recovery operations where -- out of a total expense of $44,543,900 -- $32,635,800 was assumed by 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 <u>Gemini IX</u> mission to a low of 9,054 for <u>Gemini XI</u>. Recovery forces deployed 27 ships for the <u>Gemini III</u> mission, and this number was gradually reduced over the life of the flight program to 12 for <u>Gemini XII</u>.[31]

In the Apollo program NASA would procure and launch complete space vehicle systems, including both boosters and spacecraft, eliminating dependence on the Air Force for these services. However, range support and recovery operations, as well as the interconnected communications networks which evolved through the Mercury and Gemini programs, would provide an evolutionary background for cooperation during the Apollo program.

<u>Gemini Flight Program</u>

While the Gemini program would be an advancement in manned space flight in general, it had to be executed in time to support Apollo. This time constraint became very important over the research, development, and operational life of Gemini. Due to the tight time schedule, one of the program's basic ground rules involved minimizing new developments. In the case of the spacecraft, for instance, this meant using as much of the specific technology as feasible from Mercury and other aerospace programs. Thus, the basic aerodynamic shape of the Mercury capsule, enlarged to accommodate a crew of two, was retained for the reentry module. This was augmented with an adapter section at the aft end which carried most of the expendable supplies and the propulsion system for maneuvering in orbit.

Most of the major changes in design from the Mercury program were incorporated to place increased emphasis on the role of the crew, based on the confidence acquired in early manned space flights. Where Mercury was designed for completely automatic control from the ground with backup provisions for pilot control, Gemini was designed from the beginning to be controlled by the astronauts, with ground control as the backup. The most dramatic example of this change in design philosophy was that, in Mercury, an impending launch vehicle failure was automatically sensed and the escape system activated, while a launch vehicle malfunction in Gemini was displayed on the instrument panel and the astronauts made the decision to continue or abort the mission.

Another major advancement in the Gemini design was the difference in placement of subsystems and components. In the Mercury spacecraft, almost all systems had been in the pilot's cabin, where space limitations caused them to be stacked in layers. When trouble was encountered with one component, it was often necessary to remove a number of other systems to get at the problem. In Gemini many of the subsystems were outside the cabin area, making access much easier. Further, the components were designed in modular packages, arranged so that any system could be removed without disturbing others. Also, spare packages were completely checked out and kept in reserve for replacement purposes.

As with the spacecraft, new developments were minimized 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, some modifications were made to maximize crew safety and mission reliability, to "man-rate" the missile. To provide for maximum crew safety, a malfunction detection system was installed to warn the crew of an incipient failure during the launch phase. For those few catastrophic failure conditions which would be too swift for safe crew reaction, redundant systems were installed and design modified to make these failures extremely unlikely. In addition, if the launch vehicle guidance system failed, the spacecraft guidance system would automatically take over.[32]

Late in 1963, the first Gemini Launch Vehicle had begun a lengthy series of prelaunch ground tests at Cape Kennedy. It was being prepared to demonstrate a capability to place the spacecraft into orbit and validate the structural compatibility of the spacecraft and launch vehicle. As these tests were getting underway, an important milestone was reached in the rocket's development program with the November 1, 1963 flight of a Titan II ballistic missile. Of serious concern in converting the missile to the Gemini Launch Vehicle had been the "Pogo" effect, rapid up and down motions, evident in the missile flight test program. Although acceptable for the missile, NASA regarded .25g as the maximum load tolerable for manned flights, and a special modification was being flight tested to reduce this load to the "man-rated" level. On the November 1 flight, the g load remained under the acceptable level for the first time. When two subsequent missile test flights on December 12, 1963, and January 15, 1964, performed within the g load limits, confidence was established that the vehicle could achieve man-rated status.

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. No separation or recovery was planned, with the booster and spacecraft combination reentering on the sixty-fourth orbit. This successful mission paved the way for the second and last unmanned flight test, a suborbital flight planned 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 lighting strike, two hurricanes, and an engine shutdown, before it was finally launched on January 19, 1965. The successful 19-minute flight qualified the total spacecraft as an integrated system for manned flight.[33]

Beginning with Gemini III on March 23, 1965, 10 manned missions were flown in 20 months, concluding the program with Gemini XII, flown November 11-15, 1966. A useful way of summarizing the results of the Gemini manned flight program is to relate accomplishments to the six major program objectives described at the beginning of this section.[34]*

Long Duration Flight

The long duration objective was achieved with complete 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.

Medical evaluation of astronauts after these flights revealed no serious effects from their lengthy exposure to weightlessness, and a definite pattern of adaptation to weightlessness was detected on Gemini VII when blood pressure and heart rates showed a leveling trend after the first several days. The relatively small physiological changes were similar to those obtained from experiments with physical immobilization and other stresses. No Gemini pilot felt any permanent aftereffects from his space flight. This information was of great significance, since eight days is the approximate length of the first lunar landing mission planned in Apollo, while other flights -- both lunar and earth orbital -- are planned for 14 days and more.

By the end of the Gemini program, Mercury and Gemini space flights had provided approximately 2,000 man hours 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

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

psychological reactions were observed and no vestibular disturbances related to flight occurred. Although much remains to be learned, it appears that if man is properly supported, his limitations will not be a barrier to the exploration of the universe.[35]

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. After mid-course maneuvers were practiced during the Gemini V mission, the stage was set for the first attempt at rendezvous and docking between the Gemini spacecraft and the unmanned Agena target vehicle on the Gemini VI mission.

When the target vehicle failed to achieve orbit on October 25, 1965, it appeared that a long delay would ensue before another Agena target was available and the rendezvous mission flown. An alternate plan was developed to work around the schedule problems 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, maintaining the mated integrity as much as possible. The Gemini VII booster and spacecraft would then be erected and made ready for the scheduled 14-day long endurance mission as quickly as possible. While Gemini VII was in orbit, an attempt would be made to launch Gemini VI 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.[36]

After the Gemini VII launch on December 4, 1965, and an unsuccessful launch attempt of Gemini VI on December 12, Gemini VIA was successfully launched on the rendezvous mission on December 15. In addition to accomplishing of the first rendezvous, this mission also demonstrated the high degree of launch and preflight operational proficiency necessary to carry out complex missions. On the fourth orbit of Gemini VIA, command pilot Walter Schirra maneuvered to within 120 feet of Gemini VII. In the course of extensive station keeping and formation flying maneuvers, Gemini VIA 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.

Three types of rendezvous maneuvers were performed during the Gemini IXA 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 IXA was simulation of the rendezvous between a lunar module and a command and service module in lunar orbit. The maneuver successfully performed by Gemini IXA 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 to within 50,000 feet of the moon.

The third portion of the rendezvous and docking objective, maneuvering while docked through 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 Agena vehicle remaining in orbit since the Gemini VIII mission four months earlier. Terminal rendezvous of Gemini X with Agena VIII was successfully accomplished after the Gemini spacecraft had separated from Agena X.

Gemini XI (September 12-15, 1966) completed a rendezvous with the target vehicle during its first revolution, using onboard computer information exclusively. This rendezvous was most efficient in terms of time, looking to future applications where speed 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 will find later application on missions where maximum fuel efficiency is required.

During the Gemini XI mission, docking was practiced twice by each crewman. The docked 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 during 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 in using this technique for future manned space flight missions.[37]

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, White stayed outside the spacecraft for 23 minutes, maneuvering himself about, taking pictures, and making observations of equipment. During the early portion of the maneuver, 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. Additional life support was provided by a chest pack which maintained his suit pressure and contained an emergency supply of oxygen. White wore a special protective suit and a protective helmet visor for the mission.

An expanded extravehicular mission was included in the Gemini IXA flight (June 3-6, 1966), during which Eugene Cernan worked outside the spacecraft for over two hours. A more ambitious demonstration of extravehicular mobility, using an Astronaut Maneuvering Unit, was canceled 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 left in orbit after the Gemini VIII mission, he left the cabin and maneuvered in space for 55 minutes with a hand-held maneuvering unit. Using a 50-foot tether and umbilical, Collins maneuvered to the Agena and retrieved a micrometeoroid collection experiment.

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 and 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 for this mission to evaluate them as devices to reduce the workload. 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.[38]

Reentry Control

On each Gemini flight, control of the landing point was obtained by using the aerodynamic lift of the spacecraft as it reentered the atmosphere. An onboard computer stored the necessary guidance equations and position information and the crew controlled the trajectory, guiding the spacecraft toward a preselected target. In missions Gemini III through X, this procedure was controlled by the crew; while on Gemini XI and XII, an automatic system actually fired the attitude control system thrusters in response to guidance system commands. Average navigation accuracy of the guidance system for all flights was 2.2 nautical miles. The most accurate touchdown was made by Gemini IXA, less than half a mile from the aiming point, and the last five missions all landed within 3½ miles of the aiming point.[39]

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 experiment flights. Of these, 90 returned useful information to the experimenter. The 52 experiments ranged from specific physiological measurement of the crew and precise measurement of the space environment to technological developments proving out new equipment and techniques for space flight.

Of the 52 experiments flown in the Gemini program, 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.

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

The eight medical experiments, each conducted a number of times, identified more subtle effects than could be determined from the operational medical measurements in preflight and postflight examinations. Gemini experiments were proposed from many sources including universities, laboratories, hospitals, industry, and various government agencies. Several investigators were often associated with a single experiment and they, in turn, may have had different affiliations.

To select one example of investigation results, the experiment called synoptic terrain photography, devoted to a study of the earth's terrain, was performed successfully on Gemini IV, V, VI, VII, IX, X, XI and XII missions. Approximately 1,400 color photographs were obtained for this purpose and were useable for geology, geography, oceanography, hydrology, agrology and agronomy. One photograph of the Near East taken on Gemini XII, for example, 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. The photograph may provide new evidence on this possibility through a synoptic view of the regional geology.

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 as additional data to assist in interpreting results obtained from unmanned meteorological satellites.[40]

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 worldwide 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 will be augmented further 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 complex data in real-time. A new control facility was established to support not only the Gemini program, but further 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 worldwide communications, tracking, and telemetry network. This network of stations had proved its operational capability through the Mercury flights but, for the more complex missions of Gemini, required major modification to all its systems. The network had 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. A primary consideration in design was reliability, because the ground systems operated continuously during long duration flights. Carefully coordinated planning was done in building up to support Gemini, so all the changes made 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 mission. As the flights progressed, a nucleus of qualified control personnel was developed, and increased confidence in the ability to plan and conduct ever more complex space flight missions was established.

Development of experienced teams of mission planners proved extremely useful in preparing for future manned missions. Techniques evolved during Gemini have resulted in flight plans providing the maximum probability of 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. Procedures developed for Gemini are applicable to future programs, and the people who devised and implemented them have applied their experience to Apollo flight 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 from physical conditioning to the most complicated integrated mission simulation. High fidelity mission simulators to represent the spacecraft and work with the ground control network and flight controllers proved very useful in training both flight and ground crews as a functional team, capable of dealing with problems as they arose while achieving a large percentage of planned mission objectives. The accumulated total of 1,940 man-hours of spaceflight time distributed among 16 astronauts, qualified Gemini pilots for long duration flights and complex rendezvous operations.[41]

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 increasingly defined in more elaborate 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 government-industry team produced a phenomenon rather unique for an advanced research and development program -- a schedule which had slipped forward rather than backward. That is, Gemini XII flew in November 1966 rather than early 1967, completing the program at least two months earlier than anticipated three years earlier when the revised schedule was presented to Congress. 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.[42]

TOWARD THE MANNED LUNAR LANDING 1967-1968

At the beginning of 1967 the Gemini program had been successfully completed and, after a series of delays caused principally by spacecraft environmental control unit failures during vacuum chamber tests at the Kennedy Space Center, the first manned Apollo flight aboard Saturn IB number 204 was about ready for launch. Three flights of the launch vehicle in 1966, two of them carrying Apollo spacecraft, had qualified the entire space vehicle for manned flight.[43]

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. Grissom, 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.[44]

Within a month, the basic facts were established and substantial corrective actions were already underway. Although the precise source of ignition was never determined beyond doubt, a fire had started within the spacecraft, spread rapidly through the sealed and pressurized 100 per cent oxygen atmosphere, burned through the space suits allowing toxic gases into the breathing atmosphere of the crew, and ruptured the spacecraft itself as the pressure increased. Because the danger of fire in an oxygen atmosphere was well known, safety considerations in design had always emphasized eliminating possible ignition sources and limiting the combustible material inside the spacecraft. For this ground test, which was considered routine and technically "non-hazardous", material not flight rated was present in the spacecraft. A nylon net to catch objects inadvertently dropped during the test and a foam cushion on which to rest the inner hatch during crew exit practice, for example, would not have been present in a spacecraft ready for launch. These materials, highly combustible in the pressurized oxygen atmosphere, conveyed the fire rapidly across the spacecraft when the shell was ruptured by rising pressure.

The hatch, designed to provide maximum safety during translunar flight and high speed reentry into the atmosphere, had to be opened inward; that was impossible against the high pressure created by the fire inside the spacecraft. Safety precautions on the launch pad had been focused on the danger of a large fueled rocket; since this test was atop an unfueled booster, it was considered not especially hazardous.[45]

NASA officials reported at a Senate hearing on February 27, 1967, on efforts already underway to follow the investigating board's preliminary recommendations: to identify and eliminate or reduce all flammable materials inside the spacecraft as designed; to design a new hatch, which could be rapidly opened for ground emergencies; to change all emergency and safety procedures throughout the Apollo program to recognize the extreme danger of spacecraft fire; and to study the possibility of using other than a pure oxygen atmosphere while the spacecraft was on the pad.[46]

These were the major specific corrective actions taken to recover from the impact of the accident and provide reasonable assurance that the Apollo program could move forward safely.[47] To redesign, test, and fully qualify all of these changes took many months and had the practical effect of delaying the first manned Apollo launch for at least 18 months. The impact in cost and schedule changes will be discussed briefly, and the reoriented program described. It seems premature to presume the perspective necessary to evaluate the larger impact of the Apollo 204 accident in terms of the effect on the morale and confidence of the entire NASA organization, relationship between government manager and industrial contractor program organizations, and particularly relations between Congress and NASA. The future historian will want to look carefully at these effects; they have been far-reaching and persistent and appear to have been somewhat out of proportion to their proximate cause.

The Apollo 204 Review Board reported on April 9, 1967, and a series of hearings on the accident began the next day with the Oversight Subcommittee of the House Committee on Science and Astronautics and continued in both houses until mid-June. On May 9, 1967, NASA's top Apollo program officials appeared before the Senate space committee and presented the revised planning. This called for a manned flight of the Apollo spacecraft, with all the design changes incorporated and qualified, 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, reducing the manned Saturn IB flights to a total of one. 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 11 Saturn V flights before the end of 1969, slipping two more -- now a total of four -- into 1970.

In discussing this plan, Dr. Robert C. Seamans, Jr., NASA's Deputy Administrator, judged that the impact of the accident on the goal of lunar landing before 1970 had been to "reduce that probability, not eliminate it." The immediate costs resulting from the accident, because of the slip in the launch schedule, were estimated to require no supplemental appropriation if the Fiscal Year 1968 budget request were fully supported. Run out costs of the Apollo program, of course, would increase with the slip in the schedule. These were now estimated at $23.190 billion for the 12 Saturn IB and 15 Saturn V flight program, assuming no absorption of costs by a follow-on program, an increase of $472 million from the previous year's estimate.[48]

By the time of the authorization hearings for the Fiscal Year 1969 budget, held in February 1968, the flight schedule planning had been adjusted to the funding levels established in 1968 and anticipated for 1969, and to allow for a delay in spacecraft delivery. It was now possible to make more accurate estimates in regard to costs and anticipated flight dates in the Apollo program. 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 $23.896 billion. This is where the program stood in mid 1968.[49]

While reprogramming and recovery from the impact of the Apollo 204 accident proceeded, the Apollo program moved forward in the 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. 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 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 heatshield at lunar reentry speed. In this first test of the launch vehicle with all stages and all systems operating, the performance was virtually flawless, establishing a significant landmark for the Apollo program.[50]

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 and both the ascent and descent engines fired to demonstrate several critical phases of the lunar mission, particularly the ignition of the ascent engine while the two sections of the vehicle were attached -- the so-called "fire in the hole" maneuver. The lunar module was the last major piece of Apollo hardware to be flight tested; with this successful mission, all were now qualified.[51]

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 its mission, 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 orbit, but the third stage engine would not reignite to simulate the translunar boost from orbit. 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. Post-flight analysis revealed not only that oxidizer lines in the engines of both second and third stages had failed, causing the engine problems, but that a "pogo" effect had appeared during the first stage burn, transmitting unacceptable g loads to the spacecraft portion of the vehicle. Swift and thorough detective work isolated the causes of the failures and identified adequately tested fixes so that high confidence had been attained, by mid-1968, that the next Saturn V flight could be manned.[52]

In the area of manned space flight facilities, by 1968 Launch Complex 39, the Saturn V launch complex 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 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 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.[53]

POST-APOLLO MANNED SPACE FLIGHT 1965-1968

Progressively detailed studies, conducted within NASA and under contract for NASA, had -- over a period of several years -- produced the detailed 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."*[54]

The dilemma involved in this problem, at the highest levels of decision making, was soon apparent. If a specific advanced mission were proposed to focus development effort and it gained approval, it was possible that a situation comparable to the initial Apollo program approval would be created and a new cycle of effort begun. It was consideration of the other side of the coin, however, which created the dilemma. Rejection of such a proposed advanced mission could mean disapproval of related effort and a dead end as far as future ambitious research, development, and operational programs were concerned.

Out of this situation, and under pressure from both the White House and the Congress to propose specific advanced missions, grew the post-Apollo manned space flight proposals eventually known as the Apollo Applications Program. A brief summary of that program as it evolved from its introduction in 1965 is the subject of this section.

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

Planning for future manned space flight was first spelled out in the report of NASA's Future Programs Task Group, formed to identify future missions in response to President Johnson's January 1964 request. This February 1965 report dealt with all areas of NASA's responsibility, aeronautics and unmanned spaceflight as well as manned spaceflight. 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 spacecraft provided, the report envisioned a broad spectrum of missions and identified the necessary changes to Apollo hardware which would make these Apollo extensions possible.[55]

Seen as an interim program for the immediate post-Apollo period, this recommendation was appropriately dubbed "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 capability of the Apollo spacecraft, principally 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 fund some very long lead-time components.[56]

By the late summer of 1965, planning for application of the Apollo capability to future manned missions had advanced to 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 Science at Woods Hole devoted a portion of its time to defining the role of manned spaceflight 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 spaceflight.

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.[57]

During the Fiscal Year 1967 authorization hearings, NASA presented more details of the planning and program definition process including possible flight schedules beginning in mid-1968. 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 an extended hiatus in manned spaceflight operations. In the broad context, this procedure was viewed as holding open the option to proceed with further programs beyond Apollo. Early in 1966 it was 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 mothballs, if a decision to proceed were not reached soon.[58]

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 $3.15.5 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, in other words, and in many ways related to the problems created by the 204 fire, the Apollo Applications Program was reduced from a $626.7 million proposal to a $253.2 million program.[59]

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 congressional actions on the Fiscal Year 1969 budget. In summary, NASA proposed to the Bureau of the Budget a program for the two years totalling $1,876.4 million and, through submission of the President's fiscal 1969 budget, the total emerged at just over 1/3 of that amount, $692.8 million.[60]

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 early 1968 this had been reduced to two Saturn IB and two Saturn V launch vehicles using refurbished command and service modules.

The flight of the initial Saturn I workshop, providing an emptied second stage for use as an earth orbital laboratory docked with an Apollo command module, was delayed from 1968 to 1970. Launch of the Apollo Telescope Mount, to provide a manned telescope outside the earth's atmosphere for extensive study of the sun, was deferred from 1969 to 1971. Plans for an early mission to carry experiments concerned with earth resources, a Saturn I workshop in earth orbit with revisit and reuse flights, and a second Apollo Telescope Mount were cancelled.[61]

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:[62]

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

EPILOGUE, APOLLO MANNED FLIGHTS BEGIN

On October 11, 1968 the first manned flight of the Apollo program was launched. Apollo 7, commanded by Walter M. Schirra, Jr., with Donn F. Eisele as command module pilot and Walter Cunningham as lunar module pilot, was launched successfully into earth orbit for the shake down cruise of the three-man spacecraft. This orbital flight was a prelude to successively more complex missions leading to the manned lunar landing.

NOTES TO CHAPTER III

1. Astronautics and Aeronautics, 1965, Chronology on Science, Technology, and Policy, NASA, Washington, D.C. (hereafter, these annual volumes are cited as A&A 1965, etc.), Appendix C; and A&A 1966, Appendix C. For more detail on manned space flight activity prior to 1963 see Chapter I. A detailed account of the Mercury program is found in L.S. Swenson, James M. Grimwood, and C.C. Alexander, This New Ocean: A History of Project Mercury, Washington, NASA SP-4201, 1966 and the earlier James M. Grimwood, Project Mercury, A Chronology, Washington, NASA SP-4001, 1963.

2. A&A 1966, Appendix C.

3. NASA-Apollo Program Management, Vol. I, December 1967, prepared by Apollo Program Office, NASA, Washington, D.C., pp. B-5 through 8. See Chapter I for early Apollo activity through 1963. Histories of the major portions of the Apollo program are underway as part of the NASA Historical Program. Spacecraft research and development and astronaut training are the subjects of monographs being done at the Manned Spacecraft Center, the Saturn launch vehicle research and development programs at the Marshall Space Flight Center, and the concept, design, and construction of the launch facilities at the Kennedy Space Center. The first publication of this effort will be I.D. Ertel and M.L. Morse, The Apollo Spacecraft: A Chronology, Vol. I, through November 1962, Washington, NASA SP-4009.

4. A&A 1963, pp. 14-15, 334, 474, 487. See Chapter II for details of the Fiscal Year 1964 congressional debate.

5. House Science and Astronautics Committee Fiscal Year 1965 NASA Authorization Hearings (hereafter cited House FY 1965 Authorization, etc.) Part 2, pp. 486-489; Senate Aeronautical and Space Sciences Committee Fiscal Year 1965 NASA Authorization Hearings (hereafter cited Senate FY 1965 Authorization, etc.) Part 2, pp. 529-538; NASA Tenth Semiannual Report to Congress (hereafter cited as NASA Tenth Semiannual Report, etc.), NASA, Washington, D.C. pp. 38-40.

6. A&A 1963, pp. 281, 381; Robert R. Rosholt, An Administrative History of NASA, 1958-1963, Washington, NASA SP-4101, 1966, pp. 289, 297.

7. NASA Tenth Semiannual Report, p. 55; House FY 1965 Authorization, Part 2, p. 430; Interview, George E. Mueller by W.D. Putnam and I.D. Ertel, June 27, 1967, NASA Historical Archives; NASA Release 63-226. The decision to adopt the all-up flight testing procedures is one of several NASA management decisions being studied by Paul P. Van Riper, Professor of Administration, Cornell University with the cooperation and assistance of NASA.

8. Senate FY 1965 Authorization, Part 2, p. 282; NASA-Apollo Program Management, Vol. I, December 1967, p. B-7.

9. NASA Release 63-226; NASA Tenth Semiannual Report, p. 55.

10. House FY 1965 Authorization, Part 2, pp. 406-408; Minutes, Special OMSF Staff Meeting of October 24, 1963, dated October 30, 1963.

11. NASA Tenth Semiannual Report, pp. 43-44; House FY 1965 Authorization, Part 2, p. 408; Senate FY 1965 Authorization, Part 2, pp. 517-518; interview, George E. Mueller by W.D. Putnam, October 4, 1966, in NASA Historical Archives.

12. Senate FY 1965 Authorization, Part 2, pp. 300-302, 470; House FY 1965 Authorization, Part 2, p. 373. The specific cost estimates were provided in response to a request by Senator Margaret Chase Smith (R-Me.) which was to be repeated at yearly intervals in the years to come.

13. Senate FY 1965 Authorization, Part 2, pp. 300-302; NASA-Apollo Program Management, Vol. I, December 1967, pp. B-7, 8.

14. Senate FY 1965 Authorization, Part 2, pp. 281-282.

15. 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.

16. Senate FY 1965 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.

17. 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.

18. 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 Semiannual Report, p. 37; NASA Twelfth Semiannual Report, pp. 31-33.

19. 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.

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

21. 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 testimony. 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 world-wide 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.

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

23. NASA Release 64-248.

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

25. NASA Release 65-212; see the following section of this chapter for the astronauts' accomplishemnts in the Gemini program.

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

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

28. 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.

29. See Introduction by George E. Mueller in Gemini Summary Conference, NASA SP-138, February 1967, pp. 1-3; House FY 1968 Authorization, Part 2, pp. 2-37.

30. 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.

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

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

33. 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.

34. This summary is based on the account in House FY 1968 Authorization, Part 2, pp. 2-37, elaborated by details from the Gemini Chronology.

35. Gemini Summary Conference, p. 197.

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

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

38. 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.

39. See Gemini Summary Conference, p. 159.

40. 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 Photographs from Gemini VI through XII, 1968; and SP-168, Exploring Space With a Camera, 1968.

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

42. House FY 1965 Authorization; House FY 1968 Authorization.

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

44. 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, 1967 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.

45. Senate Apollo Accident Hearings, Part 2, February 27, 1967, pp. 71-74.

46. Ibid., p. 74 and following.

47. Specific program actions are not discussed extensively here. They are reported in great detail in a two-volume report: Status of Actions Taken on the Apollo 204 Review Board Report, printed as Senate Apollo Accident Hearings, Part 8, in January 1968.

48. Senate Apollo Accident Hearings, Part 6, May 9, 1967, pp. 492-493, 487.

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

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

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

52. Apollo 6 Post Mission Operations Report.

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

54. Letter, President Johnson to Webb, January 30, 1964. 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 authoriation 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.

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

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

57. 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.

58. House FY 1967 Authorization, Part 2, pp. 1195-1205, pp. 163-184.

59. 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.

60. House FY 1969 Authorization, Part 2, pp. 206-207.

61. Ibid.

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