Document II-1

Document Title: NASA, " Minutes of Meeting of Research Steering Committee on Manned Space Flight," 25–26 May 1959.

Source: Folder 18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

Within less than a year after its creation, NASA began looking at follow-on programs to Project Mercury, the initial human spaceflight effort. A Research Steering Committee on Manned Space Flight was created in spring 1959; it consisted of top-level representatives of all of the NASA field centers and NASA Headquarters. Harry J. Goett from Ames, but soon to be head of the newly created Goddard Space Flight Center, was named chair of the committee. The first meeting of the committee took place on 25 and 26 May 1959, in Washington. Those in attendance provided an overview of research and thinking related to human spaceflight at various NASA centers, the Jet Propulsion Laboratory (JPL), and the High Speed Flight Station (HSFS) at Edwards Air Force Base. George Low, then in charge of human spaceflight at NASA Headquarters, argued for making a lunar landing NASA's long-term goal. He was backed up by engineer and designer Maxime Faget of the Space Task Group of the Langley Research Center and Bruce Lundin of the Lewis Research Center. After further discussion at its June meeting, the Committee agreed on the lunar landing objective, and by the end of the year a lunar landing was incorporated into NASA's 10-year plan as the long-range objective of the agency's human spaceflight program.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
1520 H STREET NORTHWEST
Washington 25, D.C.

Minutes of Meeting of
RESEARCH STEERING COMMITTEE
ON MANNED SPACE FLIGHT

NASA Headquarters Office
Washington, D.C.

May 25-26, 1959

Present:

Mr. Harry J. Goett, Chairman
Mr. M. B. Ames, Jr. (part time)
Mr. De E. Beeler
Dr. A. J. Eggers
Mr. M. A. Faget
Mr. Laurance K. Loftin, Jr.
Mr. George M. Low

Mr. Bruce T. Lundin
Mr. Harris M. Schurmeier
Mr. Ralph W. May, Jr., Secretary

Observers:
Mr. John Disher
Mr. Robert Crane
Mr. Warren North
Mr. Milton Rosen (part time)
Mr. Kurt Strass

COMMITTEE PURPOSE

The Directors of the Offices of Aeronautical and Space Research and Space Flight Development had planned to attend the beginning of this first meeting to express their interests in and objectives for the Committee. As circumstances prevented their attendance, the Chairman disclosed his interpretation of their views. He reaffirmed that the Committee was formed by the Office of Aeronautical and Space Research and reports to that office. The office desires that the Committee take a reasonably long term look at man-in-space problems leading eventually to recommendations as to what [2] future mission steps should be and to recommendations concerning broad aspects of Research Center (including JPL and HSFS) research programs to assure that they are providing proper information. It is hoped that the Centers will assist the Committee by making general studies for it as deemed necessary and that there will be a healthy relationship between the Centers and Committee with mutual support. Although the Committee needs to do long range thinking about space flight missions and concepts, it should be set significantly beyond Mercury and Dyna Soar. The Chairman further explained, that although the Office of Space Flight Development had no cognizance over the Committee, the director has expressed hopes that the Committee in an interim sort of way could make some recommendations by September 1959 regarding what type of approach Space Flight Development should take in using Fiscal Year 1961 budget money earmarked for Project Mercury follow-up.

Following these statements there was some discussion of our relationship to other committees, in particular the ARPA Man in Space Committee, the ARPA MRS-V Committee and the NASA Long Range Objectives and Program Planning Committees. The first committee was set up for ARPA-NASA relations on Project Mercury and apparently is being disbanded. The MRS-V Committee has just formed, has NASA representation (George Low), and concerns an ARPA manned recoverable satellite vehicle project that has no firm status as yet. The latter committee composed of Dr. Hagen and Messrs. Ames and Clement is concerned with arriving at a general ten year NASA research and development program for Dr. Glennan's use with the Space Council in connection with the 1961 budget.

Each member then gave this views about how this Committee should operate. There was unanimous feeling that we should not be influenced by other committees or groups. NASA is concerned with the national space program so this committee should do long range objective planning, decide what supporting research and to some extent what vehicle recommendations are appropriate, and then take aggressive steps to assure that the work is implemented with proper orientation and coordination among all NASA Research Centers including JPL and HSFS. Certain space flight objectives have to be decided upon early to work toward. The Committee should not get bogged down with justifying the need for man in space in each of the steps but out-rightly assume that he is needed inasmuch as the ultimate objective of space exploration is manned travel to and from other planets. It is felt that the Committee can help put [3] more objectiveness in NASA space research by stressing overall jobs to be done and concepts to be explored. Past experience as with the X-15 and Mercury has shown that research geared to definite objectives is mutually beneficial to both research planning and project development. On the other hand a point was made that the Committee has to assure that NASA research retains enough diversity to avoid overlooking important new ideas. It is questionable, however, as to whether the NASA will be able to develop space research to the degree of systematic coverage that the NACA was able to do previously for example in the case of the aerodynamics of aircraft wing and body configurations.

National Booster Program

Mr. Rosen reviewed the national booster program as presently conceived including Scout, Delta, Vega, Centaur, Saturn (formerly Juno IV) and Nova. This information is largely available in a brochure on the booster program distributed to all NASA centers and is not repeated here. A tabulated synopsis is appended however. [not included] This information is still fairly current except it now appears that the Saturn payload capabilities may be as much as 50 percent higher. The Nova vehicle depends strongly on hydrogen and its design is still very fluid. Lewis is working reasonably on this project and Mr. Lu[n]din agreed to supply reasonably detailed information on it for distrubution [*sic*] to committee members.

NASA has invited proposals to develop a system to recover the two rocket engines and associated vehicle tail section that is normally ejected from Atlas. The proposals are to be for eight Atlas' if the overall operation is shown to be at a net saving to the Government. The Committee asked for copies of the proposal invitation. Subsequent to the meeting Mr. Rosen has indicated that the contract document is not in a form suitable for distribution and probably would not be of any interest to the members since no specifications are made, Space Flight Development will be glad to make them available to the Committee.

Mr. Crane reviewed the stringent booster requirements of Dyna Soar to assure that the vehicle will not exceed critical load and temperature limits throughout the flight range. This restricts the vehicle to a rather limited altitude-velocity corridor. To accomplish this any of the [4] boosters in the present booster program would have to be modified to a major degree. A 4-barrel modified Titan first stage booster has been proposed by one of the contractors. The Committee asked to be kept informed of the Dyna Soar booster developments.

Dyna Soar

Mr. Ames briefly reviewed the history of Dyna Soar up to its present status of source selection between two contractors – Boeing and Martin-Bell. He also discussed some of the philosophy of why it is considered as a hypersonic research vehicle for exploring the flight corridor at speeds up to orbital and some of the design features.

Some concern was voiced that the Dyna Soar concept utilizes the radiation cooling principle to the limit of existing technology without leaving much room for growth. Thus some members felt that Dyna Soar did not fit in the NASA space exploration mission. Other members, however, recognized the need for continuing to look at vehicle conrecognized [*sic*] the need for continuing to look at vehicle concepts with orbital flight and conventional landing capabilities; Dyna Soar does fit into this picture and also permits exploration of winged vehicles at speeds up to orbital.

Project Mercury

Mr. Faget discussed in considerable detail the Project Mercury concept, its operational and design features, the test and build up development programs, its status and planned schedule. The material he discussed is largely summarized in a document prepared by the Langley Space Task Group entitled "Project Mercury Discussion" dated May 18, 1959, which was distributed to most Committee members. A movie was also shown dealing with the Mercury capsule fabrication, mockup, escape rocket system and orientation control system. Project Mercury has pointed up the need for general research on large parachutes.

PROGRAM REVIEWS BY COMMITTEE MEMBERS

Mr. Loftin: - Sixty percent of Langley's effort is currently related to space and reentry flight broken down approximately as follows:

Satellites and spacecraft 24% (Including 7% on Project Mercury)

Ballistic Missiles 10%

[5]

Anti-Ballistic Missiles 6%

Boost-glide winged reentry 20%

A substantial amount of Langley's work is on new flight concepts and is across the board involving investigations of overall aerodynamic characteristics, stability and control, heat transfer, structural aspects, systems analysis, pilot integration and so forth. Examples of these are work on (1) winged reentry at 90% angle of attack of a vehicle type having folding wing tips and a landing L/D of 8 to 10, (2) a kite type concept utilizing folding high temperature metal cloth between structural members, (3) inflatable wing concepts so that wings can be folded for take-off, and (4) a half pyramid configuration with possible aerodynamic heating advantages but a large base area resulting in low L/D.

Langley's more general research on spacecraft may be categorized along the general lines of –

(1) Aerodnamics [*sic*] and Gas Dynamics: - Examples – Heat transfer, general aerodynamic characteristics, boundary-layer transition, static and dynamic stability investigations.

(2) Structures: - Examples – Investigation of structural design concepts such as radiation cooling, forced cooling, ablation, heat sinks, sandwich construction, environmental effects and aeroelastic characteristics. (The Committee asked for a detailed elaboration of this at the next meeting.)

(3) Materials: - Examples – Studies of emissivity, ablating materials, refractory materials, oxidation and evaporation in high vacuums.

(4) Dynamic Loads: - Examples – Noise, vibration, flutter, fuel sloshing, gust loads and landing loads.

(5) Trajectories, guidance and control: - Examples – Trajectory calculations, static and dynamic computations of manned reentry, flight simulation studies, reaction control investigations, use of ground flight control center, and investigation of such things as solar auxiliary power, horizon scanners, flywheel inertial devices and the like.

[6]

(6) Space Flight: - Langley has a lunar committee that is considering a conceptual approach to a small lunar orbital vehicle that would be of interest to manned space flight. Mr. Loftin felt that we are reaching the point where reentry research is being overemphasized in comparison to research on actual space flight. In true space flight man and the vehicle are going to be subjected to space environment for extended periods of time and there will undoubtedly be space rendezvous requirements. All these aspects need extensive study and Mr. Loftin felt the best means would be with a true orbiting space laboratory that is manned and that can have crew and equipment changes. Langley is starting to look at this step.

Mr. Eggers: - Mr. Eggers reviewed a write-up he had prepared for the meeting summarizing research being conducted at Ames applicable to problems associated with manned space flight. Since copies were distributed to the membership, no reference is made to its content in the minutes.

In addition, Mr. Eggers discussed some preliminary long range research program thinking at Ames geared toward a space flight objective. It is difficult to evolve a good research program without some flight objectives in mind. Man's capabilities for space flight are not known and firsthand experience is needed through use of a broad based vehicle concept that is flexible in operation. With this in mind Ames set down some ground rules for thinking about a space flight mission to work toward, namely – (1) For the time being the planning should be for a concept that can be achieved within 5 to 10 years, (2) the space flight concept should be realistic in terms of money and manpower and (3) the flight concept should be one in which there would be a strong interplay between laboratory research and vehicle development. This has led to Ames' present thinking that the next step NASA manned space flight vehicle should have the following performance objectives: (1) two man occupancy, (2) escape speed capability, (3) lunar orbit capability, and (4) a minimum flight duration of one week. Ames' preliminary estimate is that the minimum weight of such a vehicle would be about 6000 pounds. Saturn could probably boost it. Ablation shielding should be able to handle the hearing satisfactorily. The vehicle should be capable of diversified space research on many problems including investigation of space and atmosphere maneuvering, pilot competence and capabilities, space science experiments, telescopic observations, lunar observations and so forth where man would be a vital link in the operation or experiment. [7]

Mr. Lundin: - Mr. Lundin also had a prepared writeup distributed to the membership which discussed Lewis' research in the categories of (1) trajectory studies, (2) mission analyses, (3) storage of cyrogenics in space, (4) power production, (5) shielding, (6) electronic propulsion, (7) supersonic parachutes and stabilizing devices, (8) jet blast and noise at launch site, (9) control, navigation and guidance, and (10) manned space capsule orientation control. The material in this write-up is not reiterated in the minutes. Lewis research now leans heavily toward rockets of various types and high energy propellants. Lewis is working mostly on applications of the type being considered for the top stages in present national booster program. There is a significant amount of work going into pumps and hydrogen-oxygen auxiliary power systems also.

In conclusion Mr. Lundin expressed his views that the Committee should not concern itself much with flight vehicle concepts well along the way such as Mercury or Dyna Soar but rather should look to longer range objectives. He felt strongly that although the Committee must consider interim space flight programs, we should not set our sights too low for the present long objective. The ultimate objective is manned interplanetary travel and our present goal should be for a manned lunar landing and return as with Nova. If we limit our present objective to manned reconnaissance, we may seriously impair the country's ultimate space flight objective. He mentioned that the Air Force already has a manned lunar landing mission under study under SR-183.

Mr. Beeler: - Mr. Beeler likewise reviewed some prepared circulated material on HSFS research pertinent to space vehicles in the categories of (1) reaction controls, (2) terminal guidance and landing problems, (3) exit and entry research, (4) crew factors, (5) air launch studies, (6) astronomical platform, and (7) space flight.

He listed some major space flight and research objectives that the NASA could work toward as follows:

Space flight objectives	Research areas
Man in space soonest (on way with Mercury)	Maneuvering entry
Lunar reconnaissance	Orbiting laboratory
Lunar landing and return	Rendezvous

[8]

Mars-Venus reconnaissance

Mars-Venus landing and return

HSFS feels that manned lunar reconnaissance is a good goal to work toward and has in mind a vehicle with the same general performance objectives as mentioned by Mr. Eggers.

Mr. Schurmeier: - Mr. Schurmeier in discussing JPL's work on Vega gave the following performance fingers which are somewhat lower than mentioned by Mr. Rosen earlier:

Attitude-circular orbit	Payload
3000 miles	1300 lbs.
1000 miles	3500 lbs.
300 miles	5000 lbs.
100 miles	5700 lbs.

Of the eight vehicles ordered, the first four are primarily for vehicle development with payload interests secondary.

The general type of payloads and approximate firing schedules are, however, as follows:

Vehicle Number	Launch Date	Payload
1	August 1960	Lunar probe
2	October 1960	Mars probe
3	January 1961	Venus probe
4	March 1961	Earth satellite
5	May 1961	Earth satellite
6	July 1961	Space mission
7	September 1961	Earth satellite
8	November 1961	Space mission

Firing pad availability at Canaveral restricts launchings to one every other month. Because of this and the necessary vehicle development required for manned flight reliability, Vega will probably not be available for manned missions before 1962.

JPL is doing a substantial amount of research on mission studies. A report on this work has recently been published which Mr. Schurmeier agreed to send copies of to the Secretary for distribution to all members. JPL considers its primary mission to be that of deep space exploration. At present it is concentrating on unmanned flight concepts although the ultimate objective is [9] manned interplanetary travel to explore life on other planets.

The last item Mr. Schurmeier covered was JPL's general research related to man in space. In particular he mentioned JPL's work in control, guidance, navigation, tracking, communications, solid propellant rockets, storable liquid propellent [*sic*] rockets, fundamental physics, nuclear propulsion and auxiliary power. JPL every two months put out a document summarizing its fundamental research programs and another summarizing its vehicle development programs. Mr. Schurmeier stressed the need for a coordinated national program in the general areas of guidance and tracking much along the lines of the present national booster program.

Mr. Faget: - Mr. Faget endorsed selecting lunar exploration as the present goal of the Committee although the end objective should be manned interplanetary travel. Space rendezvous will very likely be desirable in such operations and equatorial orbits certainly have attractive features. This places the space vehicles in the radiation belt, however, and aggressive research is needed to learn more about the radiation belt, its effects on living beings, anti-radiation medicines and shielding.

The Langley Space Task Group has done some preliminary thinking about Project Mercury follow-ups. Mr. Strauss described three ideas. The first is an enlarged Mercury type capsule (7.5 ft. diameter and 10.6 ft. long) weighing 3550 pounds to put two men in orbit for three days. The second would involve placing a two-man Mercury capsule ahead of an 8-foot diameter 12-foot long cylinder to put two men in space for about two weeks. The third idea was to mount the two-man Mercury capsule at an angle to the cylinder mentioned above, to have all of this attached by adjustable cables to the Vega motor some distance away and to rotate the whole affair about the base of the cylinder to provide artificial gravity. This system would weigh of the order of 6000 pounds.

Mr. Low: - Mr. Low recommended that the Committee –

(1) Adopt the lunar landing mission as its present long range objective with proper emphasis on intermediate steps because this approach will be easier to sell,

[10]

(2) Look into vehicle staging so that Saturn could be used for manned lunar landings without complete reliance on Nova,

(3) Look into whether parachute or airport landing techniques should be emphasized,

(4) Attach importance to research on auxiliary power plants such as hydrogen-oxygen systems.

NEXT MEETING

Committee objectives – In summarizing the present meeting it was concluded that the following is a sensible order of accomplishment:

1. Man in space soonest – Project Mercury
2. Ballistic probes
3. Environmental satellite
4. Maneuverable manned satellite
5. Manned space flight laboratory
6. Lunar reconnaissance satellite
7. Lunar landing
8. Mars-Venus reconnaissance
9. Mars-Venus landing

The committee at this meeting was not in agreement on whether the present long range objective should be number 6 or 7. The Chairman asked each member to give more thought to this before the next meeting.

Agenda – The following agenda was agreed to for the next meeting:

1. Space Flight Structural Concepts – Loftin and a Langley structures man

2. Parachute development – Low, Loftin

3. Space vehicle landing techniques – Faget, Eggers, Beeler, Loftin

4. Mercury lift capabilities – Faget

5. Reentry corridor – Eggers

[11]

6. Man's control functions – Beeler

7. Auxiliary power requirements – Lundin, Schurmeier

8. Propulsion requirements for lunar landing – Lundin, Schurmeier

9. Lift support – Schurmeier, Faget, Beeler

10. Control, guidance and navigation – Schurmeier

11. ABMA Saturn payload plans – Low

Location and Date – It was agreed to hold to next meeting at Ames on June 25 and 26.

ADJOURNMENT

The meeting adjourned at 1:15 p.m. on May 26.

Document II-2

Document Title: George M. Low, Chief, Manned Space Flight, "Manned Space Flight," NASA-Industry Program Plans Conference, 28-29 July 1960.

Source: Folder 18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

On 28 and 29 July 1960, NASA held a "NASA-Industry Program Plans Conference" in Washington to discuss the Agency's plans for future programs and to solicit industry interest in participating in them. NASA announced at this conference that the spaceflight project to follow Project Mercury would be named Project Apollo. This conference was in many ways the beginning of what eventually became the most massive engineering project undertaken since the Manhattan Project. This document is George Low's presentation to the conference.

NASA-Industry
Program Plans
Conference

July 28-29, 1960

Departmental Auditorium
Constitution Ave., N.W.
Washington, D.C.

[2]

MANNED SPACE FLIGHT

By George M. Low *Chief, Manned Space Flight*

Introduction

The benefits that might accrue from the manned exploration of space are, in a large measure, unknown. It is certainly clear that no amount of instrumentation will tell us as much about the moon, or the planets, as man himself will be able to tell, once he has visited those distant places. Only man can cope with the unexpected; and the unexpected, of course, is the most interesting.

We should, therefore, state only one broad objective for the manned space flight program:

"To provide the capability for manned exploration of space."

With this objective in mind, we have developed a program that is broadly outlined in figure 1. [not included] At this point it should be stated that official approval of this program has not been obtained. Rather, this presentation includes what we now believe to be a rational and reasonable approach to a long-range development program leading to the manned exploration of outer space.

MANNED SPACEFLIGHT PROGRAM

Program Outline

The initial step in this program is Project Mercury--a project designed to put a manned satellite into an orbit about 120 miles above the earth's surface, let it circle the earth three times, and then bring it back safely.

Project Mercury, we believe, is an essential step before we can proceed with other, more difficult manned space missions. It is true that all of our plans for the scientific exploration of space assume that eventually man will participate in that exploration. The trouble is that, although all of us think men can be useful in this new environment, none of us know for sure.

If it should turn out that men cannot perform useful work in space, it is quite possible that the direction of a substantial portion of our efforts will have to be changed. So it is important to find out about man's capabilities in space-and soon! Project Mercury is the simplest way to learn what we need to know, at the earliest possible date.

But the determination of man's capabilities in a space environment is only one of the benefits that will be derived from Project Mercury. Of equal importance is the technical knowledge being gained during the design, construction, and operation of the first vehicle specifically engineered for manned flight in space.

The accomplishment of Project Mercury will mark a tremendous step forward; man's venture into space will immeasurably extend the frontiers of flight. The speed of flight will be increased by a factor of 8 over present achievements, and the altitude by a factor of 5; the environment encountered in space flight will be one that heretofore has not even been approached. This extension of the flight envelope has required major technical advancements in many diverse fields, including aerodynamics, [3] biotechnology, instrumentation, communications, attitude control, environmental control, and parachute development-to mention only a few. By its very advanced nature, therefore, Project Mercury has opened the door for the next step in the manned space flight program.

This next step involves the development of a manned spacecraft designed to allow man to perform useful functions in space. This spacecraft should ultimately be capable of manned circumlunar flight, as a logical intermediate step toward future goals of landing men on the moon and the planets. The design of the spacecraft should also be sufficiently flexible to permit its use as an earth-orbiting laboratory, as a necessary intermediate step toward the establishment of a permanent manned space station.

In this decade, therefore, our present planning calls for the development and construction of an advanced manned spacecraft with sufficient flexibility to be capable of both circumlunar flight and useful earth-orbital missions. In the long range, this spacecraft should lead toward manned landings on the moon and planets, and toward a permanent manned space station.

This advanced manned space flight program has been named "Project Apollo."

Flight Missions

Further details of the desired dual mission capability are illustrated in figure 2. [not included] It should be pointed out, however, that these details are merely representative and may well be changed and redefined as the results of further studies become available.

The design for an ultimate circumlunar flight will require the solution of many, but not all, of the problems associated with a manned landing on the moon; this is particularly true of earth reentry and recovery. The mission will require a considerable amount of trajectory control, thereby imposing rather severe requirements on the navigation and control system. Manned circumlunar flight is the ultimate manned mission consistent with our planned booster capability, that is, with the Saturn vehicle.

Before circumlunar missions are attempted, earth-orbital flights will be required for spacecraft evaluation, for crew training, and for the development of operational techniques. In conjunction with, or in addition to, these qualification flights, the spacecraft can be used in earth orbit as a laboratory for scientific measurements or technological developments in space.

Modular Concept

In order to achieve this multiplicity of missions, it may be desirable to employ the so-called "modular concept" in the design of the advanced manned spacecraft. This concept is illustrated in figure 3. [not included]

In this design concept, various building blocks or "modules" of the vehicle system are employed for different phases of the mission. Basically, the spacecraft is conceived to consist of three modules: a command center module, a propulsion module, and a mission module.

The command center would house the crew during the launch and reentry phases of flight; [4] it would also serve as the flight control center for the remainder of the mission. We anticipate that this module will be identical for both the circumlunar and the earth-orbital missions.

The propulsion module would serve the primary function of providing safe return to earth in case of an aborted mission. In this sense, it might be compared with the escape tower and retrorockets on the Mercury capsule. In addition, for circumlunar flight, this component should have the capability of making midcourse corrections: it might also be used to place the spacecraft into an orbit around the moon and eject it from that orbit. In an earth-orbital mission, the propulsion module should permit a degree of maneuverability in orbit or rendezvous with other vehicles. Once again, it may be desirable to provide identical propulsion units for both orbital and circumlunar flights.

The command center and propulsion units together might be considered, for some applications, as a complete spacecraft, even without the mission modules.

The mission module would differ for the various flight missions. For circumlunar flight, it would be used to provide better living quarters than the command center can afford, and some equipment for scientific observations. (Detailed design studies may well indicate that the command center and circumlunar mission modules should be combined into a single package.)

For earth-orbital flight, the mission module can be considerably heavier than for circumlunar flight. Hence this module can usefully serve as an earth-orbiting laboratory, with adequate capacity for scientific instrumentation and reasonably long lifetimes in orbit.

Of all the modules mentioned, only the command center unit would be designed with reentry and recovery capability.

Command Center Module

Figure 4 [not included] illustrates some of the requirements for the command center module.

This module must be designed to reenter the earth's atmosphere at essentially parabolic velocity, or about 36,000 feet per second. It will have to withstand the severe heating encountered at these velocities, and it must be statically stable over the entire speed range from 36,000 feet per second to the landing speed.

A degree of maneuverability will be required to stay within the limits of a rather narrow flight corridor. The boundaries of this corridor are determined by maximum tolerable loads or heating, on the one hand, and minimum aerodynamic loads to cause reentry in a single pass, on the other hand. The amount of maneuverability can be minimized through the provision of adequate midcourse propulsive corrections.

The maneuverability provided for corridor control should also permit a landing at a fixed point (or within a small area) on earth.

A conventional airplane-type landing is not required. Instead, vertical landings using parachutes or other devices are acceptable. Because of the worldwide aspects of these missions, the vehicle must be capable of surviving both ground and water landings.

An important design consideration is that safe recovery must be possible for both normal and aborted missions. As in the case of the Mercury capsule, it is expected that the most severe requirements will stem from some of the off-design conditions.

There has been a great deal of discussion concerning the role to be played by the pilot in a space mission. Under the assumption that Project Mercury will demonstrate that man can indeed perform useful functions in space, we believe that in all future missions the primary control should be onboard.

[5] This guideline is not to be construed as implying that there would be no automatic guidance or control systems on board. Certainly there are many functions that can better be performed automatically than manually. But the basic decision-making capabilities, and some control functions, are to be assigned to the man.

Propulsion Module

Because of the possibility of a catastrophic failure of any of the Saturn stages, the spacecraft must be equipped with sufficient propulsion to permit safe crew recovery from aborted missions. Such capability must be provided for an abort at any speed up to maximum velocity and should be independent of the launch propulsion system.

Some of the requirements for the propulsion module are summarized as follows:

Primary	Secondary
Safe recovery from aborts	Lunar orbit
Course corrections	Maneuvering in earth orbit
Return from orbit	

Preliminary studies have indicated that, for a circumlunar mission, roughly one-third of the permissible spacecraft weight will be required for onboard propulsion.

In a normal mission, this same propulsion may be applied for course corrections, both while approaching the moon and when returning to earth. As mentioned earlier, the propulsion that must be carried for emergency considerations may, in a normal mission, be sufficient to place the spacecraft into a satellite orbit around the moon.

For the earth-orbital mission, the propulsion module would again serve the primary function of providing safe return capability from aborted missions. If it is not needed for this purpose, then the available impulse might be used for maneuvering in orbit and for orbital rendezvous with other satellites.

Mission Modules

We have tentatively specified that the advanced manned spacecraft should be designed for a 3-man crew. Our concept is that, during launch and reentry, this crew would be located in the command center unit but, for the remainder of the flight, at least two of the crew members would be in the mission module (fig. 5).[not included]

The use of a pressure suit in the command center module may be acceptable. But the mission module should definitely be designed to permit “shirtsleeve” operations, that is, operations without the use of pressure suits. We believe that pressure suits, as currently envisioned, would not be acceptable for the duration of a circumlunar flight.

The foregoing requirements apply for both the circumlunar mission and the earth-orbital mission. However, there are other requirements that differ widely between the two types of flight. For example, the circumlunar mission module requires an environmental control system that need only provide for about 1 week’s life support; on the other hand, it may be desirable to keep the earth-orbiting laboratory in space for periods ranging from 2 weeks to 2 months.

The circumlunar module would carry only a minimum amount of instrumentation required to complete the mission, whereas a great deal of instrumentation for scientific measurements and observations should be provided in the orbiting laboratory.

Required Developments

The advanced manned spacecraft will require many systems and subsystems that must be developed especially for this vehicle. Some of these systems may be entirely new, while others may be growth versions of Mercury components.

[6]Major developments that will be needed are listed as follows:
Basic reentry vehicle
Environmental control system
Attitude control system Power supplies
Communications system
Onboard propulsion
Guidance and control system
Pilot displays

The general specifications for the basic reentry vehicle were mentioned earlier. As yet, no specific recommendations regarding its configuration can be made.

The advanced manned spacecraft will involve the development of perhaps several environmental control systems. These systems would be incorporated into the command center, the orbiting laboratory, and the circumlunar module. Gaseous-, liquid-, and chemical-oxygen systems all deserve consideration for these applications.

A system for sensing and controlling the craft's attitude will have to be developed.

Suitable power supplies will have to be selected. It is estimated that the power required for the circumlunar mission will be of the order of 400 kilowatt hours, with a peak load of roughly 4 kilowatts.

Voice and telemetry communication systems most certainly will be needed. Television may also be desirable.

The onboard propulsion requirement was discussed in connection with the propulsion module. The demands on this system are many and varied, ranging from high-thrust, short-duration requirements for abort maneuvers to the very low thrust needed for course corrections.

An area that deserves considerable attention is that of guidance, control, and displays. Sufficient information must be supplied to the pilot to permit him to make trajectory corrections, to enter and stay within the appropriate corridor, and to land at a preselected [*sic*] location.

Radiation Considerations

A problem of major concern for flight beyond low earth orbits is that of radiation in space (fig. 6) [not included]

The following types of radiation are pertinent to circumlunar flight:

(1) Trapped radiation (Van Allen)

(2) Cosmic radiation

(3) Solar flare particles

The trapped radiation in the Van Allen radiation belts is of rather high intensity but of sufficiently low energy to make shielding feasible. Because the time spent in the radiation belts will be small, only a small amount of shielding is required for this type of radiation.

The energies of cosmic radiation are so high that shielding becomes impractical. However, the peak intensity is sufficiently low that no danger is expected in a 5-day mission.

The most serious problem results from the particles generated by some solar flares. The energy of these particles is of a magnitude that may require more shielding than is practical from the standpoint of weight; following a major flare, the intensity may be so high as to cause severe biological damage. However, there are some indications that it might be possible to predict major flares (or at least their absence) several days in advance. If, in the future, it should indeed be possible to predict these flares, then the radiation problem could be circumvented by avoiding flights during a time of anticipated major flare activity.

The radiation problem, more than any other, requires a great deal of study before the manned spacecraft can be employed for circumlunar flight. Many of the answers now lacking will be supplied through our scientific satellite and probe programs. The effects of the various types of radiation on living tissues are yet to be determined.

[7]

Weightless Flight

Another as yet unresolved problem area is illustrated in figure 7. [not included] A question naturally arises as to whether man will be able to function in a weightless environment for prolonged periods of time.

The answer to this question must await the completion of the first manned orbital flight in Project Mercury. That flight should shed much light on the desirability of incorporating artificial gravity into future manned spacecraft.

Inevitably, the solution to this problem will have a profound effect on the design of the orbiting laboratory module and perhaps also on the circumlunar module.

Manned Space Flight Program

Program Phasing

Our planning thus far has led to a proposed overall timetable for the advanced manned spacecraft program, as presented in figure 8.[not included]

This program is expected to be under the direction of the Space Task Group of the Goddard Space Flight Center--the same group that is currently managing Project Mercury.

Several months ago, very detailed program guidelines were presented to each of NASA's research and space flight centers. As a result of these presentations, the centers have initiated intensive research and study programs, all designed to generate the background information required for the design of the advanced manned spacecraft. This information will be available to industry, of course.

In the near future, industry will be invited to participate, by contract, in a program of system design studies. According to present plans, a systems contract for the design, engineering, and fabrication of the manned spacecraft and its components will probably be initiated in fiscal year 1962.

However, it should be emphasized that this program has no official standing as yet. Provision for the initiation of NASA's manned space flight program, beyond Project Mercury, is expected to be included in the fiscal year 1962 budgetary request to be sent to the Congress in January 1961. With that statement as a basic premise, our present thinking is outlined to indicate the probable course of future flight events (fig. 9). [not included]

Flight Program

Major Mercury flights probably will continue for several years.[8] Research and development, and prototype flights of the advanced manned spacecraft are listed to start in 1962 and to end in 1965. Early flights in this series would be used to verify final design criteria for the spacecraft shape and its heat protection; it is planned to use Atlas-Agena-B as the launch vehicle for these missions. Following the Atlas-Agena flights, the Saturn vehicle will be used for full-scale development and prototype flights.

Earth-orbital missions, using the final spacecraft, could conceivably begin in 1966, with circumlunar missions following as soon as the state of both technical and aeromedical knowledge permits such flights.

Program Costs

The final chart (table I) lists the funding associated with the manned spaceflight program. In fiscal years 1960 and 1961, the majority of the funds allocated for manned space flight will be devoted to Project Mercury.

TABLE I Manned Space Flight Funding [millions]

Fiscal	Project Mercury	Advanced manned spacecraft	Total
1960	87.06	0.10	87.16
1961	106.75	1.00	107.75

In future years, we anticipate that an increasingly larger proportion of manned space flight funds will be allocated to the more advanced programs in this area.

Concluding Remarks

NASA's manned space flight program, for the present decade, calls for the development and construction of an advance manned spacecraft with sufficient flexibility to be capable of both circumlunar flight and useful earth-orbital missions. In the long range, this spacecraft should lead toward manned landings on the moon and planets, and toward a permanent manned space station.

In order to achieve this multiplicity of missions, the use of the modular concept is proposed. In this concept, various building blocks, or modules, of the vehicle system are employed for different phases of the mission. Basically, the spacecraft is conceived to consist of three modules: a command center module, a propulsion module, and a mission module.

In addition to the basic vehicle modules, this program will require other new developments, such as environmental control systems, attitude stabilization devices, power supplies, communications, guidance-and-control systems, onboard propulsion, and pilot displays.

In the current fiscal year, contractors will be invited to participate in a program of systems studies. It is believed probable that a contract for the design, engineering, and fabrication of the complete spacecraft system may be initiated in fiscal year 1962.

Document II-3

Document Title: George M. Low, Memorandum for Director of Space Flight Programs, "Manned Lunar Landing Program," 17 October 1960.

Source: Folder 18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

Given the increasing attention in 1960 to the precursors to a future lunar landing mission, in October 1960 Manned Space Flight Program Chief, George Low, informed Director of Space Flight Programs, Abe Silverstein, that he was forming a working group to address the technical, schedule, and budgetary issues associated with a lunar landing program. The results of Low's group provided a basis for NASA's response the following year as President Kennedy considered a dramatic acceleration of the lunar landing program.

October 17, 1960

MEMORANDUM for Director of Space Flight Programs

Subject: Manned Lunar Landing Program

1. It has become increasingly apparent that a preliminary program for manned lunar landings should be formulated. This is necessary in order to provide a proper justification for Apollo, and to place Apollo schedules and technical plans on a firmer foundation.

2. In order to prepare such a program, I have formed a small working group, consisting of Eldon Hall, Oran Nicks, John Disher and myself. This group will endeavor to establish ground rules for manned lunar landing missions; to determine reasonable spacecraft weights; to specify launch vehicle requirements; and to prepare an integrated development plan, including the spacecraft, lunar landing and take-off system, and launch vehicles. This plan should include a time-phasing and funding picture, and should identify areas requiring early studies by field organizations.

3. At the completion of this work, we plan to brief you and General Ostrander on the results. No action on your part is required at this time; Hall will inform General Ostrander that he is participating in this study.

[signed]
George M. Low
Program Chief
Manned Space Flight

Document II-4

Document Title: George M. Low, Program Chief, Manned Space Flight, Memorandum for Associate Administrator, "Transmittal of Report Prepared by Manned Lunar Working Group," 7 February 1961, with Attached Report, "A Plan for a Manned Lunar Landing."

Source: Johnson Space Flight Center Archives.

George Low had been among the first in NASA to openly advocate a lunar landing goal and was a vocal proponent of that goal. In October 1960 he formed a Manned Lunar Working Group Task Force. The task force transmitted its findings to NASA Associate Administrator Robert Seamans on 7 February; its report was the first fully developed plan for how NASA proposed to send humans to the Moon. Low and his group concluded that "The present state of knowledge is such that no invention or breakthrough is believed to be required to insure the over-all feasibility of safe manned lunar flight." This was an important consideration two months later as President Kennedy considered whether to commit the United States to sending Americans to the Moon. The group also estimated that the plan could be carried out over 10 years for an average cost of $700 million per year, for a total cost of $7 billion.

[Originally marked "For Internal Use Only"]

February 7, 1961

MEMORANDUM for Associate Administrator

Subject: Transmittal of Report Prepared by Manned Lunar Working Group

1. The attached report, entitled "A Plan for Manned Lunar Landing" was prepared by the Manned Lunar Working Group. It accurately represents, to the best of my knowledge, the views of the entire Group.

2. Copies of a draft of this report were submitted to the Program Directors, NASA Headquarters, and to the Directors of Marshall Space Flight Center and Space Task Group. In cases where comments were submitted, these comments were incorporated in the report.

3. The Group stands ready to make a presentation of the material presented in the report at any time you might so desire.

4. No additional work is planned until further instructions are received.

/Signed/
George M. Low
Program Chief
Manned Space Flight

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WASHINGTON 25, D. C.

A PLAN FOR MANNED LUNAR LANDING*

INTRODUCTION

In the past, man's scientific and technical knowledge was limited by the fact that all of his observations were made either from the earth's surface or from within the earth's atmosphere. Now man can send his measuring equipment on satellites beyond the earth's atmosphere and into space beyond the moon on lunar and planetary probes. These initial ventures into space have already greatly increased man's store of knowledge.

In the future, man himself is destined to play a vital and direct role in the exploration of the moon and of the planets. In this regard, it is not easy to conceive that instruments can be devised that can effectively and reliably duplicate man's role as an explorer, a geologist, a surveyor, a photographer, a chemist, a biologist, a physicist, or any of a host of other specialists whose talents would be useful. In all of these areas man's judgment, his ability to observe and to reason, and his decision-making capabilities are required.

*Prepared by the Lunar Landing Working Group, January 1961.

[2]

The initial step in our program for the manned exploration of space is Project Mercury. This Project is designed to put a manned satellite into an orbit more than 100 miles above the earth's surface, let it circle the earth three times, and bring it back safety. From Project Mercury we expect to learn much about how man will react to space flight, what his capabilities may be, and what should be provided in future manned spacecraft to allow man to function usefully. Such knowledge is vital before man can participate in other, more difficult, space missions.

Project Mercury is the beginning of a series of programs of ever-increasing scope and complexity. The future can be expected to include the milestones shown in Figure 1.

The next step after Mercury is Project Apollo. The multi-manned Apollo spacecraft will provide for the development and exploitation of manned space flight technology in earth orbit; it also provide the initial step in a long-range program [3] for the manned exploration of the moon and the planets. In this paper we will focus on a major milestone in the program for manned exploration of space - lunar landing and exploration. This milestone might be subdivided into two phases:

1. Initial manned landing, with return to earth;

2. Manned exploration.

This report will be limited to a discussion of the initial manned lunar landing and return mission, with the clear recognition that it is a part of an integrated plan leading toward manned exploration of the moon.

An important element in the manned space flight program is the establishment of a space station in an earth orbit. Present thinking indicates that such a station can be established in the same time period as manned lunar landings can be made, and also that many of the same technological developments are required for both purposes. Although both missions were broadly considered in planning developments for the lunar program, only the lunar requirements are discussed in this paper.

An undertaking such as manned lunar landing requires a team effort on an exceedingly broad scale. The various elements of [4] this effort are indicated in Figure 2. [not provided] The basic capability is provided through the parallel development of a spacecraft and a launch vehicle. Both of these developments must proceed in an orderly fashion, leading to hardware of increasing capability. Supporting these developments are many other scientific and technical programs and disciplines, as shown in the figure. The implementation of the manned spacecraft program requires information that will be obtained in the unmanned spacecraft and life science programs. The development of launch vehicle capability requires new engines, techniques to launch from earth orbit, and might include launch vehicle recovery developments. Both the spacecraft and the launch vehicle programs can progress only as new knowledge is obtained through advanced research.

All of these program elements currently exist in the total NASA program. Work is under way in areas that are pertinent to the development of the capability for manned lunar landing. In this report the interrelationship between the various programs will be studied. Key items will be examined in detail, to determine the proper phasing between the development of new systems, and the availability of the background information required for these developments.

[5]

<u>NASA RESEARCH</u>

Already there exists a large fund of basic scientific knowledge, as a result of the advanced research of the past several years, which permits confidence that the technology required for manned lunar flight can be successfully developed. It would be misleading to imply that all of the major problems are now clearly foreseen; however, there is an acute awareness of the magnitude of the problems. The present state of knowledge is such that no invention or breakthrough is believed to be required to insure the over-all feasibility of safe manned lunar flight.

An aggressive research program which will insure a sound technological foundation for lunar vehicle system development is currently under way. This research is being carried out as a major part of the programs of the NASA Research Centers and in the supporting research activities of the NASA Space Flight Centers, both internally and by contract. It includes basic research in the physical and biological sciences; and applied research leading to the development of spacecraft, orbital operations, operations at the lunar surface, propulsion and [6] launch vehicles. This research is supported by a wide variety of experimental facilities in being, and new highly advanced facilities that are becoming available.

Consider, for example, one of the major spacecraft problems, that of aerodynamic heating. A lunar spacecraft will reenter the earth's atmosphere at about one and one-half times the reentry speed of a near-earth satellite and with twice the kinetic energy. Research to date has shown that radiative heat of the spacecraft by the hot incandescent gas envelope may become an appreciable percentage of the total heating. For the case of the reentering satellites, this radiative heat transfer had been unimportant. Analytical work and early experimental results have enabled estimates to be made of the gross radiative heat transfer. Continuing experimental research will be carried out in newer, more advanced facilities that are becoming available. Selected flight experiments to progressively higher speeds are needed for verification of the analytical and experimental results. The earliest of these, providing reentry velocities of 30,000 ft/sec, are scheduled for early 1962. All of this research will help to achieve detailed understanding of the heating problem, to allow accurate prediction of the heat [7] transfer, and to find the best materials and methods for spacecraft construction.

Research in this area, as well as in the other areas listed in Figure 3 [not provided], seeks to provide the basic information which should lead to greater simplification and reliability, and to reduced weight. The scope of the work is such that the basic information required in support of a manned lunar landing project should be in hand within three to five years.

LAUNCH VEHICLE DEVELOPMENT

The magnitude of a step in our space flight program, at any given time, will always depend on the capability of our launch vehicles. This capability, both present and projected, is shown in Figure 4 [not provided], where the payload weight at escape velocity is plotted as a function of time. During the current year, we should achieve the possibility of propelling 750 pounds to escape velocity, using the Atlas-Agena vehicle. By 1963, the Atlas-Centaur should increase this capability to 2,500 pounds; this will be doubled when the Saturn C-1 becomes operational in 1964. However, the C-1 is only an interim vehicle that is severely limited because of the lack of a sufficiently large high-energy [8] engine for the second stage. A later version of the Saturn, called the C-2, will more than triple the C-1 payload capability at escape velocity. Because the second stage of the C-2 must await the development of the J-2 (200,000 pound thrust hydrogen-oxygen) engine, it will not be operational until 1967. The Saturn C-2 will be the first launch vehicle giving us the capability of manned flight to the vicinity of the moon; however, a single C-2 cannot provide sufficient energy to complete a manned lunar landing mission.

The required launch vehicle capability can be achieved in several ways. Two promising means are: one, orbital operations, wherein a number of Saturn C-2 launched payloads are rendezvoused, assembled or refueled in earth orbit, and then launched as a single system from earth toward the moon; and two, the direct approach, using a vehicle much larger than Saturn which would have the capability of propelling a sufficiently large payload toward the moon from the surface of the earth. Both methods appear to be technically feasible, and will be discussed.

Orbital operation techniques must be developed as part of the space program, whether or not the manned lunar landing mission is considered. These techniques will be required for [9] resupply and transfer to space stations and orbiting laboratories, for inspections and repair of other satellites, for rescue operations and for military applications. Successful development of these techniques of rendezvous, refueling and launching from orbit could allow us to develop a capability for the manned lunar mission in less time than by any other means. In view of these facts, NASA is planning a vigorous program for developing orbital operations techniques. This program is outlined in Figure 5.

Under present plans, initial rendezvousing, docking and refueling tests would make use of the Atlas-Agena vehicle. In these tests, conventional storable propellants will be used. In order to demonstrate the feasibility of orbital operations with high-energy hydrogen-oxygen propellants, a refueling exercise is planned wherein an Atlas-Centaur will be used to refuel an upper stage of a Saturn C-l vehicle. This demonstration is expected to be attempted in 1965 or 1966. Following this demonstration, full-scale refueling and orbital launch operations will be conducted using Saturn C-2 vehicles. These operations will involve the launch of several C-2's to refuel an upper stage initially put into orbit. Following the development of this capability in the 1967-68 time period, this system is [10] expected to be available for operational use in 1968-69 time period.

For the purpose of the manned lunar mission, the Saturn C-2 would be used to place into earth orbit an empty upper vehicle stage that would subsequently be used to propel the spacecraft toward the moon. Four or five additional C-2 payloads would be required to fill this empty stage with propellants. The last launching would propel the manned spacecraft together with the lunar take-off stage into earth orbit. Six or seven successful Saturn launchings, therefore, are required in order to place a space vehicle system into earth orbit that will then be capable of propelling an 8,000 pound spacecraft toward the moon, landing on the moon and returning it toward earth.

Orbital operations techniques will probably be required to perform the more difficult planetary mission even with the availability of much larger launch vehicles. Many of the missions shown in Figure 1 indicate the need for vehicles larger than the Saturn C-2. Large earth space stations that may be assembled in orbit will very likely require the launching of larger sub-assemblies into orbit than can be carried with a single Saturn C-2. Exploration of the moon following the initial landing will [11] also require vehicles larger than the Saturn C-2. Also, if the spacecraft weight increases materially as a result of information gained in the areas of weightlessness and radiation, the required number of earth launchings using Saturn could increase to an extent where the orbital operations techniques with this vehicle would no longer be attractive.

It is proposed, therefore, that a vehicle larger than the Saturn C-2 be phased into the launch vehicle program in an orderly fashion following the Saturn development. Such a launch vehicle, called Nova, would use a cluster of 1,500,000 pound thrust F-l engines in its booster stage. The exact number of F-l engines will have to be determined later, when a more complete definition of Nova missions is in hand. Nova might be sufficiently large to permit a manned lunar landing with a single launching directly from earth. Or, although substantially larger than the Saturn C-2, it might still not be large enough to approach the moon directly from earth; in this case it would materially reduce the number of rendezvous operations needed in earth orbit for each lunar mission.

A Nova-class vehicle development program, based on an assumed configuration, is given in Figure 6 [not provided]. The program is phased so that major decisions concerning the vehicle size and [12] configuration need not be made until after sufficient background information is available in the spacecraft development program.

The present program for development of the F-l engine is shown in this figure. Preliminary flight rating tests are now scheduled toward the end of 1963, and further testing should lead to a qualified engine by the end of 1965. Studies are under way to determine possible configurations of the vehicle and its performance capabilities. Preliminary design of the vehicle can be started in 1962 and would continue through 1963. As will be shown later, the spacecraft weight for the manned lunar mission should be firmly established in this time period.

Construction of static test stands and launch facility will be initiated in 1963. Developmental flight tests of the first stage could begin in 1966. Subsequent tests would add various upper stages until a complete launch vehicle should be ready for operational use in 1970.

Comparison of Launch Vehicles

A comparison of the Saturn C-2 and several Nova-class vehicles, as used for the manned lunar mission, is made in Figure 7[not provided]. The numbers under each launch vehicle indicate the [13] successful launchings required for each lunar flight. Spacecraft weights from 8,000 to 16,000 pounds are assumed; corresponding weights that must be propelled to escape velocity are indicated. Uncertainties in these latter weights are a result of uncertainties in the design of the lunar landing and take-off stages. In all cases, the use of storable propellants has been assumed for the return propulsion.

Use of the Saturn C-2 requires minimum of six to seven vehicles successfully completing each orbital operation. Increased spacecraft weight, failures of the launch vehicle, failures in the orbital operations, propellant losses either during transfer or by evaporation during the operation, and extra propulsion for accomplishing the rendezvous would all increase the required number of Saturns.

At this time, operations with six or seven Saturns appear to be feasible. However, if several of the aforementioned eventualities materialize, and if the number of launchings increases appreciably, the orbital operations technique for manned lunar landings may no longer be practical. A better definition of these problems will come during the orbital operations development program and during the spacecraft development program. [14] If, as a result of these programs, it appears that orbital operations are indeed feasible, the Nova development could be slowed down and delayed. Conversely, if the orbital operations become too complex and cumbersome, this work should be de-emphasized and the Nova development could be speeded up.

Use of the Nova-class vehicle offers the possibility of greatly reducing the required number of launchings from earth. It might be possible to provide mission capability without rendezvous with a four-engine Nova; with an eight-engine Nova, this type of mission capability is virtually assured.

Thus, if future difficulties force the use of an unacceptably large number of Saturns for this mission, the availability of a Nova-class vehicle would permit accomplishment of the planned flights. It should be recognized, however, that the development of Nova will undoubtedly bring about many problems, and will not be easy.

It is possible that other propulsion developments could contribute to manned lunar flight capability. Examples are the use of large solid propellant rockets, or nuclear propulsion. In defining a Nova configuration, consideration will be given to both of these types of propulsion. At the present time it [15] appears that nuclear propulsion will not be sufficiently developed for the initial manned lunar landing; however, nuclear propulsion might be very desirable and economically attractive for later exploration of the moon.

Programs in Support of Launch Vehicle Development

Activities presently under way or planned in support of the launch vehicle development are shown in Figure 8 [not provided]. For comparative purposes, major milestones for both the orbital operations and the Nova development are indicated.

Engine Development: The chemical fuel engines currently under development include the F-l, the J-2, and the LR-119. The F-l engine produces 1,500,000 pounds of thrust using conventional LOX/RP propellants; the J-2 engine will produce 200,000 pounds of thrust using hydrogen-oxygen propellants; the LR-119 produces a thrust of 17,500 pounds and also uses hydrogen-oxygen propellant. Both the LR-119 and the J-2 engine are scheduled for use in the Saturn C-2 vehicle. All three engines could be used in the Nova launch vehicle. The end of each bar in Figure 8 indicates the time when a qualified engine could be available. Also indicated in the figure is a proposed plan for testing a cluster of F-l engines; cluster testing could be completed [16] during 1966, if test facilities can be made available in time. Nuclear propulsion is currently under development jointly by NASA and the AEC. Although actively under development, the research character of this program precludes the possibility of determining schedules for manned use of this engine at the present time.

The feasibility of using large solid rocket motors in the first stages of launch vehicles of the Nova-class is also being studied. Test firings of rocket motors in the one-quarter to one-half million pound thrust class are planned for the 1961-62 time period.

These firings will be made with segmented motors that could be assembled to provide much larger capability.

Launch Vehicle Recovery: Means to reduce the high cost of launch vehicles are continually being sought. A promising method for possible major-reductions in hardware costs for future missions, is the recovery of launch vehicles. Launch vehicle recovery would also permit postflight inspection of hardware, offering the possibility of reducing vehicle development time and increasing vehicle reliability. Because of these possible advantages, a research and development program in the area of launch vehicle recovery will be implemented as indicated [17] in Figure 8. In this program, it is first planned to recover the booster stage of the Saturn C-2; later, recovery of stages from orbit will be attempted. If these methods prove to be successful, all of the launch vehicle hardware required for the orbital operations phase of this plan could be reused. Information gained during these operations could be applied later to the recovery of Nova vehicle hardware, thus offering the possibility of greatly reducing the cost of future operations.

Hawkeye Program: This country's first program making use of rendezvous techniques will be the Air Force's Hawkeye program. Much of the technology developed for Hawkeye might be applied to the proposed program of orbital launch vehicle operations. Close coordination with Hawkeye is, therefore, being maintained in order to derive the maximum benefits from this program.

SPACECRAFT DEVELOPMENT

The spacecraft development for the manned lunar landing mission will be an extension of the Apollo program. Before a spacecraft capable of manned circumlunar flight and lunar landing can be designed, a number of unknowns must be answered.

[18] The two most serious questions are:

1. What are the effects on man of prolonged exposure to weightlessness?
2. How may man best be protected from radiation in space?

The entire spacecraft design, its shape and its weight, will depend to a great extent on whether or not man can tolerate prolonged periods of weightlessness. And, if it is determined that he cannot, then the required amount of artificial gravity, or perhaps of other forms of sensory stimulation, will have to be specified.

The spacecraft design and weight will also be greatly affected by the amount of radiation shielding required to protect a man. In this area, a clear definition of the pertinent types of radiation, and their effects on living beings, is needed.

These two unknowns, radiation and weightlessness, might cause the largest foreseeable changes in spacecraft design. Other unknowns are also important, but will have lesser effects on the vehicle weight. For example, the lunar surface [19] characteristics must be defined before a landing system can be designed; yet it is not expected that any landing device will cause major weight perturbations.

As will be shown later, the complete answers to these questions will not be available for several years. It is proposed, therefore, to implement the Apollo spacecraft development in two phases. Apollo "A" will provide the capability of multimanned flight in earth orbit; it will also be a test vehicle, perhaps unmanned, for reentry at parabolic velocities. Apollo "B" will be an advanced version of Apollo "A" and will be phased into the development program at a later date, when definitive design decisions can be made. Apollo "B" will have the capability of manned circumlunar flight, and manned landing on the moon.

It is not suggested that the entire spacecraft development would be implemented in two phases. The Apollo spacecraft is conceived to employ a number of components, or modules, as listed in Figure 9 [not provided]. With the exception of the "command center," these modules will either be common to both Apollo "A" and Apollo "B" or they will be required for only one of the two types of mission.

[20]The command center will house the crew during the launch and reentry phases of flight; it will also serve as the flight control center for the remainder of the mission. It will be the only spacecraft unit designed with

reentry and recovery capability. Apollo "A" used in conjunction with the Saturn C-1 launch vehicle, will provide the capability of multimanned flight in earth orbit for extended periods of time. It will perform missions beyond the capability of Mercury, with increased sophistication and flight duration, leading to more definitive results concerning manned space flight; and it will provide for continuity in the manned flight program.

Apollo "B," used in conjunction with Saturn C-2, will be an advanced version of Apollo "A" with the capability of manned flight to the moon. It is conceivable that only minor changes in design, together with some improvements of onboard systems, will be desirable or required to modify the Apollo "A" spacecraft for the Apollo "B" mission. On the other hand, it is also possible that future knowledge will dictate a major change from Apollo "A" to Apollo "B."

Proposed development schedules for both the "A" and "B" command center units are shown in Figure 9. Also shown in this figure are the schedules for the design, fabrication [21] and flight testing of two types of onboard propulsion system. The Launch Escape Propulsion System will be used in case of a launch vehicle malfunction in the earth's atmosphere. The Mission Abort Propulsion System will provide return-to-earth capability for the remainder of the mission; it will also provide for maneuverability and course corrections; and, for a lunar landing mission, it will be used as the take-off stage from the moon. These propulsion systems will be used in conjunction with both the "A" and "B" command center units. Both propulsion systems will have to be thoroughly tested and highly reliable. The use of existing engines, such as the Agena engine, for the Mission Abort Propulsion System, appears to be very desirable.

The two remaining modules are the Orbital Space Laboratory and the Lunar Landing System. The Orbital Space Laboratory, to be used initially with Apollo "A," will be used for spacecraft evaluation, for crew training and for the development of operational techniques; it can also serve as a base for scientific measurements and technological developments. The Lunar Landing System will be used only with the Apollo "B" command center; controlled by this command center, the landing module will provide for a manned landing on the moon's surface.

[22] The schedules (Figure 9) for the design, fabrication and flight testing of each module of the Apollo vehicle were developed so as to be consistent with the availability of the required background knowledge.

Spacecraft - Launch Vehicle Phasing

The proposed schedule of spacecraft flights is compared with launch vehicle availability in Figure 10 [not provided]. The first manned flights on Saturn C-l with the Apollo "A" spacecraft will come a reasonable period of time after this launch vehicle is operational; orbital laboratory flights on C-l are not scheduled until after two years of operational use of this vehicle have elapsed. First manned flights on Saturn C-2 will be made with the Apollo "B" spacecraft, shortly after the C-2 vehicle is operational.

The first lunar landing, using the orbital operations approach, could occur at the time this approach is developed. Manned flights using Nova could take place not much later, if it is determined that the mission should be performed with the Nova vehicle.

[23]

Support by Unmanned Spacecraft Program

A significant amount of the information required in the design of the manned lunar spacecraft will be derived from unmanned space flight programs. These programs will yield scientific data needed to develop design criteria; and technological advancements that might apply directly to the manned spacecraft.

Some of the areas of interest are listed in Figure 11 [not provided]. At the top of this figure, significant milestones in the Apollo "B" development, and in the lunar landing system development, are given. Under these milestones, pertinent areas where information is needed are shown. These include: Information concerning the cislunar and lunar environment, where the several types of radiation will be probed, fields will be measured and meteorite impact probabilities will be assessed; the measurement of lunar surface properties, including terrain texture and features, surface composition, and physical characteristics; and the determination of lunar body properties, such as shape and mass distribution. Technological developments include power systems, tracking and telecommunications, attitude orientation and stabilization, mid-course and terminal guidance and control, retropropulsion, and impact absorbers.

[24] Of all of the areas mentioned above, the information pertaining to cislunar and lunar environment, and to lunar surface characteristics, is the most important. A clear understanding of trapped, cosmic, and solar flare radiation is required before the spacecraft weight can be fully determined. For example, reliable solar flare prediction methods would be required to support a decision that shielding against this type of radiation is not required. Of, if such prediction methods should turn out to be less reliable than is currently anticipated, further information on the directionality of solar proton beams would be helpful. Questions such as: "Do solar flare particles impinge on the dark side of the moon, or in the shadow of a crater?" must be answered. Detailed knowledge about the lunar surface characteristics is required before the design for the lading gear of the manned vehicle can be finalized, and before the exact method of touchdown on the moon (i.e., vertical or horizontal) can be determined.

A detailed analysis of the information presented in Figure 11 has shown that flights are scheduled in ongoing NASA programs which could obtain all the required information; and that this information is expected to be in hand prior to the time of hardware fabrication for either the Apollo "B" command center [25] unit, or the lunar landing system.

The earth satellite programs, using Scout, Delta, and the Atlas-Agena launch vehicles, will significantly increase our store of knowledge concerning the near-earth and cislunar environment. At least 26 firings of scientific satellites are planned between now and the end of 1964. In the same period of time, the Ranger spacecraft will probe the environment between earth and moon, and planetary probes of the Mariner series will obtain additional scientific information. In this time period, it might be desirable to schedule additional Ranger flights for the purpose of fully defining the environment in the vicinity of the moon, and on the moon's surface.

Both the Ranger and the Surveyor spacecraft will obtain information concerning lunar topography, surface characteristics, and body properties. According to present schedules, and assuming reasonable success, sufficient information will be available to design a lunar landing system for the manned spacecraft at the time when such information is required.

The Prospector series of flights will provide final landing system design confirmation. It will also assist in selecting the landing site for the manned craft, and might even [26] bring equipment to the moon's surface that could be used in the manned mission. Close coordination between the Prospector and Apollo projects will be maintained in order to assure maximum utilization of developments; such coordination should greatly benefit both projects.

Advancements in spacecraft technology will be derived from the earth satellite programs, and from the Ranger, Surveyor, and Prospector developments. Some of these advancements will apply directly to the manned lunar landing program.

Weightlessness and Radiation-Biological Tests

Before the Apollo "B" spacecraft design can be completed, the question previously raised concerning weightlessness must be answered. In Figure 12 [not provided], programs that are now planned in this area are listed; for comparison, significant milestones in the Apollo "B" development are also shown.

To date, manned weightless flights have been made for a [27] maximum time duration of one minute.[1] In this short time period, no gross physiological effects were noted. Ongoing programs will soon provide information of the effects of weightlessness on man for several minutes, and then several hours; and the effects on animals for many hours and then for several days. If, in each succeeding step, it is demonstrated that there are no adverse biological effects of weightlessness, then the design of a spacecraft without provision for artificial gravity can proceed with confidence; conversely, if future experiments show marked psychological or physiological changes as a result of prolonged exposure to weightlessness, then artificial gravity will have to be incorporated into the Apollo "B" spacecraft design.

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[1] Animals have been subjected to several days of weightless flight in Russian experiments. Although there are indications that these animals suffered no adverse effects, insufficient data are available, in this country, to draw any firm conclusions.

[28] As indicated in Figure 12, a considerable amount of experimental evidence on this subject will have been obtained before the Apollo "B" design is even started; complete information should be available before fabrication of hardware is begun. These conclusions, however, are based on the assumption that all programs that are currently in the planning stage, including the biomedical orbiting satellite program using Mercury capsules, will actually be implemented.

The biological effects of radiation in space will be determined largely from a correlation of the physical measurements previously discussed (Figure 11) with the results of ground measurements on biological specimen. However, a number of selected experiments in space, involving living subjects, will have to be made before shielding requirements for Apollo "B" can be fully defined. Tests of this type that either have been made, or are firmly planned, are indicated in Figure 12. Additional tests are currently being planned by NASA, in cooperation with the Air Force and the Atomic Energy Commission.

Manned Flight Technology

Much of the information required for the design of a spacecraft for manned lunar landing will be derived directly from Project Mercury, and from DynaSoar developments.

[29]The experience gained in developing systems for manned flight in space, and in preparing both the equipment and the men for such flights, will be of major importance. Operational concepts being worked out and applied in Project Mercury and DynaSoar should apply directly to future manned missions.

For example, the Mercury spacecraft will have all the onboard systems - the attitude stabilization and control system, the communications system, the environmental control system, etc. - that will be required in future manned spacecraft. Although some of the systems required for the Apollo spacecraft will be entirely new, their design should, in general, be related to Mercury experience; it is more than likely that many of the systems will be direct growth versions of Mercury equipment.

Extensions of Project Mercury, beyond the present program, are planned as part of the Apollo development. These flights would provide for extended periods of weightlessness, and perhaps for experiments with artificial gravity. Manned rendezvous tests, using the Mercury spacecraft for control, and a version of the Hawkeye vehicle as the controlled craft, can be carried out. The Mercury capsule cap also be used as a test bed for the development of Apollo guidance and control equipment. All of these flights can occur before manned flights with Apollo "A" are scheduled to take place.

[30] SCHEDULES AND COSTS

A summary of manned space flight missions, leading toward a manned lunar landing, is presented in Figure 13 [not provided]. Starting late in 1961, the Mercury-Atlas combination will give us the capability of orbiting one man for a short period of time. The Apollo "A" spacecraft, using the Saturn C-l launch vehicle, will allow multimanned, long duration, orbital flight in 1965. Later, in 1967, an advanced version of the Apollo spacecraft (Apollo "B") launched by the Saturn C-2, will provide the capability for manned circumlunar flight, and for lunar orbits.

Manned landings on the moon, using the Apollo "B" spacecraft, could be made in the 1968-1971 time period. If orbital operations using the Saturn C-2 vehicles prove to be practicable for this mission, then it might be accomplished toward the beginning of this range of time. On the other hand, if the spacecraft becomes much more complex than now envisioned, and consequently much heavier, a Nova vehicle will most likely be required before man can be landed on the moon. In the latter event, the program goals may not be accomplished as quickly.

[31]The plan presented in this report consists of a number of relatively independent programs. Decisions to implement these programs can be made

as time progresses; no single decision committing NASA to carry out the entire plan is required at this time. The plan is also sufficiently flexible to permit major changes in objectives in later years, without the requirement that earlier phases of the program be repeated.

Some of the major phases of the Launch Vehicle Program are shown in Figure 14 [not provided]. For each of these phases, the year of initiation is shown, together with the total duration of this phase and total funding required to complete the phase. Thus, for example, a decision to go ahead with the Atlas-Agena docking demonstration would be required in FY 1962, in order to meet the total program objectives; the total funding required for these tests would be $80,000,000 distributed over a period of nearly three years.

In the Nova development, only those phases that are not now funded are included in Figure 14. Thus, it is assumed that the F-l engine development, and the Nova configuration [32] studies that are presently under way, will be continued. No major new commitment will be required until late in FY 1963, when the development of the first stage would be started.

A similar breakdown for the phasing of various components of the spacecraft is given in Figure 15 [not provided]. In order to meet the previously presented program objectives, the development of the Apollo "A" spacecraft, the Launch Escape Propulsion System, and the Mission Abort Propulsion System, would have to be initiated in FY 1963. The development of the Orbital Laboratory, the Apollo "B" spacecraft, and the Lunar Landing System would follow in later years.

The aforementioned flexibility of programming also becomes evident in this figure. Assume that for some now unknown reason it becomes undesirable to explore the moon in the suggested time period, and that a decision is made that a large space station should be developed first. Such a decision could be made as late as 1965, without previously having committed anymore than the design phases of the manned lunar vehicles.

[33]A summary of the development and funding schedules is presented in Figure 16 [not provided], where the various program phases are given as a function of the fiscal year of program initiation. Most of the funds initially committed in 1962 will be for design phases. Major hardware contracts would not be awarded until 1963, with additional hardware developments starting in 1964 and 1965. The average cost per year, over a ten year period, for the total program is of the order of $700,000,000.

A basic ground rule in developing this plan was that the funding for fiscal year 1962 cannot be increased beyond the level that has been submitted to the Congress. However, increased funding in fiscal year 1962, in selected areas, might give increased assurance of meeting the projected flight dates. In particular, acceleration of the Saturn C-2, through earlier funding of the S-2 stage, would make this vehicle operational as much as a year before it is required for manned flight; the present program does not provide for any time between launch vehicle availability and manned spacecraft flights.

Earlier C-2 availability, together with earlier funding for the orbital docking demonstrations, would allow for additional unmanned orbital operations before manned flights [34] to the moon are made. Earlier spacecraft funding, for Apollo "A, "would lead to earlier flights with this vehicle. In the area of life sciences, increased funding in fiscal year 1962 would lead to the earlier availability of information on the effects of prolonged periods of weightlessness, and the biological effects of radiation.

An examination of the required NASA staffing to carry out this plan was not made as a part of this study. However, it must be recognized that neither Marshall Space Flight Center nor Space Task Group, as presently staffed, could fully support these programs. If the program is to be adopted, immediate consideration must be given to this problem.

CONCLUDING REMARKS

In, preparing this plan for a manned lunar landing capability, it was recognized that many foreseeable problems will require solutions before the plan can be fully implemented. Yet, an examination of ongoing NASA programs, in the areas of advanced research, life sciences, spacecraft development, and engine and launch vehicle development, has shown that solutions [35] to all of these problems should be available in the required period of time.

Throughout the plan, allowances were made for foreseeable problems; but it must be recognized that unforeseeable problems might delay the accomplishment of this mission. Nevertheless, the plan is believed to be sound in that it requires, at each point in time, a minimum committment [*sic*] of funds and resources until the needed background information is in hand. Thus, the plan does not represent a "crash" program, but rather it represents a vigorous development of technology. The program objectives might be met earlier with higher initial funding, and with some calculated risks.

[pp. 36- 51 not provided]

Document II-5

Document Title: Letter from L. V. Berkner, Chairman, Space Science Board, National Academy of Sciences, National Research Council, to James E. Webb, Administrator, NASA, 31 March 1961, with attached: Space Science Board, National Academy of Sciences, "Man's Role in the National Space Program."

Source: Folder 18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

The Space Studies Board (SSB) had been formed by the National Academy of Sciences a few months before the creation of NASA in 1958, with the hope that it could be the primary influence on the scientific goals of the nation's space program. NASA resisted such a role, and used the SSB as a source of non-binding advice on scientific priorities. The SSB was chaired by Lloyd Berkner, who had been considered for the position of NASA Administrator and was a personal friend of James Webb. The SSB met on 10 and 11 February 1961 to discuss its position on human spaceflight and presented a preliminary list of its findings to Webb on 27 February. The full report, which was only three pages long, was not sent to Webb until 31 March. Copies were also sent to Jerome Wiesner, the President's science advisor; Herbert York, Director of Defense Research and Engineering; and Alan Waterman, Director of the National Science Foundation.

Unlike the negative perception of NASA's human spaceflight program held by member's of the President's Science Advisory Committee, which was reflected in the advice of President-elect Kennedy's space transition team (chaired by Jerome Wiesner), the Space Science Board policy statement presented a positive view of the scientific value of humans in space. Using this statement, Webb and others in NASA could point to scientific support of a human spaceflight effort aimed at the exploration of the Moon and planets.

NATIONAL ACADEMY OF SCIENCES
NATIONAL RESEARCH COUNCIL
OF THE UNITED STATES OF AMERICA
SPACE SCIENCE BOARD

March 31, 1961

Mr. James E. Webb, Administrator
National Aeronautics & Space Administration
1520 H Street, N.W.
Washington 25, D.C.

Dear Mr. Webb:

I am enclosing two major policy positions that have been developed by the Space Science Board as recommendations to the Government.

The first of these concerns the enunciation of the major objective of space exploration and thus embraces man's role. The Board believes that the enunciation of such a policy would clarify the objectives of the national space effort by clearly focusing upon its goals.

The second document [not included] considers the support of basic research and argues, quite aside from current flight-package and related research, that a major and broad effort is required for the long-range success of our national space efforts. Our recommendations in this area represent careful discussions over a period of some three years.

Sincerely yours,

L. V. Berkner
Chairman

SPACE SCIENCE BOARD
National Academy of Sciences
2101 Constitution Avenue
Washington 25, D.C.

Man's Role in the National Space Program

At its meeting on February 10 and 11, 1961, the Space Science Board gave particular consideration to the role of man in space in the national space science program. As a result of these deliberations the Board concluded that scientific exploration of the Moon and planets should be clearly stated as the ultimate objective of the U.S. space program for the foreseeable future. This objective should be promptly adopted as the official goal of the United States space program and clearly announced, discussed and supported. In addition, it should be stressed that the United States will continue to press toward a thorough scientific understanding of space, of solving problems of manned space exploration, and of development of applications of space science for man's welfare.

The Board concluded that it is not now possible to decide whether man will be able to accompany early expeditions to the Moon and planets. Many intermediate problems remain to be solved. However, the Board strongly emphasized that planning for scientific exploration of the Moon and planets must at once be developed on the premise that man will be included.

Failure to adopt and develop our national program upon this premise will inevitably prevent man's inclusion, and every effort should be made to establish the feasibility of manned space flight at the earliest opportunity.

From a scientific standpoint, there seems little room for dissent that man's participation in the exploration of the Moon and planets will be essential, if and when it becomes technologically feasible to include him. Man can contribute critical elements of scientific judgment and discrimination in conducting the scientific exploration of these bodies which can never be fully supplied by his instruments, however complex and sophisticated they may become. Thus, carefully planned and executed manned scientific expeditions will inevitably be the more fruitful. Moreover, the very technical problems of control at very great distances, involving substantial time delays in command signal reception, may make perfection of planetary experiments impossible without manned controls on the vehicles.

[2] There is also another aspect of planning this country's program for scientific exploration of the Moon and planets which is not widely appreciated. In the Board's view, the scale of effort and the spacecraft size and complexity required for manned scientific exploration of these bodies is unlikely to be greatly different from that required to carry out the program by instruments alone. In broad terms, the primary scientific goals of this program are immense: a better understanding of the origins of the solar system and the universe, the investigation of the existence of life on other planets and, potentially, an understanding of the, origin of life itself. In terms of conducting this program a great variety of very intricate instruments (including large amounts of auxiliary equipment, such as high-powered transmitters, long-lived power supplies, electronics for remote control of instruments and, at least, partial data processing) will be required. It seems obvious that the ultimate investigations will involve spacecraft whether manned or unmanned, ranging to the order of hundreds of tons so that the scale of the vehicle program in either case will differ little in its magnitude.

Important supporting considerations are essential to realization of these concepts:

(a) Development of new generations of space vehicles, uniquely designed for use in space research and not adaptations of military rockets, must proceed with sufficient priority to ensure that reliable vehicles of adequate thrust are available for lunar and planetary research. This program should also include development of nuclear stages as rapidly as possible.

(b) Broad programs designed to determine man's physiological and psychological ability to adapt to space flight must likewise be pushed as rapidly as possible. However, planning for "manned" scientific exploration of the Moon and the planets should be consummated only as fast as possible consistent with the development of all relevant information. The program should not be undertaken on a crash basis which fails to given reasonable attention to assurance of success or tries to by-pass the orderly study of all relevant problems.

(c) Consideration should be given soon to the training of scientific specialists for spacecraft flights so that they can conduct or accompany manned expeditions to the Moon and planets.

[3] The Board strongly urges official adoption and public announcement of the foregoing policy and concepts by the U.S. government, Furthermore, while the Board has here stressed the importance of this policy as a scientific goal, it is not unaware of the great importance of other factors associated with a United States man in space program. One of these factors is, of course, the sense of national leadership emergent from bold and imaginative U.S. space activity. Second, the members of the Board as individuals regard man's exploration of the Moon and planets as potentially the greatest inspirational venture of this century and one in which the entire world can share; inherent here are great and fundamental philosophical and spiritual values which find a response in man's questing spirit and his intellectual self-realization. Elaboration of these factors is not the purpose of this document. Nevertheless, the members of the Board fully recognize their parallel importance with the scientific goals and believe that they should not be neglected in seeking public appreciation and acceptance of the program.

Document II-6

Document Title: Memorandum to Pierre Salinger from Hugh Sidey, 14 April 1962.

Source: John F. Kennedy Presidential Library, Boston, Massachusetts.

Document II-7

Document Title: "Memorandum to the President from Jerome Wiesner Re: Sidney Memorandum," 14 April 1961.

Source: John F. Kennedy Presidential Library, Boston, Massachusetts.

President John F. Kennedy was extremely effective in his relations with print and electronic media, and often became personal friends with reporters covering his presidency. One of these individuals was Hugh Sidey, who covered the White House for Life *magazine. In the aftermath of the launching of Yuri Gagarin on 12 April 1961, Sidey requested an interview with the president and provided Kennedy's press secretary Pierre Salinger with a memorandum as background for the interview. On the date of the memorandum, 14 April, Sidey sat in on a meeting between Kennedy and his top space advisors in the Cabinet room; he described the meeting in his 1963 book,* John F. Kennedy, President. *In preparation for Sidey's discussions with the president and, separately, Kennedy's top advisor Theodore Sorenson, Presidential science advisor Jerome Wiesner prepared a response to the Sidey memorandum.*

Document II-6

Office Memorandum

To Pierre Salinger
From Hugh Sidey
Date April 14, 1962

Questions for the President on Space –

(FYI my initial surveillance of the space problem reveals some ragged dilemmas on the landscape. There are a lot of good minds in NASA and other dusty offices of the space agency that think we still are fiddling, haven't made the necessary decisions. They claim the President isn't getting the range of advice on this problem he should have. Their arguments are damned cogent. They scoff at the theory of some scientists that the Russians have now gone as far as they can for a few years. They hoot equally at the idea that our space effort is "locked in" and can't be accelerated. They claim, with compelling logic, that if we are to get in this race at all we've got to declare a national space goal, go for broke on a big booster (which means plenty of dough, granted). If we don't do this then we are going to sit here over the next eight years and watch the Soviets march right on ahead. I must confess, as near as I can tell on the surface there has been no great urgency attached to this space decision. If it has been made, we don't know it.

But knowing the President some, I can't believe he hasn't sensed [2] the urgency. Therefore if I could get a little guidance on the following questions it would help)

1. Why haven't we declared a crash program on one of the big boosters and pulled in our horns on others? Has the President accepted the theory that

we can't move faster? The extra 78 million for Saturn indeed is some boost but Saturn isN't [*sic*] the long range solution and there is no crash program in sight for the big Nova engine or solid fuels. Is the budget consideration and the political climate the confining factor this year?

2. Might there now be a change in the Project Mercury? We get rumbles that this pre-orbital shot coming up late this month has really been rushed in hopes we might beat the Soviets. But there is more hazard in it than there should be and now that shot should be delayed, maybe dropped entirely while we try to leapfrog ahead.

3. How much of the feeling of no decision is due to the newness of the administration and preoccupation with other things so far? Will there be a new and tough look followed by some hard decisions soon?

Document II-7

THE WHITE HOUSE

WASHINGTON

April 14, 1961

MEMORANDUM FOR

THE PRESIDENT

The following points are pertinent to the Sidey memorandum:

First of all, no one in the Administration believes that the Russians are finished with their space exploits or that there aren't exciting space exploits still to be carried out that they will undoubtedly drive hard to accomplish. Extended duration flights of man in an earth orbit, unmanned and manned landings on the moon, manned and unmanned exploration of the planets, manned space stations and a variety of important applications of space are still ahead. Among these are communications satellites, meteorological satellites and a variety of military applications of satellite-based systems. We, of course, have no knowledge at all about future Soviet intentions, but it would be surprising if they didn't pursue vigorously at least some of these possibilities.

Sidey is concerned that there is no long-term and very ambitious large booster program. The previous Administration made the decision not to drive vigorously for such a booster, although it did fund the F-1 engine, which would be needed for the Nova booster, and in our recent budget review we provided $9 million to accelerate that program. Because there was not a well developed program looking beyond the Mercury man in space, this Administration has undertaken to examine the range of possibilities which in turn will determine the future booster program. It should be noted that we did add $14 million to the Rover program to accelerate its research. We deferred a decision on the Rover rocket program, an expensive program (about $1 billion to a flight test) until the national policy on the long-range space goals could be established. We have had a thorough review of the Rover program, and both NASA and the Science Advisory Committee are looking into the range of possibilities in the big booster field, including the relative merits of solid fuels and large chemical boosters, as well as nuclear rockets. It should be noted that these ambitious space systems could not exist for a number of years, and it seems inappropriate to cancel all of the on-going activity until that time. It has become perfectly clear to the Administration that these decisions had to be faced, and it is our intention to do so. On the other hand, it would have been erroneous to commit very large sums of money without first establishing clear-cut national goals that go beyond the present plans. In the end it will be necessary to decide how large a share of the funds available [2] to the Federal Government should be committed to this field.

In regard to the Mercury sub-orbital flight now scheduled for April 28, the following are the facts: The dates were not advanced to compete with the Soviet flight. It has always been a tight schedule, paced by available funds and technical problems. We have analyzed it thoroughly and don't believe that its chances of success would be greatly enhanced by any reasonable delays in the firing schedule or a small number of additional test firings. Some consideration should be given to the question of whether or not the risks involved in a failure don't out-weigh the advantages of carrying out of the shot successfully. There are valid technical reasons for carrying out the experiment in view of the bio-medical and systems test information that will be obtained. It is probably fair to say that the successful orbiting of man has removed many of the bio-medical questions which it was designed to answer.

Jerome B. Wiesner

Document II-8

Document Title: John F. Kennedy, Memorandum for Vice President, 20 April 1961.

Source: Presidential Files, John F. Kennedy Presidential Library, Boston, Massachusetts.

Document II-9

Document Title: NASA, "Do We Have a Chance of Beating the Soviets?" 22 April 1961.

Source: Folder 18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

Document II-10

Document Title: Letter to the Vice President of the United States from Wernher von Braun, 29 April 1961.

Source: Folder 18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

Document II-11

Document Title: Memorandum to the Vice President from James E. Webb, NASA Administrator, and Robert S. McNamara, Secretary of Defense, 8 May 1961, with attached: "Recommendations for Our National Space Program: Changes, Policies, Goals."

Source: Folder 18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

President Kennedy's memorandum on 20 April led directly to the Apollo program. By posing the question "Is there any . . . space program which promises dramatic results in which we could win?" President Kennedy set in motion a review that concluded that only an effort to send Americans to the Moon met the criteria Kennedy had laid out. This memorandum followed a week of discussion within the White House on how best to respond to the challenge to U.S. interests posed by the 12 April1961, orbital flight of Yuri Gagarin.

Both NASA and the Department of Defense gave rapid responses to the president's questions. (The Department of Defense response can be found in Volume I, Document III-7.) While the Low study of a piloted lunar landing (Document II-4) had projected a cost of $7 billion for such an effort the NASA response gave only a cost estimate for acceleration the overall NASA program of between $22 and $33 billion.

Vice President Lyndon B. Johnson, in his new role as Chair of the National Aeronautics and Space Council, provided a preliminary report to the president on 28 April indicating that the most likely recommendation to come from his review was a focus on human missions to the Moon (Volume I, Document III-8). This conclusion had been strongly influenced by Wernher von Braun, who the vice president had consulted independent of NASA's Washington managers. Von Braun told the vice president in his letter that the United States had "an excellent chance" of beating the Russians to a lunar landing.

During the Space Council review, the vice president also contacted congressional leaders to make sure that they would be willing to support a bold space recommendation, should the president make one. He found that those whom he consulted were strongly in favor of an accelerated effort (Volume I, Document III-10).

The final recommendations of the review came in the form of a memorandum signed by NASA Administrator Webb and Secretary of Defense Robert S. McNamara. This memorandum was the hurried product of a weekend of work following the successful suborbital flight of Alan Shepard, the first U.S. astronaut, on Friday, 5 May 1961. The urgency was *caused by the vice president's desire to get recommendations to the president before he left on a rapidly arranged inspection tour to Southeast Asia. NASA, the Department of Defense, and the Bureau of the Budget staffs and senior officials met on Saturday and Sunday at the Pentagon to put together the memorandum, which the vice president approved without change and delivered to the President on Monday, 8 May. On that same day, Shepard came to Washington for a parade down Pennsylvania Avenue and a White House ceremony with President Kennedy. The recommendation that the United States undertake space programs aimed at enhancing national prestige, even if they were not otherwise justified by scientific, commercial, or military benefits, because such prestige was part of the "battle along the fluid front of the cold war," provided the underpinning rationale of Project Apollo. Only excerpts from the document directly related to setting the lunar landing goal are included here; the complete memorandum appears as Document II-11 in Volume I of this series.*

Document II-8

April 20, 1961

MEMORANDUM FOR
VICE PRESIDENT

In accordance with our conversation I would like for you as Chairman of the Space Council to be in charge of making an overall survey of where we stand in space.

1. Do we have a chance of beating the Soviets by putting a laboratory in space, or by a trip around the moon, or by a rocket to land on the moon, or by a rocket to go to the moon and back with a man. Is there any other space program which promises dramatic results in which we could win?

2. How much additional would it cost?

3. Are we working 24 hours a day on existing programs. If not, why not? If not, will you make recommendations to me as to how work can be speeded up.

4. In building large boosters should we put our emphasis on nuclear, chemical or liquid fuel, or a combination of these three?

5. Are we making maximum effort? Are we achieving necessary results?

I have asked Jim Webb, Dr. Wiesner, Secretary McNamara and other responsible officials to cooperate with you fully. I would appreciate a report on this at the earliest possible moment.

John F. Kennedy

Document II-9

NATIONAL AURONAUTICS [*sic*] AND SPACE ADMINISTRATION

April 22, 1961

1. "Do we have a chance of beating the Soviets?"

a. "By putting a laboratory in space?"

There is no chance of beating the Soviets in putting a multi-manned laboratory in space since flights already accomplished by the Russians have demonstrated that they have this capability. The U.S. program must include the development of a multi-manned orbiting laboratory as soon as possible since it is essential for the accomplishment of the more difficult flights to the moon.

b. "Or by a trip around the moon?"

With a determined effort of the United States, there is a chance to beat the Russians in accomplishing a manned circumnavigation of the moon. The Russians have not as yet demonstrated either the booster capability or the technology required for returning a man from a flight around the moon. The state of their booster technology and other technology required for such a difficult mission is not accurately known. With an accelerated program, it is not unreasonable for the U.S. to attempt a manned circumlunar flight by 1966.

[2]

c. "Or by a rocket to land on the moon?"

On September 12, 1959, the Russians crash-landed a small package on the moon. This package did not transmit any information from the surface of the moon. The NASA program currently includes impacting instruments on the moon in such a way that they may survive the impact and transmit scientific information back to earth. The first flight in this program is scheduled for January 1962. Close-up television pictures will be obtained of the surface of the moon, as the spacecraft descends to the moon. In August 1963 the current NASA program also includes a soft landing of instruments on the moon. Several flights in succeeding months are included in this program to insure the possibility of success. The Russians can accomplish this mission now if they choose.

d. "Or by a rocket to go to the moon and back with a man?"

There is a chance for the U.S. to be the first to land a man on the moon and return him to earth if a determined national effort is made. The development of a large chemical rocket booster, the spacecraft for landing and return, and major developments in advanced technology are required to accomplish this most difficult mission. The Russians initiated their earth orbiting program probably as early as 1954 as evidenced by their flight of a dog in November 1957. In the earth orbiting [3] competition the United States was attempting to accomplish in less than three years what the Russians had worked on for seven years. It is doubtful that the Russians have a very great head start on the U.S. in the effort required for a manned lunar landing. Because of the distinct superiority of U.S. industrial capacity, engineering, and scientific know-how, we believe that with the necessary national effort, the U.S. may be able to overcome the lead that the Russians might have up to now. A possible target date for the earliest attempt for a manned lunar landing is 1967, with an accelerated U.S. effort.

e. "Is there any other space program which promises dramatic results in which we could win?"

(1) The current NASA program provides the possibility of returning a sample of the material from the moon surface to the earth in 1964. An experiment of this kind would have dramatic value and may or may not be a part of the Russian program. The Russians could carry out but such an experiment in the same time period or earlier if they choose.

(2) The lead the U.S. has taken in developing communications satellites should be exploited to the fullest. Although not as dramatic as manned flight, the direct benefits to the people throughout the world in the long term are clear. U.S. national prestige will be enhanced by [4] successful completion of this program. The current program will provide for the flight of an active communications satellite in mid-1962. The experiment will enable live television pictures to be transmitted across the Atlantic. The continuing program will lead to the establishment of worldwide operational communications systems.

(3) The U.S. lead established in our successful meteorological experiments with the TIROS satellites, should be maintained with a vigorous continuing program. The whole world will benefit from improved weather forecasting with the possibility of avoiding the disastrous effects of major weather disturbances such as typhoons, hurricanes and tornadoes.

[5]

2. "How much additional would it cost?"

An estimate of the cost of the 10-year space exploration program as planned under the Eisenhower Administration was 17.91 billion dollars, as shown in Table A-1, attached. [not provided] In this program it was planned that manned lunar landing and return to earth would occur in the time period after 1970 but before 1975. Re-evaluation of the cost of this program based on providing adequate back-ups in all areas of the work has recently been made and the original cost estimate revised to 22.3 billion dollars for the ten-year period through 1970. [not provided] For an accelerated national program aiming toward achieving manned lunar landing in the 1967 period, it is estimated that the cost over the same ten-year period will be 33.7 billion dollars, as shown in Table E-1. [not provided] The additional 10 billion dollar cost of the program is due largely to paying for the program in the shorter time period. The resulting annual costs are naturally higher.

A list of the major items that would be initiated in 1962 with an accelerated program is shown in Attachment F. The total FY-62 funds, $1,744 millions, shown in Table E-1 is $509 million more than the approved current FY-62 budget.

[pp. 6-8 not provided]

[9]

Attachment F

MAJOR ITEMS IN THE ACCELERATED PROGRAM REQUIRING THE ADDITIONAL FUNDS SHOWN IN TABLE E-1 FOR FISCAL YEAR 1962

1. Increase number of Mercury capsule flights to accelerate acquisition of knowledge on man's behavior under space flight conditions.
2. Initiate possible additions to Mercury capsules for longer duration flights with intermediate launch vehicles.
3. Accelerate unmanned lunar exploration to provide fundamental scientific data for manned flight to moon.
4. Accelerate developments which will provide us with the essential knowledge and information to design spacecraft which can survive a return from the moon into the earth's atmosphere.
5. Initiate developments of solid propellant rockets which can be used as a first or second stage of a launch vehicle for manned lunar landing missions (Nova).
6. Initiate engineering design work and experimental development of a cluster of F-I engines for Nova.*
7. Initiate design and engineering of a Nova vehicle using a cluster of F-1 liquid rocket engines as a first stage.*
8. Initiate development of the tankage and engines required for a second stage of Nova.
9. Accelerate supporting technology essential to the attainment of the goals of the program.
10. Initiate construction of launch pads and other necessary facilities.
11 Provide additional vehicles and spacecraft for accelerating the TIROS meteorological program.

*The F-1 is the liquid rocket engine now under development which will have 1,500,000 pounds thrust in a single chamber.

[10]

3. <u>"Are we working 24 hours a day and, if not, why not?"</u>

There is not a 24 hour a day work schedule on existing NASA space programs, except for selected areas in Project Mercury, the Saturn C-1 booster, the Centaur engines, and the final launching phases of most flight missions.

a. <u>Project Mercury</u> at Cape Canaveral has been since October 1960 on a three-shift, seven-day- a-week basis plus shift overtime for all phases of capsule checkout and launch preparations. The McDonnell St. Louis plant, where the capsules are made, has averaged a 54-hour week on Mercury from the beginning, but also employs two or three shifts as needed in bottleneck areas. It now runs three shifts in the capsule test and checkout areas.

b. <u>SATURN C-1</u> project operates at Huntsville around-the-clock throughout any critical test periods for the first-stage booster; the remaining Saturn work is on a one-shift basis plus overtime which results in an average 47 hour week.

c. <u>CENTAUR</u> hydrogen engine, which also is needed for the Saturn upper stages, is on three shifts in Pratt &Whitney's shops and test stands.

d. Lastly, the final launch preparations of most flight missions require around-the-clock work at the launch sites [11] at Cape Canaveral, Wallops Station, or the Pacific Missile Range. In addition, NASA computer installations at Goddard and Marshall Centers operate continuous shifts in order to handle launch vehicle test analyses promptly, and determine orbital and trajectory data, and provide tracking and telemetry of space vehicles in flight.

NASA and its contractors are not working 24-hour days on the rest of its projects because:

a. Certain projects are at an early stage of experimental study or design engineering where exchange of ideas is difficult to accomplish through multi-shifts.

b. The schedules have been geared to the availability of facilities and financial resources. The funding levels for both contractors and government laboratories have been sufficient only for single-shift operations plus overtime (generally from 5 to 20%) as required to keep up the schedules.

c. The limitations on manpower and associated funding determine the extent to which the NASA flight development centers may employ extra shifts.

In a number of areas in the national space program, the work could be accelerated if more manpower and more facilities were to be provided and funded in the immediate future. Recommendations to accomplish this are made elsewhere in this memorandum.

[12]

4. <u>"In building large boosters should we put our emphasis on nuclear, chemical or liquid fuel, or a combination of these three?"</u>

In building the large launch vehicles required for the manned lunar landing mission, the immediate emphasis must be on the development of large solid and liquid rockets. It is believed that, in order to provide the necessary assurance that we will have a large launch vehicle for the lunar mission, we must have a parallel development of both a solid and liquid fueled large launch vehicle. The program on nuclear rockets must be prosecuted vigorously on a research and development basis. It is not believed that the nuclear rocket can play a role in the earliest attempt at manned lunar landing. The nuclear rockets will be needed in the even more difficult mission following manned lunar exploration. Use of the nuclear rocket for missions is not expected until after 1970 although flight test for developing the rocket will occur before then.

[13]

5a. "Are we making a maximum effort?"

No, the space program is not proceeding with a maximum effort. Additional capability exists in this country which could be utilized in this task. However, we believe that the manpower facilities and other resources now assigned are being utilized in an aggressive fashion.

5b. "Are we achieving necessary results?"

Our program is directed towards unmanned scientific investigation of space, manned exploration of space, and application of satellites to communication and meteorological systems. The scientific investigation is achieving basic knowledge important for a better understanding of the universe and also provides data necessary for the achievement of manned space flight and the satellite applications. It is generally agreed that our scientific program is yielding most significant results.

The Mercury program is the first and necessary step in an ongoing program leading to the manned laboratory, circumlunar flight, and manned lunar landing discussed under Item 1. A manned ballistic flight is scheduled in May, unmanned orbital flights and orbital flights with chimpanzee are scheduled for the Spring and Summer providing the background for the manned flight planned in 1961.

Future manned flight depends upon improved launch vehicle capability as well as a new spacecraft for the crew. The Saturn will [14] provide our first capability for large payloads but must be followed by a still larger vehicle for manned lunar landing. The launch vehicle for the first manned lunar landing will utilize either clustered F-1 liquid engines or solid propellant motors as discussed in item 4. We are achieving necessary technical data on the liquid engines but not on the large solid rocket engines. Ultimately, nuclear propulsion will be used to carry heavy payloads long distances into space. With our great capacity for engine research we have the capacity in this country to proceed more rapidly towards our objectives.

The TIROS and Echo satellites have provided important background data for meteorological and communication satellite systems. Additional experimentation is required in both fields before operational systems can be completely defined. We are continuing our meteorological program with TIROS flights and will use a newly-designed satellite called Nimbus when it is available in 1962. The first communication satellite (Echo) was a 100-ft. balloon which reflected ultra-high frequency signals between transmitters and receivers. The Echo type experiment is continuing and in addition we are instituting a program called Relay which carries microwave equipment for power amplification. This process decreases the requirements on the ground equipment but requires electronic equipment in the satellite with extremely high reliability compared to present day standards.

[15]

In summary, we are achieving significant scientific and technical results. We welcome the opportunity of reviewing these results with you to ensure that these results are compatible with our national goals.

Document II-10

April 29, 1961

Dear Mr. Vice President:

This is an attempt to answer some of the questions about our national space program raised by The President in his memorandum to you dated April 20, 1961. I should like to emphasize that the following comments are strictly my own and do not necessarily reflect the official position of the National Aeronautics and Space Administration in which I have the honor to serve.

Question 1. Do we have a chance of beating the Soviets by putting a laboratory in space, or by a trip around the moon, or by a rocket to land on the moon, or by a rocket to go to the moon and back with a man? Is there any other space program which promises dramatic results in which we could win?

Answer: With their recent Venus shot, the Soviets demonstrated that they have a rocket at their disposal which can place 14,000 pounds of payload in orbit. When one considers that our own one-man Mercury space capsule weighs only 3900 pounds, it becomes readily apparent that the Soviet carrier rocket should be capable of

— launching *several* astronauts into orbit simultaneously. (Such an enlarged multi-man capsule could be considered and could serve as a small "laboratory in space.")

— soft-landing a substantial payload on the moon. My estimate of the maximum soft-landed net payload weight the Soviet rocket is capable of is about 1400 pounds (one-tenth of its low orbit payload). This weight capability is *not* sufficient to include a rocket for the *return flight* to earth of a man landed on the moon. But it is entirely adequate for a powerful radio transmitter which would relay lunar data back to earth and which would be *abandoned* on the lunar surface after completion of this mission. A similar mission is planned for our "Ranger" project, which uses an Atlas-Agena B boost rocket. The "semi-hard" landed portion of the Ranger package weighs 293 pounds. Launching is scheduled for January 1962.

The existing Soviet rocket could furthermore hurl a 4000 to 5000 pound capsule *around* the moon with ensuing re-entry into the earth atmosphere. This weight allowance must be considered marginal for a one-man round-the-moon voyage. Specifically, it would not suffice to provide the capsule and its occupant with a "safe abort and return" capability, a feature which under NASA ground rules for pilot safety is considered mandatory for all manned space flight missions. One should not overlook the possibility, however, that the Soviets may substantially facilitate their task by simply waiving this requirement.

A rocket about ten times as powerful as the Soviet Venus launch rocket is required to land a man on the moon and bring him back to earth. Development of such a super rocket can be circumvented by orbital rendezvous and refueling of smaller rockets, but the development of this technique by the Soviets would not be hidden from our eyes and would undoubtedly require several years (possibly as long or even longer than the development of a large direct flight super rocket).

a) we do *not* have a good chance of beating the Soviets to a manned "*laboratory in space*." The Russians could place it in orbit this year while we could establish a (somewhat heavier) laboratory only after the availability of a reliable Saturn C-1 which is in 1964.

b) we *have* a sporting chance of beating the Soviets to a soft-landing of a radio *transmitter station on the moon.* It is hard to say whether this objective is on their program, but as far as the launch rocket is concerned, they could do it at any time. We plan to do it with the Atlas-Agena B- Ranger #3 in early 1962.

[3] c) we have a sporting chance of sending a 3-man crew *around the moon* ahead of the Soviets (1965/66). However, the Soviets could conduct a round-the-moon voyage earlier if they are ready to waive certain emergency safety features and limit the voyage to one man. My estimate is that they could perform this simplified task in 1962 or 1963.

d) we have an excellent chance of beating the Soviets to the *first landing of a crew on the moon* (including return capability, of course). The reason is that a performance jump by a factor 10 over their present rockets is necessary to accomplish this feat. While today we do not have such a rocket, it is unlikely that the Soviets have it. Therefore, we would not have to enter the race toward this obvious next goal in space exploration against hopeless odds favoring the Soviets. With an all-out crash program I think we could accomplish this objective in 1967/68.

Question 2. How much additional would it cost?

Answer: I think I should not attempt to answer this question before the exact objectives and the time plan for an accelerated United States space program have been determined. However, I can say with some degree of certainty that the necessary funding increase to meet objective d) above would be well over $1 Billion for FY 62, and that the required increases for subsequent fiscal years may run twice as high or more.

Question 3. Are we working 24 hours a day on existing programs? If not, why not? If not, will you make recommendations to me as to how work can be speeded up.

Answer: We are *not* working 24 hours a day on existing programs. At present, work on NASA's Saturn project proceeds on a basic one-shift basis, with overtime and multiple shift operations approved in critical "bottleneck" areas.

During the months of January, February and March 1961, NASA's George C. Marshall Space Flight Center, which has systems management for the entire Saturn vehicle and develops the large first stage as an in-house project, has worked an average of 46 hours a week. This includes all administrative and clerical activities. In the areas critical for the Saturn project (design activities, assembly, inspecting, testing), average working time for the same period was 47.7 hours a week, with individual peaks up to 54 hours per week.

Experience indicates that in Research & Development work longer hours are not conducive to progress because of hazards introduced by fatigue. In the aforementioned critical areas, a second shift would greatly alleviate the tight scheduling situation. However, additional funds and personnel spaces are required to hire a second shift, and neither are available at this time. *In this area, help would be most effective.*

Introduction of a *third* shift *cannot* be recommended for Research & Development work. Industry-wide experience indicates that a two-shift operation with moderate but not excessive overtime produces the best results.

In industrial plants engaged in the Saturn program the situation is approximately the same. Moderately increased funding to permit greater use of premium paid overtime, prudently applied to real "bottleneck" areas, can definitely speed up the program.

Question 4. In building large boosters should we put our emphasis on nuclear, chemical or liquid fuel, or a combination of these three?

Answer: It is the consensus of opinion among most rocket men and reactor experts that the future of the nuclear rocket lies in deep-space operations (upper stages of chemically-boosted rockets or nuclear space vehicles departing from an orbit around the earth) rather than in launchings (under nuclear power) from the ground. In addition, there can be little doubt that the basic technology of nuclear rockets is still in its early infancy. The nuclear rocket should therefore be looked upon as a promising means to extend and expand the scope of our space operations in the years beyond 1967 or 1968. It should not be considered as a serious contender in the big booster problem of 1961.

The foregoing comment refers to the simplest and most straightforward type of nuclear rocket, viz. the "heat transfer" or "blow-down" type, whereby liquid hydrogen is evaporated and superheated in a very hot nuclear reactor and subsequently expanded through a nozzle.

There is also a fundamentally different type of nuclear rocket propulsion system in the works which is usually referred to as "ion rocket" or "ion propulsion." Here, the nuclear energy is first converted into electrical power which is then used to expel "ionized" (i.e., electrically charged) particles into the vacuum of outer space at extremely high speeds. The resulting reaction force is the ion rocket's "thrust." It is in the very nature of nuclear ion propulsion systems that they cannot be used in the atmosphere. While very efficient in propellant economy, they are capable only of very small thrust forces. Therefore they do not qualify as "boosters" at all. The future of nuclear ion propulsion lies in its application for low-thrust, high-economy cruise power for interplanetary voyages.

As to "chemical or liquid fuel" The President's question undoubtedly refers to a comparison between "solid" and "liquid" rocket fuels, both of which involve chemical reactions.

At the present time, our most powerful rocket boosters (Atlas, first stage of Titan, first stage of Saturn) are all liquid fuel rockets and all available evidence indicates that the Soviets are also using liquid fuels for their ICBM's and space launchings. The largest solid fuel rockets in existence today (Nike Zeus booster, first stage Minuteman, first stage Polaris) are substantially smaller and less powerful. There is no question in my mind that, when it comes to building very powerful booster rocket systems, the body of experience available today with liquid fuel systems greatly exceeds that with solid fuel rockets.

There can be no question that larger and more powerful solid fuel rockets can be built and I do not believe that major breakthroughs are required to do so. On the other hand it should not be overlooked that a casing filled with solid propellant and a nozzle attached to it, while entirely capable of producing thrust, is not yet a rocket ship. And although the reliability record of solid fuel rocket *propulsion units*, thanks to their simplicity, is impressive and better than that of liquid propulsion units, this does not apply to *complete rocket systems*, including guidance systems, control elements, stage separation, etc.

Another important point is that booster performance should not be measured in terms of thrust force alone, but in terms of total impulse; i.e., the product of thrust force and operating time. For a number of reasons it is advantageous not to extend the burning time of solid fuel rockets beyond about

60 seconds, whereas most liquid fuel boosters have burning time of 120 seconds and more. Thus, a 3-million pound thrust solid rocket of 60 seconds burning time is actually not more powerful than a 1 1/2-million pound thrust liquid booster of 120 seconds burning time.

I consider it rather unfortunate that several solid fuel rocket manufacturers (with little or no background in developing complete missile systems) have recently initiated a publicity campaign obviously designed to create the impression that a drastic switch from liquid to solid rockets would miraculously cure all of this country's big booster ills. I am convinced that if we recklessly abandon our liquid fuel technology in favor of something we do not yet understand so well, we would be heading for disaster and lose even more precious time.

My recommendation is to substantially increase the level of effort and funding in the field of solid fuel rockets (by 30 or 50 million dollars for FY 62) with the immediate objectives of

- demonstration of the feasibility of very large segmented solid fuel rockets. (Handling and shipping of multi-million pound solid fuel rockets become unmanageable unless the rockets consist of smaller individual segments which can be assembled in building block fashion at the launching site.)

- development of simple inspection methods to make certain that such huge solid fuel rockets are free of dangerous cracks or voids

- determination of the most suitable operational methods to ship, handle, assemble, check and launch very large solid fuel rockets. This would involve a series of paper studies to answer questions such as

a. Are clusters of smaller solid rockets, or huge, single poured-in-launch-site solid fuel rockets, possibly superior to segmented rockets? This question must be analyzed not just from the propulsion angle, but from the operational point of view for the total space transportation system and its attendant ground support equipment.

b. Launch pad safety and range safety criteria (How is the total operation at Cape Canaveral affected by the presence of loaded multi-million pound solid fuel boosters?)

c. Land vs. off-shore vs. sea launchings of large solid fuel rockets.

d. Requirements for manned launchings (How to shut the booster off in case of trouble to permit safe mission abort and crew capsule recovery? If this is difficult, what other safety procedures should be provided?)

Question 5. Are we making maximum effort? Are we achieving necessary results?

Answer: No, I do *not* think we are making maximum effort.

In my opinion, the most effective steps to improve our national stature in the space field, and to speed things up would be to

- identify a few (the fewer the better) goals in our space program as objectives of highest national priority. (For example: Let's land a man on the moon in 1967 or 1968.)

- identify those elements of our present space program that would qualify as immediate contributions to this objective. (For example, soft landings of suitable instrumentation on the moon to determine the environmental conditions man will find there.)

- put all other elements of our national space program on the "back burner."

- add another more powerful liquid fuel booster to our national launch vehicle program. The design parameters of this booster should allow a certain flexibility for desired program reorientation as more experience is gathered.

Example: Develop in addition to what is being done today, a first-stage liquid fuel booster of twice the total impulse of Saturn's first stage, designed to be used in clusters if needed. With this booster we could

a. double Saturn's presently envisioned payload. This additional payload capability would be very helpful for soft instrument landings on the moon, for circumlunar flights and for the final objective of a manned landing on the moon (if a few years from now the route via orbital re-fueling should turn out to be the more promising one.)
b. assemble a much larger unit by strapping three or four boosters together into a cluster. This approach would be taken should, a few years hence, orbital rendezvous and refueling run into difficulties and the "direct route" for the manned lunar landing thus appears more promising.

[9]

In addition, relief in certain administrative areas would be mandatory. In my opinion, the two most serious factors causing delays in our space program are:

1. Lack of flexibility in the use of approved funds and in adapting the program to the changes caused by rapidly acquired new knowledge and experience. After the Congress and The President have established the funding level at which the aforementioned national high-priority objective is to be supported, all restraints as to how these funds are to be applied should be removed. At the present time such restraints include:

- Funds assigned to "Research and Development" may not be used to build facilities in support of R&D, and vice versa.

- Government installations such as the Marshall Space Flight Center are unable to hire more personnel or establish a second shift because "personnel spaces" are lacking. Such "spaces" must, of course, be supported with adequate salary funds, but an increase in such funds alone does not yet provide the spaces.

2. Contracting procedures. Contracting procedures must be simplified. This probably requires some special directives from the highest level. To illustrate the present dilemma: If NASA plans to let a contract for a new stage of Saturn, the first step is a wide-open invitation to everybody interested to attend a bidder's briefing. Here, the interested parties are told what the stage looks like, that substantial facilities are required to develop it, and that each bidder must prepare a very detailed proposal (which might cost him as much as $300,000 to $500,000 to prepare) before the contractor can be selected. This first go-round will usually discourage 80 per cent of the original bidders, but takes approximately eight weeks. In the meantime, NASA must prepare detailed specifications.

For the actual preparation of the proposal the contractors must be given several weeks. Usually, six to ten companies will participate in the final bid. In order to be competitive, these bids must be prepared by the best scientists and engineers at the contractor's proposal. Evaluation of all these many proposals takes [10] additional weeks. Before the contract can be signed, eight to ten months usually have elapsed since initiation of the contracting procedure, and several million dollars worth of efforts of the best rocket and missile brains have been spent.

While there is certainly some merit in this long, drawn-out competitive procedure, we must realize that our Soviet competitors are not faced with some of these problems, simply because the issue of possible favoritism does not exist in a country where all industry is government-owned.

My suggestion is <u>not</u> to switch to indiscriminate sole source procurement, but to limit the participation in important and difficult technological developments to those few companies who really have the resources, the experience and the available capacity to execute the job effectively. With a hungry aircraft and automotive industry, it is not surprising that at the present time the contracting NASA agency is subjected to all kinds of pressure aimed at giving additional contractors a chance to prove themselves. But the NASA agency involved usually knows very well the few companies which really possess the capabilities needed.

Summing up, I should like to say that in the space race we are competing with a determined opponent whose peacetime economy is on a wartime footing. Most of our procedures are designed for orderly, peacetime conditions. I do not believe that we can win this race unless we take at least some measures which thus far have been considered acceptable only in times of a national emergency.

Yours respectfully,
/s/
Wernher von Braun

Document II-11

8 May 1961

Dear Mr. Vice President:

Attached to this letter is a report entitled "Recommendations for Our National Space Program: Changes, Policies, Goals", dated 8 May 1961. This document represents our joint thinking. We recommend that, if you concur with its contents and recommendations, it be transmitted to the President for his information and as a basis for early adoption and implementation of the revised and expanded objectives which it contains.

Very respectfully,

James E. Webb
Administrator

National Aeronautics and
Space Administration

Robert S. McNamara
Secretary of Defense

[1] **Introduction**

It is the purpose of this report (1) to describe changes to our national space efforts requiring additional appropriations for FY 1962; (2) to outline the thinking of the Secretary of Defense and the Administrator of NASA concerning U.S. status, prospects, and policies for space; and (3) to depict the chief goals which in our opinion should become part of Integrated National Space Plan. These matters are covered in Sections I, II, III, respectively.

Three appendices (Tabs A through C) [not included] support these sections. Tab A highlights the Soviet space program. The bulk of this Tab (Attachment A) is separated from this report since it bears a special security classification. Tab B includes a description of major U.S. space projects and elements. Tab C provides financial summaries of the present programs, the proposed add-ons, and future costs of the program.

The first joint report contains the results of extensive studies and reappraisals. It is a first and not our last report and does not, of course, represent a complete or final word about our space undertakings.

[pp. 2- 6 not included]

[7] II. NATIONAL SPACE POLICY

The recommendations made in the preceding Section imply the existence of national space goals and objectives toward which these and other projects are aimed. Major goals are summarized in Section III. Such goals must be formulated in the context of a national policy with respect to undertakings in space. It is the purpose of this Section to highlight our thinking concerning the direction that such national policy needs to take and to present a backdrop against which more specific goals, objectives and detailed policies should, in our opinion, be formulated.

a. Categories of Space Projects

Projects in space may be undertaken for any one of four principal reasons. They may be aimed at gaining scientific knowledge. Some, in the future, will be of commercial or chiefly civilian value. Several current programs are of potential military value for functions such as reconnaissance and early warning. Finally, some space projects may be undertaken chiefly for reasons of national prestige.

The U.S. is not behind in the first three categories. Scientifically and militarily we are ahead. We consider our potential in the commercial/civilian area to be superior. The Soviets lead in space spectaculars which bestow great prestige. They lead in launch vehicles needed for such missions. These bestow a lead in capabilities which may some day become important from a military point of view. For these reasons it is important that we take steps to insure that the current and future disparity between U.S. Soviet launch capabilities be removed in an orderly but timely way. Many other factors however, are of equal importance.

b. Space Projects for Prestige

All large scale space projects require the mobilization of resources on a national scale. They require the development and successful application of the most advanced technologies. They call for skillful management, centralized control and unflagging pursuit of long range [8] goals. Dramatic achievements in space, therefore, symbolize the technological power and organizing capacity of a nation.

It is for reasons such as these that major achievements in space contribute to national prestige. Major successes, such as orbiting a man as the Soviets have just done, lend national prestige even though the scientific, commercial or military value of the undertaking may by ordinary standards be marginal or economically unjustified.

This nation needs to make a positive decision to pursue space projects aimed at enhancing national prestige. Our attainments are a major element in the international competition between the Soviet system and our own. The non-military, non-commercial, non-scientific but "civilian" projects such as lunar and planetary exploration are, in this sense, part of the battle along the fluid front of the cold war. Such undertakings may affect our military strength only indirectly if at all, but they have an increasing effect upon our national posture.

c. Planning

It is vital to establish specific missions aimed mainly at national prestige. Such planning must be aimed at both the near-term and at the long range future. Near-term objective alone will not suffice. The management mechanisms established to implement long range plans must be capable of sustained centralized direction and control. An immediate task is to specify long-range goals, to describe the missions to be accomplished, to define improved management mechanisms, to select the launch vehicles, the spacecraft, and the essential building blocks needed to meet mission goals. The long-term task is to manage national resources from the national level to make sure our goals are met.

It is absolutely vital that national planning be sufficiently detailed to define the building blocks in an orderly and integrated way. It is absolutely vital that national management be equal to the task of focusing resources, particularly scientific and engineering manpower [9] resources, on the essential building blocks. It is particularly vital that we do not continue to make the error of spreading ourselves too thin and expect to solve our problems through the mere appropriation and expenditure of additional funds.

[remainder of p.9 – p. 12 not included]

[13] III. MAJOR NATIONAL SPACE GOALS

It is the purpose of this section to outline some of the principal goals, both long range and short range, toward which our national space efforts should, in our opinion, be directed. It is not the intent to specify all of the goals or even all of the major goals of importance to a National Space Plan. We wish to stress five principal objectives which in our opinion have not been adequately formulated or accepted in the past and which we believe should be accepted as a basis for specific project undertakings in the years ahead.

a. Manned Lunar Exploration

We recommend that our National Space Plan include the objective of manned lunar exploration before the end of this decade. It is our belief that manned exploration to the vicinity of and on the surface of the moon represents a major area in which international competition for achievement in space will be conducted. The orbiting of machines is not the same as the orbiting or landing of man. It is man, not merely machines, in space that captures the imagination of the world.

The establishment of this major objective has many implications. It will cost a great deal of money. It will require large efforts for a long time. It requires parallel and supporting undertakings which are also costly and complex. Thus, for example, the RANGER and SURVEYOR Projects and the technology associated with them must be undertaken and must succeed to provide the data, the techniques and the experience without which manned lunar exploration cannot be undertaken.

The Soviets have announced lunar landing as a major objective of their program. They may have begun to plan for such an effort years ago. They may have undertaken important first steps which we have not begun.

It may be argued, therefore, that we undertake such an objective with several strikes against us. We cannot avoid announcing not only our general goals but many of our specific plans, and our successes [14] and our failures along the way. Our cards are and will be face up-their's are face down.

Despite these considerations we recommend proceeding toward this objective. We are uncertain of Soviet intentions, plans or status. Their plans, whatever they may be, are not more certain of success than ours. Just as we accelerated our ICBM program we have accelerated and are passing the Soviets in important areas in space technology. If we set our sights on this difficult objective we may surpass them here as well. Accepting the goal gives us a chance. Finally, even if the Soviets get there first, as they may, and as some think they will, it is better for us to get there second than not at all. In any event we will have mastered the technology. If we fail to accept this challenge it may be interpreted as a lack of national vigor and capacity to respond.

[remainder of memorandum not included]

Document II-12

Document Title: Bruce Lundin et al., "A Survey of Various Vehicle Systems for the Manned Lunar Landing Mission," 10 June 1961.

Source: Folder 18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

Once the decision to go to the Moon had been made, NASA had to decide how to achieve that goal. At the time of President Kennedy's decision, the leading plan was to use a very large launch vehicle called Nova to carry a spacecraft directly to the lunar surface. An alternative to this "direct ascent" approach was to carry out rendezvous operations at some location during the lunar landing mission. This study was the first of several between June 1961 and June 1962 that evaluated various rendezvous approaches and compared them to an approach using a very large booster, designated Nova. Based on its results, some sort of rendezvous in Earth orbit was given increasingly serious consideration as an alternative to the direct ascent approach for the rest of 1961. This study was also the first to examine rendezvous in lunar orbit, which in 1962 emerged as NASA's preferred approach to accomplishing the lunar landing.

A SURVEY OF VARIOUS VEHICLE SYSTEMS FOR

THE MANNED LUNAR LANDING MISSION

by

Bruce T. Lundin – Lewis, Chairman
Walter J. Downhower – JPL
A.J. Eggers, Jr. – Ames
Lt. Col. George W. S. Johnson – USAF
Laurence K. Loftin, Jr. – Langley
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William J. D. Escher – Hdqs., Secretary
Ralph W. May, Jr. – Hdqs., Secretary

June 10, 1961

[no page number]

A SURVEY OF VARIOUS VEHICLE SYSTEMS FOR

THE MANNED LUNAR LANDING MISSION

I. INTRODUCTION

In response to the request of the Associate Administrator on May 25, 1961, it has been undertaken to assess a wide variety of systems for accomplishing a manned lunar landing in the 1967-1970 time period. This study has, as directed, placed primary emphasis on the launch vehicle portions of the systems, including vehicle sizes, types and staging. In addition a number of variations on the use of rendezvous to add flexibility and improve energy management in the lunar mission have been considered. The results of this study are the subject of the present report, and they are discussed in the following order.

First, the use of rendezvous to achieve a manned lunar landing is discussed in terms of rendezvous locations, vehicle types, and mission requirements, and the more attractive types of rendezvous are rated in the light of these considerations. Then a number of alternate Nova's for accomplishing the manned lunar mission are discussed briefly, and some consideration is given to the attendant question of launch sites, booster recovery, and the role of man in the system. Finally, the various methods for achieving manned lunar landing are compared in terms of time phasing, reliability, and approximate cost.

II. MISSION STAGING BY RENDEZVOUS

II. 1. General

Mission staging by rendezvous has been the subject of much investigation at Marshall, Langley, Ames, Lewis, and JPL. The work has concerned itself with analytical and simulator studies of orbital mechanics, and control and guidance problems as applied to rendezvous. Such critical questions as launch timing, and automatic and piloted guidance of the vehicles to a rendezvous have been carefully analyzed. Orbital refueling as well as attachment of self-contained modules have been considered.

Because the use of rendezvous permits the accomplishment of a given mission in a number of different ways employing different launch vehicles, the various groups working on rendezvous have arrived [2] at a number of different concepts for accomplishing the lunar landing mission. The assumptions made by the different groups with regard to such parameters as return weight, specific impulse, etc., were, however, consistent to the extent that meaningful comparisons can be made between the different concepts. In the discussion to follow, the more attractive rendezvous concepts will be summarized, after which the advantages and disadvantages of each will be indicated and a rating system developed.

II 1. a: Mission Types

The rendezvous concepts which will be considered for the lunar landing are as follows:

1. Rendezvous in earth orbit;

2. Rendezvous in lunar orbit after take-off from the lunar surface;
3. Rendezvous in both earth and lunar orbit;
4. Rendezvous on the lunar surface.

Also possible are:

5. Rendezvous in transit to the moon;
6. Rendezvous in lunar orbit before landing.

Although advantages can be claimed for concepts 5 and 6, they are excluded from consideration because they are clearly inferior to concepts 1 through 4.

II. 1. b: Vehicles Considered

The vehicles considered were restricted to those employing engines presently under development. These vehicles are:

(a) Saturn C-2 which has the capability of placing about 45,000 pounds in earth orbit and 15,000 pounds in an escape trajectory;

(b) Saturn C-3 which has the capability of placing about 110,000 pounds in earth orbit and 35,000 pounds in an escape trajectory. The configuration of the C-3 considered here employs the following staging:

[3]

First	2 F-l
Second	4 J-2
Third	6 LR115

II. 1. c: Mission Requirements

The significant requirements employed in this examination of the manned lunar mission are as follows:

1. Return spacecraft weight -- 12,500 lbs.

2. Velocity increments (60 hr. transfer)

earth orbit to escape	10,600 fps
braking into lunar orbit	3,400 fps
lunar landing	6,860 fps
lunar ascent and return	9,930 fps

3. Stage mass fractions

launch and transfer stages	0.90
lunar landing stage	0.87

4. Impulses

hydrogen-oxygen	420 sec
storable propellants	300 sec

These figures and estimates are considered reasonable and consistent with those used in the concurrent Nova studies. With this information we can now match the previously discussed vehicles and rendezvous concepts.

II. 2. Mission Vehicle Matching

II. 2. a: Earth Rendezvous Only.

On the basis of the preceding paragraph, the following weights at different stages of the mission pertain to the case of rendezvous in earth orbit only (based on H202 performance):

[4]

Weight returned to vicinity of earth	12, 500 pounds
Lunar take-off weight	28, 800 pounds
Weight landed on moon	31, 000 pounds
Weight in escape trajectory	73, 000 pounds
Weight in earth orbit	210, 000 pounds

These weights indicate that five C-2's or two C-3's are required in order to accomplish the mission.

II. 2. b: Lunar Rendezvous.

A concept in which a rendezvous is made in lunar orbit only or together with earth orbit rendezvous possesses basic advantages in terms of energy management and thus launch vehicle requirements. This approach involves placing the complete spacecraft in orbit about the moon at a relatively low altitude. One or two of the three-man crew then descends to the lunar surface in a special capsule which detaches from the spacecraft. Upon leaving the lunar surface, the capsule performs a rendezvous with that portion of the spacecraft which remained in lunar orbit. The lunar capsule is, of course, left behind on the return trip of the spacecraft to earth. A variation on this approach involves two lunar landing capsules, one of which remains with the "mother" ship and can be used for rescue operations on the lunar surface.

The basic advantage of the system is that the propellant required for the lunar landing and take-off is reduced which in turn translates into a reduction in the amount of weight which must be put into an escape trajectory. The escape weight saving achieved is related to the fraction of the spacecraft weight which is retained in lunar orbit. The actual weight saving which can be realistically achieved by this method can only be determined after detailed consideration of the design and integration of the complete spacecraft. Calculations suggest, however, that the amount of weight which must be put into an escape trajectory for a given reentry vehicle weight might be reduced by a factor of two by use of the lunar rendezvous technique. The earth booster requirement might therefore be reduced to one C-3 with lunar rendezvous or two to three C-2 's with earth and lunar rendezvous.

II. 2. c. Lunar Surface Rendezvous

This scheme envisions accomplishment of the initial manned lunar mission with C-2 launched vehicles assembled on the lunar surface. An unmanned transport spacecraft launched by a C-2 can deposit an approximately 5, 000 lb. payload on the moon. (No.1 on fig. 7).[not included] Previous SURVEYOR or RANGER shots would establish the landing spot and provide [5] homing beacons, TV monitoring equipment, and so forth (Items 4, 5, and 6 on fig. 7). [not included]

A number of methods for refueling on the lunar surface may be envisioned. One possible concept may be recounted as follows: Four 5,000 lb. refueler vehicles (Item 2 on fig. 7) [not included]would be landed approximately equally spaced around a spacecraft carrying a capsule suitable for returning one man to the earth, and within 45 feet of it. Solid propulsion units would be transferred from the refuelers to the centrally located spacecraft by means of specially designed transfer tracks. The assembly operation would be monitored by TV, and the assembled vehicle would be checked out before sending man from earth to the area via a second landing capsule (Item 3). [not included] The space station would be capable of maintaining itself in the lunar environment. The astronaut would walk from the landing capsule to the take-off vehicle and depart for earth. The four solid rockets used for launch from the lunar surface would be identical to the four retro-rockets used for each vehicle in landing on the moon. These retro-rockets would be jettisoned before touchdown and a soft landing controlled with liquid vernier rockets. A great deal of the technology developed for SURVEYOR would be utilized in this concept for manned lunar landing. The return vehicle weight would be approximately 5,500 lbs. at lunar injection, 5,200 lbs. as the earth is approached, and 3,500 to 4,000 lbs. at earth reentry. Careful study of Apollo study contractor results has indicated this to be adequate for a full-sized three-man Apollo capsule having only one man aboard. (Further description is given in Appendix II-2-c.) [not included]

Saturn C-2's would be used throughout for earth-based launch vehicles. A minimum of 6 successful launches would be required for the basic mission. The actual number required to accomplish the mission would be a direct function of the success rate of the firings and assembly operations on the lunar surface; however, any failure before manned capsule landing does not affect the success of the manned lunar landing sequence. Identical transport spacecraft would be used in all C-2 launches; also, only the payloads would differ, i.e., capsules or return propellant.

[6]

II. 2. d: Mixed Nova-Saturn Operations for the Time Period 1966 – 1969

Basic launch vehicles available in the time period of interest to accomplish the manned lunar landing and return missions may be both the SATURN and NOVA. Two basic modes of operations using either SATURN or NOVA are as follows:

1. The NOVA vehicle places the spacecraft with or without capsule in the waiting orbit first. A SATURN vehicle standing by on a launch pad will be launched with the lunar crew after the orbit of the NOVA payload has been established, and will rendezvous with the remainder of the spacecraft in the waiting orbit. If desirable either the entire capsule will be mechanically connected with the spacecraft or the crew changes ships only. The SATURN at this time will have had around 30 flights, and therefore be considerably more reliable than the NOVA. The very first NOVA which successfully orbits the payload will offer the first chance for a manned lunar landing. This procedure is expected to save one year in the total program schedule, and possibly to reduce overall cost as a smaller number of NOVA vehicles is required.

2. Same procedure as outlined under 1., but the entire lunar return vehicle with a payload of approximately 60, 000 lbs. will be orbited by a SATURN C-3 and will rendezvous (including docking) with the NOVA payload, which is a stage used both for acceleration to escape and for the landing maneuver on the moon. This procedure offers a 20 percent performance margin and can be used in case the capsule reentry weight should grow beyond the maximum design weight for which the original NOVA was designed.

[Sections II.3 – II.6 not included] …

[16] II. 7. Summary Rating

Various combinations *of* boosters and rendezvous concepts for performing the manned lunar mission were reviewed. Guidelines which were adopted for the rating process placed primary emphasis on (1) ability to accomplish the lunar landing mission as soon as possible and (2) relative reliability of the concept. Considerably lesser importance was attached to cost and/or growth potential for other future space missions.

The results are tabulated in the following table.

Rendezvous Concepts	Order *of* Preference by each committee member						Total
	A	B	C	D	E	F	
Earth RV with 5-7 C-2's	4	4	4	6	3	3	24
Earth RV with 2-3 C-3's	2	1	1	1	2	1	8
Lunar RV with 1 C-3	5	3	2	3	4	4	21
Earth and Lunar RV with C-2's	6	6	3	5	5	5	30
RV on Lunar Surface	3	5	6	4	1	6	25
Earth RV with NOVA and C-l	1	2	5	2	6	2	18

The concept of a low altitude earth orbit rendezvous utilizing Saturn C-3's is a clear preference by the group.

[Sections III-VI not included]

[26]

Mission staging by rendezvous offers two advantages of particular significance to such large, complex, and long-range missions as a manned lunar landing. Because both future payload requirements and vehicle capability are uncertain at best, the ability to increase payload by adding a vehicle to the operation reduces the critical dependance [*sic*] of future mission capability on decisions relating to launch vehicle design and development. The inherently smaller vehicles associated with this method also permit the development of effective and efficient launch vehicles with engines currently in development.

Of the various orbital operations considered, the use of rendezvous in earth orbit by two or three Saturn C-3 vehicles (depending on estimated payload requirements) was strongly favored. This preference stemmed largely from the small number of orbital operations required and the fact that the C-3 is considered an efficient vehicle of large utility and future growth.

The rendezvous technique itself, in terms of launch operations, guidance and control, and orbital operations, is considered feasible of development within the time period of interest. Some justification for this point of view is found in both current technology and in the fact that many of the technological advancements required for the lunar landing and take-off operations are applicable to the rendezvous with an artificial satellite.

[27]

The principal difficulties involved in the development of a new 4,000,000 pound RP-LOX engine for a NOVA vehicle are associated with size and the development time span required through PFRT is estimated at 6 years. If a NOVA vehicle incorporating a new large engine development is contemplated, the Phoenix concept possesses sufficient attractive features to warrant serious study. The utilization of pressurized storable propellants for a large first-stage engine offer important reductions in complexity; solid rocket engines are, however, believed to offer even greater simplification without significant performance differences. The "standpipe" concept of propellant delivery through acceleration-head effects incorporates sufficient difficulties of engine system development and manned abort capability as to render it unattractive for application to a NOVA vehicle.

Document II-13

Document Title: Ernest W. Brackett, Director, Procurement & Supply, to Robert R. Gilruth, Space Task Group, "Transmittal of Approved Project Apollo Spacecraft Procurement Plan and Class Determination and Findings," 28 July 1961, with attached: Robert C. Seamans, Jr., Associate Administrator, "Project Apollo Spacecraft Procurement Plan," 28 July 1961; Robert C. Seamans, Associate Administrator, to Robert R. Gilruth, Space Task Group, "Appointment of Source Evaluation Board," 25 July 1961; James E. Webb, Administrator, "Establishment of Sub-Committees to the NASA Source Evaluation Board Project Apollo," 25 July 1961.

Source: Folder 18675, NASA Historical Reference Collection, History Division, NASA headquarters, Washington, DC.

Once President Kennedy had established the lunar goal, NASA had to establish procurement procedures for the necessary equipment, as well as evaluation boards for approving contractors. The first major element of Project Apollo to be put under contract would be the Apollo spacecraft. Procedures and committees for the spacecraft procurement were established just over two months after President Kennedy's announcement of Project Apollo on 25 May 1961.

Washington 25, D.C.
July 28, 1961

From: NASA Headquarters

To: Space Task Group

ATTENTION: Mr. Robert R. Gilruth

Subject: Transmittal of Approved Project Apollo Spacecraft Procurement Plan and Class Determination and Findings

Reference: (a) Director, Space Task Group letter of June 26, 1961 to NASA Headquarters transmitting proposed Project Apollo Procurement Plan

1. Reference (a) forwarded a proposed procurement plan for Project Apollo. As a result of reviews made by various offices of NASA Headquarters a

revised procurement plan for Project Apollo Spacecraft has been signed by the Associate Administrator under date of July 28, 1961, and is attached hereto as Enclosure 1. Also attached as Enclosure 2, is the Class Determination and Findings for this project which was signed by the Administrator under date of July 25, 1961.

2. A paragraph has been included in the approved procurement plan (first paragraph, page 4) which provides that, "Prior to commencement of negotiations, NASA will develop a contract clause which will assure NASA control over the selection and retention of the Contractor's key personnel assigned to the project." For your information, the Associate Administrator interprets this paragraph to mean that the number of key personnel that NASA will exercise control over should be restricted to a number not exceeding ten, and if at all possible, some lesser number.

3. The Director of Reliability, NASA Headquarters, recommended that Mr. James T. Koppenhaver of his office be added to the Source Evaluation Board as a non-voting member in accordance with NASA General Management Instruction 2-4-3. This has been done. He also recommends that Dr. William Wolman of the Office of Reliability, NASA Headquarters, be made a member of the technical subcommittee. He also suggests that consideration be given to establishing a subcommittee consisting of two members of NASA Headquarters and three members of Space Task Group to evaluate the reliability and quality assurance aspects of the proposals. The last suggestions submitted, without recommendation, for your consideration.

[signed]
Ernest W. Brackett Director,
Procurement & Supply

[2]

<u>PROJECT APOLLO SPACECRAFT PROCUREMENT PLAN</u>

The procurement plan describes in brief the requirements for Project Apollo, the overall procurement program, and specifies the policies and procedures to be utilized in the selection of a qualified contractor who will be responsible for the development of the Command Module and Service Module for all missions and for performing systems integration and systems engineering.

<u>DESCRIPTION OF PROJECT APOLLO SCOPE OF WORK</u>

1. <u>Missions</u>. Project Apollo will be developed in three separate but related mission concepts:

   a. <u>Phase "A"</u>. A manned spacecraft to be placed in orbit around the earth at 300 nautical mile altitude for a two-week duration for the purpose of developing space flight technology and conducting scientific experimentation. The spacecraft is to be capable of rendezvous in earth orbit.

b. Phase "B". A manned spacecraft for circumlunar and orbital flight around the moon at an appropriate height and duration to permit the development of flight operations in deep space and provide an assessment of the system for the lunar landing mission.

c. Phase "C". A manned spacecraft to be soft landed on the surface of the moon and returned to earth.

2. Module concept. It is contemplated that the spacecraft for each of these three phases of Project Apollo will consist of separate modules as follows:

a. A Command Module which will serve as a control center for spacecraft and launch vehicle operation, as crew quarters for the lunar mission, and as the entry and landing vehicle for both nominal and emergency mission phases. To the greatest extent possible, the same command module will be used for all three phases cited in paragraph 1a, b, and c above.

b. A Service Module which will house support systems and components and will contain propulsion systems, as required, for emergency aborts, returning from earth orbit, mid-course corrections, lunar orbit and de-orbit, and lunar take-off. It is contemplated that separate contracts will be issued for some of these propulsion systems.

[3]

c. An Orbiting Laboratory Module for use in earth orbiting missions, as a laboratory technological or scientific experiments and measurements.

d. A Propulsion Module to be added for the lunar landing mission, for the purpose of landing the Command and Service Modules on the moon's surface.

PROCUREMENT PROGRAM

It is intended, under the overall procurement program, to award several contracts for each separate phase or sub-phase of the Apollo Project Spacecraft specifically as follows:

1. A contract to a Principal Contractor for the following elements of the Project:

a. A Command Module and Service Module to serve all flight missions.

b. A propulsion system for the earth-orbiting mission, if needed.

c. Responsibility for systems engineering and systems integration for all elements being developed by other contractors associated with Project Apollo Spacecraft systems. It is intended that the same Principal Contractor will be retained for all three phases, however, the Government will retain the option of selecting a new Principal Contractor for Phases "B" and "C" if it is considered desirable to do so.

2. A contract for the development of an Orbiting Laboratory Module and vehicle adapter for the earth orbiting mission.

3. A contract for the development of a Propulsion Module to provide a propulsion system for lunar landing.

4. An associate contract for the development of a guidance and navigation system, to be housed in the Command Module, required for use on all manned missions.

RESPONSIBILITIES OF CONTRACTORS

The responsibilities of each of the associated contractors participating in Project Apollo Spacecraft procurement will be different and will be developed and defined separately as each contract is negotiated and written. Each contract will contain reliability requirements for mission accomplishment and flight safety. General types of responsibility, however, can be summarized as follows:

[4]

A. Command Module and Service Module Contractor. (Principal Contractor)

The contractor assigned responsibility for the development of the command module and service module will also be responsible for systems integration and systems engineering for all missions. The Principal Contractor will serve in the role of principal integrator of all modules of the spacecraft to assure compatibility and timely and complete execution of all requirements of each mission. The contractor will also serve as the principal point of coordination with the launch vehicle developer to assure effective solution of interface problems between launch vehicle and spacecraft components, and with ground support developers to meet all of their requirements.

B. Space Laboratory Module and Propulsion Module Contractors.

The contractors assigned responsibility for the development of Phase A Space Laboratory Module or Phases C Propulsion Module will be expected to complete all aspects of their subsystem and to work under the general technical direction of the Principal Contractor to assure the full and timely completion of the integrated spacecraft system and its integration with the launch vehicle and relate ground support facilities.

TYPE OF CONTRACT ADMINISTRATION

It is intended that a Cost-Plus-a-Fixed-Fee type of contract will be used initially in the procurement of the spacecraft.

A copy of the necessary Class Determination and Findings authorizing negotiation of contracts for Apollo Spacecraft, pursuant to 10 USC 2304(a)(11), is attached. (Enclosure No. 1)

In view of the magnitude, complexity, and substantial dollar value of the Apollo Spacecraft, a Principal Contractor and Associate Prime Contractor method of procurement is recommended. The spacecraft Principal Contractor will be contractually assigned responsibility and authority for the design of the system and the integration of the performance specification of all sub-systems and components to assure that they fit into a compatible, efficient system, and to manage the day-to-day development and production. The Space Task Group will retain authority to make major decisions, resolve conflicts between the Spacecraft Principal Contractor and the associated contractors; review and/or approve decisions made by the Principal Contractor; approve the make-or-buy policies. In addition, the Space Task Group will control concentration of Principal Contractor "in house" effort; assure competition in the selection of sub-contractors by requiring the Spacecraft Principal Contractor to take full advantage of the facilities and capabilities of existing sub-system manufacturers by subcontracting or the placement of systems direct by NASA with associated contractors.

[5]

Requests for proposals will require, [*sic*] that companies will furnish a description of the proposed organization and management plan for the spacecraft project including names of personnel to be assigned to key positions within such organization. Prior to commencement of negotiations, NASA will develop a contract clause which will assure NASA control over the selection and retention of the contractor's key personnel assigned to the project.

NASA will reserve the right to issue a separate contract to a qualified organization to assess systems reliability. If it is subsequently determined that such a contract is to be issued, this will be done at about the same time as the principal contractor is selected. Similar reliability assessment contracts may be placed for associated systems, as required.

CONTRACT NEGOTIATION AND AWARD

It is the intention of the Government to select at this time a contractor qualified to perform all the tasks set forth under paragraph 1a, b, and c of the Procurement Program section of this plan and to award a contract broad enough in scope to provide, with subsequent amendment, for the accomplishment of the total tasks required toward the completion of the Project Apollo Spacecraft Program. The initial contract will specifically cover the engineering study, detail design, development of manufacturing techniques, fabrication of breadboards, test hardware, laboratory models, "test" spacecraft, certain long lead items, and a detailed engineering mockup of the Apollo Spacecraft.

The Administrator may determine that negotiation will be conducted with several companies. If such negotiations are directed, the names of the companies selected for negotiations will not be announced. Following completion of such negotiation, the Source Evaluation Board will again report to the Administrator the results of the negotiations at which time he will determine that company with which to negotiate a contract if satisfactory terms can be arranged. Announcement of such selection will then be made in accordance with NASA regulations. Negotiations will be conducted by the Space Task Group procurement and technical staffs, with supplemental assistance from Headquarters management and technical staffs. The contract will be negotiated to spell out as extensively as possible all facets of contractor organization, management, technical performance and cost control to achieve the maximum assurance of protection of the interests of the Government, consonant with the urgency of the work of the Project.

SELECTION OF BIDDERS LIST

The field of contractors suitably qualified to undertake a program of this magnitude is limited. It is intended to solicit proposals from only 12 [6] companies who have indicated their definite interest in the Apollo Program and who have demonstrative competence and capability to successfully perform the procurement under consideration. Any other firms who may request an opportunity to submit a proposal will be required to furnish substantiating evidence as to their ability to perform before a request for proposal will be furnished. Space Task Group will maintain a complete documentation of the reasons for selection of companies invited to receive request for proposal and the reasons for declining to furnish requests for proposal to any company so requesting.

The selected sources are as follows:

1. Boeing Airplane Company
   Seattle, Washington

2. Chance Vought Aircraft, Inc.
   Dallas, Texas

3. General Dynamics Corporation
   San Diego, California

4. Douglas Aircraft Company, Inc.
   Santa Monica, California

5. General Electric Corporation
   Philadelphia, Pennsylvania

6. Goodyear Aircraft Corporation
   Akron, Ohio

7. Grumman Aircraft Engineering Corporation
   Bethpage, Long Island

8. Lockheed Aircraft Corporation
   Sunnyvale, California

9. Martin Company
   Baltimore, Maryland

10. McDonnell Aircraft Corporation
    St. Louis, Missouri

11. North American Aviation
    Los Angeles, California

12. Republic Aviation Corporation
    Farmingdale, New York

[7]

In addition, a synopsis of this procurement will be publicized for the benefit of subcontractors in accordance with NASA Circular No. 131, dated April 17, 1961, Subject: Publicizing of NASA Proposed Research and Development Procurement, Reference 18-2.203-4.

SCHEDULE OF PROCUREMENT ACTION

July 28	Request for Proposals mailed and bidders invited to conference
Aug. 14-15	Bidders Conference
Oct. 9	Proposals due
Dec. 1	Evaluation of proposals completed
Dec. 28	Selection of contractor
Dec. 29	Letter Contract (if desirable)
Apr. 30	Definitive contract

SOURCE EVALUATION

It is proposed that a NASA Source Evaluation Board be appointed by the Associate Administrator, NASA Headquarters, to be chaired by Mr. W. C. Williams, Associate Director of Space Task Group. The members of this Board will be specifically designated from appropriate NASA personnel. The Chairman of the Board will appoint such business and technical committees as may be necessary to assist the Board in the evaluation. The membership of these committees will be drawn from appropriate Government personnel. Recommendations for Board appointments are attached, (Enclosure No. 2) for approval by the Associate Administrator. Committee appointments anticipated at this time are also attached for information, (Enclosure No. 3).

REQUEST FOR PROPOSALS

The Source Evaluation Board will review the Request for Proposals, prior to the release to the selected prospective contractors, to assure that the RFP is complete in all details as to the technical, management and cost aspects and further, that it will adequately serve the intended purposes. The Source Evaluation Board shall be free to comment on and recommend any changes in the RFP considered essential to meet all Project Apollo objectives.

[8]

PROPOSAL EVALUATION

The evaluation of proposals submitted by industry will be the primary responsibility of the Source Evaluation Board. In these evaluations the Board will be free to seek further information from bidders or to offer bidders the opportunity of making further oral or written clarification of their submissions. In addition, the Board should be authorized to establish additional sub-committee, work groups or consulting relationships with other NASA employees or with other Government consultants as required. Where desirable, members of the Source Evaluation Board will be authorized to visit the facilities of bidders to acquaint themselves at first hand with the personnel and facilities with which project work would be carried out. The final product of the work of the Source Evaluation Board will be a presentation of findings to the Administrator.

BIDDERS CONFERENCE

Twelve days after release of the RFP a principal contractors bidders conference will be held at the Space Task Group, Langley Field, Virginia or such other suitable location in this geographical area as considered appropriate, for a detailed briefing on the proposed procurement. Contractors who are invited will be limited to a maximum of 10 representatives each which limitation shall include any subcontractor representatives. Attendance by contractors will be limited to those companies invited to submit proposals.

CONTRACT COST DETERMINATION

In view of the significant nature of this procurement, specific attention, review, and analysis will be given by STG in determining the reasonableness of costs submitted by a contractor. To meet this objective, contractors will be required to prepare comprehensive and extensive cost breakdowns for each category of proposed contract performance. Each contractor will be required to furnish with his proposal his procedures and techniques, as appropriate, for his accounting system, which shall include but not necessarily be limited to; methods of costing labor, material, burdens, etc., to each contract; cost estimation and reimbursement billing procedures. All contracts will incorporate all clauses required by law and regulation, plus other special conditions that may be necessary to adequately protect the Government's interests.

Approved

[signed by Robert Seamans]
Associate Administrator

Enclosure No. 1

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE TASK GROUP

LANGLEY FIELD, VIRGINIA

DETERMINATION AND FINDINGS

AUTHORITY TO NEGOTIATE CLASS OF CONTRACTS

Upon the basis of the following determination and findings which I hereby make as agency head, the proposed class of contracts described below may be negotiated without formal advertising pursuant to the authority of 10 U.S.C 2304 (a) (11).

This procurement will consist of more than one contract for the accomplishment of Project Apollo.

Findings

I hereby find that the primary objective of Project Apollo is to safely place a manned vehicle containing a 3-man crew into an earth and lunar orbital flight making a soft lunar landing and return take-off and to effect a safe recovery of the men and vehicle. A secondary objective is to study the capabilities of men for extended periods of approximately 14 days in the environments associated with earth and lunar launchings, orbital flights, lunar landings and recovery. There is an urgent requirement for this program to be completed at the earliest date compatible with reasonable assurance of success and with a high degree or assurance that the human occupants can safely escape from any forseeable [*sic*] situation which may develop. First attempt at orbital flight will be preceded by a program involving numerous research, experimental, and developmental contracts.

In addition to studies and services essential to the successful operation of Project Apollo, there is a continued need for research and development, design, engineering, fabrication and assembly of material and equipment.

The proposed class of contracts does not call for quantity production of any article.

It is impossible to describe in precise detail, or by any definite drawings or specifications, the nature or the work to be performed; only the ultimate objectives and the general scope or the work can be outlined. The materials, equipment, and services to be procured for Project Apollo will be in quantities requiring the high reliability and performance critical to the successful performance or the Manned Satellite Vehicle program.

[2]

<u>Determination</u>

Based on the findings above made, I hereby determine that the proposed contracts are for experimental, developmental or research work, or for the making or furnishing of property for experiment, test, development and research.

This class determination shall remain in effect until June 30, 1962.

James E. Webb, Administrator

Date July 25, 1961

Enclosure No. 2

From NASA Headquarters
To Space Task Group ATTENTION: Robert R. Gilruth

Subject: Appointment of Source Evaluation Board

1. The following personnel are designated to serve as a Source Evaluation Board in connection with the procurement of development of spacecraft required for the Apollo Project. This Board, operating at the direction of the chairman, will review proposals from prospective contractors and based on its findings recommend source selection to this office for approval:

Walter Williams (Chairman) – Asst. to Director, Space Task Group
Robert O. Piland – Head, Apollo Project Office, Space Task Group
George M. Low – Chief, Manned Space Flight, NASA Headquarters
Wesley L. Hjornevik – Asst. Director for Administration, Space Task Group
Brooks C. Preacher – Office of Procurement Review, NASA Headquarters
Maxime A. Faget – Chief, Flight Systems Division, Space Task Group
James A. Chamberlin – Head, Engineering Division, Space Task Group

Charles W. Mathews – Head, Operations Division, Space Task Group
Dave W. Lang – Procurement & Contracting Officer, Space Task Group
* James T. Koppenhaver – Office of Reliability and Systems Analysis, NASA Headquarters

[signed by Robert Seamans]
Associate Administrator

* Non-voting Member (Gen. Management Instruction 2-4-3)

Enclosure No. 3

[10]

ESTABLISHMENT OF SUB-COMMITTEES
TO THE NASA SOURCE EVALUATION BOARD
PROJECT APOLLO

Technical Sub-Committee

Robert O. Piland (Chairman) – Head, Apollo Projects Office, Space Task Group
John B. Becker – Aero Physics Division, Langley Research Center
Andre J. Meyer – Assistant Chief, Engineering Division, Space Task Group
Caldwell C. Johnson, Jr. – Head, Systems Engineering Branch, Space Task Group
Robert G. Chilton – Head, Flight Dynamics Branch, Space Task Group
S. C. White – Chief, Life Systems Division, Space Task Group
William A. Mrazek – Director, Structures and Mechanics Division, George C. Marshall Space Flight Center

Such other technical representation as may be required from other Government activities may be requested or designated as required.

Business Sub-Committee

Glenn F. Bailey – Contract Specialist, Space Task Group
Phillip H. Whitbeck – Special Ass't. to the Assistant Director for Administration, NASA Headquarters
John D. Young – Director of Management Analysis Division, NASA Headquarters
Douglas E. Hendrickson – Budget and Finance Officer, Space Task Group
George F. MacDougall, Jr. – Head, Contract Engineering Branch, Space Task Group

John M. Curran – Procurement Review Office – NASA Headquarters
Wilbur H. Gray – NASA Technical Representative, McDonnell Aircraft Corp.

Such other business management of financial representation as may be required from other government activities may be requested or designated as requested.

Document II-14

Document Title: "Memorandum for the President by James Webb, 14 September 1961.

Source: Folder 18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

With Presidential announcement of the decision to go to the Moon, it was clear that NASA would need to create a new Field Center dedicated to human spaceflight. The chair of NASA's House Appropriations Committee, Representative Albert Thomas of Houston, Texas, made it very clear that he expected the new Center to be located in or near his district (Volume II, Document III-7). Even so, at the very least NASA had to go through the motions of an open competition for the location of the Center, and a number of localities in different states (and their Governors, Senators, and Congressmen) made their interest in being chosen well known. President Kennedy's home state of Massachusetts put particular pressure on NASA and the White House to consider Hingham Air Force Base near Boston as the location.

September 14, 1961

MEMORANDUM FOR THE PRESIDENT

In view of the situation which has arisen in Massachusetts, I believe you should know personally that Dr. Hugh Dryden and I, last night and this morning, have carefully reviewed all the factors relating to the location of the manned space flight center. It included a careful examination of the material brought back from Hingham yesterday by the site survey team. The team was sent without notification to the Governor or anyone in Massachusetts and made its visit and examination without any publicity so far as I know.

Our decision is that this laboratory should be located at Houston, Texas, in close association with Rice University and the other educational institutions there and in that region.

A press release has been prepared announcing this decision, and we are holding it for issue after White House notification of those which your staff feels should have advance information.

The only personal commitment I have in connection with the release is to personally call the Acting Chairman of the House Committee on Science and Astronautics, Congressman George Miller of California, so that he will know in advance of newspaper release what the decision is. He has been very active and concerned on behalf of California.

Attached hereto is the transcript of the talk I gave at the National Press Club on September 12. [not included] On page 15 you will find underlined the reference I made to your instructions. You may need this at your next press conference.

[2]

There are also marked sections in the transcript which refer to you, Vice President Johnson, and the facilities location question on pages 1, 2, 3, 6, 13, 14, 15 and 16.

Incidentally, since we had too little time at our meeting Monday for me to give you as full a report on our activities as I would like, you might wish to take this transcript along for reading, perhaps on the plane. Particularly, the checked paragraph at the bottom of page 10 is an area of thought which you and I need to explore. If we can develop this idea in terms of regional patterns of developing science and technology and feeding them back into economic growth, it may be one of the tremendous accomplishments of your Administration.

/Signed/
James E. Webb
Administrator

Enclosure:

Transcript of National Press Club
Speech, September 12, 1961. [not included]

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<u>SITE SELECTION PROCEDURE</u>

The procedure established for the selection of a site for the manned space flight laboratory, one of four major facilities required for the manned lunar landing mission on the accelerated schedule set by the President, is as follows:

I. The selection of the site is to be made by the Administrator of NASA in consultation with the Deputy Administrator.

II. As the first step in the collection of information to aid the Administrator in his selection, the Associate Administrator on July 7, 1961 instructed the Director of the Office of Space Flight Programs to establish preliminary site criteria and to propose the membership for a site survey team. The team, appointed on August 7, 1961 consisted of

John F. Parsons, Chairman
Associate Director
Ames Research Center
N. Philip Miller
Chief, Facilities Engineering Division
Goddard Space Flight Center

Wesley L. Hjornevik
Assistant Director for Administration
Space Task Group

I. Edward Campagna
Construction Engineer
Space Task Group

[2]

Because of the sudden illness of Mr. Hjornevik on August 12, 1961, he was replaced by

Martin A. Byrnes
Project Management Assistant
Space Task Group

III. The site survey team met on August 11 with the Director of the Office of Space Flight Programs, the Associate Director of the Space Task Group, and the Assistant Director of Space Flight Programs for Manned Space Flight. During this meeting tentative site requirements were developed.

IV. The site requirements were formulated in detail by the site survey team, and at a meeting with the Administrator; Deputy Administrator; Director of Space Flight Programs; Director, Office of Programs; and the Assistant Director for Facilities, Office of Programs, the following criteria were approved by the Administrator:

<u>Essential Criteria</u>

1. <u>Transportation</u>:

Capability to transport by barge large, cumbersome space vehicles (30 to 40 feet in diameter) to and from water shipping. Preferably the site should have its own or have access to suitable docking facilities. Time required in transport will be considered.

Availability of a first-class all-weather commercial jet service airport and a Department of Defense air base installation in the general area capable of handling high-performance military aircraft.

2. Communications:

Reasonable proximity to main routes of the long-line telephone system.

[3]

3. Local Industrial Support and Labor Supply:

An existing well-established industrial complex including machine and fabrication shops to support a research and development activity of high scientific and technical content, and capable of fabricating pilot models of large spacecraft.

A well-established supply of construction contractors and building trades and craftsmen to permit rapid construction of facilities without premium labor costs.

4. Community Facilities:

Close proximity to a culturally attractive community to permit the recruitment and retention of a staff with a high percentage of professional scientific personnel.

Close proximity to a well-established institution of higher education with emphasis on an institution specializing in the basic sciences and in space related graduate and post graduate education and research.

5. Electric Power:

Strong local utility system capable of developing up to 80,000 KVA of reliable power.

6. Water:

Readily available good-quality water capable of supplying 300,000 gallons per day potable and 300,000 gallons per day industrial.

7. Area:

1,000 usable acres with a suitable adjacent area for further development. Suitable areas in the general location for low hazard and nuisance subsidiary installations requiring some isolation.

8. Climate:

A mild climate permitting year-round, ice-free, water transportation; and permitting out-of-door work for most of the year to facilitate operations, reduce facility costs, and speed construction.

[4]

Desirable Criteria

1. Impact on Area:

Compatibility of proposed laboratory with the regional planning that may exist and ability of community facilities to absorb the increased population, and to provide the related industrial and transport support required.

2. Site Development Costs:

Consideration of costs for site development required for the proposed laboratory.

3. Operating Costs:

Consideration of costs for normal operations including utility rates, construction costs, wage scales, etc.

4. Interim Facilities:

Availability of reasonably adequate facilities for the temporary use of up to 1,500 people in the same general area as the permanent site.

V. The site survey team at the same meeting was instructed to survey possible sites on the basis of published and other available information, selecting on the basis of the approved criteria those which should be visited by the team, visiting these sites and such others as might be directed by the Administrator, and preparing a report, including a listing of the advantages and disadvantages of the sites considered.

VI. A review by the site survey team of climatological data furnished by the United States Weather Bureau and information provided by the Department of the Army, Corps of Engineers, on water-borne commerce in [5] the United States (references 1 and 2), provided the following preliminary list of prospective areas which would fulfill the essential criteria of water transportation and climate:

Norfolk, Virginia
Charleston, South Carolina
Savannah, Georgia
Jacksonville, Florida
Miami, Florida
Tampa, Florida
Mobile, Alabama
New Orleans, Louisiana
Baton Rouge, Louisiana
Memphis, Tennessee
Houston, Texas
Corpus Christi, Texas
San Diego, California

Los Angeles, California
Santa Barbara, California
San Francisco, California
Portland, Oregon
Seattle, Washington

This preliminary list of possible areas was then reviewed with regard to the other essential site criteria with the assistance of references 3 and 4 and through consultations with the General Services Administration regarding surplus Government property, and the list was reduced on August 16, 1961, to the following nine areas:

Jacksonville, Florida (Green Cove Springs Naval Station)
Tampa, Florida (MacDill Air Force Base)
Baton Rouge, Louisiana
Shreveport, Louisiana (Barksdale Air Force Base)
Houston, Texas (San Jacinto Ordnance Depot)
Victoria, Texas (FAA Airport)
Corpus Christi, Texas (Naval Air Station)
San Diego, California (Camp Elliott)
San Francisco, California (Benicia Ordnance Depot)

[6]

To properly evaluate each area accurately a physical inspection of the area by members of the site survey team was deemed essential. Accordingly, arrangements were made to visit these nine areas. While in certain areas additional sites were brought to the attention of the team and arrangements were made to visit those sites. Hence, the original nine sites were increased to twenty-three by the addition of the following:

Bogalusa, Louisiana
Houston, Texas (University of Houston Site)
Houston, Texas (Rice University Site)
Houston, Texas (Ellington Air Force Base)
Liberty, Texas
Beaumont, Texas
Harlingen, Texas
Berkeley, California
Richmond, California
Moffett Field, California (Naval Air Station)
St. Louis, Missouri (Daniel Boone Site)
St. Louis, Missouri (Industrial Park Site)
St. Louis, Missouri (Lewis and Clarke Site)
St. Louis, Missouri (Jefferson Barracks Site)

Visits to the above twenty-three sites were initiated on August 21, 1961 and completed September 7, 1961.

It will be noted that the team felt that locations north of the freezing line were unlikely to meet the requirements and hence proposed no visits to sites in this area.

VII. While the team was visiting sites, several presentations were made directly to the Administrator, Deputy Administrator, and other officials, notably from proponents of sites in the Boston, Rhode Island, and Norfolk areas. It was agreed to consider these sites in the final review.

[7]

On August 12th the Administrator and Deputy Administrator reviewed the factors which had entered into the approved criterion on climate, i.e.:

> "A mild climate permitting year-round, ice-free, water transportation; and permitting out-of-door work for most of the year to facilitate operations, reduce facility costs, and speed construction."

The considerations leading to this criterion are as follows:

1. The purpose of specifying a mild climate which will permit year-round, ice-free, water transportation is self-evident. It is necessary so that the spacecraft and/or its components can be transported by water to other sites at any time of the year to avoid delays in the overall program.

2. The requirement for out-of-door work most of the year stems from our experience with aircraft and large missiles. Since the spacecraft will be of comparable size it is expected that all work cannot be efficiently done within buildings. An appreciable amount of fitting, checking, and/or calibration work will be accomplished out-of-doors to facilitate the overall operation. Also the possibility of handling much larger spacecraft, such as a 10-15 man space station, must be considered. The climate factor will become more important as such spacecraft become parts of the program.

3. A mild climate avoids the necessity of special protection to the spacecraft against freezing of moisture in the many complicated components while transferring to and from sites and between site buildings. To provide such protection would be time-consuming and costly.

4. A mild climate will facilitate recovery procedure training of the astronauts and other activities which must be conducted out-of-doors.

5. A mild climate permits a greater likelihood of day-to-day access by air to and from the site from other parts of the country.

6. In summary, the selection of a site in an area meeting the stated climate criterion will minimize both the cost and the time required for this project. A mild climate will permit year-round construction activity, thereby accelerating the advancement of the project.

[8]

Sites north of the freezing line fail to meet these requirements. For example, in the case of the Boston area, the U.S. Department of Commerce Weather Bureau report entitled "Local Climatological Data with Comparative Data, 1960, Boston, Massachusetts," states:

> In the year 1960 it rained 114 days for a total amount of 44.46 inches. The rainfall was distributed uniformly throughout the year. The normal total annual rainfall over the years is 38.86 inches falling on 133 days.
>
> The daily minimum temperature for the months of December, January, February and March ranges from 21.6° F to 30.0 °F well below freezing while the average maximum temperature for December, January, and February is below 40 °F.
>
> Normal degree days, a measure of the heating required, is 5791 — a high value.
>
> Approximately 52 inches of snow and sleet fell in 1960, the average over the years is about 40 inches.
>
> The average hourly wind speed is 12.5 miles per hour.

In addition to the detailed information outlined above, this same report in describing the Boston climate states:

> The city's latitude places it … in … large bodies of air from tropical and polar regions resulting in variety and changeability of the weather elements.
>
> … assuring an ordinarily dependable precipitation supply.
>
> Hot summer afternoons are …"
>
> The average date of the last killing frost in spring is April 16.
>
> The average date of the first killing frost in autumn is October 25.
>
> Boston has no dry season; …
>
> Coastal storms, or 'northeasters', are prolific producers of rain and snow. The main snow season extends from November through March.

[9]

> Although winds of 32 m.p.h. or higher may be expected on at least one day in every month of the year, gales are both common and more severe in winter.

By direction of the Administrator, the site survey team visited the Hingham, Massachusetts, site near Boston on September 13 for an inspection of the terrain and existing buildings.

References Used by Site Survey Team

1. Waterborne Commerce of the United States, Calendar Year 1958, Department of the Army, Corps of Engineers.

2. The Intercoastal Waterway, Corps of Engineers, U.S. Army, 1961.

3. Army Map Service Map of Major Army, Navy and Air Force Installations of the United States. 8205 Edition 21-AMS.

4. Education Directory 1959-1960, Part 3, Higher Education, U.S. Department of Health, Education and Welfare, Office of Education

Document II-15

Document Title: John C. Houbolt, NASA, Langley Research Center, Letter to Dr. Robert C. Seamans, Jr., Associate Administrator, NASA, 15 November 1961.

Source: Folder 18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

Document II-16

Document Title: Langley Research Center, NASA, "MANNED LUNAR-LANDING through use of LUNAR-ORBIT RENDEZVOUS," Volume 1, 31 October 1961.

Source: Folder 18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

Document II-17

Document Title: Joseph Shea, Memorandum for the Record, 26 January 1962.

Source: Folder 18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

Document II-18

Document Title: "Concluding Remarks by Dr. Wernher von Braun About Mode Selection for the Lunar Landing Program Given to Dr. Joseph F. Shea, Deputy Director (Systems) Office of Manned Space Flight," 7 June 1962.

Source: Folder 18675, NASA Historical Reference Collection, History Division, NASA headquarters, Washington, DC.

John Houbolt of NASA's Langley Research Center, along with several Langley colleagues, had been examining rendezvous concepts in 1959 and 1960. Although not the sole originator of the lunar orbit rendezvous (LOR) mode, Houbolt became its most persistent supporter and in 1961 went outside of normal bureaucratic channels to advocate the approach as a means of accomplishing the lunar landing mission, rather than the Earth orbit rendezvous (EOR) mode that had gained favor in the months following President Kennedy's speech announcing the lunar landing goal. This letter from Houbolt to NASA Associate Administrator Robert Seamans was a catalyst in shifting the thinking within NASA in favor of the LOR mode. The Saturn C-3 that Houbolt refers to in his letter was a configuration of the Saturn booster with two F-1 engines in its first stage. The Saturn C-2 was a less powerful booster using older rocket engines in its first stage that NASA had decided not to develop by the time Houbolt wrote his letter. NOVA was a very large booster with eight F-1 engines in its first stage that was designed to take astronauts directly to the Moon without need for rendezvous. The Fleming, Lundin, and Heaton Committees were groups set up within NASA earlier in 1961 to examine various approaches to the lunar landing mission. The Golovin Committee was a NASA-DOD group attempting to develop a national launch vehicle program. PERT was a chart-based management approach to complex projects.

The 31 October 1961 Langley Study that was the basis for Houbolt's arguments indicates the other key members of the Langley team that developed the lunar orbit rendezvous scheme.

By the end of 1961, the new Manned Spacecraft Center in Houston was beginning to be interested in the LOR concept, while Wernher von Braun and his team at the Marshall Space Flight Center focused their studies on the EOR approach to accomplishing the lunar landing mission. This led Brainerd Holmes, head of piloted spaceflight at NASA Headquarters, and his assistant Joseph Shea to conclude that further study of the LOR concept should be managed by Headquarters to minimize inter-Center rivalries.

Following Shea's memorandum, the choice of an approach to carrying out the lunar landing mission received intensive attention within NASA in the first five months of 1962. Project Apollo leaders at the new Manned Spacecraft Center in Houston,Texas, gradually came to favor the LOR approach. Wernher von Braun and his associates at the Marshall Space Flight Center in Huntsville, Alabama, had based their launch vehicle planning on the use of the EOR approach. At a climactic meeting at the Marshall Space Flight Center on 6 June 1962, von Braun made the concluding remarks. (This document, dated 7 June, is the text of those remarks.) Much to the surprise of many of his associates at Marshall, von Braun endorsed the LOR mode as the preferred approach. With his endorsement, NASA soon adopted this approach in its planning for the lunar landing mission.

The C-1 and C-5 vehicles referred to in von Braun's statement became known as the Saturn I and Saturn IB and the Saturn V. The C-8 was a configuration with eight first-stage engines that were never built. The S-IVB was the third stage of the Saturn V vehicle and the S-II its second stage. Robert "Bob" Gilruth was the Director of the Manned Spacecraft Center and Chuck Matthews a senior manager there. NAA was North American Aviation, the contractor building the Apollo Command and Service Module and the S-II and S-IVB stage of the Saturn V launcher. Rocketdyne was the company building the F-1 and J-2 rocket engines.

Document II-15

National Aeronautics and
Space Administration
Langley Research Center
Langley Air Force Base, Va.

November 15, 1961

Dr. Robert C. Seamans, Jr.
Associate Administrator
National Aeronautics and
Space Administration
1520 H Street, N.W.
Washington 25, D.C.

Dear Dr. Seamans:

Somewhat as a voice in the wilderness, I would like to pass on a few thoughts on matters that have been of deep concern to me over recent months. This concern may be phrased in terms of two questions: (1) If you were told that we can put man on the moon with safe return with a single C-3, its equivalent or something less, would you judge this statement with the critical skepticism that others have? (2) Is the establishment of a sound booster program really so difficult?

I would like to comment on both these questions, and more, would like to forward as attachments condensed versions of plans which embody ideas and suggestions which I believe are so fundamentally sound and important that we cannot afford to overlook them. You will recall I wrote to you on a previous occasion. I fully realize that contacting you in this manner is somewhat unorthodox; but the issues at stake are crucial enough to us all that an unusual course is warranted.

Since we have had only occasional and limited contact, and because you therefore probably do not know me very well, it is conceivable that after reading this you may feel that you are dealing with a crank. Do not be afraid of this. The thoughts expressed here may mot be stated in as diplomatic a fashion as they might be, or as I would normally try to do, but this is by choice and the moment is not important. The important point is that you hear the ideas directly, not after they have filtered through a score or more of other people, with the attendant risk that they may not even reach you.

[2]

Manned Lunar Landing Through Use of Lunar Orbit Rendezvous

The plan. - The first attachment [Document II-16] outlines in brief the plan by which we may accomplish a manned lunar landing through use of a lunar rendezvous, and shows a number of schemes for doing this by means of a single C-3, its equivalent, or even something less. The basic ideas of the plan were presented before various NASA people well over a year ago, and were since repeated at numerous interlaboratory meetings. A lunar landing program utilizing rendezvous concepts was even suggested back in April. Essentially, it had three basic points: (1) the establishment of an early rendezvous program involving Mercury, (2) the specific inclusion of rendezvous in Apollo developments, and (3) the accomplishment of lunar landing through use of C-2's. It was indicated then that the two C-2's could do the job, C-2 being referred to simply because NASA booster plans did not go beyond the C-2 at that time; it was mentioned, however, that with a C-3 the number of boosters required would be cut in half, specifically only one.

Regrettably, there was little interest shown in the idea - indeed, if any, it was negative.

Also (for the record), the scheme was presented before the Lundin Committee. It received only bare mention in the final report and was not discussed further (see comments below in section entitled "Grandiose Plans ").

It was presented before the Heaton Committee, accepted as a good idea, then dropped, mainly on the irrelevant basis that it did not conform to the ground rules. I even argued against presenting the main plan considered by the Heaton Committee, largely because it would only bring harm to the rendezvous cause, and further argued that if the committee did not want to consider lunar rendezvous, at least they should make a strong recommendation that it looks promising enough that it deserves a separate treatment by itself - but to no avail. In fact, it was mentioned that if I felt sufficiently strong about the matter, I should make a minority report. This is essentially what I am doing.

We have given the plan to the presently meeting Golovin Committee on several occasions.

In a rehearsal of a talk on rendezvous for the recent Apollo Conference, I gave a brief reference to the plan, indicating the benefit derivable therefrom, knowing full well that the reviewing committee would ask me to withdraw any reference to this idea. As expected, this was the only item I was asked to delete.

[3] The plan has been presented to the Space Task Group personnel several times, dating back to more than a year ago. The interest expressed has been completely negative.

Ground rules. - The greatest objection that has been raised about our lunar rendezvous plan is that it does not conform to the "ground rules". This to me is nonsense; the important question is, "Do we want to get to the moon or not?", and, if so, why do we have to restrict our thinking along a certain narrow channel. I feel very fortunate that I do not have to confine my thinking to arbitrarily set up ground rules which only serve to constrain and preclude possible equally good or perhaps better approaches. Too often thinking goes along the following vein: ground rules are set up, and then the question is tacitly asked, "Now, with these ground rules what does it take, or what is necessary to do the job?". A design begins and shortly it is realized that a booster system way beyond present plans is necessary. Then a scare factor is thrown in; the proponents of the plan suddenly become afraid of the growth problem or that perhaps they haven't computed so well, and so they make the system even larger as an "insurance" that no matter what happens the booster will be large enough to meet the contingency. Somehow, the fact is completely ignored that they are now dealing with a ponderous development that goes far beyond the state-of-the-art.

Why is there not more thinking along the following lines: Thus, with this given booster, or this one, is there anything we can do to do the job? In other words, why can 't we also think along the deriving a plan to fit a booster, rather than derive a booster to fit a plan?

Three ground rules in particular are worthy of mention: three men, direct landing, and storable return. These are very restrictive requirements. If two men can do the job, and if the use of only two men allows the job to be done, then why not do it this way? If relaxing the direct requirements allows the job to be done with a C-3, then why not relax it? Further, when a hard objective look is taken at the use of storables, then it is soon realized that perhaps they aren't so desirable or advantageous after all in comparison with some other fuels.

Grandiose plans, one-sided objections, and bias.- For some inexplicable reason, everyone seems to want to avoid simple schemes. The majority always seems to be thinking in terms of grandiose plans, giving all sort of arguments for long-range plans, etc. Why is there not more thinking in the direction of developing the simplest scheme possible? Figuratively, why not go buy a Chevrolet instead of a Cadillac? Surely a Chevrolet gets one from one place to another just as well as a Cadillac, and in many respects with marked advantages.

[4]

I have been appalled at the thinking of individuals and committees on these matters. For example, comments of the following type have been made: "Houbolt has a scheme that has a 50 percent chance of getting a man to the moon, and a 1 percent chance of getting him back." This comment was made by a Headquarters individual at 'high level [‘] who never really has taken the time to hear about the scheme, never has had the scheme explained to him fully, or possible even correctly, and yet he feels free to pass judgment on the work. I am bothered by stupidity of this type being displayed by individuals who are in a position to make decisions which affect not only the NASA, but the fate of the nation as well. I have even grown to be concerned about the merits of all the committees that have been considering the problem. Because of bias, the intent of the committee is destroyed even before it starts and, further, the outcome is usually obvious from the beginning. We knew what the Fleming Committee results would be before it started. After one day it was clear what decisions the Lundin Committee would reach. After a couple days it was obvious what the main decision of the Heaton Committee would be. In connection with the Lundin Committee, I would like to cite a specific example. Considered by this committee was one of the most hair-brained ideas I have ever heard, and yet it received one first place vote. In contrast, our lunar rendezvous scheme, which I am positive is a much more workable idea, received only bare mention in a negative vein, as was mentioned earlier. Thus, committees are no better than the bias of the men composing them. We might then ask, why are men who are not competent to judge ideas, allowed to judge them?

Perhaps the substance of this section might be summarized this way. Why is NOVA, with its ponderous ideas, whether in size, manufacturing, erection, site location, etc., simply just accepted, and why is a much less grandiose scheme involving rendezvous ostracized or put on the defensive?

<u>PERT chart folly</u>. - When one examines the various program schedules that have been advanced, he cannot help from being impressed by the optimism shown. The remarkable aspect is that the more remote the year, the bolder the schedule becomes. This is, in large measure, due to the PERT chart craze. It has become the vogue to subject practically everything to a PERT chart analysis, whether it means anything or not. Those who apply or make use of it seem to be overcome by a form of self-hypnosis, more or less accepting the point of view, "Because the PERT chart says so, it is so." Somehow, perhaps unfortunately, the year 1967 was mentioned as the target year for putting a man on the moon. The Fleming report through extensive PERT chart analysis then "proved" this could be done. One cannot help but get the feeling that if the year 1966 had been mentioned, then this would have been the date proven; likewise, if 1968 had been the year mentioned.

[5]

My quarrel is not with the basic theory of PERT chart analysis; I am fully aware of its usefulness, when properly applied. I have been nominally in charge of a facility development and know the merits, utility, and succinctness by which it is helpful in keeping a going job moving, uncovering bottlenecks, and so forth. But when it is used in the nature of a crystal ball, then I begin to object. Thus, when we scrutinize various schedules and programs, we have to be very careful to ask how realistic the plan really is. Often simple common sense tells us much more than all the machines in the world.

I make the above points because, as you will see, we have a very strong point to make about the possibility of coming up with a rea1istic schedule; the plan we offer is exceptionally clean and simple in vehicle and booster requirements relative to other plans.

Booster is pacing item. - In working out a paper schedule we have adopted the C-3 development schedule used by Fleming and Heaton, not necessarily because we feel the schedule is realistic, but simply to make a comparison on a parallel basis. But whether the date is right, or not, doesn't matter. Here, I just want to point out that for the lunar rendezvous scheme the C-3 booster is the pacing item. Thus, we can phrase our lunar landing date this way. We can put a man on the moon as soon as the C-3 is developed, and the number of C-3's required is very small. (In fact, as I mentioned earlier, I would not be surprised to have the plan criticized on the basis that it is not grandiose enough.)

Abort. - An item which perhaps deserves special mention is abort. People have leveled criticism, again erroneously and with no knowledge of the situation, that the lunar rendezvous scheme offers no abort possibilities. Along with our many technical studies we have also studied the abort problem quite thoroughly. We find that there is no problem in executing an abort maneuver at any point in the mission. In fact, a very striking result comes out, just the reverse of the impression many people try to create. When one compares, for example, the lunar rendezvous scheme with a direct approach, he finds that on every count the lunar rendezvous method offers a degree of safety and reliability far greater than that possible by the direct approach. These items are touched upon to a limited extent in the attached plan.

Booster Program

My comments on a booster program will be relatively short, since the second attachment [not included] more or less speaks for itself. There are, however, a few points worthy of embellishment.

[6]

Booster design. - In the course of participating in meetings dealing with vehicle design, I have sometimes had to sit back completely awed and astonished at what I was seeing take place. I have seen the course of an entire meeting change because of an individual not connected with the meeting walking in, looking over shoulders, shaking his head in a negative sense, and then walking out without uttering a word. I have seen people agree on velocity increments, engine performance, and structural data, and after a booster design was made to these figures, have seen some of the people then derate the vehicle simply because they couldn't believe the numbers. I just cannot cater to proceedings of this type. The situation is very much akin to a civil engineer who knows full well that the material he is using will withstand 60,00 psi. He then applies a factor of safety of 2.5, makes a design, then after looking at the results, arbitrarily doubles the size of every member because he isn't quite sure that the design is strong enough. A case in point is the C-3. In my initial contacts with this vehicle, we were assured that it had a payload capability in the neighborhood of 110,000-120,000 lbs. Then it was derated. The value used by the Heaton Committee was 105,000 lbs. By the time the vehicle had reached the Golovin Committee, I was amazed to find that it had a capability of only 82, 570 lbs. Perhaps the only comment that can be made to this is that if we can't do any better on making elementary computations of this type, then we deserve to be in the pathetic situation we are. I also wonder where we will stand after NOVA is derated similarly.

"Quantizing" bad. - One of the reasons our booster situation is in such a sad state is the lack of appropriate engines, more specifically the lack of an orderly stepping in engine sizes. Booster progress is virtually at a standstill because there are no engines available, just as engines were the major pacing item in the development of aircraft. Aside from the engines on our smaller boosters, and the H-1 being used on the [Saturn] C-1, the only engines we have in development are:

Capability	Ratio
15,000	
	13.3
200,000	
	7.5
1,500,000	

The attempt to make boosters out of this stock of engines, having very large ratios in capability, can only result in boosters of grotesque and unwieldy configurations, and which require many, many in-flight engine starts. What is needed are engines which step up in size at a lower ratio. Consideration of the staging of an "ideal" rocket system indicates that whether accelerating to orbit speed or to escape speed, the ratio of engine sizes needed is in the order of 3. Logically then we ought to have engines that step in capability by a factor of around 2, 3, or 4. An every-day analog that can be mentioned is outboard motors. There is a motor to serve nearly every need, and in the extreme cases the process of doubling up is even used.

[7]

Booster Program. - In light of the preceding paragraph, and taking into account the engines under development, we should add the following two:

80,000 - 100,000	H_2 - O_2
400,000 - 500,000	H_2 - O_2

This would then give a line-up as follows:

15,000	H/O
80,000 - 100,000	H/O
200,000	H/O
400,000 - 500,000	H/O
1,500,000	RP/O

with the 15,000-lb. engine really not needed. This array (plus those mentioned immediately below) would allow the construction of almost all types of boosters conceivable. For example, a single 80,000-100,000 engine would take the place of the six L-115 engines being used on S-IV; not only is the arrangement of six engines on this vehicle bad, but these engines have very poor starting characteristics. The 400,000-500,000 would be used to replace the four J-2's on the S-II. Thus, C-3 would change from a messy 12-engined vehicle requiring 10 in-flight engine starts to a fairly simple 5-engine vehicle with only 3 in-flight engine starts.

In addition, the following engines should be included in a program:

1,000,000 - 1,500,000 lb.	Solid	
	5,000,000	Solid
and/or	5,000,000	Storable

The 1,000,000 - 1,500,000 lb. solid would in itself be a good building block and would probably work in nicely to extend the capabilities of vehicles, such as Titan. The 5,000,000 solid and/or storable would also be good building blocks and specifically would serve as alternate first-stage boosters for C-3, aiming at simplicity and reliability.

[8]

It may be said that there is nothing new here and that all of the above is obvious. Indeed, it seems so obvious that one wonders why such a program was not started 5 years ago. But the fact that it may be obvious doesn't help us; what is necessary is putting the obvious into effect. In this connection, there may be some who ask, "But are the plans optimum and the best?" This question is really not pertinent. There will never be an optimized booster or program. We might have an optimum booster for a given situation, but there is none that is optimum for all situations. To seek one, would just cause deliberation to string out indefinitely with little, if any, progress being made. The DynaSoar case is a good example of this.

A criticism that undoubtedly will be leveled at the above suggestion is that I'm not being realistic in that there is just not enough money around to do all these things. If this is the situation, then the answer is simply that's why we have Webb and his staff. That's why he was chosen to head the organization, this is one of his major functions, to ask the question, do we want to do a job or not?, and, if so, then to find out where the gaps or holes are, and then to go about doing what is necessary to fill the gaps to make sure the job gets done. Further, the load doesn't have to be carried by the NASA alone. The Air Force and NASA can work together and share the load, and I'm sure that if this is done, the necessary money can be found. Even if some project, say, for example, the 5,000,000-lb. storable engine has to be dropped for some reason after it gets started; no harm will be done. This happens every day. On the contrary, some good, some new knowledge, will have been uncovered, even if it turns out to be the discovery of the next obstacle which prevents such a booster from being built.

Nuclear booster and booster size. - Although not mentioned in the previous section, work on nuclear engines should, of course, continue. Any progress made here will integrate very nicely into the booster plans indicated in the attachment.

As regards booster size, the following comment is offered. Excluding for the moment NOVA type vehicles, we should strive for boosters which make use of the engines mentioned in the preceding section and which are the biggest that can be made and yet still be commensurate with existing test-stand sites and with the use of launch sites that are composed of an array of assembly buildings and multiple launch pads. The idea behind launch sites of this type is an excellent one. It keeps real estate demands to a minimum, allows for ease in vehicle assembly and check-out, and greatly eases the launch rate problem. Thus, C-3 or C-4 should be designed accordingly. We would then have a nice work-horse type vehicle having relative ease of handling, and which would permit a lunar landing mission, as indicated earlier in the lunar rendezvous write-up section. From my point of view, I would much rather confine my spending to a single versatile launch site of the type mentioned, save money in real estate acquisition and launch site development necessary for the huge vehicles, and put the money saved into an engine development program.

[9]

Concluding Remarks

It is one thing to gripe, another to offer constructive criticism. Thus, in making a few final remarks, I would like to offer what I feel would be a sound integrated overall program. I think we should:

1. Get a manned rendezvous experiment going with the Mark II Mercury.

2. Firm up the engine program suggested in this letter and attachment, converting the booster to these engines as soon as possible.

3. Establish the concept of using a C-3 and lunar rendezvous to accomplish the manned lunar landing as a firm program.

Naturally, in discussing matters of the type touched upon herein, one cannot make comments without having them smack somewhat against NOVA. I want to assure you, however, I'm not trying to say NOVA should not be built. I'm simply trying to establish that our scheme deserves a parallel front-line position. As a matter of fact, because the lunar rendezvous approach is easier, quicker, less costly, requires less development, less new sites and facilities, it would appear more appropriate to say that this is the way to go, and that we will use NOVA as a follow on. Give us the go-ahead, and C-3, and we will put men on the moon in very short order - and we don't need any Houston empire to do it.

In closing, Dr. Seamans, let me say that should you desire to discuss the points covered in this letter in more detail, I would welcome the opportunity to come up to Headquarters to discuss them with you.

Respectfully yours,

John C. Houbolt

Document II-16

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LANGLEY RESEARCH CENTER

VOLUME 1

MANNED LUNAR-LANDING through use of LUNAR-ORBIT RENDEZVOUS

[i]

FOREWORD

In the course of conducting research on the problem of space rendezvous and on various aspects of manned space missions, Langley Research Center has evolved what is believed to be a particularly appealing scheme for performing the manned lunar landing mission. The key to the mission is the use of lunar rendezvous, which greatly reduces the size of the booster needed at the earth.

More definitely the mission may be described essentially as follows: A manned exploration vehicle is considered on its way to the moon. On approach, this vehicle is decelerated into a low-altitude circular orbit about the moon. From this orbit a lunar lander descends to the moon surface, leaving the return vehicle in orbit. After exploration the lunar lander ascends for rendezvous with the return vehicle. The return vehicle is then boosted into a return trajectory to the earth, leaving the lander behind.

The significant advantage brought out by this procedure is the marked reduction in escape weight required; the reduction is, of course, a direct reflection of the reduced energy requirements brought about by leaving a sizable mass in lunar orbit, in this case, the return capsule and return propulsion system.

This report has been prepared by members of the Langley Research Center to indicate the research that has been conducted, and what a complete manned lunar landing mission using this system would entail. For further reference, main contacts are John D. Bird, Arthur W. Vogeley, or John C. Houbolt.

J.C.H.
October 31, 1961

[ii]

OUTLINE AND INDEX

[iii]

PART II

PART III

[1]

SUMMARY AND CONCLUSIONS

Studies made at Langley Research Center of various schemes for performing the manned lunar landing mission indicate that the lunar rendezvous method is the simplest, most reliable, and quickest means for accomplishing the task. This technique permits a lunar exploration to be made with a single C-3 booster. A first landing is indicated in March 1966, with a possibility of an attempt as early as November 1965. These dates do not require changes in previously established Apollo, C-l, and C-3 development schedules. Further, the lunar rendezvous approach contains a number of features which tend to raise the schedule confidence level; the most important of these are:

(a) The Apollo vehicle, the lander, and the rendezvous experiment can all proceed on an independent parallel basis, thus avoiding schedule conflicts; further, the overall development is simplified because each vehicle has only a single function to perform.

(b) The lunar rendezvous approach permits complete system development to be done with C-l, which will be available and well developed, and makes the entire C-3 picture exceptionally clean and simple, thus resulting in a minimum cost program.

In amplification of these general remarks, the following specific conclusions are drawn from the technical studies which are summarized in the body of this report:

A. Mission Approach and Scheduling:

1. The lunar rendezvous method requires only a single C- 3 or C-4 launch vehicle. Earth orbital weights required for various system arrangements are summarized in figure 1. (See also tables VI and VII later in the text.) [not provided]

2. The lunar rendezvous method schedules the first landing in March 1966.

3. The lunar rendezvous method does not require that the Apollo vehicle be compromised because of landing considerations.

4. The lunar rendezvous method allows the landing vehicle configuration to be optimized for landing.

5. The lunar rendezvous method requires only C-l boosters for complete system deve1opment.

[2]

6. The lunar rendezvous method provides for complete lander checkout and crew training in the lunar landing, lunar launch, and rendezvous docking operations on the actual vehicle.

B. Funding:

The lunar rendezvous method results in a program cost which will be less than the cost of other methods for the following reasons:

1. Requires fewer (20 to 40 percent) large boosters than other programs.

2. Requires no Nova vehicles.

3. Requires less C-3 or C-4 vehicles than other programs.

4. Programs most flights on best-developed booster (C-1).

5. Requires a minimum of booster ground facilities, because large boosters are avoided and because of a low launch rate.

The lunar rendezvous method can be readily paralleled with some other program at least total program cost.

C. Lunar Rendezvous:

The lunar rendezvous under direct, visual, pilot control is a simple reliable operation which provides a level of safety and reliability higher than other methods as outlined below.

D. Safety and Reliability:

1. The lander configuration is optimized.

2. The single-lander system permits safe return of the primary vehicle in event of a landing accident.

3. The two-lander system provides a rescue capability.

4. Crews can be trained in lunar landing, lunar launch, and rendezvous docking operations in the actual vehicle.

5. Requires fewest number of large booster flights.

6. Provides for most flights on best-developed booster (C-1).

[3]

E. Abort Capability:

1. An abort capability meeting the basic Mercury-Apollo requirements can be provided.

2. This abort capability can be provided with no additional fuel or weight penalties.

F. Lunar Lander Development:

l. Lunar lander design is optimized for landing.

2. Being essentially separate from Apollo, development can proceed with a minimum of schedule conflict.

3. Research, development, and checkout can be performed on ground facilities now under procurement and which will be available in time to meet the program schedule.

G. Development Facilities:

1. The lunar rendezvous method requires no additional booster ground facilities (see item B-5).

2. The ground facilities required for rendezvous-operations development are now being procured and will be ready.

3. The ground facilities for lander development and checkout are now being procured and will be ready.

[remainder of report not provided]

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January 26, 1962

MEMORANDUM FOR THE RECORD

Brainerd and I agreed that LOR looks sufficiently attractive to warrant further study. He feels that the study should be run from OMSF, rather than either Center, to provide a measure of objectivity.

Apparently we have to go for an open competition, which I shall try to get under way as quickly as possible. Because of the implications on the overall program, we shall attempt to conduct the study at a secret level. We are also concerned that MSFC will be especially negative with LOR because they have not studied it. I will attempt to define areas in which they can contribute to our overall studies, in order to expose them to the details of the mode.

I am concerned that MSC's weight estimates are quite optimistic. We shall concentrate, in the LOR study, on the detail, conservative estimation of the LEM weight, and the mechanization of rendezvous.

[Signed J. F. Shea]

J.F. Shea

Document II-18

CONCLUDING REMARKS BY DR. WERNHER VON BRAUN ABOUT MODE SELECTION FOR THE LUNAR LANDING PROGRAM GIVEN TO DR. JOSEPH F. SHEA, DEPUTY DIRECTOR (SYSTEMS) OFFICE OF MANNED SPACE FLIGHT

JUNE 7, 1962

In the previous six hours we presented to you the results of some of the many studies we at Marshall have prepared in connection with the Manned Lunar Landing Project. The purpose of all these studies was to identify potential technical problem areas, and to make sound and realistic scheduling estimates. All studies were aimed at assisting you in your final recommendation with respect to the mode to be chosen for the Manned Lunar Landing Project.

Our genera1 conclusion is that all four modes investigated are technically feasible and could be implemented with enough time and money. We have, however, arrived at a definite list of preferences in the following order:

1. Lunar Orbit Rendezvous Mode - with the strong recommendation (to make up for the limited growth potential of this mode) to initiate, simultaneously, the development of an unmanned, fully automatic, C-5 logistics vehicle.

2. Earth Orbit Rendezvous Mode (Tanking Mode).

3. C-5 Direct Mode with minimum size Command Module and High Energy Return.

4. Nova or C-8 Mode.

I shall give you the reasons behind this conclusion in just one minute.

But first I would like to reiterate once more that <u>it is absolutely mandatory that we arrive at a definite mode decision within the next few weeks, preferably by the first of July, 1962</u>. We are already losing time in our over-all program as a result of a lacking mode decision.

[2] A typical example is the S-IVB contract. If the S-IVB stage is to serve not only as the third (escape) stage for the C-5, but also as the second stage for the C-l B needed in support of rendezvous tests, a flyable S-IVB will be needed at least one year earlier than if there was no C-1 B at all. The impact of this question on facility planning, buildup of contractor level of effort, etc., should be obvious.

Furthermore, if we do not freeze the mode now, we cannot layout a definite program with a schedule on which the budgets for FY - 1964 and following can be based. Finally, if we do not make a clear-cut decision on the mode very soon, our chances of accomplishing the first lunar expedition in this decade will fade away rapidly.

I. <u>WHY DO WE RECOMMEND LUNAR ORBIT RENDEZVOUS MODE PLUS C-5 ONE-WAY LOGISTICS VEHICLE</u>?

a. We believe this program offers the highest confidence factor of successful accomplishment within this decade.

b. It offers an adequate performance margin. With storable propellants, both for the Service Module and Lunar Excursion Module, we should have a comfortable padding with respect to propulsion performance and weights. The performance margin could be further increased by initiation of a back-up development aimed at a High Energy Propulsion System for the Service Module and possibly the Lunar Excursion Module. Additional performance gains could be obtained if current proposals by Rocketdyne to increase the thrust and/ or specific impulses of the F-l and J -2 engines were implemented.

c. We agree with the Manned Spacecraft Center that the designs of a maneuverable hyperbolic re-entry vehicle and of a lunar landing vehicle constitute the two most critical tasks in producing a successful lunar spacecraft. A drastic separation of these two functions into two separate elements is bound to greatly simplify the development of the spacecraft system. Developmental cross-feed between results from simulated or actual landing tests, on the one hand, and re-entry tests, on the other, are minimized if no attempt is made to include the Command Module into the lunar landing process. The mechanical separation of the two functions would virtually permit completely parallel developments of the Command Module and the Lunar Excursion Module. While it may be difficult to accurately appraise this advantage in terms of months to be gained, we have no doubt whatsoever that such a procedure will indeed result in very substantial saving of time.

[3] d. We believe that the combination of the Lunar Orbit Rendezvous Mode and a C-5 one-way Logistics Vehicle offers a great growth potential. After the first successful landing on the moon, demands for follow-on programs will essentially center on increased lunar surface mobility and increased material supplies for shelter, food, oxygen, scientific instrumentation, etc. It appears that the Lunar Excursion Module, when refilled with propellants brought down by the Logistics Vehicle, constitutes an ideal means for lunar surface transportation. First estimates indicate that in the l/6 G gravitational field of the moon, the Lunar Excursion Module, when used as a lunar taxi, would have a radius of action of at least 40 miles from around the landing point of the Logistics Vehicle. It may well be that on the rocky and treacherous lunar terrain the Lunar Excursion Module will turn out to be a far more attractive type of a taxi than a wheeled or caterpillar vehicle.

e. We believe the Lunar Orbit Rendezvous Mode using a single C-5 offers a very good chance of ultimately growing into a C-5 direct capability. At this time we recommend against relying on the C-5 Direct Mode because of its need for a much lighter command module as well as a high energy landing and return propulsion system. While it may be unwise to count on the availability of such advanced equipment during this decade (this is why this mode was given a number 3 rating) it appears entirely within reach in the long haul.

f. If and when at some later time a reliable nuclear third stage for Saturn C-5 emerges from the RIFT program, the performance margin for the C-5 Direct Mode will become quite comfortable.

g. Conversely, if the Advanced Saturn C-5 were dropped in favor of a Nova or C-8, it would completely upset all present plans for the implementation of the RIFT program. Contracts, both for the engines and the RIFT stage, have already been let and would probably have to be cancelled until a new program could be developed.

h. We conclude from our studies that an automatic pinpoint letdown on the lunar surface going through a circumlunar orbit and using a landing beacon is entirely possible. Whether this method should be limited to the C-5 Logistics Vehicle or be adopted as a secondary mode for the Lunar Excursion Module is a matter that should be carefully discussed with the Manned Spacecraft Center. It may well be that the demand for incorporation of an additional automatic landing capability in the Lunar Excursion Module buys more trouble than gains.

[4] i. The Lunar Orbit Rendezvous Mode augmented by a C-5 Logistics Vehicle undoubtedly offers the cleanest managerial interfaces between the Manned Spacecraft Center, Marshall Space Flight Center, Launch Operations Center and all our contractors. While the precise effect of this may be hard to appraise, it is a commonly accepted fact that the number and the nature of technical and managerial interfaces are very major factors in conducting a complex program on a tight time schedule. There are already a frightening number of interfaces in existence in our Manned Lunar Landing Program. There are interfaces between the stages of the launch vehicles, between launch vehicles and spacecraft, between complete space vehicles and their ground equipment, between manned and automatic checkout, and in the managerial area between the Centers, the Washington Program Office, and the contractors. The plain result of too many interfaces is a continuous and disastrous erosion of the authority vested in the line organization and the need for more coordination meetings, integration groups, working panels, ad-hoc committees, etc. Every effort should therefore be made to reduce the number of technical and managerial interfaces to a bare minimum.

j. Compared with the C-5 Direct Mode or the Nova/C-8 Mode, the Lunar Orbit Rendezvous Mode offers the advantage that no existing contracts for stages (if we go to Nova) or spacecraft systems (if we go to C-5 Direct) have to be terminated; that the contractor structure in existence can be retained; that the contract negotiations presently going on can be finished under the existing set of ground rules; that the contractor build-up program (already in full swing) can be continued as planned; that facilities already authorized and under construction can be built as planned, etc.

k. We at the Marshall Space Flight Center readily admit that when first exposed to the proposal of the Lunar Orbit Rendezvous Mode we were a bit skeptical - particularly of the aspect of having the astronauts execute a complicated rendezvous maneuver at a distance of 240,000 miles from the earth where any rescue possibility appeared remote. In the meantime, however, we have spent a great deal of time and effort studying the four modes, and we have come to the conclusion that this particular disadvantage is far outweighed by the advantages listed above.

We understand that the Manned Spacecraft Center was also quite skeptical at first when John Houbolt of Langley advanced the proposal of the Lunar Orbit Rendezvous Mode, and that it took them quite a while to substantiate the feasibility of the method and finally endorse it.

Against this background it can, therefore, be concluded that the issue of "invented here" versus "not invented here" does not apply to [5] either the Manned Spacecraft Center or the Marshall Space Flight Center; that both Centers have actually embraced a scheme suggested by a third. Undoubtedly, personnel of MSC and MSFC have by now conducted more detailed studies on all aspects of the four modes than any other group. Moreover, it is these two Centers to which the Office of Manned Space Flight would ultimately have to look to "deliver the goods". I consider it fortunate indeed for the Manned Lunar Landing Program that both Centers, after much soul searching, have come to identical conclusions. This should give the Office of Manned Space Flight some additional assurance that our recommendations should not be too far from the truth.

II. WHY DO WE NOT RECOMMEND THE EARTH ORBIT RENDEZVOUS MODE?

Let me point out again that we at the Marshall Space Flight Center consider the Earth Orbit Rendezvous Mode entirely feasible. Specifically, we found the Tanking Mode substantially superior to the Connecting Mode. Compared to the Lunar Orbit Rendezvous Mode, it even seems to offer a somewhat greater performance margin. This is true even if only the nominal two C-5's (tanker and manned lunar vehicle) are involved, but the performance margin could be further enlarged almost indefinitely by the use of additional tankers.

We have spent more time and effort here at Marshall on studies of the Earth Orbit Rendezvous Mode (Tanking and Connecting Modes) than on any other mode. This is attested to by six big volumes describing all aspects of this mode. Nor do we think that in the light of our final recommendation - to adopt the Lunar Orbit Rendezvous Mode instead - this effort was in vain. Earth Orbit Rendezvous as a general operational procedure will undoubtedly play a major role in our over-all national space flight program, and the use of it is even mandatory in developing a Lunar Orbit Rendezvous capability.

The reasons why, in spite of these advantages, we moved it down to position number 2 on our totem pole are as follows:

a. We consider the Earth Orbit Rendezvous Mode more complex and costlier than Lunar Orbit Rendezvous. Moreover, lunar mission success with Earth Orbit Rendezvous requires two consecutive successful launches. If, for example, after a successful tanker launch, the manned lunar vehicle aborts during its ascent, or fails to get off the pad within a certain permissible period of time, the first (tanker) flight must also be written off as useless for the mission.

b. The interface problems arising between the Manned Spacecraft Center and the Marshall Space Flight Center, both in the technical and management areas, would be more difficult if the Earth Orbit Rendezvous Mode was adopted. For example, if the tanker as an unmanned vehicle was handled by MSFC, and the flight of the manned lunar vehicle was [6] conducted by the Manned Spacecraft Center, a managerial interface arises between target and chaser. On the other hand, if any one of the two Centers would take over the entire mission, it would probably bite off more than it could chew, with the result of even more difficult and unpleasant interface problems.

c. According to repeated statements by Bob Gilruth, the Apollo Command Module in its presently envisioned form is simply unsuited for lunar landing because of the poor visibility conditions and the undesirable supine position of the astronauts during landing.

III. <u>WHY DO WE NOT RECOMMEND THE C-5 DIRECT MODE?</u>

It is our conviction that the C-5 Direct Mode will ultimately become feasible - once we know more about hyperbolic re-entry, and once we have adequate high energy propulsion systems available that can be used conveniently and reliably on the surface of the moon. With the advent of a nuclear third stage for C-5, the margin for this capability will be substantively widened, of course.

a. Our main reason against recommending the C-5 Direct Mode is its marginal weight allowance for the spacecraft and the demand for high energy return propulsion, combined with the time factor, all of which would impose a very substantial additional burden on the Manned Spacecraft Center.

b. The Manned Spacecraft Center has spent a great deal of time and effort in determining realistic spacecraft weights. In the opinion of Bob Gilruth and Chuck Mathews, it would simply not be realistic to expect that a lunar spacecraft light enough to be used with the C-5 Direct Mode could be developed during this decade with an adequate degree of confidence.

c. The demand for a high energy return propulsion system, which is implicit in the C-5 Direct Mode, is considered undesirable by the Manned Spacecraft Center - at the present state-of-the-art at least - because this propulsion system must also double up as an extra-atmospheric abort propulsion system. For this purpose, MSC considers a propulsion system as simple and reliable as possible (storable and hypergolic propellants) as absolutely mandatory. We think the question of inherent reliability of storable versus high energy propulsion systems - and their usability in the lunar surface environment - can be argued, but as long as the requirement for "storables" stands, the C-5 Direct Mode is not feasible performance wise.

[7] d. NASA has already been saddled with one program (Centaur) where the margin between performance claims for launch vehicle and demands for payload weights were drawn too closely. We do not consider it prudent to repeat this mistake.

IV. <u>WHY DO WE RECOMMEND AGAINST THE NOVA OR C-8 MODE?</u>

It should be clearly understood that our recommendation against the Nova or C-8 Mode at this time refers solely to its use as a launch vehicle for the implementation of the President's commitment to put a man on the moon in this decade. We at Marshall feel very strongly that the Advanced Saturn C-5 is not the end of the line as far as major launch vehicles are concerned! Undoubtedly, as we shall be going about setting up a base on moon and beginning with the manned exploration of the planets, there will be a great need for launch vehicles more powerful than the C-5. But for these purposes such a new vehicle could be conceived and developed on a more relaxed time schedule. It would be a true follow-on launch vehicle. All of our studies aimed at NASA's needs for a true manned interplanetary capability indicate that a launch vehicle substantially more powerful than one powered by eight F-l engines would be required. Our recommendation, therefore, should be formulated as follows: "Let us take Nova or C-8 out of the race of putting an American on the moon in this decade, but let us develop a sound concept for a follow-on 'Supernova' launch vehicle".

Here are our reasons for recommending to take Nova or C-8 out of the present Manned Lunar Landing Program:

a. As previously stated, the Apollo system in its present form is not landable on the moon. The spacecraft system would require substantial changes from the presently conceived configuration. The same argument is, of course, applicable to the Earth Orbit Rendezvous Mode.

b. With the S-II stage of the Advanced Saturn C-5 serving as a second stage of a C-8 (boosted by eight F-l engines) we would have an undesirable, poorly staged, hybrid launch vehicle, with a payload capability far below the maximum obtainable with the same first stage. Performance wise, with its escape capability of only 132,000 lbs. (in lieu of the 150,000 lbs. demanded) it would still be too marginal, without a high energy return propulsion system, to land the present Apollo Command Module on the surface of the moon.

c. Imp1ementation of the Nova or C-8 program <u>in addition</u> to the Advanced Saturn C-5 would lead to two grossly underfunded and undermanaged programs with resulting abject failure of both. Implementation [8] of the Nova or C-8 program <u>in lieu of</u> the Advanced Saturn C-5 would have an absolutely disastrous impact on all our facility plans.

The rafter height of the Michoud plant is 40 feet. The diameter of the S-IC is 33 feet. As a result, most of the assembly operations for the S-IC booster of the C-5 can take place in a <u>horizontal</u> position. Only a relatively narrow high bay tower must be added to the main building for a few operations which <u>must</u> be carried out in a vertical position. A Nova or C-8 booster, however, has a diameter of approximately 50 feet. This means that the roof of a very substantial portion of the Michoud plant would have to be raised by 15 to 20 feet. Another alternative would be to build a very large high bay area where every operation involving cumbersome parts would be done in a vertical position. In either case the very serious question arises whether under these circumstances the Michoud plant was a good selection to begin with.

The foundation situation at Michoud is so poor that extensive pile driving is necessary. This did not bother us when we acquired the plant because the many thousands of piles on which it rests were driven twenty years ago by somebody else. But if we had to enter into a major pile driving operation now, the question would immediately arise as to whether we could not find other building sites where foundations could be prepared cheaper and faster.

Any tampering with the NASA commitment to utilize the Michoud plant, however, would also affect Chrysler's S-1 program, for which tooling and plant preparation are already in full swing at Michoud. Raising the roof and driving thousands of piles in Michoud may turn out to be impossible while Chrysler is assembling S-I's in the same hangar.

In summary, the impact of a switch from C-5 to Nova/C-8 on the very concept of Michoud, would call for a careful and detailed study whose outcome with respect to continued desirability of the use of the Michoud plant appears quite doubtful. We consider it most likely that discontinuance of the C-5 plan in favor of Nova or C-8 would reopen the entire Michoud decision and would throw the entire program into turmoil with ensuing unpredictable delays. The construction of a new plant would take at least 2-1/2 years to beneficial occupancy and over 3 years to start of production.

d. At the Marshall Space Flight Center, construction of a static test stand for S-IC booster is well under way. In its present form this test stand cannot be used for the first stage of Nova or C-8. Studies indicate that as far as the noise level is concerned, there will probably be no objection to firing up eight F-1 engines at MSFC. However, the Marshall [9] test stand construction program would be greatly delayed, regardless of what approach we would take to accommodate Nova/C-8 stages. Detailed studies seem to indicate that the fastest course of action, if Nova or C-8 were adopted, would be to build

— a brand new eight F-l booster test stand south of the present S-IC test stand, and

— convert the present S-IC test stand into an N-II test stand. (This latter conclusion is arrived at because the firing of an N-II stage at Santa Susanna is not possible for safety reasons, the S-II propellant load being considered the absolute maximum permissible.)

The Mississippi Test Facility is still a "cow pasture that NASA doesn't even own yet," and cannot compete with any test stand availability dates in Huntsville. Developments of basic utilities (roads, water, power, sewage, canals, rail spur, etc.) at MTF will require well over a year, and all scheduling studies indicate that whatever we build at MTF is about 18 months behind comparable facilities built in Huntsville. MTF should, therefore, be considered an acceptance firing and product improvement site for Michoud products rather than a basic development site.

e. In view of the fact that the S-II stage is not powerful enough for the Apollo direct flight mission profile, a second stage powered by eight or nine J-2's or two M-l's is needed. Such a stage would again be on the order of 40 to 50 feet in diameter. No studies have been made as to whether it could be built in the Downey/Seal Beach complex. It is certain, however, that its static testing in Santa Susanna is impossible. As a result, we would have to take an entirely new look at the NAA contract.

f. I have already mentioned the disruptive effect a cancellation of the C-5 would have on the RIFT program.

g. One of the strongest arguments against replacement of the Advanced Saturn C-5 by Nova or C-8 is that such a decision would topple our entire contractor structure. It should be remembered that the temporary uncertainty about the relatively minor question of whether NAA should assemble at Seal Beach or Eglin cost us a delay of almost half a year. I think it should not take much imagination to realize what would happen if we were to tell Boeing, NAA and Douglas that the C-5 was out; that we are going to build a booster with eight F -1 engines, a second stage with eight or nine J –2's or maybe two M-1 engines; and that the entire problem of manufacturing and testing facilities must be re-evaluated.

[10] We already have several thousands of men actually at work on these three stages and many of these have been dislocated from their home plants in implementation of our present C-5 program. Rather than leaving these thousands of men suspended (although supported by NASA dollars) in a state of uncertainty over an extended period of new systems analysis, program implementation studies, budget reshuffles, site selection procedures, etc., it may indeed turn out to be wiser to just terminate the existing contracts and advise the contractors that we will call them back once we have a new program plan laid out for them. We have no doubt that the termination costs incurring to NASA by doing this would easily amount to several hundred million dollars.

I have asked a selected group of key Marshall executives for their appraisal, in terms of delay of the first orbital launch, if the C-5 was to be discontinued and replaced by a Nova or C-8. The estimates of these men (whose duties it would be to implement the new program) varied between 14 and 24 months with an average estimate of an over-all delay of 19 months.

h. In appraising the total loss to NASA, it should also not be overlooked that we are supporting engine development teams at various contractor plants at the rate of many tens of millions of dollars per year for every stage of C-l and C-5. If the exact definition of the stages were delayed by switching to Nova/C-8, these engine development teams would have to be held on the NASA payroll for just that much longer, in order to assure proper engine / stage integration.

i. More than twelve months of-past extensive effort at the Marshall Space Flight Center to analyze and define the Advanced Saturn C-5 system in a great deal of engineering detail would have to be written off as a flat loss, if we abandoned the C-5 now. This item alone, aside from the time irretrievably lost, represents an expenditure of over one hundred million dollars.

j. The unavoidable uncertainty in many areas created by a switch to Nova or C-8 (Can we retain present C-5 contractors? Where are the new fabrication sites? Where are we going to static test? etc.) may easily lead to delays even well in excess of the estimates given above. For in view of the political pressures invariably exerted on NASA in connection with facility siting decisions, it is quite likely that even the NASA Administrator himself will find himself frequently unable to make binding decisions without demanding from OMSF an extensive re-appraisal of a multitude of issues related with siting. There was ample evidence of this during the past year.

k. For all the reasons quoted above, the Marshall Space Flight Center considers a discontinuation of the Advanced Saturn C-5 in favor of Nova or C-8 as the worst of the four proposed modes for implementation of the manned lunar landing project. We at Marshall would consider a decision in favor of this mode to be tantamount with giving up the race to put a man on the moon in this decade even before we started.

[11]

IN SUMMARY I THEREFORE RECOMMEND THAT:

a. The Lunar Orbit Rendezvous Mode be adopted.

b. A development of an unmanned, fully automatic, one-way C-5 Logistics Vehicle be undertaken in support of the lunar expedition.

c. The C-l program as established today be retained and that, in accordance with progress made in S-IV B development, the C-l be gradually replaced by the C-I B.

d. A C-l B program be officially established and approved with adequate funding.

e. The development of high energy propulsion systems be initiated as a back-up for the Service Module and possibly the Lunar Excursion Module.

f. Supplements to present development contracts to Rocketdyne on the F -1 and J -2 engines be let to increase thrust and/ or specific impulse.

[signed]
Wernher von Braun, Director
George C. Marshall Space Flight Center

Document II-19

Document Title: Jerome Wiesner, "Memorandum for Theodore Sorensen," 20 November 1961.

Source: John F. Kennedy Presidential Library, Boston, Massachusetts.

This memorandum from President Kennedy's science advisor to the president's top advisor provides a top-level snapshot of the status of Project Apollo at the end of 1961.

THE WHITE HOUSE
WASHINGTON
November 20, 1961

MEMORANDUM FOR

Mr. Theodore C. Sorensen

Outline of major problems related to the NASA Manned Lunar Program:

1. Required decisions
   Rendezvous
   Advanced Saturn
   Nova

2. Initiate hardware programs
   Launch vehicles (beyond Saturn C - 1)
   Engines (in addition to F-1, J-2)
   Spacecraft
   Launch pads
   Static test stands (for new stages)
   Rendezvous development

3. Activate new field stations
   Houston (Spacecraft)
   Michoud (Boosters)
   Pearl River (Static test)
   AMR expansion (Launching)

4. Secure supporting information
   Space environment
   Long-term weightlessness
   Lunar characteristics

5. Manpower (FY'63 total in-house: 26, 224 ∠ JPL)
   Availability
   Competence
   Salaries

[2]

6. University support
   Research grants
   Facilities
   Education

7. DOD support and related programs
   Biomedical program
   Titan II and III
   Dyna Soar

8. Financial support
   Supplemental FY '62: $156 M - FY '63: $4238.2 M
   Future predictions

Note: NASA responsibilities not directly related to the manned Lunar Program:

9. Space Applications (i.e., Meteorology and Communications)

10. Aeronautics

11. Nuclear technology (Snap and Rover)

12. Other space science including Planetary and Interplanetary

13. Long-range spacecraft and vehicle technology

Comments on outline:

1. The major decisions have not been announced as to what extent rendezvous will be employed, what Advanced Saturn vehicle will be built (probably C-4), and what will be the characteristics of the so-called Nova which could put man on the moon by direct ascent. The relative emphasis of rendezvous versus direct ascent is a key to the entire program.

2. Six months have elapsed since the decision was announced to put man on the moon, yet none of these crucial hardware programs have progressed beyond the study phase. Lead times on these development and construction programs are of critical importance.

[3]

3. It is hoped that there will be no further field stations beyond these already announced. However, there are major problems related to the activation of these centers.

4. These are the major questions related to the lunar undertaking which can only be obtained by a broad supporting space and life science program.

5. Many people believe that the space program may severely tax our supply of technical manpower for in-house and contractor needs. It is also important that competent leadership be available, and adequate salary scales are a continuing problem.

6. NASA must support a broad program of basic research related to the space effort in the universities. The impact on the universities and upon the educational requirements must also be considered.

7. There are still major problems in the NASA-DOD relationship related to booster development and supporting technology.

8. The total being requested of the next Congress is about 50% greater than was predicted for FY '63 last May. Extrapolation to future years of the funding trend does not lend itself to any optimism as to a leveling-off in the next year or two.

9 - 13. The major item in here which should be singled out at this time is the Nuclear Rocket Program (Rover). The total NASA-AEC request for FY '63 is about $200 million. Is this level of funding realistic for a program which will probably not produce an operational vehicle until 1970 or later?

[signed]
Jerome B. Wiesner

Document II-20

Document Title: NASA, "Project Apollo Source Evaluation Board Report: Apollo Spacecraft," NASA RFP 9-150, 24 November 1961.

Source: Folder 18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

The first element of the system to carry astronauts to the Moon was the Apollo spacecraft. Even before President Kennedy set a lunar landing by the end of the decade as a national goal, NASA had been planning a three-person spacecraft for Earth orbital and circumlunar missions. After Kennedy's 25 May 1961 speech announcing the decision to send Americans to the Moon, the spacecraft requirements were modified to support a lunar landing mission, even though the approach to be taken in carrying out the mission had not yet been chosen.

The Source Evaluation Board ranked the proposal by The Martin Company first among the five companies that submitted a bid, with North American Aviation a "desirable alternative." NASA Administrator James E. Webb, Deputy Administrator Hugh Dryden, and Associate Administrator Robert Seamans reversed this ranking, and the contract to build the Apollo spacecraft was awarded to North American Aviation on 28 November 1961.

PROJECT APOLLO

SOURCE EVALUATION BOARD REPORT

APOLLO SPACECRAFT

NASA RFP 9-150

CLASSIFICATION CHANGE
To Unclassified on 8/17/71

November 24, 1961

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Manned Spacecraft Center Langley Air Force Base, Virginia

REPORT OF THE SOURCE EVALUTION BOARD
APOLLO SPACECRAFT
NASA RFP 9-150

Submitted by:

Chairman:	Maxime A. Faget ,Manned Spacecraft Center
Member:	Robert O. Piland, Manned Spacecraft Center
Member:	George M. Low, NASA Headquarters
Member:	Wesley L. Hjornevik, Manned Spacecraft Center
Member:	Kenneth S. Kleinknecht, Manned Spacecraft Center
Member:	Charles W. Mathews, Manned Spacecraft Center
Member:	James A. Chamberlin, Manned Spacecraft Center
Member:	A. A. Clagett, NASA Headquarters
Member:	Dr. Oswald H. Lange, Marshall Space Flight Center
Member:	Dave W. Lang, Manned Spacecraft Center
*Member:	James T. Koppenhaver, NASA Headquarters
Ex Officio:	Robert R. Gilruth, Manned Spacecraft Center

*Non-voting member (reliability representative)

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[pp. 1-5 not included]

[6] REQUEST FOR PROPOSAL DISSEMINATION

Subsequent to the Headquarter's approval of the Statement of Work and a Procurement Plan, the Request for Proposal was disseminated on July 28, 1961 to the following twelve companies.

Boeing Airplane Company
Chance Vought Aircraft
General Dynamics Corporation
Douglas Aircraft Company, Inc.
General Electric Company
Goodyear Aircraft Corporation
Grumman Aircraft Engineering Corporation
Lockheed Aircraft Corporation
The Martin Company
McDonnell Aircraft Corporation
North American Aviation, Inc.
Republic Aviation Corporation

In addition, a synopsis of the proposed procurement was publicized in accordance with NASA Circular No. 131, which deals with the publicizing of NASA-proposed research and development procurements.

Four additional companies were provided with the Request for Proposal upon request.

Radio Corporation of America
Space General Corporation
Space Technology Laboratories
Bell Aerospace Systems

There were no complaints received from companies not invited to submit proposals. Potential subcontractors requesting Request for Proposals were referred to the potential prime contractors.

A preproposal conference attended by representatives of the sixteen companies was held on August 14, 1961, at which time NASA personnel discussed the technical and business aspects of the Request for Proposal .Approximately four hundred questions were answered orally and subsequently documented and confirmed by mail.

[7] PROPOSALS SUBMITTED

Five companies submitted proposals on October 9, 1961, ten weeks after the Request for Proposal was mailed. No complaints on the time allowed were received and no time extensions were requested. The five companies submitting proposals were as follows:

General Dynamics/Astronautics
General Electric Company/MSVD
The Martin Company
McDonnell Aircraft Corporation
North American Aviation, Inc./S and ID

The General Electric Company and McDonnell Aircraft Corporation proposed to form teams to carry out the contract. General Electric proposed to team with Douglas Aircraft, Grumman Aircraft, and Space Technology Laboratories. McDonnell proposed to team with Chance Vought, Lockheed and Hughes. General Dynamics proposed a single team member, AVCO. Martin and North American both proposed the prime-subcontractor approach. Representatives of the proposers made oral presentations on October 11, 1961 to members of the NASA evaluation team.

[8] EVALUATION PROCEDURE

Organization

The evaluation was conducted by the Source Evaluation Board. The Chairman of the board appointed Technical and Business Subcommittees to assist in the evaluation. These subcommittees in turn were assisted by panels of specialists. The detail procedures and membership of the subcommittees and panels is presented in references 2 and 3. A total of 190 personnel representing all major elements of the NASA and including several representatives of the DOD participated in the evaluation.

Assessment Areas

The Technical Evaluation consisted of two major areas, Technical Qualifications and Technical Approach. The Technical Qualifications portion covered experience, facilities, personnel, and the technical ramifications of the proposed project organization. The Technical Approach portion consisted of eleven areas which covered mission and system design; systems integration; development, reliability, and manufacturing plans; and operational concepts. The Business Management and Cost Evaluation consisted of the areas of organization and management, logistics, subcontract administration, and cost.

Weighting Factors

The weighting factors assigned to the major proposal areas were as follows:

Technical Qualifications	30
Technical Approach	30
Business Management and Cost	40
	100

[9] Rating Method

Ratings were made on a 0-10 rating system, defined in the following manner.

10 9 8	Excellent
7 6 5	Good
4 3 2	Fair
1	Poor
0	Unsatisfactory

Evaluation Schedule

October 9 – 21	Detail assessment by panels
October 23 – 28	Subcommittee review
November 1 – 22	Source Evaluation Board review

[10] EVALUATION RESULTS

Ratings

The Source Evaluation Board reviewed the reports of the Technical and Business Subcommittees and discussed the reports with the subcommittees. The reports and ratings were accepted with minor modifications. The board examined the sensitivity of the weighting factors used by the various panels during the evaluation. It was determined that the results are not sensitive to moderate changes in the weighting factors. The board considered in further detail the item of applicable experience which had been rated by the Technical Subcommittee in the area of Technical Qualifications to insure that the factor of quality of experience had been adequately considered. The board's findings confirmed the ratings given by the subcommittee. The board recognized that the Cost Panel had not had access to sufficient information to adequately rate the items of Cost Experience and Cost Estimate. The board further found that the Organization and Management Panel had sufficient information to adequately assess the Cost Experience item and so its rating of this item was used. The board through the use of an Ad Hoc Panel analysed the realism of the cost estimates in relation to the work proposed and subsequently rated this item. The rating for each proposal in the three major areas and a summary weighting obtained by applying the weight factors is presented below.

Ratings by Area

	Technical Approach (30%)	Technical Qualifications (30%)	Business (40%)
The Martin Company	5.58	6.63	8.09
General Dynamics/ Astronautics	5.27	5.35	8.52
North American Aviation, Inc.	5.09	6.66	7.59
General Electric Company	5.16	5.60	7.99
McDonnell Aircraft Corporation	5.53	5.67	7.62

Summary Ratings

The Martin Company	6.9
General Dynamics/Astronautics	6.6
North American Aviation, Inc.	6.6
General Electric Company	6.4
McDonnell Aircraft Corporation	6.4

As can be seen, the North American and General Dynamics/Astronautics proposals received the same rating. In assessing the ratings, the board recognized that all the proposals had received high ratings in the Business area, the lowest rating (7.59) being higher than the highest rating (6.66) received in either the Technical Approach or Technical Qualifications area. Since those ratings established [11] that all the companies could more than adequately handle the business aspects of the program, the board turned its consideration to the Technical Evaluation for further analysis of the ratings.

The ratings of the proposals considering only the Technical Evaluation areas of Approach and Qualifications are as follows:

The Martin Company	6.1
North American Aviation, Inc.	5.9
McDonnell Aircraft Corporation	5.6
General Electric Company	5.4
General Dynamics/Astronautics	5.3

It may be concluded that General Dynamics/Astronautics' tie for second place rating is due entirely to its very high rating in the Business area, since it rated last in the Technical Evaluation. In view of the relatively high ratings of all companies in the Business area, and General Dynamics lowest rating in the Technical Evaluation, the board finds North American Aviation the clearly preferred source of the two proposals which received the tie second place ratings.

Assessment of Proposed Costs

The Request for Proposal did not specify a particular program for the development of the Apollo spacecraft. Part of each contractor's responsibility in deve1oping his proposal was to indicate a technical development plan, a program schedule inc1uding hardware and testing, and a cost estimate supporting this proposed plan and program. The cost estimates received, therefore, were not subject to direct comparison. The cost estimates received for Phase A, the earth orbital portion of the project, were as follows:

GD/A	GE	Martin	MAC	NAA
550	899	563	629	351

(Cost in Millions)

As mentioned above, these costs are based on the particular program proposed by the different offerors. These proposed programs varied to a considerable degree. For purposes of analysing the cost estimate an "adjusted" cost was determined. This "adjusted" cost modified the submitted estimate to a reference number of spacecrafts, flights, and months. These adjusted costs are given below. They do not necessarily represent the negotiated contract cost and were used here for the purpose of cost analysis.

GD/A	GE	Martin	MAC	NAA
431	830	473	702	352

The cost estimates were examined in detail. Particular attention was given to rating the realism, validity, and overall quality of the cost proposals. In this regard both General Dynamics/Astronautics and Martin were considered to have high quality cost estimates, [12] well supported, detailed, and carefully considered. The low estimate of NAA was noted and carefully reviewed by the board, its Ad Hoc Panel, the Business Subcommittee and its Cost Panel. Although the quality of NAA's past cost history was recognized, the overall quality of this estimate was not as high as General Dynamics/Astronautics or Martin and the detail and summary information appeared questionable in areas of engineering, design, and subcontracts cost. NAA, accordingly, was not rated as highly as GD/A and Martin. The General Electric Company and McDonnell Aircraft estimates were rated below the other estimates because of high costs for programs proposed which reflected their proposed management philosophy for the Apollo spacecraft development.

Conflict of Resource Requirement

The board was concerned with the possible conflict of resource requirements between Apollo and other present or anticipated projects within the companies. Of particular concern, since they involved the preferred and alternate source, was the possible conflict between Apollo and the anticipated Titan III at The Martin Company and between Apollo and the S-II stage at North American. In order to further assess the possible conflict with the Titan III, the following request for information was sent to The Martin Company.

"NASA would like to ascertain the degree of conflict in manpower and resources between a possible Titan III program by Martin and Martin's Apollo proposal. Martin is asked to review Section 2.3 of their Management Proposal and inform NASA what changes would result in their proposed manpower and resources."

The Martin reply was as follows: "Martin reaffirms the subject proposal delivered October 9 to NASA and calls particular attention to the statements made in our letter of submittal and Section 2.3 of our Management Proposal concerning the priority Apollo will have if an award is made to us. Follow-on Titan programs have always been included in our future planning and, hence, were considered before developing the Manpower and Resources Sections of our Management Proposal. Titan III effort would be accomplished in our Denver Division and, therefore, does not constitute a conflict with Apollo. In any event, we never contemplated use of Denver-Titan manpower or resources for execution of the Apollo program. Therefore, we contemplate no change in our proposed manpower or resources as a result of a possible Titan III program."

A similar request for information related to the S-II was sent to NAA as follows: "NASA would like to ascertain the degree of conflict in manpower and resources between the Saturn S-II contract and NAA's Apollo proposal. North American is asked to correct figures 2.3-12, 2.3-14, and 2.3-16 of their Management Proposal to include the S-II load. NAA is also asked to reaffirm or correct the names of key personnel on pages 2.3-24 through 2.3-32."

[13] North American presented a detailed reply which has been filed with the original proposal. The reply contained considerable detailed discussion and data which in essence reaffirmed North American's position of "no conflict" as presented in the proposal.

The board considered both replies in detail and has satisfied itself to the degree possible that the manpower and resources proposed for Apollo are not in conflict with those required for Titan III at Martin or the S-II at North American.

Discussion of Results

The Martin Company is considered the outstanding source for the Apollo prime contractor. Martin not only rated first in Technical Approach, a very close second in Technical Qualifications, and second in Business Management, but also stood up well under the further scrutiny of the board.

The Martin Company appears to be well prepared to undertake the Apollo effort. This was evidenced by a Technical Proposal that was complete, well integrated with balanced emphasis in all areas, and of high overall quality with a minimum amount of superflous material. Martin's proposal was first in five of the eleven major Technical Approach areas including Technical Development Plan, Flight Mechanics, Onboard Systems, Manufacturing, and Ground Operational Support Systems and Operations. Martin, therefore, scored high in planning, design, manufacturing and operations, reflecting the quality across the complete scope of the job.

Martin has experience in large technically complex systems such as Titan and Vanguard. The personnel proposed and company have a general background of manned aircraft experience, as well as varied background of experience including airplanes (B-5l and B-57), missiles (Titan, Matador, Mace, Bullpup, and Pershing), and space vehicles (Vanguard). Their inhouse experience in many of the required technical areas results in a high confidence as to their capability as a systems integrator. The individual key technical personnel Martin proposed to assign to the project were evaluated as excellent both in competence and experience. Martin's proposed management arrangement of a prime contractor with subcontractors appears technically to be the most sound both as far as reaching technical decisions quickly and properly and also for implementing these decisions. Short lines of communications involved in their proposed arrangement will minimize interface problems and required documentation and thereby result in fewer opportunities for error.

Martin proposed a strong project organization for Apollo. They would create a Project Apollo Division managed by a Vice President who reports directly to the President of the company. The parent company would put under the direct control of this [14] division the necessary resources of manpower and facilities for this job.

Martin's cost proposal compared well with the others. Their cost estimate was considered to be both realistic and reasonable.

North American Aviation, Inc. is considered the desirable alternate source for the Apollo spacecraft development. It rated highest of all proposers in the major area of Technical Qualifications. North American's pertinent experience consisting of the X-15, Navajo, and Hound Dog coupled with an outstanding performance in the development of manned aircraft (F-1OO and F-86) resulted in it being the highest rated in this area. The lead personnel proposed showed a strong background in development projects and were judged to be the best of any proposed. Like Martin, NAA proposed a project managed by a single prime contractor with subsystems obtained by subcontracting, which also had the good features described for the Martin proposal. Their project organization, however, did not enjoy quite as strong a position within the corporate structure as Martin's did. The high Technical Qualifications rating resulting from these features of the proposal was therefore high enough to give North American a rating of second in the total Technical Evaluation although its detailed Technical Approach was assessed as the weakest submitted. This relative weakness might be attributed to the advantage of the McDonnell Aircraft Corporation's Mercury experience, and the other three proposers' experience on the Apollo study contracts. The Source Evaluation Board is convinced that NAA is well qualified to carry out the assignment of Apollo prime contractor and that the shortcomings in its proposal could be rectified through further design effort on their part. North American submitted a low cost estimate which, however, contained a number of discrepancies. North American's cost history was evaluated as the best.

The remaining three companies, General Dynamics/Astronautics, General Electric Company, and McDonnell Aircraft Corporation, were not considered to be as desirable as Martin and NAA as a source for Apollo. These offerors supplemented their skills and resources with those of one or more additional companies in order to create a team prepared to carry out the Apollo effort. While the board found that these teams did indeed show adequate, or more than adequate, resources for the job, it was also apparent that the ramifications of a large team were serious. The communications problems created by geographical locations, the complex coordination required which leads to slow process of actions, the overlapping and similar capabilities of several team members which may lead to disagreement, and the committee approach [15] to project decision all tend to detract from the desirability of the team approach. There was also an apparent relation between high project cost and the two large teams.

It should be pointed out that the same degree of management difficulty is not inherent in the three team offerors. GD/A with only one team associate should be expected to suffer very little in this respect. MAC showed awareness of the problem and attempted to invest adequate control responsibility in a strong Project Manager, who is also properly located at a high level in the MAC corporate structure. GE's proposal is particularly vulnerable to this criticism since it emphasizes councils and committees. GE was also found in many important technical respects to be weaker than its other team members. Consequently, it may prove to be in a poor position to direct its team's effort in conflicting situations.

General Dynamics/ Astronautics rated third in Technical Approach and last in Technical Qualifications. They rated excellently in big systems experience of an advanced technological nature (Atlas), but exhibited no manned aircraft or spacecraft experience in the Astronautics Division and their experience was not broad being limited to Atlas and Centaur. Relative to the other companies proposing, GD/A did not rate highly in facilities. While enjoying excellent conventional laboratories, no evidence of large-scale simulation or environmental equipment was noted. The personnel proposed were relatively shy in total experience and project experience.

GD/A submitted a cost proposal that was considered best. Like Martin, its estimate of cost was considered both realistic and reasonable. Although they clearly made the best business management proposal, the other offerors all rated sufficiently high in this area to lead the board to the conclusion that the technical aspects should be the controlling consideration. With the weakest technical showing, GD/A is not considered a desirable source.

General Electric Company was rated fourth overall resulting from a third place rating in Business Management and fourth place ratings in both Technical Approach and Qualifications. GE'S middle rating in Business resulted from having excellent facilities and a willingness to invest heavily of company funds. The GE/MSVD experience in managing systems of the scope of Apollo was lacking, and their management and program organizations were considered weaker than top proposers. GE made the highest cost proposal. This was considered by the board to be a true reflection of the [16] layering of fees, the duplication of effort, and the extra, complexity associated with the far-flung large team organization they proposed. For this reason, the GE team was not considered a desirable source.

McDonnell Aircraft Corporation rated lowest in overall rating. Although MAC rated a close second in Technical Approach, it rated third in Technical Qualifications. MAC proposed the second highest cost. With a team approach quite similar to that of GE's, MAC was also considered by the board to be a high cost producer. For these reasons, MAC did not appear to be a desirable source despite its high relative rating in the Technical Approach area.

Document II-21

Document Title: Joseph F. Shea, Deputy Director for Systems, Office of Manned Space Flight, to Director of Aerospace Medicine and Director of Spacecraft and Flight Missions, "Selection and Training of Apollo Crew Members," 29 March 1962.

Source: Folder 18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

As NASA began detailed scientific planning for Apollo, one issue was whether to expand the astronaut corps, which to that point had been limited to accomplished test pilots, to include professional scientists as astronauts. This memorandum solicits the views of key NASA human spaceflight offices on this question. NASA decided to recruit scientist astronauts for Apollo, but only one, Dr. Harrison Schmitt, flew, on Apollo 17, the final Apollo mission to the Moon.

To: Director of Aerospace Medicine March 29, 1962
Director of Spaceflight & Flight Missions

From: Joseph F. Shea

Re: Selection and Training of Apollo Crew Members

At the request of the Office of Systems, the NASA Space Science Steering Committee has established an ad hoc group to recommend scientific tasks to be performed on the moon by Apollo crew members. This group, under the chairmanship of Dr. Sonnett, will include scientific consultants as well as representatives from appropriate NASA groups.

Dr. Sonnett has asked the OMSF to present a briefing to this group at its first formal meeting, establishing a context and the ground rules within which they are to perform their task. One of the topics to be covered is the possible use of one or more professional scientists as crew members on lunar missions.

To assist in the preparation of this briefing, it would be helpful if you furnished this office with memoranda, no later than April 16, directed to the following two questions:

1. Is there any fundamental reason which would prevent the use of one or more professional scientists as crew members?

2. What serio us practical problems would result if such personnel were included in the selection [and] training program?

It is assumed that the NH [Aerospace Medicine] memorandum will cover these questions from the viewpoint of medical selection, and that MS [Spaceflight & Flight Missions] will consider the problem in terms of background skills and training requirements.

Joseph F. Shea
Deputy Director for Systems
Office of Manned Space Flight

Document II-22

Document Title: Owen E. Maynard, Spacecraft Integration Branch, NASA Manned Spacecraft Center, Memorandum for Associate Director, "Comments on Mr. Frank Casey's visit to J.P.L. to discuss Ranger and follow-on programs which could provide information pertinent to Apollo missions," 1 February1962.

Source: Folder 18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

Since the beginning, it had been clear to those planning for human missions to the Moon that they would need information from robotic lunar missions. Those missions were under the management of the Jet Propulsion Laboratory (JPL), a Federally-Funded Research and Development Center operated for NASA by the California Institute of Technology. JPL's mission designs were aimed at answering scientific questions, not providing support for human spaceflight missions, and JPL was rapidly developing within NASA a reputation for excessive independence from the rest of NASA. This was proven after a visit to JPL to see if the lunar hard landing Ranger missions and potential follow-on robotic missions (which *became the Surveyor program) could contribute to the planning for Project Apollo. It is interesting to note that in this early stage of planning for Apollo, the Sea of Tranquility had already been identified as a potential lunar landing site.*

At this point in the evolution of Apollo, the program was divided into three elements: Apollo A, Earth-orbital tests of the Apollo spacecraft; Apollo B, flights around the Moon; and Apollo C, flights to land on the Moon.

NASA – Manned Spacecraft Center
Langley AFB, Virginia
February 1, 1962

MEMORANDUM for Associate Director

Subject: Comments on Mr. Frank Casey's visit to J.P.L. to discuss Ranger and follow-on programs which could provide information pertinent to Apollo missions.

1. During a recent visit to J.P.L. at Pasadena, California, a group of NASA employees from Langley Research Center, Ames Research Center and Manned Spacecraft Center had an opportunity to discuss the Ranger program and its follow-on programs with the J.P.L. staff. The purpose of this meeting was to determine if the present series of Ranger payloads and the follow-on payloads could be of value to the Apollo mission.

2. Since both the time and experiments available for obtaining further engineering data for design of Apollo systems and components is limited when viewed in terms of the unknowns, the following question was posed within the NASA group as a basis [*sic*] criterion for the planning of payloads to obtain further information on environmental data for the Apollo program:

"What are the environmental parameters for which additional data must be obtained before the Apollo missions will be attempted"?

In consideration of three Apollo phases, this criterion leads to the following conclusions:

Apollo Phase A	No further environmental data required
Apollo Phase B	Possibly additional data on radiation and meteoroids in cis-lunar and lunar space
Apollo Phase C	The above comments on radiation and meteoroids is [*sic*] appropriate. In addition, more definite data on both the large and small scale lunar surface features, the existence and nature of lunar surface dust, and the physical properties of the lunar surface which constitute its ability to support a vehicle.

3. It was recognized that the limits, accuracy and coverage of environmental data to better establish the physical nature of the lunar surface in terms of Apollo missions requirements are incomplete, and that further inputs should be reminded of this need and attempts should be made to supply available information to plan instrumentation of Ranger follow-on payloads.

[2]

4. On the basis of current knowledge and thinking relative to the nature of the lunar surface environment, and the need for engineering data for the design of Apollo systems and sub-systems, it appears that the selection of Ranger follow-on payloads should be directed primarily on the ability of these payloads to yield data which would permit a better evaluation of:

a. The large scale features of the lunar surface such as the locations, magnitude, and slopes of mountains, craters, and protuberances;

b. The existence and distribution of small scale features of the lunar surface such as roughness, slopes, faults, sharpness, and vesicularity which will aid in the evaluation of the extent to which the Apollo vehicle must be able to hover and translate prior to landing;

c. The existence of a dust layer on the lunar surface and the properties of this layer which will permit it to be entrained in the jet exhaust and form clouds which may foul systems components and obstruct optical and R.F. transmission from the vehicle to the surface and from the vehicle to space and the earth;

d. The ability of the lunar surface to support the Apollo vehicle including the existence and bearing strength of dust layers in excess of six inches in depth and the bearing strength and hardness of sub-surface material.

Secondary consideration should be given to the measurement of meteoroid and radiation parameters.

5. In consideration of the difficulty associated with obtaining environmental information over a substantial portion of the lunar surface to the accuracy required by Apollo C missions, it would be extremely helpful in the selection of Ranger and follow-on experiments if MSC and J.P.L. could agree on the landing site. It is not possible to get Ranger payloads over to the western limb of the moon where the Sea of Tranquility is located. This would allow the maximum Ranger payload weight to be used to advantage.

6. Since the design freeze date for Apollo occurs in 1964 it is imperative that lines of communication be established immediately if Apollo is to have an input from Ranger and follow-on programs in time to be used as design.

7. J.P.L. is presently investigating the problems of conducting experiments to obtain direct design data for Apollo. They will investigate [3] launch vehicle capabilities to implement the investigations and report their findings to NASA Headquarters about February 8, 1962.

Owen E. Maynard
Spacecraft Integrating Branch

Document II-23

Document Title: Letter to the President from James E. Webb, 13 March 1962.

Source: John F. Kennedy Presidential Library, Boston, Massachusetts.

In this letter, NASA Administrator Webb asks the president to assign the highest national priority to Project Apollo. Such a priority meant that Apollo would get preferred treatment in the allocation of scarce resources. President Kennedy approved this request.

R 13 1962 [stamped]

The President
The White House
Washington, D. C,

My Dear Mr. President:

Programs that enjoy the highest (DX) national priority attain this stature only on approval of the President. In order to meet the objectives of the Nation's space program as stated by you and endorsed by the Congress, I consider it essential that Project Apollo – to effect a manned lunar landing and return in this decade – receive such a priority.

Accordingly, I hereby recommend that the highest national priority be assigned to Project Apollo and in order to assure that you have the advice of the National Aeronautics and Space Council, I have addressed a memorandum, copy attached, to the Vice President asking the Council to consider this matter.

Respectfully yours,

James E. Webb
Administrator

Attachment
[2]

Memorandum for the Chairman, National Aeronautics and Space Council

Subject: Request for Highest National Priority for the Apollo Program

1. The programs that now enjoy the highest (DX) national priority are: Atlas, Titan, Minuteman, Polaris, BMES, SAMOS, Nike-Zeus, Discoverer, Mercury, and Saturn. Of these, the first eight are managed by the Department of Defense, and the last two by the National Aeronautics and Space Administration. The prescribed criteria under which the President has made these determinations is that these programs have objectives of key political, scientific, psychological or military import.

2. The NASA is requesting that the Apollo program be added to this list. Recognizing the need to restrict the number of projects on the list to the absolute minimum, NASA is prepared to drop Project Mercury from the list by the end of Calendar Year 1962, at which time its mission should be essentially complete. NASA will also expect to drop the Saturn vehicle project from the list except insofar as it pertains to the Apollo mission. In adding Apollo, the NASA would be requesting a DX priority for all of these elements of the Apollo program that are essential to its ultimate mission: to effect a manned lunar landing and return in this decade. The essential elements of the Apollo program would include development of the spacecraft and launch vehicles as well as the facilities which are required for their development, testing and use. Elements of certain other name projects would thus be included, such as Saturn and Gemini, but only insofar as they are directly applicable to the manned lunar landing.

3. Decisions on the assignment of highest national priority are made by the President and in the case of space program projects, he takes into consideration the advice of the National Aeronautics and Space Council. Therefore, I ask that this matter be placed before the Council at an early date.

4. I shall be pleased to supply any further information you think is essential to the Council's consideration.

James E. Webb
Administrator

Document II-24

Document Title: Ted H. Skopinski, Assistant Head, Trajectory Analysis Section, NASA-Manned Spacecraft Center, to Chief, Systems Integration Division, "Selection of lunar landing site for the early Apollo lunar missions," 21 March 1962.

Source: Folder 18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

There were discussions in 1962 about selecting a single site on the Moon for the initial lunar landing, with the selection being made primarily on the scientific interest of that particular location. Ted Skopinski, assistant head of the Trajectory Analysis section at the Manned Spacecraft Center, questioned this approach as he outlined the mission operations criteria for a lunar site. Skopinski's letter highlighted the fact that landing sites were to be determined not only by scientific interest, but by other factors such as the need for daylight operations and facilitating the return to Earth. He suggested the desirability of adding to JPL's planned lunar missions a lunar orbiter that could obtain high quality photographs of the lunar surface. This suggestion was accepted and led to the Lunar Orbiter program, which was managed by the Langley Research Center and built by the Boeing Company using a camera modified from its original mission as part of a highly classified intelligence satellite called SAMOS.

NASA-Manned Spacecraft Center
Langley Station, Hampton, Va.
March 21, 1962

MEMORANDUM for Chief, Systems Integration Division

Subject: Selection of lunar landing site for the early Apollo lunar missions

References: (a) Memorandum for Chief, Flight Operations Division by John E. Dornbach, dated Jan. 23,1962, re meeting on circumlunar photographic experiment

(b) Memorandum for Associate Director by Owen E. Maynard, dated Feb. 1, 1962, re comments on Frank Casey's visit to J.P.L. to discuss Ranger and follow-on programs which could provide information pertinent to Apollo missions

1. The need for obtaining both [*sic*] photographic, cartographic, and geologic information about the lunar surface in order to select a landing site for the Apollo lunar mission is defined in references (a) and (b). A recommendation was made in reference (b) that MSC and JPL agree on a landing site because of the difficulty of obtaining desired environmental data over a substantial portion of the lunar surface. At the present time JPL has defined their prime area of interest for unmanned lunar impacts as approximately 8°N to 8°S latitude and from 25° to 45°W longitude.

2. The purpose of this memorandum is to see if a single lunar landing site is compatible with the techniques which reduce the need of plane changes near the moon. The JPL direct ascent and impact type of trajectories differ from the Apollo trajectories in that the following mission rules have to be adhered to in the selection of the Apollo trajectories:

a. return to the continental U.S.A. or Australia

b. daylight reentry and a.

c. lunar landing in earth reflected or direct sunlight and b.

d. mission design for immediate insertion checking by tracking

e. allowance for solar interference with deep space tracking and c.

[2]

f. adequate tracking immediately prior and subsequent to reentry and follow-up to landing to ensure minimum recovery time.

The above rules have been investigated by the Operational Analysis Section of the Mission Analysis Branch, FOD, to see how they affect the Apollo launch window. These same mission rules will also influence the selection of possible lunar landing sites.

3. Taking into account the mission rules stated in paragraph 2, the following disadvantages for the selection of a single lunar landing site are noted:

a. Mission rule of a single lunar landing site imposes a severe restraint on the launching day and time because of its dependency on the lunar declination.

b. A single lunar landing site is not compatible with the variable launch azimuth and parking orbit scheme which opens the launch window and thus eliminates the need of major plane changes.

c. Without an extensive investigation this extra restraint might be too restrictive because not knowing the final design weights the amount of fuel needed to make a necessary plane change may be prohibitive. Any plane changes in the vicinity of the moon must result in suitable earth return trajectories compatible with 2f.

d. The photographic and geophysical data obtained from the Ranger and Surveyor programs and the Apollo manned lunar missions may drastically alter present day concepts of the lunar surface, the single landing site selected now could therefore be worthless.

4. The present day thinking is to restrict the landing site to a belt approximately 10 degrees on either side of the lunar equator and on the front side of the moon. If this will be true a few years from now then the following suggestions of obtaining lunar surface data prior to manned lunar landings could be followed.

a. Obtain USAF lunar charts 1:1,000,000 scale of the landing area belt that are based on today's state of the cartographic art using lunar telescopic photography taken on earth.

b. Augment the JPL Ranger and Surveyor programs to include several landing sites in the ±10 degree latitude belt on the front side of the moon.

[3]

c. Launch a circumlunar photographic satellite with a recoverable package to obtain high quality photographs of the lunar surface in the area of interest.

d. Expect the information obtained from the manned lunar orbit reconnaissance missions to be the most reliable and after comparing it with the data obtained from all other sources select several landing sites for the first Apollo manned lunar landing missions.

[signed]
Ted H. Skopinski
Asst. Head, Trajectory Analysis Section

Copies to: J.P. Mayer
M.V. Jenkins
P.F. Weyers, Apollo Project Office
R.O. Piland, Apollo Project Office
C.C. Johnson, Apollo Project Office
O.E. Maynard, Spacecraft Int. Branch
J.E. Dornbach, Space Physics Div.

Document II-25

Document Title: Memorandum to Administrator from Robert C. Seamans, Jr., Associate Administrator, "Location of Mission Control Center," 10 July 1962.

Source: NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

Although the decision to locate a new Manned Spacecraft Center in Houston, Texas had been made in September 1961, it was not decided at that time whether to move the Mission Control Center to Houston or to keep it close to the launch site in Florida, as was being done for Project Mercury. This memorandum records the reasoning behind the decision to move the Mission Control Center to Houston.

MEMORANDUM for Administrator

Subject: Location of Mission Control Center

1. One of the facilities for which NASA has required funds in our FY 1963 Budget Request is the Mission Control Center. The Mission Control Center would be use to control Gemini and Apollo operations in a similar manner to the control of Mercury operations by the Mercury Control Center. In the FY1963 Budget Request, the Mission Control Center is listed in the section titled "Various Locations".

Considerable thought has been given to the proper geographical location for this most important facility. It is the purpose of this memorandum to advise you of the recommended location and to request your concurrence.

2. The factors which were determined to be of prime importance in selecting the site are:

a. The Center should be co-located with the Gemini and Apollo Project Offices (so that project personnel would be available for advice and consultation during its construction and during operations. Project personnel would be needed, in case of an emergency situation on-board the spacecraft, to provide immediate and detailed information about the spacecraft.)

b. The Center should be co-located with the Flight Operations Division (so that the Flight Operations personnel can guide the construction of the Facility and have the Facility readily available for training and operation.)

c. The Center should be co-located with the astronauts (so that the facility is readily available for their training, as well as their advice during an operation.)

d. The Center must have good communications (in order to link the Center with the world-wide facilities and forces involved in an operation.)

[2]

e. The Center must be able to keep completely abreast of the status of preparations for an operation (in order to have the information required to make operational decisions.)

3. The choice of sites narrowed rapidly to either Cape Canaveral or Houston. Both sites have good communication capabilities. At the Cape it is a little easier to keep abreast of preparation for a launch, although good communications between the Cape and Houston reduces this Cape advantage. However, the overriding factor in recommending a specific site is the existing location of the Project personnel, the Astronauts and the Flight Operations personnel at Houston. Therefore, after a careful consideration of pertinent factors and extensive consultation and coordination, it is recommended that Mission Control Center be located in Houston.

4. It is planned to control the Gemini rendezvous flights, all manned orbital Apollo flights, and all subsequent Gemini and Apollo flights from this Center. Thus the schedule requires the Center to be operational in April, 1964. To keep this schedule, a vigorous development effort must be initiated and maintained. Procurement actions must be undertaken immediately, in which, to provide proper guidance for bidders, it must be stated that this Center will be located in Houston. Therefore, your early concurrence on the Houston location for the Mission Control Center is requested.

[signed]
Robert C. Seamans, Jr.
Associate Administrator

Concurrence___[signed]________ Date_July 10, 1962
James E. Webb
Administrator

cc: M/Holman
MS/Low
MSC/Gilruth
MP-Lilly (handwritten)

Document II-26

Document Title: Memorandum from Donald Hornig, Chairman, Space Vehicle Panel, President's Scientific Advisory Committee, to Dr. Jerome Wiesner, "Summary of Views of Space Vehicle Panel," 11 July 1962.

Source: John F. Kennedy Presidential Library, Boston, Massachusetts.

Document II-27

Document Title: Letter to James Webb from Jerome Wiesner, 17 July 1962.

Source: John F. Kennedy Presidential Library, Boston, Massachusetts.

Document II-28

Document Title: Letter from James Webb to Jerome Wiesner, 20 August 1962.

Source: John F. Kennedy Presidential Library, Boston, Massachusetts.

Document II-29

Document Title: Letter to Jerome Wiesner from James E. Webb with attached Office of Manned Space Flight, NASA, "Manned Lunar Landing Mode Comparison," 24 October 1962.

Source: Folder 18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

Document II-30

Document Title: "Memorandum to Dr. (Jerome) Wiesner from McG.B. (McGeorge Bundy)," 7 November 1962.

Source: John F. Kennedy Presidential Library, Boston, Massachusetts.

Document II-31

Document Title: Letter from James E. Webb to the President, (no day) November 1962.

Source: John F. Kennedy Presidential Library, Boston, Massachusetts.

After its key centers and the Office of Manned Space Flight had agreed that the lunar orbit rendezvous (LOR) approach was NASA's preferred choice for sending people to the Moon, NASA scheduled a 11 July 1962 press conference to announce that choice. However, President Kennedy's science advisor, Jerome Wiesner, and the Space Vehicle Panel of the president's Science Advisory Committee came to the conclusion that the LOR choice was ill-conceived, and insisted that NASA carry out additional studies before finalizing its selection of the LOR mode. Wiesner and the Space Vehicle Panel were influenced in their belief by a senior staff person in Wiesner's office, Nicholas Golovin, who had left NASA at the end of 1961 on unfriendly terms and almost immediately gone to work for Wiesner.

NASA did carry out several additional studies during the summer of 1962, but their results did not change the Agency's thinking. Wiesner and his associates also did not change their position, and the dispute flared into the open as President Kennedy visited the Marshall Space Flight Center on 11 September 1962. Wiesner and Webb got into a somewhat heated discussion in front of the President as the nearby press watched.

After this public conflict, the argument between NASA and the president's science advisor continued through the rest of September and October. Webb on 24 October transmitted what he hoped would be a final comparison of the various ways of accomplishing the lunar landing mission to the White House Office of Science and Technology. It arrived in the midst *of the tense week that has come to be known as the Cuban Missile Crisis. In his letter Webb challenged science advisor Wiesner to either accept NASA's decision or force the president to decide between NASA's views and those of Wiesner's office. Despite lingering misgivings, Wiesner did not accept this challenge, and President Kennedy decided that the choice was ultimately NASA's responsibility. The memorandum from McGeorge Bundy, the president's National Security Advisor, to Jerome Wiesner, indicated how the president wanted to bring the controversy to a close. (PSAC is the President's Scientific Advisory Committee.) Webb responded a few days later with the requested letter. NASA announced its final choice of the LOR mode on 7 November 1962.*

Document II-26

July 11, 1962

MEMORANDUM FOR

Dr. Jerome B. Wiesner

SUBJECT: Summary of Views of Space Vehicle Panel

The purpose of this memorandum is to summarize for you somewhat informally the Space Vehicle Panel's views as presented during discussions with NASA management on July 6, 1962. A somewhat more detailed Panel report is being prepared for submission to the PSAC.

The Panel has now spent a total of 10 days in meetings trying to understand the Manned Lunar Landing mission and its problems. In particular, we have recently concentrated on the question of which mode of approach offers the previous promise of getting us to the moon (and back) at a very early date and which also contributes most to the development of the national space capability.

One of the early ground rules for the competition was that it would be wise to have three men on the mission, traveling in a "shirt-sleeve environment." No rigorous justification has been made for this requirement, but if it can be met, it is reasonable. However, it is clearly subject to re-examination.

This requirement leads to an estimated weight for a landing and return spacecraft, which, if it is used on a direct ascent mission, approximately size a NOVA rocket. It was realized, and we concur, that the step to such a rocket was too large a single step to be the basis of a sound national program. In fact, it was judged that a rocket of the size of the C-5, which is five times the size of the C-1 and employs previously untried large main engines (F-1) plus large hydrogen-oxygen engines (J-2) in its upper stage, was about as large a development step beyond the C-1 as was reasonable to undertake next. With this conclusion we are also in general agreement.

[2] Consequently, a second ground rule has been that the mission should start with a C-5. Since the C-5 is incapable of carrying out the originally contemplated direct mission, this condition implies steps such as:

a. Assembly of components in space, fueling in space, or other means of effectively enlarging the rocket, e.g., EOR.

b. Cutting the payload by one means or another, e.g., C-5 direct.

c. Devising more efficient staging arrangements, e.g., LOR. Actually, although rockets larger than C-5 can be built, the prospect of long-range growth solely through bigger and bigger rockets, using bigger and bigger launch facilities, is not an attractive one. Hence, there has been insistent pressure that techniques for orbital assembly, orbital fueling etc., be developed as an integral part of the route to space stations, eventual planetary exploration, and the development of a military space capability. So the present context, such arguments led to the proposal of the EOR mode which Mr. Webb has supported and justified so eloquently in many speeches.

The modes which were analyzed and presented to us were:

1. EOR, 3-man crew, 14 days total capability (up to 4 on moon), storable propellant for lunar landing and takeoff.

2. LOR, 2-plus man crew, 14 day total (1 max. on moon), storables.

3. C-5 direct, 3-man-crew, 10 day (4 on moon), hydrogen-oxygen for landing and takeoff.

In the analysis (as presented) all three can carry out the mission. However, in LOR only two-plus men are involved in the most difficult phases of the mission as compared to three in the others, and the stay time is significantly shorter. It is presumably for this reason, that MSFC has insisted that the choice of LOR be accompanied by the development of a direct ascent C-9 "logistics" vehicle. It was not evident to the Panel that there was any significant difference in the development difficulties which could be anticipated for EOR and LOR. It appeared possible that the direct mode would involve the fewest new developments.

[3] The analysis of inherent probabilities of mission success, of disasters, and of disasters per success appeared to be carefully done, but offered no basis for distinction within the probable uncertainty of results obtained. As a matter of fact, if one counts critical operations, such as staging and rendezvous, the order of choice from most reliable to least would be: (1) Direct, (2) EOR, and (3) LOR. In addition, a factor which is hard to weigh quantitatively is the fact that all the most difficult operations in the LOR mode take place far from the earth where two of the men have no (earth) abort capability.

And to cost and schedule, it is clear that EOR requires more C-5 vehicles. Hence, if vehicles are, indeed, the pacing item, the EOR approach is more costly and, according to NASA schedule, at least five months slower. It also requires more extensive launch facilities. These conclusions are modified, of course, if a "logistic" vehicle capable of near simultaneous launching is needed to support LOR.

Lastly, the analysis of payload margins also offered no significant basis for choice. LOR is a very ingenious idea which has a fundamental advantage in that the heat shield and re-entry mechanism need not be carried to the lunar surface. However, it must pay the price of carrying an entire life support system, communications system, and navigation (for rendezvous) system. The most recent detailed studies indicate that there is no resultant payload advantage for LOR, and that there is probably a disadvantage if the landing is made more than a few degrees from the moon's equator or the stay time is increased because of the plane change which is introduced as the moon rotates.

The clearest point which came out is that the comparison on all scores involved a mission in which <u>two</u> men stayed on the moon a very short time (LOR) with missions involving <u>three</u> men for longer times. With this background of experiences gained from studies already made, it should be possible to estimate the perturbation on the existing estimates if a <u>two</u>-man capsule were employed for EOR or direct ascent in a very short time, say two to three weeks. It is most strongly recommended that this be done. If possible, optimum trajectories should be considered for each mode since there appears to be no need for lunar orbit in the EOR or Direct modes. It is our guess that EOR will then show a substantial payload margin, and that it will be possible to employ earth storable propellants for the lunar liftoff stages.

[4] Our further thinking has converged on the following conclusions:

1. LOR is an extremely ingenious but highly specialized mode which does not appear to occupy a central role in the development of a continuing national space program -- at least as compared to orbital fueling of large vehicles.

2. LOR appears to have the largest number of critical operations which must be carried out far from the earth after a period of extreme crew stress.

3. We, therefore, feel that at the present time we would choose the EOR mode with a <u>two</u>-man capsule. It ought to be possible then to gain a substantial weight margin.

4. The history of all ICBM systems has been one of upgrading, even early in their careers. The "official" escape rating of C-5 has already grown from 68,000 lbs. to 90,000 lbs. Consequently, we would press efforts to upgrade C-5 in parallel with its present development. Several possibilities are clearly open. With reasonable success in upgrading, the same (item 3) two-man capsule might be carried on

a Direct Ascent with C-5, using storable propellants for lunar landing and takeoff. Alternatively, hydrogen-oxygen technology may reach the point where it is sufficiently reliable to use for landing. In either case, the way would be open when we are farther down-stream to substitute the Direct Ascent for EOR (although we would not gamble on it alone at the present time). One would thus have alternatives without setting up a full backup program.

5. The LOR is an isolated development from which experience and hardware cannot be so readily transferred to the direct ascent mode.

6. If, nevertheless, LOR is adopted, we feel strongly that the C-5 "Logistic" support vehicle should be carried through in parallel and that studies be promptly instituted on its use as a potential manned vehicle.

[5]

We also have a few other observations:

1. A unmanned lunar orbiter from which the moon's gravitational field can be accurately determined must have very high priority. Otherwise it is impossible to seriously discuss lunar orbits as low as those proposed for LOR.

2. None of the modes should rely on their own reconnaissance of the lunar surface. Unmanned reconnaissance of the lunar surface should have very high priority.

3. Since the mission will be carried out near in time to the other solar flare maximum in 1970, we were distressed at not finding any hard consideration of the radiation problem and its effect on mode selection. This problem requires urgent attention.

Finally, it has been noted that MSFC, MSC, and the Office of Manned Space Flight have all concurred in the choice of the LOR mode. We are impressed by this fact. We can only note that the Panel was originally widely divided in its opinions, but that after hearing and discussing the evidence presented to us, there is no dissent in the Panel to the views presented here.

Donald J. Hornig, Chairman
Space Vehicle Panel

Document II-27

July 17, 1962

Dear Jim:

As I agreed to do during our recent meeting, I am forwarding Don Hornig's informal summary of the Space Vehicle Panel's views as presented to you and your staff at that time. I would also like to take this opportunity to put down, more or less systematically, the substance of my own ideas: these overlap in some respects there of the Panel, and have been at least in part passed on to you verbally during the last two weeks.

First, I think that the final lunar mode choice must provide sufficient payload margins to have a reasonable chance of coping with realistic shielding requirements to meet solar flare radiation hazards which will be approaching their cyclical peak at about the same time that the manned lunar mission will be attempted unless other means are developed to cope with this serious problem. Also, it is possible that exposure to zero-g conditions for the time intervals in this mission may be found to present serious crew problems. Clearly, a mission mode choice at this time must assume that this may turn out to be so, and should, therefore, not exclude sufficient growth capability to offer some chance of dealing with such a difficulty. Accordingly, I feel that both of these potential problem areas should be as thoroughly explored as present scientific knowledge makes possible. It seems to me that a combination of Jim Van Allen's group and of STL could supply a competent team to survey the flare hazard problem.

The matter of which mission mode is most consistent with the main stream of our national space program, and therefore the one most likely to be useful in overtaking and keeping ahead of Soviet space technology, is also one that I believe requires further consideration. For example, if LOR is chosen and the NOVA slipped by two years, then the U.S. will most likely not have an escape capability significantly above 90,000 pounds until 1971 or 1972 at the earliest. With LOR and C-5 Direct, on the other hand, a capability of 160,000 pounds to escape will be available in 1966 or early 1967. Which of these situations, broadly considered, is best for the [2] U.S. posture in space? Similarly, the question of which mode is likely to be most suitable for enhancing our military capabilities in space, if doing so should turn out to be desirable, should be reviewed with care. The Space Vehicle Panel considered this item only casually and, as far as I know, your mode studies had no inputs at all from the DOD in this area. Accordingly, I see a need for an appropriate team of engineers and scientists to explore this area on a time scale compatible with the LOR proposal period.

Thirdly, neither the Space Vehicle Panel nor your staffs, insofar as the data presented to us is made clear, delved adequately into the likely effects of environmental stresses on the crew during the journey, and therefore with the effects on crew capabilities to cope either with the normal or the conceivable emergency conditions to be encountered during various phases of each mode. I would certainly recommend that these matters be reexamined in greater technical depth before you allow final commitment to a mode choice. If you like, we can have the PSAC Bioastronautics Panel assist your staffs in dealing with this job. I might also add that with added time the quantitative analyses of mission mode success probability, and of crew safety, might well be carried to substantially higher level of detail in equipment and crew functional sequencing.

Finally, as has been emphasized by the Space Vehicle Panel, the NASA studies of mission modes did not present the relative advantages and defects of each as a valid basis for comparison principally because some modes involved the use of three men in critical mission phases while others used only two. Payload margins and crew survival probability for the various alternatives are both likely to change substantially, in the Panel's opinion, if the LOR and Direct modes are carried out doing a crew of only two men. Studies along these lines should probably be conducted as direct extensions of previous work at Ames, STL, and MSFC.

I have reported the results of our discussion to the President and assured him that there is ample time to make the additional studies we have agreed upon before the contracts for the lunar landing vehicle need be awarded.

[3]

In closing, you should know that I have instructed the Space Vehicle Panel, as well as my staff, to remain in close touch with the Manned Lunar Landing Program and to be available to you for any purpose you may desire. Since the Panel's future usefulness as to the PSAC, as well as to your agency, will both largely depend on the currency and completeness of their knowledge of the program, I am sure your organizational elements and contractors will do their utmost to be helpful in this regard as they have in the past.

My best wishes to you in your vast and vital undertaking.

Sincerely,

Jerome B. Wiesner

Attachment

Honorable James E. Webb
Administrator
National Aeronautics and Space
Administration
Washington 25, D.C.

Document II-28

Dr. Jerome B. Wiesner, Chairman
President's Science Advisory Committee
Executive Office Building
Washington 25, D.C.

Dear Jerry:

I was pleased to receive your letter of July 17, 1962, summarizing your thoughts on the lunar mission mode. We are, as I have already told you, conducting several system investigations related to the suggestions of the Space Vehicle Panel. The specific studies currently underway are:

1. An analysis of the North American Aviation studies on the C-5 direct mode, including consideration of a two-man capsule;

2. Continuation of the Space Technology Laboratory effort on a direct ascent utilizing a smaller three-man capsule and a two-man capsule based on the same design approach;

3. Preliminary design by McDonnell Aircraft of a two-man lunar mission capsule.

The results of these studies will be available before the end of September, and their impact on both the C-5 direct and EOR mission profiles will be evaluated by our Office of Manned Space Flight and compared to our current planning of the LOR mode based on the proposal submissions of the Lunar Excursion Module.

We have a continuing concern about the specific items you mentioned. The solar flare radiation problem has been much discussed, and although some data is available, we are keeping in close touch with those performing studies in this area, including Dr. Van Allen. Indeed, data from Dr. Van Allen's latest work is being factored into our radiation hazard effort at Houston. The potential problems from prolonged exposure to [2] zero-g can represent a major problem for any of the modes. Both the mechanization of the spacecraft and the payload requirements of the booster will be seriously affected if artificial gravity is required. As you know, we consider that the Gemini program will be a basic source of information in this area. However, our present feeling is that weightlessness, per se, will not be a limiting problem, and we are not presently compromising the system design to accommodate the generation of artificial gravity.

The implications of the mode decision on our national space capability has been one of our major concerns. We believe that our program provides the basis for a national capability in three major areas:

1. Booster payload capability, both to earth orbit and escape.

2. General spacecraft technology.

3. Operational capability in space.

It is our considered opinion that the LOR mode, which requires the development of both the C-5 launch vehicle and the rendezvous technique, provides as comprehensive a base of knowledge and experience for application to other possible space programs, either military or civilian, as either the EOR mode or the C-5 direct mode. The decision to delay Nova vehicle is dictated as much by economic considerations, both fiscal and manpower, as by the technical need. The realities of our budget do not allow for the almost simultaneous development of two major launch vehicles. In addition, the redefinition of the Nova for payload capability considerably in excess of the C-5 will, I am convinced, provide us with a better national capability in the long run.

The question of evaluating the effects of environmental stress in the various mission modes is a difficult one. This area is one in which there has been considerable debate, and we are attempting to place the comparative data on a more sound scientific basis. I doubt, however, that this can be accomplished in time to contribute significantly to our present deliberations. Again, it is the considered opinion of our people that there are no significant differences between the modes in the area of stress on the astronauts.

[3] I appreciate the interest you and your panels continue to show in our program. I have passed your comments and the Report of the Space Vehicle Panel of July 26, 1962, on to Mr. Holmes and Dr. Shea for their consideration. This constructive criticism by eminently qualified men is of tremendous value, and I am looking forward to further discussions with you as the results of our present studies begin to crystallize.

Sincerely,

[signed]
James E. Webb
Administrator

Document II-29

October 24, 1962

Dr. Jerome B. Wiesner
Director
Office of Science and Technology
Executive Office Building
Washington 25, D.C.

Dear Jerry:

In accordance with our conversation, I enclose herewith two copies of our confidential report entitled "Manned Lunar Landing Mode Comparison." My understanding is that you and such members of your staff as you choose will examine this and that you will let me know your views as to whether we should ask for an appointment with the President.

My own view is that we should proceed with the lunar orbit plan, should announce our selection of the contractor for the lunar excursion vehicle, and should play the whole thing in a low key.

If you agree, I would like to get before you any facts, over and above the report, perhaps in a thorough briefing, which you believe you should have in order to put me in position to advise Mr. O'Donnell that neither you nor the Defense Department wishes to interpose a formal objection to the above. In that case, I believe Mr. O'Donnell will not feel it wise to schedule the President's time and that the President will confirm this judgment.

With much appreciation for your assistance, believe me,

Sincerely yours,

James E. Webb
Administrator

Enclosed: two copies of report

Dated October 24, 1962

MANNED LUNAR LANDING MODE COMPARISON

OFFICE OF SYSTEMS

OFFICE OF MANNED SPACE FLIGHT

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WASHINGTON 25, D.C.

OCTOBER 24, 1962

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[i]

INTRODUCTION

On July 11, 1962, the National Aeronautics and Space Administration announced its decision to base its studies, planning and procurement for lunar exploration primarily on the lunar orbit rendezvous mode while continuing studies on the earth orbital and direct flight modes, subject to confirmation at the time industry proposals to build the Lunar Excursion Module were finally evaluated. Certain additional studies were also to be completed by that time.

This report summarizes the result of recent studies of the possible application of a 2-man capsule to the earth orbit rendezvous and direct-flight modes. It is concluded that the lunar orbit rendezvous mode is the best choice for achieving a manned lunar landing mission before the end of the decade.

[no page number]

MANNED LUNAR LANDING MODE COMPARISON

One of the major factors in the selection of a mode for the manned lunar landing program is a comparison of the several modes being considered with a series of technical criteria which establish mission feasibility and identify unique considerations. The prime technical criteria are physical realizability [*sic*], mission safety and mission success probability. These technical criteria must be balanced against time and cost to arrive at the mission objectives. The mode selection study of July 30[1] demonstrated that both the Lunar Orbit Rendezvous (LOR) and Earth Orbit Rendezvous (EOR) modes were feasible with adequate weight margins, and that the 3-man C-5 direct ascent mode was undesirable because of small performance margins and high developmental risks. Subsequent studies have been conducted on 2-man capsules which might be used in either the C-5 direct flight or the EOR mode. Results of these studies (summarized in Appendix A) show that the 2-man C-5 direct flight mode is only feasible with cryogenic propulsion systems in all spacecraft stages, or with smaller performance margins than we deem desirable at this point in a program. The 2-man capsule would either increase the weight margins for EOR or allow simpler propulsion systems to be utilized throughout the spacecraft. These improvements are not sufficient to make EOR the preferred mode.

All of the sub-systems required to implement each mode can be developed within the scope of the manned lunar program. Estimates of the degree of developmental difficulty which might be encountered are qualitative, varying with the past experience of those conducting the analysis.

Comparisons of the 2-man lunar mission capsules with the present LOR approach lead to the conclusion that LOR is the preferred mode on the basis of technical simplicity, scheduling and cost considerations.

Mission Safety and Success Probabilities

The Mode Selection Report of July 30 demonstrated only minor differences in mission safety probabilities between EOR and LOR. Although LOR showed a higher probability of mission success than EOR (0.43 for LOR vs. 0.30 for EOR), the number of disasters per mission success for LOR was found to be slightly higher than the EOR figure (0.23 for LOR vs. 0.21 for EOR).

[2] A subsequent analysis was conducted in greater detail, considering the LOR, EOR and C-5 direct flight modes. These studies (summarized in Appendix B) [not provided] show that the overall mission success probability for EOR is 0.30, for C-5 direct 0.36, and for LOR 0.40. The number of disasters per mission success for EOR is 0.38, for C-5 direct 0.46, and the LOR 0.37. In particular, analysis has shown that LOR has the highest safety probability for operations in the vicinity of the moon. We believe that LOR is at least as safe as EOR while still enjoying a considerably higher overall mission success probability.

It could be stated that the LOR mode appears preferable based upon the calculated mission safety and success probabilities. However, the analyses leading to these results involve the estimation of the inherent reliability levels which will be reached by the individual sub-systems, and the detailed mechanization of the particular mode with respect to redundancy. These reliability predictions are not exact during the period when the detailed mechanization of the modes is still evolving. The relative results of both the mission success and safety probability

1. Manned Lunar Landing Program Mode Comparison Report. OMSF, 7/30/62 (CONFIDENTIAL)

calculations are sufficiently sensitive that the assumptions related to equipment performance can change the order of the results.

This leads to the conclusion that the difference between the modes from a mission safety standpoint as known at this point in time is the same order of magnitude as the uncertainty of the analysis. Reliability calculations, per se, are therefore not an adequate basis for choosing among the modes.

Major Differences Between Modes

The major technical differences between the modes lie in the following areas:

1. Cryogenic vs. storable stages in space;

2. Weight margin;

3. Lunar landing configurations;

4. Rendezvous.

These differences will be discussed in the following paragraphs.

Cryogenic vs. Storable Stages. The question of cryogenic vs. storable stages in space has two aspects: the reliability of the engines, and the storability of the stage. Most propulsion experts agree that a hypergolic, pressure-fed engine is simpler and, by implication, inherently more reliable than a pumped, regenerative cryogenic engine. Study of engine design confirms this. However, it is also agreed that engines reach inherent reliability only after an extended development program. The RL-10 hydrogen-oxygen engine has been in development for about four years; the storable engines are just starting their development cycle. [3] Hence, at the time of the first lunar missions the cryogenic engine (if the RL-10 could be used in all space stages) might be closer to its inherent reliability than the storable engine. Judgment is again involved. The above arguments nonwithstanding [*sic*], it is believed that storable engines will have reached a higher reliability than cryogenic engines at the time of the initial manned lunar attempts.

Space storability depends on the detailed thermal design of the stage. In space, the cryogenic fuels must be insulated to prevent excessive boil-off, the storable fuels insulated to prevent freezing. On the lunar surface, both cryogenic and storables are subject to boil-off during the lunar day, the problem being more severe for the cryogenics. During the lunar night, the cryogenics are subject to boil-off, the storables to freezing. Either stage will require careful design to insure compatibility with the environment. The problems appear to be more severe for the cryogenic fuels, especially since the storable fuels require an environment more compatible with the rest of the lunar vehicle.

The above considerations have led to the conclusion that storable propellants should be used for the Apollo applications. Storables are also the conservative choice on a performance basis, since it is possible from a weight standpoint to convert from storables to cryogenics at a later date, but the reverse is not true. Only LOR or 2-man EOR are compatible with the choice of storables in all space stages.

Weight Margin. The establishment of a proper weight margin is a factor in the realizability of the C-5 direct modes. Our experience has shown that weight levels for manned space vehicles have grown approximately 25% over initial "hard" estimates. This growth accommodates initial misestimates of hardware weights, equipment additions to increase mission capability, and design changes required by better definition of the environment. As a result of their studies, both Space Technology Laboratories and McDonnell Aircraft Corporation concluded that a 10% weight margin would be adequate to cover initial weight misestimations. Our experience dictates that an additional 15% be included for both increased mission capability and design changes which might result from increased environmental knowledge. The requirement for this increased weight margin does affect the possibility of using a storable return propulsion system for the 2-man C-5 direct mission. Considering all factors, the use of storable return propulsion would not provide sufficient assurance of success for the 2-man C-5 direct mode.

Lunar Landing Configuration. There are important differences in landing configuration between the Lunar Excursion Module (LEM) and the Command Module (CM). Although the landing can be achieved with either module, the LEM can be "optimized" for the lunar operations more readily than the CM which must also accommodate reentry. The main factors are the internal arrangement of the capsules, and the degree of visibility provided the astronauts during the lunar landing phase. Landing the CM (particularly the 2-man version) would undoubtedly require use of television cameras to augment the pilot's field of view.

[4] In comparing the modes in the vicinity of the moon, both the C-5 direct and the EOR flight configurations must be staged during the terminal descent phase to reduce engine throttling requirements and landing gear loads. This staging requirement and the less desirable module arrangement are the factors in the direct landing mode which must be weighed against the requirement for rendezvous in the LOR mode. Continued study of alternate configurations has indicated that the simplicity of the LOR landing configuration is most desirable for early mission success.

In LOR, the re-entry and flight capsule can be separated from the lunar landing capsule during the course of the development program. Re-entry and flight requirements will affect the mass and moment of inertia of the re-entry and flight capsule, as well as the internal couch arrangement and the pilot displays. Astronaut position during lunar landing will affect the internal arrangement of the lunar landing capsule, and the visibility requirements can profoundly affect both capsule shape and structural integrity.

The industrial firms bidding on the LEM concluded that this separation of function was highly advantageous. (Their comments are summarized in Appendix C.)

Rendezvous. The major concern with respect to the Lunar Orbit Rendezvous arises from the requirement for rendezvous during the return phase of the mission. The mechanization of rendezvous has been studied in detail, and the planned configuration provides a redundant rendezvous capability within the LEM for all equipment failures except those in the main propulsion system. A similar capability exists in the command module. Hence the rendezvous maneuver is backed up with essentially a fourfold redundant mechanization. The duplicate contact, both radar and optical, which can be established between CM and LEM before launch from the lunar surface and maintained until docking, assures adequate relative velocity and position information between the two craft. Although earth tracking will not participate directly in the lunar operation, earth-based antennas will monitor the maneuvers and will aid in certification of the ephemeris of the CM lunar orbit. Studies of the rendezvous implementation, and simulations conducted at NASA centers and industry facilities, have indicated that the rendezvous maneuver is less difficult than the lunar landing. Specifically, the rendezvous in lunar orbit is no more difficult than rendezvous in earth orbit. Indeed, the configuration of the LEM may actually make the lunar rendezvous easier for the astronauts to execute than an earth orbit rendezvous operation involving two C-5 vehicles.

Summary of Technical Considerations. The summation of these considerations leads to the conclusion that the conservative approach to the manned lunar mission dictates the use of a 25% weight margin for any new capsule design and the use of storable engines in space. This conclusion, in conjunction with analyses of the several modes, rules out all modes save LOR and 2-man EOR. After comparison of landing configurations and rendezvous mechanizations, we conclude that the technical trade-offs distinctly favor the LOR mode.

[5]

Human Factors

A factor in the LOR mode which has been frequently mentioned is the effect of mission duration and stress on crew performance during the rendezvous maneuver. Our study of these factors is summarized in Appendix D [not provided], which concludes that "pilot performance is not a limiting factor for either direct or lunar orbit rendezvous missions" based on a survey of the applicable literature and available test data. Another consideration is that the stress which the astronauts will undergo during both lunar landing and earth re-entry is at least equivalent to that experienced during rendezvous. The time constants for both re-entry and landing maneuvers are set by the mission. The time constant for rendezvous is at the astronaut's discretion–several orbits may be used to accomplish the actual docking in an extreme case. Based on these considerations, we conclude that the human factors implications are not significant for purposes of selecting a preferred mode.

National Space Capability

Appendix E [not provided] discusses the implications of the mode choice on National Space Capability. The conclusion is that the only payload requirements exceeding the C-5 escape capability of 90,000 pounds which have presently been defined are for manned space flights, and then only if the EOR mode is utilized for the lunar mission. The operational techniques and the specific hardware developed in either the LOR or EOR mode are similar, with the exception of the tanker and fueling technology required for EOR. LOR does require crew transfer techniques and the development of structural docking mechanisms. The development of fuel transfer techniques which may ultimately be required for a wide class of fluids in space (from earth storables to hydrogen), can be most efficiently carried out in an exploratory development program rather than as an in-line element of the manned lunar landing program. We conclude that, on balance, there is no significant difference between LOR and EOR from a national capabilities viewpoint.

Conclusions

Based on the results of the studies summarized in the Appendices and the above discussion, we conclude that:

(1) The C-5 direct flight mode requires cryogenic fuels and is marginal, even with a two-man capsule;

(2) Both the EOR and LOR modes are feasible;

(3) The reliability differences between LOR and EOR cannot be demonstrated conclusively by analysis at this time; however, LOR does appear to have higher mission probability of success at less risk to the astronauts;

[6]

(4) The capability to design the LEM specifically for the lunar landing, and the desirability of performing the mission with a single C-5 launch are important advantages of the LOR mode, offsetting the lesser problems associated with lunar rendezvous;

(5) Human factor considerations are not significant in the mode selections; the addition of rendezvous to the requirement for lunar landing and re-entry does not add appreciably to crew stress or fatigue, or to the overall hazards of the mission;

(6) Both EOR and LOR provide the basis for projected national space requirements prior to the development of NOVA-class vehicles. The C-5 vehicle capability meets estimated payload requirements. LOR provides experience in personnel transfer between space vehicles as contrasted with fuel transfer in EOR.

The scheduling studies last June demonstrated that the LOR mode could accomplish the lunar mission at least six to fifteen months earlier than the EOR mode. The fact that we have pursued the LOR approach during the intervening months has widened the schedule difference. The reason for the increased schedule difference can be identified in terms of the number of tests which must be completed before a lunar mission can be attempted, and the difference in firing schedules. Because of the requirement for two launchings per mission, EOR can only perform a mission every three months. LOR, on the other hand, can launch a mission every two months, since it requires only a single C-5 launch. We are convinced that the time difference between the EOR and LOR modes is now at the very least one year, and most probably in excess of 18 months.

The original mode selection study indicated that the LOR mode was 10 to 15% less expensive than the EOR approach. This difference arises primarily from the extra cost of launch vehicles for the EOR mode. This conclusion is still valid.

In addition to both schedule and cost advantages, the LOR mode provides the cleanest management structure within the NASA organization. The interface between the spacecraft and launch vehicle is simpler, and the responsibilities of the Manned Spacecraft Center at Houston and the Marshall Space Flight Center at Huntsville are easily defined and provide minimum interfaces between items under development at the two Centers.

In conclusion, the studies conducted since June of this year, and the additional work done within NASA and industry on the LOR approach, have indicated that the LOR mode offers the best opportunity of meeting the U.S. goal of manned lunar landing within this decade.

[Appendices not included]

Document II-30

November 7, 1962

MEMORANDUM TO: Dr. Wiesner

The President's conclusion on the moon method is that he would like a last letter to Webb stating something of the following:

(1) that the choice of a means is obviously a matter of the highest importance rendering the most careful technical reviews;

(2) that serious reservations had been expressed by PSAC panel (with some discussion of its terms of reference and its competence) and that for that reason the President has been glad to know that the matter is being reexamined in NASA;

(3) that the President thinks the time is coming for a final recommendation and relies on Director Webb to review all the arguments and to produce that recommendation.

You may think of other things that should be in such a letter –but what the President has in mind is that we should make Webb feel the responsibility for a definite decision and the importance of weighing all opinions, without trying to make his decision for him.

McG. B.

Document II-31

The President
The White House
Washington 25, D.C.

Dear Mr. President:

In accordance with Dr. Wiesner's suggestion that your file on the Lunar Orbit Rendezvous selection might well contain a letter summarizing the action taken and the reasons therefor [*sic*], the following is set forth.

Early in November, NASA announced that it was reaffirming an earlier tentative decision of July 1962 which selected Lunar Orbit Rendezvous as the mode this nation would adopt in accomplishing the first manned lunar landing. A detailed report on the numerous studies that led to this decision has been submitted previously to the office of your Scientific Advisor and is attached for your file. [not included]

The decision to adopt the Lunar Orbit Rendezvous mode was based on major systems and engineering studies which involved over a million man-hours of effort on the part of government and contractor personnel. Despite the very extensive study efforts, however, we are dealing with a matter that cannot be conclusively proved before the fact, and in the final analysis the decision has been based upon the judgment of our most competent engineers and scientists who evaluated the studies and who are experienced in this field. Because we are dealing in an area where judgment is an important factor, we have held several meetings with Dr. Wiesner and his staff to ensure that their views and opinions could be given most careful consideration. These meetings were constructive and assisted in sharpening the critical factors which would determine the final decision.

Following are the most important conclusions which led to the decision to adopt Lunar Orbit Rendezvous:

a. Using the Advanced Saturn C-5, the largest booster which will be available in this decade, the Lunar Orbit Rendezvous (LOR) and Earth Orbit Rendezvous (EOR) approaches are technically feasible and both can be conducted with three-man crews. The direct flight mode would require cryogenic fuels for the lunar landing (which we consider less reliable), and would be marginal with regard to weight limitations even using a two-man capsule.

[2]

b. By adopting LOR, the mission can be accomplished at least one year earlier in comparison with the EOR mode.

c. The cost will be 10% to 15% less than for the EOR approach. If it were feasible, a two-man direct mode could be conducted at approximately the same cost as LOR.

d. Although our studies show a slight advantage for LOR in terms of reliability, there was not sufficient difference in the safety and mission success calculations for each mode to consider that this factor could significantly influence mode selection.

e. Touch down on the Moon is the most difficult maneuver of the entire mission. Since the LOR mode is the only one which includes a vehicle which will be used for the lunar landing without having to consider earth re-entry problems, it will be possible to design the lunar excursion vehicle to maximize the probability of success in the lunar touch down operation.

f. The techniques and the spacecraft which will be developed for EOR and LOR are similar with the exception that refueling technology is required for the earth orbital mode and a crew transfer for the lunar orbital mode. On balance, there appears to be no significant difference between these modes from a national capability viewpoint. The third mode, a two-man direct ascent, would not provide an opportunity for testing space rendezvous and docking techniques.

If future missions are undertaken which would require a longer stay on the lunar surface, it is probable that a lunar logistics system would be required regardless of the mode chosen for the initial landings. We are well along in the study phase of this supporting system and believe it holds promise as a backup mode for the LOR in a later time period. Successful development of this backup potential depends heavily on whether sufficient weight reductions can be made in the spacecraft system to permit a direct ascent flight using the Advanced Saturn C-5.

The decision on the mode to be used for the lunar landing had to be made at this time in order to maintain our schedules, which aim at a landing attempt in late 1967. We are confident that the decision is the correct one, but recognize that in any matter in which judgment plays an important role, we must be prepared to change our concepts in the light of convincing new evidence. For this reason, we are conducting the program in a manner which will permit us to react promptly to any new factors introduced by the new information we are gaining every day.

[3] We intend to drive forward vigorously on every segment of the manned lunar landing program. To do so, we have marshaled a major segment of this country's finest resources for the effort. We have working with us a group of outstanding industrial firms. Additionally, we are being supported by many of our finest universities as well as by the Department of Defense and other government agencies. Within NASA, the three field centers you visited this past September–the Marshall Space Flight Center under Dr. von Braun; the Manned Spacecraft Center under Dr. Gilruth; and the Launch Operations Center under Dr. Debus–devote their full capabilities to this task. We believe that this team, under the leadership of Mr. Holmes, the Director of Manned Space Flight, provides a cohesive network of research and development resources which can achieve the objective you have established.

Respectfully yours,

[signed]
James E. Webb
Administrator

Document II-32

Document Title: Letter from James E. Webb, NASA Administrator, to President John F. Kennedy, 29 October 1962.

Source: Folder 18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

Document II-33

Document Title: Transcript of Presidential Meeting in the Cabinet Room of the White House, 21 November 1962.

Source: *http://history.nasa.gov/JFK-Webbconv/* (accessed 29 January 2007).

Document II-34

Document Title: "Memorandum to President from Jerome Wiesner Re: Acceleration of the Manned Lunar Landing Program," 10 January 1963.

Source: John F. Kennedy Presidential Library, Boston, Massachusetts.

During his 11 though 12 September visit to the three NASA installations most involved in Project Apollo, there were suggestions made to President Kennedy (apparently by manned spaceflight head Brainerd Holmes) that the first lunar landing, at that point tentatively scheduled for late 1967, might actually be accomplished up to a year earlier if additional funds were provided to the Apollo program. Holmes and NASA Administrator James Webb disagreed on the wisdom of seeking additional funds from Congress, but Webb told the president in a 29 October letter that with additional funding it might indeed be possible to accelerate the Apollo program.

However, Webb did not press aggressively enough for such an increase to satisfy Holmes. Tensions between him and Webb had been festering since at least August 1962, when Holmes was featured on the cover of Time *magazine and labeled "Apollo czar." Another* Time *story appeared on 19 November, this time suggesting that the program was in trouble and badly needed the extra funds. Holmes was the apparent source of the story.*

Following Webb's 29 October letter, the president had asked his Bureau of the Budget to take a careful look at the financial and schedule aspects of Apollo. The results of that review were sent to the president by budget director David Bell on 13 November (Volume I, Document

III-13). The White House called a 21 November meeting in the Cabinet room to try to understand exactly what was going on at NASA. Like some other White House meetings during the Kennedy presidency, this meeting was secretly recorded; the John F. Kennedy Presidential Library released a copy of the recording in 2001, and space historian Dwayne Day later prepared a transcript of the tape.[1]

As he left the 21 November meeting, President Kennedy asked James Webb to prepare a letter summarizing Webb's view on the appropriate position that the White House should take on Apollo and the NASA program overall. Webb did so, and sent Kennedy the letter on 30 November (Volume I, Document III-14).

Kennedy's interest in accelerating the date for the first lunar landing continued even after the 21 November meeting and Webb's response. During an 8 December visit to Los Alamos National Laboratory, he asked his science advisor Jerome Wiesner to look again into the potential for a lunar landing earlier than NASA was planning.

Document II-32

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Washington 25, D.C.

October 29, 1962

Office of the Administrator

The President
The White House
Washington 25, D.C.

Dear Mr. President:

In accordance with the request you made during your recent tour of selected NASA installations, a preliminary analysis has been completed to determine the feasibility and the resources implications of accelerating the manned lunar landing program in order to establish a target date for the first landing in late 1966, one year earlier than the present target.

The late 1967 target date is based on a vigorous and driving effort, but does not represent a crash program. A late 1966 target would require a crash, high-risk effort. The nature of a development program such as the manned lunar landing, however, makes the possibility of achieving target dates set this far in advance no better than fifty-fifty. In contrast, the odds that we can accomplish the landing within this decade are excellent. You might, therefore, think of this matter of target dates as one in which we fix a date which is difficult, but not

1. The tape of the meeting can be found at John F. Kennedy Library, President's Office files, Presidential recordings collection tape #63.

impossible to attain. We schedule the work against this date and thereby insure a driving effort. However, until later in the development cycle, target dates cannot be viewed as certain forecasts of when the mission will be accomplished.

The depth of this special analysis on a late 1966 target date is in no way comparable with the detailed analysis which formed the basis of the operating plan for a late 1967 target date. A definitive study of time and resources requirements for the many sequential events involved in the accomplishment of this mission by late 1966 would necessitate a much more intensive and detailed review by the NASA headquarters and field centers, our prime contractors and the principle subcontractors. However, the preliminary analysis which follows permits a gross evaluation of the possibilities currently available.

Current Plan - Mission in late 1967

The NASA operating plan of $3.7 billion for FY 1963 and the requested budget level of $6.2 billion for FY 1964 are aimed at the target date of late 1967 for the manned lunar landing. Within these budget levels, the amounts planned for the manned lunar landing are $2.4 billion in FY 1963 and $4.2 billion in FY 1964. These funds include $2.0 billion and $3.4 billion respectively for propulsion systems, launch vehicles, spacecraft, facilities, and flight operations; and $.4 billion and $.8 billion respectively for necessary supporting effort in unmanned scientific investigations, advanced technology, and improvements to the tracking network. These funds do not cover the personnel costs of NASA employees or amounts for the operation of the NASA centers for which the totals are $446 million in FY 1963 and $579 million in FY 1964.

The major program segments are funded at the following rate under this plan:

	(In Billions) 1963	1964
Spacecraft and Flight Missions	$ .7	$1.5
Development of Launch Vehicle and Propulsion Systems	.7	1.0
Facilities, Launch Operations, Integration and Checkout, Systems Engineering and Aerospace Medicine	.6	.9
	$2.0	$3.4

Alternative Plan - Mission in mid-1967

In preparing an operating plan for FY 1963 based on Congressional appropriations, it was estimated from detailed studies that the first landing might be possible six months earlier if an additional $427 million were available early in FY 1963. Thus, the late 1967 target date in the current plan is six months later than a date possible with optimum FY 1963 funding. The additional funds in FY 1963 would provide (1) heavier contractor effort on launch vehicles at Chrysler, Boeing, North American Aviation, and Douglas (2) procurement of hardware associated with Apollo spacecraft which is now deferred until FY 1964, and (3) accomplishment of the Gemini rendezvous mission nine months earlier than the current plan with resulting benefit to Apollo. The revised program would then be as follows:

	(In Billions) 1963	1964
Spacecraft and Flight Missions	$ .9	$1.5
Development of Launch Vehicle and Propulsion Systems	.8	1.0
Facilities, Launch Operations, Integration and Checkout, Systems Engineering and Aerospace Medicine	.7	.9
	$2.4	$3.4

Analysis indicates that if a mid-1967 target date were approved and the additional $427 million were made available in a FY 1963 supplemental appropriation in the early days of the 88th Congress, NASA could revise its target date to mid-1967. NASA would also require deficiency authority to cover total agency operations until receipt of the supplemental, since it would be necessary to commence operation at a higher level immediately in order to attain this schedule.

Alternative Plan - Mission in late 1966

In analyzing the actions which would be necessary to establish a target date for manned lunar landing in late 1966, the following major milestone changes would have to be accomplished relative to the current plan:

1. Advance the first manned Apollo command module flight on the Saturn launch vehicle six months to November 1964 from May 1965.

2. Move the first manned Apollo command and service module flight on the Saturn C-1B launch vehicle forward seven months to October 1965 from May 1966.

3. Accelerate the first Advanced Saturn development flight seven months to September 1965 from April 1966.

4. Change the first manned Apollo command and service module flight on Advanced Saturn 12 months to June 1966 from June 1967.

If these new milestones could be achieved, the first manned lunar landing would be late 1966. To achieve these milestone changes, a number of departures would have to be made from the present development plan. (1) The extremely tight schedule would require heavy sub-system effort very early in the development cycle and would leave no room for any significant test or flight failures. (2) Parallel testing of all stages and an increased rate of development on the Advanced Saturn first stage would be necessary. (3) Concurrent development would have to be initiated on alternative components and subsystems to give better assurance that schedules could be met. (4) The current contractor overtime rate and amount of double and triple shifting would be markedly increased and extensive overtime and multiple shifting would be necessary. (5) A crash contractor manpower buildup and heavy NASA effort would be required to reschedule and execute the new plan.

The runout cost from FY 1965 through FY 1967 for the late 1966 target date is estimated to be 10-15% higher than the funds required for a late 1967 date. The funds required in FY 1963 and FY 1964 to meet this schedule are approximately $900 million and $800 million more respectively than the current FY 1963 availability and FY 1964 budget request. The total would be distributed as follows:

	(In Billions)	
	1963	1964
Spacecraft and Flight Missions	$1.1	$1.9
Development of Launch Vehicle and Propulsion Systems	1.0	1.2
Facilities, Launch Operations, Integration and Checkout, Systems Engineering and Aerospace Medicine	.8	1.1
	$2.9	$4.2

Summary

On the basis of our current analysis, we believe that we can maintain the late 1967 target date for the manned lunar landing with $3.7 billion in FY 1963 funds and $6.2 billion in FY 1964. A budget increase of $427 million to $4.1 billion in FY 1963 and $6.2 billion in FY 1964 is required for a mid-1967 target date; and total resources of $4.6 billion in FY 1963 and $7.0 billion in FY 1964 are required for a late 1966 target date.

Let me emphasize again the preliminary nature of our conclusion that a target date of late 1966 could be established for the manned lunar landing with the indicated funding levels. This conclusion is not based on detailed programmatic plans. With this qualification, however, we are prepared to place the manned lunar landing program on an all-out crash basis aimed at the 1966 target date if you should decide this is in the national interest.

Respectfully yours,

[Signed James E. Webb]
James E. Webb
Administrator

Document II-33

Present at the meeting:
President John F. Kennedy
James Webb, NASA Administrator
Dr. Jerome Wiesner, Special Assistant to the President for Science and Technology
Edward Welsh, Executive Secretary, National Aeronautics and Space Council
David E. Bell, Director, Bureau of the Budget
Dr. Hugh Dryden, Deputy Administrator, NASA
Dr. Robert Seamans, Associate Administrator, NASA
Dr. Brainerd Holmes, Associate Administrator for Manned Space Flight, NASA
Elmer Staats, Deputy Director, Bureau of the Budget
Willis H. Shapley, Deputy Division Chief, Military Division, Bureau of the Budget

President Kennedy: What I understand, it is a question of whether we need four hundred million dollars more to maintain our present schedule, is that correct?

James Webb: Well, it's very hard to say what our present schedule is. I think the easiest way to ... to understand what has happened is to say that we started out after you made the decision in May to come forward with a driving program. We used the best information we had and we settled on late '67 or early '68 as the landing date. We wanted to have some leeway within the decade. Now this was a target date-we recognized we might have some slippage. We had some financial estimates at that time, which have proved to be too small, that the...the increased cost estimated by the contractor is partly because each of them has added to the cost that he submitted on his contract proposals to us. And second, we have added requirements to each of these vehicles.

[2] Now the combination of the increased cost now estimated by the contractors, plus our own increased knowledge as result of about a year's work, has led us first to confirm the fact that the late '67 or '68 date is a good date for us to have as our target date.

Second, that to accomplish that now and to run that kind of program that you want run, we have to go through a real strong, vigorous management period to shake down these things. Obviously you can make it an Apollo that would include a tremendous number of things that would cost a lot of money and probably are not necessary. On the other hand, you could make one that was too marginal and that we would not want to entrust [unknown]. We have to find a place in between as we go along with these projects.

[Additional discussion not included]

[3] **President Kennedy:** Now, let me just get back to this, what is your ... uh, your view is we oughta spend this four hundred forty million?

Brainerd Holmes: My view is that if can strictly spend, it would accelerate the Apollo schedule, yes, sir. Let me say I was very ... I oughta add that I'm very sorry about this ... I have no disagreement with Mr. Webb ... he says with the policy, oh, I think my job is to say how fast I think we can go for what dollars.

James Webb: Well, I think it's fair to say one other thing, Mr. President, that after your visit when you were saying how close this was, the speech you made. I think Brainerd and Wernher von Braun and Gilruth all felt, "We've got to find out how fast we can move here. The President wants to move." So they went to the contractors and said, "How fast can you move, boys, if money were not a limit?" Now, this sort of got cranked up into a feeling that this money was going to be made available, that a policy decision had already been [4] made to ask for the supplemental. And I think, to a certain extent, then, the magazines like *Time,* they picked this up in order to make a controversy.

President Kennedy: Well, as I at least hear, it wasn't so much that we wanted to speed it up as it was how much we were gonna slip ... you don't like that word, but that's what we're talking about.

James Webb: Well, no, sir, I don't think so. The reason I don't like the word is that those schedules were never approved by Dryden, Seamans, or me. They were not officially scheduled flights in the Agency. But they were tagged as the schedule in order to ask the contractors how much they could do, for Brainerd to ... to really get moving. When he came into this program.

President Kennedy: Are you saying that these dates were not ever set?

James Webb: They were not officially set by me or Dryden or Seamans....

President Kennedy: Were set....

James Webb: We were waiting to determine what the Budget Director was going to give us on the '64 budget to definitely set our dates. Because this made a big difference.

President Kennedy: You mean, what part of '67 was never set?

James Webb: Well, the '67 date has been set. And we're going to make it.

President Kennedy: What part of '67 was never set, is that correct?

James Webb: We talk all the time of late '67 or early '68.

Hugh Dryden: You never set a month....

James Webb: That's right.

President Kennedy: So now, when we talk about four hundred million, well now, tell me what's happened here. You had a date in your mind which unless you get the four hundred million you feel that's a good chance it'll go back to the end of until about six months. And, ah, Mr. Webb says that there was [n]ever a date in '67.

Brainerd Holmes: What's happened is this, I think. First of all, we didn't have a definitized program; we had to decide what size booster it would be, for instance, at the very end last year. So as soon as we could, we'd definitize all of the elements of the program but then still until one decides the mission which you are going to go you couldn't [5] interweave these schedules, you couldn't decide *really* what kind of a program you're gonna have and what kind of funding you're gonna have. So once we assumed what the mission would be in June going with this LOR, and I am not here talking about one mission versus another, but *a* mission to justify schedules. So I'm gonna put down all the details hundreds of schedules that interweave, we came up with costs associated with those schedules, and these costs and dates came out to be this first schedule which appears to be a not unreasonable schedule done on a crash basis. Further than that, just as Mr. Webb has said, the contractor estimates were low; our estimates of what they required were low; all that information was pouring in. We put the two together to go versus this time with these dollars that we had as estimates, it came out that we were short in Fiscal '63. So we didn't know that before that.

James Webb: So then we started talking to the Budget Director.

[Many people talking all at once.]

Unknown speaker: August and September.

Hugh Dryden [?]: Mr. President, may I say one more thing which I think you should keep in mind. Practically every program at this point that we've ever had has grown by a factor between two and three in cost from the beginning to end. The Mercury was what? About two and a half ... three. I think you have to bear in mind that these program costs are still going to grow. I'm not sure that Jim or Brainerd will agree with me. On any schedule you pick, you're going to have to face increasing cost year after year, in my opinion. And if we find some trouble, which undoubtedly we're going to find, intangibles stretch and go up in cost. And depending on the level you select now, the rate in which the costs are going to accelerate on you in the future years will be determined.

Unknown speaker: Mr. President....

Unknown speaker: Compared to future years....

Hugh Dryden: I think we learned a great deal from Mercury. As far as the so-called increase in Mercury. For the [honest] definition of what Mercury included. We started an estimate of what the McDonnell contract would be to build a capsule. But Mercury involves not only the capsule, it involves a worldwide tracking network; it involves ground support equipment for handling the capsule on the ground, check-out equipment. And we were learning with Mercury we kept adding new elements, new revisions to the cost, so that it did wind up Mercury cost five hundred million dollars all total. Two dollars and a quarter for each person in the United States, seventy-five cents a year for three years, if you want to look at it that way. And there's no question that it cost a large sum. Now in this analysis, the number of man-hours and years is inexpensive; again working out these numbers, it looks fantastic compared with the corresponding figures on Mercury.

[6] **James Webb:** We know a great deal more.

Unknown speaker: I think this is a much sounder basis. I would be surprised if the cost went up by three…

Robert Seamans: I would be surprised if it went up more than sixty percent.

Unknown speaker: But that's still a lot of money!

James Webb: Well, let me make a statement on that I have made to the Budget Director. You remember when I first talked to you about this program, the first statement I made to Congress was that the lunar program would cost between twenty and forty billion dollars. Now I am able to say right now it's going to be under the twenty billion, under the lower limit that we used. The question is how rapidly do you spend the money and…and how efficiently you manage this so as to get the most possible for the money. This can be speeded up at the expense of…of certain things which I outlined in this letter to you. It can be slowed up if, a year from now, we find that we don't have to proceeded at this basis. But this is a good, sound, solid program that would keep all of the governmental agencies and the contractors and the rest moving ahead. But we're prepared to move if you really want to put it on a crash basis.

President Kennedy: Do you put…. Do you put this program…. Do you think this program is the top-priority of the Agency?

James Webb: No, sir, I do not. I think it is *one* of the top-priority programs, but I think it's very important to recognize here…and that you have found what you could do with a rocket as you could find how you could get out beyond the Earth's atmosphere and into space and make measurements. Several scientific disciplines that are the very powerful and being to converge on this area.

President Kennedy: Jim, I think it is the top priority. I think we ought to have that very clear. Some of these other programs can slip six months, or nine months, and nothing strategic is gonna happen, it's gonna… But this is important for political reasons, international political reasons. This is, whether we like it or not, in a sense a race. If we get second to the Moon, it's nice, but it's like being second any time. So that if we're second by six months, because we didn't give it the kind of priority, then of course that would be very serious. So I think we have to take the view that this is the top priority with us.

James Webb: But the environment of space is where you are going to operate Apollo and where you are going to do the landing.

[7] **President Kennedy:** Look, I know all these other things and the satellite and the communications and weather and all, they're all desirable, but they can wait.

James Webb: I'm not putting those.... I am talking now about the scientific program to understand the space environment within which you got to fly Apollo and make a landing on the Moon.

President Kennedy: Wait a minute-is that saying that the lunar program to land the man on the Moon is the top priority of the Agency, is it?

Unknown speaker: And the science that goes with it....

Robert Seamans: Well, yes, if you add that, the science that is necessary....

President Kennedy: The science.... Going to the Moon is the top-priority project. Now, there are a lot of related scientific information and developments that will come from that which are important. But the whole thrust of the Agency, in my opinion, is the lunar program. The rest of it can wait six or nine months.

James Webb: The trouble ... Jerry is holding up his hand.... Let me say one thing, then maybe you want to [unknown] the thing that troubles me here about making such a flat statement as that is, number one, there are real unknowns as to whether man can live under the weightless condition and you'll ever make the lunar landing. This is one kind of political vulnerability I'd like to avoid such a flat commitment to. If you say you failed on your number-one priority, this is something to think about. Now, the second point is that as we can go out and make measurements in space by being physically able to get there, the scientific work feeds the technology and the engineers begin to make better spacecraft. That gives you better instruments and a better chance to go out to learn more. Now right all through our universities some of the brilliant able scientists are recognizing this and beginning to get into this area and you are generating here on a national basis an intellectual effort of the highest order of magnitude that I've seen develop in this country in the years I've been fooling around with national policy. Now, to them, there is a real question. The people that are going to furnish the brainwork, the real brainwork, on which the future space power of this nation for twenty-five or a hundred years are going be to made, have got some doubts about it and....

President Kennedy: Doubts about what, with this program?

James Webb: As to whether the actual landing on the Moon is what you call the highest priority.

President Kennedy: What do they think is the highest priority?

[8] **James Webb:** They think the highest priority is to understand the environment and ... and the areas of the laws of nature that operate out there as they apply backwards into space. You can say it this way. I think Jerry ought to talk on this rather than me, but the scientists in the nuclear field have penetrated right into the most minute areas of the nucleus and the subparticles of the nucleus. Now here, out in the universe, you've got the same general kind of a structure, but you can do it on a massive universal scale.

President Kennedy: I agree that we're interested in this, but we can wait six months on all of it.

James Webb: But you have to use that information to....

President Kennedy: Yeah, but only as that information directly applies to the program. Jim, I think we've gotta have that....

[Unintelligible.]

Jerome Wiesner: [Unintelligible – 'If you got enough time?"] Mr. President, I don't think Jim understands some of the scientific problems that are associated with landing on the Moon and this is what Dave Bell was trying to say and what I'm trying to say. We don't know a damn thing about the surface of the Moon. And we're making the wildest guesses about how we're going to land on the Moon and we could get a terrible disaster from putting something down on the surface of the Moon that's very different than we think it is. And the scientific programs that find us that information have to have the highest priority. But they are associated with the lunar program. The scientific programs that aren't associated with the lunar program can have any priority we please to give 'em.

Unknown speaker: That's consistent with what the President was saying.

Robert Seamans: Yeah. Could I just say that I agree with what you say, Jerry, that we must gather a wide variety of scientific data in order to carry out the lunar mission. For example, we must know what conditions we'll find on the lunar surface. That's the reason that we are proceeding with Centaur in order to get the Surveyor unmanned spacecraft to the Moon in time that it could affect the design of the Apollo.

President Kennedy: The other thing is I would certainly not favor spending six or seven billion dollars to find out about space no matter how on the schedule we're doing. I would spread it out over a five- or ten-year period. But we can spend it on.... Why are we spending seven million dollars on getting fresh water from saltwater, when we're spending seven billion dollars to find out about space? Obviously, you wouldn't put it on that priority except for the defense implications. And the second point is the fact that the Soviet Union has made this a test of the system. So that's why we're doing it. So I think we've got to take the view that this is the key program. The rest of this ... we can find out all about [8] it, but there's a lot of things we can find out about; we need to find out about cancer and everything else.

James Webb: But you see, when you talk about this, it's very hard to draw a line between what....

President Kennedy: Everything that we do ought to really be tied into getting onto the Moon ahead of the Russians.

James Webb: Why can't it be tied to preeminence in space, which are your own....

President Kennedy: Because, by God, we keep, we've been telling everybody we're preeminent in space for five years and nobody believes it because they have the booster and the satellite. We know all about the number of satellites we put up, two or three times the number of the Soviet Union ... we're ahead scientifically. It's like that instrument you got up at Stanford which is costing us a hundred and twenty-five million dollars and everybody tells me that we're the number one in the world. And what is it? I can't think what it is.

Interruption from multiple unknown speakers: The linear accelerator.

President Kennedy: I'm sorry, that's wonderful, but nobody knows anything about it!

James Webb: Let me say it slightly different. The advanced Saturn is eighty-five times as powerful as the Atlas. Now we are building a tremendous giant rocket with an index number of eighty-five if you give me Atlas one. Now, the Russians have had a booster that'll lift fourteen thousand pounds into orbit. They've been very efficient and capable in it. The kinds of things I'm talking about that give you preeminence in space are what permits you to make either that Russian booster or the advanced Saturn better than any other. A range of progress possible it is so much different [unknown].

President Kennedy: The only.... We're not going to settle the four hundred million this morning. I want to take a look closely at what Dave Bell.... But I do think we ought get it, you know, really clear that the policy ought to be that this is *the* top-priority program of the Agency, and one of the two things, except for defense, the top priority of the United States government. I think that that is the position we ought to take. Now, this may not change anything about that schedule, but at least we ought to be clear, otherwise we shouldn't be spending this kind of money because I'm not that interested in space. I think it's good; I think we ought to know about it; we're ready to spend reasonable amounts of money. But we're talking about these fantastic expenditures which wreck our budget and all these other domestic programs and the only justification for it, in my opinion, to do it in this time or fashion, is because we hope to beat them and demonstrate that starting behind, as we did by a couple years, by God, we passed them.

[9] **James Webb:** I'd like to have more time to talk about that because there is a wide public sentiment coming along in this country for preeminence in space.

President Kennedy: If you're trying to prove preeminence, this is the way to prove your preeminence.

James Webb: It's not if you've got an advanced Saturn rocket ... [unintelligible].

President Kennedy: We do have to talk about this. Because I think if this affects in any way our sort of allocation of resources and all the rest, then it is a substantive question and I think we've got to get it clarified. I'd like to have you tell me in a brief … you write me a letter, your views. I'm not sure that we're far apart. I think all these programs which contribute to the lunar program are ... come within, or contribute significantly or really in a sense ... let's put it this way, are *essential*, put it that way...*are essential* to the success of the lunar program, are justified. Those that are not essential to the lunar program, that help contribute over a broad spectrum to our preeminence in space, are secondary. That's my feeling.

James Webb: All right, then let me say this: if I go out and say that this is the number-one priority and that everything else must give way to it, I'm going to lose an important element of support for your program and for your administration.

President Kennedy [interrupting]: By who? Who? What people? Who?

James Webb: By a large number of people.

President Kennedy: Who? Who?

James Webb: Well, particularly the brainy people in industry and in the universities who are looking at a solid base.

President Kennedy: But they're not going to pay the kind of money to get that position that we are [who are] spending it. I say the only reason you can justify spending this tremendous ... why spend five or six billion dollars a year when all these other programs are starving to death?

James Webb: Because in Berlin you spent six billion a year adding to your military budget because the Russians acted the way they did. And I have some feeling that you might not have been as successful on Cuba if we hadn't flown John Glenn and demonstrated we had a real overall technical capability here.

President Kennedy: We agree. That's why we wanna put this program.... That's the dramatic evidence that we're preeminent in space.

[10] **James Webb:** But we didn't put him on the Moon ... [unintelligible].

Unknown speakers: [Unintelligible] ... we did what we needed to do.

David Bell: I think, Mr. President, that you're not as far apart as this sounds. Because the budget that they have submitted, 464....

President Kennedy: I know we're not far apart, I'm sure, and the budget we may not be apart at all. But I do think at least we're in words somewhat apart. And I'd like to get those words just the same.

James Webb: It's, it's perfectly fine. I think....

President Kennedy: How about you writing me and telling me how you assign these priorities. And perhaps I could write you my own....

James Webb: But I do think it ... it certainly doesn't hurt us to have this *Time* article that shows we are really going ahead with the program. I don't think that hurts the Agency; I don't think it hurts at all. You have tried several times to say that's number one. But I also think that as Administrator, I've got to take a little broader view of all the budgets here including those that are [unintelligible] appropriation in the Congress. I don't think we've got to use precisely the same word.

Robert Seamans: Could I state my view on this? I believe that we proceeded on Mercury, and we're now proceeding on Gemini and Apollo as the number-one program in NASA. It has a DX priority. Nothing else has a DX priority.

James Webb: And recommended four-point-seven billion funds for it for 1962! That's a....

Robert Seamans: At the same time, when you say something has a top priority, in my view it doesn't mean that you completely emasculate everything else if you run into budget problems on the Apollo and the Gemini. Because you could very rapidly completely eliminate you[r] meteorological program, your communications program, and so on. If you took that to too great of an extreme....

James Webb: And the advanced technology on which military power is going to be based.

Hugh Dryden: Mr. President, I think this is the issue. Suppose Apollo has an overrun of five hundred million dollars, to reprogram five hundred million dollars for the rest of the space program would just throw the whole thing all away. And I think this is the worry in Jim's mind about top priority.

[11] **President Kennedy:** Listen, I think in the letter you ought to mention how the other programs which the Agency is carrying out tie into the lunar program, and what their connection is, and how essential they are to the target dates we're talking about, and if they are only indirectly related, what their contribution is to the general and specific things [unknown-possibly "we're doing"] in space. Thank you very much.

[Kennedy gets up to leave the room.]

[Rest of discussion not included].

Document II- 34

January 10, 1963

MEMORANDUM FOR THE PRESIDENT

Subject: Acceleration of the Manned Lunar Landing Program

On the recent trip to Los Alamos I agreed to look further into the possibility of speeding up the manned lunar program. We have done this and are convinced that approximately 100 million dollars of the previously discussed 326 million dollar supplementary could have a very important effect on the schedule, but that to do so it would have to be available in the very near future.

The November 28, 1962 NASA letter to the Director of the Bureau of the Budget specified Fiscal Year 1963 supplemental appropriations which could be utilized to accelerate the Apollo Program. The data contained in this letter, as well an [*sic*] additional information obtained subsequently from the NASA Office of Manned Space Flight, suggest the following estimates of possible schedule changes and associated funding requirements–assuming that the additional funds would become available for obligation beginning January 1, 1963:

	Without Supplemental For FY 1963	With FY 1963 Supplemental Available Jan. 1. 1963
Apollo Spacecraft Available at AMR for the first manned flight	November 1964	September1964
First Manned Flight -C-1	February 1965	December 1964
First C-1B Launch	August 1965	April 1965
First C-5 Launch	March 1966	October 1965
First Lunar Landing Attempt	October 1967	May 1967

[2] Supplemental funds required for the above:

	(In millions of dollars)
Apollo	$125.2
C-l	23.4
C-1B	27. 2
C-5	103.8
Construction of Facilities	47.1
Total–	$326.7

I have reviewed the arguments contained in NASA's November 28 letter, as well as the general technical situation in the over-all Manned Lunar Landing Program. My principal conclusions are as follows:

1. Although some doubts are present that additional funds at this time will expedite the Apollo system proper, there is no doubt that the date of the first lunar landing attempt can be accelerated only if C-5 rocket availability is advanced.

2. The C-5 has been under development for a longer time than any other major system in the Manned Lunar Landing Program and estimates for what additional funds could or could not do for it are, therefore, more likely to be realistic

than for other systems. The estimate that an additional $103.8 million, available beginning January 1, 1963, could advance the date of the first C-5 launch by some five months, appears well founded. This conclusion is reinforced by the fact that the Marshall Space Flight Center has been relieved in recent month of responsibilities for several vehicles and may be expected, therefore, to exercise effective technical and managerial control over the C-5 development and its funding.

3. In view of the many engineering uncertainties with respect to the eventual reliability of systems as complex as the C-5, any advancement in the date of first launch will enable more extensive testing, and therefore earlier elimination of design inadequacies and faster growth in the reliability of the vehicle to be used for the first manned lunar landing attempt.

4. Although it cannot be argued at this time that an advance in the C-5 launch schedule will necessarily result in an earlier date for the first lunar landing attempt, it is quite certain that time lost now on the C-5 cannot be regained later. Accordingly, if future successes in the spacecraft development program should promise earlier availability of the Apollo system, it would be possible to take advantage of this only if earlier availability of the C-5 has been previously assured.

[3] In view of the above, it appears to be important to proceed immediately with the acceleration of the C-5 development and to provide the $103.8 million in FY 1963 supplemental appropriations as soon as possible. As I point out earlier, this step would only be effective if it can be taken very soon. If authorized these funds would be used by the NASA as follows:

	(In millions of dollars)
First Stage (S-1C at Boeing)	$ 25.8
Second Stage (S-II and F-1, J-2 engines at NAA)	$68.0
Guidance, ground support, etc.	10.0
Total—	$103.8

Jerome B. Wiesner

Document II- 35

Document Title: "Letter to James Webb from Vannevar Bush," 11 April 1963.

Source: Folder 18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

Dr. Vannevar Bush was the head of the World War II Office of Scientific Research and Development and in 1945 authored the seminal report "Science: the Endless Frontier," which was the charter for the post-war involvement of the Federal Government in the support of *research. He was thus for many years one of the leaders of the U.S. scientific community. Bush and Webb knew each other well, dating back to their work together during the Truman administration. This 1963 letter expressed Bush's misgivings about the commitment to sending Americans to the Moon; during 1963, similar criticism of the lunar landing program emerged from within the scientific community and from those who have preferred that money being spent on space would instead be allocated to other social priorities.*

11 April 1963

Mr. James E. Webb
Administrator
National Aeronautics and
Space Administration
3200 Idaho Avenue
Washington 16, D.C.

Dear Jim:

I have pondered the subject of this letter for a long time. Now I think I should write it out for you.

Early in the space program, I testified to a Senate Committee. As was my duty, I gave my considered judgment, critical of the program.

But since then I have made no public statements. This has been due to a number of reasons. First, I have felt that, being nearly alone in criticism, I would be regarded as an old fogy who could not appreciate the efforts of young men. More important, I hesitated to oppose a program ordered by the President after full advice.

You and I understand this well. During the war I took the position strongly that my job was to transmit to the President the best scientific advice available, and to carry out his orders loyally and without question. I know you have this point of view intensely, for I have seen you respond to the President's wishes many times when it involved hardship or risk on your part.

A part of this attitude has been involved in my relations at M.I.T. There I have taken the point of view that, when duly constituted government called for aid on a program, which aid only M.I.T. because of its unique position could supply, there was a duty to respond, and that my personal estimate of the advisability of the program should not interfere with it doing so.

Now the scene is changing. There are an increasing number of critical editorials and articles. It could change abruptly.

[2] No great program of this sort can proceed without occasional disasters. We have been lucky, and very careful thus far. But, some one of these days, a couple of young attractive men are going to be killed, with the eyes of millions upon them. Worse, they may be caught in space to die, still talking to us, who are helpless to aid them.

It is often said the public is fickle. It is also said that there is, unfortunately, a measure of bull fight complex in the peoples' following of flights. I mean something deeper than either of these. The American public often fails for a long time utterly to grasp a situation, and, when it finally does, its reversal of attitude can be sobering or terrifying. A prime example is the prohibition experiment. A better example is the attitude in 1916. At first unconcerned about a war in Europe, electing a president who would keep us out of war, it suddenly reversed itself and plunged in to halt the Kaiser.

Thus far the public attitude has been one of national pride, enthusiasm over a good show, wonder at the accomplishments of science. It has been uninformed on, or has chosen to ignore, the adverse aspects. It can change its attitude in a month's time. When it does it can be utterly unreasonable, and it can be cruel. I do not know when this will occur; I do not even know that it will occur. But I fear it.

Now do not misunderstand me. If I were sure the program were sound I would applaud your driving it forward in spite of any amount of criticism, or any amount of personal risk. And I know you well enough to be sure that is just what you would do. The difficulty is that the program, as it has been built up, is not sound.

The sad fact is that the program is more expensive than the country can now afford; its results, while interesting, are secondary to our national welfare. Moreover the situation is one on which the President, and the people, cannot possibly have adequate unbiased advice.

Our national budget has been unbalanced for many years. We have a serious problem in the outflow of gold. Our taxes are so high that they impede commercial vigor, [3] and our rate of growth is hence low compared to recovered nations with which we compete. We have by no means halted the wage-price spiral. We have genuine danger of inflation. The strength of the dollar is questioned. This calls for vigorous, courageous measures to avert disaster. I will not comment here on the nature of the measures I would advocate. But I believe it is crystal-clear that this is no time at which to make enormous - and unnecessary - expenditures.

While the scientific results of an Apollo program would be real, I do not think that anyone would attempt to justify an expenditure of 40 or 50 billion dollars to obtain them. The Academy report was weak on this point. The justifications given are of quite a different nature. First, it is said we are in a race and our national prestige is at stake. I believe we can disregard the matter of race. I do not know whether there is a race to the moon or not; I doubt it. But national prestige is a far more subtle thing than this. The courageous, and well conceived, way in which the President handled the threat of missiles in Cuba advanced our national prestige far more than a dozen trips to the moon. Having a large number of devoted Americans working unselfishly in undeveloped countries is far more impressive than mere technical excellence. We can advance our prestige by many means, but this way is immature in its concept.

I hear that the program will be justified by its by-products. We might get a billion dollars worth of benefit that way. I doubt if it would exceed this.

I also hear, and some of my good friends advance this argument in all seriousness, that the program is inspiring the youth of the country, and spurring us on to great accomplishment. It inspires youth all right, and it also misleads them as to want is really worthwhile in scientific effort. In fact, it misleads them as to what science is. It is well to inspire a child, and the use of fairy tales is legitimate as this is done. But when a child becomes a man he should be inspired to judge and choose soundly, to avoid being carried away by mass enthusiasms, to understand the tough world in which he will play his part, technically and economically. It is wrong to inspire him to have an exciting adventure at his neighbors' expense.

I also hear that this is a form of pump priming, that it is a shot in the arm to industry. Anyone who still [4] believes in pump priming should read again about the 1929 debacle, and the sorry following years when we long failed to emerge from the resulting depression.

In other words, I hear excuses and rationalization, not cold analysis.

A most serious point about this whole affair is that the people of this country, and the President with his appalling responsibilities, cannot possibly have adequate sound scientific, engineering, and economic advice regarding it. This is due to the very vast size of the project. Nearly every man who could speak with authority on the subject has a conflict of interest. Now do not misinterpret this to mean that the scientists of the country are all feeding at the trough, and so selfish they would subordinate their judgment as to what is true to what is advantageous to them. There are some of these of course. I even hear rumors of artificial pressures being brought to bear on individuals and companies to ensure conformity, but such rumors always float about when there are great undertakings, and in any very large organization there are always subordinates of little sense, as we have seen exemplified often.

I do not mean this sort of thing at all. The scientist or engineer in a university or a company is in a difficult quandary. He may honestly believe the program as a whole is highly fallacious. But it has been decided upon at the top level of government. It is supported by his colleagues, many of whom have enthusiasm. His organization has been urged to participate. Who is he to stand out against this powerful trend? He consoles himself by Cromwell's admonition, "I beseech you, bethink you that you may be mistaken", and sides along with the crowd.

We pride ourselves that, in this democracy, the minority has opportunity to speak. Yet it takes courage and an unusual sort of detachment, to stand against a nearly unanimous opinion of friends and colleagues, and to risk one's reputation in a futile attempt to halt an avalanche. I know this whole program has never been evaluated objectively by an adequately informed and disinterested group, and I fear it never will be.

The whole problem is in the hands of the President, and he has many problems on his mind today. He leans on [5] you, to steer him straight. As we now go there is danger ahead for the program, and danger to his prestige. I hope he will alter his handling of this whole affair before a balky Congress, or public opinion, forces him to do so.

You and I think alike on the tough problem of the relation to the President of a man on his team; we have discussed it a number of times. Your creed and mine depends on two main principles. First, the President on a problem should have the best advice this country can afford, with differences of opinion where there are any faithfully transmitted, and it is the job of the man who reports to him in an area to see that he gets it. Second, when the President, with full grasp of a subject and thus advised, makes a decision and issues an order, it is the job of his lieutenant on a subject to carry it out loyally and effectively whether or not he agrees with it. This is especially true in time of war, but it is also true of a key subject in time of cold war. The only exception would be a situation in which the lieutenant's disagreement was so complete that he found himself unable to perform well, in which case he should step aside, and, incidentally, say nothing.

I believe the President could alter his attitude and his orders without a reversal of form which would embarrass him.

I know what I think should be done. As a part of lowering taxes and putting our national financial affairs in order, we should have the sense to cut; back severely, on our rate of expenditure on space. As a corollary they could remove all dates from plans for a trip to the moon; in fact, he could announce that no date will be set, and no decision made to go to the moon, until many preliminary experiments and analyses have rendered the situation far more clear than it is today. He could lop off, without regret, marginal programs that cannot be soundly supported, and continue only where results are clearly attainable and worthwhile, in weather and communication satellites for example. He could order experimentation concerned with long space flights confined to those features which are clearly central and determining, avoiding hardware except where it is necessary. Then, after a year or so, the entire program could be reviewed through a professional dis-[6]interested board, made up of scientists, engineers, economists, financial men, and men with keen judgment of public attitudes here and abroad.

By so doing, he could reduce the rate of current expenditure at a time when any such cutback would help him in his tax program. He could avoid commitment to vast expenditures until such time as economic prosperity justified them, and thorough analysis had shown them to be warranted. And I believe he could do this without real damage to an overall logical sound space program.

There were times when you and I both reported to the President, and we worked closely together in so doing, even when we did not totally agree. Today you are still doing so while I have dropped out of the active picture.

But, whatever you do, and however the program may work out, you have my best wishes, my deep personal regard.

Cordially yours,

[Signed]

V. Bush

Document II-36

Document Title: John Disher and Del Tischler, "Apollo Cost and Schedule Evaluation," 28 September 1963.

Source: Folder 18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

Document II-37

Document Title: Clyde B. Bothmer, "Minutes of Management Council Meeting, October 29, 1963, in Washington, D.C." 31 October 1963.

Source: Folder 18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

Document II-38

Document Title: George E. Mueller, Deputy Associate Administrator for Manned Space Flight, NASA, to the Directors of the Manned Spacecraft Center, Launch Operations Center, and Marshall Space Flight Center, "Revised Manned Space Flight Schedule," 31 October 1963.

Source: Folder 18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

When George Mueller joined NASA in September 1963, replacing D. Brainerd Holmes, he was concerned that the existing schedule for Project Apollo would not result in an initial lunar landing before the end of the decade, the goal that had been set by President Kennedy. Mueller asked two veteran NASA engineers, John Disher and Del Tischler, to conduct a two-week assessment of the situation. The two presented their findings to Mueller on 28 September. Their findings, as presented in the excerpts from their briefing included here, were troubling. After he had heard their briefing, Mueller took the two to present it to NASA Associate Administrator Robert Seamans. According to a 22 August 1976 hand-written note by NASA Historian Eugene Emme on the copy of the briefing sent to the NASA History Division, Seamans asked that all copies of the Disher/Tischler briefing be "withdrawn"; some accounts suggest that because the findings were so at variance with the official schedule that Seamans suggested that all copies of the briefing be destroyed. This briefing was a catalyst to Mueller's rethinking of the Apollo schedule that led to the "all-up" testing concept, in which the Saturn 1B and Saturn V launch vehicles would be tested with all of their stages active, rather than the stage-by-stage testing that was then the plan.

The "all-up" approach was first announced by Mueller at a management meeting on 29 October 1963; more details were provided in a teletyped memorandum two days later.

Mueller's approach was strongly resisted by both the Marshall Space Flight Center and the Manned Spacecraft Center, but Mueller, who soon after this memorandum was written became Associate Administrator for Manned Space Flight, was a strong-willed individual whose views eventually prevailed. The "all-up" decision is regarded by many as key to the United States being able to reach the Moon "before this decade is out."

Document II-36

APOLLO SCHEDULE AND COST EVALUATION

OBJECTIVES

- PROVIDE A REALISTIC ESTIMATE WITH MODERATE CONFIDENCE (~50%) OF THE EARLIEST DATE FOR THE FIRST LUNAR LANDING ATTEMPT
- PROVIDE A CORRESPONDING PROGRAM COST ESTIMATE
- ASSESS TIME AND COST INCREASES REQUIRED TO RAISE CONFIDENCE TO A HIGH LEVEL (~90%)
- ESTIMATE ADDITIONAL COSTS OF WORK WHICH COULD INCREASE CONFIDENCE LEVEL OF EARLIEST DATE

APOLLO SCHEDULE AND COST EVALUATION GROUND RULES

- NO BASIC CHANGE IN TECHNICAL CONCEPT OR APPROACH
- PERSONNEL CEILING FIXED AT FY 65 LEVEL
- FY 64 AND FY 65 FUNDING AT GUIDLINE LEVELS
- FY 66 AND SUBSEQUENT R&D FUNDING CEILING OF $3.00 BILLION PER YEAR (INCLUDES ADVANCED PROGRAM)
- CONTINUATION OF DX PRIORITY
- NORMAL PROCUREMENT LEAD TIMES
- TWO SCHEDULED FLIGHTS REQUIRED FOR ACCOMPLISHMENT OF EACH FLIGHT MISSION
- MAXIMUM FREQUENCY FOR MANNED FLIGHTS OF FOUR PER YEAR
- INFLATION FACTORS NOT CONSIDERED

<u>CONCLUSIONS AND RECOMMENDATIONS</u>

- If funding constraints assumed herein prevail, lunar landing cannot likely be attained within the decade with acceptable risk.
- First attempt to land men on moon is likely about late 1971 under study guideline funding and constraints.
- Program cost through initial lunar landing attempt will approximate 24 billion dollars (R&D Direct only)
- Progress on program inadequate to provide schedule associated with 90% confidence.
- Projection of lunar landing attempt on early manned Saturn V unrealistic in terms of probable technical problems.

- Late manned spacecraft availability, plus resource diversion to Saturn I from IB and V would strongly indicate cancellation of Saturn I manned flights.
- Funding increases of $400M to $700M in FY 65 and $700M to $1100M each in FY 66 and 67 could accelerate the program by one to two years with a decrease in total program cost.

Document II-37

October 31, 1963

MEMORANDUM FOR DISTRUBUTION LIST

Subject: Management Council Meeting, October 29, 1963 in Washington, D.C.

The subject meeting convened at 8:30 a.m. All members were present with the exception of Mr. Elms.

The Program Review portion of the meeting was conducted from 8:30 a.m. - 2:40 p.m. as scheduled, and the action minutes for that portion of the session are attached. [not included]

The following additional items were considered outside the Program Review.

1. Dr. Mueller stressed the importance of a philosophical approach to meeting schedules which minimizes "dead-end" testing, and maximized "all-up" systems flight tests. He also said the philosophy should include obtaining <u>complete</u> systems at the Cape (thus minimize "re-building" at the Cape), and scheduling both delivery and launch dates. (In explaining "dead-end" testing he referred to tests involving components or systems that will not fly operationally without major modification.)

[remainder of minutes not included]

Document II-38

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON 25, D.C.

IN REPLY REFER TO:
M-C M 9330.186

OCT 31, 1963 [stamped]

TO: Director, Manned Spacecraft Center
Houston 1, Texas
Director, Launch Operations Center
Cocoa Beach, Florida
Director, Marshall Space Flight Center
Huntsville, Alabama

FROM: Deputy Associate Administrator for Manned Space Flight

SUBJECT: Revised Manned Space Flight Schedule

Recent schedule and budget reviews have resulted in a deletion of the Saturn I manned flight program and realignment of schedules and flight mission assignments on the Saturn IB and Saturn V programs. It is my desire at this time to plan a flight schedule which has a good probability of being met or exceeded. Accordingly, I am proposing that a flight schedule such as shown in Figure 1 [not included], with slight adjustments as required to prevent "stack-up," be accepted as the official launch schedule. Contractor schedules for spacecraft and launch vehicle deliveries should be as shown in Figure 2.[not included] This would allow actual flights to take place several months earlier than the official schedule. The period after checkout at the Cape and prior to the official launch date should be designated the "Space Vehicle Acceptance" period.

With regard to flight missions for Saturn 1, MSC [the Manned Spacecraft Center] should indicate when they will be in a position to propose a firm mission and spacecraft configuration for SA-10. MSFC [The Marshall Space Flight Center] should indicate the cost of a meteoroid payload for that flight. SA-6 through SA-9 missions should remain as presently defined.

[2] It is my desire that "all-up" spacecraft and launch vehicle flights be made as early as possible in the program. To this end, SA-201 and 501 should utilize all live stages and should carry complete spacecraft for their respective missions. SA-501 and 502 missions should be reentry tests of the spacecraft at lunar return velocity. It is recognized that the Saturn IB flights will have CM/SM [Command Module/Service Module] and CM/SM/LEM [Command Module/ Service Module/Lunar Excursion Module] configurations.

Mission planning should consider that two successful flights would be made prior to a manned flight. Thus, 203 could conceivably be the first manned Apollo flight. However, the official schedule would show the first manned flight as 207, with flights 203-206 designated as "man-rating" flights. A similar philosophy would apply to Saturn V for "man-rating" flights with 507 shown as the first manned flight,

I would like your assessment of the proposed schedule, including any effect on resource requirements in FY 1964, 1965 and run-out by November 11, 1963. My goal is to have an official schedule reflecting the philosophy outlined here by November 25, 1963.

George M. Low [signed for]
George E. Mueller
Deputy Associate Administrator
for Manned Space Flight

Enclosures:
Figure 1
Figure 2

Document II-39

Document Title: Letter to Representative Albert Thomas from President John F. Kennedy, 23 September 1963.

Source: John F. Kennedy Presidential Library, Boston, Massachusetts.

Document II-40

Document Title: Memorandum from Jerome B. Wiesner to the President, "The US Proposal for a Joint US-USSR Lunar Program," 29 October 1963.

Source: John F. Kennedy Presidential Library, Boston, Massachusetts.

Speaking before the United Nations General Assembly on 20 September 1963, President Kennedy suggested that the United States and the Soviet Union might cooperate in a "joint mission to the moon." Given that Project Apollo originated in 1961 in a desire to beat the Soviet Union to the Moon, and that the president had reiterated in 1962 that this was his primary motivation for funding the undertaking at a high level, this proposal came as a surprise to many. But President Kennedy had been interested in space cooperation with the Soviet Union since he had come to the White House, and according to his top advisor, Theodore Sorenson, he would have preferred to cooperate with the Soviet Union rather than compete with them. The reaction to the 12 April 1961 Soviet launch of Yuri Gagarin, however, suggested to Kennedy that competition was his only option. When he suggested cooperation to Soviet Premier Nikita Khrushchev at a June 1961 summit meeting, Khrushchev rebuffed the idea, and this reinforced Kennedy's belief that competition was the only path open to him. By September 1963, Kennedy tried once again to raise the possibility of cooperation.

Kennedy's proposal angered those in the Congress who had been strongest in support of Apollo as a competitive undertaking. In a letter to Representative Albert Thomas, who chaired the House Appropriations Subcommittee that controlled the NASA budget, Kennedy explained how his proposal was consistent with a strong Apollo effort. There were also a number of suggestions that Kennedy's proposal was primarily a public relations move, or a way of gracefully withdrawing from the M oon race after the U.S. success during the Cuban Missile Crisis. Balanced against *such suggestions are a memorandum from Kennedy's science advisor, Jerome Wiesner, suggesting a detailed approach to cooperation, and a 12 November 1963 National Security Action Memorandum signed by Kennedy asking NASA to take the lead in developing an approach to U.S.-Soviet cooperation in missions to the Moon (Volume II, Document I-42).*

Document II-39

THE WHITE HOUSE

September 23, 1963

Dear Al:

I am very glad to respond to your letter of September 21 and to state my position on the relation between our great current space effort and my proposal at the United Nations for increased cooperation with the Russians in this field. In my view an energetic continuation of our strong space effort is essential, and the need for this effort is, if anything, increased by our intent to work for increasing cooperation if the Soviet Government proves willing.

As you know, the idea of cooperation in space is not new. My statement of our willingness to cooperate in a moon shot was an extension of a policy developed as long ago as 1958 on a bipartisan basis, with particular leadership from Vice President Johnson, who was then the Senate Majority Leader. The American purpose of cooperation in space was stated by the Congress in the National Aeronautics and Space Act of 1958, and reaffirmed in my Inaugural Address in 1961. Our specific interest in cooperation with the Soviet Union, as the other nation with a major present capability in space, was indicated to me by Chairman Khrushchev in Vienna in the middle of 1961, and reaffirmed in my letter to him of March 7, 1962, which was made public at the time. As I then said, discussion of cooperation would undoubtedly show us "possibilities for substantive scientific and technical cooperation in manned and unmanned space investigations." So my statement in the United Nations is a direct development of policy long held by the United States government.

Our repeated efforts of cooperation with the Soviet Union have so far produced only limited responses and results. We have an agreement to exchange certain information in such limited fields as weather observation and passive communications, and technical discussions of other limited possibilities are going forward. But as I said in July of this year, there are a good many barriers of suspicion and fear to be broken down before we can have major progress in this field. Yet our intent remains: to do our part to bring those barriers down.

At the same time, as no one knows better than you, the United States in the last five years has made a steadily growing national effort in space. On May 25, 1961, I proposed to the Congress and the nation a major expansion of this effort, and I particularly emphasized as a target the achievement of a manned lunar landing in the decade of the 60's. I stated that this would be a task requiring great effort and very large expenditures' the Congress and the nation approved this goal; we have been on our way ever since. In a larger sense this is not merely an effort to put a man on the moon; it is a means and a stimulus for all the advances in technology, in understanding and in experience, which can move us forward toward man's mastery of space.

This great national effort and this steadily stated readiness to cooperate with others are not in conflict. They are mutually supporting elements of a single policy. We do not make our space effort with the narrow purpose of national aggrandizement. We make it so that the United States may have a leading and honorable role in mankind's peaceful conquest of space. It is this great effort which permits us now to offer increased cooperation with no suspicion anywhere that we speak from weakness. And in the same way, our readiness to cooperate with others enlarged the international meaning of our own peaceful American program in space.

In my judgment, therefore, our renewed and extended purpose of cooperation, so far from offering any excuse for slackening or weakness in our space effort, is one reason the more for moving ahead with the great program to which we have been committed as a country for more than two years.

So the position of the United States is clear. If cooperation is possible, we mean to cooperate, and we shall do so from a position made strong and solid by our national effort in space. If cooperation is not possible—and as realists we must plan for this contingency too—then the same strong national effort will serve all free men's interest in space, and protect us also against possible hazards to our national security. So let us press on.

Let me thank you again for this opportunity of expressing my views.

With warm personal regards,

Sincerely,

/s/
John F. Kennedy

The Honorable Albert Thomas
House of Representatives
Washington, D/C.

Document II-40

October 29, 1963

MEMORANDUM FOR

The President

Subject: The US Proposal for a Joint US-USSR Lunar Program

I believe that Premier Khrushchev's statement of October 26 that the USSR does not plan to land a man on the moon gives us a unique opportunity to follow through on your UN proposal for a joint US-USSR program in a way that will not only be in accord with U.S. objectives for peaceful cooperation if accepted by the USSR, but will also decisively dispel the doubts that have existed in the Congress and the press about the sincerity and feasibility of the proposal itself. Specifically, I would propose a joint program in which the USSR provides unmanned exploratory and logistic support for the U.S. Apollo manned landing. I believe such a program would utilize the combined resources of US and USSR in a technically practical manner and might, in view of Premier Khrushchev's statement, be politically attractive to him.

The manned lunar program encompasses much more that the manned landing vehicle itself. The PSAC space panels have consistently emphasized the importance of the unmanned lunar exploration program to develop technical information about the lunar surface. This information appears critical to a successful manned landing. The U.S. unmanned program hinges around the Surveyor program which at best is a marginal one. At the present time its estimated payload has dropped to 65 pounds and its schedule is unreliable. The Soviet Union, however, apparently has a substantial capability at this time for this type of exploratory mission. A joint program which would use this capability would be very valuable to us.

More directly involved with the manned landing itself is a vehicle and spacecraft for placing a large stock of supplies and equipment at [2] the site of the manned landing. NASA and the PSAC space panels all agree that the 24-48 hours staytime provided by Apollo does not permit the astronauts to conduct significant scientific exploration. It is agreed that to make Apollo a useful scientific endeavor an additional 7000 pounds of equipment and supplies must be landed at [t]his site to permit him 5 to 7 days of useful scientific exploration before he returns to earth. This logistic support requires another large vehicle and spacecraft to be available on about the same time schedule as Apollo. The U.S. development program to provide this capability has not yet been initiated. If the Soviet Union could be convinced that the logistical support was indeed an essential and integral part of the manned landing and persuaded to provide this support system, the resulting program would again result in an effective use of combined resources. The Apollo program would remain a purely U.S. technical program without modification of present plans. A Russian could easily be included as a member of the landing team without complicating the engineering effort. In addition, the proposal would have the practical value of minimizing requirements for complicated joint engineering projects and launching operations and would emphasize the exchange of plans, information and possibly people.

If we assume that Premier Khrushchev is telling the truth (and I believe that he is), this proposal will give the USSR the opportunity of sharing the credit for a successful lunar mission without incurring major expenditures much beyond those that they probably plan to undertake as a part of their present space program. By not including joint engineering and launching activities, the proposal minimizes the security impact on the USSR that undoubtedly acts as a restraint on joint activities because of the close association of the Soviet space and military missile programs.

It is true that the above proposal assumes that the USSR would be willing to follow the now well established U.S. operational plan for manned lunar exploration. This did seem reasonable as long as it appeared likely that Russia has a well developed program of her own. Now, however, Premier Khrushchev's statement, whether it is true or not, makes such a proposal by the United States reasonable from [3] every standpoint. The proposal now not only offers a program which truly enhances the manned lunar exploration effort while leaving the Apollo program intact, but also one which ought to be acceptable to the USSR.

It might be extremely advantageous for you to publicly offer this plan to the USSR as a specific proposal for a joint program, formulated in the light of Premier Khrushchev's statement and designed to effectively combine the resources of both countries. The effectiveness of the offer would be enhanced if it were made while Khrushchev's statement is still fresh in the mind of the public. If the proposal is accepted we will have established a practical basis for cooperative program. If it is rejected we will have demonstrated our desire for peaceful cooperation and the sincerity of our original proposal.

If you believe this proposal has merit, I suggest that you request that NASA prepare as soon as possible a specific plan along these lines for your consideration.

Jerome B. Wiesner

Document II-41

Document Title: Memorandum to Robert R. Gilruth, Director, Manned Spacecraft Center from Verne C. Fryklund, Jr., Acting Director, Manned Space Sciences Division, Office of Space Sciences, NASA Headquarters, "Scientific Guidelines for the Project Apollo," 8 October 1963.

Source: Folder 18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

The National Academy of Sciences Space Science Board held a 1962 summer study on the campus of the University of Iowa to address all issues of space science (Volume V, Document I-22). Two working groups, one on lunar and planetary exploration and the other on the scientific role of humans in space, addressed the scientific aspects of the Apollo missions. The latter group recommended that astronomical observations from the Moon be relegated to later flights. These views were adopted by NASA as the basic scientific guidelines for early Apollo flights to the Moon. The Apollo Logistics Support System was a proposed extension of the basic Apollo capabilities to enable more extensive exploration of the Moon; it was never developed.

[stamped "OCT 8 1963"]

To: Director, Manned Spacecraft Center
Attention: Robert R. Gilruth

From: SH/Acting Director, Manned Space Sciences Division
Office of Space Sciences

Subject: Scientific Guidelines for the Apollo Project

Reference: Scientific Guidelines for Apollo Logistic Support System

The following general and preliminary guidelines are being used by the Office of Space Sciences and should be used by the Manned Spacecraft Center in the consideration of scientific investigations to be done by means of the Apollo project. As defined herein, Apollo refers only to the approved project with restricted stay time. The guidelines for the Apollo Logistic Support Systems (ALSS) previously Sent to MSFC are enclosed for your information. [not included]

These guidelines, unless modified in writing, should be followed in the preparation of your plans.

The Office of Space Sciences has established that the primary scientific objective of the Apollo project is acquisition of comprehensive data about the Moon. The steps that resulted in this decision are, I am sure, of interest to you. The Office of Space Sciences formed the Ad Hoc Working Group on Apollo Experiments and Training at the request of the Office of Manned Space Flight in March 1962. This working group issued a draft report (the Sonett Report) on July 6, 1962, that was immediately made available to the various subcommittees of the Iowa Summer Study, which was sponsored by the National Academy of Sciences. The reviews of the Subcommittees were extensive and though the general conclusions of the Sonett Report were accepted, the final report of the Iowa Summer Study ("A Review of Space Research" National Academy of Sciences-National Research Council Publication 1079) recommends that the scope of Apollo scientific investigations be more restricted that those proposed in the Sonnet [2] Report. The Officer of Space Sciences has concurred with the recommendations of the Academy and they are incorporated in those guidelines.

As the moon itself is the primary subject of observation, it follows that the structure of the moon's surface, gross body properties and large-scale measurements of physical and chemical characteristics, and observation of whatever phenomena may occur at the actual surface will be prime scientific objectives.

The guidelines that follow are intended to place some specific constraints on studies in keeping with the paragraphs above.

Guidelines:

1. The principal scientific activity will be observation of the moon.

2. The use of the moon as a platform for making astronomical and other observations is, in general, not a function of the Apollo project. (See ALSS Guidelines for additional comment on this subject.)

3. We may assume that Apollo activities will be largely reconnaissance in nature. The intention is to acquire knowledge of as large an area as possible, and by as simple a means as possible, in the limited time available.

4. The three functional scientific activities listed in order of decreasing importance, will be:

a. Comprehensive observation of lunar phenomena;

b. Collection of representative samples; and

c. Replacement of monitoring equipment.

5. Quantitative analytical chemistry will not be done on the moon by the Apollo project.

6. Qualitative and semi-quantitative analytical chemistry should be planned for, though there is not yet an obvious need for such data to be obtained on the moon by the Apollo project.

[3] 7. Seismometers, scintillometers, and magnetometers, among other instruments intended to determine the physical properties of the moon, will be studied for inclusion in payloads.

8. Sample collecting, for geological and biological purposes, will be an important activity and possible special equipment requirements should be studied.

Verne C. Fryklund, Jr.

Document II-42

Document Title: Bureau of the Budget, "Special Space Review," Draft Report, 29 November 1963.

Source: Lyndon B. Johnson Presidential Library, Austin, Texas.

This draft report summarizes a 1963 "special review" of the U.S. space program that began under President John F. Kennedy and continued after his assassination under President Lyndon Johnson. This report suggests that consideration was being given, at least within the Bureau of the Budget staff, to "backing off from the manned lunar landing goal." How seriously this possibility was taken at this point in time is not clear from the historical record. This report was a draft; there were no recommendations in it, since they would have had to come from senior officials. It is not clear whether a final version of this report, with such recommendations, was ever prepared, or whether any thought of not following through on the goal that had been set by President Kennedy was quickly abandoned after his death.

SPECIAL SPACE REVIEW

DRAFT REPORT

Bureau of the Budget
November 29, 1963

[2]

SPECIAL SPACE REVIEW - 1965 BUDGET
INTRODUCTION

This report summarizes the principal results of the special review of the goals, nature, and pace of the space programs in the light of 1964 and 1965 budget pressures, which has been undertaken by the Bureau of the Budget in conjunction with the 1965 budget review and in response to the decisions at the October 8, 1963, meeting of the Secretary of Defense, the Administrator of the National Aeronautics and Space Administration, and the Special Assistant to the President for National Security Affairs.

The purposes of the review have been to consider the goals of the space programs and the minimum requirements of a national program to achieve them, and to identify the policy questions, alternatives, and other major issues to be dealt with in the 1965 budget decisions.

The draft report has been prepared by Bureau of the Budget staff in consultation with senior representatives of NASA and the Department of Defense, and others, on the basis of information submitted by the agencies and discussions with agency officials in 1965 budget reviews now in process. The views expressed in the draft are necessarily those of the Bureau of the Budget staff. It is expected that the recommendations of the Director of the Bureau of the Budget, and the concurrences or[hand-written] differing views of the Secretary of Defense; the Administrator, NASA; the Director of OST; and the Executive Secretary of the NASC will be inserted as appropriate after discussion.

Section I covering the Manned Lunar Landing Program and Section II covering Military Space Objectives (including the proposed manned earth orbit experiments) are attached. Problems relating to communications satellites, meteorology, geodesy, space sciences, and technological development are being handled separately.

[3]
[budget table omitted]

[4]

I. MANNED LUNAR LANDING PROGRAM

A. STATEMENT OF PRESENT GOAL:

To attempt to achieve a manned lunar landing and return by the end of this decade, on a high priority but not "crash" basis, with prudent regard for the safety of the astronauts, for the principal purposes of (a) demonstrating an important space achievement ahead of the USSR, (b) serving as a focus for technological developments necessary for other space objectives and having potential significance for national defense, and (c) acquiring useful scientific and other data to the extent feasible.

B. QUESTIONS, DISCUSSION, ALTERNATIVES, AND RECOMMENDATIONS:

1. Should consideration be given at this time to backing off from the manned lunar landing goal?

Discussion: The review has pointed to the conclusion that in the absence of clear changes in the present technical or international situations, the only basis for backing off from the MLL objective at this time would be an overriding fiscal decision either (a) that the budgetary totals in 1965 or succeeding years are unacceptable and should be reduced by adjusting the space program, or (b) that within present budgetary totals an adjustment should be made shifting funds from space to other programs.

Alternatives

a. Adhere to the present goal as stated above. The arguments supporting this alternative include:

(1) That the reasons for adopting the manned lunar landing goal are still valid;

[5]

(2) That in the absence of clear and compelling external circumstances a change in present policies and commitments would involve an unacceptable "loss of face" both domestically and internationally; and

(3) That it is doubtful if budgetary reductions in the manned lunar program would in fact reduce criticism of the total magnitude of the budget or increase support for other meritorious programs to which the funds might be applied.

b. Decide now to abandon current work directly related to the manned lunar landing objective but to continue development of the large launch vehicle (Saturn V) so that it will be available for future space programs. It is estimated that cancellation in January 1964 of Apollo and other programs supporting the manned lunar landing only would result in NOA and expenditure savings in FY 1965 of about $1 billion, less amounts required for any new objectives that might be substituted. The arguments supporting this alternative could include:

(1) The overriding need for economy in the 1965 budget;

(2) The doubts that Congress will provide adequate support for the manned lunar landing program in 1965 and succeeding years, regardless of the administration's recommendations; and

(3) The apparent absence of a competitive USSR manned lunar landing program at this time.

c. Decide now to abandon both current work toward the manned lunar landing objective and the development of the Saturn V large launch vehicle. If the programs involved are cancelled or adjusted in January 1964, savings approaching $2.5 billion in 1965 NOA and expenditures could be anticipated. The arguments supporting this alternative could include, [6] in addition to those for alternative "b" above:

(1) That proceeding with development of the Saturn V launch vehicle is not justified in the absence of approved goals requiring its use; and

(2) That an adequate continuing space program can be built around the use of the Saturn IB (and perhaps the Titan III) launch vehicle.

Recommendations

(Recommendation of Director, Bureau of the Budget, and concurrences or differing recommendations of Secretary of Defense; Administrator, NASA; Director, OST; and Executive Secretary, NASC, to be inserted after discussions)

* * * * * * * * *

2. Does the present-program represent the minimum necessary for achieving the MLL goal?

Discussion: The review has pointed to the conclusions:

a. That the elements comprising the present program (with Saturn I manned flights eliminated) are required for achieving the goal (recognizing the somewhat indirect contribution of the Gemini program), except for certain construction and other relatively minor items in which adjustments are under consideration in the regular budget review; and

b. That the current NASA 1964 and 1965 estimates represent the minimum funding level required to continue the program on the schedule now planned, except for the possible adjustments being considered in the regular budget review.

[7]

Alternatives

a. Approve the program and cost estimates as submitted by NASA, subject to separate resolution of the adjustments under consideration in the budget review. (The question of a 1964 supplemental estimate is considered in Item 3 below.)

b. Decide now that the program should be geared to a schedule slipping the first manned lunar landing attempts one or two years later than now planned to the very end of the decade (i.e., end of CY 1969 or 1970, depending on the definition of "decade"). This alternative might permit reductions in the range of $100 to 200 million in the 1965 budget. Other things being equal, the total cost of the MLLP to the achievement of the first manned lunar landing would probably be greater by at least $200 million because of the need to maintain the same engineering and other overhead costs over a longer period. However, this would probably not mean a corresponding increase in total annual budgets over what they would be under the present schedule, since expected successor programs would then consume the funds that would otherwise go for completing the stretched out MLLP.

In support of this alternative it could be argued that it would recognize the need for minimizing outlays in the 1965 budget without necessitating a decision at this time to abandon the goal of attempting to achieve manned lunar landing in this decade.

Opposing it, the point can be made that some degree of slippage in present schedules is recognized to be inevitable, so that eliminating the present margin between the current scheduled first manned lunar landing [8] attempts (late CY 1968) and the end of the decade would be tantamount to and generally recognized as an admission that achievement of the goal has been deferred beyond the end of the decade.

Recommendations

(Recommendation of Director, Bureau of the Budget, and concurrences or differing recommendations of Secretary of Defense; Administrator, NASA; Director, OST; and Executive Secretary, NASC, to be inserted after discussions)

* * * * * * * * *

3. Should a 1964 supplemental estimate be submitted to Congress in January for restoration in part or in full of the $250 million congressional reductions below the total legislative authorizations for NASA in 1964?

Alternatives

a. Decide to submit a 1964 supplemental in the amount required to keep the MLLP on the current schedules. Arguments that can be made for this course include:

(1) That restoration of 1964 funds is necessary to avoid forced slippage in the program; and

(2) That submission of a supplemental estimate would once again place the question of maintaining the pace in the MLLP squarely before Congress.

b. Decide not to submit a 1964 supplemental estimate to Congress, and accept as the will of Congress whatever slippage in the MLLP is caused by insufficient funds in 1964. Arguments for this course include:

(1) It would avoid placing the administration in the untenable [9] budgetary posture of seeking restoration of the NASA reduction so soon after congressional action without making similar requests for other important programs reduced by Congress;

(2) There is no reason to believe that the Congress will look with more favor on a supplemental estimate than it did on the regular 1964 request;

(3) The outcome of a supplemental request is likely to be uncertain for several months, and the uncertainty will create operating difficulties which will tend to offset the advantages even if the supplemental is ultimately approved; and

(4) Congress has taken the responsibility for slippage in the MLL-program because of insufficient funds in 1964.

c. Decide not to submit a 1964 supplemental estimate but to seek to make up in the 1965 budget the amounts required to adhere to the current MLLP schedules insofar as practicable. The arguments for this alternative are:

(1) It avoids the problems of a 1964 supplemental estimate referred to above [Items (1), (2), and (3) under "b" above];

(2) It offers a possibility of minimizing the impact of congressional 1964 reductions on the MLLP through adjustments in the timing of obligations between 1964 and 1965; and

(3) It may be feasible without increasing previously expected 1965 budget totals for NASA because of possible offsetting 1965 reductions that have been identified in the regular budget review, as follows:
[9]

		(NOA in millions)		
NASA estimates:		MLLP	All Other	Total NASA
	1964	4,129.7	1,220.3	5,350.0
	1965	4,197.5	1,377.5	5,575.0
	Total	8,327.2	21,597.8	10,925.0

Adjustments:

Possible 1965 adjustments in			
Budget review	–88.4*	–313.8*	–402.2*
Congressional 1964 reductions	–190.0*	–60.0*	–250.0
Restoration in 1965 for MLLP	+190.0*	-	+190.0*

Revised totals:

1964	3,939.7*	1,160.3*	5,100.0
1965	4,299.1*	1,063.7*	5,362.8*
Total	8,238.8*	2,224.0*	10,462.8*

*Tentative numbers; subject to change in final budget recommendations.

Recommendations

(Recommendation of Director, Bureau of the Budget, and concurrences or differing recommendations of Secretary of Defense; Administrator, NASA; Director, OST; and Executive Secretary, NASC, to be inserted after discussions)

* * * * * * * * *

4. Should our posture on the manned lunar landing program attribute a greater degree of military significance to the program?

Discussion: The review points to the conclusions that:

a. The facts of the situation justify the position that the launch vehicle, spacecraft, facilities, and general technology being developed by NASA in the MLLP do have important potential future military significance;

[11] b. That overplaying this point unduly could have the effects of undercutting the general peaceful image of the program, jeopardizing possibilities for international cooperation, or calling into question the need for a large-scale NASA non-military space program; and

c. That the question of public posture on potential military significance is separable from, but must be considered in relation to the questions of the composition of the NASA and Defense programs and of possible transfers of projects from NASA to Defense or vice versa.

Alternatives

a. Decide (1) to place greater stress on the potential military significance of the capabilities being developed in the MLLP in domestic public statements, exercising due restraint to avoid undesirable international effects; (2) to emphasize that NASA programs are being relied on by Defense for general technological capabilities and developments; and (3) to point to Defense use of Gemini (on whatever basis is decided separately below) as a tangible example of how NASA technological advances contribute to potential Defense needs. The principal advantage of this alternative is that if properly handled it would permit greater use of potential military applications in securing and maintaining congressional and public support for the administration's manned lunar landing program without creating demands for an unwarranted expansion in military space programs in addition to or in lieu of the approved NASA programs.

b. Decide (1) to play down the potential military significance of the capabilities being developed in the MLLP; (2) to emphasize that all clearly established military requirements are being met by Department of [12] Defense programs coordinated with NASA and drawing on NASA's experience; and (3) to point to the DOD use of Gemini (on whatever basis is decided separately below) as indicating that prompt attention is being given to the exploitation of possible military uses of space. The advantage of this alternative is that it would avoid possible international complications and unwarranted demands for a larger military space program that might result from too much stress on the potential military significance of the MLLP,

Recommendations

(Recommendation of Director, Bureau of the Budget, and concurrences or differing recommendations of Secretary of Defense; Administrator, NASA; Director, OST; and Executive Secretary, NASC, to be inserted after discussions)

* * * * * * * * * * * * * * * * *

5. What should be the posture with respect to a joint effort with the USSR?

Discussion: The review points to the conclusion that in the present situation we must necessarily take the posture that we are prepared to enter into any constructive arrangement which will not jeopardize vital national security interests and which will not delay or jeopardize the success of our MLL program. We will necessarily have to wait to see what proposals, if any, the USSR may make, and then expect an extended series of negotiations.

Recommendation: That the posture be as indicated above.

(remainder of document not provided)

Document II-43

Document Title: "Oral History Interview w/Theodore Sorensen," 26 March 1964.

Source: John F. Kennedy Presidential Library, Boston, Massachusetts.

A few month after President John F. Kennedy's assassination, his top advisor, Theodore Sorenson, was interviewed by Carl Kaysen, another Kennedy associate who had worked for the National Security Council during the Kennedy presidency. Sorenson provides a fascinating insider's view of the space issues facing President Kennedy.

Oral History Interview

with

THEODORE C. SORENSEN

March 26, 1964

By Carl Kaysen

For the John F. Kennedy Library

KAYSEN: Ted, I want to begin by asking you about something on which the President expressed himself very strongly in the campaign and early in his Administration, and that is space. What significance, in your mind, did the President attach to the space race in terms of, one, competition with the Soviet Union and, two, the task which the United States ought to do whether or not the element of competition with the Soviet Union was important in it?

SORENSEN: It seems to me that he thought of space primarily in symbolic terms. By that I mean he had comparatively little interest in the substantive gains to made from this kind of scientific inquiry. He did not care as much about new breakthroughs in space medicine or planetary exploration as he did new breakthroughs in rocket thrust or humans in orbit. Our lagging space effort was symbolic, he thought, of everything of which he complained in the [Dwight D.] Eisenhower Administration: the lack of effort, the lack of initiative, the lack of imagination, vitality, and vision; and the more the Russians gained in space during the last few years in the fifties, the more he thought it showed up the Eisenhower Administration's lag in this area and damaged the prestige of the United States abroad.

[2] KAYSEN: So that your emphasis was on general competitiveness but not specific competitiveness with the Soviet Union in a military sense. The President never thought that the question of who was first in space was a big security issue in any direct sense.

SORENSEN: That's correct.

KAYSEN: Now the first big speech and the first big action on space was taken in a special message on extraordinary needs to the Congress in May. What accounted for this delay? What was the President doing in the period between his inauguration and May? He didn't really say much about space in the State of the Union message. He mentioned the competition with the Soviet Union in his State of the Union message, but he didn't really say much or present any programs. What was going on in this period between the inauguration and the inclusion of space in a message which was devoted to extraordinary, urgent was the word, urgent national need?

SORENSEN: There was actually a considerable step-up in our space effort in the first space supplementary budget which he sent to the Congress. You can check that against the actual records, but my recollection is that it emphasized more funds for the Saturn booster. Then came the first Soviet to orbit the earth – [Yuri] Gargarin, I believe that was – and the President felt, justifiably so, that the Soviets had scored a tremendous propaganda victory, that it affected not only our prestige around the world, but affected our security as well in the sense that it demonstrated a Soviet rocket thrust which convinced many people that the Soviet Union was ahead of the United States militarily. First we had a very brief inquiry – largely because the President was being interviewed by Hugh Sidey of Time magazine and wanted to be prepared to say where we stood, what we were going to do, what we were unable to do, how much it would cost and so on–in which he asked me and [Jerome B.] Wiesner and others to look into our effort in some detail.

I do not remember the exact time sequence, but I believe it was shortly after that he asked the Vice President, as the chairman of the Space Council, to examine and to come up with the answers to four or five questions of a similar nature: What were we doing that was not enough? what could we be doing more? [3] where should we be trying to compete and get ahead? what would we have to do to get ahead? and so on. That inquiry led to a joint study by the Space Administration and the Department of Defense. Inasmuch as that study was going on simultaneously with the studies and reviews we were making of the defense budget, military assistance, and civil defense, and inasmuch as space, like these other items, obviously did have some bearing upon our status in the world, it was decided to combine the results of all those studies with the President's recommendations in the special message to Congress.

KAYSEN: Was the moon goal chosen as the goal for the space program because it was spectacular, because it was the first well-defined thing which the experts thought we could sensibly say we ought to pick as a goal we could be first in, because it was far enough away so that we could have a good chance of being first? What reason did we have for defining this as the goal of the space program and making it the center of the space element of the message?

SORENSEN: The scientists listed for us what they considered to be the next series of steps to be taken in the exploration of space which any major country would take, either the Soviet Union or the United States. They included manned orbit, two men in orbit, laboratory in orbit, a shot around the moon, a landing of instruments on the moon, etc. In that list, then, came the sending of a man, or a team of men, to the moon and bringing them back safely. After that was exploration of the planets and so forth.

Looking at that list, the scientists were convinced–on the basis of what they assumed to be the Russian lead at that time – that with respect to all of the items on the list between where we were then, in early 1961, and the landing of a man on the moon, sometime in the late 1960's or early 1970's, there was no possibility of our catching up with the Russians. There was a possibility, if we put enough effort into it, of being the first to send a team to the moon and bringing it back. And it was decided to focus our space effort on that objective.

KAYSEN: Now, as early as the inaugural message, the President talked about making space an area of cooperation instead of conflict. He repeated this notion [4] in his speech to the U. N. September '61, although with a rather narrow set of specifics on weather and communications satellites and things like that. At various times in the course of '61 and '62, I think the record suggests that there was a division of emphasis between the competitive element with the Soviet Union and the notion of offering to cooperate in space in the President's 1963 speech to the U.N., he made a specific suggestion that we cooperate in going to the moon. Do you think this represented a change in emphasis, do you think it represented a change in the assessment of our relations with the Soviets, or do you think it represented a change in the assessment of the feasibility and desirability of trying to meet the goal set of getting to the moon in 1970 and being the first on the moon?

SORENSEN: I don't believe it represented the latter. It may have had an element of the first two in it. I think the President had three objectives in space. One was to assure its demilitarization. The second was to prevent the field from being occupied by the Russians to the exclusion of the United States. And the third was to make certain that American scientific prestige and American scientific effort were at the top. Those three goals all would have been assured in a space effort which culminated in our beating the Russians to the moon. All three of them would have been endangered had the Russians continued to outpace us in their space effort and beat us to the moon. But I believe all three of those goals would also have been assured by a joint Soviet-American venture to the moon.

The difficulty was that in 1961, although the President favored joint effort, we had comparatively few chips to offer. Obviously the Russians were well ahead of us at that time in space exploration, at least in terms of the bigger, more dramatic efforts of which the moon shot would be the culmination. But by 1963, our effort had accelerated considerably. There was a very real chance that we were even with the Soviets in this effort. In addition, our relations with the Soviets, following the Cuban missile crisis and the test ban treaty, were much improved – so the President felt that, without diminishing our own space that effort, and without harming any of those three goals, we now were in a position to ask the Soviets to join with us and make it more efficient and economical for both countries.

[5]
KAYSEN: In this last element, was the President persuaded, as some people argued, that the Soviets weren't really in the race; that, for example, we were developing the Saturn, our intelligence suggested to us that the Soviets had no development of comparable thrust and character; and that, in a sense, we were

racing with ourselves, and we'd won, because once we'd make the commitment to develop the Saturn and it looked as if this was feasible, although maybe the schedule wasn't clear, that we could do it and the Soviets really didn't have anything that could match that; and that, therefore, the psychological moment had come to sort of make it clear to them that we knew it?

SORENSEN: I don't know if that was in his mind. I did not know that.

KAYSEN: Now, this is a speculative question, but do you think once an offer of cooperation that was more than trivial, that went beyond the kind of things we had agreed, about exchange of weather information or other rather minor and technical points about recovery of parts and all that kind of thing, that once any offer of cooperation of that sort was made and accepted and some cooperation actually started to take place, do you think space would have become politically uninteresting?

SORENSEN: Politically, in domestic politics?

KAYSEN: Yes.

SORENSEN: It probably would have been less interesting, that's right.

KAYSEN: I'm assuming, and I take it you're assuming, that in the initial exchanges there'd be static and the right wing of the Republicans would shout and so on, but I'm assuming we'd get past all that and some actually useful cooperation would result?

[6]

SORENSEN: I think it would be less interesting. Even though the President would stress from time to time that the idea of a race or competition was not our sole motivation, there was no doubt that that's what made it more interesting to the Congress and to the general public.

KAYSEN: Was there any indication that you are aware of that in '63, that in the process of assembling the budget for '63, at the time of the first review, midyear review – that is, I'm talking about the '65 budget, of course, which took place in '63–just the size of this program and its rate of growth were beginning to worry the President, and that he was more eager to stress the cooperative issue because he was dubious about either the wisdom or the possibility of maintaining the kind of rate of increase in this program that NASA [National Aeronautics and Space Administration] talked about?

SORENSEN: I think he was understandably reluctant to continue that rate of increase. He wished to find ways to spend less money on the program and to cut out the fat which he was convinced was in the budget. How much that motivated his offer to the Russians, though, I don't know.

KAYSEN: What would you assign it to? You'd say that the political interest in trying to find positive things we could do together was much more important than any budgetary concern about the space program or any feeling that this was not the most important effort that ought to be maintained.

SORENSEN: Right.

KAYSEN: Let me ask a couple more, rather narrower questions. What led the President to pick [James E.] Jim Webb as administrator of NASA? What kind of a man was the President looking for, and two years later did he think he'd gotten the kind of man he was looking for in this rather difficult area?

SORENSEN: My recollection here is not very good, and I'm sure my participation in that decision was remote. I believe that Webb was highly recommended, not only [7] by the Vice President and, I would assume, by Senator [Robert S.] Kerr and others who knew him well, but also by [David E.] Dave Bell and Elmer Staats who had known him when he'd been in the government previously. I also have a dim recollection that the President had tried to get others to take the job although I do not now remember any names, whom he tried or why they turned it down.

The President never expressed any specific dissatisfaction with Webb as space administrator. I think Webb was not what we would call a Kennedy type individual. He was inclined to talk at great length, and the President preferred those who were more concise in their remarks. He was inclined to be rather vague, somewhat disorganized in-his approach to a problem, and the President preferred those who were more precise. From time to time, the President would check with him on progress he was making –whether the President's own commitments would be upheld. The President was willing to see a large chunk of the space program developed within the Department of Defense, undoubtedly because he had more confidence in [Robert S.] McNamara's managerial ability than he did in Webb's. But even taking all of these qualifications, I don't know that the President ever regretted his appointment of Webb, or wished that he had named someone else.

[rest of discussion omitted, not related to space]

Document II-44

Document Title: Letter to J. Leland Atwood, President, North American Aviation, Inc. from Major General Samuel C. Phillips, USAF, Apollo Program Director, with attached "NASA Review Team Report," 19 December 1965.

Source: Folder 18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

In late 1965, at the request of NASA Associate Administrator for Manned Space Flight George Mueller, Major General Samuel Phillips, Apollo Program Director at NASA Headquarters, initiated a review of the work of North American Aviation, Inc. (referred to in this document as NAA) to determine why the company was behind schedule and over budget on both the Apollo Command and Service Module and the second (S-II) stage of the Saturn V launch vehicle. This highly critical review was transmitted to North American's president Lee Atwood on 19 December. The review took on added significance in the aftermath of the *fatal Apollo 204 fire on 27 January 1967 when it was discovered that NASA Administrator James E. Webb was apparently unaware of its existence.*

IN REPLY REFER TO: MA December 19, 1965

Mr. J. L. Atwood
President
North American Aviation, Inc.
1700 E. Imperial Highway
El Segundo, California

Dear Lee:

I believe that I and the team that worked with me were able to examine the Apollo Spacecraft and S-II stage programs at your Space and Information Systems Division in sufficient detail during our recent visits to formulate a reasonably accurate assessment of the current situation concerning these two programs.

I am definitely not satisfied with the progress and outlook of either program and am convinced that the right actions now can result in substantial improvement of position in both programs in the relatively near future.

Enclosed are ten copies of the notes which was [*sic*] compiled on the basis of our visits. They include details not discussed in our briefing and are provided for your consideration and use.

The conclusions expressed in our briefing and notes are critical. Even with due consideration of hopeful signs, I could not find a substantial basis for confidence in future performance. I believe that a task group drawn from NAA at large could rather quickly verify the substance of our conclusions, and might be useful to you in setting the course for improvements.

[2] The gravity of the situation compels me to ask that you let me know, by the end of January if possible, the actions you propose to take. If I can assist in any way, please let me know.

Sincerely,

SAMUEL C. PHILLIPS
Major General, USAF
Apollo Program Director

[Attachment p. 1]

NASA Review Team Report

I. Introduction

This is the report of the NASA's Management Review of North American Aviation Corporation management of Saturn II Stage (S-II) and Command and Service Module (CSM) programs. The Review was conducted as a result of the continual failure of NAA to achieve the progress required to support the objective of the Apollo Program.

The scope of the review included an examination of the Corporate organization and its relationship to and influence on the activities of S&ID [Space and Information Systems Division of North American Aviation], the operating Division charged with the execution of the S-II and CSM programs. The review also included examination of NAA offsite program activities at KSC and MTF [Mississippi Test Facility].

The members of the review team were specifically chosen for their experience with S&ID and their intimate knowledge of the S-II and CSM programs. The Review findings, therefore, are a culmination of the judgements [*sic*] of responsible government personnel directly involved with these programs. The team report represents an assessment of the contractor's performance and existing conditions affecting current and future progress, and recommends actions believed necessary to achieve an early return to the position supporting Apollo program objectives.

The Review was conducted from November 22 through December 6 and was organized into a Basic Team, responsible for over-all [3] assessment of the contractor's activities and the relationships among his organizational elements and functions; and sub-teams who [*sic*] assessed the contractor's activities in the following areas:

Program Planning and Control (including Logistics)
Contracting, Pricing, Subcontracting, Purchasing
Engineering
Manufacturing
Reliability and Quality Assurance.

Review Team membership is shown in Appendix 7. [not provided]

Team findings and recommendations were presented to NAA Corporate and S&ID management on December 19.

II. NAA's Performance to Date-Ability to Meet Commitments

At the start of the CSM and S-II Programs, key milestones were agreed upon, performance requirements established and cost plans developed. These were essentially commitments made by NAA to NASA. As the program progressed NASA has been forced to accept slippages in key milestone accomplishments, degradation in hardware performance, and increasing costs.

A. S-II

1. Schedules
As reflected in Appendix VI [not provided] key performance milestones in testing, as well as end item hardware deliveries, have slipped continuously in spite of deletions of both hardware and test content. The fact that the delivery [4] of

the common bulkhead test article was rescheduled 5 times, for a total slippage of more than a year, the All System firing rescheduled 5 times for a total slippage of more than a year, and S-II-1 and S-II-2 flight stage deliveries rescheduled several times for a total slippage of more than a year, are indicative of NAA's inability to stay within planned schedules. Although the total Apollo program was reoriented during this time, the S-II flight stages have remained behind schedules even after this reorientation.

2. Costs
The S-II cost picture, as indicated in Appendix VI, [not provided] has been essentially a series of costs escalations with a bow wave of peak costs advancing steadily throughout the program life. Each annual projection has shown either the current or succeeding year to be the peak. NAA's estimate of the total 10 stage program has more than tripled. These increases have occurred despite the fact that there have been reductions in hardware.

3. Technical Performance
The S-II stage is still plagued with technical difficulties as illustrated in Appendix VI. [not provided] Welding difficulties, insulation bonding, continued redesign as a result of component failures during qualification are indicative of insufficiently aggressive pursuit of technical resolutions during the earlier phases of the program.

[5] B. CSM

1. Schedules
A history of slippages in meeting key CSM milestones is contained in Appendix VT. [not provided] The propulsion spacecraft, the systems integration spacecraft, and the spacecraft for the first development flight have each slipped more than six months. In addition, the first manned and the key environmental ground spacecraft have each slipped more than a year. These slippages have occurred in spite of the fact that schedule requirements have been revised a number of times, and seven articles, originally required for delivery by the end of 1965, have been eliminated. Activation of two major checkout stations was completed more than a year late in one case and more than six months late in the other. The start of major testing in the ground test program has slipped from three to nine months in less than two years.

2. Costs
Analysis of spacecraft forecasted costs as reflected in Appendix VI [not provided] reveals NAA has not been able to forecast costs with any reasonable degree of accuracy. The peak of the program cost has slipped 18 months in two years. In addition, NAA is forecasting that the total cost of the reduced spacecraft program will be greater than the cost of the previous planned program.

[6] 3. Technical Performance
Inadequate procedures and controls in bonding and welding, as well as inadequate master tooling, have delayed fabrication of airframes. In addition, there are still major development problems to be resolved. SPS engine life, RCS performance, stress corrosion, and failure of oxidizer tanks has resulted in degradation of the Block I spacecraft as well as forced postponement of the resolution of the Block II spacecraft configuration.

III. NASA Assessment-Probability of NAA Meeting Future Commitments

A. S-II

Today, after 4 1/2 years and a little more than a year before first flight, there are still significant technical problems and unknowns affecting the stage. Manufacture is at least 5 months behind schedule. NAA's continued inability to meet internal objectives, as evidenced by 5 changes in the manufacturing plan in the last 3 months, clearly indicates that extraordinary effort will be required if the contractor is to hold the current position, let alone better it. The MTF activation program is being seriously affected by the insulation repairs and other work required on All Systems stage. The contractor's most recent schedule reveals further slippage in completion of insulation repair. Further, integration of manual GSE has recently slipped 3 weeks as a result of configuration discrepancies discovered during engineering checkout of the system. Failures in timely [7] and complete engineering support, poor workmanship, and other conditions have also contributed to the current S-II situation. Factors which have caused these problems still exist. The two recent funding requirements exercises, with their widely different results, coupled with NAA's demonstrated history of unreliable forecasting, as shown in Appendix VI, [not provided] leave little basis for confidence in the contractor's ability to accomplish the required work within the funds estimated. The team did not find significant indications of actions underway to build confidence that future progress will be better than past performance.

B. CSM

With the first unmanned flight spacecraft finally delivered to KSC, there are still significant problems remaining for Block I and Block II CSM's. Technical problems with electrical power capacity, service propulsion, structural integrity, weight growth, etc. have yet to be resolved. Test stand activation and undersupport of GSE still retard schedule progress. Delayed and compromised ground and qualification test programs give us serious concern that fully qualified flight vehicles will not be available to support the lunar landing program. NAA's inability to meet spacecraft contract use deliveries has caused rescheduling of the total Apollo program. Appendix VI [not provided] indicates the contractor's schedule trends which cause NASA to have little confidence that the S&ID will meet its future spacecraft commitments. While our management review indicated that some progress is [8] being made to improve the CSM outlook, there is little confidence that NAA will meet its schedule and performance commitments within the funds available for this portion of the Apollo program.

[9] **IV. Summary Findings**

Presented below is a summary of the team's views on those program conditions and fundamental management deficiencies that are impeding program progress and that require resolution by NAA to ensure that the CSM and S-II Programs regain the required program position. The detail findings and recommendations of the individual sub-team reviews are Appendix to this report.

A. NAA performance on both programs is characterized by continued failure to meet committed schedule dates with required technical performance and within costs. There is no evidence of current improvement in NAA's management of these programs of the magnitude required to give confidence that NAA performance will improve at the rate required to meet established Apollo program objectives.

B. Corporate interest in, and attention to, S&ID performance against the customer's stated requirements on these programs is consider[ed] passive. With the exception of the recent General Office survey of selected functional areas of S&ID, the main area of Corporate level interest appears to be in S&ID's financial outlook and in their cost estimating and proposal efforts. While we consider it appropriate that the responsibility and authority for execution of NASA programs be vested in the operating Division, this does not relieve the Corporation of its responsibility, and accountability to NASA for results. [10] We do not suggest that another level of program management be established in the Corporate staff, but we do recommend that the Corporate Office sincerely concern itself with how well S&ID is performing to customer requirements and ensure that responsible and effective actions are taken to meet commitments.

C. Organization and Manning
We consider the program organization structure and assignment of competent people within the organization a prerogative of the manager and his team that have been given the program job to do. However, in view of what we consider to be an extremely critical situation at S&ID, one expected result of the NASA review might be the direction of certain reorganizations and reassignments considered appropriate, by NASA, to improve the situation. While we do have some suggestions for NAA consideration on this subject, they are to be accepted as such and not considered directive in nature. We emphasize that we clearly expect NAA/S&ID to take responsible and thoroughly considered actions on the

organization and assignment of people required to accomplish the S-II and CSM Programs. We expect full consideration, in this judgement [*sic*] by NAA, of both near and long term benefits of changes that are made.

Frankly stated-we firmly believe that S&ID is overmaned [*sic*] and that the S-II and CSM Programs can be done, and done better, with fewer people. This is not to suggest that an arbitrary [11] percentage reduction should be applied to each element of S&ID, but we do suggest the need for adjustments, based on a reassessment and clear definition of organizational responsibilities and task assignments.

It is our view that the total Engineering, Manufacturing, Quality, and Program Control functions are too diversely spread and in too many layers throughout the S&ID organization to contribute, in an integrated and effective manner, to the hard core requirements of the programs. The present proliferation of the functions invites non-contributing, "make-work" use of manpower and dollars as well as impediments to program progress.

We question the true strength and authority of each Program Manager and his real ability to be fully accountable for results when he directly controls less that 50% of the manpower effort that goes into his program. This suggests the need for an objective reappraisal of the people and functions assigned to Central versus Program organizations. This should be done with full recognition that the Central organization's primary reason for existence is to support the requirements of the Program Managers. Concurrently, the Program Manager should undertake a thorough and objective "audit" of all current and planned tasks, as well as evaluate the people assigned to these tasks, in order to bring the total effort down to that which truly contributes to the program.

[12] It is our opinion that the assignment of the Florida Facility to the Test and Quality Assurance organization creates an anomaly since the Florida activities clearly relate to direct program responsibilities. We recognize that the existence of both CSM and S-II activities at KSC may require the establishment of a single unit for administrative purposes. However, it is our view that the management of this unit is an executive function, rather than one connected with a functional responsibility. We suggest NAA consider a "mirror image" organizational relationship between S&ID and the Florida operation, with the top man at Florida reporting to the S&ID President and the two program organizations reporting to the S&ID Program Managers.

D. Program Planning and Control

Effective planning and control from a program standpoint does not exist. Each organization defines its own job, its own schedules, and its own budget, all of which may not be compatible or developed in a manner required to achieve program objectives. The Program Managers do not define, monitor, or control the interfaces between the various organizations supporting their program.

Organization-S&ID's planning and control functions are fragmented; responsibility and authority are not clearly defined.

[13] Work Task Management-General Orders, task authorizations, product plans, etc., are broad and almost meaningless from a standpoint of defining end products. Detailed definitions of work tasks are available at the "doing level"; however, these "work plans" are not reviewed, approved, or controlled by the Program Managers.

Schedules-Each organization supporting the programs develops its own detailed schedules; they are not effectively integrated within an organization, nor are they necessarily compatible with program master schedule requirements.

Budgeting System-Without control over work scope and schedules, the budget control system cannot be effective. In general, it is an allocation system assigning program resources by organizations.

Management Reports-There is no effective reporting system to management that evaluates performance against plans. Plans are changed to reflect performance. Trends and performance indices reporting is almost nonexistent.

E. Logistics

The CSM and S-II Site Activations and Logistic organizations are adequately staffed to carry out the Logistics support. The problems in the Logistics area are in arriving at a mutual agreement, between NAA and NASA, clearly defining the tasks required to support the programs. The areas requiring actions are as follows:

[14]
1. Logistics Plan
2. Maintenance Manuals
3. Maintenance Analysis
4. NAA/KSC Relationship
5. Common and Bulk Item Requisitioning at KSC
6. Review of Spare Parts, Tooling, and Test Equipment Status

F. Engineering

The most pronounced deficiencies observed in S&ID Engineering are:

1. Fragmentation of the Engineering function throughout the S&ID organization, with the result that it is difficult to identify and place accountability for program-required Engineering outputs.

2. Inadequate systems engineering job is being done from interpretation of NASA stated technical requirements through design release.

3. Adequate visibility on intermediate progress on planned engineering releases is lacking. Late, incomplete, and incorrect engineering releases have caused significant hardware delivery schedule slippages as well as unnecessary program costs.

[15]
4. The principles and procedures for configuration management, as agreed to between NAA and NASA, are not being adhered to by the engineering organizations.

G. Cost Estimating

The "grass roots" estimating technique used at S&ID is a logical step in the process of arriving at program cost estimates and developing operating budgets. However, there are several aspects of the total process that are of concern to NASA:

1. The first relates to the inadequate directing, planning, scheduling, and controlling of program work tasks throughout S&ID. While the grass roots estimates may, in fact, represent valid estimates (subject to scrubbing of "cushion") of individual tasks by working level people, we believe that the present deficiencies in Planning and Control permit, and may encourage, the inclusion in these estimates of work tasks and level of efforts that are truly not required for the program.
2. The second concern is that the final consolidation of grass roots estimates, developed up through the S&ID organization in parallel through both Central functional and Program organizations, does not receive the required [16] management judgements [*sic*], at successive levels for (a) the real program need for the tasks included in the estimate, or (b) adequate scrubbing and validation of the man-hours and dollars estimates.
3. The third concern, which results from I and 2 above, is that the final estimate does not represent, either in tasks to be done or in resources required, the legitimate program requirements as judged by the Program Manager, but represents total work and dollars required to support a level of effort within S&ID.

Several recommendations are made in the appended reports for correcting deficiencies in the estimating process. The basic issue, however, is that an S&ID Management position must be clearly stated and disciplines established to ensure that the end product of the estimating process be only those resources required to do necessary program tasks. In addition, the Program Management must be in an authoritative position that allows him to accept, reject, and negotiate these resource requirements.

H. Manufacturing Work Force Efficiency

There are several indications of less than effective utilization of the manufacturing labor force. Poor workmanship is evidenced by the continual high rates of rejection and MRB actions which result in rework that would not be necessary if the workmanship [17] had been good. This raises a question as to the effectiveness of the PRIDE program which was designed to motivate personnel toward excellence of performance as a result of personal responsibility for the end product. As brought out elsewhere in this report, the ability of Manufacturing to plan and execute its tasks has been severely limited due to continual changing engineering information and lack of visibility as to the expected availability of the engineering information. Recognizing that overtime shifts are necessary at this time, it is our view that strong and knowledgeable supervision of these overtime shifts is necessary, and that a practical system of measuring work accomplished versus work planned must be implemented and used to gauge and to improve the effectiveness of the labor force. The condition of hardware shipped from the factory, with thousands of hours of work to complete, is unsatisfactory to NASA. S&ID must complete all hardware at the factory and further implement, without delay, an accurate system to certify configuration of delivered hardware, properly related to the DD 250.

I. Quality
NAA quality is not up to NASA required standards. This is evidence[d] by the large number of "correction" E.O.'s and manufacturing discrepancies. This deficiency is further compounded [17] by the large number of discrepancies that escape NAA inspectors but are detected by NASA inspectors. NAA must take immediate and effective action to improve the quality of workmanship and to tighten their own inspection. Performance goals for demonstrating high quality must be established, and trend data must be maintained and given serious attention by Management to correct this unsatisfactory condition.

J. Following are additional observations and findings that have resulted from discussions during the Review. Most of them are covered in most detail in the appended sub-team reports. They are considered significant to the objective of improving NAA management of our programs and are therefore highlighted in this section of the report:

1. S&ID must assume more responsibility and initiative for carrying out these programs, and not expect step-by-step direction from NASA.
2. S&ID must establish work package management techniques that effectively define, integrate, and control program tasks, schedules, and resource requirements.
3. S&ID must give concurrent attention to both present and downstream tasks to halt the alarming trend of crisis operation and neglect of future tasks because of concentration on today's problems.
4. A quick response capability must be developed to work critical "program pacing" problems by a short-cut route, with follow-up to ensure meeting normal system requirements.

[19] 5. S&ID must maintain a current list of open issues and unresolved problems, with clear responsibility assigned for resolving these and insuring proper attention by Program and Division Management.
6. Effort needs to be applied to simplify management systems and end products. There must be greater emphasis on making today's procedures work to solve today's problems, and less on future, more sophisticated systems. The implementation and adherence to prescribed systems should be audited.
7. NAA must define standards of performance for maintaining contracts current then establish internal disciplines to meet these standards. Present undefinitized subcontracts and outstanding change orders on the S-II prime contract must be definitized without delay.

CONCLUSIONS AND RECOMMENDATIONS

The NASA Team views on existing deficiencies in the contractor's management of the S-II and CSM Programs are highlighted in this section of the report and are treated in more detail in the appended sub-team reports. The findings are expressed frankly and result from the team's work in attempting to relate the end results we see in program conditions to fundamental causes for these conditions.

[20] In most instances, recommendations for improvement accompany the findings. In some cases, problems are expressed for which the team has no specific recommendations, other than the need for attention and resolution by NAA.

It is not NASA's intent to dictate solutions to the deficiencies noted in this report. The solution to NAA's internal problems is both a prerogative and a responsibility of NAA Management, within the parameters of NASA's requirements as stated in the contracts. NASA does, however, fully expect objective, responsible, and timely action by NAA to correct the conditions described in this report.

It is recommended that the CSM incentive contract conversion proceed as now planned.

Incentivization of the S-II Program should be delayed until NASA is assured that the S-11 Program is under control and a responsible proposal is received from the contractor.

Decision on a follow-on incentive contract for the CSM, beyond the present contract period, will be based on contractor performance.

It is recommended that NAA respond to NASA, by the end of January 1966, on the actions taken and planned to be taken to correct the conditions described in this report. At that time, NAA is also to certify the tasks, schedules, and resource requirements for the S-II and CSM Programs.

[21] It is further recommended that the same NASA Review Team revisit NAA during March 1966 to review NAA performance in the critical areas described in this report.

Document II-45

Document Title: Memorandum to Assistant Administrator, Office of Planning, from William E. Lilly, Director, MSF Program Control, "Saturn Apollo Applications Summary Description," 3 June 1966.

Source: Folder 18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

Beginning in 1964, NASA began planning for missions to follow a lunar landing using the systems developed for Apollo. This program started out with a great deal of ambition, as this document suggests, but neither President Lyndon B. Johnson nor President Richard M. Nixon was willing to provide the funding needed to implement NASA's ideas. The program was formally named the Apollo Applications Program in 1968. Ultimately, only one Apollo Applications mission was flown, the interim space station known as Skylab.

Willis Shapley was a policy advisor to NASA Administrator James Webb; PSAC was the acronym for the President's Science Advisory Committee; OSSA, for NASA's Office of Space Science and Applications; and OART, NASA's Office of Advanced Research and Technology.

UNITED STATES GOVERNMENT
MEMORANDUM

Dir., Office of
Program Review

DATE: Jun 3, 1966

TO : P/Assistant Administrator
Office of Programming

From : MP/Director, MSF Program Control

Subject: Saturn Apollo Applications Summary Description

Attached per Mr. Shapley's request of May 31 is a summary description for PSAC of current Saturn Apollo Applications planning as reflected in the May 1966 NASA submission to the Bureau of the Budget. This paper has been coordinated with and included inputs from OSSA (Mr. Foster) and OART (Mr. Novik).

/Signed/

William E. Lilly

Attachment:

Saturn Apollo Applications
Summary Description (CONFIDENTIAL) [DECLASSIFIED]
3 copies

[2]

June 9, 1966

SATURN APOLLO APPLICATIONS PROGRAM

SUMMARY DESCRIPTION

SCOPE

This document summarizes the assumptions, objectives, program content, hardware availability and flight schedules for the proposed Saturn Apollo Applications program, as currently planned and as reflected in the May 1966 NASA submission to the Bureau of the Budget. The plans described in this document are under active consideration within NASA but have not been approved at this time and are subject to further review and change.

PROGRAM ASSUMPTIONS

1. Prior to 1970, the Gemini and Apollo programs, building on results of Mercury and Saturn I, will have provided:

a. The capability to explore space out to 250,000 miles from earth and to conduct manned operations and experiments on flights of up to two weeks duration.

b. The Saturn IB and Saturn V boosters, which will have injected 20 and 140 tons of payload per launch, respectively, into near-earth orbit. The Saturn V will have sent 48 tons to the vicinity of the moon.

c. The Apollo spacecraft, which will have sustained a three-man crew for two weeks in a two-compartment, modular, [3] maneuverable vehicle and will have landed two men on the moon and returned them, with samples of lunar material, to earth.

d. A U.S. manned space flight log of over 500 man days in space, during which data and experience will have been acquired from approximately 100 in-flight experiments in response to the needs of the scientific and technological communities. (To date, U.S. astronauts have logged approximately 75 man-days in space.)

2. The currently approved Apollo mission objectives can be accomplished with the currently funded flight vehicles.

a. If the approved Apollo objectives can be achieved with fewer flights, the remaining flight vehicles can be used for alternate missions during 1968-71. Follow-on missions requiring procurement of flight hardware beyond that now funded would continue the manned space flight effort, based on Apollo systems, beyond that time.

b. If all of the presently funded hardware is required for the basic Apollo lunar missions, the program content of the alternate missions can be appropriately phased into the follow-on period.

PROGRAM OBJECTIVES

The basic purposes of the Saturn Apollo Applications Program are to continue without hiatus an active and productive [4] post Apollo Program of manned space flight and to exploit for useful purposes and further develop the capabilities of the Saturn Apollo System. The major flight mission objectives of the proposed Saturn Apollo Applications flight program fall into two principal categories of essentially equal importance as follows:

A. Long Duration Flights

1. Man

2. Systems

B. Space flight experiments in the following areas:

1. Life Sciences (both biomedical and bioscience/technology)

2. Astronomy and space physics

3. Extended Lunar Exploration

4. Applications (including meteorology, communications, earth resources)

5. Technology (spent stage utilization, advanced EVA, propellant handling in space, orbital assembly and maintenance, etc.)

A careful review of future mission requirements in relation to long range objectives has shown that extended duration manned flight experience as early as possible is required to establish the basic capabilities required for any of the projected next generation of manned space flight goals (earth orbital space station, lunar station or manned planetary [5] exploration). Flights of up to a year's duration would be attained in Apollo Applications through the use of modified Apollo hardware with resupply. Such an adaptation of Apollo hardware might be used as a long duration Manned Orbital Research Facility.

The experiments in the areas listed above would be responsive to specific needs, as defined by the scientific and engineering communities and as reviewed and approved by the Office of Space Science and Applications in the case of scientific or applications experiments; by the Office of Advanced Research and Technology in the case of technology experiments, and by the Office of Manned Space Flight in the case of operations experiments and experiments on biomedical effects on man. All experiments proposed for flight on manned missions will be reviewed and approved by the joint NASA/DOD Manned Space Flight Experiments Board.

Experiment areas two and three above would support the National Astronomical Observatories objectives proposed in the 1965 Woods Hole Summer Study and extended lunar exploration as recommended at the 1965 Falmouth Summer Study.

PROGRAM CONTENT

Attachment 1 summarizes the Saturn Apollo Applications mission objectives and indicates the planned target dates for flights to meet these objectives. The black triangular symbols represent planned missions, each of which requires one or more Saturn Apollo launches. Most of the missions [6] are planned to accomplish more than one objective, as indicated by the vertical alignment of the mission symbols for the same launch date. The following paragraphs summarize current plans for each of the objectives listed on Attachment 1.

The long duration flight objectives are (1) to measure the effects on men and on manned systems of space flights of increasing duration, (2) to acquire operational experience with increasingly longer manned space flights, and (3) to accomplish this (a) through modifications and adaptations of existing systems without a major new launch vehicle or spacecraft development, and (b) in such a way that the equipment used as modified for this program can serve as important elements of the systems that would be required for one or more of the projected next generation of manned space flight goals.

During 1968-69, extended mission duration can be achieved by adding expendable supplies to each flight and by rendezvous resupply using a second spacecraft launched two to four weeks after the first launch. By this means, missions of up to 56 days duration are possible in 1968-69, each consisting of two flights employing the basic Apollo 14-day spacecraft. Beginning in 1970, up-rated Apollo spacecraft subsystems (primarily electrical fuel cells and cryogenic oxygen and hydrogen storage tanks) are planned to provide a 45-day capability for a single flight. (Attachment 2 describes the various extended Apollo spacecraft capabilities planned for the Saturn Apollo Applications missions.) During 1970, a [7] double-rendezvous mission involving three 45-day spacecraft is planned to achieve a total mission duration of approximately 135 days. In 1971, the objective is a one-year mission involving a Saturn V launch of a crew module derived from the Saturn S-IVB stage, with re-supply by up-rated Apollo spacecraft launched on Saturn IB's. The objectives for 1972-73 are missions of greater than one year's duration as precursors of later earth orbital space stations or manned planetary flights. Suitable biomedical instrumentation is planned to monitor the effects on the crews of these long duration flights.

The same series of flights that is planned for these long duration flight objectives will be used for important space flight experiments in a variety of fields. The present planning for the experiments is discussed below.

Life sciences experiments during 1968-69 will concentrate on the biomedical effects of long duration flight on men, as discussed above. A biomedical laboratory is planned for flight in 1970 in conjunction with the 135-day mission. This laboratory will consist of an Apollo spacecraft module equipped with biomedical and behavioral apparatus to test and record human responses to various stresses (e.g., physical exercise, variable gravity, complex task performance, etc.) during long duration space flights. During 1971-72, bioscience and biotechnology laboratories are planned to extend earlier investigations on various sub-human life forms, ranging from simple cells to primates. In these laboratories, [8] greater stresses can be applied to sub-human life specimens than are normally planned for human subjects, and the results can benefit both the bio-scientific community and later manned spaceflight technology.

Orbital astronomy mission objectives are planned around use of the Apollo Telescope Mount (ATM) concept during 1968-72 (see Attachment 3). During the 1968-70 period of maximum solar activity, emphasis will be on solar astronomy using the ATM in low altitude earth orbit. These first ATM missions, in addition to providing valuable scientific data, will provide an experimental basis for developing the techniques of manned astronomical observations in space and assessing their value and possibilities. Stellar astronomy missions are being studied for the 1971-73 period. Based on experience gained from the early ATM flights, an orbital astronomy mission involving a large aperture telescope (60" to

100") is scheduled for late 1973. This may be a test of a large mirror leading to development of the National Astronomical Observatories.

Space physics experiments are planned generally for flight on astronomy missions. During 1968-69, instrumentation flown on the 1966-67 short duration Apollo earth orbital missions will be reflown to acquire more extensive data in such fields as X-ray astronomy, ultra-violet spectroscopy, ion wake physics and investigations of particles and fields. Beginning in 1971, advanced space physics experiments are planned.

[9] The extended lunar exploration missions planned for Saturn Apollo Applications include both orbital mapping missions and extended lunar surface explorations. The objective is to extend knowledge of the moon beyond that achievable in the earlier Ranger, Surveyor, unmanned Lunar Orbiter and early Apollo missions, and to provide the basis for possible establishment in the mid or late 1970's of semi-permanent or permanent manned stations on the moon. The lunar orbital missions are planned to acquire high quality mapping and survey photography from polar or near-polar lunar orbits for study of geological features over wide areas of the lunar surface exploration missions. The lunar surface missions surface, and to aid in selection of sites for extended duration are planned to provide up to two weeks stay at selected exploration. Equipments planned for these missions include lunar sites for extensive geological, geophysical and biological small, wheeled vehicles to permit traverses within line-of sight of the landed spacecraft; drills for sub-surface sampling and vertical profile measurements; and instrumentation for acquiring geophysical data to be transmitted back to earth by RF link for up to a year after departure of the astronauts. One such lunar surface mission per year is planned, beginning in 1970. For the 1973 mission, an objective is to provide optical and radio telescopes to evaluate the lunar surface environment for astronomical experiments.

[10] Applications experiments are planned to develop techniques and to measure the effectiveness of man's participation in such fields as orbital meteorology (see Attachment 4), communications, and remote sensing of earth resources. Low altitude orbits at medium and high inclinations have been studied for meteorology and natural resources missions during 1969-70. An initial synchronous orbit mission is planned to test man's ability to operate effectively in that environment and to test operational techniques for linking low altitude manned spacecraft to central ground control stations. The later synchronous orbit missions are planned for continued operational use as well as for possible experiments in astronomy, space physics, meteorology and advanced communications techniques.

Technology experiments planned for Saturn Apollo Applications missions are focused generally toward the development of equipment and techniques which appear fundamental to the accomplishment of the next generation of post-Apollo space flight missions. During 1968-69, emphasis will be placed on the use as an orbital laboratory of the spent S-IVB stage, which injects an Apollo spacecraft into orbit. Advanced EVA experiments are planned, for example, to retrieve micrometeorite panels from a Pegasus spacecraft orbited in 1965 by a Saturn I vehicle. Resupply and crew transfer techniques are planned, both to extend mission duration, rotate crews, and to test orbital rescue operations. An orbital fluids laboratory is [11]scheduled for flight in 1970 to extend knowledge of propellant behavior and transfer techniques under zero gravity conditions. Orbital assembly of complex structures and in flight maintenance of vehicles and experiment apparatus are planned. Most of the technology experiments are integrally combined with experiments planned to meet other objectives.

HARDWARE AVAILABILITY AND FLIGHT SCHEDULES

The reference baseline for Saturn Apollo Applications mission planning is the flight hardware delivery schedule which has been established to meet the requirements of the Apollo lunar landing program. This schedule provides for delivery of 12 Saturn IB's, 15 Saturn V's, 21 Command and Service Modules and 15 Lunar Excursion Modules for launch during 1966 through early 1970.

Attachments 5 and 6 depict the two alternate Saturn Apollo Applications launch schedules for the period 1968-73 which formed the basis for NASA's May 1966 submission to the Bureau of the Budget. Both cases are based on the assumption that the last four Saturn IB's (AS 209-212) and the last six Saturn V's (AS 510-515) with their associated spacecraft from the approved Apollo program might become available for alternate missions as the initial phase of the Saturn Apollo Applications flight program. Both in Case I (Attachment 5) and in Case II (Attachment 6), the launch dates for these alternate missions using approved Apollo vehicles are planned to occur as much as one year later than the launch date scheduled for those vehicles under the basic Apollo program. This stretch-out of launch schedules [12] for the early Saturn Apollo Applications missions allows time for development and integration of suitable experiment apparatus under the limited funding available in FY 1966-67.

Case I differs from Case II primarily in the rate at which follow-on Saturn IB vehicles are delivered for launch to meet the Saturn Apollo Applications mission objectives. It represents the lowest rate of follow-on vehicle deliveries which could permit accomplishing the basic program objectives, and it would require phasing down both production and launch operations activity during 1969-70, followed by a partial build-up of both activities beginning in 1971. Case I (Attachment 5) provides for carrying out the experiments discussed previously on approximately the schedule shown in Attachment 1, although the Saturn IB missions (low altitude earth orbit) after AS 212 would be delayed from 3 to 9 months. Funding estimates associated with Case I make no provision prior to FY 1972 for developing post-Apollo space vehicles or modules for the next generation of manned space flight objectives.

Case II, starting from the same baseline of approved Saturn Apollo flight vehicles, provides for earlier delivery of follow-on vehicles, and the associated funding estimates would permit a start in FY 1969 on the development of next generation subsystems and modules for flights beyond 1971 on the schedule shown on Attachment 6. Because of the earlier delivery of follow-on vehicles, the Saturn IB missions planned for 1969 and beyond can be scheduled from 3 to 9 months earlier in Case II than in Case I. Thus, Case II has been planned to [13] permit an early and extensive utilization of Saturn Apollo capabilities, with an earlier focus on a post-Apollo national space objective involving the development of new space modules (such as a prototype of a space station or a planetary mission module) for initial earth orbital flight in the early 1970's.

Attachment 7 lists the objectives of planned Saturn Apollo Applications missions scheduled on the flight indicated on Attachment 6. These missions are under continual study to identify and trade-off alternative modes of accomplishing the mission objectives. Approximately two years prior to the scheduled launch date for each mission, the objectives and flight assignments for that mission to be firmly established and a period of intensive mission planning must begin throughout the NASA organization and its contractors. The Saturn Apollo Applications missions planned for 1968-69 will enter this two-year mission preparation phase during FY 1967, while the post-1969 missions will be the subject of further definition studies and long lead item development effort. The total process of identification, definition, selection, hardware development, flight qualification and procurement of experiments can take a total of 3 to 4 years and must be initiated long enough in advance to be in phase with the schedule requirements for detailed mission planning and launch. Similarly, adequate lead times must be allowed for procurement of basic space vehicle hardware.

[14] Attachments: [not provided]

1. Saturn Apollo Applications Mission Objectives
2. Extended Capability of Apollo Space Vehicles Planned for Saturn Apollo Applications Missions
3. Apollo Telescope Mount (ATM) Concept
4. Applications A Experimental System (AAP A) (Primarily Meteorology)
5. Saturn Apollo Applications Launch Schedule, Case I
6. Saturn Apollo Applications Launch Schedule, Case II

Document II-46

Document Title: Letter from Thomas Gold to Harold Urey, 9 June 1966.

Source: Archives of the Royal Society, London, England (reprinted with permission).

Professor Thomas Gold was a well-known astronomer at Cornell University, noted for his unconventional views. Gold had suggested that the lunar surface was covered with a deep layer of fine dust, and thus might not support the weight of a landing spacecraft with astronauts aboard. In this letter to equally well-known astronomer Harold Urey, Gold reflects of the results of the Surveyor 1 mission, which landed on the moon on 2 June 1966.

June 9, 1966

Dr. Harold C. Urey

School of Science and Engineering

University of California

La Jolla, California

Dear Harold:

Thank you for your nice letter. I completely agree with you that the Surveyor results are quite incompatible with a frozen lava explanation of the surface. Not only is the imprint of the foot clearly visible and I believe about five inches deep despite the fact that the peak impact loading seems to have been no more than about four pounds per square inch, there apparently is even a detailed fine structure visible in the imprint matching precisely the corrugation on the side of the foot. It is therefore a compressible and slightly cohesive material which one can mold. That is of course just what we have always said it would be, and I recall we had given such examples as that one could build igloos with it by cutting it like chunks of snow with a knife.

Many of the objects that are seen on the surface – the so called rocks – very likely are rocks or harder material, but they are evidently not mostly lying on the surface. In several cases one can clearly see that the contact line with the surface is about the largest perimeter that the object possesses, a very unlikely situation for a stone lying on the surface. One of the objects is a neat pyramid and reminds one of the New Yorker cartoon of the two archaeologists in the middle of the desert who had just brushed away the sand from the tiniest little peak of a pyramid sticking out and one says to the other, "Well, there's no telling how much work it's going to be". It is clear the majority of these objects are mainly submerged with just the tops sticking out. The shore line around each such object meets up with it quite neatly, which it would of course not do if it were merely thrown into a softish material and [2] partly submerged. It will then have a trench some places around it just like the foot of the Surveyor does. This is not the case. The only explanation that I can see for that is to suppose that the filler material fills in flat gradually over the course of time and while this is occurring stones of various sizes are thrown by major explosions so that they accumulate at the same time as the fine stuff sediments. I would guess that such chunks are distributed throughout the interior of the sediment and the radar evidence in fact has been in favor of a substantial amount of scattering being derived from many feet below the surface.

I want to emphasize again that I have always said that I believe the fine particles to be very considerably cohesive, especially in the lunar conditions (most fine dust is already quite cohesive on the earth, too) and that I regarded the material as crunchy and certainly not as flowing. I have also never said that I believed it would not hold the Surveyor or the Apollo, but only that this was uncertain, while of course all the lava experts never even contemplated the possibility it could sink in at all. I regard the amount of sinkage that has occurred as quite within the range of slightly cemented powders.

You mention the word "sand" in your letter. From the pictures of course one cannot directly tell the grain size, but one does see little crumbles thrown out from the foot. Dry sand would not go in crumbles and the chunks that you see are certainly too big to be the individual particles. A slightly cohesive powder on the other hand is well known to result in just such crumbs. Also, a sand could not be cohesive enough to maintain the vertical surface, though of course a sand mixed with a lot of much smaller particles could, as could an aggregate of small particles only. I personally think that the majority of the particles will in fact be very small since I know that the packing fraction must be rather low; not much more than one-third of the volume can be occupied by pieces. If there is a great spread in the size of the particles then usually denser packing results. Yet the radar and the thermal evidence are quite clear about the lower packing that is required. For that reason I believe that the small stuff is all in particle sizes of not much more than a few microns and in that case I can understand as I have always stressed that there are ways in which they can be deposited flat. Sand particles could be [3] scattered among all this but it would be very hard to find any mechanism that would tend make them bed down flat in the absence of wind and water.

I have just read again what I have said in the past on this subject to see why everyone keeps assuming that a deep deposit of dust would make everything disappear out of sight. I find that I have always stressed in print, already in 1956, that vacuum welding will be important and that such a material will not flow. However, that I am not quite sure that it will everywhere be strong enough to suppor [*sic*] the weights and that I would still maintain now. I quite agree with you that there are many signs of subterranian [*sic*] holes into which overburden has fallen and I would still be very worried about that also. The plain fact of the matter is that while on earth wind and water has tested most areas of ground and human interference is only a trivial addition, this is not so on the moon. Just like on a glacier after fresh snow, there can easily be structures that are weak and untested as yet.

I expect to be coming out to Los Angeles next week, possibly also to take part in the CBS program to be taped on the Saturday. I understand you will be present there, too. I am looking forward to seeing you there and having a little more discussion on the side.

With best regards,

Yours sincerely,

T. Gold

TG:vs

Document II-47

Document Title: Memorandum to Dr. Wernher von Braun, Director of NASA Marshall Space Flight Center, from James E. Webb, NASA Administrator, 17 December 1966.

Source: Folder #18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

After its budget peaked in 1965, the Apollo Program had to fight in the White House and Congressional budget processes for the funds needed to make sure that both President Kennedy's "end of the decade goal" was met and the program could be carried through to its planned conclusion. NASA had estimated in 1962 that 15 Saturn V launchers would be needed to ensure this outcome.

Perhaps the most recognizable personality within NASA during the development phase of Apollo was Wernher von Braun. He was an optimist by nature, and was frequently sought out by the media for comments on Apollo's progress. In a late 1966 interview with the magazine U.S. News and World Report, von Braun suggested that the first lunar landing might come relatively early in the Saturn V sequence, with the implication that Apollo's objectives might be accomplished with the use of less than the 15 vehicles that had been ordered. NASA Administrator James E. Webb, who was working hard in Washington to sustain support for Apollo, was not happy with von Braun's remarks.

December 17, 1966

MEMORANDUM FOR: Dr. Wernher von Braun
Director, Marshall Space Flight Center

THROUGH: Dr. Seamans / AD
Dr. Mueller / M

Following our recent Program Review and the exchange I had with Joe Shea about the difficulty our senior officials are having sustaining the credibility of their public statements and the Congressional testimony we gave last year when those responsible for program management were giving optimistic statements about the time when 504 might "well go to the Moon," I thought we had pretty well established the policy that we would not make those kinds of statements. I had this in mind particularly because I testified last year that we had no extra vehicles in the program, and I made the strongest representation I know how to make in the Bureau of the Budget this year that we should not cancel any of the 15 Saturn V's with the high risk of this program. Therefore, you can imagine my surprise when I read the U.S. News and World Report statements in your interview. While I recognize that they overplayed your statements, it does seem to me that your answers to the questions made it possible for them to do so and that you could have given answers which would have made the situation clearer.

In any event, I have now examined the Apollo program adjustments established on December 7 by George Mueller and they clearly indicate that there is certainly a very, very low possibility that complete Saturn V systems will be available for flights out as far as the Moon in 1968. Under these circumstances, it seems to me that you will need to be very careful in dealing with the press not to return to the kind of statements you made in the U.S. News and World Report interview. I hope you can find a way to backtrack to a position that is more consistent with the official estimate established by George Mueller in these recent adjustments.

[2]

Even this series of adjustments does not, in my view, take account of all the difficulties we are likely to encounter in this very complex Saturn V-Apollo system, particularly as we are now so hemmed in, have so little room to make adjustments, and have no financial margins. We could lose several hundred million dollars of badly needed funds for 1968 under conditions as they exist. I know you don't want to contribute to this.

While we have been talking about the SII stage as the pacing item, I understand there is even doubt as to whether the complete LEM system test can take place on AS-206. If the complete test has to go over to 209, and this is not flown until late 1967, it would certainly not seem realistic to take any position publicly that did not indicate we are going to have very great difficulty making the lunar landing in this decade – within the last quarter of 1969.

I know you will understand I am writing in this detail because it is of deep concern to me that statements such as your own in the interview mentioned do have an impact on the credibility of the official statements Seamans and I have made and will have to make again in our Congressional testimony. I know you do not wish to undermine the credibility of those of us who are working so hard to get the money to continue this program and to avoid having the vehicles now approved (15 Saturn V's) deleted from the program on the basis that they are not needed to accomplish the mission.

One possible course you could take in future statements is the same which I took last year before Congress when asked if we had closed the gap with the Russians during the year. You will remember this came about when Congressman Davis asked if I expected to find "Russians" on the Moon when we arrived, as predicted sometime ago by Edward Teller. I stated that a year ago I had felt we would be there first but that during the year I had developed more doubts and now felt much less assurance about it. You might recede from the positions you have taken publicly by saying at the next opportunity, and then repeating in the future, the fact that up until recently you thought we would be able to have the Saturn V-Apollo system so perfected and tested that the experience from the Saturn I-B program added in would permit early Saturn V flights to be released toward the Moon with a good chance that one of the early ones would land, but that the difficulties encountered have now caused you to have much more concern and doubt as to whether this will be possible. If you do not have these doubts, Wernher, than I think Mueller, Seamans, and I should get together and find out how your own views could differ so markedly from our own.

[Signed James E. Webb]

James E. Webb
Administrator

Enclosure:
Excerpt, 1967 House Authorization Hearings

Document II-48

Document Title: Robert C. Seamans, Jr., Deputy Administrator, "Memorandum for the Apollo 204 Review Board," 28 January 1967.

Source: Folder #18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

Document II-49

Document Title: NASA, Office of the Administrator, "Statement by James E. Webb," 25 February 1967.

Source: Folder #18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

Document II-50

Document Title: Apollo 204 Review Board, "Report of Apollo 204 Review Board to the Administrator, National Aeronautics and Space Administration," 5 April 1967.

Source: Folder #18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

A 27 January 1967 fire during a launch pad spacecraft test resulted in the deaths of astronauts Virgil "Gus" Grissom, Edward White, and Roger Chaffee. NASA Administrator James Webb was able to convince President Lyndon B. Johnson that NASA could and should conduct an objective review of what came to be known as the Apollo 204 accident. On 28 January, NASA constituted an internal Review Board for the accident investigation after Administrator Webb convinced the White House that NASA could conduct its own review on an impartial basis. The Review Board was chaired by the Director of the Langley Research Center, Floyd Thompson, to investigate the accident and suggest remedial measures. During the investigation, NASA hoped to damp down Congressional criticism by sharing with the

Congress information on the progress of the review. The report of the Apollo 204 Review Board was released on 5 April 1967.

Document II-48

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Washington D.C. 20546

Office of the Administrator January 28, 1967

MEMORANDUM For the Apollo 204 Review Board

1. The Apollo 204 Review Board is hereby established in accordance with NASA Management Instruction 8621.1, dated April 14, 1966, to investigate the Apollo 204 accident which resulted in the deaths of Lt. Col. Virgil I. Grissom, Lt. Col. Edward H. White and Lt. Cmdr. Roger B. Chaffee on Launch Complex 34, on January 27, 1967.

2. The Board will report to the Administrator of the National Aeronautics and Space Administration.

3. The following are hereby appointed to the Board:

   Dr. Floyd L. Thompson, Director, Langley Research Center,
   NASA, Chairman

   Lt. Col. Frank Borman, Astronaut, Manned Spacecraft
   Center, NASA

   Maxime Faget, Director, Engineering & Development,
   Manned Spacecraft Center, NASA

   E. Barton Geer, Associate Chief, Flight Vehicles &
   Systems Division,

   Langley Research Center, NASA

   George Jeffs, Chief Engineer, Apollo, North
   American Aviation, Inc.

   Dr. Frank A. Long, PSAC Member, Vice President for Research
   and Advanced Studies, Cornell University

   Col. Charles F. Strang, Chief of Missiles & Space Safety Division
   Air Force Inspector General
   Norton Air Force Base, California

George C. White, Jr., Director, Reliability & Quality, Apollo Program Office, Headquarters, NASA

John Williams, Director, Spacecraft Operations, Kennedy Space Center, NASA

[2]

4. George Malley, Chief Counsel, Langley Research Center, will serve as counsel to the Board.

5. The Board will:

   a. Review the circumstances surrounding the accident to establish the probable cause or causes of the accident, including review of the findings, corrective action, and recommendations being developed by the Program Offices, Field Centers, and contractors involved.

   b. Direct such further specific investigations as may be necessary.

   c. Report its findings relating to the cause of the accident to the administrator as expeditiously as possible and release such information through the Office of Public Affairs.

   d. Consider the impact of the accident on all Apollo activities involving equipment preparation, testing, and flight operations.

   e. Consider all other factors relating to the accident, including design, procedures, organization, and management.

   f. Develop recommendations for corrective or other action based upon its findings and determinations.

   g. Document its findings, determinations, and recommendations and submit a final report to the Administrator which will not be released without his approval.

6. The Board may call upon any element of NASA for support, assistance, and information.

Document II-49

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WASHINGTON. D.C. 20546

OFFICE OF THE ADMINISTRATOR February 25, 1967

STATEMENT BY

JAMES E. WEBB

NASA is releasing today a third interim report on the work of the Apollo 204 Review Board resulting from two days of meetings with the Board by Deputy Administrator Robert Seamans at Cape Kennedy. These meetings took place on February 23 and 24.

This statement and Dr. Seamans' third interim report have been reviewed with Chairman Clinton Anderson and Senior Minority Committee Member Senator Margaret Chase Smith and with Congressman George Miller. In continuation of the Senate Committee's review of the Apollo 204 accident. Senator Anderson has announced that the Senate Committee will hold an open hearing on the preliminary findings of the Board and actions to be taken by NASA at 3 p.m., Monday, February 27.

In addition to the information set forth by Dr. Seamans in his three interim reports, I have had the benefit of a review by three members of the Board – the Chairman, Dr. Floyd Thompson, Astronaut Frank Borman, and Department of Interior combustion expert Dr. Robert Van Dolah. This included the preliminary views of the Board as to the most likely causes of ignition, the contributing factors in the rapid spread of the fire, the inadequacy of the means of emergency egress for the astronauts, and the need to recognize that all future such tests be classified as involving a higher level of hazard.

The following emerges from the preliminary views of the Board and the Board's preliminary recommendations:

(1) The risk of fire that could not be controlled or from which escape could not be made was recognized when the procedures for the conduct of the test were established. Our experience with pure oxygen atmospheres included not only the successful Mercury and Gemini flights but a number of instances where a clearly positive source of ignition did not result in a fire. In one such instance an electric bulb was shattered, exposing the incandescent element to the oxygen atmosphere without starting a fire.

(2) Our successful experience with pure oxygen atmospheres in Mercury and Gemini, our experience with the difficulty of storing and using hand–held equipment under zero–gravity conditions, and our experience with the difficulty of making sure before flight that no undiscovered items had been dropped or found their way into the complex maze of plumbing, wiring, and equipment in the capsule, led us to place in the Apollo 204 capsule such items as Velcro pads to which frequently used items could be easily attached and removed, protective covers on wire bundles, nylon netting to prevent articles dropped in ground testing from being lost under or behind equipment in the capsule, and a pad or cushion on which, in the planned escape exercise, the hatch could be placed without damage to the hatch itself or to the equipment in the spacecraft. While most of these were constructed of low-combustion-potential material, they were not so arranged as to provide barriers to the spread of a fire. Tests conducted in an Apollo-type chamber since the accident have

shown that an oxygen fire in the capsule will spread along the surface of Velcro and along the edges of nylon netting much faster than through the material itself.

[2] (3) Soldered joints in piping carrying both oxygen and fluids were melted away, with resultant leakage contributing to the spread of the fire.

(4) The bursting of the capsule happened in such a way that the flames, as they rushed toward the rupture and exhausted through it, traveled over and around the astronauts' couches. Under these conditions, and with just a few seconds of time available, the astronauts could not reach the hatch and open it.

(5) This fire indicates that a number of items to the design and performance of the environmental control unit will require the most careful examination and may require redesign.

Astronaut Borman, in commenting on his reactions to the conditions surrounding the Apollo 204 test and the subsequent knowledge he has gained as a result of serving on the Review Board, stated to Dr. Seamans, Dr. Thompson, and to me that he would not have been concerned to enter the capsule at the time Grissom, White and Chaffee did so for the test, and would not at that time have regarded the operation as involving substantial hazard. However, he stated that his work on the Board has convinced him that there were hazards present beyond the understanding of either NASA's engineers or astronauts. He believes the work of the Review Board will provide the knowledge and recommendations necessary to substantially minimize or eliminate them.

Dr. Thompson, Astronaut Borman, and Dr. Van Dolah have returned to Cape Kennedy are proceeding with the work of the Board. This will require several weeks to complete.

Chairman George Miller, of the House Committee on Science and Astronautics, has announced that as soon as the Board's work is complete, the Committee's Oversight Subcommittee, chaired by Congressman's Olin Teague, will conduct a complete investigation of all factors related to the accident and NASA's actions to meet the conditions disclosed. Chairman Teague spent Friday and Saturday at Cape Kennedy with members of the Manned Space Flight Subcommittee, of which he is also Chairman, reviewing progress in the Apollo Program. Dr. Seamans, Dr. George Mueller, and I will report further to him at 10 a.m., Monday, February 27.

Document II-50

REPORT OF

APOLLO 204

<u>REVIEW BOARD</u>

TO
THE ADMINISTRATOR
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

[Following text in Box on Un-numbered Page]

APOLLO SPACECRAFT

The spacecraft (S/C) consists of a launch escape system (LES) assembly, command module (C/M), service module (S/M) and the spacecraft/lunar module adapter (SLA). The LES assembly provides the means for rapidly separating the C/M from the S/M during pad or suborbital aborts. The C/M forms the spacecraft control center, contains necessary automatic and manual equipment to control and monitor the spacecraft systems, and contains the required equipment for safely and comfort of the crew. The S/M is a cylindrical structure located between the C/M and the SLA. It contains the propulsion systems for attitude and velocity change maneuvers. Most of the consumables used in the mission are stored in the S/M. The SLA is a truncated cone which connects the S/M to the launch vehicle. It also provides the space wherein the lunar module (L/M) is carried on lunar missions.

TEST IN PROGRESS AT TIME OF ACCIDENT

Spacecraft 012 was undergoing a "Plugs Out Integrated Test" at the time of the accident on January 27, 1967. Operational Checkout Procedure, designated OCP FO-K-0021-1, applied to this test. Within this report this procedure is often referred to as OCP-0021.

TESTS AND ANALYSES

Results of tests and analyses not complete at the time of publication of this report will be contained in Appendix G, Addenda and Corrigenda.[not provided]

CONVERSION OF TIME

Throughout this report, time is stated in Greenwich Mean Time (GMT). To convert GMT to Eastern Standard Time (EST), subtract 17 hours. For example, 23:31 GMT converted is 6:31 p.m. EST.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO April 5, 1967

The Honorable James E. Webb
Administrator
National Aeronautics and Space Administration
Washington, D. C. 20546

Dear Mr. Webb:

Pursuant to your directive as implemented by the memorandum of February 3,1967, signed by the Deputy Administrator, Dr. Robert C. Seamans, Jr., the Apollo 204 Review Board herewith transmits its final, formal report, each member concurring in each of the findings, determinations, and recommendations.

Sincerely,

/Signed/
Dr. Floyd L. Thompson
Chairman

/Signed/
Frank Borman, Col., USAF

/Signed/
Dr. Robert W. Van Dolah

/Signed/
Dr. Maxime A. Faget

/Signed/
George C. White, Jr.

/Signed/
E. Barton Geer

/Signed/
John J. Williams

/Signed/
Charles F. Strang, Col., USAF

[Parts 1-5 of report not included]

[6-1]

Part VI BOARD FINDINGS, DETERMINATIONS AND RECOMMENDATIONS

In this Review, the Board adhered to the principle that reliability of the Command Module and the entire system involved in its operation is a requirement common to both safety and mission success. Once the Command Module has left the earth's environment the occupants are totally dependent upon it for their safety. It follows that protection from fire as a hazard involves much more than quick egress. The latter has merit only during test periods on earth when the Command Module is being readied for its mission and not during the mission itself. The risk of fire must be faced; however, that risk is only one factor pertaining to the reliability of the Command Module that must received adequate consideration. Design features and operating procedures that are intended to reduce the fire risk must not introduce other serious risks to mission success and safety.

1. FINDING:

a. There was a momentary power failure at 23:30:55 GMT.

b. Evidence of several arcs was found in the post fire investigation.

c. No single ignition source of the fire was conclusively identified.

DETERMINATION:

The most probable initiator was an electrical arc in the sector between the -Y and +Z spacecraft axes. The exact location best fitting the total available information is near the floor in the lower forward section of the left-hand equipment bay where Environmental Control System (ECS) instrumentation power wiring leads into the area between the Environmental Control Unit (ECU) and the oxygen panel. No evidence was discovered that suggested sabotage.

2. FINDING:

a. The Command Module contained many types and classes of combustible material in areas contiguous to possible ignition sources.

b. The test was conducted with a 16.7 pounds per square inch absolute, 100 percent oxygen atmosphere.

DETERMINATION:

The test conditions were extremely hazardous.

RECOMMENDATION:

The amount and location of combustible materials in the Command Module must be severely restricted and controlled.

3. FINDING:

a. The rapid spread of fire caused an increase in pressure and temperature which resulted in rupture of the Command Module and creation of a toxic atmosphere. Death of the crew was from asphyxia due to inhalation of toxic gases due to fire. A contributory cause of death was thermal burns.

b. Non-uniform distribution of carboxyhemoglobin was found by autopsy.

DETERMINATION:

Autopsy data leads to the medical opinion that unconsciousness occurred rapidly and that death followed soon thereafter.

4. FINDING:

Due to internal pressure, the Command Module inner hatch could not be opened prior to rupture of the Command Module.

DETERMINATION:

The crew was never capable of effecting emergency egress because of the pressurization before rupture and their loss of consciousness soon after rupture.

RECOMMENDATION:

The time required for egress of the crew be reduced and the operations necessary for egress be simplified.

5. FINDING

Those organizations responsible for the planning, conduct and safety of this test failed to identify it as being hazardous. Contingency preparations to permit escape or rescue of the crew from an internal Command Module fire were not made.

a. No procedures for this type of emergency had been established either for the crew or for the spacecraft pad work team.

b. The emergency equipment located in the White Room and on the spacecraft work levels was not [6-2] designed for the smoke condition resulting from a fire of this nature.

c. Emergency fire, rescue and medical teams were not in attendance.

d. Both the spacecraft work levels and the umbilical tower access arm contain features such as steps, sliding doors and sharp turns in the egress paths which hinder emergency operations.

DETERMINATION:

Adequate safety precautions were neither established nor observed for this test.

RECOMMENDATIONS:

a. Management continually monitor the safety of all test operations and assure the adequacy of emergency procedures.

b. All emergency equipment (breathing apparatus, protective clothing, deluge systems, access arm, etc.) be reviewed for adequacy

c. Personnel training and practice for emergency procedures be given on a regular basis and reviewed prior to the conduct of a hazardous operation.

d. Service structures and umbilical towers be modified to facilitate emergency operations.

6. FINDING:

Frequent interruptions and failures had been experienced in the overall communication system during the operations preceding the accident.

DETERMINATION:

The overall communication system was unsatisfactory.

RECOMMENDATIONS:

a. The Ground Communication System be improved to assure reliable communications between all test elements as soon as possible and before the next manned flight.

b. A detailed design review be conducted on the entire spacecraft communication system.

7. FINDING:

a. Revisions to the Operational Checkout Procedure for the test were issued at 5:30 pm EST January 26, 1967 (209 pages) and 10:00 am EST January 27, 1967 (4 pages).

b. Differences existed between the Ground Test Procedures and the In-Flight Check Lists.

DETERMINATION:

Neither the revision nor the differences contributed to the accident. The late issuance of the

revision, however, prevented test personnel from becoming adequately familiar with the test procedure prior to its use.

RECOMMENDATIONS:

a. Test Procedures and Pilot's Checklists that represent the actual Command Module configuration be published in final form and reviewed early enough to permit adequate preparation and participation of all test organization.

b. Timely distribution of test procedures and major changes be made a constraint to the beginning of any test.

8. FINDING:

The fire in Command Module 012 was subsequently simulated closely by a test fire in a full-scale mock-up.

DETERMINATION:

Full-scale mock-up fire tests can be used to give a realistic appraisal of fire risks in flight-configured spacecraft.

RECOMMENDATION:

Full-scale mock-ups in flight configuration be tested to determine the risk of fire.

9. FINDING:

The Command Module Environmental Control System design provides a pure oxygen atmosphere.

DETERMINATION:

This atmosphere presents severe fire hazards if the amount and location of combustibles in the Command Module are not restricted and controlled.

RECOMMENDATIONS:

a. The fire safety of the reconfigured Command Module be established by full-scale mock-up tests.

b. Studies of the use of a diluent gas be continued with particular reference to assessing the problems of gas detection and control and the risk of additional operations that would be required in the use of a two gas atmosphere.

[6-3] 10. FINDING:

Deficiencies existed in Command Module design, workmanship and quality control, such as:

a. Components of the Environmental Control System installed in Command Module 012 had a history of many removals and of technical difficulties including regulator failures, line failures and Environmental Control Unit failures. The design and installation features of the Environmental Control Unit makes removal or repair difficult.

b. Coolant leakage at solder joints has been a chronic problem.

c. The coolant is both corrosive and combustible.

d. Deficiencies in design, manufacture, installation, rework and quality control existed in the electrical wiring.

e. No vibration test was made of a complete flight-configured spacecraft.

f. Spacecraft design and operating procedures currently require the disconnecting of electrical connections while powered.

g. No design features for fire protection were incorporated.

DETERMINATION:

These deficiencies created an unnecessarily hazardous condition and their continuation would imperil any future Apollo operations.

RECOMMENDATIONS:

a. An in-depth review of all elements, components and assemblies of the Environmental Control System be conducted to assure its functional and structural integrity and to minimize its contribution to fire risk.

b. Present design of soldered joints in plumbing be modified to increase integrity or the joints

be replaced with a more structurally reliable configuration.

c. Deleterious effects of coolant leakage and spillage be eliminated.

d. Review of specifications be conducted, 3-dimensional jigs be used in manufacture of wire bundles and rigid inspection at all stages of wiring design, manufacture and installation be enforced.

e. Vibration tests be conducted of a flight-configured spacecraft.

f. The necessity for electrical connections or disconnections with power on within the crew compartment be eliminated.

g. Investigation be made of the most effective means of controlling and extinguishing a spacecraft fire. Auxiliary breathing oxygen and crew protection from smoke and toxic fumes be provided.

11. FINDING:

An examination of operating practices showed the following examples of problem areas:

a. The number of the open items at the time of shipment of the Command Module 012 was not known. There were 113 significant Engineering Orders not accomplished at the time Command Module 012 was delivered to NASA; 623 Engineering Orders were released subsequent to delivery. Of these, 22 were recent releases which were not recorded in configuration records at the time of the accident.

b. Established requirements were not followed with regard to the pre-test constraints list. The list was not completed and signed by designated contractor and NASA personnel prior to the test, even though oral agreement to proceed was reached.

c. Formulation of and changes to pre-launch test requirements for the Apollo spacecraft program were unresponsive to changing conditions.

d. Non-certified equipment items were installed in the Command Module at time of test.

e. Discrepancies existed between NAA and NASA MSC specifications regarding inclusion and positioning of flammable materials.

f. The test specification was released in August 1966 and was not updated to include accumulated changes from release date to date of the test.

DETERMINATION:

Problems of program management and relationships between Centers and with the contractor have led in some cases to insufficient response to changing program requirements.

RECOMMENDATION:

Every effort must be made to insure the maximum clarification and understanding of the responsibilities of all the organizations involved, the objective being a fully coordinated and efficient program.

Document II-51

Document Title: Letter to Senator Clinton P. Anderson from James E. Webb, NASA Administrator, 8 May 1967.

Source: Folder #18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

The attempt by NASA Administrator James E. Webb to limit congressional and public criticism of NASA following the Apollo 204 fire by carrying out a thorough internal investigation was not totally successful. On 27 February, in testimony before the Senate Committee on Aeronautical and Space Sciences, the existence of the critical review of North American Aviation carried out by Apollo Program Manager General Sam Phillips was brought to Webb's attention; he had apparently not been previously aware of its existence.

Later testimony before the same committee did not reassure the Committee's chair, Senator Clinton Anderson, that NASA was being totally forthcoming. Webb valued his credibility with Congress very highly, and in this letter suggested an approach to rebuilding confidence between members of the Committee and NASA.

National Aeronautics and Space Administration
Washington, D.C. 20546

Office of the Administrator

May 8, 1967

Honorable Clinton P. Anderson
United States Senate
Washington, D. C. 20510

Dear Mr. Chairman:

I am deeply troubled by your statement to me last Saturday that members of the Committee are not satisfied with our testimony on NASA's actions in follow-up of the deficiences [*sic*] found by the management review team headed by General Phillips at North American Aviation in 1965. Your statement that members of the Committee believe NASA is endeavoring to put a disproportionate part of the blame for the Apollo 204 accident on North American Aviation and avoid its proper acceptance of blame troubles me even more.

On April 13, 1967, General Phillips testified before your Committee and summarized the actions of his team and the responses made by North American Aviation during the following several months. He answered all questions that were asked. The Oversight Subcommittee of the House Committee on Science and Astronautics, because it had not pressed this line of questioning, immediately asked for a summary of the team report, which was furnished to Chairman Teague on April 15, 1967, and publicly released by him.

Over the past six years, NASA has placed contracts with American industry for more than 22 billion dollars of work. To do this kind of advanced aeronautical and space research and build flight hardware, American industry has had to introduce new, very difficult fabrication and test capabilities. It has had to learn to use new management systems. In this process, NASA has provided a technical interface and technical monitoring function as an addition to the normal or standard process of contract monitoring, much of which is performed for us by the Department of Defense contract administration service. In cases where contractors have encountered serious technical or management difftcu1ties, it has been our policy [2] to assist them to develop strengths they did not have and to utilize our knowledge of the factors which brought success to one contractor to help others take advantage of this experience. We and most of our contractors have cooperated fully in approaching problems in whatever manner was best calculated to solve them and get on with the work, rather than to try to fix blame. At the same time, we have had to find new ways to reward efficiency and penalize poor performance. We and our contractors have placed a high premium on self-analysis and self-criticism, as painful as it has had to be in many cases.

The plain fact is that our U.S. industrial system has in the past generally made its profits from large-scale production and the initial learning period on complex space development projects has not had the incentive of anticipated profits from large production orders. However, after six years, the process we have developed is in its final stages and demonstrating efficiency in most companies with large contract obligations to NASA.

In Apollo, we are very near to a flight demonstration of all the equipment that will prove that six large companies could take contracts for major segments and that the resulting vehicle provides for this country the space capability we have needed since the USSR flew Sputnik in 1957 and Gagarin in 1961. In the Saturn V Apollo system, Boeing makes the first stage, North American the second, Douglas the third, International Business Machines the instrumentation unit, Grumman the lunar excursion module, and North American the command and service module. The General Electric Company provides the automated checkout equipment. Even the smallest of these projects runs into tens or hundreds of millions of dollars.

Almost without exception each company has encountered serious difficulties at one time or another. Many NASA management review teams have had to work with prime or sub-contractors to move the work ahead. The end result is going to be success for Apollo, but it is going to be much harder to achieve if every detail of every difficulty is now to be put on the public record as a failure of either the contractor or NASA.

It is a hard fact of life in this kind of research and development that success cannot be achieved without a certain amount of experimentation in design to find the limits that can be safely reached. This means a high initial rate of failure on inspection and test, [3] and consequent redesign. We are still in or near many areas of the unknown.

As I have pondered the meaning of your statements to me on Saturday, I have tried to think of ways through which the Committee could reestablish the confidence in NASA it formerly had and in the system we are using. I have tried to find some way this could be done without violating the basic commitments we have made to individuals and companies to regard information given as confidential and also without having the Committee undertake the enormous task of forming a judgment about at least a sample of the management review criticisms we have recorded with respect to every major unit in the program.

With the pressure of time to get the program moving, now that we have established a basic plan which will bring us to the next manned flight at an early date, which we will be presenting to your Committee tomorrow, May 9, and with the limited investment of time which the Committee is able to make in understanding the complexities which alone permit valid judgments, I can think of nothing better than to request an executive session of the Committee, to which I would bring General Phillips and all the members of the review team which made the study of

North American Aviation in December of 1965. In such major matters, it is our practice to include on a management review team a knowledgeable senior person from outside NASA. In this case, the member was General G. F. Keeling of the Air Force Systems Command. The NASA members, other than General Phillips, are Dr. J. F. Shea, Dr. E. F. M. Rees, and General E. F. O'Connor.

In such an executive session, this group can lay on the table all of the documentation which it used in its analysis of the situation at NAA and the six volumes of responses made by North American. These responses show the actions taken by North American between December 1965 and April 1966. In an executive session, General Phillips and other appropriate officials will also be prepared to present and answer questions on the actions taken by both North American and NASA in the 1966-1967 period following the April reviews. Statements of most of these actions will be referenced to the management review team materials. Examples are enclosed in order that you may see that NASA and NAA have continued to take vigorous action in the period since the management review.

[4] To answer the questions you have raised, there is no way to exclude from the documentation we are prepared to present in executive session such business confidential data on North American as indirect cost rates, burden rates, direct and indirect employees, general and administrative expenses, bidding expense, independent research and development expense, and other similar information. This material falls within the purview of section 1905 of Title 18, United States Code, which means that the Committee must restrict this information to use by Committee members.

At the end of your executive session, it will be my purpose to gather up the materials referred to above and return them to NASA files, unless the Committee takes action to the contrary.

Through the expenditure of about 25 billion dollars over the last six years, NASA has brought the efforts of over 400,000 men and women working in American laboratories and factories into the development of the space capabilities our nation needs. Our success is shown by the fact that we are now laying off from this work force 5,000 workers per month. We have utilized the American industrial system flexibly and in ways that have added vast new strengths that have permeated practically every segment of our national economy. We have created within NASA's developmental centers such as Huntsville, Houston, and Cape Kennedy, an ability to work with contractors to do new and almost impossible tasks. To make public every detail of the difficulties we have encountered out of the context of the total program efforts involved will do grave injustice to many individuals in private life and many outstanding industrial units, and undoubtedly will destroy our ability to continue this system on the cooperative basis essential to its success. However, after you have inspected the attached materials and we have answered your questions in executive session, that decision must become the responsibility of the Committee. I can only give you my judgment as to what is in the best interests of the country.

Because time is so short, I am sending you sufficient copies of this letter to permit distribution to the members of the Committee should that be considered desirable.

Sincerely yours,

[Signed James E. Webb]

James E. Webb
Administrator

Enclosure

Document II-52

Document Title: Interagency Committee on Back Contamination, "Quarantine Schemes for Manned Lunar Missions," no date, but probably August 1967.

Source: Folder #18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

Document II-53

Document Title: NASA, "Policy Directive RE Outbound Lunar Biological Contamination Control: Policy and Responsibility," 6 September 1967.

Source: Folder #18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

Document II-54

Document Title: Letter to Thomas Paine, Administrator , NASA, from Frederick Seitz, President, National Academy of Sciences, 24 March 1969.

Source: Folder #18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

Document II-55

Document Title: Letter from Senator Clinton Anderson, Chairman, Committee on Aeronautical and Space Sciences, U.S. Senate, to Thomas Paine, Administrator, NASA, 15 May 1969.

Source: Folder #18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

Document II-56

Document Title: Letter to Senator Clinton Anderson, Chairman, Committee on Aeronautical and Space Sciences, from Homer Newell, Acting Administrator, NASA, 4 June 1969.

Source: Folder #18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

During the early years of the Apollo program NASA recognized that planetary protection, particularly protection against back contamination of Earth by hypothetical lunar organisms, was a critical issue that had to be addressed before lunar landing missions could go forward. In 1966, the Interagency Committee on Back Contamination (ICBC) was established to determine what measures were needed to preserve public health and protect agricultural and other resources against the possibility of contamination by lunar organisms conveyed in returned sample material or other material exposed to the lunar surface (including astronauts), and to preserve the biological and chemical integrity of lunar samples and scientific experiments with minimal compromise to the operating aspects of the program. This report summarizes the conclusions of the ICBC with respect to quarantine requirements for both returning astronauts and lunar samples.

The contamination of the lunar surface during visits by Apollo astronauts was also of concern, and NASA in September 1967 adopted a policy in this regard.

As the first lunar landing attempt grew closer, concerns were raised about both the readiness of the Lunar Receiving Laboratory (LRL) at the Manned Spacecraft Center to receive the Apollo astronauts and the material they would return from the Moon and the adequacy of the measures being taken to ensure that the astronauts and their spacecraft would not carry back alien organisms to Earth. In particular, NASA a few months before the Apollo 11 mission decided that the astronauts would leave the command module shortly after it landed in the ocean, rather than stay aboard the capsule until it was placed in quarantine aboard the recovery aircraft carrier. Concerns that this approach would undercut other quarantine measures were brought to the attention of Congress in May 1969. NASA was able to convince most members of Congress and scientists that the protections it had put in place were adequate, but even up to a few days before the mission was launched on 16 July 1969 there were a few individuals seeking to delay the launch until more stringent protections were put in place.

Document II-52

QUARANTINE SCHEMES

FOR

MANNED LUNAR MISSIONS

BY: INTERAGENCY COMMITTEE
ON BACK CONTAMINATION

TABLE OF CONTENTS

TABLES

QUARANTINE SCHEMES FOR MANNED LUNAR MISSIONS

Introduction

Presented herein are the fundamental quarantine and sample release plans for manned lunar missions as established by the Interagency Committee on Back Contamination. Obviously, the scheme does not contain all possible finite technical details about quarantine test methods and containment provisions, but it provides the necessary framework for action by the Interagency Committee on Back Contamination and substantive methods for satisfying the quarantine requirements of the Regulatory Agencies.*

*In this document the U. S. Department of Health, Education and Welfare, the U. S. Department of Agriculture, and the U. S. Department of the Interior are referred to as the Regulatory Agencies.

It is, of course, impossible in any set of quarantine plans to anticipate every eventuality. Therefore, it is necessary that the schemes include a contingency provision that gives the Interagency Committee and the Regulatory Agencies adequate opportunity to provide requirements and suggestions for situations not covered in the formal plans. It is likewise necessary to emphasize that in spite of efforts being made to assure aseptic collection and return of lunar samples, there is no certainty of the complete absence of earth microbial contaminants. And certainly, the potential of earth contaminants in returned lunar samples will be significantly greater after the first Apollo mission.

Astronaut Release Scheme

Table I provides the general scheme for the quarantine and release of the astronauts and medical support personnel in the Crew Reception Area (CRA) of the Lunar Receiving Laboratory (LRL). The scheme covers three possible results and indicates the course of action for each. Implicit in each is an appropriate review by the Interagency Committee and the accomplishment of any formal action and recommendation that might be required.

Proposition I is the most likely with release of the astronauts and medical support personnel from the CRA after approximately 21 days. This action will accrue if there are no alterations in the general health of the quarantined people and no other indications of infectious disease due to lunar exposure.

[2] Should a definite alteration in the health of one or more persons in the CRA occur (Proposition II), release of the people would probably not be delayed if the alteration is diagnosed as non infectious or is of terrestrial origin. If the source of the alteration cannot be readily diagnosed, however, some prolongation of the quarantine may be necessary. In either case, under Proposition II, review of the data and recommendations by the Interagency Committee are required.

Proposition III establishes the requirement that laboratory personnel from the sample laboratory of the LRL be housed in the CRA following a severe rupture of a cabinet system containing lunar material suspected of containing harmful or infectious materials. While precise specification of events for Proposition III are not outlined in Table I, the NASA medical team should consider all available information and make recommendations concerning release of the laboratory people. These recommendations should be reviewed and approved by the Interagency Committee. If it is decided that the laboratory personnel must undergo quarantine, the medical observations would identify Propositions I or II in Table 1. It must be recognized that this situation could result in prolonged quarantine of the astronauts.

Phase I Sample Release Scheme

The scheme outlined in Table II provides a general plan for each of three sets of circumstances resulting from quarantine testing of lunar samples. Examination and review of the quarantine data by the Interagency Committee before release or non release of the sample is provided in each case. In other words, in each case the Interagency Committee would have identified an appropriate time for coordinating their position and making their recommendations to the National Aeronautics and Space Administration.

Proposition I of Table II shows the course of action for what should be the most probable result of sample quarantine testing, the situation in which the protocol is carried out in the LRL with completely negative results: no viable organisms being isolated and no pathogenic effects being noted in the animals and plant systems tested. For this eventuality, Proposition I calls for the Interagency Committee to meet, examine, and review the quarantine data, and if satisfied as to its validity and reliability, recommend to NASA the release of samples from that returned mission. Formal clearance by the Regulatory Agencies is effected as a part of this plan.

Proposition II of Table II prescribes the course of action to be followed in the event that a replicating organism is detected in the lunar sample without any deleterious effects being noted on the life systems or terrestrial niches tested in the LRL. Should this result materialize, the aim of the flow chart under Proposition II is to [3] determine: (1) if the organism isolated is of terrestrial origin, unmodified by any lunar exposure and generally considered as "non pathogenic", or (2) if the organism is not readily classified as being of terrestrial origin and therefore or potential hazard to terrestrial ecology.

In regard to statement (1) above, demonstration that the organism in question is identical with organisms collected from the spacecraft, from spacecraft equipment, or from the astronauts during preflight sampling, or classification of the organism as a harmless terrestrial microbe would be adequate reason for neither extending nor expanding the quarantine. The inability to recover a common, identifiable, and non pathogenic organism a second time from a duplicate lunar sample would further indicate that an earth contaminant rather than an organism indigenous to the lunar sample was involved. In this same regard, lunar sample contamination could result following a break in the primary barrier of the LRL. If the organism isolated cannot be readily classified or otherwise shown to be of terrestrial origin, there then would be the need for initiation of a contingency quarantine plan.

Under Proposition II, Table II, the scheme requires review by the Interagency Committee at the points indicated. Adequate demonstration that the organisms are terrestrial, unchanged, and usually regarded as "non pathogenic" would be considered by the Interagency Committee as sufficient reason for not requiring challenge of additional terrestrial niches before sample release. Failure of the protocol tests to provide this information about organisms isolated from the lunar sample, however, would signal the need for further quarantine testing (indicated as Phase II quarantine) and/or release of sample according to conditions* then specified by the Regulatory Agencies, and/or release of samples after sterilization.

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*Release to certain specified laboratories for further study; or sterilization before release, but only after consultation with investigators to determine if this is satisfactory to their specific experiment; or release to the LRL so that visiting scientists (Principal Investigators) can work in the LRL under containment conditions to carry out early experiments.

Proposition III of Table II covers the situation where definite deleterious effects are noted on one or more of the life systems tested in the LRL. Should this occur, the effects observed may be due to chemical toxicity rather than to invasion by a replicating organism. This would be indicated if sterilized lunar material (the control) produced the same deleterious effects and if no replicating organisms were found. It is always possible, however, that replicating contaminants will be uncovered along with a toxic chemical. In such cases,

[4] it will be necessary to identify the organisms as of terrestrial origin and to classify them as "harmless" in order to avoid testing additional terrestrial niches or life systems.

Finally, if replicating organisms are indicated as the cause of definite deleterious effects on tested life systems, Phase II quarantine will be indicated with the possibility of a subsequent conditional release and/or only sterilized samples will be released. Under Proposition III appropriate places for review and action by the Interagency Committee are indicated.

Phase II Sample Release Scheme

The probability is very remote of a contingency quarantine of a lunar sample due to the presence of unidentified replicating organisms or because of non-explained deleterious effects on life systems that are not due to chemical toxicity. Nevertheless, it is necessary that the prevention of possible terrestrial back contamination be specific with regard to these remote probabilities in order that the intent of the Interagency Committee on Back Contamination Terms of Reference* be fulfilled and that the legal requirements of the Regulatory Agencies be satisfied. The Phase II quarantine scheme for these eventualities is specified in Table III.

*Interagency Agreement between the National Aeronautics and Space Administration, the Department of Agriculture, the Department of Health, Education and Welfare, the Department of the Interior, and the National Academy of Sciences on the protection of the Earth's biosphere from lunar sources of contamination: Attachment A: Interagency Committee on Back Contamination Terms of Reference.

Phase II requires a prolongation of the quarantine for an unspecified time interval. However, even at the outset of Phase II, the Interagency Committee could recommend release of some portions of the lunar samples to non-biological institutions under specific conditions of handling. The conditions would, for the most part, relate to the use of the sample inside biological barriers.

Otherwise, Phase II quarantine involves continued testing of animal and plant species in the LRL. As indicated in Table III, the scheme could also provide for conditional release of cultures isolated in the LRL or specimens to certain biological laboratory institutions in the United States for more detailed study of possible pathogenic effects. These laboratories, however, must meet existing specifications of the Regulatory Agencies for handling potentially virulent pathogens.

[5] (Phase II quarantine could take advantage of visiting scientists in the LRL as bioscience specialists to carry out specific tests for pathogenicity, should such talents be available.)

Contingency Landings

The release schemes outlined above assume that a nominal or near nominal landing of the crew, spacecraft, and related equipment has been achieved. In the event of a contingency landing – off nominal – the details and method of quarantine must be adapted to the exigencies of the situation. Immediate authoritative decisions must be made as they apply to quarantine and back contamination as well as other time critical problems.

For such cases, the quarantine aspects will be represented by a Quarantine Control Officer.* To the extent possible during a disaster, he will obtain direction from the Regulatory members of the Interagency Committee before initiating disaster control procedures. Prior to the first returned lunar mission it will be the responsibility of the Quarantine Control Officer to prepare and have approved by the NASA medical team and the Science and Applications Director (Manned Spacecraft Center), and the Regulatory Agencies a document outlining typical courses of action for several types of contingency landings.

*Manned Spacecraft Center Management Instruction 8030.1, dated January 9, 1967: Assignment of Responsibility for the Prevention of Contamination of the Biosphere by Extraterrestrial Life.

Release of Film and Data Tapes

The film and data tapes will be returned to the LRL in the same manner as the lunar samples, admitted to quarantine, and maintained behind a biological barrier. The data tapes will then be played through the biological barrier for outside processing.

The film will be processed inside the quarantine facility and printed through the biological barrier with an optical printer for outside use.

If current studies indicate that ethylene-oxide sterilization of the film is possible when the film is contaminated with bacterial spores and that no degradation of the film occurs, there is the possibility that immediate release of sterilized film will be allowed without printing through the barrier. The statistical reliability of the ethylene-oxide process should be such that the treatment will fail to give sterility no more than 1 in 10,000 times ($P=1x10^{-4}$).

[6]

Spacecraft Release

The spacecraft will enter the LRL in a sealed configuration and be placed in isolation near the CRA (this area can become a part of the quarantine facility if necessary). It will follow the same time constraints as the sample – 30 days – prior to release if all results are negative. It will, however, be available for additional bio-sampling if deemed necessary by Quarantine Control Officer. At his discretion, it may also be, entered for technical inspection provided that it is placed inside the biological barrier and the personnel and spacecraft become an integral part of the quarantine facility and scheme of release at that time.

Summary

The Interagency Committee has prepared this document in order that all agencies and persons involved in returned lunar samples may have a clear understanding of the procedures the Interagency Committee feels are necessary for the realistic program to protect this planet from possible back contamination. Moreover, the Interagency Committee presents this document as one that will satisfy the requirements of the Regulatory Agencies of Government without undue hardship on NASA. Although the Interagency Committee feels that very few alternates to this plan are possible, it wishes to acknowledge a speedy and unconditional release of the sample; a minimum of expense and delay is highly advantageous to the scientific community.

The schemes proposed may be summarized as follows:

1. Astronauts and Medical Support Personnel

a. Release after 21 days if no alternations in general health are observed and in the absence of an infectious disease attributable to lunar exposure.

b. If significant alterations in general health occur, release is still indicated if alterations are diagnosed as of terrestrial origin or as non communicable.

c. If alterations are apparent and not diagnosed, some delay in release would be indicated with the final action to be recommended by the NASA medical team.

[7]

Conditions for Lunar Sample Release

a. It is expected that prompt release of lunar samples after completion of the protocol tests can be recommended by the Interagency Committee to the Administrator of NASA or NASA's designated representative. The nominal results expected would obviously not impose any unusual conditions upon the release.

b. Interagency Committee conditional release could result if there is sufficient doubt regarding the presence of pathogenic organisms in the lunar samples. In this instance, release of sterilized samples would be possible, or some samples might be released providing they are used only behind a suitable biological barrier. In the case of a conditional release, Phase II quarantine testing will proceed as rapidly as possible in an attempt to clarify the data regarding possible pathogenic effects.

3. Validity Constraints for Sample Release

It is in the interest of all concerned that the quarantine testing procedures be designed to avoid events that would produce invalid results. To insure that "lunar pathogens" will not be falsely detected, the sample release scheme contains the following constraints.

a. If replicating organisms are found in the sample and no deleterious effects are noted in any of the terrestrial niches tested in the LRL, release will not be delayed beyond the time needed to identify the organisms as terrestrial contaminants.

b. If deleterious effects from lunar material are noted with the terrestrial life systems tested in the LRL, release will not be delayed beyond the time needed to show that the effects were due to chemical toxicity and that any replicating organisms isolated from the sample were of terrestrial origin, harmless, and not responsible for the effects.

c. Should Phase I quarantine procedures indicate the presence of a substance pathogenic to terrestrial life, Phase II procedures will be initiated to verify or more adequately explain the Phase I results.

[8]

INTERAGENCY COMMITTEE ON BACK CONTAMINATION

Membership

Primary	Alternate
David J. Sencer, M. D. (Chairman) National Communicable Disease Center U.S. Public Health Service	
Dr. John Bagby, Jr. (Co-Chairman) National Communicable Disease Center U.S. Public Health Service	
Dr. Wolf Vishniac University of Rochester (National Academy of Sciences representative)	Dr. Allan Brown University of Pennsylvania
Dr. Ernest Saulmon Department of Agriculture	Dr. A. B. Park Department of Agriculture
Mr. Howard H. Eckles Department of the Interior	Dr. John Buckley Department of the Interior
Dr. Harold P. Klein Ames Research Center, NASA	Dr. Adrian Mandel Ames Research Center, NASA
Charles A. Berry, M.D. Manned Spacecraft Center, NASA	Walter W. Kemmerer, M.D. Manned Spacecraft Center, NASA

Dr. Wilmot N. Hess
Manned Spacecraft Center, NASA

Mr. Lawrence B. Hall
Office of Space Science
and Applications, NASA

Dr. James Turnock
Office of Manned Space Flight, NASA

Colonel John E. Pickering
(Executive Secretary)
Office of Manned Space Flight, NASA

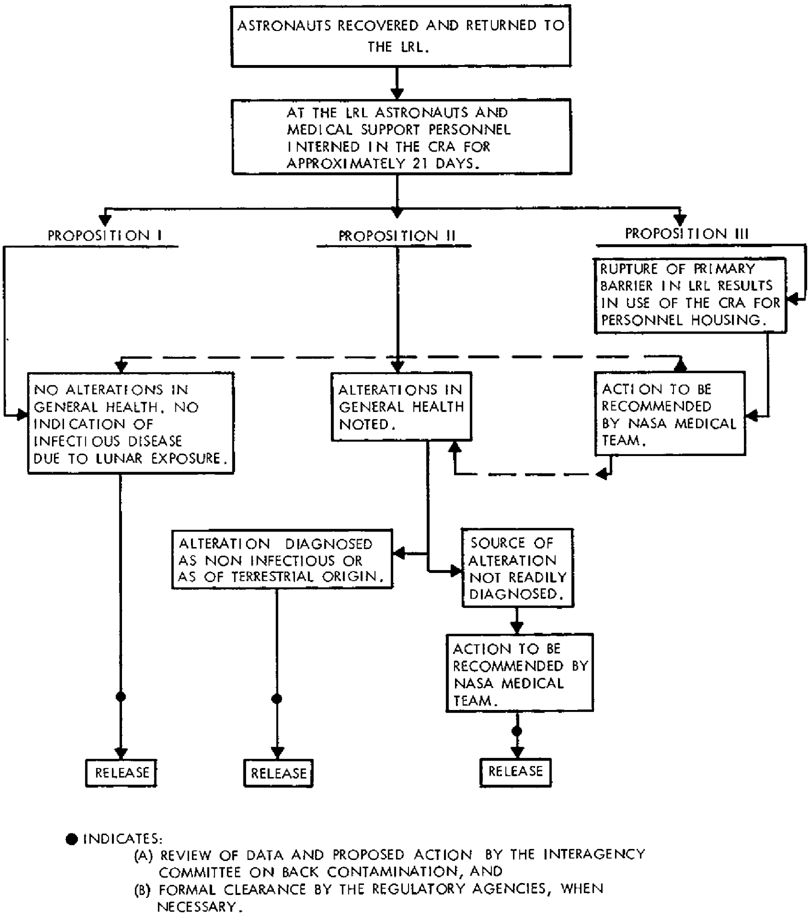
Dr. G. Briggs Phillips
U.S. Public Health Service Consultant

Mr. Joseph V. Piland
Manned Spacecraft Center, NASA

Captain Arthur H. Neill
Office of Space Science
and Applications, NASA

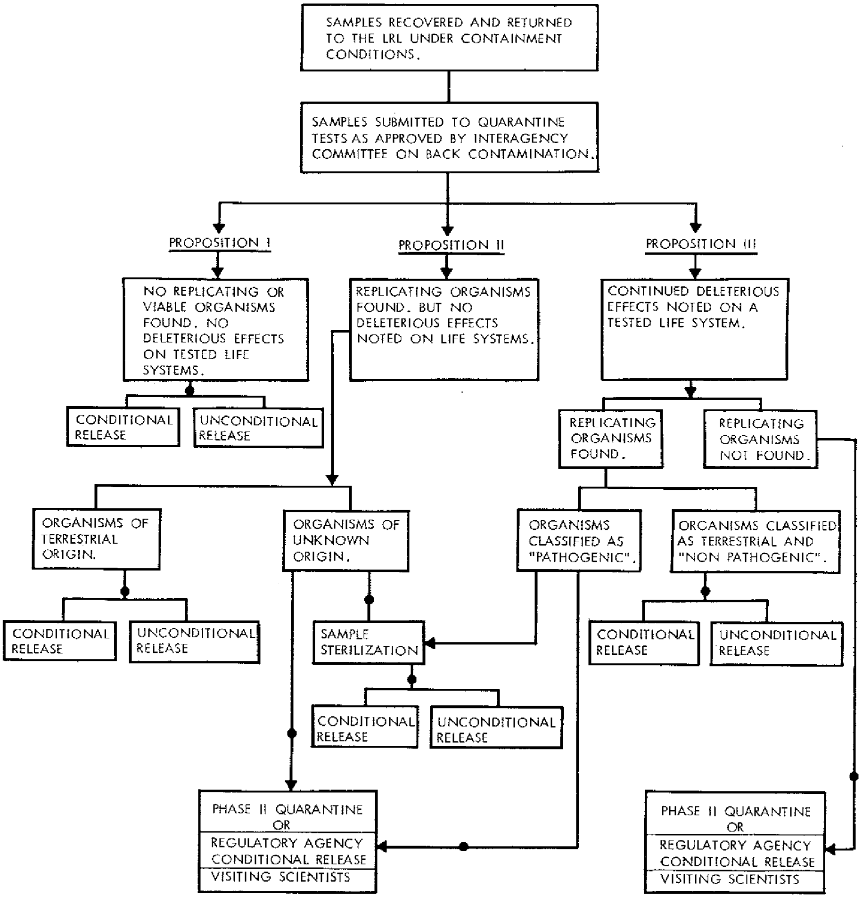
[9]

TABLE I. ASTRONAUT QUARANTINE SCHEME FOR MANNED LUNAR MISSIONS



[10]

TABLE II. QUARANTINE SCHEME FOR RETURNED LUNAR SAMPLES (PHASE I)



● INDICATES:
(A) REVIEW OF DATA AND PROPOSED ACTION BY THE INTERAGENCY COMMITTEE ON BACK CONTAMINATION, AND
(B) FORMAL CLEARANCE BY THE REGULATORY AGENCIES, WHEN NECESSARY.

[11]

Document II-53

Policy Directive

SUBJECT: OUTBOUND LUNAR BIOLOGICAL CONTAMINATION CONTROL: POLICY AND RESPONSIBILITY

1. PURPOSE

This Directive establishes the operational responsibilities for manned and automated lunar missions with regard to the amount of biological contamination and its placement on the lunar surface.

2. SCOPE AND APPLICABILITY

This Directive applies to all NASA Installations with respect to all outbound missions intended to or which may encounter the Moon.

3. DEFINITION

For the purpose of this Directive, the Apollo Landing Zone (ALZ) is defined as that portion of the Moon located between 5° north latitude and 5° south latitude, and between 45° east longitude and 45° west longitude.

4. SPACE SCIENCE BOARD– NATIONAL ACADEMY OF SCIENCES RECOMMENDED POLICY

During the early phases of lunar exploration, NASA undertook to minimize contamination on Ranger probes in order to avoid depositing terrestrial organisms on the Moon. Eventually, it became apparent that, although the objective was complete sterility, each probe that impacted on the Moon carried a number of microorganisms. In its review of NASA's experience of three years with lunar probe contamination control, the Space Science Board of the National Academy of Sciences made the following pertinent recommendations concerning spacecraft programmed to land on the Moon:

"(i) Minimize contamination to the extent technically feasible. By appropriate selection of components (favoring those which are inherently sterile internally) and the use of surface sterilants, it should be possible to achieve a cleanliness level to approximate that which prevails in most hospital surgery rooms.

[2]

"(ii) Inventory all organic chemical constituents. This will permit the interpretation of analytical results from future collections of lunar material.

* * *

"(iv) Undertake the development of the sterile drilling system to accompany an early Apollo mission to return an uncontaminated sample of the lunar subsoil. Samples aseptically collected from this subsoil will be of both biological and geochemical interest. Should life exist on the Moon, it might be expected at some depth below the surface where temperatures never exceed 100°C and below the zone of ultraviolet radiation. Every effort should be made to keep this level free of contaminants until it can be sampled by drilling."

5. POLICY

a. Landings: Unless otherwise authorized by the Deputy Administrator, all manned landings will be confined to the Apollo Landing Zone.

b. Biological Loading

(1) Contamination of the manned landers will be held to the minimum practical level consistent with achieving the major mission objectives as specified in the appropriate mission assignment document as approved.

(2) Contamination on the surface of automated landers and orbiters will be kept below a level such that, if contamination is confined to an area of 2.59 square kilometers (1 square mile) around the lunar impact point, there will not be more than one viable organism per square meter.

c. Biological Inventory: An inventory of probable post-landing biological contamination levels at each Apollo and automated landing site and a total inventory for the Moon will be obtained and maintained for future reference in the event sites are revisited and to aid in the interpretation of data obtained in subsequent experiments.

[remainder of document not provided]

Document II-54

NATIONAL ACADEMY OF SCIENCES

March 24, 1969

Dr. Thomas O. Paine
Administrator
National Aeronautics and
Space Administration
Washington, D. C. 20546

Dear Tom:

As you know, Professor Wolf Vishniac serves as our representative on the Interagency Committee on Back Contamination, which is concerned with precautions to be taken in connection with lunar materials and vehicles returning from the moon.

In connection with his responsibilities on this committee, and as noted in the enclosed copy of his letter to me, Professor Vishniac has identified apparent weaknesses in the quarantine procedures to be followed at the time of recovery of the lunar vehicle. Although these have been discussed with representatives of the Public Health Service and the Department of Agriculture, Professor Vishniac feels that these questions should be given immediate consideration by the Academy and the National Aeronautics and Space Administration. I am sure that he will be willing to discuss this matter in further detail with you and/or other appropriate representatives of the Administration.

Sincerely yours,

[signed]

Frederick Seitz
President

Enclosure

THE UNIVERSITY OF ROCHESTER
COLLEGE OF ARTS AND SCIENCE
RIVER CAMPUS STATION
ROCHESTER, NEW YORK 14627

Department of Biology March 5, 1969

Dr. Frederick Seitz
President
National Academy of Sciences
2101 Constitution Avenue
Washington, D.C. 20418

Dear Dr. Seitz:

It is my unpleasant duty to report to you the present unsatisfactory status of the quarantine program which has been the concern of the Interagency Committee on Back Contamination. At the time of this writing there is a six week simulation in progress at the Lunar Receiving Laboratory, previous simulations having shown substantial faults in the functioning of various Lunar Receiving Laboratory components. One simulation had to be called off within two days after several neoprene gloves in the glove boxes gave way.

On February 12 and 13 the representatives of the Regulatory Agencies met at Houston to review the operation of the LRL and the retrieval scheme of the Apollo astronauts. I shall not bore you with a long list of technical faults that were found in the operation of the LRL, let me just mention a few significant samples. It has as yet been impossible to keep colonies of mice alive in the LRL. The mouse colonies, being behind biological barrier, are at reduced pressure with respect to the atmosphere outside the biological barrier. So far every single mouse colony has died, even without being intentionally infected with any pathogenic agent. Routine apparatus does not seem to work properly, so for instance autoclaves tend to fill with water. This was still true on February 27. There seems to be no way of carrying out rapid minor emergency repairs. Although there is a list of spare parts to be kept at the LRL, no parts are actually available. I could continue this unhappy list at great length.

Our major concern which I wish to report is the recurring problem of controlling the spacecraft atmosphere after re-entry. When the Interagency Committee first met it was presented with a procedure whereby the spacecraft, immediately after splash-down, would be ventilated with fresh air for the necessary comfort of the astronauts. Such uncontrolled outventing does not, naturally, impose any biological restraint on whatever particles or microorganisms may be suspended in the spacecraft atmosphere. At that time the Committee directed NASA to investigate the feasibility of installing biological filters in the air vents. The engineering response was that the installation of filters would require larger fans and more power to drive them than could be accommodated, and that filters were therefore not practical.

Meanwhile, calculation had been carried out that the re-cycling of air through the barium hydroxide canisters would remove free floating particles from the atmosphere during the return from the Moon. This calculation has since been shown to be in error by several orders of magnitude. Eventually a compromise solution was reached whereby the divers, in attaching the floatation collar around the craft, would place a biological filter over the vent holes from outside, and also provide a power pack to drive sufficiently powerful fans. On February 13 the members of the regulatory agencies were told that no such filtration was intended and that upon splash-down the capsule would have to be vented without any control. The reaction of the representatives of the various agencies was mixed. In the opinion of Dr. Bagby (PHS) this procedure did not seem to pose a direct threat to human beings and therefore the Public Health Service was not too concerned. Dr. Park (Department of Agriculture) felt that no immediate threat to agricultural crops was presented, and therefore he too was willing to go along with this procedure or at least not make a strong opposition to it.

This left matters up to Mr. Eckles of the Department of the Interior. Dr. Eckles would have to answer to his colleagues for the safety of the marine environment. Dr. Eckles was most unhappy about this procedure, and repeated the frequent complaint voiced by all members of the Interagency Committee, that at every meeting the ground rules previously given to us by MSC have been changed. Dr. Eckles suggested that a meeting might be arranged with a few competent biological oceanographers, in particular he had in mind Dr. Francis Haxo of the Scripps Oceanographic Institution, Dr. Luige Provasoli, of Haskens Laboratories and Dr. Carl Oppenheimer at Florida State University. My feeling is that in such a conference a few experts on atmospheric circulation should also be involved. Mr. Eckles feels that he is not in a strong position to object to the flight of Apollo 11 in its present configuration nor does he see any way in which he could influence a change in spacecraft design or recovery procedure.

My own reaction is based entirely on whether we consider back contamination a matter of concern or not. I believe that this question has been answered in the affirmative since NASA has gone to the expense of constructing a quarantine facility and working out an elaborate system by which astronauts could be transported behind biological barriers from the recovery area to the Lunar Receiving Laboratory. Once we have committed ourselves to this course it would be irresponsible to leave a large breach in the biological barrier in any part, of the recovery procedure. The uncontrolled outventing of the spacecraft is such a breach. I do not believe that either the Department of Agriculture or the Public Health Service should be as unconcerned about the problem as they appear to be. Should pathogenic organisms be brought back, and I will grant readily that the likelihood of this event is small, and should they infect organisms in the ocean, which is Mr. Eckles' concern, then there is the same danger that they may spread to land and become simultaneously a very great concern to the Public Health Service and the Department of Agriculture. If Apollo 11 is allowed to return in the currently contemplated manner, and if the atmosphere on the Spacecraft is to be vented to the outside without any control or restraint, then I see little reason for maintaining the biological isolation garments, the elaborate mobile quarantine units, the transport to Ellington Air Force base, and the entire Lunar Receiving Laboratory quarantine. If we abandon the entire quarantine then we may as well admit that we do so. However, if the quarantine is to be taken seriously then it must be enforced at every link in the chain of events. Another breach of quarantine appears to be the insistence of spacecraft engineers of entering the spacecraft immediately or at least after a very short time, without the three week quarantine that had been contemplated for it.

I am frankly at a loss to suggest what should be done at this mement [*sic*]. Clearly the Apollo Program is moving at a pace which we cannot stop. It is equally clear that this irresistible progress is being used to brush aside the inconvenient restraints which the Interagency Committee has considered to be an essential part of the Quarantine Program. The least I can do is to price [*sic*] you of the facts as they stand at the moment and to call them to the attention of the Space Science Board.

Sincerely yours,

[signed]
Wolf Vishniac

Document II-55

United States Senate
Committee on Aeronautical and Space Sciences
Washington, DC 20510

May 15, 1969

The Honorable Thomas O. Paine, Administrator
National Aeronautics and Space Administration
Washington, DC 20546

Dear Dr. Paine:

Recent news articles say that NASA is considering plans to relax its precaution against the spread of alien organisms that might be brought back from the moon by the Apollo 11 space flight because of recommendations made by an interagency committee. Under the change, it is my understanding that the Astronauts would be permitted to leave the spacecraft while it is still in the water instead of, as previously planned, bringing the spacecraft with the Astronauts inside aboard the carrier and releasing them into a biologically isolated vehicle. It is said that the changes are being proposed so as to air out the aircraft, save the Astronauts some discomfort, and avoid the hazard of bringing the tossing capsule near the hull of the carrier.

I wonder if it is wise to go to a procedure that can be regarded as having less concern for possible contamination of the earth; and hope that you will very carefully consider that if the Agency is to err it ought to err on the side of caution. The program has come a long way and is about to meet its objective. I would not like to see people start to criticize the program on the basis that all necessary and practical caution has not been taken to prevent the spreading of any possible harmful pathogens brought back from the moon.

Sincerely yours,

Clinton P. Anderson
Chairman

Cc: Mr. Robert Allnutt

Document II-56

National Aeronautics and Space Administration
Washington 25, D.C.

Jun 4 1969

Honorable Clinton P. Anderson
Chairman
Committee on Aeronautical and
Space Sciences
United States Senate
Washington, D.C. 20510

Dear Mr. Chairman:

This is further in response to your letter of May 15 regarding the recovery procedures for the Apollo 11 mission.

The subject of possible back-contamination of the earth's biosphere through Apollo operations has, of course, received our very serious attention for some time. NASA and other agencies of Government have spent considerable effort to insure that everything possible is done to prevent such contamination consistent with safe accomplishment of the mission. To this end, in 1964 an Interagency Committee on Back Contamination (ICBC) was established to provide expert guidance to us on all matters concerning possible back-contamination. This Committee, composed of members from the Departments of Agriculture, Interior, Health, Education, and Welfare (U.S. Public Health Service), National Academy of Sciences and NASA, has the responsibility of insuring that our Apollo mission plans do no violate the integrity of the Earth's biosphere. Hence the preventive procedures we plan to employ must have the ICBC's approval before implementation.

A very difficult problem and decision we and the ICBC have had to resolve is the one you mention, that is, all constraints considered, determining the optimum recovery procedure which would protect the lives of the returned astronauts while at the same time providing the lowest practicable possibility of back-contamination. Our efforts have been directed toward both recovery procedures and methods to prevent uncontained lunar material from entering and leaving the Lunar Module and the Command Module.

The current astronaut-recovery procedure, which has been approved by the ICBC for the Apollo 11 mission, involves egressing them from the spacecraft into a raft and transferring them by helicopter to the recovery ship where they will enter the Mobile Quarantine Facility. The astronauts will don Biological Isolation Garments prior to departing the spacecraft if sea conditions permit; otherwise the garments will be donned in the life raft.

We had considered having the astronauts remain inside the Command Module while it was hoisted onto the recovery ship. Since this represented a departure from the present recovery procedures which have been developed over a period of several years and which are based on the cumulative experience of Mercury, Gemini, and Apollo, a thorough review was made of the difficulties involved in transferring the Command Module to the carrier deck, particularly in a heavy sea. The hazards demonstrated in actual practice led to our decision to transfer the astronauts to the carrier deck by helicopter. The current astronaut recovery procedures received ICBC approval for the Apollo 11 mission only after the ICBC became convinced that (1) there was a real hazard involved in sea retrieval of a manned spacecraft and (2) any increased risk of biosphere contamination was not significant. The former concern has been validated in both tests and previous end-of-mission recoveries. Test data has dictated the installation by a swimmer of a recovery loop or sling onto the spacecraft prior to lifting it from the water because the integral loop on the Command Module will not accommodate all possible recovery loads. Such a procedure is acceptable to us for use only on an unoccupied spacecraft. At the conclusion of the Apollo 9 mission, for example, the spacecraft was dropped back into the water due to a mechanical failure of the crane.

The increase in the contamination potential from extracting the astronauts has been minimized by programming improved housekeeping procedures by the astronauts and by recognition of the scrubbing action of the Lunar Module and Command Module lithium hydroxide (LiOH) canisters on the cabin atmosphere. The astronauts will now bag all items exposed to the lunar surface prior to transfer to the Command Module. They plan to vacuum the cabin at frequent intervals during the return trip from lunar orbit. Of additional significance, however, is recently developed data which indicates that the LiOH canisters will remove essentially all of the particulate effects of minimizing cabin interior contamination and understanding LiOH filtering capabilities have led us to conclude, and the ICBC to concur, that the recovery procedure described does not materially increase the probability of earth contamination.

In these few paragraphs I have not described all the detailed procedural steps we plan to take to reduce the possibility of Earth back-contamination. For instance, the maximum number of items possible which have contacted the lunar surface will either be left on the lunar surface or in the LM. This and many other steps we are taking represent a heavy concentration of effort to tighten our procedures to minimize the possibility of back-contamination of the earth's biosphere.

If we can provide any additional information, please let me know.

Sincerely yours,

Homer E. Newell
Acting Administrator

Document II-57

Document Title: Director of Central Intelligence, "The Soviet Space Program," 4 April 1968.

Source: Central Intelligence Agency Historical Review Program.

Throughout the 1960s the Central Intelligence Agency (CIA) used its various capabilities to track the Soviet space program. This update to a November 1967 National Intelligence Estimate gives a sense of what the CIA was saying about the Soviet lunar landing program. According to this estimate, the United States was well in the lead in achieving the first lunar landing. Of particular note , however, is the estimate that the Soviet Union might attempt a manned circumlunar flight before the end of 1968. Senior NASA officials were certainly aware of this possibility as they considered whether to approve sending the Apollo 8 mission into orbit around the moon in December 1968.

TOP SECRET [DECLASSIFIED]
CONTROLLED DISSEM
[declassified 1/16/1997]

NIE 11-1-67
4 April 1968
TS 0089284/1

MEMORANDUM TO HOLDERS

NATIONAL INTELLIGENCE ESTIMATE

NUMBER 11-1-67

The Soviet Space Program

Submitted by

[Signed Richard M. Helms]

Director of Central Intelligence

Concurred in by the

UNITED STATES INTELLIGENCE BOARD

As indicated overleaf

4 April 1968

Authenticated

[Signed]

EXECUTIVE SECRETARY USIB Pages 10

[1]

THE SOVIET SPACE PROGRAM

THE PROBLEM

To examine significant developments in the Soviet space program since the publication of NIE 11-1-67, "The Soviet Space Program," dated 2 March 1967, TOP SECRET, and to assess the impact of those developments on future Soviet space efforts with particular emphasis on the manned lunar landing program.

DISCUSSION

1. In the year since publication of NIE 11-1-67, the Soviets have conducted more space launches than in any comparable period since the program began.[1] Scientific and applied satellites, particularly those having military applications, largely account for the increased activity. The Soviets also intensified efforts to develop what we believe to be a fractional orbit bombardment system (FOBS).[2] The photoreconnaissance program continued at the same high rates of the previous two years.

2. In general, the Soviet space program progressed along the lines of our estimate. It included the following significant developments: new spacecraft and launch vehicle development, rendezvous and docking of two unmanned spacecraft, an unsuccessful manned flight attempt (which ended in the death of Cosmonaut Komarov), the successful probe to Venus, an unmanned circumlunar attempt which failed, and a simulated circumlunar mission. Evidence of the past year indicates that the Soviets are continuing to work toward more advanced missions, including a manned lunar landing, and it provides a better basis for estimating the sequence and timing of major events in the Soviet space program.

3. Considering additional evidence and further analysis, we continue to estimate that the Soviet manned lunar landing program is not intended to be competitive with the US Apollo program. We now estimate that the Soviets will

1 See Annex for a detailed breakdown of launches during the past year.

2 For a discussion of FOBS, see NIE 11-8-67, "Soviet Capabilities for Strategic Attack," dated 26 October 1967, TOP SECRET.

attempt a manned lunar landing in the latter half of 1971 or in 1972, and we believe that [2] 1972 is the more likely date. The earliest possible date, involving a high risk, failure-free program, would be late in 1970. In NIE 11-1-67 we estimated that they would probably make such an attempt in the 1970-1971 period; the second half of 1969 was considered the earliest possible time.

4. The Soviets will probably attempt a manned circumlunar flight both as a preliminary to a manned lunar landing and as an attempt to lessen the psychological impact of the Apollo program. In NIE 11-1-67, we estimated that the Soviets would attempt such a mission in the first half of 1968 or the first half of 1969 (or even as early as late 1967 for an anniversary spectacular). The failure of the unmanned circumlunar test in November 1967 leads us now to estimate that a manned attempt is unlikely before the last half of 1968, with 1969 being more likely. The Soviets soon will probably attempt another unmanned circumlunar flight.

5. Within the next few years the Soviets will probably attempt to orbit a space station which could weigh as much as 50,000 pounds, could carry a crew of 6-8 and could remain in orbit for a year or more. With the Proton booster and suitable upper staging they could do so in the last half of 1969, although 1970 seems more likely. Alternatively, the Soviets could construct a small space station by joining several spacecraft somewhat earlier—in the second half of 1968 or 1969—to perform essentially the same functions. We previously estimated that the earliest the Soviets could orbit such a space station was late 1967 with 1968 being more likely.

6. We continue to believe that the Soviets will establish a large, very long duration space station which would probably weigh several hundred thousand pounds and would be capable of carrying a crew of 20 or more. Our previous estimate, which gave 1970-1971 as the probable date and late 1969 as the earliest possible, was based primarily upon launch vehicle capacity. We now believe that the pacing item will be the highly advanced life support/environmental control technology required, and that such a station will probably not be placed in orbit before the mid-1970's.

[remainder of estimate not provided]

Document II-58

Document Title: Memorandum to Associate Administrator for Manned Space Flight from James E. Webb, Administrator, "Termination of the Contract for Procurement of Long Lead Time Items for Vehicles 516 and 517," 1 August 1968.

Source: Folder #18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

To ensure that there were enough heavy-lift boosters to complete the Apollo program, NASA had contracted for the elements of 15 Saturn V vehicles. George Mueller, Associate Administrator for Manned Spaceflight, hoped to keep open the various production lines involved in the Saturn V program, anticipating that there would be other uses for the giant vehicle—extended lunar exploration and launching a space station, for example—that would require a heavy-lift capability during the 1970s. The program to carry out such activities was known as the Apollo Applications Program. The first step in ensuring that this could be done was to contract for those components of the vehicle's S-IC first stage that required the longest time to manufacture. In mid-1968, Mueller requested authorization from James Webb to enter into such contracts.

Webb's answer was negative— no uses for Saturn Vs beyond the original 15 had been approved, and the budget outlook for such approval was gloomy. This memorandum, issued even before the initial lunar landing, was thus the first step in a process that led to a 1970 decision to terminate the Saturn V program.

Memorandum to Associate Administrator for Manned Space Flight

SUBJECT: Termination of the Contract for Procurement of Long lead Time Items for Vehicles 516 and 517

REFERENCE: M memorandum to the Administrator, dated June 2, 1968, same subject
D memorandum to the Administrator, dated July 31, 1968
AD memorandum to M dated July 13, 1967

After reviewing the referenced documentation and in consideration of the FY 1969 budget situation, your request to expend additional funds for the procurement of long lead time items for the S-IC stages of the 516 and 517 vehicles is disapproved. The decision, in effect, limits at this time the production effort of Saturn through vehicle 515. No further work should be authorized for the development and fabrication of vehicles 516 and 517.

James E. Webb
Administrator

Document II-59

Document Title: Memorandum to Manager, Apollo Spacecraft Program from Chief, Apollo Data Priority Coordination, "Re: LM rendezvous radar is essential," 1 August 1968.

Source: Folder #18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

One of the key managers of Project Apollo at the Manned Spacecraft Center was Howard W. "Bill" Tindall. He became famous throughout the program for his "Tindallgrams," messages expressed in direct, often pithy terms. This is an example. The high official referred to was George Mueller, NASA Associate Administrator for Manned Space Flight.

TO : PA/Manager, Apollo Spacecraft Program DATE: AUG 1 1968 [stamped]

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: LM rendezvous radar is essential

A rather unbelievable proposal has been bouncing around lately. Because it is seriously ascribed to a high ranking official, MSC and GAEC are both on the verge of initiating activities - feasibility studies, procedures development, etc. - in accord with it. Since effort like that is at a premium, I thought I'd write this note in hopes you could proclaim it to be a false alarm or if not, to make it one. The matter to which I refer is the possibility of deleting the rendezvous radar from the LM.

The first thing that comes to mind, although not perhaps the most important, is that the uproar from the astronaut office will be fantastic - and I'll join in with my small voice too, for the following reason. Without rendezvous radar there is absolutely no observational data going into the LM to support rendezvous maneuvers. This would be a serious situation both during the major rendezvous maneuvers (CSI, CDH, and TPI) and during terminal braking. Please let me discuss these separately.

First of all, let it be clearly understood the MSFN cannot support rendezvous maneuver targeting during lunar operations. That must be an entirely onboard operation due to limitations in MSFN navigation (i.e., orbit determination) using short arcs of data on a maneuvering spacecraft and because much of the rendezvous is conducted out-of-sight - and - voice of the earth. In other words, we couldn't tell them what to do if we knew!

Therefore, without the LM radar the only source of maneuver targeting is the CSM. Using what? A VHF ranging device to be flown for the first time on the lunar mission and a spacecraft computer program (Colossus), which does not have the CSI and CDH targeting programs in it. Thus, the CSM pilot would have to use charts! I'd like to emphasize the fact, though, that the CSM pilot is so busy making sextant observations (which are mandatory - VHF alone is not adequate) and performing mirror image targeting, etc. along with routine spacecraft management that it has been concluded he can not and will not perform onboard chart computations.

[2] And - even if we were to think negative schedule-wise and assume we will get a flight qualified VHF ranging device and CSI/CDH targeting in Colossus, Jr. in time for the lunar mission, I can't believe we'd be willing to fly a rendezvous with no backup or alternate data source for comparison. The ΔV margins are too small and the consequence of failure is unacceptable!

Now, let me speak of terminal phase braking. Range and range rate information are essential for this operation. This can be obtained crudely by visual means and without radar that's the only source. (Lighting conditions must be satisfactory - although poor CSI/CDH targeting will cause TPI time slippage almost certain to mess it up.) The DSKY displays of range and range rate from the computers are based on the state vectors obtained by the rendezvous navigation and they degrade badly at close ranges. That is, their usefulness is highly questionable. (Unless lunar operations are better than "earthal," they are worthless; I'm not sure if lunar is better or not.) So it's the eyeballs then and plenty of RCS.

If I sound like I'm on some higher energy level about this, it's cause I am. I'm sure most will agree that a rendezvous radar failure is the worst that can happen in the PGNCS (and AGS) during rendezvous since without it all data is lost. (For example, the current "D" rendezvous mission rule is that rendezvous radar failure dictates aborting the rendezvous exercise, the CSM goes active for TPI and midcourse corrections, using the sextant, and whoever can see best will give a try at braking.)

Please see if you can stop this if it's real and save both MSC and GAEC a lot of trouble.

[signed]

Howard W. Tindall, Jr.

Document II-60

Document Title: George M. Low, "Special Notes for August 9, 1968, and Subsequent," 19 August 1968.

Source: Papers of George M. Low, Rensselaer Polytechnic Institute, Troy, New York.

Document II-61

Document Title: Sam C. Phillips, Apollo Program Director, "Apollo Mission Preparation Directive," 19 August 1968.

Source: Folder #18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

Document II-62

Document Title: Letter to Robert Gilruth, Director, NASA Manned Spacecraft Center, from George E. Mueller, NASA Associate Administrator for Manned Space Flight, 4 November 1968.

Source: NASA Manned Spacecraft Center Archives.

Document II-63

Document Title: George M. Low "Special Notes for November 10 and 11, 1968," 14 November 1968.

Source: Papers of George M. Low, Rensselaer Polytechnic Institute, Troy, New York.

Document II-64

Document Title: Memorandum to Associate Administrator for Manned Space Flight [George Mueller] from Apollo Program Director [Sam C. Phillips], "Apollo 8 Mission Selection," 11 November 1968.

Source: Papers of George M. Low, Rensselaer Polytechnic Institute, Troy, New York.

Document II-65

Document Title: Memorandum to Associate Administrator for Manned Space Flight [George Mueller] from Acting Administrator [Thomas Paine], 18 November 1968.

Source: Papers of George M. Low, Rensselaer Polytechnic Institute, Troy, New York.

One of the boldest decisions made during the Apollo program was to send astronauts into lunar orbit on the first Saturn V launch with a crew aboard. The result was the 21–27 December 1968 Apollo 8 mission which carried Frank Borman, James Lovell, and Bill Anders into lunar orbit on Christmas eve and produced the iconic "Earthrise" picture of the blue Earth rising over the desolate lunar surface.

This series of documents illustrates how this decision was made. Apollo program manager George M. Low periodically dictated what he called "special notes" as a chronicle of the Apollo program *from his central perspective. These notes, which were supplemented by official documents, form an invaluable record of space policy and management actions from 1967 until Low left NASA in 1976. In his August and November 1968 notes, Low narrates the series of events and decisions that led to the decision to fly Apollo 8 around the Moon. Perhaps most remarkable were the events of 9 August, which began with a brief conversation about the desirability of such a decision between Low and the Director of the Manned Spacecraft Center Robert Gilruth and, by the time the day was over, involved key Apollo decision makers in Houston, Huntsville, and Washington. When NASA Administrator James Webb and Head of Manned Space Flight George Mueller, who were attending a United Nations Conference in Vienna, Austria, heard of the Apollo 8 plan, they were taken quite aback, and insisted that no decision be announced until after the Apollo 7 mission, which was to test the post-fire Apollo Command and Service Modules in Earth orbit. Although final approval of the preliminary decisions taken that day would be months in coming, it is remarkable that the basics of such a momentous choice could be put in place in just a few hours on one day, and then put in motion a few days later.*

The Apollo 8 lunar orbit mission was designated C' (C Prime) because it was inserted in the previously planned Apollo mission sequence which included the following missions: C – test of the Apollo Command and Service module in low Earth orbit; D – test of the Apollo Command and Service and Lunar Modules in low Earth orbit; E – test of the Apollo Command and Service and Lunar Modules in a mission beyond Earth orbit, but not headed to the moon; F – test of all equipment in lunar orbit; and G – lunar landing mission.

There is no mention in any of these documents of any concern that the Soviet Union might be able to fly a cosmonaut crew around the M oon before the United States was able to send its astronauts to the lunar vicinity, even though intelligence estimates and several 1968 flights of the Soviet "Zond" spacecraft suggested that such a mission might be in preparation.

In addition to Low's notes, documents included here are reservations about the wisdom of undertaking the mission raised by Associate Administrator for Manned Space Flight George Mueller, Apollo Program Manager Lieutenant General Sam Phillip's memoranda making the changes in mission plans that would allow the circumlunar choice and formally recommending approval of the circumlunar Apollo 8 mission, and NASA Acting Administrator Thomas Paine's memorandum documenting his decision to approve that recommendation.

Document II-60

SPECIAL NOTES FOR AUGUST 9, 1968, AND SUBSEQUENT

Background:

June, July 1968. The current situation in Apollo was that LM - 3 had been delivered to KSC somewhat later than anticipated; and CSM 103 would be delivered to KSC in late July. Checkout of 101 at KSC was proceeding well, and a launch in the Fall of 1968 appeared to be assured. There was every reason to believe that 103 would also be a mature spacecraft but that for many reasons LM-3 might run into difficulties. Certification tests of LM were lagging; there were many open failures; and the number of changes and test failures at KSC was quite large.

It had been clear for some time that a lunar landing in this decade could be assured only if the AS 503/CSM 103/LM 3 mission could be flown before the end of 1968. During the June-July time period the projected launch date had slipped from November into December, and the December date was by no means assured. The over-all problem was compounded by the Pogo anomaly resulting from the Apollo 6 mission, and this remained a significant unknown.

In this time period also the possibility of a circumlunar or lunar orbit mission during 1968, using AS 503 and CSM 103, first occurred to me as a contingency mission to take a major step forward in the Apollo Program.

July 20 to August 5, 1968. By now the Pogo situation looked a lot more encouraging. MSFC had demonstrated analytically that a relatively simple launch vehicle fix was available to cure the problem. The results of many tests and analyses at MSC led to the general conclusion that the Spacecraft/LM Adapter problem would most likely be cured if the launch vehicle Pogo is cured.

In the same time period, work on CSM 103 continued to progress somewhat slower than expected but in a satisfactory manner. Delivery of the spacecraft to KSC during the second week of August was virtually assured. The spacecraft was extremely clean. LM-3, however, required much more work at KSC than anticipated. There was a significant number of changes in addition to test failures, requiring trouble-shooting, changeouts and retest, and a serious EMI problem that continued to persist. The [2] outlook for a 1968 launch, although mathematically still possible, appeared to be very dim.

August 6, 1968. Presented a long list of LM changes to the OMSF Management Council review in Houston. In collecting this information it had become more and more apparent that we still weren't quite on top of the situation and that the list of problems continued to grow instead of decreasing.

August 7, 1968. With the background of open work and continued problems on LM-3 and the real concern that the mission might not be able to fly until February or March, 1969, I asked Chris Kraft to look into the feasibility of a lunar orbit mission on AS 503 with CSM 103 and without a LM.

August 8, 1968. Spent the day at KSC, reviewing 503 open work and schedules with Debus, Petrone, Phillips, Hage, Bolender, and many others. The official KSC schedule showed an earliest possible launch date during the first week of January, 1969; however, the EMI problem was still open. KSC pointed out that the hardware changes were not the real cause of the problem. The many retest requirements and checkout problems caused real concern. There was little confidence in the assembled group that the early January launch date could be met. In fact, until the EMI problem was solved, things were essentially at a standstill.

Steps in Planning the Mission:

August 9, 1968. Met with Gilruth at 0845 and reported to him the detailed status of LM-3 and CSM 103 and informed him that I had been considering the possibility of an AS 503 lunar orbit mission. Gilruth was most enthusiastic and indicated that this would be a major step forward in the program.

Met with Chris Kraft at 0900, and he indicated that his preliminary studies had shown that the mission was technically feasible from the point of view of ground control and onboard computer software. (A step of major importance to make this possible had been taken several months ago when we had decided to use the Colossus onboard computer program for the 103 spacecraft.)

At 0930, I met with Gilruth, Kraft and Slayton. After considerable discussion, we agreed that this mission should certainly [3] be given serious consideration and that we saw no reason at the present time why it should not be done. We immediately decided that it was important to get both von Braun and Phillips on board in order to obtain their endorsement and enthusiastic support. Gilruth called von Braun, gave him the briefest description of our considerations, and asked whether we could meet with him in Huntsville that afternoon. I called Phillips at KSC and also informed him of our activities and asked whether he and Debus could join us in Huntsville that afternoon. Both von Braun and Phillips indicated their agreement in meeting with us, and we set up a session in Huntsville for 2:30 p.m.

August 9, 1968 - 2:30 p. m. Met in von Braun's office with von Braun, Rees, James and Richard from MSFC; Phillips and Hage from OMSF; Debus and Petrone from KSC; and Gilruth, Kraft, Slayton and Low from MSC. I described the background of the situation, indicating that LM-3 has seen serious delays and that presently we were one week down on the KSC schedule, indicating a 31 December launch. I went on to indicate that, under the best of circumstances, given a mature spacecraft, we might expect a launch at the end of January; however, with the present situation on LM, I would expect that the earliest possible D mission launch date would be during the middle of March. It therefore appeared that getting all of the benefits of the F (lunar orbit) mission before the D mission was both technically and programmatically advisable. Under this concept a lunar orbit mission, using AS 503 and CSM 103, could be flown in December, 1968. The most significant milestone in this plan would have to be an extremely successful C mission, using CSM 101. However, if 101 were not completely successful, an alternate to the proposed mission would be a CSM alone flight, still in December, using AS 503 and CSM 103 in an earth orbital flight rather than a lunar orbit flight. Under this plan the D mission would be flown on AS 504 with CSM 104 and LM-3, probably still in mid-March. In other words, we would get an extra mission in ahead of the D mission; would get the earliest possible Pogo flight; and would get much of the information needed from the F mission much earlier than we could otherwise. Chris Kraft made the strong point that, in order to gain the F mission flight benefits, the flight would have to be into lunar orbit as opposed to circumlunar flight.

During the remainder of the meeting in Huntsville, all present exhibited a great deal of interest and enthusiasm for this flight.

[4] Phillips outlined on the blackboard the actions that would have to be taken over the next several days. Generally, KSC indicated that they could support such a mission by December 1, 1968; MSFC could see no difficulties from their end;

MSC's main concern involved possible differences between CSM 103 and CSM 106, which was the first one that had been scheduled to leave earth orbit, and finding a substitute for the LM for this flight.

The Huntsville meeting ended at 5 p.m. with an agreement to get together in Washington on August 14, 1968. At that time the assembled group planned to make a decision as to whether to proceed with these plans or not. If the decision was affirmative, Phillips would immediately leave for Vienna to discuss the plans with Mueller and Webb, since it would be most important to move out as quickly as possible once the plan was adopted. It was also agreed to classify the planning stage of this activity secret, but it was proposed that, as soon as the Agency had adopted the plan, it should be fully disclosed to the public.

August 9, 1968 - 8:30 p.m. After returning to Houston, held a meeting with Kleinknecht, Bolender, Dale Myers of NR, and George Abbey. We agreed to move out as described earlier with a view toward identifying any difficulties over the weekend. Bolender immediately left for Bethpage to discuss the proposal with GAEC and to find the best possible LM substitute. Myers returned to Downey to work the problem from that end.

August 10, 1968. No difficulties identified as yet. Kleinknecht is defining detailed configuration differences between CSM 103 and 106, and the most outstanding difficulty will probably be in the area of the high gain antenna. (This was known at the time the plan was discussed on August 9.) Insofar as a LM substitute is concerned, it looks as though LM-2 might be able to support this flight. Kotanchik, however, made a strong point that we should not fly a LM but install a simple crossbeam instead. He indicated that if a residual Pogo problem remained, it would be best not to have a LM on this flight; and if Pogo were solved, the LM would not be necessary. I discussed this with Hage in Washington and Richard at MSFC. Both agreed that a high-fidelity LM would not be necessary but that a mass representation might be required to avoid Saturn V control systems dynamics problems.

I also discussed the proposed mission with Bill Bergen, who appeared less receptive than most of the people who had been exposed to this plan.

[5] August 12, 1968. Held many meetings and telephone conversations on the subject of the new mission during the day.

Kraft indicated that the biggest constraint was the launch window; a December 20 launch would be required if a daylight launch was desired. (All agreed that for the first manned Saturn V flight a daylight launch would be a requirement.) We thought it would be best to plan for a December 1 launch and build in a "hold" period until December 20 to give maximum assurance of meeting that date.

In the area of a LM substitute, LTA-B appeared on the scene. This test article had been through the dynamic test vehicle program at MSFC and was now stored at KSC, ready for an unmanned 503 launch. It has the proper mass distribution and is in a flight-ready condition. All except Kotanchik agreed that this would be a good choice. Kotanchik made a strong point that we should fly with a lightweight crossbeam in order to get a maximum possible safety factor in the SLA region. During several discussions with MSFC we determined that this was not possible for the previously stated reasons concerning the launch vehicle dynamics.

GAEC proposed that LM-2 should not be flown in order to save it for the drop test program. They suggested instead that we build an LTA-4, consisting of the LM-9 descent stage with LM-8 ascent stage. However, since this would take another flight LM out of the program, I concluded that LTA-B would be our best choice.

August 13, 1968. Continued working detailed problems in Houston. A thorough analysis of configuration differences between 103 and 106 identified the high gain antenna as the most critical item. However, Kraft indicated that it would be possible to fly the mission even if the high gain antenna should fail during the flight. There were no "show stoppers" in any of the spacecraft systems and, in fact, only minor changeouts would have to be made to bring the spacecraft into a position to fly the proposed mission.

Kraft had reviewed all of the operational elements and determined that there would be no insurmountable difficulties. The available launch window will be from December 20 to December 26 (with the exception of December 25). In early January a launch window with an Atlantic injection would become available, and toward the end of January another Pacific injection window would open up.

[6] Slayton had decided to assign the 104 crew to this mission (Borman, Lovell and Anders, backed up by Armstrong, Aldrin and Haise) in order to minimize possible effects on the D mission. Slayton had talked to Borman on Saturday and found him to be very much interested in making this flight.

August 14, 1968. Went to Washington with Gilruth, Kraft and Slayton to meet with Paine, Phillips, Hage, Schneider and Bowman from Headquarters; von Braun, James and Richard from Marshall; and Debus and Petrone from KSC. The meeting started with an MSC review of spacecraft, flight operations, and flight crew support for the proposed mission. I reviewed the Spacecraft 103 hardware configuration, the proposed LM substitute, consumable requirements, and the proposed alternate mission. Copies of the charts used in this review are attached. [not included]

Kraft indicated that there were no major problems with either the MSFN or the Mission Control Center and flight operations. He discussed the launch window constraints and indicated that NASA management would have to get with the Department of Defense in order to obtain recovery support. Our conclusion was that we should go for the December 20, 1968, launch window with a built-in two week hold prior to the launch. Then, if it is logistically possible to shift to the Atlantic insertion period, we should try for the January 3, 1969, launch window if we miss the December launch window. If this is not feasible, we would have to go from the December 20 date to the January 20 date.

MSFC indicated that there were no significant difficulties with the launch vehicle to support this mission. We agreed that LTA-B would be loaded for a total payload weight of 85,000 pounds. MSFC also agreed that they could provide telemetry for the LTA-B measurements.

Petrone outlined his plans for activities at KSC and indicated that the earliest possible launch date would be December 6, 1968. Other dates included the first manned altitude chamber run on September 14; the move to the VAB on September 28; and move to the pad on October 1.

We also discussed the mission sequence to be followed after the proposed mission and proposed that the best plan would be to fly the D mission next, followed by an F mission, which, in turn, would be followed by the first lunar landing mission. In other words, the [7] proposed mission would take the place of the E mission but would be flown before D. MSC also proposed that for internal planning purposes we should schedule the D mission for March 1, 1969; the F mission for May 15, 1969; and the G mission for July or August, 1969. However, dates two weeks later for D, one month later for F, and one month later for G should be our public commitment dates.

During the course of the meeting Phillips received a call from George Mueller in Vienna. Apparently Phillips had discussed the proposal with Mueller on the previous day, and after thinking it over, Mueller's reception was very cool. Mueller was concerned over stating the plan before the flight of Apollo 7 and was against announcing a plan as we might have to back away from it if 101 did not work. He also indicated that Phillips' arrival and departure in Vienna might create problems with the press and therefore urged Phillips not to come. Mueller's plans were to return to the country on August 21 for a speech in Detroit, and he would not be able to meet with us in Washington until August 22.

All present indicated that we would have to move out immediately in order to meet the December launch window and that a delay until August 22 or later would automatically mean the mission would have to slip until January. It was also hard for us to believe that Mueller was unwilling to accept the plan which was unanimously accepted by all Center Directors and Program Managers. We again urged Phillips to review our findings with Mueller and make a strong plea to visit Mueller in Vienna immediately, assuming, of course, that it was not possible for Mueller to return to this country. We also pointed out that if we were to implement our plan with any degree of confidence, so many people would have to become involved that it would be impossible to keep it quiet for very long.

Following the over-all discussions of the mission, Dr. Paine indicated that it had not been too long since we were uncertain as to whether the Apollo 503 mission should even be manned. Now we were proposing an extremely bold mission. Had we really considered all of the implications? He specifically wanted to know whether anyone present was against making this move. In going around the table, one by one, the following comments were made:

von Braun: Once a decision has been made to fly a man on 503, it doesn't matter to the launch vehicle how far we go. From the [8] program point of view, this mission appears to be simpler than the D mission. The mission should by all means be undertaken.

Hage: There are a number of way stations in the mission. Decision points can be made at each of these way stations, thereby minimizing the over-all risk. I am all for the mission.

Slayton: This is the only chance to get to the moon before the end of 1969. It is a natural thing to do in Apollo today. There are many positive factors and no negative ones.

Debus: I have no technical reservations; however, it will be necessary to educate the public, for if this is done wrong and we fail, Apollo will have a major setback. By all means fly the mission.

Petrone: I have no reservations.

Bowman: It is a shot in the arm for manned space flight.

James: Manned safety in this flight and in the following flights is enhanced. The over-all Apollo budget and schedule position is enhanced. An early go-ahead is needed.

Richard: The decision to fly manned has already been made for 503. Our lunar capability in Apollo is enhanced by flying this mission now.

Schneider: This has my whole-hearted endorsement. There are very valid reasons for pressing on.

Gilruth: Although this may not be the only way to make our goal, it certainly enhances our possibility. There is always risk in manned space flight, but this is a path of less risk. In fact, it has a minimum risk of all of our Apollo plans. If I had the key decision, I would make it in the affirmative.

Kraft: Probably the flight operations people have the most difficult job in this. We will need all kinds of priorities. It will not be easy to do, but I have every confidence in our doing it. However, it should be a lunar orbit mission and not a circumlunar mission.

[9]

Low: This is really the only thing to do technically in the current state of Apollo. Assuming a successful Apollo 7 mission, there is no other choice. The question is not whether we can afford to do it, it should be can we afford not to do it.

Following this set of comments, Paine congratulated the assembled group for not being prisoners of previous plans and indicated that he personally felt that this was the right thing for Apollo and that, of course, he would have to work with Mueller and Webb before it could be approved.

Phillips indicated that his conclusion was that this was a technically sound thing to do and does not represent a short cut introducing additional risks. Our plan would be to meet with Mueller on Thursday, August 22, in Washington. Phillips reiterated Mueller's reservations. These included reservations about program risks such as possible questions about irresponsible scheduling, possible program impact if the Apollo 7 mission should fail and we could not proceed with an announced major step forward, and the question concerning program impact of a catastrophic failure on this special mission.

At the conclusion of the meeting we agreed to move out on a limited basis. Since the day-by-day timing was critical, Phillips agreed that we should involve the next level of people required to carry forward with our plans, giving them, of course, proper instructions about the current security classification of the mission. At the conclusion of the meeting Phillips indicated the earliest possible decision would come in 7 to 10 days under the best of circumstances.

August 15, 1968. Received a call from Phillips while at Bethpage for a GAEC CCB. Phillips indicated "we broke the log jam" and that Mueller had agreed to our plan. However, he would prefer if publicly we did not commit to the total plan but indicate only that AS-503 mission would be flown without a LM; that we were reviewing many objectives for the actual mission; and that these objectives included plans for an earth orbital flight like the Apollo 7 mission and plans for a lunar orbital flight; the final mission decision would not be made until after the Apollo 7 flight. The internal program directive, however, would be that we should make our plans for the most difficult mission and that our planning should proceed for a lunar orbit mission in December.

[10] Later in the day, Phillips and Paine discussed the plan with Webb, who apparently had not yet heard from Mueller. (Webb is in Vienna, too.) Webb wanted time to think about the plan and requested that information be sent to him via diplomatic courier. Paine and Phillips expected a call from Webb and Mueller on August 16, 1968.

I discussed our plans with Lew Evans at GAEC. He, of course, had previously been informed by Joe Gavin. Evans' reaction was very favorable, indicating that this was the best thing that Apollo could do at this time.

August 16, 1968. No news from Washington today. Apparently Phillips and Paine have been in meetings most of the day with some correspondence going back and forth to and from Vienna. Late in the day, Phillips called and indicated that he and Hage would come to Houston tomorrow to meet with Gilruth, Kraft, Slayton and Low to decide how to proceed within the constraints imposed by Mr. Webb.

In the meantime, we worked several of the detailed problems and moved out on many of the required spacecraft changes. Kleinknecht asked Arabian to be sure that we will have a high-gain antenna. We moved out on several other spacecraft changes, without divulging to the people involved why the changes are required. (Many of the changes we are authorizing today were firmly turned down in recent CCB's.)

August 17, 1968. Phillips and Hage came to Houston to meet with Gilruth, Kraft, Slayton and Low. Phillips indicated that we have clear-cut authority from Mr. Webb to prepare for a December 6 flight of 103/LTA-B/503; that this mission will be known as the C' [C prime] mission, designated as Apollo 8; that the E mission crew will fly this mission; that this will be an earth-orbital mission with basic objectives to mature the CSM and Saturn V systems; and that we may proceed with studies and plans to gain the maximum flexibility when the final C' mission objectives are defined after Apollo 7.

Webb also authorized preparation of 104/LM-3/504 for a February 20 flight of the D mission.

A copy of General Phillips' notes on this subject is attached. Also attached is a copy of a telegram from Mr. Webb to Dr. Paine. [not included]

Phillips indicated that the major problem expressed by Dr. Mueller was that we could not obtain clearance to proceed with a lunar orbit mission until after the results of Apollo 7 were available.

[11]

Phillips indicated that Webb's initial reaction (on August 15) was one of shock and that he was fairly negative to the proposed lunar orbital mission. Following this, Paine and Phillips sent a lengthy paper to Vienna, giving the rationale for the need to change the mission sequence and proposing that the full range of capabilities from earth orbital up to lunar orbit should be authorized and discussed publicly. However, for many reasons Webb was unwilling to permit a commitment at this time beyond an earth orbital mission. Phillips was convinced, however, that Webb would consider going all the way to a lunar orbital mission after Apollo 7, provided, of course, that Apollo 7 was a successful flight.

Our challenge, therefore, is to be prepared to carry out a full lunar orbit mission without committing the Agency to such a mission at this time. This had been our objective as well, even during our initial meeting in Huntsville, but at that time we saw no way to achieve this.

We discussed many alternatives, always keeping in mind that we had to be completely honest and forthright with Dr. Mueller, Dr. Paine and Mr. Webb, and be prepared to fly an earth orbital mission in December. However, we wanted to keep the door open to be able to fly a lunar orbital mission, should we be ready to do so after Apollo 7. At the same time we agreed that whatever we did, we would have to be perfectly honest within NASA and with the press in stating what we were doing and why we were doing it.

Our first consideration was to determine whether the C' mission as presently defined should be like a C mission (low earth orbit) or like an E mission (4000 miles apogee). My recommendation was to make it like E, because this would give a better public justification for selecting the Borman crew and because it would demonstrate a step forward, publicly, beyond the C mission. However, since Mr. Webb's main concern had been that we should not announce and implement plans from which we would later have to retrench, Phillips decided it would be best to define the C' mission to be like a C mission, with the Saturn V launch vehicle instead of the Saturn I-B.

After much discussion, we finally decided that the most important thing Apollo can achieve this year is a lunar capability in hardware, software, crew training, etc. This, we believe, is necessary whether the C' mission goes to the moon or not. We also agreed that the only [12] way to achieve this lunar capability is to plan the mission as though it were going to fly to the moon. By so doing, all involved would, without question, have to face the real issues and make the real decisions that would allow us to go to the moon. An earth orbital mission would, of course, be a natural fallout because such a mission would have to be an abort option for a lunar mission in the event that the S-IVB stage could not make its second burn. Therefore, by planning such a mission, we would have, in December, an earth orbital capability on the C' mission while at the same time having completed all the planning and preparation that would be necessary should conditions be such that we could go to the moon. We would not commit now, either within NASA or outside, to do any more than the earth orbital mission.

This plan was adopted, and the over-all program plan can best be summarized as follows:

a. AS-503, designated Apollo 8, will be prepared to be ready for launch on December 6, 1968. It will consist of CSM 103, LTA-B, and AS-503. The reasons for making the change from the previously defined mission are that this will give us the earliest possible Pogo checkout flight and that LM checkout delays have prevented us from making an early flight with the LM.

b. The mission will be designated as C'. It will be an earth orbital mission, including whatever elements of C need to be repeated and elements of D, E, F, and G that can be incorporated.

c. Final definition of the mission will not come after Apollo 7.

d. The crew will be the E mission crew so that the D mission crew can continue its active preparation for that mission.

e. We recognize that after the C' mission the remaining missions will be upon us and that it is essential to bring lunar capability into being while we are implementing the C' mission. This includes lunar capability in hardware, software, flight operations, and crew operations.

f. This capability can only be brought into being if we plan for it now. Therefore, we will do all of our planning for the C' mission as though it were a lunar orbit mission. This will give us maximum flexibility to fly the assigned earth orbital mission with whatever elements of all other missions, including the lunar landing mission, are best to put into that flight after the results of Apollo 7 are known.

[13]

August 19, 1968. Received a copy of the proposed press release and program directive sent from Phillips to Gilruth. (A copy is attached.) A supplement to the program directive, which will authorize the planning to obtain the capability for a lunar orbit mission, is still in work in Washington.

Held my regular ASPO staff meeting and summarized our proposed plans as outlined in the August 16 notes. Dr. Gilruth held a Senior Staff Meeting, informing other Center elements of this approach. Phillips held a press conference in Washington which, from all reports, also went according to plan. Our job now is to implement the C' mission and, as stated, bring along the lunar capability at the same time. These special notes will be discontinued and the effort in implementing the C' mission will be reported in my daily notes to Dr. Gilruth.

Document II-61

FOR OFFICIAL USE ONLY

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

19 August 1968

TO: Director
John F. Kennedy Space Center, NASA
Kennedy Space Center, Florida 32899

Director
George C. Marshall Space Flight Center, NASA
Marshall Space Flight Center, Alabama 35812

Director
Manned Spacecraft Center, NASA
Houston, Texas 77058

FROM: Apollo Program Director

SUBJECT: Apollo Mission Preparation Directive

The following changes will be made in planning and preparation for Apollo flight missions:

1. Apollo-Saturn 503

a. Assignment of Saturn V 503, CSM 103 and LM-3 to Mission D is cancelled.

b. Saturn V 503 will be prepared to carry CSM 103 and LTA B on a manned CSM only mission to be designated the C prime mission.

c. The objectives and profile of the C prime mission will be developed to provide the maximum gain consistent with standing flight safety requirements in maturing of the Apollo-Saturn V space system in earth orbital operation. Studies will be carried out and plans prepared so as to provide reasonable flexibility in establishing final mission objectives after the flight of AS 205.

[2] d. All planning and preparations for the C prime mission will proceed toward a launch readiness date of 6 December 1968.

2. <u>Apollo-Saturn 504</u>

a. Saturn V 504, CSM 104, and LM-3 are reassigned to the D Mission.

b. The D Mission will be scheduled for launch readiness no earlier than 20 February 1969 with all mission and hardware preparations proceeding toward that goal.

3. <u>Crew Assignment</u>

a. The crews now assigned to the D Mission remain assigned to the D Mission. The crews currently assigned to the E Mission are reassigned to the newly defined C prime mission.

4. <u>Crew Training and Equipping and Operational Preparations</u>

b. Training and equipping of the D Mission crews and operational preparations will proceed as previously planned but to meet the newly established flight readiness date.

c. Training and equipping of the C prime crews and operational preparations will proceed as required to meet mission requirements and to meet the newly established flight readiness date.

/Signed/
Sam C. Phillips
Lt. General, USAF
Apollo Program Director

[3]

Proposed Press Release by NASA Headquarters

NASA Acting Administrator Thomas O. Paine announced that Lunar Module operations will be dropped from the first manned Apollo-Saturn V flight, Apollo

8. Dr. Paine also stated that the Office of Manned Space Flight will begin planning for an alternate manned Command and Service Module mission for launch in December.

Dr. Paine emphasized that no final decision will be made on the precise mission plan for the alternate flight until after the first manned Apollo flight (Apollo 7) this Fall. Apollo 7 is a mission of up to 10 days duration to complete flight qualification of the Command and Service Modules.

To assure greatest value from the mission, planning and training for Apollo 8 must begin in the period before the Apollo 7 mission is flown but the final content of the mission plan will be selected only after the Apollo 7 mission results are evaluated.

Lunar Module 3, which has been delayed in checkout, will be flown next year on the fourth Saturn V (AS 504) with Command and Service Modules No. 104. This decision is based on preliminary studies which indicate that many Apollo program objectives scheduled for later flights can be attained by utilizing the Apollo 8 Command Service Module mission.

[4]

2.

General Samuel Phillips, Apollo Program Director, said one very important advantage of flying Apollo 8 this year is the opportunity for earlier experience in the operation of the Saturn V and Command and Service Modules then can otherwise be obtained. Two problems previously experienced in the Saturn Apollo systems – vertical oscillation or "POGO effect" in the first stage of the Saturn V and the rupture of small propellant lines in the upper stages – have been corrected and the solutions verified in extensive ground tests.

Document II-62

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Washington, D.C. 20546
November 4, 1968

Dr. Robert R. Gilruth, Director
Manned Spacecraft Center
National Aeronautics and Space Administration
Houston, Texas 77058

Dear Bob:

In inviting the Apollo Executives and their program managers to meet with us on November 10, it is with the deepest recognition that the Apollo 8 mission involves many issues in addition to the technical capabilities of the Apollo systems. Before reaching a decision of such importance to the total national space program, we must be sure that we have weighed all the considerations, and evaluated their advantages and disadvantages.

There are grave risks to the program as a whole, not just to the Apollo 8 mission, in embarking on a lunar orbit mission with the second manned flight of the CSM. We have to face the possibility that this type of mission could appear to the public, and to our peers in government, to be a precipitous, risky venture where the propaganda value is the only gain. In assessing the alternatives, I am concerned that I have seen no real criticism of a lunar orbit mission. The general reaction both inside and outside NASA has been one of enthusiasm and anticipation of a major feat. Yet, you and I know that if failure comes, the reaction will be that anyone should have known better than to undertake such a trip at this point in time. Considering the potential risks to the public acceptance of the program and the basic confidence in future manned space flight, the very vital issues are:

1. Does a C' mission move us measurably towards a lunar landing?

2. Does it enhance the probability of a safe landing in the future?

3. What do we gain in a technical sense from carrying out a C' mission?

4. What are the consequences of a failure?

[2]

On the pro side, it is quite clear that any vehicle can experience a failure; however, it is reasonable to believe that since the first manned CSM, Apollo 7, performed well for 10.8 days, the second manned CSM can be just as successful and as safe as the third, fourth, or fifth flight. Although different to some extent, each lunar-capable CSM is built and checked out to give a consistent performance. From the standpoint of the probability of reliable performance, unless basic design flaws are uncovered, each flight should be equally likely to succeed. The technical advantages of obtaining early information on communications, navigation, guidance and control, thermal conditions, and gravitational potential at lunar distances are clearly positive gains in increasing the safety and success of subsequent missions. Perhaps the greatest single advantage is the motivation that the alternate planning for a lunar orbital mission has given to the entire Apollo organization. Since the establishment of the lunar orbital mission as an Apollo 8 alternate three months ago, the Apollo Program has been meeting every one of its major milestones.

On the con side, a lunar orbital mission involves a very difficult decision in that we are dealing with a complex, new vehicle. The paradox between the 501 and 502 launch vehicle performances illustrates this point. In addition, there is the obvious risk of being three days instead of one hour away from land. I must say that as far as I can see, and depending on the detailed Apollo 7 results and Apollo 8 evaluations and reviews, the CSM should perform consistently, and the risks from a purely technical aspect are probably reasonable and acceptable. If such a mission failed, however, the risks to the program as a whole could be significant.

I would very much appreciate your thoughtful consideration of these aspects of the decision, as well as any other facets of the problem which we may not have considered, so that we may benefit from your views at the meeting on Sunday.

One technique that we have been using in our considerations of the risk involved is the Mission Risk Assessment Form. I am sending along a copy of the form and an explanation of its use. I have found it helpful in trying to arrive at an assessment of how to minimize the overall risk of a lunar landing. If you can find the time to complete the form and wish to provide me with a copy, I would be very grateful.

[3]

I am looking forward to our meeting on Sunday. Again, you have my personal thanks and appreciation for your willingness to give up so much of your time for the progress of the Apollo Program.

Sincerely,
[Signed George]

Associate Administrator
For Manned Space Flight

Document II-63

SPECIAL NOTES FOR NOVEMBER 10 AND 11, 1968

Introduction:

During the period of August 9 to August 19, 1968, I set forth in some special notes the activities that took place in that time period concerning the Apollo 8 lunar orbit flight.

In the intervening time since the middle of August, planning in the entire manned space flight organization has proceeded in accordance with the steps outlined in the earlier notes. Spacecraft checkout went extremely well, and a modification period to make those changes that were necessitated by the mission reassignment took place in good order. The spacecraft went through its unmanned and manned altitude chamber tests, was moved to the VAB, erected on AS 503, and moved to the launch pad several days prior to the Apollo 7 flight. In the same time period, all of the mission planning and flight crew training also focused on the planned circumlunar flight. No new factors came to light that weren't understood, at least in general terms, at the time of the mid-August decisions.

The Apollo 7 flight took place in the period from October 11 to October 22. All of the mission objectives were accomplished, and the spacecraft's performance far exceeded my expectations. There were, of course, some anomalies with the equipment; but, in general, these were explained either during the flight or shortly after the flight. There was no question in any of our minds after completion of the Apollo 7 flight that the Apollo 8 flight should perform the lunar orbit mission. During the flight, as well as after the flight, we had a series of reviews with Phillips, Mueller, and the Management Council, discussing the present status of the hardware, mission operations, and crew training, over and over again. If anything, the period was marked by so many reviews that many of us felt that we really didn't have the time to do the job at hand. The reviews culminated in two meetings in Washington on November 10 and 11, 1968, first with the Apollo Executives and then with NASA management. The details of these meetings are as follows:

Apollo Executives Meeting, November 10, 1968

This meeting started with an introduction by Phillips, giving the background of the Apollo 8 mission recommendation, the sequence of [2] of [*sic*] flight missions, and a summary of the present status. Following Phillips' introduction, Lee James reported on the launch vehicle status, its readiness for manned flight, and the results of all of the work in connection with POGO.

Following Lee James' briefing, it was my turn to discuss the spacecraft situation and our readiness to complete a lunar orbit flight. I indicated that the pertinent questions were:

a. Is the spacecraft design adequate?

b. Will the systems perform as designed?

c. Are the benefits worth the risks?

I felt that it was important to cast the issues in this light, since over the last several weeks we have been asked many questions that indicated that people really didn't understand that the mission we are about to fly is the design mission for the Apollo spacecraft. It is a mission that we would have had to face sooner or later anyway, and the risk involved in performing the mission now after a successful Apollo 7 flight is no greater than it would be a year from now. I went into considerable detail discussing the Apollo design redundancy in critical systems such as propulsion, power, environmental control, and communications. This was followed by a review of Apollo 7 anomalies and conclusions concerning the benefits and the risks of this flight. On the latter point, we indicated that the risks were no greater than those that are generally inherent in a progressive flight test program and that we believed that the probability of success of the ultimate lunar landing mission would be greatly enhanced.

My briefing was followed by a very clear discussion by Chris Kraft concerning the flight mission operations and a review by Deke Slayton of the flight plan, with emphasis on the lunar timeline. After Deke's briefing, Petrone reported on the checkout readiness status of the space vehicle, indicating that we would be ready to launch as early as December 10 or 12 and that he could foresee no problems with a launch on December 21 which is the day on which the lunar window opens. The work at KSC on AS 503 has been quite remarkable in that the very tight schedule which was laid down early in August was met in spite of a great deal of additional work.

[3] Phillips summed up at the conclusion of our meeting and repeated many of the thoughts expressed by all of us during the review. He indicated that he would make a firm recommendation on the next day to proceed with an Apollo 8 lunar orbit flight. Following Phillips' summation, Mueller asked the Apollo Executives for their personal views concerning this flight. The following is a brief summary of each of the Executive's opinions and views:

Walter Burke, McDonnell Douglas. The S-IVB is ready to do any of the missions listed; however, McDonnell Douglas feels that we ought to fly a circumlunar flight instead of a lunar orbit mission in order to minimize the risks.

Hilly Paige, GE. GE would like to go on record that we should go ahead with an Apollo 8 lunar orbit flight.

Paul Blasingame, AC Electronics. The G&N hardware is completely ready. Generalizing to the mission as a whole, when we risk the lives of people, we ought to get something for this risk. A lunar orbit flight looks like the right size of step to make.

Stark Draper, MIT. We should go ahead with the mission.

Bob Evans, IBM. The program is in good shape, and the instrumentation unit is ready to go.

George Bunker, Martin Marietta. The presentations made a persuasive case to fly a lunar orbit mission. The risk in lunar orbit is certainly greater than in earth orbit, but in assessing the risks for a lunar landing mission on a cumulative basis, it appears that the lunar orbit mission now will lessen the overall risk. I am for a lunar orbit mission.

Wilson, Boeing. There is every indication that the lunar orbit mission is the right thing to do.

Lee Atwood, North American Rockwell. As manufacturers of the spacecraft, our motivation to take chances is no higher than Frank Borman's, but we are ready to go.

Bob Hunter, Philco-Ford. I have no reservations in supporting the complete mission.

[4] Tom Morrow, Chrysler. We have no hardware on this mission, but we wish we had. We strongly feel that we ought to go for it. We must take steps like this one. We cannot move forward without progressing on each step. I vote yes.

Bill Gwinn, United Aircraft. It is difficult to quantify the risks. I am impressed by what I heard. The risks appear to be less than I thought before I came down here. George Low's recommendation not to change the fuel cells or the components is the right one.[1] I support the recommendation to proceed with the mission.

---

1 As a result of the condenser exit temperature problem on Apollo 7, Pratt & Whitney had first recommended that we should replace the fuel cells on Spacecraft 103, and on the morning of November 10, recommended that we should change-out the hydrogen pump motors in order to install the new higher temperature pinions. Myers and I held a meeting with Pratt & Whitney prior to the Executives meeting, and after discussing the whole situation in detail, decided that we should not replace these motors. The reasons for this decision were that: (a) The vibration flushing of the radiators decreased the probability of the problem's recurrence on Apollo 8; (b) Replacement of the pinion would only slightly increase the temperature margin, but would not really fix the problem; and (c) Detailed analyses have indicated that, even under the worst-case conditions of recurrence, there was no flight safety degradation, and it was unlikely that the mission would be degraded in any way. I reported the situation in detail during my briefing at the Executives review. Stu Conley, the Pratt & Whitney Program Manager, however, still felt that the motors should be replaced. This would have required breaking into systems that were already checked out, and KSC felt that they could not guarantee that the systems would not be degraded by so doing.

Joe Gavin, Grumman. Since we have no hardware on this flight, our interest is only with respect to the overall program. The mission makes a lot of sense. If we don't do it on this flight, we should do it anyway. I have no reservations.

Bill Bergen, Space Division, North American Rockwell. I agree that there are more risks in a lunar orbit mission than in an earth orbit mission. Also, it is unlikely that we will have as high performance of [5] our systems as we had on Apollo 7, but I am confident that our systems will perform satisfactorily. Although there would be less risks with a repeat flight, there are risks with no gain. We should make the lunar orbit flight.

George Stoner, Boeing. I endorse the recommendation without any reservations.

Gerry Smiley, GE. We have built up a head of steam in Apollo since we first started talking about C'. To do anything other than fly a lunar orbit mission now would set the program back.

The meeting was adjourned with the conclusion that a firm recommendation to fly the Apollo 8 mission to lunar orbit would be made the next day to the Acting Administrator.

NASA Management Meeting. November 11, 1968

On November 11, 1968, Dr. Mueller, the Center Directors, General Phillips, and the Center Program Managers met with Dr. Paine, Dr. Newell, Mr. Shapley, Mr. Finger, and a large number of staff members to discuss the Apollo 8 flight. The briefings were the same as those given to the Apollo Executives. The recommendations by Phillips and each of us were to firmly commit to a lunar orbit flight.

Following the briefings, Dr. Mueller indicated that this situation had been discussed with STAC, PSAC, DOD, and the Apollo Executives. He pointed out that STAC members had made a penetrating review of the flight and clearly understood the risks. Their reaction was a positive one, with the exception of

Gordon MacDonald who had reservations in that he believed the risks far outweighed the benefits.

PSAC was favorably disposed to support the mission, but had no firm recommendation. DOD also generally favors the mission. The Apollo Executives' reactions have already been reported in previous pages. Dr. Mueller also pointed out that Bellcomm had been quite negative. Bellcomm's reasoning was that the risk of a lunar orbit mission is considerably greater than that for an earth orbit mission. Bellcomm, therefore, believed that a lunar orbit mission should only be flown if this made it possible to reduce the total number of flights in the lunar landing program. If this were not possible, then Bellcomm believed the lunar orbit mission was not justified.

[6] Dr. Paine indicated that he had hoped that it would be possible to quantify the risks better than had been done in the course of the briefings. Dr. Mueller mentioned that we had tried to perform a numerical risk assessment, but that this had not turned out to be as positive as he had hoped it would be. However, in generalizing the results, he mentioned that the least cumulative risk in the lunar landing program resulted from making the minimum number of flights. Dr. Gilruth rebutted by stating that this is like saying that "the faster you drive your car, the safer you are because your exposure is less." Dr. Paine also felt that Dr. Mueller's statement was not valid since we will be in the flying business for a long time to come and we will fly on all Saturn V's, whether we use them in the lunar program or not. The general view expressed by many of us was that the highest probability of success for the lunar landing mission would come from a progressive buildup of flight experience. We felt that although there is risk in each manned flight, it was impossible to quantify this risk. Instead, the flight test program should be based on the best available judgment and experience and should, of course, be reviewed after each mission. Today's best indications are that the sequence of missions, C' (lunar orbit), D (earth orbit with LM), F (lunar orbit with LM), and G (lunar landing), would give us the best chance at a successful lunar landing in this decade.

At the conclusion of these discussions, Dr. Paine convened a smaller meeting, involving some of his immediate staff, Dr. Mueller, General Phillips, and the Center Directors. This was followed by a third meeting, involving only Paine, Newell, and Mueller. At the conclusion of these meetings, Dr. Paine announced that the Apollo 8 flight would be a lunar orbit mission. This was announced publicly in a press conference in Washington on Tuesday, November 12, 1968.

Document II-64

TO : M/Associate Administrator for Manned Space Flight
Date: 11 Nov, 1968

FROM : MA/Apollo Program Director

SUBJECT : Apollo 8 Mission Selection

The purpose of this memorandum is to obtain your approval to fly Apollo 8 on an open-ended lunar orbit mission in December 1968.

My recommendation is based on an exhaustive review of pertinent technical and operational factors and also on careful consideration of the impact that either a success or a failure in this mission will have on our ability to carry out the manned lunar landing in 1969.

THE APOLLO 8 C' LUNAR ORBIT MISSION:

Attachment I to this memorandum [not included] contains a detailed description of the Apollo 8 lunar orbit mission. Significant features of this mission plan are:

Planned Schedule:

Launch: 0750 EST, 21 December 1968
Translunar Injection: 1040 EST, 21 December 1968
Lunar Orbit Insertion:
LOI_1 Initiate: (60X170 NM Orbit) 0457 EST, 24 December 1968
LOI_2 Initiate: (60 NM Circular Orbit) 0921 EST, 24 December 1968
Transearth Injection: 0105 EST, 25 December 1968
Landing: 1053 EST, 27 December 1968

Alternate Schedule:

Monthly Launch Windows: 21-27 December 1968 or as soon thereafter as possible.

Daily Launch Windows: Approximately 5 hours duration.

Open-Ended Mission Concept:

A large number of abort and alternate mission options are provided for in the Mission Plan and associate Mission Rules. Noteworthy examples of the way in which this open-ended concept could operate in this mission are the following:

A low earth orbital mission in the event of a "no go" in earth orbit prior to translunar injection.

[2] Early return to earth in event of certain malfunction conditions during translunar coast.

A circumlunar mission in event of a "no go" during checkout prior to the lunar orbit insertion burn.

APOLLO 8 MISSION SELECTION:

On August 19, 1968, we announced the decision to fly Apollo 8 as a Saturn V, CSM-only mission. The basic plan provided for Apollo 8 to fly a low earth orbital mission, but forward alternatives were to be considered up to and including a lunar orbital mission. Final decision was to be reserved pending completion of the Apollo 7 mission and a series of detailed reviews of all elements of the Apollo 8 mission including the space vehicle, launch complex, operational support system, and mission planning.

Apollo 7 Mission Results:

An important factor in the total decision process leading to my recommendation has been and continues to be the demonstrated performance of the Apollo 7 Command and Service Module (CSM) subsystems, and the compatibility of the CSM with crew functions, and the Manned Space Flight Network. Comprehensive understanding of all Apollo 7 flight anomalies and their impact on a lunar mission is fundamental to arriving at a proper decision. Attachment II to this memorandum [not included] provides a recap of the Apollo 7 flight anomalies, their disposition, and a statement of any known risk remaining on the proposed Apollo 8 mission together with the actions proposed.

Apollo 4 and Apollo 6 Results:

The results of the Apollo 4 and Apollo 6 missions, in which the performance of the 501 and 502 Saturn V launch vehicles was tested, have been carefully analyzed. All flight anomalies have been resolved. In particular, the two most significant problems encountered in Apollo 6–longitudinal oscillation or "POGO" effect in the first stage of the Saturn V and the rupture of small propellant lines in the upper stages–have been corrected and the solutions verified in extensive ground tests.

Meetings and Reviews:

The decision process, resulting in my recommendation, [*sic*] has included a comprehensive series of reviews conducted over the past several weeks to examine in detail all facets of the considerations involved in planning for and providing a capability to fly Apollo 8 on a lunar orbit mission. The calendar for and purpose of these meetings are presented in Attachment III. [not included] An important milestone [3] was achieved with successful completion of the Design Certification Review on November 7, 1968. A copy of the signed Design Certification is appended as Attachment IV. [not included]

Pros and Cons of a Lunar Orbital Flight:

My objective through this period has been to bring into meaningful perspective the trade–offs between total program risk and gain resulting from introduction of a CSM-only lunar orbit mission on Apollo 8 into the total mission sequence leading to the earliest possible successful Apollo lunar landing and return. As you know, this assessment process is inherently judgmental in nature. Many factors have been considered, the evaluation of which supports a recommendation to proceed forward with an Apollo 8 open-ended lunar orbit mission. These factors are:

PROS:

Mission Readiness:

- The CSM has been designed and developed to perform a lunar orbit mission and has performed very well on four unmanned and one manned flights (CSM's 009, 011,017,020, and 101).

- We have learned all that we need in earth orbital operation except repetition of performance already demonstrated.

- The extensive qualification and endurance-type subsystem ground testing conducted over the past 18 months on the CSM equipments has contributed to a high level of system maturity, as demonstrated by the Apollo 7 flight.

- Performance of Apollo 7 systems has been thoroughly reviewed, and no indication has been evidenced of design deficiency.

- Detailed analysis of Apollo 4 and Apollo 6 launch vehicle anomalies, followed by design modifications and rigorous ground testing gives us high confidence in successful performance of the Apollo 8 launch vehicle.

- By design all subsystems affecting crew survival (Environmental Control System, Electrical Power System, Reaction Control System, and Guidance and Navigation System) are redundant and can suffer significant degradation without crew or mission loss. The sole exceptions are the injector and thrust chamber of [4] the Service Propulsion System. These two engine components are of simple, rugged design, with high structural and thermal safety margins. (See Attachment V) [not included]

- Excellent consumables and performance margins exist for the first CSM lunar mission because of the reduction in performance requirements represented by omitting the weight of the lunar module. An example of the predicted spacecraft consumables usage is provided below to illustrate this point:

Consumable	Total Usable	Total Used	Reserve
Service Module Reaction Control System Propellant (Pounds)	1140	294.5	845.5
Command Module Reaction Control System Propellant (Pounds)	231.2	29.4	201.8
Service Propulsion System Propellant (Pounds)	40,013	28,987	11,026
Cryogenic Oxygen (Pounds)	640	410	230
Cryogenic Hydrogen (Pounds)	56	40	16

PROS:

Effect on Program Progress:

The lunar orbit mission will:

- Provide valuable operational experience on a lunar CSM mission for flight and ground and recovery crews. This will enhance probability of success on the subsequent more complex lunar missions by permitting training emphasis on phases of these missions as yet untried.

- Provide an opportunity to evaluate the quality of MSFN and on-board navigation in lunar orbit including the effects of local orbit perturbations. This will increase anticipated accuracy of rendezvous maneuvers and lunar touchdown on a lunar landing mission.

- Permit validation of Apollo CSM communications and navigation systems at lunar distance.

- [5] Serve to improve consumables requirements prediction techniques.

- Complete the final verification of the ground support elements and the onboard computer programs.

- Increase the depth of understanding of thermal conditions in deep space and lunar proximity.

- Confirm the astronauts' ability to see, use, and photograph landmarks during a lunar mission.

- Provide an early opportunity for additional photographs for operational and scientific uses such as augmenting Lunar Orbiter coverage and for obtaining data for training crewmen on terrain identification under different lighting conditions.

CONS:

Mission Readiness:

- Marginal design conditions in the Block II CSM may not have been uncovered with only one manned flight.
- The life of the crew depends on the successful operation of the Service Propulsion System during the Transearth Injection maneuver.
- The three days endurance level required of backup systems in the event of an abort from a lunar orbit mission is greater than from an earth orbit mission.

CONS:

Effect on Program Progress:

- Validation of Colossus spacecraft software program and Real Time Computer Complex ground software program could be accomplished in a high earth orbital mission.
- Only landmark sightings and lunar navigation require a lunar mission to validate.

Impact of Success or Failure on Accomplishing Lunar Landing in 1969:

A successful mission will:

- Represent a significant new international achievement in space.
- [6] Offer flexibility to capitalize on success and advance the progress of the total program towards a lunar landing without unreasonable risk.
- Provide a significant boost to the morale of the entire Apollo program, and an impetus which must, inevitably enhance our probability of successful lunar landing in 1969.

A mission failure will:

- Delay ultimate accomplishment of the lunar landing mission.

- Provide program critics an opportunity to denounce the Apollo 8 mission as precipitous and unconservative.

RECOMMENDATION:

In conclusion, but with the proviso that all open work against the Apollo 8 open-ended lunar orbit mission is completed and certified, I request your approval to proceed with the implementation plan required to support an earliest December 21, 1968, launch readiness date.

/Signed/
Sam C. Phillips
Lt. General, USAF

Document II-65

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WASHINGTON, D.C. 20546

[stamped Nov 18, 1968]

MEMORANDUM to: Associate Administration for Manned Space Flight

FROM : Acting Administrator

REFERENCE : a. Memorandum for Acting Administrator from Associate for Manned Space Flight from Apollo Director, Subject: Apollo 8 Selection, dated November 11, 1968

b. Memorandum for Acting Administrator from Associate Administrator for Manned Space Flight, dated November 11, 1968

c. Memorandum to Acting Administrator from Associate Administrator for Manned Space Flight, Subject: Request for Approval to Man the Apollo Saturn V Launch Vehicle, dated November 5, 1968

Based on careful consideration and analyses of all of the information, comments, results of engineering tests and analysis, etc. provided to me, I approved on November 11 Lt. Gen. Samuel C. Phillips' recommendation (reference a), transmitted and agreed to by your memorandum to me (reference b), that the Apollo 8 mission be conducted as a manned lunar orbit mission with CSM 103 on Saturn 503 pending successful accomplishment of all necessary preparation and checkout activities for this mission. Included among the various inputs that I considered were:

1. The recommendation of Lt. Gen. Samuel C. Phillips, Apollo Program Director, with the supporting reasoning attached to his memorandum to you dated November 11 (reference a);

2. The presentations made to me on November 11 by Gen. Phillips, Mr. Lee James, Saturn V Program Manager-MSFC, Mr. George Low, Apollo Program Manager-MSC, Mr. Christopher C. Kraft, Director of Flight Operations-MSC, Mr. Rocco A. Petrone, Director of Launch Operations-KSC;

3. The statements of Mr. Gerald M. Truszynski, Associate Administrator for Tracking and Data Acquisition, and Lt. Gen. Vincent Houston, USAF, indication the ability of their systems and forces to be ready for such a mission;

[2] 4. The statements supporting a manned lunar orbit mission by each of the following (in the separate meeting on November 11, following the formal presentation by Gen. Phillips and the Apollo Program Managers listed above):

Mr. Harold B. Finger, Associate Administrator for Organization and Management

Mr. Willis H. Shapley, Associate Deputy Administrator

Mr. Bob P. Helgeson, NASA Safety Director

Mr. Julian Scheer, Assistant Administrator for Public Affairs

Dr. Kurt H. Debus, Director KSC

Dr. Robert R. Gilruth, Director MSC

Dr. Wernher von Braun, Director MSFC

Dr. Floyd L. Thompson, Special Assistant to the Administrator

Mr. Eberhard F. M. Rees, Deputy Director-Technical, MSFC

5. The information that you provided to me concerning the comments of the Science [and] Technology Advisory Committee (STAC), the reactions of PSAC, and the comments of the representatives of the industrial organizations responsible for various elements in the Apollo program;

6. The separate statements that you and Dr. Newell, Associate Administrator, made also supporting this mission;

7. The information provided to me in various briefings and in your memorandum of November 5 (reference c) to indicate that the problems or anomalies encountered in AS-502 have been solved and proven in analysis and tests;

8. My telephone conversation with Command Pilot Frank Borman who also supports this mission.

It should be made clear to all participating organizational elements throughout the Apollo program that any problem encountered during the preparation for this mission that may, in any way, increase the potential risk of the mission must be made known to all appropriate levels of NASA management as [3] soon as the problem is encountered. I will rely on you and those organizations to notify me as soon as such a problem is encountered, since my approval was based on consideration of the benefits to be derived from this mission and the risks involved in undertaking it.

/Signed/
T. O. Paine

Document II-66

Document Title: Memorandum from George M. Low, Manager of Apollo Spacecraft Program, "Program Plan revision," 20 August 1968.

Source: NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

The tentative decision to transform the Apollo 8 mission into a flight into lunar orbit caused a significant revision to the previously planned Apollo flight schedule. In particular, for the first time the third mission after Apollo 8, i.e., Apollo 11, could, if all preceding missions went off without problems, become the first attempt at a lunar landing. The Apollo 8 lunar orbit mission was designated C' (C Prime) because it was inserted in the previously planned Apollo mission sequence which included the following missions: C—test of the Apollo Command and Service module in low Earth orbit; D—test of the Apollo Command and Service and Lunar Modules in low Earth orbit; E—test of the Apollo Command and Service and Lunar Modules in a mission beyond Earth orbit, but not headed to the moon; F—test of all equipment in lunar orbit; and G—lunar landing mission. With the success of Apollo 8, the E mission was dropped from NASA's planning. Apollo 9 flew the D mission, and Apollo 10 flew the F mission, clearing the way for Apollo 11 to fly the G mission, aimed at the first lunar landing.

[CONFIDENTIAL] [DECLASSIFIED]

DATE: [stamped AUG 20 1968]

TO : See attached list

FROM : PA/Manager, Apollo Spacecraft Program

SUBJECT : Program Plan revision

The recent decision to fly a mission C ‘ (manned CSM on AS 503) prior to the first CSM/LM manned mission on AS 504 has resulted in significant program plan revisions.

Only the revised assignments, delivery, and launch schedules are provided to you at this time in order to expedite distribution of the revisions. I intend to provide you with a complete revised program plan during the first week in September.

The offices responsible for the timely completion of the Controlled Milestones are to notify Mr. C. L. Taylor, Assistant Chief, Program Control Division, immediately whenever a situation exists, or is anticipated to exist, that will impact or potentially impact these milestones.

[Signed George M Low 8-20]

George M. Low

Enclosure

PP3:GHJordan:jt 8-20-68

8-20-68 (Rev. 9)
Attachment A
Page 1 of 2

SPACECRAFT DELIVERY AND LAUNCH DATES Ø

MISSION DESIGNATION	MISSION TYPE	LAUNCH COMPLEX	LAUNCH VEHICLE	CSM	CSM DELIVERY	SLA	LM	LM DELIVERY	LAUNCH SCHEDULE
Apollo 4	A	39A	501	017	Dec 22, 1966A	8	10R	Sep 20, 1966A	Nov 9, 1967A
Apollo 5	B	37B	204	---	---	7	1	Jun 23, 1967A	Jan 22, 1968A
Apollo 6	A	39A	502	020	Nov 22, 1967A	9	2R	Feb 16, 1967A	Apr 4, 1968A
Apollo 7	C	34	205	101	May 29, 1968A	5	--	---	Oct 11, 1968
Apollo 8	C ‘	39A	503	103	Aug 12, 1968A	11	LTA B	Jan 9, 1968A	Dec 6, 1968
	D	39B	504	104	Sep 1, 1968	12	3	Jun 14, 1968A	Feb 20, 1969
	E	39A	505	106	Oct 27, 1968	13	4	Sep 15, 1968	May 1, 1969
	F or G	39A	506	107	Jan 6, 1969	14	5	Oct 5, 1968	Jul 10, 1969
	G	39A	507	108	Mar 6, 1969	15	6	Nov 27, 1968	Sep 18, 1969
	G	39A	508	109	May 7, 1969	16	7	Jan 15, 1969	Nov 27, 1969
	G	39A	509	110	Jul 8, 1969	17	8	Mar 15, 1969	Feb 5, 1970

A – Actual

[p. 2 not provided]

Document II-67

Document Title: Memorandum to George Mueller, NASA Associate Administrator for Manned Space Flight from Lt. General Sam C. Phillips, Apollo Program Director, "Extravehicular Activities for the First Lunar Landing Mission," 19 October 1968.

Source: NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

As the Earth-orbiting Apollo 7 mission, launched on 11 October 1968, was underway, marking the return to flight of the redesigned Apollo spacecraft after the 27 January 1967 Apollo 1 fire, senior Apollo managers were deciding on the details of the first lunar mission. This memorandum lays out the somewhat conservative plans for what the astronauts would do as they became the first humans to step onto another celestial body. In fact, this original plan called for only one of the two astronauts who landed on the lunar surface to actually leave the lunar module, except in an emergency situation. There were a number of subsequent revisions to this original proposal as the first landing mission grew closer.

National Aeronautics and
Space Administration

DATE: Oct 19 1968

TO : M/Dr. George E. Mueller

FROM : MA/Lt. General Sam C. Phillips

SUBJECT : Extravehicular Activities for the First Lunar Landing Mission

Since the inception of the Apollo Program the primary objective of the first lunar landing mission has been the safe manned lunar landing and return. The hardware has, however, been designed and procured to give us the capability to conduct significant scientific investigations in anticipation of a series of lunar missions. Our planning, testing and simulations to date have been such as to assure this capability.

In view of our current schedules and mission planning and crew training activities, I believe that it is now necessary to firmly commit to the scope of EVA activities for the first lunar landing mission. To this end this mission was reviewed in detail on August 26 and 27, 1968. Based on this review, a proposal was made for the EVA activities for the first mission:

1. Plan for one EVA of approximately two hours duration

2. Carry out this EVA with one crewman on the surface and the other in the spacecraft on the umbilicals but prepared to carry out rescue.

3. The EVA activity planning to provide for an early contingency sample, photography and Lunar Module inspection, and a more extensive second soil sample in that order of importance.

4. The EVA would not include the deployment of the erectable antenna, the Apollo Lunar Surface Experiments Package (ALSEP) or the Lunar Geology Investigation (LGI).

RATIONALE (PRO)

The rationale for this proposal is:

1. On the first lunar landing mission the LM descent, landing, surface activities and ascent will be accomplished for the first time under lunar conditions. As a result of these many new activities the timelines must be scheduled in a conservative manner. A comparison of scheduled times for one and two EVA plans is:

	Two EVA Plan	One EVA Plan
Awakening to touchdown	9	9
Touchdown to sleep	8:20	8:20
Total first day	17:20 hrs	17:20 hrs
Sleep	7	7
Awakening to ascent	10:30	3:30
Ascent to docking	4	4
Total	14:30 hrs	7:30 hrs

Under the two EVA plan the long first day, coupled with the tasks of deploying ALSEP and the LGI on the second EVA, could result in added risk in the rendezvous phase because of crew fatigue.

2. Safety is increased because of lower probability of random equipment failures as the LM is separated from the CSM for a shorter period of time. Although weight and consumables margins are not a motivating

factor, the proposal results in approximately 100 ft/sec increase in LM descent ΔV capability, which represents an increase of 30 per cent in the propellant budgeted for landing point redesignation and hover during descent. The consumables margins could also be increased because of the shorter separation time.

3. The first landing mission represents a large step from orbital operations. The descent, landing, EVA, and ascent are new operations in a new environment. From a training point of view the crew should concentrate on the crucial, necessary tasks to achieve a safe landing and return. By not including ALSEP (180 hours of training), the LGI and the erectable antenna on the first mission, additional training and concentration on the descent, landing and ascent phases can be accomplished.

4. Our Gemini EVA experience showed that a methodical increase in task complexity was necessary in order to understand the zero g environment. The 1/6 g lunar surface environment will be a new experience, one which cannot be simulated on earth. It seems prudent, therefore, to plan the lunar EVA sequence in a methodical fashion in increasing complexity. In this light, it appears that the deployment of ALSEP and the Lunar Geology Investigation should be deferred to the second mission. Planning to accomplish these tasks on the first mission and failing could result in a slower build-up of lunar exploration capability than if they were deferred to the second mission.

RATIONALE (CON)

Several arguments have been advanced against the proposal:

1. Scientific data from the moon will be lost. The significance of this loss can only be judged in the context of the magnitude of the follow-on lunar exploration program. If only two additional flights are authorized, then the loss would be most significant, as a viable seismic net could not be established. If there are ten additional flights, the loss may not be significant.

2. The reduction in scientific return will result in some adverse comments. The overall significance to manned space flight of these comments can only be assessed in terms of (1) above.

3. There are serious reservations that, if one one-man EVA is all that we can commit based on our current state of knowledge, the second flight will similarly be limited in scope of scientific investigation.

4. The proposed plan may be too conservative at this point in time. If the flight proves our pessimism was not warranted, then we could be criticized for not being in a position to capitalize on success.

DISCUSSION

The proposal and rationale were transmitted to the Science and Technology Advisory Committee, the Lunar and Planetary Missions Board, the Manned Spacecraft Center, Marshall Space Flight Center, Kennedy Space Center, and Headquarters offices for comment. The responses are in general agreement with the proposal, with some of the scientific community in opposition. Modifications to the proposal have been suggested:

1. TV on the first mission was accorded increased emphasis especially in the area of observing the initial EVA activities. To assure TV, either mission planning must be complex, hardware changes must be made, or the erecetable antenna must be carried. Studies are in progress to more fully understand these alternatives. If a requirement for coverage of the first egress is generated, then the LM steerable antenna-Goldstone method is the only available path without hardware modifications. It was recommended that the erecetable antenna be retained until the mission constraints on the use of Goldstone are more fully understood.

2. The Kennedy Space Center, the Manned Spacecraft Center, the Apollo Lunar Exploration Office and Bellcomm have suggested that if the second EVA period is eliminated, both crewmen should egress during the first period, either together or in sequence. LM failure modes should be examined to ascertain which would be safer. Other than the safety question, the psychological factor of going to the moon and not egressing must be considered. Further, the interaction of the two subjects with the lunar surface environment would give us twice the data upon which to plan the succeeding mission EVA, hence move the program more rapidly toward a scientific exploration capability.

3. Several comments have been made with respect to assuring that we are moving as rapidly as is prudent towards achieving a scientific exploration capability. It seems reasonable, therefore, that for the first mission a primary objective should be to obtain data on the capabilities and limitations of the astronaut plus Extravehicular Mobility Unit in the lunar surface environment. This specific data gathering should be well planned and covered as an approved experiment or Detailed Test Objective for the flight in order to assure that the full capabilities are achieved on the second mission.

4. Total EVA time is limited. We should, therefore, move as rapidly as possible to hardware modifications designed to free the crew from mechanical tasks (such as unstowing and transferring equipment from the descent stage to the ascent stage) and maximizing the time available for science.

5. It appears that a one-man two-hour EVA is the minimum-risk situation, but what is not clear is how the risk changes as the EVA activity is increased. It is also not clear as to the relative magnitude of the EVA risk to the total mission risk. Two 1.5 hour EVA's (separate astronauts)

may involve only a slight increase in total mission risk over one two-hour one-man EVA, yet the scientific return could be increased significantly. If it is planned to have both crewmen egress, it was suggested that it be in sequence with one in the LM at all times. This allows the status of the LM and the EVA crewman to be monitored at all times, one man is always on the LM life support system and the communications to earth (both voice and biomedical telemetry) are independent for the two crewmen.

6. If ALSEP and LGI are not carried, several suggestions were made for other scientific experiments. These included uprating the preliminary sample to be of greater scientific value, and to examine the possibility of including the laser ranging retroreflector, a Surveyor seismometer, and soil mechanics experiments.

OMSF ACTION

The proposal, comments, and recommendations of the Apollo Program Director were presented to the OMSF Management Council on September 11, 1968. The Council approved the following:

1. A single EVA period open-ended to three hours will be planned for the first mission. The surface traverse will be open-ended to a maximum of 300 feet from the LM. Training experience, simulations, timeline verification studies and failure mode analyses will be used as the basis for a decision between one-man and two-man EVA's and two one-man EVA's during the period.

2. The ALSEP and LGI will not be carried. A lunar soil sample will be collected in a manner which will maximize the scientific value, and other candidate scientific experiments will be identified and submitted for consideration by October 10, 1968.

3. TV will be carried. Planning will be such as to exploit both its operational and public information uses. The MSC will identify changes in mission planning and/or hardware necessary to utilize only the LM steerable antenna.

4. In order to maximize the scientific return from the second mission, a Primary Objective of the first mission will be to obtain data to assess the capabilities and limitations of the astronaut and his equipment in the lunar surface environment. The MSC will plan and implement Detailed Test Objectives and experiments for the first lunar landing mission to achieve this objective.

5. The MSC should study and schedule recommendations, including cost and schedules, to the Apollo Program Director for any changes in hardware for future lunar missions which would increase the percentage of EVA time available for scientific investigations.

[Signed Sam. C Phillips]

Sam C. Phillips
Lt. General, USAF
Apollo Program Director

Attachments 1-26

Cc: (w/o attachments)
CD/HKDeubs
DIR/WvonBraun
AA/RRGilruth
MA-A/GHHage
MA/WCSchneider
MAO/JKHolcomb
MAL/LRScherer

Document II-68

Document Title: Letter to George M. Low, Manager, Apollo Spacecraft Program, from Julian Scheer, Assistant Administrator for Public Affairs, 12 March 1969.

Source: Folder #148675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

Document II-69

Document Title: Letter to Julian Scheer, Assistant Administrator for Public Affairs, from George M. Low, Manager, Apollo Spacecraft Program, 18 March 1969.

Source: Folder #18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

Julian Scheer was one of NASA Headquarter's "inner circle" during the Apollo program, in addition to his role as NASA top public spokesman. In this letter to NASA veteran manager of human space flight George Low, who assumed responsibility for the Apollo spacecraft project after the January 1967 Apollo 1 fire, Scheer suggested that it would be inappropriate to suggest to the Apollo 11 crewmembers what they might say as they reached the Moon. Low's reply indicates that he agreed with Scheer, and that there had been a misunderstanding of what actions Low had taken. The "Shapley Committee" was headed by senior NASA Headquarters staff member Willis Shapley, who was responsible for NASA's top-level political and budgetary strategy. Simon Bourgin was an employee of the U.S. Information Agency with a particular focus on the space program.

Document II-68

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WASHINGTON. D.C 20546

March 12, 1969

Mr. George M. Low
Manager
Apollo Spacecraft Program
NASA Manned Spacecraft Center
Houston, Texas 77058

Dear George:

It has come to my attention that you have asked someone outside of NASA to advise you on what the manned lunar landing astronauts might say when they touch down on the Moon's surface. This disturbs me for several reasons.

The Agency has solicited from within NASA any suggestions on what materials and artifacts might be carried to the surface of the Moon on that historic first flight. But we have not solicited comment or suggestions on what the astronauts might say. Not only do I personally feel that we ought not to coach the astronauts, but I feel it would be damaging for the word to get out that we were soliciting comment. The ultimate decision on what the astronauts will carry is vested in a committee set up by the Administrator; the committee will not, nor will the Agency by any other means, suggest remarks by the astronauts.

Frank Borman solicited a suggestion from me on what would be appropriate for Christmas Eve. I felt–and my feeling still stands–that his reading from the Bible would be diminished in the eyes of the public if it were thought that NASA pre-planned such a thing. I declined both officially and personally to suggest words to him despite the fact that I had some ideas. I believed then [2] and I believe the same is true of the Apollo 11 crew that the truest emotion at the historic moment is what the explorer feels within himself not for the astronauts to be coached before they leave or to carry a prepared text in their hip pocket.

The Lunar Artifacts Committee, chaired by Willis Shapley, asked that all elements of NASA consider what might be carried on Apollo 11. I know that General Phillips has properly reiterated the request by asking all elements of Manned Flight to suggest things, but it was not the desire or intent of the committee to broaden the scope of the solicitation to verbal reactions.

There may be some who are concerned that some dramatic utterance may not be emitted by the first astronaut who touches the lunar surface. I don't share that concern. Others believe a poet ought to go to the Moon. Columbus wasn't a poet and he didn't have a prepared text, but his words were pretty dramatic to me. When he saw the Canary Islands he wrote, "I landed, and saw people running around naked, some very green trees, much water, and many fruits."

Two hundred years before Apollo 8, Captain James Cook recorded while watching the transit of Venus over the sun's disk, "We very distinctly saw an atmosphere or dusky shade around the body of the planet."

Meriwether Lewis, traveling with William Clark, recorded, "Great joy in camp. We are in view of the ocean, this great Pacific Ocean which we have been so long anxious to see, and the roreing [*sic*] or noise made by the waves brakeing [*sic*] on the rockey [*sic*] shore may be heard distinctly."

Peary was simply too tired to say anything in 1909 when he reached the North Pole. He went to sleep. The next day he recorded in a diary, "The pole at last. The [3] prize of three centures [*sic*]. I cannot bring myself to realize it. It seems all so simple and commonplace."

The words of these great explorers tell us something of the men who explore and it is my hope that Neil Armstrong or Buzz Aldrin will tell us what they see and think and nothing that we feel they should say.

I have often been asked if NASA indeed plans to suggest comments to the astronauts. My answer on behalf of NASA is "no."

I'd appreciate your comments.

Regards,

[signed]
Julian Scheer
Assistant Administrator
for Public Affairs

Document II-69

March 18, 1969

Mr. Julian Scheer
Assistant Administrator
for Public Affairs
National Aeronautics and Space Administration
Washington, D. C. 20546

Dear Julian:

I have just received your letter of March 12, 1969, which apparently stemmed from a misunderstanding. Let me first point out that I completely agree with you that the words said by the astronauts on the lunar surface (or, for that matter, at any other time) must be their own. I have always felt that way and continue to do so.

I am, of course, aware of the Shapley Committee that was established by Dr. Paine, and have also received a copy of a telegram from General Phillips soliciting our comments on what should be carried to the lunar surface. I felt that in order to respond properly to General Phillips and to the Shapley Committee, I would like to seek the advice of Si Bourgin, whose judgment I respect a great deal in these matters. As you know, I met Si on our trip to South America and found that he offered excellent advice to all of us throughout our trip. I, therefore, called Si as soon as he returned from Europe and asked him whether he could offer any advice concerning what the astronauts should do (not say) when we have first landed on the moon. Si called me back [2] the night before the Apollo 9 launch, and we discussed his ideas at some length. We again agreed at that time that it is properly NASA's function to plan what artifacts should be left on the lunar surface or what should be brought back, but that the words that the astronauts should say must be entirely their own.

Since then, I have had a meeting with Neil Armstrong to discuss with him some of our ideas and suggestions, including those of Si Bourgin's, in order to solicit his views. Even though I had not yet received your letter at that time, we also discussed the point that whatever things are left on the lunar surface are things that he must be comfortable with, and whatever words are said must be his own words.

All of these activities—my discussions with Si, my discussions with Neil, and discussions with many others within and outside of NASA—are to gain the best possible advice that I can seek for what I consider to be a most important event. The result for of all of this will be my input to Dr. Gilruth so that he can forward it to the Shapley Committee, should he so desire.

I hope that this clarifies any misunderstanding that we might have had on this matter.

Sincerely yours,

/Signed/
George M. Low
Manager
Apollo Spacecraft Program

Document II-70

Document Title: Memorandum to Dr. [George] Mueller from Willis H. Shapley, Associate Deputy Administrator, "Symbolic Items for the First Lunar Landing," 19 April 1969.

Document Source: Folder #18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

Document II-71

Document Title: Memorandum to Dr. (George) Mueller from Willis Shapley, NASA Associate Deputy Administrator, "Symbolic Activities for Apollo 11," 2 July 1969.

Source: Folder #18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

As planning for the first lunar landing picked up in intensity, attention turned to the symbolic aspects of the mission. Willis Shapley, a veteran Washington bureaucrat who served as a policy advisor to the NASA Administrator, chaired a Symbolic Activities Committee that was set up to determine what items would be carried to the Moon, and what symbolic activities would be carried out on the lunar surface on the Apollo 11 mission. The final decisions on these matters were communicated to the Apollo program management just two weeks before the 16 July liftoff of the mission.

Document II-70

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Washington, D.C. 20546

April 19, 1969

MEMORANDUM FOR: M/Dr. Mueller

Subject: Symbolic Items for the First Lunar Landing

This is to advise you, the Apollo Program Office, and MSC of the thinking that has emerged from discussions among members of the Symbolic Activities Committee to date on symbolic activities in connection with the first lunar landing, including articles to be left on the moon and articles to be taken to the moon and returned.

Further discussions will be necessary prior to the time we will make final recommendations for decision by the Administrator, and comments and suggestions from all members of the Committee and others are still in order. However, in view of the general agreement on approach that has been manifested so far and the tight deadlines for decisions on matters directly affecting preparations for the mission, the approach outlined below should be taken as the basis for further planning at this time.

1. Symbolic activities must not, of course, jeopardize crew safety or unduly interfere with or degrade achievement of mission objectives. They should be simple, in good taste from a world-wide standpoint, and have no commercial implications or overtones.

2. The intended overall impression of the symbolic activities and of the manner in which they are presented to the world should be to signalize the first lunar landing as an historic forward step of all mankind that has been accomplished by the United States of America.

3. The "forward step of all mankind" aspect of the landing should be symbolized primarily by a suitable inscription to be left on the moon and by statements made on earth, and also perhaps by leaving on the moon miniature flags of all nations. The UN flag, flags of all other regional or international organizations, or other international or religious symbolism will not be used.

4. The "accomplishment by the United States" aspect of the landing should be symbolized primarily by placing and leaving a U.S. flag on the moon in such a way as to make it clear that the flag symbolized the fact that an effort by American people reached the moon, not that the U.S. is [2] "taking possession" of the moon. The latter connotation is contrary to our national intent and would be inconsistent with the Treaty on Peaceful Uses of Outer Space.

5. In implementing the approach outlined above, the following primary symbolic articles and actions or their equivalents should be considered for inclusion in the mission:

a. A <u>U.S. flag</u> to be placed and left on the moon. The flag should be such that it can be clearly photographed and televised. If possible, the act of emplacing the flag by the astronaut, as well as the emplaced flag with an astronaut beside it, should be photographed and televised. Current thinking is that a recognizable traditional flag should be emplaced on the moon. The flag decal on the LM decent stage would not by itself suffice unless a flag proved to be clearly not feasible. Consideration of how best to emplace the flag should include but not be limited to the following suggestions:

(1) Cloth flag on vertically emplaced pole, with astronaut to hold flag in visible position for photographing.

(2) Cloth flag on pole emplaced at an angle so that flag is visible for photographing.

(3) An adaptation of the Solar Wind Experiment device in the form of a flag.

(4) Flag on a pole using the commemorative marker (item b below) as a base.

b. A permanent commemorative marker, suitably inscribed, to be placed and left on the lunar surface, with photographic and television coverage as suggested above for the U.S. flag, if possible. Possibilities to be considered should include, but not be limited to:

(1) A thin-walled metal pyramid, with inscriptions on each of its three or four sides, which could also serve as a sealed repository for a set of miniature flags of all nations (item c below).

(2) A container of cylindrical or other more convenient shape to perform the same function as suggested in (1) above.

(3) A pyramid or other container, as above, which would also serve as the base for the U.S. flag to be emplaced on the moon.

[3]

c. Miniature flags of all nations, one set to be left on the moon in a suitable container (see above), and a duplicate set to be returned to earth for possible presentation by the President to foreign Chiefs of State. If flag container is not feasible, the set of flags might be left on or in the LM decent stage.

d. One or more U.S. flags to be presented to NASA prior to the mission by the President and/or other senior officials, taken to the moon and back, and then suitably displayed, perhaps with photographs of the astronauts on the moon, in suitable national locations such as the Capitol, White House, National Archives, Smithsonian Institution, Library of Congress, or elsewhere.

6. The LM decent stage itself will be of prime symbolic significance since the descent stage will become a permanent monument on the surface of the moon. For this reason, the name given to the LM and any inscriptions to be placed on it must be consistent with the overall approach on symbolic articles and must be approved by the Administrator. The present thinking is that:

a. The name of the vehicle should be dignified and hopefully convey the sense of "beginning" rather than "culmination" of man's exploration of other worlds.

b. Assuming that a commemorative marker with inscription is carried, inscriptions on the LM should be limited to the present flag decal and words "United States."

7. The principal secondary symbolic articles receiving favorable consideration so far include the following:

a. A small postage stamp die to be taken to the moon and back from which commemorative stamps would be printed. Weight and dimensions alternatives are being investigated.

b. A jeweler's die to be taken to the moon and back from which lapel type pins associated with the NASA special "Apollo Achievement Awards" now under consideration would be stamped out. Weight and size requirements are being investigated.

8. It would be appreciated if any comments, further suggestions, or problems you or others receiving copies of this memorandum may have with respect to the foregoing tentative plans and conclusions are made known promptly to me and the Committee via the secretary, Mr. Daniels.

/Signed/
Willis H. Shapley
Associate Deputy Administrator

Document II-71

[stamped Jul 2 1969]

MEMORANDUM FOR: M/Dr. Mueller

Subject: Symbolic Activities for Apollo 11

As your office has previously been advised, the symbolic articles approved for the Apollo 11 mission as of this date are as follows:

A. Symbolic articles to be left on the moon

1. A U.S. flag, on a metal staff with an unfurling device, to be emplaced in the lunar soil by the astronauts. This will be the only flag emplanted [*sic*] or otherwise placed on the surface of the moon.

2. A commemorative plaque affixed to the LM descent stage to be unveiled by the astronauts. The plaque will be inscribed with:

a. A design showing the two hemispheres of the earth and the outlines of the continents, without national boundaries.

b. The words: "Here men from the planet earth first set foot upon the moon. We came in peace for all mankind."

c. The date (month and year).

d. The signatures of the three astronauts and the President of the U.S.

3. A microminiaturized photoprint of letters of good will received from Chiefs of State or other representatives of foreign nations.

B. Symbolic articles to be taken to the moon and returned to earth

1. Miniature flags (1 each) of all nations of the UN, and of the 50 states, District of Columbia, and U.S. territories—for subsequent presentation as determined by the President. "All nations" has been defined on the advice of the State Department to include "the members of the United Nations and the UN Specialized Agencies." These items will be stowed in the LM.

[2]

2. Small U.S. flags—for special presentation as determined by the President or the Administrator of NASA. These will also be stowed in the LM.

3. Stamp die from which Post Office Department will print special postage stamps commemorating the first lunar landing and a stamped envelope to be cancelled with the cancellation stamping device. Cancellation can be done as convenient during the mission in the CM. The stamp die will be stowed in the LM; the stamping device and envelope will be stowed in the CM. These items will not be announced in advance.

4. Two full size U.S. flags—which have been flown over the Capitol, the House and the Senate, to be carried in CM but will not be transferred to the LM.

C. Personal Articles

Personal articles of the astronauts' choosing under arrangements between Mr. Slayton and the flight crews.

With respect to all items under categories A and B above, it should be clearly understood that the articles are "owned" by the Government and that the disposition of the articles themselves or facsimiles thereof is to be determined by the Administrator or NASA. The articles returned from the mission should be turned over to a proper authority at MSC promptly upon return. In the case of Item B2, the Administrator has determined that a reasonable number of small U.S. flags will be made available to the flight crew for presentation as they see fit, subject to the avoidance of conflict with plans for presentation of these flags by the President or the Administrator.

With respect to articles in Category C above, Mr. Scheer should be notified in advance of the mission of any items which are or may appear to be duplicates of items the President or others might present to Governors, Heads of State, etc. The value of these "one-of-a-kind" presentations can be diminished if there is a proliferation of such items. Flags and patches particularly fall into this category.

Public announcement has or will be made of all items in Categories A and B in advance of the mission except for the items under B3, any release concerning which is subject to a separate decision.

[Signed Willis H. Shapley]

Willis H. Shapley
Associate Deputy Administrator

cc: A/Dr. Paine
AA/Dr. Newell
F/Mr. Scheer
C/Mr. Allnutt
I/Mr. Frutkin

Document II-72

Document Title: Letter from Frank Borman, NASA Astronaut, to Paul Feigert, 25 April 1969.

Source: Folder #18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

For the general public, the two highlights of the Apollo 8 mission at Christmas time 1968 were the photograph of Earth rising over the desolate lunar surface and the reading of the first 10 verses of Genesis from the Bible by the crew on Christmas Eve.

[stamped April 25, 1969]

Mr. Paul F. Feigert
1702 Terrace Drive
Lake Worth, Florida 33460

Dear Mr. Feigert:

Dr. Gilruth has asked me to answer your inquiry concerning the reading of the first 10 verses of Genesis.

a. Three small Bibles supplied by the Gideons did accompany us on the flight.

b. Because the Bibles were flammable, they were sealed in fireproof plastic and not opened during the flight.

c. The first 10 verses of Genesis were copied from the Bible and printed on the flame resistant paper of the fight plan.

Thank you for your interest in this matter.

Sincerely,

[Signed Frank Borman]

Frank Borman
Colonel, USAF
NASA Astronaut

Document II-73

Document Title: "General Declaration: Agriculture, Customs, Immigration, and Public Health," 24 July 1969.

Source: Folder #18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

Like all travelers who return to the United States from trips outside the country, the Apollo 11 crew had to file this declaration as the ship carrying them and their cargo reached their first port of entry, Honolulu, Hawaii, after their return from the Moon.

GENERAL DECLARATION

(Outward/Inward)

AGRICULTURE, CUSTOMS, IMMIGRATION, AND PUBLIC HEALTH

Owner or Operator: NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Marks of Nationality and Registration: U.S.A. Flight No. APOLLO 11 Date JULY 24, 1969

Departure from: MOON (Place and Country) Arrival at: HONOLULU, HAWAII, U.S.A. (Place and Country)

FLIGHT ROUTING

("Place" Column always to list origin, every en-route stop and destination)

PLACE	TOTAL NUMBER OF CREW	NUMBER OF PASSENGERS ON THIS STAGE	CARGO
CAPE KENNEDY	COMMANDER NEIL A. ARMSTRONG		
MOON	[signature]	Departure Place: Embarking NIL; Through on same flight NIL	MOON ROCK AND MOON DUST SAMPLES Cargo Manifests Attached
JULY 24, 1969 HONOLULU	COLONEL EDWIN E. ALDRIN, JR. [signature]	Arrival Place: Disembarking NIL; Through on same flight NIL	
	[signature] LT. COLONEL MICHAEL COLLINS		

Declaration of Health

Persons on board known to be suffering from illness other than airsickness or the effects of accidents, as well as those cases of illness disembarked during the flight:

NONE

Any other condition on board which may lead to the spread of disease:

TO BE DETERMINED

Details of each disinsecting or sanitary treatment (place, date, time, method) during the flight. If no disinsecting has been carried out during the flight give details of most recent disinsecting:

Signed, if required .... Crew Member Concerned

For official use only

HONOLULU AIRPORT
Honolulu, Hawaii
ENTERED
[signature]
Customs Inspector

I declare that all statements and particulars contained in this General Declaration, and in any supplementary forms required to be presented with this General Declaration are complete, exact and true to the best of my knowledge and that all through passengers will continue/have continued on the flight.

Document II-74

Document Title: Memorandum to Captain Lee Scherer from Julian Scheer, NASA Assistant Administrator for Public Affairs, 24 July 1969.

Source: Folder #18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

The Apollo 11 crew brought back 44 pounds of lunar material. While most of this material was reserved for scientific investigations, a small amount was set aside for more public purposes. Lee Scherer was the Director of the Lunar Exploration Office at the Manned Spacecraft Center at the time of the Apollo 11 mission.

[ADMINISTRATIVE CONFIDENTIAL] [DECLASSIFIED]

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Washington, D.C. 20546

Office of the Administrator

[stamped July 24,1969]

MEMORANDUM to Captain Lee Scherer

Mittauer informed me of your preliminary plan of one percent lunar samples for "public affairs" purposes. This included suggestion of grains for Nixon to present heads of state, rotating exhibit, small rocks for Nixon, Agnew, others personally. We approve setting aside of this sample and wish it impounded immediately for purposes to be outlined only by Administrator. There should be no discussion of possible uses. Administrator emphatic that this sample and no others be used for this purpose and no other part or parts of sample be released to anyone for public or private giveaways. Suggest that egg-size samples be retained, since they can be used as large display or broken into grains, depending on Administrator's conclusion.

Julian Scheer
Assistant Administrator
for Public Affairs

Document II-75

Document Title: Letter to Robert R. Gilruth, Director, Manned Spacecraft Center, from George E. Mueller, Associate Administrator for Manned Space Flight, 3 September 1969.

Source: Folder #18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

The managers of the Apollo program at the Manned Spacecraft Center in Houston were primarily from an engineering background, and tended to view the Apollo missions as engineering achievements rather than expeditions driven by scientific requirements. This led to continuing tensions between Houston and members of the scientific community interested in lunar science. This letter reflects such tensions. Ultimately, NASA decided to fly a scientist-astronaut, geologist Harrison "Jack" Schmitt, on the final Apollo mission, Apollo 17.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Sep 3, 1969

Dr. Robert R. Gilruth
Director
Manned Spacecraft Center
Houston, Texas 77058

Dear Bob,

To the public, the success of Apollo 11 is an historical fact. However, to your Center in particular, and to many of the rest of us, the mission is not yet completed and will not be for some time to come. As we have discussed informally, completion of data analysis, posturing solutions for the minor, yet important anomalies which occurred in flight, and, provision for adequate and continuing support of the science effort are items of priority. The latter item, science support, is of particular concern at this time.

Over the past couple of years we have taken steps both here at NASA Headquarters and at MSC to establish a science management, administration and support capability for the Apollo Program. This has been done with significant sacrifice to other program areas within a steadily reducing total Manned Flight and NASA personnel ceiling. During the pre-Apollo 11 time-period the workload of this group increased steadily and it was difficult to obtain a commensurate increase in the number and appropriate types of personnel to do the many jobs involved. Now, with operating experiments on the lunar surface returning data and the return of Apollo 11 lunar samples for analysis, the workload has increased many fold. The resulting increased interest and direct participation of the scientific community in Apollo is taxing our capability to the limit. Despite this, we will certainly detract measurably from the success of Apollo 11, and the missions yet to be flown, unless we meet the challenge. Therefore, we must provide the support required in the science area.

A problem of immediate concern is prompt and proper distribution of the lunar samples to the Principle [*sic*] Investigators through their home institutions. To protect the government and public interest in these materials, contractual coverage must be obtained. At the current rate of contract negotiation I am concerned that we will have clearance from the ICBC for sample release before all of the sample analysis contract processing is completed. I urge you to assign whatever resources are necessary to bring completion of contract processing into phase with sample release.

[2]The successful accomplishment of the initial Apollo lunar landing was necessarily the focus and emphasis in the program for many years. The operational complexity of the next few missions will also require concentration on that aspect. We will be increasing our capability to do more and more interesting science simultaneously. Still, some members of the scientific community are impatient and as you know, are willing to air their views without necessarily relating those views to what is practicable and possible.

Public discussion aside, it is our policy to do the maximum science possible in each Apollo mission and to provide adequate science support. For the long term we must assure ourselves and the world of science that we are making those adjustments which will provide steadily increasing and effective support for the science area. Good progress has been made to date, but we must do even better to meet the future challenge. I ask your personal involvement in this as well as in solving the immediate concerns relating to Apollo 11.

Sincerely yours,

/Signed/
George E. Mueller
Associate Administrator
for Manned Space Flight

Document II-76

Document Title: Space Science Board, National Academy of Sciences, "Report of Meeting on Review of Lunar Quarantine Program," 17 February 1970.

Source: Folder #18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

After two landings on the Moon, Apollo 11, and Apollo 12, and no sign of dangerous life forms being returned to Earth, NASA was contemplating the end of the quarantine that had been in place for those two missions. The National Academy of Sciences was asked to examine the question. This report contains the recommendation of the ad hoc committee set up to prepare the Academy's response. It also provides an overview of the testing for signs of life done on the returned lunar samples.

Report of

Meeting on

Review of Lunar Quarantine Program

February 17, 1970
At
The Manned Spacecraft Center
National Aeronautical and Space Administration
Houston, Texas

Space Science Board
National Academy of Sciences
2101 Constitution Avenue
Washington, D.C.

PREFACE

On December 24, 1969 the Administrator of the National Aeronautics and Space Administration requested the President of the National Academy of Sciences to form a committee to review the Academy's 1964 recommendations for a lunar quarantine program in light of information acquired from lunar flights, Apollos 11 and 12. The President referred the request to the Space Science Board where it was favorably considered at the Board's meeting on January 12-13, 1970. An ad hoc committee was authorized by the Space Science Board to consider new evidence accumulated about the earth's moon since its 1964 conference and to make recommendations pertinent to the continuation of the lunar quarantine program.

The ad hoc committee met at the National Aeronautics and Space Administration's Manned Spacecraft Center, Houston, Texas on February 17, 1970. A listing of the participants is shown.

The agenda for the meeting provided for an exchange of views and facts in geology, geochemistry, and biology, including microbiology and medicine. We believe the varied positions were thoroughly argued.

The recommendations of the ad hoc committee are summarized at the beginning of the report and the rationale in arriving at the recommendations follows in the body of the report. Minority views are attached in the appendix.

Participants in the Space Science Board's

Review of the National Academy of Sciences of Lunar

Quarantine Recommendations

Manned Spacecraft Center, Houston, Texas
February 17, 1970

Members

Martin Alexander	Cornell University
Klaus Biemann	Massachusetts Institute of Technology
Allan H. Brown, (Chairman)	University of Pennsylvania
Gustave J. Dammin	Harvard Medical School
Paul Gast	Columbia University
Lawrence B. Slobodki	University of New York at Stony Brook
John Spizizen	Scripps Clinic, La Jolla
Wolf Vishniac	University of Rochester
Frank G. Favorite	Space Science Board, National Academy of Sciences

Liaison Representatives and Other Participants

Earl H. Arnold	NASA Headquarters, Office of Manned Space Flight
Charles A. Berry	NASA, Manned Spacecraft Center
Howard H. Eckles	NASA, Manned Spacecraft Center
Lawrence B. Hall	NASA, Headquarters, Office of Space Science and Applications
Rufus R. Hessberg	NASA Headquarters, Office of Manned Space Flight
James W. Humphreys, Jr.	NASA Headquarters, Office of Manned Space Flight
R. E. Kallio	University of Illinois
Walter W. Kemmerer, Jr.	NASA, Manned Spacecraft Center

Adrian Mandel	NASA, Manned Spacecraft Center
John A. Mason	NASA, Manned Spacecraft Center
Carl Sagan	Cornell University
E. E. Salmon	U.S. Department of Agriculture
David J. Sencer	Department of Health, Education and Welfare, Communicable Disease Center Atlanta
Gerald R. Taylor	NASA, Manned Spacecraft Center
Bennic C. Wooley	NASA, Manned Spacecraft Center

Summary of Finding and Major Recommendations

Finding

In Apollo 13 the proposed highland landing site and core sample to a depth of 8 feet constitute a substantially new lunar environment in comparison to the landing sites and sampled areas of Apollo 11 and 12 missions.

Recommendations

Lunar Quarantine Program

A majority recommend continuance of the 3-week lunar quarantine period. A minority favor discontinuance of quarantine.

Lunar Samples

We recommend development of procedural changes in the handling of lunar samples to preclude alteration of the sample prior to analysis.

Biological Testing Program

We recommend the continued development of a research program within the LRL to develop greater confidence in the adequacy of the test program and the validity of both negative and positive findings.

Introduction

Our committee heard from representations of the National Aeronautics and Space Administration's Office of Manned Space Flight and Manned Spacecraft Center, from lunar sample experimenters and from persons responsible for operations in the Lunar Receiving Laboratory. Summaries were presented of medical tests on astronauts and other quarantined personnel and of the examination of lunar samples including tests for pathogenicity, or toxicity and for the presence of life forms.

We believe that the quarantine policy which has applied to lunar samples, spacecraft and astronauts was conscientiously implemented in Apollo 11 and 12 missions. It was noted that some procedures have been less than ideal. Nevertheless, a quarantine policy implementation, beset from the start with severe difficulties of interdisciplinary communication and inflexible schedules, was as successful as could have been expected.

It is noteworthy that the Interagency Committee on Back-Contamination (ICBC) was effective in formulating the policies and approving the operational procedures which guided the implementation of those policies by NASA. We feel credit is due, both to the ICBC and to NASA for meeting numerous challenges so successfully.

The committee agrees with the wisdom of lunar quarantine as a policy of caution, well justified at the time it was established by the potential hazard of back-contamination from what was a largely unknown environment. The possibility existed that Apollo astronauts, infected with a virulent, contagious, lunar, biological agent, would exhibit disease symptoms within the period of quarantine and thus alert attending physicians to the need for continued effective containment of the infectious agent. A small possibility of this still exists and views expressed by qualified persons and groups who have appraised the current status of the subject differ chiefly because everyone cannot agree on the magnitude of this possibility.

It is well recognized that quarantine at best is imperfect protection against diseases even of known etiology. Some members of our committee feel that close medical surveillance of the returned Apollo astronauts would be quite sufficient. However, the majority feel that astronaut quarantine, employing essentially the same procedures as were used on the Apollo 12 mission, ought to be in effect for any future missions which may be judged to involve a risk of back-contamination.

Discussion

It seems as it did prior to Apollo 11 that any change in the U.S. Quarantine Policy must be based on a revised or more confident assessment of the overall back-contamination hazard to man and his environment. Results from Apollo 11 and 12 missions have made available substantial new information about the moon, and some of this is directly relevant to the charge of our committee. Briefly stated, we view the evidence as follows:

Hazard to Human Beings

There have been no medical signs or symptoms of illness among lunar astronauts during or subsequent to quarantine which could reasonably be attributed to lunar pathogens. Moreover, no such indications of pathology have been reported among some 150 individuals who have had at least some contact either with Apollo astronauts or with lunar sample material, however, no formal medical surveillance of this group has been maintained. We consider these negative findings reassuring but not definitive. With the relatively short duration of exposure and the small number of astronauts involved, lack of observed infection is not equivalent to a confirmed absence of pathogens.

Hazards to Animals and Plants

The lunar sample material was not found to be pathogenic to any of a number of test species of plants and animals. Again it is our view that this evidence (which pertains to many species) is more reassuring than the absence of evident human pathology. Nevertheless, such negative evidence seems insufficient to warrant the conclusion that no pathogens exist on the moon. It has been noted that lunar material under some test conditions is capable of stimulating plant growth. It is not yet clear whether such effects are attributable to the direct biological action of lunar material or perhaps to nutritional stimulation which in this context would be trivial. Until these growth augmentation results, samples were biologically inert.

Evidence of Life Forms

No living organisms were detected in lunar sample material. We feel that this evidence by itself is inconclusive, partly because there may be some question that the biological assay was fully adequate to reveal exotic life forms, but chiefly because the material which has been tested represents a limited sampling of the lunar environment. What has been examined so far is essentially surface material from two mare sites, largely igneous in origin, predictably sterile, and not for certain representative of what may be found, for example, at several meters depth in the highland region which will be sampled during the Apollo 13 mission.

We find it exceptionally difficult to conceive of an ecological model whereby life forms could endure and maintain themselves even in the most favorable environment we can imagine which could be compatible with the analytical measurements of lunar samples from Apollo 11 and 12. It is this, perhaps, even more than the negative results from direct biological testing, which constitutes the more persuasive argument against lunar life existing in those particular mare sites.

Evidence of Water and Carbon

New chemical evidence of several kinds makes it seem improbable that indigenous life could ever have existed in the environment represented by the Apollo samples so far obtained. The salient evidence is first, the absence of any hydrous minerals in the samples examined (indicating that water was not an environmental constituent when crystallization took place, and the preservation of delicate glassy surfaces and finely divided particles of iron and iron sulfide indicate the samples have not been exposed to water, vapor or liquid since crystallization); and second, the extremely low content of organic carbon which characterizes the samples.

We recognize that if only a minute quantity of organic material is present, but that it includes some living organisms, it is quite reasonable to expect nearly all of the organic carbon to be contained in those organisms. The sensitivity of testing for such organisms by chemical or physical assays without the benefit of biological amplification (growth) is inadequate. The "noise level" of such test procedures would correspond to the carbon content of hundreds or thousands of microbial cells.

Lunar "Gardening"

Geological evidence of lunar surface turnover as this applies to Apollo 11 and 12 sites persuades us against the existence at these places of a protected region containing at least some water and organic matter, and therefore a possible abode for lunar organisms. Finally, mineralogical findings and evidence from isotope dating indicate a kind of sample heterogeneity which could best be explained by assuming transport of substantial amounts of material onto the mare, presumably from the neighboring highlands. It seems quite possible or even likely that in the Apollo 11 and 12 samples, several percent may represent highland material. Even so, it would hardly be permissible to generalize from knowledge of these two sites to the many particular local environments to be found on the moon. Much of the moon is as yet unknown and thus predictions of biological significance about the landing site of Apollo 13 may be in error.

Lunar Quarantine Program

We note that the Apollo 11 and 12 samples were in all likelihood from the upper surfaces of lava beds. It is therefore not surprising that the samples from both areas appear sterile. Any possible pre-existing life would have been destroyed by processes which created these formations, and the likelihood of reinoculation from other (highland?) areas might have been negligible. On or near the surface, radiation and temperature extremes probably preclude growth and perhaps even survival of live organisms. In any case, other Apollo landing sites are apt to have quite different and new chemical characteristics. Even the two mare sites, originally expected to be much the same, have turned out to be surprisingly different. It is surely unwise to generalize from this limited Apollo sampling and it seems to most of us that the new information gained from past Apollo missions is insufficient to justify a substantial change in lunar quarantine policy applicable to the Apollo 13 mission which is targeted for a highland landing site. We therefore endorse the policy established by the ICBC which asserts that each time a substantially new type of lunar environment is visited or sampled a maximum back-contamination hazard obtains and whatever quarantine measures have been agreed upon for that circumstances become fully applicable.

Quarantine of Lunar Samples

The overriding reason for continuing the quarantine of the astronauts and the lunar samples returned from the Apollo 13 mission is the possibility that materials that have not been exposed on the lunar surface for long periods will be returned in the lower portion of a drill core sample. An additional but secondary reason for continuing the quarantine is the planned return of materials that differ significantly in composition, age and origin from the Apollo 11 and 12 samples. In previous missions the sample chosen for the biological protocol was selected to be representative of all the returned rocks and soil. Detailed study of these rock and soil samples have not shown us that there is little variation among the rock types. The requirement of pooled test samples has resulted in severe time constraints in the preliminary examinations of the lunar samples. Handling lunar samples in the LRL under quarantine restrictions precludes some desirable operations, introduces chemical contamination of the samples, and is responsible for harming delicate surface features of the rock due to the awkward manipulations which are performed. We therefore recommend that Apollo 13 samples used for the biological protocol be restricted to a much smaller portion of the returned samples. An aliquot of the lower portion of the drill core and one soil sample might be adequate. As presently planned, both of these samples could come from the ALSRC containing the drill core section. The second ALSRC, and sample returned in other containers, need not be involved in the biological protocol.

Lunar-Planetary Quarantine Relationship

There are important long-range benefits to be gained from Apollo quarantine experience. Perhaps within two decades manned missions will explore Mars and perhaps other space objectives about which we have little biologically significant information. At this time it seems advisable for NASA to plan to establish and implement a quarantine policy applicable to those more ambitions missions on the assumption that the back-contamination risks, with respect to Mars at least, will continue to be much greater than was ever thought to be the case for the earth's moon. We believe that the recommendations of the 1964 Conference on Potential hazards of back-contamination from the Planets continue to apply to the planning for a manned Mars mission. In this connection it would be valuable for NASA to document its Apollo quarantine experience in such a manner that a future generation of planners can benefit maximally from what was learned during Apollo. Substantial savings in the cost of quarantine, avoidance of compromises and more effective communication between design engineers and those responsible for biomedical aspects of quarantine policy and procedures would be facilitated by an enlightened accounting of the many lessons which are being learned in the course of the lunar quarantine program.

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*Space Science Board, National Academy of Sciences, 29-30 July 1964. Revised 19 February 1965. 15pp.

Biological Testing Program

In the course of our meeting we studied the design and results of biological tests performed with lunar samples and visited the biological laboratories of the Lunar Receiving Laboratory. Each specialist had reason to comment upon the design, conduct and results of these biological tests. An absence of direct testing methods such as microscopy scanning was noted. We found complete agreement with our views by resident scientists. The biological lunar testing program has raised many fundamental questions about the selection of host organisms and culture media, rout of inoculation with lunar material, incubation period and temperature, control samples and test procedures that we feel warrant immediate attention.

We recommend a continuing research effort at LRL to develop a wide based biological testing program, expanded to include other competent biological laboratories, with sufficient diversity not only to maximize the chance of positive findings but also to validate negative findings through adequate controls, particularly those inoculated with material known to be capable of infecting the host or culture.

Appendix

Minority Views

Dr Frank Favorite, Space Science Board

National Academy of Sciences 2101 Constitution Ave Was/DC

I disagree with continuation of lunar quarantine procedure. I recommend a post-flight isolation of one week for astronauts followed by surveillance of two months or longer. Samples should be contained in aseptic manner and released if biological testing proves negative after three weeks. Investigation should be made in depth, using expert consultants, of the plant stimulation and microbial toxicity test. Research on the survival of micro-organisms in lunar environment should be conducted as soon as possible. Better methods for detection of organisms should be investigated, especially direct methods with electron microscopy.

John Spizizen, Scripps Clinic

Harvard Medical School – Peter Bent Brigham Hospital

February 24, 1970

Memorandum for: Dr. Allan H. Brown, Chairman, ad hoc Committee of the Space Science Board in lunar quarantine, National Academy of Sciences

From: Gustave J. Dammin, M.D., member, ad hoc, Committee

1. The recommendations pertaining to "Lunar Samples" and "Biological Testing Program" contained in the "Summary of Finding and Major Recommendations" of the report of the ad hoc Committee, I concur in. However, I wish to dissent from the recommendation which calls for the continuance of the 3-week lunar quarantine procedure with reference to Apollo 13. The evidence gathered before, and the evidence presented at our meeting Feb. 17, was not sufficient in my evaluation to establish a basis for suspecting lunar samples might contain agents that would be inimical to man, animals or plants.

2. I would recommend, with reference to study of the astronauts, a period of isolation following return to earth during which specimens could be collected for such purposes as determining possible changes in flora, and the like. Conceivably no more than 3-4 days might be needed, depending upon the details of the protocol.

3. The experience gained with the 21-day quarantine procedure for Apollo 11 and 12 is indeed valuable. It will be helpful in planning the quarantine

protocol to be pursued with reference to the Mars exploration. Recording of the procedures employed in all their detail is essential since future teams of scientists concerned with the quarantine procedure may not include those who have profited from the recent Apollo experiences.

/Signed/
Gustave J. Dammin, M.D.

Document II-77

Document Title: George Low, Personal Notes No. 30, Interim Operating Budget and Apollo Decisions.

Source: Papers of George M. Low, Rensselaer Polytechnic Institute, Troy, New York.

Document II-78

Document Title: George M. Low, Acting Administrator, Letter to Edward E. David, Jr., Science Advisor to the President, "Apollo versus Skylab and Research Airplane Programs," 30 October 1970.

Source: Folder #18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

Document II-79

Document Title: James C. Fletcher, Administrator, Letter to Caspar W. Weinberger, Deputy Director, Office of Management and Budget, 3 November 1971.

Source: Papers of James C. Fletcher, University of Utah Library, Salt Lake City, UT.

George Low had become NASA Deputy Administrator in December 1969, and Dale Myers had replaced George Mueller as NASA Associate Administrator for Manned Space Flight in early 1970. During 1970, NASA was trying to gain White House approval to begin development of both an Earth-orbiting space station and a fully reusable space shuttle to service it, while the top White House priority was reducing the NASA budget. The future of the remaining Apollo missions and of the interim space station, Skylab, which was based on the conversion of the upper stage of an unneeded Saturn V booster, were caught up in the conflict between NASA's desire to get started on new development programs and the White House push for budget limitations.

NASA Administrator Thomas Paine had announced in early August 1970 his intention to resign on September 15. Low became Acting Administrator upon Paine's departure. Of the people mentioned in Low's note, Peter Flanigan was Special Assistant to President Nixon, with responsibility for space matters; Lee DuBridge was the President's Science Adviser and Russ Drew was his top staff person for space; Apollo 8 astronaut Bill Anders had become Executive Secretary of the National Aeronautics and Space Council; George Shultz was Director of the Office of Management and Budget.

NASA's decision to cancel two Apollo missions did not satisfy the White House; there was continuing pressure to either cancel additional Apollo missions and/or not fly the Skylab mission, planned for 1973. By the end of October 1970, Edward E. David, Jr. had replaced Lee Dubridge as Science Adviser, and he asked George Low to compare the priorities of additional Apollo missions and Skylab.

Even after the successful flights of Apollo 14 and Apollo 15, the White House gave serious consideration to canceling the last two Apollo missions, but ultimately NASA flew Apollo 16 and Apollo 17 in 1972 and launched the Skylab station on 14 May 1973. James Fletcher, former President of the University of Utah, became NASA Administrator in May 1971.

Document II-77

September 6, 1970

PERSONAL NOTES NO. 30

Interim Operating Budget and Apollo Decisions

I spent most of the last two weeks in August on vacation, but did return to the office on August 24th for a meeting concerning whether we should have six additional Apollo flights as planned, or should reduce the number to four. At the meeting on August 24th, we heard Dale Myers' proposal to reduce the number of flights to four, with a saving of approximately $40 million in Fiscal Year 1971, but an overall saving over the next four or five years of approximately $800 million. Also, Drs. Findlay and Ruby reported the results of the Lunar and Planetary Missions Boards meetings and the Space Science Board meetings, looking into the question concerning the additional scientific aims that could be had by maintaining six Apollo flights. The scientists' view was that they strongly recommended flying out all six remaining missions; but that the loss of one mission (Apollo 15 with its lesser capability) would not be nearly as serious as the loss of both Apollo 15 and Apollo 19.

In meetings later on August 24th and on August 31st, September 1st and September 2nd, we decided to delete two flights, Apollo 15 and Apollo 19. (The remaining Apollo flights would, of course, be redesignated Apollos 14, 15, 16, and 17.) At the same time, we developed an interim operating plan which we will use until we get a 1971 Appropriations Bill. This plan is based on the Appropriations Bill that was passed by the Congress but was subsequently vetoed by the

President. It is, therefore, at a level of approximately $64 million less than the 1971 President's budget.

In arriving at these decisions, we had invited Flanigan or his representative, DuBridge's representative, and Bill Anders to the August 24th meeting. Anders and Russ Drew, representing DuBridge, showed up, but Flanigan did not send anybody. Our intention had been to notify the White House and the Office of Management and Budget of our decision before making it public on September 1st or September 2nd. However, prior to our notification, we had a call from Shultz of OMB questioning the wisdom of making the decision at this time. His main concern was that we might lose additional funding in the Congress if we made the decision now. However, after a number of telephone conversations, we were allowed to move out with the decision. The interesting part was that the substance of the decision was not questioned, but merely our strategy relative to Congress. Shultz made the strong recommendation, however, that we do not mention the $800 million saving over a number of years. [2] We reluctantly agreed to this approach, which is probably the main reason why the publicity on the cancellation of Apollos 15 and 19 was not as good as it might have been. THE NEW YORK TIMES editorially stated that we were cancelling [*sic*] the potentially, scientifically, most fruitful missions for a relatively small amount of $40 million. Had we publicized the $800 million, I would guess that they could not have taken this stand.

Document II-78

OCT 30 1970 [stamped]
Honorable Edward E. David, Jr.
Science Advisor to the President
Executive Office Building
Washington, D.C. 20506

Dear Ed:

During our meeting last Monday, we promised to write to you on the following subjects: the relative priorities of Apollo and Skylab; and the requirement for the research airplane programs proposed in our FY 1972 budget.

<u>Apollo Versus Skylab</u>

Looking first to Apollo, we have already had a successful program that has met the fundamental objective laid down in 1961: to prove American technological superiority without military confrontation, to build a new level of national pride and prestige, and to create a base of science and technology for the future. The Apollo 11 and 12 missions have, in addition, opened a new field of lunar-related science with the return of samples, emplacement of seismic and other instruments on the surface, and erection of the laser reflector. These alone have already provided substantial scientific return on the nature of the moon and its environment, and will continue to do so for many years. Study of the data from these two missions should contribute a great deal to our understanding of the origin and evolution not only of the moon, but also of our own earth.

The remaining four Apollo missions will add incrementally to the science base as the radius of exploratory activity increases, as the diversity of sites visited enlarges, and as the sophistication of surface and orbital instrumentation grows with each flight. To reduce or constrain the scientific returns from Apollo by dropping one or more missions would involve very great losses. Moreover, any impression that each successive Apollo mission is constantly in jeopardy of being cancelled for budget reasons will have serious impact on the technical teams responsible for the safety of the flights, thereby adding to the existing dangers of the already difficult remaining missions. It would, of course, also reinforce the sentiment in the scientific community that the priority of science is decreasing on the national scene.

[2] Nevertheless, continuing Apollo missions through the next four flights, while significantly increasing our scientific understanding of the Earth-Moon system, would in another sense be dead-ended. No new capabilities or techniques would be explored that could be further exploited in the conduct of manned or unmanned programs; no major new opportunities for international leadership and prestige would likely accrue; and the potential of Apollo for international cooperation is limited.

A budgetary alternative to cutting back one or more Apollo missions would be the cancellation of Skylab. Here the situation differs, in that there has as yet been no return from the considerable investment to date; the basic objectives of Skylab are yet to be achieved. We simply have no data on man's ability to live and work in space for long periods of time. Our own 14-day and the U.S.S.R.'s 18-day manned mission experience is [*sic*] inadequate as a basis for future decisions. Our experience with man as a necessary contributor to science and applications tasks is severely limited. Our experience with long-duration habitable space systems is non-existent.

Although there are some who question the worth of space stations at this time, there is also a body of scientific and engineering opinion today that a space station will be an important and extremely valuable next step in man's exploration and utilization of space. (In fact, today's support, by scientists, for the space station appears to be greater than their support for Apollo as little as two years ago!) With Skylab, we can extend our experience from two weeks to two months; we can test realistically man's contribution to science, applications, and engineering functions; and we can develop an understanding of our future options early enough to permit the rational, deliberate evolution of our programs.

At the same time, Skylab-borne experiments are of unique scientific and technical value in themselves. The Apollo Telescope Mount (ATM) will, because of its capability to use film, have data acquisition rates a million times higher than that of the automated Orbiting Solar Observatory; the ATM is therefore ideally suited for the very high resolution study of rapidly varying solar phenomena. The earth resources survey package will give us the first meaningful intercomparison of photographic, infrared, and microwave remote sensors to correlate with aircraft ERTS experiments for determination of the next step in this exciting and relevant applications area. This package will also provide a special resolution far greater than the unmanned ERTS instruments.

[3] To forego Skylab would have a powerful negative impact on astronomy and earth resources surveys. It would leave the U.S. without the data base for any future manned mission decisions. It would surrender to the U.S.S.R. the option of having the first real space station in orbit. It would leave underdeveloped the desirable precedent of openly shared manned flight program scientific and technical results, a possibility currently underscored by the discussions in Moscow on the suggestion that the U.S. and U.S.S.R. use common docking hardware in their orbital spacecraft.

On balance, the weight of evidence seems to favor Skylab over Apollo if a choice must be made. The scientific returns from the single Skylab mission promise to be greater than those from a sixth Apollo lunar landing. We have already capitalized on our Apollo investment but not yet on that of Skylab; we will have more new options better developed stemming from Skylab than from Apollo; and, for this increased return, we risk less in earth orbit than at lunar distances.

[remainder of letter not included]

Sincerely yours,

/Signed/
George M. Low
Acting Administrator

Document II-79

PRIVILEGED INFORMATION [DECLASSIFIED]

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON. D.C, 20546

November 3, 1971

Honorable Caspar W. Weinberger
Deputy Director
Office of Management and Budget
Executive Office of the President
Washington, D. C. 20503

Dear Cap:

In our conversation last week, you indicated that cancellation of Apollo 16 and 17 was being considered by the President and asked for my views on the actions that should be taken to offset or minimize the adverse consequences if such a decision is made.

From a scientific standpoint these final two missions are extremely important, especially Apollo 17 which will be the only flight carrying some of the most advanced experiments originally planned for Apollos 18 and 19, cancelled last year. With what we have learned from Apollo 15 and previous missions, we seem to be on the verge of discovering what the entire moon is like: its structure, its composition, its resources, and perhaps even its origin. If Apollo 16 and 17 lead to these discoveries, the Apollo program will go down in history not only as man's greatest adventure, but also as his greatest scientific achievement. Recognizing the great scientific potential and the relatively small saving ($133 million) compared to the investment already made in Apollo ($24 billion), I must as Administrator of NASA strongly recommend that the program be carried to completion as now planned.

If broader considerations, nevertheless, lead to a decision to cancel Apollo 16 and 17, the consequences would be much more serious than the loss of a major scientific opportunity. Unless compensatory actions are taken at the same time to offset and minimize the impact, this decision could be a blow from which the space program might not easily recover. As you requested, I will summarize the principal adverse consequences as I see them and then outline my recommendations on the compensatory actions necessary.

[2] PRINCIPAL ADVERSE CONSEQUENCES

1. Negative Effect on Congressional and Public Support.

Without strong compensatory actions, a decision to cancel Apollo 16 and 17 would undermine the support the space program now enjoys and jeopardize the continued support that is required over the years to sustain the nation's position in space. Even though enthusiasm for the space program has diminished since the first lunar landing, NASA has continued to receive better than 98 percent of its budget requests each year (99.94% in FY 1972) because a substantial majority has accepted the judgments of the Administration and NASA's leadership that the space program is vital to the United States and that the programs recommended each year are necessary to achieve our goals. Cancellation of Apollo 16 and 17 would undermine this support in two ways.

First, it would call into question our credibility on this and other major elements of the space program since it would be a sudden reversal of the position we have so recently strongly supported in defense of our FY 1972 budget.

Second, it would terminate our best known, most visible and most exciting program which, in the minds of many in Congress and the public, has been the symbol of the space program and its success.

These factors, unless offset by strong positive actions, could result in a loss of confidence and interest that would have a "domino" effect, causing us to lose support for the programs which are essential to the long-term future of the nation in space.

2. Impact on Science and the Scientific Community

At this time, the entire cognizant scientific community is strongly in favor of Apollo 16 and 17. Cancellation would come as a shock and a surprise in view of the strong support these missions have received from the President's Science Adviser, all of NASA's science advisory groups, NASA management, and the Congress. There will be strong and vocal critical reaction.

[3] 3. Impact on Industry.

Taken by itself, the direct impact of the cancellation of Apollo 16 and 17 would be further reductions in 1972 of over 6,000 aerospace jobs. The hardest hit areas would be Southern California, Long Island, Cape Kennedy, and Houston. Unless the decision is coupled with commitments and actions to proceed with and possibly expedite other programs, like the space shuttle, it will be a devastating blow, actually and psychologically, to an already hard-hit industry.

4. Impact on NASA.

The impact on NASA will be felt most strongly at Houston and, to a lesser extent, at Huntsville and Cape Kennedy. A major problem will be to hold together for over a year the team we will need to rely on to conduct safely the Skylab missions in 1973. We will have to deal with the difficult and visible problem of the futures of the 16 astronauts now assigned to Apollo 16 and 17. The blow to morale throughout NASA will be serious unless, again, the decision is coupled with clear decisions and commitments on future programs.

5. Impact on the Public.

The large segment of space enthusiasts in the population at large would be extremely disappointed by the proposed cancellation. Included in this group would be millions who have come to Cape Kennedy, often from very long distances, to witness Apollo launches, and the much larger numbers who follow each mission closely on TV. These groups may be a minority in the U.S. but they are quite vocal and certainly non-negligible in size.

6. Impact Abroad

It is our understanding from USIA reports that the Apollo flights have been a major plus factor for the U.S. image abroad. The impact of cancelling [*sic*] Apollo 16 and 17 should be assessed in arriving at a decision.

[4] RATIONALE AND ACTIONS REQUIRED

If a decision is made to cancel Apollo 16 and 17, it is essential to provide a clearly stated and defensible rationale and take constructive actions to minimize the adverse impacts of the cancellation on the space program, the Administration, and the individuals, "communities of interest," and organizations affected. The rationale and actions must make it clear that, in spite of the cancellation, the President continues to support a program involving man in space and with strong scientific content. Specifically:

1. The reason given for cancelling [*sic*] Apollo would be budgetary; there are no other limitations to carrying Apollo to completion.

2. The total space program recommended by the President must be one that does not put an end to manned space flight (or even portends to do so in the future) and must, therefore, include Skylab and a real commitment to the shuttle with a go-ahead in the spring of 1972, and some earth orbit Apollo ("gap-filler") missions between Skylab and the shuttle.

3. The scientific content of the space program should be enhanced to offset the science lost with Apollo 16 and 17.

4. The total NASA budget should not drop below the essentially constant level of FY 1971 and FY 1972 (about $3.3 billion in budget authority) to demonstrate the President's intent to maintain a strong space program.

<u>Rationale</u>

The rationale supporting this position would be as follows:

> "Our space program has three basic purposes: exploration; the acquisition of scientific knowledge; and practical applications for man on earth. (See President's statement of March 7, 1970.) We must always strive to achieve the proper balance among these purposes.
>
> "Today we must stress two aspects of our space program. We must give a top priority to practical applications now possible and press forward with [5] the development of earth oriented systems which will enable us to make wider and more effective practical uses of space in the future.
>
> "The key to the future in space–in science and exploration as well as practical applications–is routine access to space. Space activities will be part of our lives for the rest of time. These activities cannot continue, for long, to be as complex, as demanding, or as costly as they are today. We must develop new, simpler, less expensive techniques to go to space and to return from space. This is the goal of the space shuttle program. The sooner we get on with this development, the sooner will we be able to turn our knowledge gained in space science and space exploration toward helping man on earth.
>
> "To operate in space most effectively we must also learn more about how man can best live and work in space. So while we are developing the shuttle, we must conduct space operations over longer periods of time–with Skylab.

"But to do all these things within limited resources, we must give up something. And when all factors are considered, the best project to give up--most reluctantly–is the remainder of Apollo: Apollo 16 and 17. This will for a time curtail our program of manned exploration and science.

"But we will, of course, continue exploration deep into space with unmanned spacecraft, including a landing on Mars in July 1976 with Viking, and the exploration of all the outer planets, Jupiter and beyond, with the Grand Tour late in this decade. The unmanned science program, with its High Energy Astronomy Observatory and other spacecraft will also continue to expand our fundamental knowledge of the universe. It is only manned science, and manned exploration, that will be curtailed.

"The United States must continue to fly men in space. Man will fly in space, and we cannot forego our responsibility–to ourselves and to the free world–to take part in this great venture. But for a time man can devote his own efforts, from space, toward practical [6] needs here on earth, while leaving exploration beyond the earth to machines."

I believe that this is the best rationale that can be given, although it is admittedly somewhat complex, and neither it nor any other rationale will be accepted by the interested scientific community.

Actions

The actions required to offset the adverse impact of the cancellation of Apollo 16 and 17 should include:

1. A commitment to a strong manned space flight program including Skylab and a good start on the space shuttle.

2. The earth-oriented emphasis of manned space flight can be further amplified by flying "surplus" Apollo spacecraft in earth orbit in the 1974-76 time period, i.e., "gap-filler" missions after Skylab and before the shuttle, as proposed in the NASA FY 1973 budget submissions. These spacecraft can be equipped with sophisticated earth-oriented experiments as precursors to the type of operations to be carried out with the shuttle. At the same time, they could provide the means for a joint flight with the Soviet Union–a step that has already been hailed editorially as one in the right direction for the U.S. space program in that it could lead to an ultimate sharing of the expense of space among many nations.

3. Science: NASA needs the support of the "scientific community" to carry out its programs. And although the impact of this community on the Administration as a whole is small, it is important to minimize and divert the criticism the Administration will receive as a result of a decision to cancel Apollo 16 and 17.

Nothing can be done to get general acceptance of a cancellation by the lunar scientists. However, the impact on them, as well as criticism by all scientists, can be minimized if the following steps are taken:

a. Announcement of a sound program for the continued analysis of lunar materials already obtained. Such a [7] program would have a great scientific value, and would also continue financial support to the scientists involved in lunar analysis, who would otherwise be out of a job.

b. Initiation of a small effort toward Jupiter orbiters and probes ("Pioneer" class spacecraft). One of the most important concerns of the National Academy of Sciences Space Science Board is that NASA's present plans for the Grand Tour missions to the outer planets do not include a parallel program for the detailed exploration of Jupiter. The inclusion of a continuing Pioneer program, in addition to the Grand Tour, would partially offset the negative impact of the cancellation of Apollo.

c. Reinstatement of the Orbiting Solar Observatories I, J, and K, proposed for deletion in NASA's FY 1973 budget proposal, and the full funding of the High Energy Astronomy Observatory, proposed for reduced funding in NASA's budget, would demonstrate the Administration's desire to support science to a large segment of the space science community.

4. The effectiveness of the above compensatory actions will depend in large measure on the total budget level approved for NASA for FY 1973. Unless the NASA FY 1973 budget is essentially at or above the FY 1971 and FY 1972 budget authority level of about $3.3 billion, the decision to cancel Apollo 16 and 17 will be regarded by the Congress, the public, and the scientific community as a part of a general backing away from and downgrading of the space program.

<u>Effect of Actions on Budget</u>

The actions discussed above would result in a net reduction in NASA's FY 1973 minimum recommended budget estimates but would not take the total estimate for budget authority below $3.3 billion, as indicated below.

[8]

	(in millions)	
	Budget <u>Authority</u>	Budget <u>Outlays</u>
NASA FY 1973 Budget Submission—Minimum Recommended Program	$3,385	$3,225
Cancellation of Apollo 16 & 17	–133	–109
Start Space Shuttle	(no change)	(no change)
Reinstate OSO-I, J, K	+ 20	+ 15
Start Pioneer Orbiter/ Probes	+ 15	+ 5

Full Support for HEAO	+ 26	+ 20
1974-1976 Manned Orbital Flights	+ 38	+ 30
TOTAL	$3,351	$3, 186

Effect on Employment

If the actions previously discussed–the early go-ahead on the shuttle, the inclusion of the gap-filler missions, and the augmentation of science missions–are taken, then the negative impact on the industry, and on employment, will to some degree be alleviated. The effects of these actions on employment during calendar year 1972, in terms of changes in contractor employment projected under our FY 1973 budget recommendations, would be approximately as follows:

[9]

Employment End of 1972	Contractor
Estimated under NASA FY 1973 Budget Submission (Minimum Recommended Program)	109, 200
Cancellation of Apollo 16 & 17	- 6,200
Start Space Shuttle	(no change)
Reinstate OSO I, J, K	+ 700
Start Pioneer orbiter/probes	(no significant effect until 1973)
Full support for HEAO	+ 1,200
1974-1976 manned orbital flights	+ 1,900
TOTAL	106, 800

The net effect on employment will be downward since the decrease would be almost immediate but increases due to new programs obviously take a few months to materialize.

In a separate exercise, we have provided information to Fred Foy to show how employment on the shuttle could be increased above our FY 1973 budget recommendations.

CONCLUSIONS

I recommend against the cancellation of Apollo 16 and 17 because these flights are scientifically important, and because much of the overall support for NASA's space program depends on our actions with respect to these flights.

If, nevertheless, for reasons external to NASA, Apollo 16 and 17 must be cancelled, then it becomes necessary to:

1. Provide strong backing to the manned earth-oriented space program.

[10] 2. Develop a rationale for the actions taken that is credible and supportable.

3. Take compensatory actions that will minimize the impact on the remaining NASA programs and their support.

The proposed rationale for the cancellation of Apollo 16 and 17 is that, in these times of pressing domestic needs, the manned space program should be earth-oriented instead of exploration and science-oriented.

The compensatory actions involve an early go-ahead for the space shuttle, the inclusion of "gap-filler" missions between Skylab and the shuttle, a number of augmented unmanned space science programs, and maintaining a total NASA budget at the FY 1971-1972 level of about $3.3 in budget authority.

I would be pleased to discuss these matters with you at your convenience.

Sincerely,

James C. Fletcher
Administrator

Document II-80

Document Title: Letter to Congressman G. P. Miller, Chairman of the House Committee on Science and Astronautics, from 39 Scientists, 10 September 1970.

Source: Folder #18675, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

NASA announced the cancellation of the Apollo 15 and Apollo 19 missions on 2 September 1970. There was an outcry from the media and many members of the scientific community, but the decision could not be reversed. This meant that the Apollo lunar landing program would end with the Apollo 17 mission in December 1972.

September 10, 1970

Congressman G. P. Miller
Chairman House Committee on Science
and Astronautics
House Office Building
Washington, D. C. 20515

Dear Chairman Miller:

We, the undersigned scientists concerned with the space program, would like to express to you our deep misgivings about the NASA decision of cancelling [*sic*] two of the remaining lunar Apollo flights, resulting in a severe curtailment of the lunar exploration program. In particular, we would like to stress the following points:

1. The Apollo lunar program is intended to supply not merely information of interest to scientists, but to give us finally a clear understanding of the origin of the earth-moon system and with this, an understanding of the origin and mode of construction of our earth. The structure of the Apollo program is one of increasing capabilities, and the two cancelled missions represent much more than one third of the planned scientific program. With this curtailment, the program may fail in its chief purpose of reaching a new level of understanding.

2. The NASA policy leading to the cancellations appears to be one of favoring the early construction of large manned earth orbital systems following after Skylab A, and the effort and funds saved by the curtailment will probably go towards these. The merit of these programs for science or applications should be investigated, and the very important decision regarding their funding should in our view be made as a separate step. At present, it appears that the approved and scientifically most fruitful lunar program will suffer in favor of an as yet unapproved program for whose scientific value there is no consensus, and whose purpose is unclear.

3. The majority of the equipment saved by the proposed cancellations will in all probability be shelved indefinitely, since large funds would be required for its adaptation to other purposes or its rehabilitation at a later date for lunar flights, as well as for the re-creation of the Apollo launch capability.

We hope that these decisions are not yet final, and that the country will not give up a plan of very great significance when the preparation for it is so nearly complete.

Yours sincerely,

(See attached pages)

cc: Congressman Olin E. Teague
House Office Building
Washington, D.C. 20515

[Signed] Dr. M. E. Langseth
Lamont-Doherty Geological Observatory –
Columbia University

[Signed] Dr. William M. Kaula
Professor of Geophysics
University of California

[Signed] Dr. Lincoln R. Page
U.S. Geological Survey

[Signed] Dr. William R. Muehlberger
Professor of Geology
University of Texas

[Signed] Dr. Rolf Meissner
Visiting Professor
University of Hawaii

[Signed] Dr. T. W. Thompson
Jet Propulsion Laboratory

[Signed] Dr. Brian H. Mason, Curator
Division of Meteorites
U.S. National Museum

[Signed] Dr. Roman A. Schmitt
Radiation Center
Oregon State University

[Signed] Dr. Ian D. MacGregor
Department of Geology
University of California

[Signed] Professor Thomas Gold
Center for Radio Physics and Space Research –
Cornell University

[Signed] Dr. William W. Ruby, Director
The Lunar Science Institute and
Prof. of Geology, the University
of California, Los Angeles

[Signed] Dr. Leon T. Silver
Division of Geological Sciences
California Institute of Technology

[Signed] S. O'Sullivan

[Signed] Dr. Eugene Schoemaker [*sic*]
Division of Geological Sciences
California Institute of Technology

[Signed] Dr. Jeffrey L. Warner
Geology Branch
Manned Spacecraft Center

[Signed] Dr. Charles E. Helsley
Acting Head, Geosciences
University of Texas, Dallas

[Signed] Dr. Warren G. Meinschein
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[Signed] Dr. George Wetherill
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[Signed]	Mr. Ernest Schonfeld Geology Branch Manned Spacecraft Center
[Signed]	Dr. George E. Ulrich U.S. Geological Survey
[Signed]	Mr. J. D. Strobell, Jr. U.S. Geological Survey
[Signed]	Dr. David S. McKay
[Signed]	Dr. John Reynolds Department of Physics University of California, Berkeley

Document II-81

Document Title: Mission Evaluation Team, NASA Manned Spacecraft Center, "Apollo 11: Mission Report," 1971.

Source: Johnson Space Center Archives.

This report captures in flat prose what actually took place during the historic Apollo 11 lunar landing mission. Included here are a brief mission overview and the crew's report on mission activities.

APOLLO 11

Mission Report

PREPARED BY
MISSION EVALUATION TEAM
NASA MANNED SPACECRAFT CENTER

Scientific and Technical Information Office 1971
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Washington, D.C.

[1-1]

1.0 SUMMARY

The purpose of the Apollo 11 mission was to land men on the lunar surface and to return them safely to earth. The crew were Neil A. Armstrong, Commander; Michael Collins, Command Module Pilot; and Edwin E. Aldrin, Jr., Lunar Module Pilot.

The space vehicle was launched from Kennedy Space Center, Florida, at 8:32:00 a.m., e.s.t., July 16, 1969. The activities during earth orbit checkout, translunar injection, transposition and docking, spacecraft ejection, and translunar coast were similar to those of Apollo 10. Only one midcourse correction, performed at about 27 hours elapsed time, was required during translunar coast.

The spacecraft was inserted into lunar orbit at about 76 hours, and the circularization maneuver was performed two revolutions later. Initial checkout of lunar module systems was satisfactory, and after a planned rest period, the Commander and Lunar Module Pilot entered the lunar module to prepare for descent.

The two spacecraft were undocked at about 100 hours, followed by separation of the command and service modules from the lunar module. Descent orbit insertion was performed at approximately 101-1/2 hours, and powered descent to the lunar surface began about 1 hour later. Operation of the guidance and descent propulsion systems was nominal. The lunar module was maneuvered manually approximately 1100 feet down range from the nominal landing point during the final 2-1/2 minutes of descent. The spacecraft landed in the Sea of Tranquility at 102:45:40. The landing coordinates were 0 degrees 41 minutes 15 seconds north latitude and 23 degrees 26 minutes east longitude reference to lunar map ORB-II-6(100), first edition, December 1967. During the first 2 hours on the lunar surface, the two crewmen performed a postlanding checkout of all lunar module systems. Afterward, they ate their first meal on the moon and elected to perform the surface operations earlier than planned.

Considerable time was deliberately devoted to checkout and donning of the back-mounted portable life support and oxygen purge systems. The Commander egressed through the forward hatch and deployed an equipment module in the descent stage. A camera in this module provided live television coverage of the Commander descending the ladder to the surface, with first contact made at 109:24:15 (9:56:15 p.m. e.s.t., July 20, 1969). The Lunar Module Pilot egressed soon thereafter, and both crewmen used the initial period on the surface to become acclimated to the reduced gravity and unfamiliar surface conditions. A contingency sample was taken from the surface, and the television camera was deployed so that most of the lunar module was included in its view field. The crew activated the scientific experiments, which included a solar wind detector, a passive [1-2] seismometer, and a laser retro-reflector. The Lunar Module Pilot evaluated his ability to operate and move about, and was able to translate rapidly and with confidence. Forty-seven pounds of lunar surface material were collected to be returned for analysis. The surface exploration was concluded in the allotted time of 2-1/2 hours, and the crew reentered the lunar module at 111-1/2 hours.

Ascent preparation was conducted efficiently, and the ascent stage lifted off the surface at 124-1/4 hours. A nominal firing of the ascent engine placed the vehicle into a 48- by 9-mile orbit. After a rendezvous sequence similar to that of Apollo 10, the two spacecraft were docked at 128 hours. Following transfer of the crew, the ascent stage was jettisoned, and the command and service modules were prepared for transearth injection.

The return flight started with a 150-second firing of the service propulsion engine during the 31st lunar revolution at 135-1/2 hours. As in the translunar flight, only one midcourse correction was required, and passive thermal control was exercised for most of transearth coast. Inclement weather necessitated moving the landing point 215 miles downrange. The entry phase was normal, and the command module landed in the Pacific Ocean at 195-1/4 hours. The landing coordinates, as determined from the onboard computer, were 13 degrees 19 minutes north latitude and 169 degrees 09 minutes west longitude.

After landing, the crew donned biological isolation garments. They were then retrieved by helicopter and taken to the primary recovery ship, USS Hornet. The crew and lunar material samples were placed in the Mobile Quarantine Facility for transport to the Lunar Receiving Laboratory in Houston. The command module was taken aboard the Hornet about 3 hours after landing.

With the completion of Apollo 11, the national objective of landing men on the moon and returning them safely to earth before the end of the decade had been accomplished.

[Sections 2 and 3 not included]

[4-1]

4.0 PILOTS' REPORT

4.1 PRELAUNCH ACTIVITIES

All prelaunch systems operations and checks were completed on time and without difficulty. The configuration of the environmental control system included operation of the secondary glycol loop and provided comfortable cockpit temperature conditions.

4.2 LAUNCH

Lift-off occurred precisely on time with ignition accompanied by a low rumbling noise and moderate vibration that increased significantly at the moment of hold-down release. The vibration magnitudes decreased appreciably at the time tower clearance was verified. The yaw, pitch, and roll guidance-program sequences occurred as expected. No unusual sounds or vibrations while passing through the region of maximum dynamic pressure and the angle of attack remained near zero. The S-IC/S-II staging sequence occurred smoothly and at the expected time.

The entire S-II stage flight was remarkably smooth and quiet, and the launch escape tower and boost protective cover were jettisoned normally. The mixture ratio shift of the was accompanied by a noticeable acceleration decrease. The S-II/S-IVB staging sequence occurred smoothly and approximately at the predicted time. The S-IVB insertion trajectory was completed without incident and the automatic guidance shutdown yielded an insertion-orbit ephemeris, from the command module computer, of 102.1 by 103.9 miles. Communications between the crewmembers and the Network were excellent throughout all stages of launch.

4.3 Earth Orbit Coast and Translunar Injection

The insertion checklist was completed, and a series of spacecraft systems checks disclosed no abnormalities. All tests of the navigation equipment, including alignments and drift checks, were satisfactory. The service module reaction control thrusters were fired in the minimum impulse mode and were verified by telemetry.

No abnormalities were noted during preparation for translunar injection. Initiation of translunar injection was accompanied by the proper onboard indications and the S-IVB propellant tanks were repressurized on schedule.

[4-2] The S-IVB stage reignited on time at 2:44:16 without ignition or guidance transients. An apparent 0.50- to 1.5- degree pitch-attitude error on the attitude indicators was not confirmed by the command module computer, which indicated that the attitude and the attitude rate duplicated the reference trajectory precisely (see section 8.6). The guided cutoff yielded a velocity very close to that expected, as indicated by the onboard computer. The entry monitor system further confirmed that the forward velocity error for the translunar injection maneuver was within 3.3 ft/sec.

4.4 Transposition and Docking

The digital autopilot was used for the transposition maneuver scheduled to begin 20 seconds after spacecraft separation from the S-IVB. The time delay was to allow the command and service modules to drift approximately 70 feet prior to thrusting back toward the S-IVB. The separation and the beginning of transposition were on time. In order to assure a pitch-up maneuver for better visibility through the hatch window, pitch axis control was retained in a manual mode until after a pitch-up rate of approximately 1 deg/sec was attained. Control was then given to the digital autopilot to continue the combined pitch/roll maneuver. However, the autopilot stopped pitching up at this point, and it was necessary to reestablish manual control (see section 8.6 for more discussion of this subject). This cycle was repeated several times before the autopilot continued the transposition maneuver. Consequently, additional time and reaction control fuel (18 pounds above preflight nominal) were required, and the spacecraft reached a maximum separation distance of at least 100 feet from the S-IVB.

The subsequent closing maneuvers were made normally under digital autopilot control, using a 2-deg/sec rate and 0.5-degree deadband control mode.

Contact was made at an estimated 0.1 ft/sec, without side velocity, but with a small roll misalignment. Subsequent tunnel inspection revealed a roll index angle of 2.0 degrees and a contact mark on the drogue 4 inches long. Lunar module extraction was normal.

4.5 Translunar Coast

The S-IVB was targeted to achieve a translunar injection cut-off velocity 6.5 ft/sec in excess of that required to place it on the desired free-return trajectory. This overspeed was then cancelled by a service propulsion correction of 20 ft/sec at 23 minutes after spacecraft ejection.

[4-3] Two periods of cislunar midcourse navigation, using the command module computer program (P23), were planned and executed. The first, at 6 hours, was primarily to establish the apparent horizon altitude for optical marks in the computer. The first determination was begun at a distance of approximately 30,000 miles, while the second determination, at 24 hours, was designed to accurately determine the optical bias errors. Excess time and fuel were expended during the first period because of difficulty in locating the substellar point of each star. Ground-supplied gimbal angles were used rather than those from the onboard computer. This technique was devised because computer solutions are unconstrained about the optics shaft axis; therefore, the computer is unable to predict if the lunar module structure might block the line of sight to the star. The ground-supplied angles prevented the lunar module structure from occulting the star, but were not accurate in locating the precise substellar point, as evidenced by the fact that the sextant reticle pattern was not parallel to the horizon. Additional maneuvers were required to achieve a parallel reticle pattern near the point of horizon-star superposition.

The second period of navigation measurements was less difficult, largely because the earth appeared much smaller and trim maneuvers to the substellar point could be made much more quickly and economically.

The digital autopilot was used to initiate the passive thermal control mode at a positive roll rate of 0.3 deg/sec, with the positive longitudinal axis of the spacecraft pointed toward the ecliptic North Pole during translunar coast (the ecliptic South Pole was the direction used during transearth coast). After the roll rate was established, thruster firing was prevented by turning off all 16 switches for the service module thrusters. In general, this method was highly successful in that it maintained a satisfactory spacecraft attitude for very long periods of time and allowed the crew to sleep without fear of either entering gimbal lock or encountering unacceptable thermal conditions. However, a refinement to the procedure in the form of a new computer routine is required to make it foolproof from an operator's viewpoint. [Editor's note: A new routine (routine 64) was available for Apollo 12.] On several occasions and for several different reasons, an incorrect computer-entry procedure was used, resulting in a slight waste of reaction control propellants. Satisfactory platform alignments (program P52, option 3) using the optics in the resolved mode and medium speed were possible while rotating at 0.3 deg/sec.

4.6 Lunar Orbit Insertion

The spacecraft was inserted into a 169.9- by 60.9-mile orbit based on the onboard computer with a 6-minute service propulsion maneuver. Procedurally, this firing was the same as all the other service propulsion [4-4] maneuvers, except that it was started by using the bank-B propellant valves instead of the bank-A valves. The steering of the docked spacecraft was exceptionally smooth, and the control of applied velocity change was extremely accurate, as evidenced by the fact that residuals were only 0.1 ft/sec in all axes.

The circularization maneuver was targeted for a 66- by 54-mile orbit, a change from the 60-mile circular orbit which had been executed in previous lunar flights. The firing was normally accomplished using bank-A propellant valves only, and the onboard solution of the orbit was 66.1 by 54.4 miles. The ellipticity of this orbit was supposed to slowly disappear because of irregularities in the lunar gravitational field, such that the command module would be in a 60-mile circular orbit at the time of rendezvous. However, the onboard estimate of the orbit during the rendezvous was 63.2 by 56.8 miles, indicating the ellipticity decay rate was less than expected. As a result the rendezvous maneuver solutions differed from the preflight estimates.

4.7 Lunar Module Checkout

Two entries were made into the lunar module prior to the final activation on the day of landing. The first entry was made at about 57 hours, on the day before lunar orbit insertion. Television and still cameras were used to document the hatch probe and drogue removal and the initial entry into the lunar module. The command module oxygen hoses were used to provide circulation in the lunar module cabin. A leisurely inspection period confirmed the proper positioning of all circuit breaker and switch settings and stowage items. All cameras were checked for proper operation.

4.8 Descent Preparation

4.8.1 Lunar Module

The crew was awakened according to the flight plan schedule. The liquid cooling garment and biomedical harnesses were donned. In anticipation, these items had been unstowed and prepositioned the evening before. Following a hearty breakfast, the Lunar Module Pilot transferred into the lunar module to accomplish initial activation before returning to the command module for suiting. This staggered suiting sequence served to expedite the final checkout and resulted in only two crewmembers being in the command module during each suiting operation.

[4-5] The sequence of activities was essentially the same as that developed for Apollo 10, with only minor refinements. Numerous Network simulations and training sessions, including suited operations of this mission phase, ensured the completion of this exercise within the allotted time. As in all previous entries into

the lunar module, the repressurization valve produced a loud "bang" whenever it was positioned to CLOSE or AUTO with the cabin regulator off. Transfer of power from the command module to the lunar module and then electrical power system activation were completed on schedule.

The primary glycol loop was activated about 30 minutes early, with a slow but immediate decrease in glycol temperature. The activation continued to progress smoothly 30 to 40 minutes ahead of schedule. With the Commander entering the lunar module early, the Lunar Module Pilot had more than twice the normally allotted time to don his pressure suit in the command module.

The early powerup of the lunar module computer and inertial measurement unit enabled the ground to calculate the fine gyro torquing angles for aligning the lunar module platform to the command module platform before the loss of communications on the lunar far side. This early alignment added more than an hour to the planned time available for analyzing the drift of the lunar module guidance system.

After suiting, the Lunar Module Pilot entered the lunar module, the drogue and probe were installed, and the hatch was closed. During the ascent-battery checkout, the variations in voltage produced a noticeable pitch and intensity variation in the already loud noise of the glycol pump. Suit-loop pressure integrity and cabin regulator repressurization checks were accomplished without difficulty. Activation of the abort guidance system produced only one minor anomaly. An illuminated portion of one of the data readout numerics failed, and this resulted in some ambiguity in data readout (see section 16.2.7).

Following command module landmark tracking, the vehicle was maneuvered to obtain steerable antenna acquisition and state vectors were uplinked into the primary guidance computer. The landing gear deployment was evidenced by a slight jolt to the vehicle. The reaction control system, the descent propulsion system, and the rendezvous radar system were activated and checked out. Each pressurization was confirmed both audibly and by instrument readout.

The abort guidance system calibration was accomplished at the preplanned vehicle attitude. As the command and service modules maneuvered both vehicles to the undocking attitude, a final switch and circuit breaker configuration check was accomplished, followed by donning of helmets and gloves.

[4-6]

4.8.2 Command Module

Activities after lunar orbit circularization were routine, with the time being used primarily for photographs of the lunar surface. The activation of the lunar module in preparation for descent was, from the viewpoint of the Command Module Pilot, a well organized and fairly leisurely period. During the abort guidance system calibration, the command module was maintained at a fixed attitude for several minutes without firing thrusters. It was easy to stabilize the spacecraft with minimum-impulse control prior to the required period so that thruster firings were needed for at least 10 minutes.

The probe, drogue, and hatch all functioned perfectly, and the operations of closing out the tunnel, preloading the probe, and cocking the latches were done routinely. Previous practice with installation and removal of the probe and drogue during translunar coast was most helpful.

Two periods of orbital navigation (P22) were scheduled with the lunar module attached. The first, at 83 hours, consisted of five marks on the Crater Kamp in the Foaming Sea. The technique used was to approach the target area in an inertial attitude hold mode, with the X-axis being roughly horizontal when the spacecraft reached an elevation angle of 35° from the target, at which point a pitch down of approximately 0.3 deg/sec was begun. This technique was necessary to assure a 2-1/2 minute mark period evenly distributed near the zenith, was performed without difficulty.

The second navigation exercise was performed on the following day shortly prior to separation from the lunar module. A series of five marks was taken on a small crater on the inner north wall of crater 130. The previously described technique was used, except that two forward-firing thrusters (one yaw and one pitch) were inhibited to preclude thrust impingement on the deployed rendezvous-radar and steerable antennas. The reduced pitch authority doubled the time required, to approximately 3 seconds when using acceleration command, to achieve a 0.3 deg/sec pitch-down rate. In both cases, the pitch rate was achieved without reference to any on board rate instrumentation by simply timing the duration of acceleration-command hand controller inputs, since the Command Module Pilot was in the lower equipment bay at the time.

To prevent the two vehicles from slipping and hence upsetting the docked lunar module platform alignment, roll thruster firings were inhibited after the probe preload until the tunnel had been vented to approximately 1 psi. Only single roll jet authority was used after the l-psi point was reached and until the tunnel pressure was zero.

[4-7]

4.9 UNDOCKING AND SEPARATION

Particular care was exercised in the operation of both vehicles throughout the undocking and separation sequences to ensure that the lunar module guidance computer maintained an accurate knowledge of position and velocity.

The undocking action imparted a velocity to the lunar module of 0.4 ft/sec, as measured by the lunar module primary guidance system. The abort guidance system disagreed with the primary system by approximately 0.2 ft/sec, which is well within the preflight limit. The velocity was nulled, assuming the primary system was assumed to be correct. The command module undocking velocity was maintained until reaching the desired inspection distance of 40 feet, where it was visually nulled with respect to the lunar module.

A visual inspection by the Command Module Pilot during a lunar module 360-degree yaw maneuver confirmed proper landing gear extension. The lunar module maintained position with respect to the command module at relative rates believed to be less than 0.1 ft/sec. The 2.5-ft/sec, radially downward separation maneuver was performed with the command and service modules at 100 hours to enter the planned equiperiod separation orbit.

4.10 LUNAR MODULE DESENT

The first optical alignment of the inertial platform in preparation for descent orbit insertion was accomplished shortly after entering darkness following separation. The torquing angles were approximately 0.3 degree, indicating an error in the docked alignment or platform drift. A rendezvous radar lock was achieved manually, and the radar boresight coincided with that of the crew optical sight. Radar range was substantiated by the VHD ranging in the command module.

4.10.1 Descent Orbit Insertion

The descent orbit insertion maneuver was performed with the descent engine in the manual throttle configuration. Ignition at the minimum throttle setting was smooth, with no noise or sensation of acceleration. After 15 seconds, the thrust level was advanced to 40 percent, as planned. Throttle response was smooth and free of oscillations. The guided cutoff left residuals of less than 1 ft/sec in each axis. The X- and Z-axis residuals were reduced to zero by using the reaction control system. The computer determined ephemeris was 9.1 by 57.2 miles, as compared with the [4-8] predicted value of 8.5 by 57.2 miles. The abort guidance system confirmed that the magnitude of the maneuver was correct. An additional evaluation was performed by using the rendezvous radar to check the relative velocity between the two spacecraft at 6 and 7 minutes subsequent to the maneuver. These values corresponded to the predicted data within 0.5 ft/sec.

4.10.2 Alignment and Navigation Checks

Just prior to powered descent, the angle between the line of sight to the sun and a selected axis of the inertial platform was compared with the onboard computer prediction of that angle and this provided a check on inertial platform drift. Three such measurements were all within the specified tolerance, but the 0.08-degree spread between them was somewhat larger than expected.

Visual checks of downrange and crossrange position indicated that ignition for the powered descent firing would occur at approximately the correct location over the lunar surface. Based on measurements of the line-of-sight rate of landmarks, the estimates of altitudes converged on a predicted altitude at ignition 52 000 feet above the surface. These measurements were slightly degraded because of a 10 - to 15-degree yaw bias maintained to improve communications margins.

4.10.3 Powered Descent

Ignition for powered descent occurred on time at the minimum thrust level, and the engine was automatically advanced to the fixed throttle point (maximum thrust) after 26 seconds. Visual position checks indicated the spacecraft was 2 or 3 seconds early over a known landmark, but with little cross-range error. A yaw maneuver to a face-up position was initiated at an altitude of about 45 900 feet approximately 4 minutes after ignition. The landing radar began receiving altitude data immediately. The altitude difference, as displayed from the radar and the computer, was approximately 2800 feet.

At 5 minutes 16 seconds after ignition, the first of a series of computer alarms indicated a computer overload condition. These alarms continued intermittently for more than 4 minutes, and although continuation of the trajectory was permissible, monitoring of the computer information display was occasionally precluded (see section 16.2.5).

Attitude-thruster firings were heard during each major attitude maneuver and intermittently at other times. Thrust reduction of the descent propulsion system occurred nearly on time (planned at 6 minutes 24 seconds after ignition), contributed to the prediction that the [4-9] landing would probably be down range of the intended point, inasmuch as the computer had not been corrected for the observed downrange error.

The transfer to the final-approach-phase program (P64) occurred at the predicted time. After the pitch maneuver and the radar antenna position change, the control system was transferred from the automatic to the attitude hold mode and control response checked in pitch and roll. Automatic control was restored after zeroing the pitch and yaw errors.

After it became clear that an automatic descent would terminate in a boulder field surrounding a large sharp-rimmed crater, manual control was again assumed, and the range was extended to avoid the unsatisfactory landing area. The rate-of-descent mode of throttle (program P66) was entered in the computer to reduce altitude rate so as to maintain sufficient height for landing-site surveillance.

Both the downrange and the crossrange positions were adjusted to permit final descent in a small, relatively level area bounded by a boulder field to the north and sizable craters to the east and south. Surface obscuration caused by blowing dust was apparent at 100 feet and became increasingly severe as the altitude decreased. Although visual determination of horizontal velocity, attitude, and altitude rate were degraded, cues for these variables were adequate for landing. Landing conditions are estimated to have been 1 or 2 ft/sec left, 0 ft/sec forward, and 1 ft/sec down; no evidence of vehicle instability at landing was observed.

4.11 COMMAND MODULE SOLO ACTIVITIES

The Command Module Pilot consolidated all known documentation requirements for a single volume, known as the Command Module Pilot Solo Book, which was very useful and took the place of a flight plan, a rendezvous book, an updates book, a contingency extravehicular checklist, and so forth. This book normally was anchored to the Command Module Pilot by a clip attached to the end of his helmet tie-down strap. The sleep period was timed to coincide with that of the lunar module crew so that radio silence could be observed. The Command Module Pilot had complete trust in the various systems experts on duty in the Mission Control Center and therefore was able to sleep soundly.

The method used for target acquisition (program P22) while the lunar module was on the surface varied considerably from the docked case. The optical alignment sight reticle was placed on the horizon image, and the resulting spacecraft attitude was maintained manually at the orbital rate in the minimum-impulse control mode. Once stabilized, the vehicle maintained this attitude long enough to allow the Command Module Pilot to [4-10] move to the lower equipment bay and take marks. He could also move from the equipment bay to the hatch window in a few seconds to cross-check the attitude. This method of operation in general was very satisfactory.

Despite the fact that the Command Module Pilot had several uninterrupted minutes each time he passed over the lunar module, he could never see the spacecraft on the surface. He was able to scan an area of approximately 1 square mile on each pass, and ground estimates of lunar module position varied by several miles from pass to pass. It is doubtful that the Command Module Pilot was ever looking precisely at the lunar module and more likely was observing an adjacent area. Although it was not possible to assess the ability to see the lunar module from 60 miles, it was apparent there were no flashes of specular light with which to attract his attention.

The visibility through the sextant was good enough to allow the Command Module Pilot to acquire the lunar module (in flight) at distances of over 100 miles. However, the lunar module was lost in the sextant field of view just prior to powered descent initiation (120-mile range) and was not regained until after ascent insertion (at an approximate range of 250 miles), when it appeared as a blinking light in the night sky.

In general, more than enough time was available to monitor systems and perform all necessary functions in a leisurely fashion, except during the rendezvous phase. During that 3-hour period when hundreds of computer entries, as well as numerous marks and other manual operations, were required, the Command Module Pilot had little time to devote to analyzing any off-nominal rendezvous trends as they developed or to cope with any systems malfunctions. Fortunately, no additional attention to these details was required.

4.12 LUNAR SURFACE OPERATIONS

4.12.1 Postlanding checkout

The postlanding checklist was completed as planned. Venting of the descent oxidizer tanks was begun almost immediately. When the oxidizer tank pressure was vented to between 40 and 50 psi, fuel was vented to the same pressure level. Apparently, the pressure indications received on the ground were somewhat higher and they increased with time (see section 16.2.2). At ground request, the valves were reopened and the tanks vented to 15 psi.

[4-11]

Platform alignment and preparation for early lift-off were completed on schedule without significant problems. The mission timer malfunctioned and displayed an impossible number that could not be correlated with any specific failure time. After several unsuccessful attempts to recycle this timer, it was turned off for 11 hours to cool. The timer was turned on for ascent, and it operated properly and performed satisfactorily for the remainder of the mission (see section 16.2.1).

4.12.2 Egress Preparation

The crew had given considerable thought to the advantage of beginning the extravehicular activity as soon as possible after landing instead of following the flight plan schedule of having the surface operations between two rest periods. The initial rest period was planned to allow flexibility in the event of unexpected difficulty with postlanding activities. These difficulties did not materialize, the crew were not overly tired, and no problem was experienced in adjusting to the 1/6-g environment. Based on these facts, the decision was made at 104:40:00 to proceed with the extravehicular activity prior to the first rest period.

Preparation for extravehicular activity began at 106:11:00. The estimate of the preparation time proved to be optimistic. In simulations, 2 hours had been found to be a reasonable allocation; however, everything had also been laid out in an orderly manner in the cockpit, and only those items involved in the extravehicular activity were present. In fact, items involved in the extravehicular activity were present. In fact, there were checklists, food packets, monoculars, and other miscellaneous items that interfered with an orderly preparation. All these items required some thought as to their possible interference or use in the extravehicular activity. This interference resulted in exceeding the time line estimate by a considerable amount. Preparation for egress was conducted slowly, carefully, and deliberately, and future missions should be planned and conducted with the same philosophy. The extravehicular activity preparation checklist was adequate and was closely followed. However, minor items that required a decision in real time or had not been considered before flight required more time than anticipated.

An electrical connector on the cable that connects the remote control unit to the portable life support system gave some trouble in mating (see section 16.3.2). This problem had been occasionally encountered with the same equipment before flight. At least 10 minutes were required in order to connect each unit, and at one point it was thought the connection would not be successfully completed.

Considerable difficulty was experienced with voice communications when the extravehicular transceivers were used inside the lunar module. At times communications were good, but at other times they were garbled on the [4-12] ground for no obvious reason. Outside the vehicle, there were no appreciable communication problems. Upon ingress from the surface, these difficulties recurred, but under different conditions. That is, the voice dropouts to the ground were not repeatable in the same manner.

Depressurization of the lunar module was one aspect of the mission that had never been completely performed on the ground. In the various altitude chamber tests of the spacecraft and the extravehicular mobility unit, a complete set of authentic conditions was never present. The depressurization of the lunar module through the bacteria filter took much longer than had been anticipated. The indicated cabin pressure did not go below 0.1 psi, and some concern was experienced in opening the forward hatch against this residual pressure. The hatch appeared to bend on initial opening, and small particles appeared to be blown out around the hatch when the seal was broken (see section 16.2.6).

4.12.3 Lunar Module Egress

Simulation work in both the water immersion facility and the 1/6-g environment in an airplane was reasonably accurate in preparing the crew for lunar module egress. Body positioning and arching-the-back techniques that were required in to exit the hatch were preformed, and no unexpected problems were experienced. The forward platform was more than adequate to allow changing the body position from that used in egressing the hatch to that required for getting on the ladder. The first ladder step was somewhat difficult to see and required caution and forethought. In general, the hatch, porch, and ladder operation were not particularly difficult and caused little concern. Operations on the platform could be performed without losing body balance, and there was adequate room for maneuvering.

The initial operation of the lunar equipment conveyor in lowering the camera was satisfactory, but after the straps had become covered with lunar surface material, a problem arose in transporting the equipment back into the lunar module. Dust from this equipment fell back onto the lower crewmember and into the cabin and seemed to bind the conveyor so as to require considerable force to operate it. Alternatives in transporting equipment into the lunar module had been suggested before flight, and although no opportunity was available to evaluate these techniques, it is believed they might be an improvement over the conveyor.

[4-13]

4.12.4 Surface Exploration

Work in the 1/6-g environment was a pleasant experience. Adaptation to movement was not difficult and movement seemed to be natural. Certain specific peculiarities, such as the effect of the mass versus the lack of traction, can be anticipated but complete familiarization need not be pursued.

The most effective means of walking seemed to be the lope that evolved naturally. The fact that both feet were occasionally off the ground at the same time, plus the fact that the feet did not return to the surface as rapidly as on earth, required some anticipation before attempting to stop. Although movement was not difficult, there was noticeable resistance provided by the suit.

On future flights, crewmembers may want to consider kneeling in order to work with their hands. Getting to and from the kneeling position would be no problem, and being able to do more work with the hands would increase productive capability.

Photography with the Hasselblad cameras on the remote control unit mounts produced no problems. The first panorama was taken while the camera was hand-held; however, it was much easier to operate on the mount. The handle on the camera was adequate, and very few pictures were triggered inadvertently.

The solar wind experiment was easily deployed. As with the other operations involving lunar surface penetration, it was only possible to penetrate the lunar surface material only about 4 or 5 inches. The experiment mount was not quite as stable as desired, but it stayed erect.

The television system presented no difficulty except that the cord was continually in the way. At first, the white cord showed up well, but it soon became covered with dust and was therefore more difficult to see. The cable had a "set" from being coiled around the reel and it would not lie completely flat on the surface. Even when it was flat, however, a foot could still slide under it, and the Commander became entangled several times (see section 16.3.1).

Collecting the bulk sample required more time than anticipated because the modular equipment stowage assembly table was in deep shadow, and collecting samples in that area was far less desirable than taking those in the sunlight. It was also desirable to take samples as far from the exhaust plume and propellant contamination as possible. An attempt was made to include a hard rock in each sample and approximately 20 trips were required to fill the box. As in simulations, the difficulty of scooping up the material without throwing it out as the scoop [4-14] became free created some problem. It was almost impossible to collect a full scoop of material, and the task required about double the planned time.

Several of the operations would have been easier in sunlight. Although it was possible to see in the shadows, time must be allowed for dark adaptation when walking from the sunlight into shadow. On future missions, it would advantageous to conduct a yaw maneuver just prior to landing so that the descent stage work area would be in sunlight.

The scientific experiment package was easy to deploy manually, and some time was saved here. The package was easy to manage, but finding a level area was quite difficult. A good horizon reference was not available, and in the 1/6-g environment, physical cues were not as effective as in a one-g. Therefore, the selection of a deployment site for the experiments caused some problems. The experiments were placed in an area between shallow craters in surface material of the same consistency as the surrounding area and which should be stable. Considerable effort was required to change the slope of one of the experiments. It was not possible to lower the equipment by merely forcing it down, and it was necessary to move the experiment back and forth to scrape away the excess surface material.

No abnormal conditions were noted during the lunar module inspection. The insulation on the secondary struts had been damaged from the heat, but the primary struts were only singed or covered with soot. There was much less damage than on the examples that had been seen before flight.

Obtaining the core tube sample presented some difficulty. It was impossible to force the tube more than 4 or 5 inches into the surface material, yet the material provided insufficient resistance to hold the extension handle in the upright position. Since the handle had to be held upright, this precluded using both hands on the hammer. In addition, the resistance of the suit made it difficult to steady the core tube and swing with any great force. The hammer actually missed several times. Sufficient force was obtained to make dents in the handle, but the tube could be driven only to a depth of about 6 inches. Extraction offered little or virtually no resistance. Two samples were taken.

Insufficient time remained to take the documented sample, although as wide a variety of rocks was selected as remaining time permitted.

The performance of the extravehicular mobility unit was excellent. Neither crewman felt any thermal discomfort. The Commander used the minimum cooling mode for most of the surface operation. The Lunar Module Pilot switched to the maximum diverter valve position immediately after [4-15] sublimator startup and operated at maximum position for 42 minutes before switching to the intermediate position. The switch remained in the intermediate position for the duration of the extravehicular activity. The thermal effect of shadowed areas in [*sic*] versus those areas in sunlight was not detectable inside the suit.

The crewmen were kept physically cool and comfortable, and the ease of performing in the 1/6-g environment indicate that tasks requiring greater physical exertion may be undertaken on future flights. The Commander experienced some physical exertion while transporting the sample return container to the lunar module, but his physical limit had not been approached.

4.12.5 Lunar Module Ingress

Ingress to the lunar module produced no problems. The capability to do a vertical jump was used to an advantage in making the first step up the ladder. By doing a deep knee bend, then springing up the ladder, the Commander was able to guide his feet to the third step. Movements in the 1/6-g environment were slow enough to allow deliberate foot placement after the jump. The ladder was a bit slippery from the powdery surface material, but not dangerously so.

As previously stated, mobility on the platform was adequate for developing alternate methods of transferring equipment from the surface. The hatch opened easily, and the ingress technique developed before flight was satisfactory. A concerted effort to arch the back was required when about half way through the hatch, to keep the forward end of the portable life support system low enough to clear the hatch. There was very little exertion associated with transition to a standing position.

Because of the bulk of the extravehicular mobility unit, caution had to be exercised to avoid bumping into switches, circuit breakers, and other controls while moving around the cockpit. One circuit breaker was in fact broken as a result of contact (see section 16.2.11).

Equipment jettison was performed as planned, and the time taken before flight in determining the items not required for lift-off was well spent. Considerable weight reduction and increase in space was realized. Discarding the equipment through the hatch was not difficult, and only one item remained on the platform. The post-ingress checklist procedures were performed without difficulty; the checklist was well planned and was followed precisely.

[4-16]

4.12.6 Lunar Rest Period

The rest period was almost a complete loss. The helmet and gloves were worn to relieve any subconscious anxiety about a loss of cabin pressure and presented no problem. But noise, lighting, and a lower-than-desired temperature were annoying. It was uncomfortably cool in the suits, even with the water-flow disconnected. Oxygen flow was finally cut off, and the helmets were removed, but the noise from the glycol pumps was then loud enough to interrupt sleep. The window shades did not completely block out light, and the cabin was illuminated by a combination of light through the shades, warning lights, and display lighting. The Commander rested on the ascent engine cover and was bothered by the light entering through the telescope. The Lunar Module Pilot estimated that he slept fitfully for perhaps 2 hours and the Commander did not sleep at all, even though body positioning was not a problem. Because of the reduced gravity, the positions on the floor and on the engine cover were both quite comfortable.

4.13 LAUNCH PREPERATION

Aligning the platform before lift-off was complicated by the limited number of stars available. Because of sun and earth interference, only two detents effectively remained from which to select stars. Accuracy is greater for stars close to the center of the field, but none were available at this location. A gravity/one-star alignment was successfully performed. A manual averaging technique was used to sample five successive cursor readings and then five spiral readings. The result was then entered into the computer. This technique appeared to be easier than taking and entering five separate readings. Torquing angles were close to 0.7° in all three axes and indicated that the platform drifted. (Editor's note: Platform drift was within specification limits.)

After the alignment, the navigation program was entered. It is recommended that future crews update the abort guidance system with the primary guidance state vector at this point and then use the abort guidance system to determine the command module location. The primary guidance system cannot be used to determine the command module range and range rate, and the radar will not lock on until the command module is within 400 miles range. The abort guidance system provides good data as this range is approached.

A cold-fire reaction control system check and an abort guidance system calibration were performed, and the ascent pad was taken. About 45 minutes prior to lift-off, another platform alignment was performed. The landing site alignment option at ignition was used for lift-off. The torquing angles for this alignment were approximately 0.09 degree.

[4-17]

In accordance with ground instructions, the rendezvous radar was placed in the antenna SLEW position with the circuit breakers off for ascent to avoid recurrence of the alarms experienced during a descent.

Both crewmembers had forgotten to watch for the small helium pressure decrease indication that the Apollo 10 crew experienced when the ascent tanks were pressurized, and the crew initially believed that only one tank had been pressurized. This oversight was temporary and delayed the crew verification of proper pressurization of both tanks.

4.14 ASCENT

The pyrotechnic noises at descent stage separation were quite loud, but ascent-engine ignition was inaudible. The yaw and pitch maneuvers were very smooth. The pitch- and roll-attitude limit cycles were as expected and were not accompanied by physiological difficulties. Both the primary and the abort guidance systems indicated the ascent to be a duplicate of the planned trajectory. The guided cutoff yielded residuals of less than 2 ft/sec; and the inplane components were nulled to within 0.1 ft/sec with the reaction control system. Throughout the trajectory, the ground track could be visually verified, although a pitch attitude confirmation by use of the horizon in the overhead window was found to be quite difficult because of the horizon lighting condition.

4.15 RENDEZVOUS

At orbital insertion, the primary guidance system showed an orbit of 47.3 by 9.5 miles, as compared to the abort guidance system solution of 46.6 by 9.5 miles. Since radar range-rate data were not available, the Network quickly confirmed that the orbital insertion was satisfactory.

In the preflight planning, stars had been chosen that would be in the field of view and that would require a minimum amount of maneuvering to get through alignment and back in plane. This maintenance of a nearly fixed attitude would permit the radar to be turned on and the acquisition conditions designated so that marks for a coelliptic sequence initiation solution would be immediately available. For some reason, during the simulations, these preselected stars had not been correctly located relative to the horizon, and some time and fuel were wasted in first maneuvering to these stars, then failing to mark on them, and then maneuvering to an alternate pair. Even with these problems, the alignment was finished about 28 minutes before coelliptic sequence initiation, and it was possible to proceed with radar lock-on.

[4-18]

All four sources for the coelliptic sequence initiation solution agreed to within 0.2 ft/sec, an accuracy that had never been observed before. The Commander elected to use the primary guidance solution without any out-of-plane thrusting.

The coelliptic sequence initiation maneuver was accomplished by using the plus Z thrusters, and the radar lock-on was maintained throughout the firing. Continued navigation tracking by both vehicles indicated a plane change maneuver of about 2-1/2 ft/sec, but the crew elected to defer this small correction until terminal phase initiation. The very small out-of-plane velocities that existed between the spacecraft orbits indicated a highly accurate lunar surface alignment. As a result of the higher-than-expected ellipticity of the command module orbit, backup chart solutions were not possible for the first two rendezvous maneuvers, and the constant differential height maneuver had a higher-than-expected vertical component. The computers in both spacecraft agreed closely on the maneuver values, and the lunar module primary guidance computer solution was executed, using the minus X thrusters.

During the coelliptic phase, radar tracking data were inserted into the abort guidance system to obtain an independent intercept guidance solution. The primary guidance solution was 6-1/2 minutes later than planned. However, the intercept trajectory was quite nominal, with only two small midcourse corrections of 1.0 and 1.5 ft/sec. The line-of-sight rates were low, and the planned braking schedule was used to reach a stationkeeping position.

In the process of maneuvering the lunar module to the docking attitude, while at the same time avoiding direct sunlight in the forward windows, the platform inadvertently reached gimbal lock. The docking was completed by using the abort guidance system for attitude control.

4.16 COMMAND MODULE DOCKING

Pre-docking activities in the command module were normal in all respects, as was docking up to the point of probe capture. After the Command Module Pilot ascertained that a successful capture had occurred, as indicated by "barberpole" indicators, the CMC-FREE switch position was used and one retract bottle fired. A right yaw excursion of approximately 15° immediately took place for 1 or 2 seconds. The Command Module Pilot went back to CMC-AUTO and made hand-controller inputs to reduce the angle between the two vehicles to zero. At docking thruster firings occurred unexpectedly in the lunar module when the retract mechanism was actuated, and attitude excursions of up to 15° were observed. The lunar module was manually realigned. While [4-19] this maneuver was in progress, all 12 docking latches fired, and docking was completed successfully. (See section 8.6.1 for further discussion.)

Following docking, the tunnel was cleared, and the probe and drogue were stowed in the lunar module. The items to be transferred to the command module were cleaned using a vacuum brush attached to the lunar module suit return hose. The suction was low and made the process rather tedious. The sample return containers and film magazines were placed in appropriate bags to complete the transfer, and the lunar module was configured for jettison according to the checklist procedure.

4.17 TRANSEARTH INJECTION

The time between docking and transearth injection was more than adequate to clean all equipment contaminated with lunar surface material and to return it to the command module for stowage so that the necessary preparations for transearth injection could be made. The transearth injection maneuver, the last service propulsion engine firing of the flight, was nominal. The only difference between it and previous firings was that without the docked lunar module the start transient was apparent.

4.18 TRANSEARTH COAST

During transearth coast, faint spots or scintillations of light were observed within the command module cabin. These phenomena became apparent to the Commander and Lunar Module Pilot after they became dark-adapted and relaxed. [Editor's note: The source or cause of the light scintillations is as yet unknown. One explanation involves primary cosmic rays with energies in the range of billions of electron volts, bombarding an object in outer space. The theory assumes that numerous heavy and high-energy cosmic particles penetrate the command module structure, causing heavy ionization inside the spacecraft. When liberated electrons recombine with ions, photons in the visible portion of the spectrum are emitted. If a sufficient number of photons are emitted, a dark-adapted observer can detect the photons as a small spot or a streak of light. Two simple laboratory experiments were conducted to substantiate the theory, but no positive results were obtained in a 5-psi pressure environment because a high enough energy source was not available to create the radiation at that pressure. This level of radiation does not present a crew hazard.]

[4-20] Only one midcourse correction, a reaction control system firing of 4.8 ft/sec, was required during transearth coast. In general, the transearth coast period was characterized by a general relaxation on the part of the crew, with plenty of time available to sample the excellent variety of food packets and to take photographs of the shrinking moon and the growing earth.

4.19 ENTRY

Because of the presence of thunderstorms in the primary recovery area (1285 miles downrange from the entry interface of 400 000 feet), the targeted landing point was moved to a range of 1500 miles from the entry interface. This change required the use of computer program P65 (skip-up control routine) in the computer, in addition to those programs used for the planned shorter range entry. This change caused the crew some apprehension, since such entries had rarely been practiced in preflight simulations. However, during the entry, these parameters remained within acceptable limits. The entry was guided automatically and was nominal in all respects. The first acceleration pulse reached approximately 6.5g and the second reached 6.0g.

4.20 RECOVERY

On the landing, the 18-knot surface wind filled the parachutes and immediately rotated the command module into the apex down (stable II) flotation position prior to parachute release. Moderate wave-induced oscillations accelerated the uprighting sequence, which was completed in less than 8 minutes. No difficulties were encountered in completing the postlanding checklist.

The biological isolation garments were donned inside the spacecraft. Crew transfer into the raft was followed by hatch closure and by decontamination of the spacecraft and crewmembers by germicidal scrubdown.

Helicopter pickup was performed as planned, but visibility was substantially degraded because of moisture condensation on the biological isolation garment faceplate. The helicopter transfer to the aircraft carrier was performed as quickly as could be expected, but the temperature increase inside the suit was uncomfortable. Transfer from the helicopter into the mobile quarantine facility completed the voyage of Apollo 11.

[remainder of report not included]