Document II-6

[1] 31 January 1958

SUBJECT: Advanced Hypersonic Research Aircraft

TO: Commander
Air Research and Development Command
Andrews Air Force Base
Washington 25, D.C.

1. It is desired that ARDC in collaboration with the NACA expedite the evaluation of existing or planned projects, appropriate available proposals and other competitive approaches with a view to providing an experimental system capable of an early flight of a manned vehicle making an orbit of the earth. The Air Force-NACA team relationship which has proven so productive in earlier programs of the X-airplane series will be continued in the conception and conduct of this new program. A letter, copy attached, has been sent to invite NACA collaboration. It is contemplated that as soon as possible without delaying the evaluation, the Research Aircraft Committee will be convened to invite Navy participation.

2. A manned orbital flight, whether by a glide vehicle or by a minimum altitude satellite essentially outside the earth's atmosphere is a significant technical milestone in the USAF space program. It is also vital to the prestige of the nation that such a feat be accomplished at the earliest technically practicable date—if at all possible before the Russians. However, it should be clearly understood that only those approaches to an early demonstration of manned orbital flight will be considered which can be expected to contribute information of a substantial value to follow-on systems.

3. It is understood that the boost-glide test vehicle which will be developed under the Dyna-Soar I program will be able to orbit as a satellite. It is also understood, however, that the problems associated with a manned orbital flight as a satellite, [are] outside the stringent design requirements than the lower altitude, hypersonic Dyna-Soar I flight profile. Consequently, it may be feasible to demonstrate an orbital flight appreciably earlier with a vehicle designed only for the satellite mission than would be possible with a vehicle capable of executing the boost-glide mission as well. An important objective of the evaluation, then, will be to determine whether a test vehicle designed only as a satellite will give us an orbital flight of technical significance enough sooner than a vehicle designed for the glide mission to warrant a separate development. Consequently, it is desired that the evaluation consider separately the following approaches:

a. What is the best design concept, the minimum time to first orbital flight and the dollar cost of demonstrating a manned one-orbit flight in a vehicle capable only of a satellite orbit? Time [2] is a primary consideration, but to qualify, an approach must offer prospects of tangible contributions to the over-all astronautics program.

b. What is the minimum time to first orbital flight and dollar cost of demonstrating a manned one-orbit flight with a vehicle designed to utilize the boost-glide concept? In this approach it is not necessary that the first orbit flight be made within the atmosphere under typical boost glide conditions—it could be made outside the atmosphere if an "outside" orbit offered the possibility of an earlier successful flight. . . .

5. The following additional guidance is provided:

a. The program to meet the stated objective should be the minimum consistent with a high degree of confidence that the objective will be met. Maximum practical use must be made of existing components and technology and of the momentum of existing programs.

b. The hazard at launch and during flight will not be greater than that desired by good engineering and flight safety practice. If feasible, in order to save time and money, pilot safety may be provided by emergency escape systems rather than insisting on standards of component reliability normally required for routine repetitive flights of weapon systems. This statement is particularly pointed at the problem of qualifying boosters for inisial [sic] orbital flights.

6. It is requested that this Headquarters be furnished the results of your evaluation of each of the approaches specified in paragraph 4. Finally, your over-all conclusions and recommendations for accomplishing the objective stated in paragraph 1 are desired.

7. The requested information should be forwarded at the earliest practicable date, but in no event later than 15 March 1958.

FOR THE CHIEF OF STAFF:

Gen. Donald L. Putt

Document II-7

[1]

Memorandum of Understanding

Subject: Principles for Participation of NACA in Development and Testing of the "Air Force System 464L Hypersonic Boost Glide Vehicle (Dyna Soar I)."

1. System 464L is being developed to:
   a. Determine the military potential of hypersonic boost glide type weapon systems and provide a basis for such developments.
   b. Research characteristics and problems of flight in the boost glide flight regime up to and including orbital flight outside of the earth's atmosphere.
2. The following principles will be applied in conduct of the project:
   a. The project will be conducted as a joint Air Force-NACA project.
   b. Overall technical control of the project will rest with the Air Force, acting with the advice and assistance of the NACA. The two partners will jointly participate in the technical development to maximize the vehicle's capabilities from both the military weapon system development and aeronautical-astronautical research viewpoints.
   c. Financing of the design, construction, and Air Force test operation of the vehicles will be borne by the Air Force.
   d. Management of the project will be conducted by an Air Force project office within the Directorate of Systems Management, Hq ARDC. The NACA will provide liaison representation in the project office and provide the chairman of the technical team responsible for data transmission and research instrumentation.
   e. Design and construction of the system will be conducted through a negotiated contract with a prime contractor selected by the USAF on the basis of the recommendations of the ARDC-AMC-SAC Source Selection Board, acting with the consultation of the NACA.

[2] f. Flight test of the vehicle and related equipments will be accomplished by the NACA, the USAF, and the prime contractor in a combined test program under the overall control of a joint NACA-USAF Committee, chaired by the Air Force.

General Thomas D. White
Chief of Staff, USAF
13 May 1958

Hugh L. Dryden
Director, NACA
20 May 1958

Document II-8

Document title: T. Keith Glennan, NASA Administrator, and Roy W. Johnson, Director, Advanced Research Projects Agency, "Memorandum of Understanding: Program for a Manned Orbital Vehicle," November 20, 1958.

Source: NASA Historical Reference Collection, NASA History Office, NASA Headquarters, Washington, D.C.

NASA Administrator Glennan and Advanced Research Projects Agency (ARPA) Director Roy Johnson agreed in mid-September 1958 that their two agencies would cooperate on a "man-in-space" program based on the development of space capsules; this program would complement the Air Force Dyna-Soar program. They established a joint NASA-ARPA Manned Satellite Panel, which included six representatives from NASA and two from ARPA, reflecting the Eisenhower Administration's desire to have NASA primarily responsible for manned spaceflight. This memorandum of understanding established guidelines for this early cooperation.

[no pagination] November 20, 1958

Memorandum of Understanding

SUBJECT: Program for a Manned Orbital Vehicle

1. The Administrator of NASA is responsible for management and technical direction of a program for a manned orbital vehicle to be conducted in cooperation with the Department of Defense. The objectives of the program are to achieve, at the earliest practicable date, orbital flight and successful recovery of a manned satellite and to investigate the capabilities of man in this environment. The accomplishment of the program is a matter of national urgency.

2. In carrying out the program, the Administrator of NASA intends to make full use of the background and capabilities existing in the Department of Defense.

3. The Department of Defense will support the program until it is terminated by the achievement of a sufficient number of manned orbital flights to accomplish the above objectives.

4. $8,000,000 of FY 1959 funds will be contributed by ARPA in support of the program and will be made available by appropriation transfer to NASA. NASA will budget for and fund all subsequent years' costs.

5. A working committee consisting of members of the staff of NASA and ARPA will be established to advise the Administrator of NASA on technical and management aspects of the program. The chairman of the committee will be a member of the NASA staff.

T. Keith Glennan
Administrator
National Aeronautics and
Space Administration

Roy W. Johnson
Director
Advanced Research Projects
Agency

Document II-9

Document title: T. Keith Glennan, Administrator, NASA, and Wilber M. Brucker, Secretary of the Army, "Cooperative Agreement on Jet Propulsion Laboratory Between the National Aeronautics and Space Administration and the Department of the Army," December 3, 1958.

Document II-10

Document title: T. Keith Glennan, Administrator, and Wilber M. Brucker, Secretary of the Army, "Cooperative Agreement on Army Ordnance Missile Command Between the National Aeronautics and Space Administration and the Department of the Army," December 3, 1958.

Source: Both from NASA Historical Reference Collection, NASA History Office, NASA Headquarters, Washington, D.C.

In 1958, the Army was called on to transfer two major development agencies to the newly created NASA. The Jet Propulsion Laboratory (JPL) was part of the California Institute of Technology, with expertise in guidance, communications, telemetry, and rocket propellants. All agreed that JPL was a center of technical expertise important to the future of NASA and the space program, and the transfer was complete and immediate. In contrast, the transfer of the Army Ballistic Missile Agency (ABMA) generated substantial controversy, because it was the major development arm of the Army Ordnance Missile Command, and the Army leadership considered it too important to relinquish. ABMA's development work included weather satellite programs such as TIROS, rocket engine work such as the F-1 engine (which later powered the Saturn V), and the booster development group headed by Wernher von Braun. The Army was reluctant to lose von Braun and his team of talented engineers. The Department of Defense had been willing to transfer to NASA such research work as that performed by JPL, recognizing that it could still benefit from the research performed. However, the Army resisted losing a major development group such as ABMA, despite its unsure budgetary footing. The Army's initial intransigence eventually required presidential intervention to resolve the situation.

Document II-9

[1]

Cooperative Agreement on Jet Propulsion Laboratory Between the National Aeronautics and Space Administration and the Department of the Army

A. *AUTHORITIES*

This agreement is authorized by Public Law 85-568 as implemented by Executive Order 10793, dated 3 Dec 1958.

B. *PURPOSE*

The purpose of this agreement is to establish the relationships between the National Aeronautics and Space Administration (NASA) and the Department of the Army (Army) that will govern the following:

1. Implementation of Executive Order No. 10793 dated 3 Dec 58, which is incorporated herein by reference.

2. Planning for the orderly transition from current Army military operations and weapons systems development program to programs predominately in the field of exploration and exploitation of space science and technology for peaceful purposes under NASA direction.

3. Provision for certain Army administrative and logistical support desired by NASA in the operation of JPL.

C. *POLICY*

The Army states and NASA recognizes that an abrupt transfer or cessation of Army activities relating to military operations and weapons systems development programs performed at the JPL would be deleterious to both national defense and the accomplishment of NASA objectives. Both NASA and the Army recognize that NASA is not fully staffed to perform certain administrative functions and to provide the administrative and logistical support essential to the uninterrupted operation of JPL and that NASA may request that certain services and support be provided by the Army.

D. *OPERATING CONCEPTS*

1. NASA will provide for the general management and technical direction of the JPL, except as to projects relating to military operations and weapons systems development programs.

[2] 2. For Calendar Year 1959 the Army will continue its contractual relations with the California Institute of Technology for continued effort by the JPL on the following programs which are specifically related to military operations and weapons systems development programs:

a. The SERGEANT guided missile program.

b. Special intelligence investigations.

c. Secure communications research.

d. Aerodynamic testing and research.

It is expected that these specific Army activities will be largely phased out during CY 59; however, if it is necessary to continue certain activities for a longer period of time, this may be done by direct Army contract or through NASA as may be mutually agreed by NASA and the Army.

3. The Army budgets on a program basis and Army installations receive funds on the basis of assigned program activities. Traditionally, the Army has funded the activities performed at JPL on a Calendar rather than Fiscal Year basis. For these reasons, a firm 1959 program had been agreed to by the Army and JPL prior to the publishing of the Executive Order effecting transfer of JPL. NASA, through assumption of technical direction of the general supporting research portion of the program on 1 January 1958, can reorient the effort toward NASA objectives by the end of the first half of the Calendar Year 1959. Therefore, the Army and NASA reached prior agreement and the Executive Order provided for transfer of Army funds in the amount of $4,078,250 to NASA for this general supporting research program for the first half of Calendar Year 1959. The additional funds for general supporting research during CY 1958 will be provided by NASA.

4. NASA may request from time to time, and the Army agrees, that certain administrative and logistical support can and will be furnished to NASA on a non-reimburseable [sic] basis for servicing contract activities at JPL for Calendar Year 1959. Provision of this support may require in certain instances delegations of authority from NASA to the Army where appropriate to the service or support action requested. After Calendar Year 1959 such services and support may be provided in such scope and under such conditions as may be mutually agreed upon.

The following types of services and support are contemplated:

[3] a. Contract administration;

b. Property transfer; and

c. Such other matters as fall within the purview of this instrument.

The Administrator, NASA, and the Secretary of the Army hereby designate respectively the Director of Business Administration, NASA, and the Chief of Ordnance, Army, to jointly formulate the necessary teams to effectuate this Agreement.

5. It is understood and agreed that the Administrator will delegate to the Secretary of the Army, or his designee, such authority as may be required to authorize the Army to fulfill the intent and purposes of this Agreement.

Date: 3 December 1958
Washington, D.C.

T. KEITH GLENNAN	WILBER M. BRUCKER
Administrator, NASA	Secretary of the Army

Document II-10

[1]

Cooperative Agreement on Army Ordnance Missile Command Between the National Aeronautics and Space Administration and the Department of the Army

A. *AUTHORITY*

This agreement is authorized by public Law 85-583.

B. *PURPOSE*

This agreement is for the purpose of establishing relationships between the National Aeronautics and Space Administration and the Department of the Army for the efficient utilization of United States Army resources in the accomplishment of the purposes of the National Aeronautics and Space Act of 1958. This agreement is intended to provide for relationships in the national interest that will prevent undue delay of progress in the national space program, and prevent undesirable disruption of military programs. This agreement is also intended to contribute to effective utilization of the scientific and engineering resources of the country by fostering close cooperation among the interested agencies in order to avoid unnecessary duplication of facilities.

C. *POLICY*

The National Aeronautics and Space Administration (NASA) and the Department of the Army recognize the often inseparable nature of the efforts of this Nation in meeting military and scientific objectives in the missile and space field. Continuation of the organizational strength of the Army Ballistic Missile Agency (ABMA) of the U.S. Army Ordnance Missile Command (AOMC) and its established contractor structure and support from other elements of the Army has been stated by the Defense Department to he essential to the Defense mission. The proper provisions for asking the capabilities of this organization available for meeting objectives of NASA permit the application of these resources to the needs of both civilian space activities and essential military requirements. Accordingly, this agreement establishes relationships between NASA and the Department of the Army which make the AOMC and its subordinate organizations immediately, directly, and continuously responsive to NASA requirements.

D. *PROCEDURES*

1. The CG, AOMC, will have full authority, as the principal agent of the Army, to utilize the resources of his Command, those organizations [2] directly under his control through contractual structure, and other elements of the Department of the Army with which he deals directly, for the accomplishment of assigned NASA projects.

2. Key personnel of AOMC and appropriate subordinate elements, as may be requested by NASA, will serve on technical committees under the chairmanship of NASA, or on advisory groups, or will serve as individual consultants to:

   a. Assist in the development of broad requirements and objectives in space programs.
   b. Assist in the determination of specific projects and specific methods (including hardware development) by which NASA may accomplish its overall objective.

3. Specific orders for projects to be accomplished for NASA will be placed direct by NASA upon AOMC with provision of funds for their accomplishment. AOMC will accept full responsibility for the fulfillment of the assigned projects as accepted from NASA.

4. NASA will have direct and continuing access, through visits or resident personnel, for technical contact and direction of effort on assigned NASA projects. In this connection, NASA is invited to place a small staff in residence at AOMC. This staff will provide for a continuing exchange of information on all projects assigned by NASA, as well as exchange of information on supporting research in the entire missile and space field.

5. On request by NASA, in connection with projects funded by NASA, the prime and sub-contractor facilities of the Army in weapons systems and other programs, including scientific and educational institutions and private industry, will be made available through identical procurement channels and with use of the special authorities delegated to the CG, AOMC, by the Secretary of the Army. In addition, resources of other elements of the Army, available to AOMC on a direct basis for space and missile system development, will be used as deemed necessary in the fulfillment of assigned NASA projects.

6. The CG, AOMC, is responsible for scheduling the space and missile activities under his control to meet the priority requirements of NASA in a manner consistent with overall National priorities. He is further responsible for anticipating in advance any possible conflict in the commitment of effort to NASA and Defense programs, and for providing a timely report to NASA, as well as to the Department of the Army, for the purpose of resolving such conflicts.

[3] 7. Public information and historical and technical documentation of assigned NASA projects will be under the direction and control of NASA.

8. The CG, AOMC, is authorized to enter into specific agreements with the duly designated representative of the Administrator, NASA, in implementation of this agreement.

Date: 3 December 1958
Washington, D.C.

T. KEITH GLENNAN
Administrator

WILBER M. BRUCKER
Secretary of the Army

Document II-11

Document title: T. Keith Glennan, Administrator, NASA, and Thomas S. Gates, Acting Secretary of Defense, Memorandum for the President, "Responsibility and Organization for Certain Activities," October 21, 1959.

Source: Presidential Papers, Dwight D. Eisenhower Library, Abilene, Kansas.

The Army had been reluctant to transfer the Development Operations Division of the Army Ballistic Missile Agency (ABMA) to NASA; it required presidential intervention to settle the matter. This joint agreement finally settled the issue of the transfer of the Development Operations Division headed by Wernher von Braun and the assignment to NASA as the lead in developing a U.S. heavy-lift booster. President Eisenhower approved the proposals outlined in this memorandum on November 2, 1952.

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[1] October 21, 1959

Memorandum for the President

SUBJECT: Responsibility and Organization for Certain Space Activities

The Secretary of Defense and the Administrator of NASA have agreed upon, and recommend to the President, certain actions designed to clarify responsibilities, improve coordination, and enhance the national space effort. The actions recommended below are consistent with the steps taken by the Secretary of Defense to clarify responsibilities and assignments in the field of military space applications within the Department of Defense.

The Secretary of Defense and the Administrator have agreed upon and recommend to the President the following actions:

A. The assignment to NASA of sole responsibility for the development of new space booster vehicle systems of very high thrust. Both the DOD and NASA will continue with a coordinated program for the development of space vehicles based on the current ICBM and IRBM missiles and growth versions of those missiles.
B. The transfer from the Department of the Army to NASA of the Development Operations Division of the Army Ballistic Missile Agency, including its personnel and such facilities and equipment which are presently assigned and required for the future use of NASA at the transferred activity, and such other personnel, facilities and equipment for administrative and [2] technical support of the transferred activity as may be agreed upon.
C. The provision by the Army to NASA of such administrative services as may be agreed upon to effect a smooth transition of management and funding responsibility of the transferred activity.

The Secretary of Defense and the Administrator of NASA are in agreement on the following:

1. The nation requires and must build at least one super booster and responsibility for this activity should be vested in one agency. There is, at present, no clear military requirement for super boosters, although there is a real possibility that the future will bring military weapons systems requirements. However, there is a definite need for super boosters for civilian space exploration purposes both manned and unmanned. Accordingly, it is agreed that the responsibility for the super booster program should be vested in NASA. It is agreed that the recommendations to center this function in NASA and to transfer the Development Operations Division of ABMA to NASA are independent of any decisions on whether either or both of the super booster systems currently under development are continued in their presently conceived form.

2. The transfer of the Development Operations Division of ABMA shall include transfer of responsibility for Saturn, together with 1960 funds allocated for the project, and transfer to the NASA 1961 budget of such amounts as may be approved for this project in the 1961 Department of Defense budget.

3. In carrying out its responsibilities, NASA will keep the Department of Defense thoroughly and completely informed on its booster program and will [3] be fully responsive to specific requirements of the Department of Defense for the development of super boosters for future military missions as requested by the Secretary of Defense.

4. It is NASA's intent to center at the transferred activity the bulk of its space booster vehicle systems work, including an appropriate research and development effort, and ultimately, substantial responsibility for NASA launch operations.

5. It is agreed that NASA wall provide support to the Department of Defense and military services at the transferred activity in the same manner as it now does at all other field centers.

6. The management and employment of the transferred activity will be the responsibility of NASA, and no commitment is possible with respect to levels of staffing or funding for the operation. NASA, however, will make every possible effort within its responsibilities and resources to utilize the capabilities of the Development Operations Division of ABMA.

7. The transfer of personnel, facilities, end equipment will he on a nonreimbursable basis.

8. The Department of the Army will provide and maintain on a reimbursable basis station-wide services as required by NASA within the Redstone Arsenal complex.

9. NASA will provide for continuation, transfer, or phasing out of military projects under way at the transferred activity as may be requested and to the extent funded by the Department of Defense, and will undertake at the transferred activity such additional military projects as may be agreed upon by NASA and the [4] Department of Defense.

10. The Department of Defense, the Department of the Army, and NASA, recognizing the value to the nation's space program of maintaining at a high level the present competence of ABMA, will cooperate to preserve the continuity of the technical and administrative leadership of the group.

11. The detailed implementation of the actions proposed will be accomplished through the subsequent negotiation of cooperative agreements between the Department of Defense and NASA.

The Secretary of Defense and the Administrator of NASA have reached agreement and recommend approval of the above actions in the firm belief that the national space effort requires a strong civilian agency and progress and a strong military space effort by the Department of Defense, and clear lines of responsibility and authority if the U.S. is to employ its best efforts in the exploration of outer space and to assure the defense of the nation.

If the President approves the recommended actions set forth in A, B, and C above, the Secretary of Defense and the Administrator of NASA will proceed immediately to form the necessary staff teams to develop the required implementing documents.

Administrator, NASA

Acting Secretary of Defense

OCT 30 1959

[Handwritten presidential note: "Approved Dwight Eisenhower 2 Nov 59"]

Document II-12

Document title: T. Keith Glennan, NASA Administrator, "DOD-NASA Agreement—Reimbursement of Costs," NASA Management Instruction 1052.14, November 17, 1959, with attached: Thomas S. Gates, Jr., Deputy Secretary of Defense, and T. Keith Glennan, NASA Administrator, "Agreement Between the Department of Defense and the National Aeronautics and Space Administration Concerning Principles Governing Reimbursement of Costs," November 12, 1959.

Source: NASA Historical Reference Collection, NASA History Office, NASA Headquarters, Washington, D.C.

As resources from other government agencies were being allocated to NASA, it became imperative to draw up policies outlining reimbursement procedures. These agreements represented the first comprehensive policy on reimbursement between the Department of Defense and NASA that did not apply to a specific program. They also demonstrated the dominant role of the Defense Department as a provider of various services to NASA in the early years.

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[1] November 17, 1959

Management Instruction

SUBJECT: *DOD-NASA AGREEMENT—REIMBURSEMENT OF COSTS*

1. *PURPOSE*

This Instruction incorporates into the NASA Issuance System an agreement entered into between the Department of Defense (DOD) end NASA for the reimbursement of certain costs incurred by either agency in providing services, equipment, supplies, personnel, and facilities for use by the other agency. Provisions of the agreement are effective as of November 12, 1959.

2. *AUTHORITY*

Section 203(b)(6) of the National Aeronautics and Space Act of 1958 (42 U.S.C. 2473(b)(6)).

3. *SCOPE*
   a. Principles set forth in the DOD-NASA agreement, which is included as Attachment A, shall govern the reimbursement of costs incurred by NASA or DOD in providing services, equipment, supplies, personnel, and facilities of the types and for the purposes described therein for use by the other agency.
   b. The agreement shall not apply to existing agreements or arrangements already [agreed] upon between NASA and the military departments or the Advanced Research Projects Agency (ARPA) which may not yet be formalized. However, all future arrangements, agreements, and amendments of existing agreements between NASA and the military departments or ARPA shall conform to the provisions of Attachment A.

[2] 4. *IMPLEMENTATION . . .*

5. *CANCELLATION*

NASA Management Manual Instruction 2-3-5 (TS 43), November 17, 1959.

Administrator

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[1]

Attachment A to NMI 1052.14

Agreement Between the Department of Defense and the National Aeronautics and Space Administration Concerning Principles Governing Reimbursement of Costs

1. *Purpose.*

Section 203(b)(6) of the National Aeronautics and Space Act of 1958, authorizes the National Aeronautics and Space Administration (NASA) "to use, with their consent, the services, equipment, personnel, and facilities of other Federal agencies with or without reimbursement, and on a similar basis to cooperate with other public and private agencies and instrumentalities in the use of services, equipment,and facilities." Federal agencies are also required to cooperate fully with NASA in making their services, equipment, personnel, and facilities available, and are authorized by this statute "to transfer to or to receive from NASA, without reimbursement, aeronautical and space vehicles, and supplies and equipment other than administrative supplies or equipment." It is the purpose of this Agreement to set forth the general principles governing the reimbursement of costs incurred by DOD or NASA in providing for use by the other of its services, equipment, personnel and facilities and in transferring equipment and supplies.

2. *Principles Governing Reimbursement.*

Subject to the provisions of paragraph 3 hereof, DOD and NASA agree upon the following general principles governing the reimbursement of costs:

[2] A. *Orders Contracted Out.* Where DOD or NASA places an order with the other which is contracted out (in whole or in part) to industry, reimbursement will be limited to the direct costs to the contracting agency of the contract, or the standard price established for the item being procured where procurement is accomplished through consolidated contracts covering the same or similar items (or components thereof) for the contracting agency. Except as otherwise provided in subparagraph E below, the agency placing the contract shall bear without reimbursement therefor the administrative costs incidental to its procurement of material or services for the ordering agency. As used in the foregoing sentence the term, "administrative costs" includes the normal administrative services performed in connection with placing, administering or terminating contracts, and such related administrative services as security, contract auditing, inspection, etc. (not all inclusive). Administrative costs are to be distinguished from the procurement costs of end items or services, the latter being appropriate for reimbursement under the provisions of this subparagraph.

B. *Orders Performed "In-House."* Where DOD performs an "in-house order" for NASA and the order is performed (in whole or in part) in facilities using an industrial-type cost accounting system, the basis of billing will be the same as that used for all customers of the Federal Government. Where the order is performed in facilities not using an industrial-type cost accounting system, reimbursement [3] will be limited to the direct costs (including an allowance for annual and sick leave, holidays, contributions for group life insurance and civil service retirement, etc.) attributable to the performance of the order. In no case, however, will charges be made for depreciation or rent for use of facilities and equipment in connection with the performance of orders.

C. *Administration of Other Agency's Contract.* Where DOD or NASA assigns one of its contracts to the other for purposes of administration, the administering agency may be reimbursed for the cost of contract administration services performed in connection with the contract to the extent of the special direct costs incurred in providing these services to the other and mutually agreed upon as clearly identified added costs.

D. *Material.* Where DOD or NASA provides the other with materials, supplies or equipment from stock, reimbursement will be made in accordance with established agency pricing practice. DOD materials, supplies or equipment which are in excess of DOD requirements (called "transferable-nonreimbursable" property in the DOD), will be furnished without charge, except that the furnishing agency may require reimbursement for transportation and handling costs. DOD may loan equipment to NASA without charge, subject to return in the same condition as when loaned, normal wear and tear excepted. The return of such equipment may be waived by DOD under the circumstances set forth in paragraph 3 of this Agreement. Where the loaned equipment is not returned, DOD will [be] reimbursed for the value thereof, unless the return of the equipment has been specifically waived by DOD under the circumstances set forth in paragraph 3 of this Agreement. [4] Where the loaned equipment is returned in a damaged condition, DOD will be reimbursed for the cost of restoring it to the same condition as when loaned, unless such reimbursement has been waived under the provisions of paragraph 3 of this Agreement, or waived on the basis that the equipment, at the time of return, is excess to the requirements of DOD.

E. *Travel.* In connection with the services covered by subparagraphs A, B, and C above, special travel costs attributable to the performance of these services will be reimbursed.

F. *Construction or Public Works.* Construction or public works projects undertaken by the DOD for NASA will be charged directly to NASA funds (or where appropriate will be reimbursed) on the basis of "project costs," the customary basis used by the DOD for charging DOD sponsored projects.

G. *Tenancy on Installation.* Except where other arrangements are in existence or are agreed upon, where either DOD or NASA is a tenant on an installation of the other, all direct costs or increases in direct costs attributable to such tenancy will be reimbursed.

H. *Use of Government-Owned Facilities.* No charge will be made for rent or depreciation in connection with the use by either DOD or NASA of Government owned facilities under their cognizance whether operated by the government or by a contractor.

3. *Exceptions.*

The foregoing principles do not apply to work or services, materials, supplies or equipment furnished to NASA or DOD for use in connection with specific projects of either agency, which are mutual interest and benefit to each. In such cases, work or services, materials, supplies or equipment furnished by one agency to the other will be on a non-reimbursable basis to the extent of the furnishing agency's interest in the particular project.

4. *Effective Date.*

This Agreement is effective immediately, but it does not apply to existing agreements or arrangements already agreed upon which may not yet be formalized between NASA and the military department or ARPA. However, all future arrangements, agreements and amendments of existing agreements between NASA and the military departments or ARPA shall conform to the provisions of the Agreement.

5. *Duration of Agreement.*

The provisions of the Agreement may be revised at any time, based upon further experience of the two agencies.

Deputy Secretary of Defense

Administrator
National Aeronautics and
Space Administration

NOV 12 1959
Date

Document II-13

Document title: T. Keith Glennan, NASA Administrator, and James H. Douglas, Deputy Secretary of Defense, "Agreement Between the Department of Defense and the National Aeronautics and Space Administration Concerning the Aeronautics and Astronautics Coordinating Board," reprinted in: U.S. Congress, House, Committee on Science and Astronautics, Subcommittee on NASA Oversight, "The NASA-DOD Relationship," 88th Cong., 2d sess. (Washington, DC: U.S. Government Printing Office, 1964), pp. 10-11.

The drafters of the 1958 Space Act considered it necessary to have close coordination of activities between NASA and the Department of Defense; therefore, a liaison board was provided for in the Act. By 1960, this liaison board was no longer effective and was replaced by the Aeronautics and Astronautics Coordinating Board. Over the years since then, the board has varied in its importance in coordinating cooperation between NASA and the Defense Department.

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[10]

Agreement Between the Department of Defense and the National Aeronautics and Space Administration Concerning the Aeronautics and Astronautics Coordinating Board

I. POLICIES AND PURPOSE

(a) It is essential that the aeronautical and space activities of the National Aeronautics and Space Administration and the Department of Defense be coordinated at all management and technical levels. Where policy issues and management decisions are not involved, it is important that liaison be achieved in the most direct manner possible, and that it continue to be accomplished as in the past between project level personnel on a day-to-day basis.

(b) It is essential that [a] close working relationship between decision-making officials within the National Aeronautics and Space Administration and the Department of Defense be developed at all management levels. Where policy issues and management decisions are involved, it is important that the planning and coordination of activities, the identification of problems, and the exchange of information be facilitated between officials having the authority and responsibility for decisions within their respective offices.

(c) To implement the forgoing [sic] policies it is the purpose of this agreement to establish the Aeronautics and Astronautics Coordinating Board.

II. ESTABLISHMENT OF THE BOARD

There is hereby established the Aeronautics and Astronautics Coordinating Board, which shall be responsible for facilitating

(1) the planning of activities by the National Aeronautics and Space Administration and the Department of Defense to avoid undesirable duplication and to achieve efficient utilization of available resources;

(2) the coordination of activities in areas of common interest to the National Aeronautics and Space Administration and the Department of Defense;

(3) the identification of problems requiring solution by either the National Aeronautics and Space Administration or the Department of Defense; and

(4) the exchange of information between the National Aeronautics and Space Administration and the Department of Defense.

III. COMPOSITION OF THE BOARD

(a) The Board shall be headed by the Deputy Administrator of the National Aeronautics and Space Administration and the Director of Defense Research and Engineering as Cochairmen.

(b) The other Board members shall consist of chairmen of panels as hereinafter established, and a minimum number of additional members as may be equipped to insure that each military department is represented and that the National Aeronautics and Space [11] Administration and Department of Defense have an equal number of members.

(c) The members of the Board, other than the Cochairmen, shall be appointed by the Administrator and the Secretary of Defense, jointly.

IV. PRINCIPLES OF OPERATION

(a) Panels of the Board shall be established by the Administrator and the Secretary of Defense and, initially, shall include the following:

(1) Manned Space Flight.
(2) Spacecraft.[1]
(3) Launch Vehicles.
(5) Supporting Space Research and Technology.
(6) Aeronautics.

(b) Terms of reference shall be prescribed for each panel by the cochairmen of the Board. The members of each panel shall be designated by the cochairmen of the Board.

1. For purposes of clarity, the name of the Panel was changed to Unmanned Spacecraft by the Aeronautics and Astronautics Coordinating Board at the second meeting on July 26, 1960.

(c) The board shall meet at the call of the Cochairmen, at least bimonthly, and the cochairmen shall alternately preside over the meetings. Only Board members, and such others as the cochairmen specifically approve, may attend meetings.

(d) The cochairmen shall establish a small secretariat to maintain records of the meetings of the Board and of its panels and to perform such other duties as the cochairmen may direct.

(e) The board, its panels, and the secretariat shall make full use of available facilities within the National Aeronautics and Space Administration and the Department of Defense, and all elements of the Administration and the Department of Defense shall cooperate fully with the board, its panels, and the secretariat.

(f) Actions based on consideration of matters by the board may be taken by individual members utilizing the authority vested in them by their respective agencies.

For the National Aeronautics and Space Administration:

T. KEITH GLENNAN,
Administrator.

For the Department of Defense:

JAMES H. DOUGLAS,
Deputy Secretary of Defense.

Promulgated this 13th day of September 1960.

Document II-14

Document title: "General Proposal for Organization for Command and Control of Military Operations in Space," with attached: "Schematic Diagrams of Proposed Organization for Command and Control of Military Operations in Space," no date.

Source: White House Office, Office of the Special Assistant for Science and Technology, Records (James R. Killian and George B. Kistiakowsky, 1957-61), Box 15, "Space [July-December 1959] (7)," Dwight D. Eisenhower Library, Abilene, Kansas.

ARPA was created in February 1958 to manage all the military space programs. Once NASA was created, several programs were taken from ARPA and given to the civilian space agency. ARPA did maintain managerial control of the military space program, but this was not popular with the military services. The Army and the Navy were concerned, however, that if ARPA was eliminated, the Air Force would be given control of all space programs. In April 1959, Chief of Naval Operations Admiral Arleigh Burke urged the Joint Chiefs of Staff to create a single military space agency. The Army leadership agreed, but the Air Force chief of staff objected that this would remove the weapons systems from the unified commands. By July 1959, White House and Department of Defense officials began evaluating this separate military space agency. It would report directly to the Joint Chiefs, and command would rotate among the military services. It was to be known as the Defense Astronautical Agency. The authorship of this document is unknown, but it was probably presented to the President's Science Advisory Committee in the summer of 1959. The idea was ultimately rejected, and the space programs were returned to the services. The Air Force was given control of most of the military space program, with the Army and Navy responsible for developing payloads for their own use.

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[1]

General Proposal for Organization for Command and Control of Military Operations in Space

Encl: (1) Schematic Diagrams of Proposed Organization for Command and Control of Military Operations in Space

The rapid advances achieved by our research and development agencies need to be exploited by the uniformed services. A whole family of militarily useful satellite vehicles is now coming into being. Facilities for launching, tracking, data acquisition and recovery of satellite and space vehicles are now in operation. In the very near future these new capabilities will become accepted operational techniques of the Army, Navy and Air Force units deployed over the oceans and land masses of the Free World. The military implications of these developments to the National Security dictate the command attention of the Joint Chiefs of Staff.

The basic facilities required for conducting satellite and space vehicle operations are: launching equipment with associated safety and control instrumentation, tracking, data acquisition and communication networks and coordinated vehicle recovery equipment located on land, sea and in the air. The compression of time in relation to the new space era, wherein satellites encircle the globe in 90 minutes, dictates the need for integrating all satellite and space vehicle facilities under one military commander. Each of the 3 national missile range commanders, presently has the facilities for conducting, in at least a limited capability, satellite and space vehicle operations. The global nature of military satellite and space vehicle operations, particularly satellite vehicle recovery operations, requires that the 3 national missile range commanders be incorporated into one over-all military command.

It is recommended that a joint command for the coordination of military operations in space be established incorporating the following features:

[2] 1. That the commander report directly to the Joint Chiefs of Staff.

2. That the command position be rotated among the services.

3. That a Scientific Director be designated as a staff assistant to the Space Commander whose prime function would be scientific direction and the assurance of rapid military exploitation of technological breakthroughs in astronautics. The incumbent of this position would be designated by NASA or ARPA and would be satisfactory to those two agencies. The incumbent could fill joint positions on the Space Command and NASA similar to joint military and AEC billets.

4. That the joint headquarters be located at the primary space surveillance control center to minimize time involved in receipt and processing of intelligence and the transmission of command decisions.

5. That consideration be given to locating this control center within reasonable distance from Washington D.C. to simplify liaison with all the Services and with NASA.

6. That the space surveillance control center be manned by a group consisting of personnel from the 3 services.

7. That all the facilities of each particular service related to satellite and space tracking, data acquisition and communications continue to function within that service, but under the respective range commander for operational control by the joint command.

8. That all research and development and training activity continue as heretofore on a not-to-interfere basis with the national security responsibilities of the joint space command.

9. That each national range commander report directly to the commander of the joint space command for operational control, and to his normal commander for other control.

[3] The commander of the space command force would perform the following 5 functions:

1. Under the direction of the Joint Chiefs of Staff, command the 3 national ranges in-so-far as they contribute operationally to our national security.

2. Review and approve the planned operation of the 3 national ranges to assure consonance with the operational requirements of over-all national security.

3. Review the annual budgetary requirements of the 3 national ranges for national priority, scope and adequacy in support of national security objectives and make recommendations accordingly to the Joint Chiefs of Staff.

The Joint Chiefs of Staff would submit the annual budgetary requirements to the Secretary of Defense who in turn would submit the requirements to the National Security Council for review concerning national priority, scope and adequacy for support of national security objectives and for financial coordination with the Atomic Energy Commission, National Aeronautics and Space Administration and the Bureau of the Budget.

4. Integrate satellite and space vehicle tracking, data acquisition and communications control into one centralized global system.

5. Provide for the participation by all services, as appropriate, for indoctrination and training in the field of satellite and space vehicle operations.

The following advantages would accrue for national security by the establishment of a joint task force:

1. A central command, responsive directly to the Joint Chiefs of Staff, would insure the earliest possible military effectiveness of satellite and space vehicles.

2. Parallel developments and duplicative installations for R&D with [an] expensive network of communications, launching facilities and logistics systems would be eliminated.

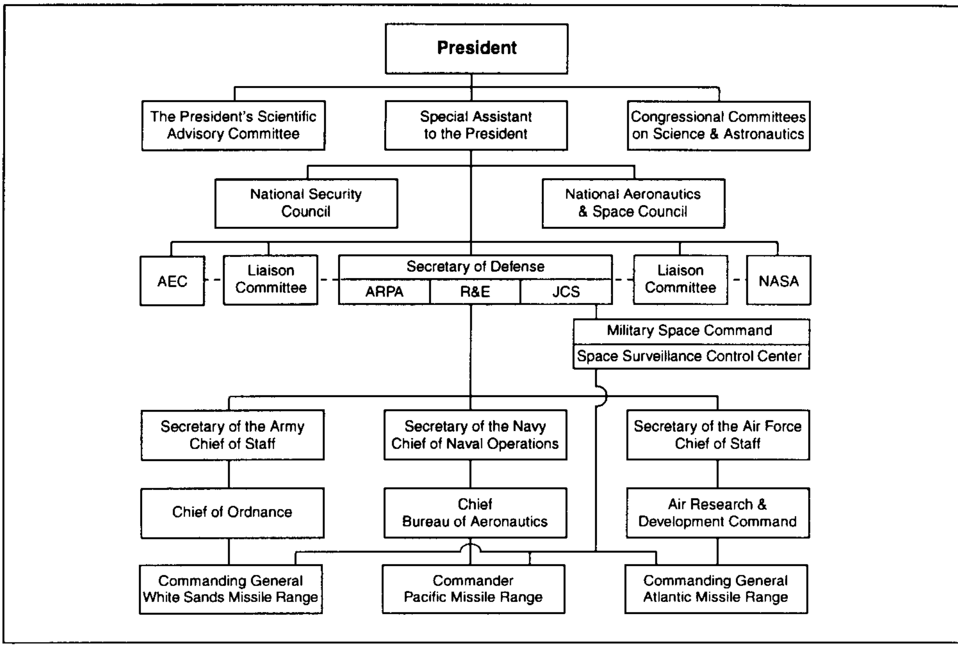
[4] 3. Indoctrination and training of the uniformed services in all aspects of space operations would be insured.

4. The evolution of sound military requirements would be improved.

5. The relative importance of military space operations in national security would be responsibly defined.

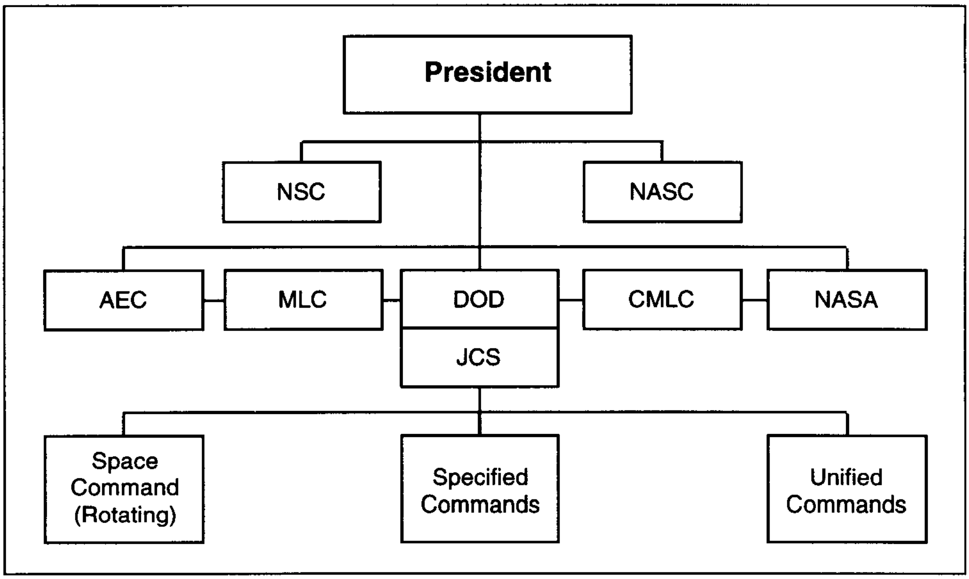
It is to be noted that since ARPA does not actually operate any facilities it is not involved in this type of operational chain of command.

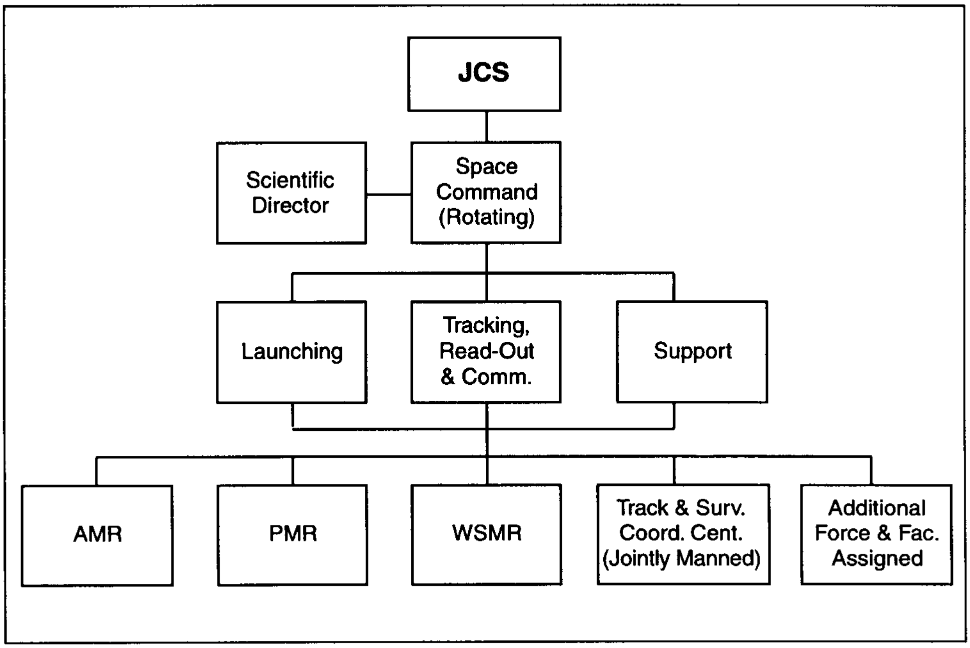
Regarding the tie-in with NASA's facilities, it is proposed that consideration be given that NASA facilities be controlled in a manner similar to the relationship between the Coast Guard and the Navy. That is, in time of emergency operationally useful equipment and facilities would be at the disposal of the joint space commander.

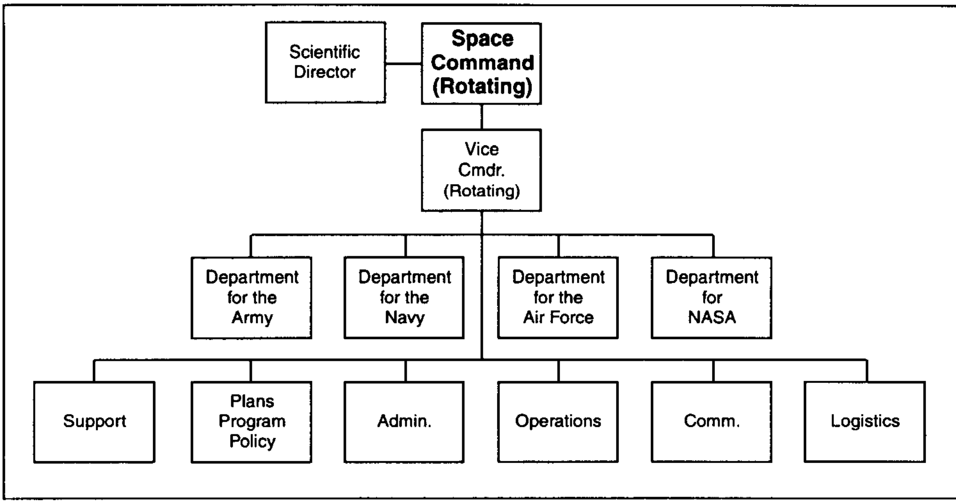


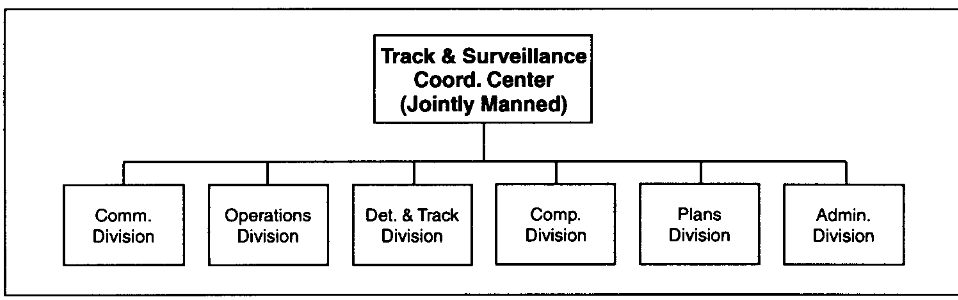
Orbital Space Operations

Combat Systems	MET	GEO	Comm.	NAV	RECCO	EW	ECM
STRAC	●		●		●	●	●
Deployed Armies	●		●		●	●	●
Amphib	●		●	●	●	●	●
Carrier Strike	●	●	●	●	●	●	●
FBM	●	●	●	●	●	●	
ASW	●		●	●	●	●	●
Air Def	●		●		●	●	
Mis Def			●		●	●	
TAC	●		●		●	●	●
Strat Air	●	●	●	●	●	●	●
ICBM		●	●		●	●	
IRBM		●	●		●	●	


President
NSC
NASC
AEC
MLC
DOD
JCS
CMLC
NASA
Space Command (Rotating)
Specified Commands
Unified Commands


JCS
Scientific Director
Space Command (Rotating)
Launching
Tracking, Read-Out & Comm.
Support
AMR
PMR
WSMR
Track & Surv. Coord. Cent. (Jointly Manned)
Additional Force & Fac. Assigned





Advantages - JCS Desig. Command

- Insures Earliest Space Exploitation for U.S.A.
- Eliminates Duplicative Installations
- Insures Indoctrination and Training of Uniformed Personnel
- Would Improve Evolution of Sound Operational Requirements
- Would Define Relative Importance of Military Space Operations

Document II-15

Document title: "Military Lunar Base Program or S.R. 183 Lunar Observatory Study," Study Summary and Program Plan, Air Research and Development Command, Project No. 7987, Task No. 19769, Directorate of Space Planning and Analysis, Air Force Ballistic Missile Division, April 1960, pp. 1-9.

Source: NASA Historical Reference Collection, NASA History Office, NASA Headquarters, Washington, D.C.

The Space Act did not settle the issue of which organization—NASA or the Air Force—would conduct human spaceflight. The Space Act clearly indicated, however, that NASA would be responsible for most basic science in space. This created a much higher standard of justification of humans in space for the Air Force, which searched for practical missions requiring piloted spacecraft. In April 1960, the Air Research and Development Command completed a report on the feasibility of establishing a lunar base and argued that it should be recognized as an Air Force requirement. The base could serve as the site of a lunar-based Earth bombardment system capable of launching nuclear missiles with an accuracy of two to five nautical miles. Echoing the arguments made for many civilian manned space programs, the report noted that the cost of such a base ($8.14 billion over ten years) was less than the annual cost of the Farm Subsidy Program. It was more ambiguous about the need for such a base.

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[1]

Study Summary

The purpose of this study was to "determine an economical and sound approach for establishing a manned intelligence observatory on the moon." Normally the end product of this type of study is an Evaluation Report. However, due to the importance of the study conclusions and the significance of time, it was decided to prepare a preliminary Program Plan, as part of the final Report.

The final report has been prepared in two volumes. Volume I includes this Study Summary and the Program Plan. Volume II consists of the Technical Requirements to support the Program Plan. The Technical Requirements are presented in "technical packages" that cover each of the major technical areas. Each package includes the characteristics and required development schedules for all known items within the specific technical area, as well as the development philosophy to be followed.

The "technical packages" have been prepared to assist the appropriate development agencies to initiate the required applied research and technical development programs. The complete Military Lunar Base Program Report is suitable for use by personnel in a Program Office to establish a Lunar Base Program, or to coordinate Air Force lunar requirements with the NASA.

Based on present knowledge, the study has concluded that it is technically feasible to establish a manned base on the moon. "Technically feasible" is not meant to imply that the equipments are available, or the techniques are completely known. Actually it means that the problems have been analyzed, and logical and reasonable extensions to the "state-of-the-art" should provide the desired techniques and equipments and this is comparable to the establishment of the original "design objectives" for the Ballistic Missile Programs in the year, 1954.

As the study progressed it became obvious that this is *not* a program "far off in the future." Actually the long lead development items should be started *immediately* if maximum military advantage is to be derived from a lunar program. If this is done the United States could send a man to the moon and return him to the earth during the last quarter of 1967.

The final decision concerning the types of strategic systems to be placed on the moon (such as a Lunar Based Earth Bombardment System) can be safely deferred for three to four years. However, the program to establish a lunar base must not be delayed and the initial base design must meet *military* requirements. For example, the base should be designed as a permanent installation, it should be underground, it should strive to be completely self-supporting, and it should provide suitable accommodations to support extended tours of duty. A companion study of Strategic Lunar Systems (SR-192) has shown that the lunar base is the most time-critical part of the system, so it is obvious that any delay in initiating the base development program will proportionally delay the final operational capability.

The subject of establishing a military lunar base is extremely complex and includes almost every known technical discipline. For the technical portion of this report the technical problems have been categorized as Propulsion, Secondary Power, Guidance, Life Support, Communications and Data Handling, Sensors, Materials and Resources, Lunar Base Design, and Environment. However, the general subject can be simply described as searching for the answers to the following four questions.

1. HOW can a manned base be established on the moon?
2. WHEN can a manned base be established on the moon?
3. HOW MUCH will it cost to establish a manned lunar base?
4. WHY should a manned base be established on the moon?

A majority of the study effort was expended on the question of "How can a manned base be established on the moon?" The first step was to perform a Transportation Analysis and determine [2] the most advantageous method of transporting men and materials to the moon and returning the men to earth. All conceivable chemical, nuclear and ion propulsion systems, using earth and lunar satellites, as well as "direct shot" trajectories, were considered. In addition, every reasonable technical perturbation was considered. *As a result of the analysis it was conclusively shown that the "direct shot" to the moon, using a five stage chemically propelled vehicle, is the most desirable.* This was not the expected conclusion since the establishment and use of a manned earth satellite-refueling station has been proposed for many years as the best way for man to travel to the moon. However, these original proposals did not have the benefit of a detailed analysis like the one performed in this study.

The analysis indicated the nuclear propulsion system could not be operational before 1970, so it was not advisable to rely on this system to establish the lunar base. However, if a nuclear system is available as expected in 1970, it could be used as indicated on the Master Program Schedule to logistically support the base.

With the "direct shot" determined to be the most desirable approach, it was possible to develop a vehicle concept. Based on technical and payload considerations, as well as the psychologists['] philosophy on "ideal crew size," it was concluded that a three-man aerodynamic re-entry vehicle would be the best method for transporting men to the moon and for returning them to the earth. This vehicle would weigh approximately 30,000 pounds as it enters the earth's atmosphere, and it would be capable of completely automatic-unmanned-10 day flights. The initial unmanned earth re-entry flights will require a landing area of 10 x 20 miles. When mail has been included in the system a more conventional landing strip will be usable, but to meet both of these requirements a facility like Edwards Air Force Base will be necessary.

The vehicle would be launched as the payload of a fire stage system that has six million pounds of thrust in the first stage. All stages of the system would use liquid hydrogen and oxygen for propulsion, since this combination has about a 3 to 1 payload advantage over the more conventional liquid oxygen and RP-1 combination. It was determined that the proposed NOVA vehicles using liquid oxygen and RP-1 in the first stage would not be adequate for supporting manned lunar base operations. Therefore, it is desirable to go completely to the use of liquid hydrogen and oxygen as soon as possible.

The first four stages of this same system will provide the capability of soft landing a payload of 50,000 to 80,000 pounds at a preselected lunar site. This provides a configuration suitable for transporting large cargo payloads to the moon for use in constructing the permanent lunar base. Approximately one million pounds of cargo will need to be delivered to the lunar surface in order to construct and support the permanent base. Part of this cargo will consist of telescopic and sensing equipment for performing "surveillance and control" of cislunar space.

An analysis of the functions that are necessary to operate a lunar base has shown that a base complement of 21 personnel will be required. The tour of duty for space personnel is extremely critical, since "personnel transport" is one of the most important cost factors in a space program. Present studies show the maximum tour of duty on an orbiting space satellite is in the neighborhood of 30 days. However, it seems reasonable to expect tours of 7 to 9 months on a lunar base due to the possibility of better living conditions, availability of a natural gravity environment, and greater protection from natural hazards while in the underground base.

Once the decision was made to use a "direct shot" chemical system and a vehicle configuration was determined, it became possible to outline a program for development equipments and a plan for establishing the lunar base. The program broke down into six logical phases with each phase designed to meet a specific secondary objective. These objectives all lead directly to the prime objective of establishing a manned military lunar base.

Basic to each phase of the program is our present knowledge of the environment in space and on the moon. Therefore, as part of this study all existing space and lunar environment knowledge [3] was surveyed, analyzed, summarized and applied to the program plan. The environmental data obtained from each phase of the program will add to this knowledge and assist in the design of equipments for the following phases.

Reliability and safety are of basic importance to each program phase. Reliability is equally essential to the unmanned as well as the manned flights. However, when man is placed in the vehicles safety becomes of prime importance. It was determined that the multi-engine vehicles should be capable of performing the mission even following the loss of one engine. Normally the loss in payload and efficiency to achieve an "engine out" capability is undesirable, but in this program where large quantities of hydrogen and oxygen are part of the regular payload to support the base, the corresponding loss in payload to provide extra fuel and oxidizer is not a disadvantage. Actually a "real" payload loss will only take place when a catastrophic engine failure occurs. In the cases of non-catastrophic failure, the mission will still be accomplished at reduced efficiency.

The following table presents the objectives and systems to be used in each of the six program phases.

PHASE	OBJECTIVE	BOOSTER	PAYLOAD (Pounds)	NO. OF SHOTS	METHOD
1. Lunar Probes	Obtain Lunar and Cislunar Environmental Data	ATLAS-ABLE	370	6	High Resolution Video System and Sensors.
2. Lunar Orbits	Map Complete Lunar Surface (10-15' Resolution)	ATLAS-CENTAUR	1,200	6	Solar energy and strip mapping.
3. Lunar Soft Landing	Soft Land on Moon and obtain environmental data	SATURN (4 stages)	2,000	9	Deceleration stage, terminal guidance alighting gear, core sampling devices.
	SATURN (5 stages)	4,500			
	NOVA-4 (5 stages)	25,000			
4. Lunar Landing and Return	Return First Payload from Moon (A core sample of the lunar surface)	SATURN (5 stages) NOVA-4 (5 stages)	1,400 10,000	6	Core drilling and analysis package, lunar launching-atmospheric drag and retro-rocket re-entry, earth terminal guidance.
5. Manned Vehicle Development	Develop a Three Man Space Vehicle for Aerodynamic Earth Re-entry	NOVA-4 (5 stages) *ARAGO (5 stages) (Lunar Landing & Return with Man)	30,000 (Hi alt & Lunar Pass) 30,000	13	Extend Dyna Soar Techniques to Re-entry velocities of 37,000 ft/sec, fully automatic flight of manned space vehicle to moon and return to earth.
6. Lunar Base Development	Construct an Operational Permanent Base on the moon and support a 21 man crew.	*ARAGO (5 stages)	30,000 Man Space Vehicle) 57,000 80,000 (One Way Cargo Vehicle)	1/mo 1/mo	Construct temporary base, build underground permanent base, install operational surveillance equipment. Support of the completed base will require a total of 1 flight/month.

*ARAGO is the term used to describe the 6 million pound thrust, liquid hydrogen and oxygen, propulsion stage.

[4] Many items of equipment will be required for the lunar base program and wherever existing or programmed equipments would meet the requirements of the lunar base program they were scheduled for use. Where the item did not presently exist and none is programmed, a development schedule was provided. In addition, all necessary items are scheduled for use in the program as early as possible. This will improve reliability by use and growth, and allow the equipments to be "man-rated" by the desired time.

The major-pacing hardware items that require development to start immediately are as follows:

1. A liquid hydrogen and oxygen rocket stage which develops six million pounds of thrust.
2. A 30,000 pound, three man, earth return vehicle.
3. A 100 KW nuclear power unit capable of operating on the lunar surface for two years.
4. A suit/capsule capable of protecting personnel in the lunar environment.
5. A closed ecological system for use in the permanent lunar base.

6. A high definition video strip mapping system to map the lunar surface.
7. Suitable biopacks for use in the first three phases of the program.
8. A fully throttable, 6,000 pound thrust, liquid hydrogen and oxygen propulsion system.
9. A hydrogen-oxygen fuel cell.
10. A horizon scanner and altitude control system for lunar terminal guidance.
11. A command link midcourse guidance system.
12. A communications and terminal guidance package to be dropped on the lunar surface from orbiting vehicles.

The second major question concerning the establishment of a manned base on the moon is, "When can this be accomplished?" The Master Program Schedule for establishing a manned lunar base was obtained by scheduling the development of every known technical item and then integrating these individual schedules to determine when the base could become a reality. . . .

Five major milestones worthy of special mention are:

1.	First lunar sample return to earth	November 1964
2.	First manned lunar landing and return	August 1967
3.	Temporary lunar base initiated (This temporary base will be on the lunar surface and it will provide facilities while the permanent underground base is under construction.)	November 1967
4.	Permanent lunar base completed (The permanent base will support a complement of 21 men.)	December 1968
5.	Operational Lunar Base (Equipment will be installed to perform surveillance of earth-lunar space.)	June 1969

The third major question is, "How much will it cost to establish a manned lunar base?" . . . These cost figures were prepared by the Air Force. After the technical program plan was completed, the Cost Analysis Panel "coated" the program using the best Air Force information available from present ballistic missile and aircraft programs.

[5] The important cost figures are summarized below:

Total Cost-Permanent Lunar Base	$7,726 million
Total Cost-10 Year Program (Includes installation of the permanent base and 6 months of operations.)	8,146 million
Annual Operating Cost	631 million

These costs are based on the following assumptions:

1. The major development engineering costs on the Saturn B and the NOVA 4 boosters has [sic] been assumed to be provided under independently funded programs. However, the actual cost of the boosters has been included and it was assumed that the first vehicle would be made available to the lunar program. If this is not the case, due to the "learning curve" it is expected that the vehicle costs would be decreased.
2. The costs include all shots in the program except the nuclear shots shown in the last half of 1970. The development costs for the nuclear system were not included because the lunar base program is not dependent upon the nuclear system. However, if the nuclear system is available and more economical it would be used to support the operational base.
3. Costs of all items normally considered as part of a weapon system (such as, launch pads and ground facilities) have been included.
4. It was assumed that adequate earth based tracking facilities will be available as the result of other programs. If they are not available the costs could increase by 300-600 million dollars in the later phases of the program.

When the average annual cost ($814 million) of the proposed program is compared to the Air Force efforts, it becomes apparent that this program is approximately equal to the output of just one of the major airframe companies normally supported by the Air Force. As a matter of information, the annual cost of the U.S. Farm Subsidy Program is approximately the same as the 9 1/2 year program required to install the permanent lunar base.

One point worthy of particular mention when considering costs, is the development of lunar resources. Analysis has shown that the development of lunar resources could decrease the cost of Strategic Lunar Operations by as much as 25 per cent [sic]. This is based on the fact that the moon's surface probably consists of many types of silicates. Since hydrogen and oxygen are used as propellants in the transport vehicles, as essential elements in the secondary power systems, as an element for personnel breathing, and when combined as water for life support, the value of obtaining these two elements on the moon is obvious. Should oxygen and hydrogen be obtained on the lunar surface they would be literally worth more than their weight in gold. This study has shown that it may be very possible to process lunar silicates to obtain water and then, by dissociation, the elements oxygen and hydrogen. It seemed very worthwhile to pursue this objective so a program schedule has been presented in the Environment section of Volume II. A glance at the lunar resource program schedule shows that the sample "core" of the lunar surface to be obtained in Phase IV, is critical to this effort. Although the process will require large quantities of power, solar energy is available in unlimited supply and nuclear power has been programmed for use on the lunar base.

The fourth major question, "Why should a manned base be established on the moon?," was not answered as a part of this SR-183 study. SR-192, the Strategic Lunar System Study was initiated on 29 August 1958 for the specific purpose of looking at this question. However, to provide a complete picture on the lunar base it seems necessary to consider the question in this report. Since the [6] final results of SR[-]192 are not yet available, the mid-term conclusions have been utilized. The Space Mission Analysis portion of this final SR[-]183 report briefly discusses these conclusions. The essential factors can be stated as follows:

1. The lunar base possesses strategic value for the U.S. by providing a site where future military deterrent forces could be located.
2. The decision on the types of military forces to be installed at the lunar base can be safely deferred for 3 to 4 years provided a military lunar base program is initiated immediately.
3. A lunar based earth bombardment system could have a CEP of two to five nautical miles.
4. The development of lunar resources could enhance the potential for strategic space operations in the cislunar volume.

[7] CONCLUSIONS

The most important conclusions of this study can be summarized by the following statements:

1. It is technically feasible to establish a lunar base by logical extension of present techniques.
2. Earliest lunar operations may be attained through the use of a direct shot chemically powered booster.
3. A 6 million pound thrust LOX/LH propulsion capability must be developed for the three-manned vehicle for lunar landing and return missions.

4. Investigation indicates that the payload penalty for using earth re-entry retro rockets is so great that the only logical re-entry approach is by means of aerodynamic braking. Therefore, the present Dyna Soar program is essential to provide re-entry vehicle design data.
5. A multi-phased program is essential to establish an operational lunar base. The Program Plan presented in this report included the following six phases:

Phase I	Lunar Probes
Phase II	Lunar Orbits
Phase III	Soft Lunar Landing
Phase IV	Lunar Landing and Return
Phase V	Manned Vehicle Development
Phase VI	Lunar Base Development

6. Based on the above program the following milestones have been established as reasonable objectives.

a.	First Lunar Sample Returned to Earth	November 1964
b.	Manned Lunar Landing and Return	August 1967
c.	Temporary Lunar Base Initiated	November 1967
d.	Permanent Lunar Base Completed	December 1968
e.	Operational Lunar Base	June 1969

7. The initial pleases of the program can be undertaken for an investment which averages approximately 800 million dollars per year during the initial building phase. After the establishment of the base the annual costs will decrease to about 600 million dollars per year. This may be still further reduced when nuclear propulsion becomes available and as lunar resources are developed to provide oxygen and hydrogen to support space operations.
8. A lunar base is the initial and essential step in the attainment of a military capability in the lunar volume.
9. A military lunar system has potential to increase our deterrent capability by insuring positive retaliation.
10. The decisions regarding the type of military operations to be conducted in lunar and cislunar space can be safely deferred for several years provided a military lunar base is established which can be readily expanded to support lunar operations.
11. From a national viewpoint it is desirable that a lunar base be established as soon as possible. This conclusion is based on the strategic potential as well as the psychological, political and scientific implications.

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[9] The following actions are recommended as a result of this study.

1. The program for establishing a military lunar base be recognized as an Air Force requirement.
2. Immediate action be taken to implement the early phases of the program.
3. Immediate action be taken to start the development of the critical long lead items listed below:
   a. Six million pound thrust LOX/LH propulsion system.
   b. Three-man space vehicle which can re-enter earth's atmosphere.
   c. There are smaller items that should be started before the end of 1960. These are listed in the separate technical areas.
4. A program office be established within ARDC to coordinate with NASA, all activities directed toward the establishment of the lunar base.

5. The military requirements and NASA's requirements be integrated into one national lunar program.
6. Responsibilities be assigned for the various phases of the integrated lunar program.
7. The establishment of the base be considered a military expedition.
8. The Air Force develop space operational know-how by being intimately involved in all phases of the lunar program. This is in keeping with the philosophy of concurrency and is necessary to shorten the development cycle.
9. Further study be initiated as explained in each section of the technical report. The follow-on SR-183 study will tie all of these together into a comprehensive systems study.

Document II-16

Document title: General Thomas D. White, Chief of Staff, United States Air Force, to General Landon, Air Force Personnel Deputy Commander, and General Wilson, Air Force Development Deputy Commander, April 14, 1960, reprinted in: *Defense Space Interests*, Hearings Before the Committee on Science and Astronautics, U.S. House of Representatives, 87th Cong., 1st sess. (Washington, DC: U.S. Government Printing Office, 1961).

Document II-17

Document title: Robert S. McNamara, Secretary of Defense, to the Secretaries of the Military Departments, *et al.*, "Development of Space Systems," March 6, 1961, with attached: Department of Defense Directive 5160.32, "Development of Space Systems," March 6, 1961, reprinted in: *Defense Space Interests*, Hearings Before the Committee on Science and Astronautics, U.S. House of Representatives, 87th Cong., 1st sess. (Washington, DC: U.S. Government Printing Office, 1961).

Document II-18

Document title: Overton Brooks, Chairman, Committee on Science and Astronautics, U.S. House of Representatives, to the President, March 9, 1961.

Source: NASA Historical Reference Collection, NASA History Office, NASA Headquarters, Washington, D.C.

Document II-19

Document title: President John F. Kennedy, to Overton Brooks, Chairman, Committee on Science and Astronautics, U.S. House of Representatives, March 23, 1961.

Source: NASA Historical Reference Collection, NASA History Office, NASA Headquarters, Washington, D.C.

After the Advanced Research Projects Agency (ARPA) returned control of the military space program to the individual services—primarily the Air Force—there was gradually increasing concern in Congress and the press that the Air Force was interested in expanding its power over other aspects of the civilian space program as well. In April 1960, Air Force Chief of Staff Thomas White wrote a *memorandum to his staff stating that he wanted them to cooperate more fully with NASA and that it might be possible that NASA would eventually be combined with the military. Almost a year later, newly appointed Secretary of Defense Robert McNamara gave the Air Force control of the development of all military space systems. The other services would still conduct basic research, but after some predetermined point, the program would be turned over to the Air Force. White's memo "leaked" and, combined with the McNamara policy statement, led to hearings before the House Committee on Science and Astronautics, chaired by Overton Brooks. Before the hearings started, Brooks sent a letter to President Kennedy asking for clarification of the Air Force's role in conducting aspects of the national space program. By the last day of the hearings, Kennedy responded, declaring that manned and unmanned exploration of space and the application of space technology to peaceful activities were NASA missions, but that there also were exclusively military missions in space as well.*

Document II-16

[no pagination] 14 April 1960

AFPDC (Gen Landon)
AFDDC (Gen Wilson)

1. I am convinced that one of the major long range elements of the Air Force future lies in space. It is also obvious that NASA will play a large part in the national effort in this direction and, moreover, inevitably will be closely associated, if not eventually combined with the military. It is perfectly clear to me that particularly in these formative years the Air Force must, for its own good as well as for national interest, cooperate to the maximum extent with NASA, to include the furnishing of key personnel even at the expense of some Air Force dilution of technical talent.

2. It has come to my attention that key personnel in NASA feel that there has been a shift in Air Force policy in respect to the type of cooperation stated above. I want to make it crystal clear that the policy has not changed and that to the very limit of our ability, and even beyond it to the extent of some risk to our own programs, the Air Force will cooperate and will supply all reasonable key personnel requests made to it by NASA.

3. To meet the above requirements I have no doubt that some shifting of Air Force personnel within the Air Force will be necessary in order to feed new talent into [the Air Research and Development Command]. This should be done. In addition, while late, we must increase the number of slots in civil technical institutions for Air Force officers. I want this type of technical education to be given the highest priority in our civil educational program and the percentage of slots in this respect to be radically increased, effective as early as possible.

THOMAS D. WHITE
Chief of Staff

cc: Under Secretary of the Air Force Dr. Perkins
General LeMay
General Schriever

Document II-17

[no pagination]

THE SECRETARY OF DEFENSE
Washington, D.C., March 6, 1961

Memorandum for the Secretaries of the Military Departments
The Director of Defense Research and Engineering
The Chairman, Joint Chiefs of Staff
The Assistant Secretaries of Defense
The General Counsel
The Assistants to the Secretary of Defense

SUBJECT: *Development of Space Systems*

Having carefully reviewed the military portion of the national space program, the Deputy Secretary and I have become convinced that it could be much improved by better organization and clearer assignment of responsibility. To this end, I directed the General Counsel of the Department of Defense to obtain your comments on a new draft DOD Directive, "Development of Space Systems."

After careful consideration of the comments and alternate plans that were submitted, the Deputy Secretary and I have decided to assign space development programs and projects to the Department of the Air Force, except under unusual circumstances.

This assignment of space development programs and projects does not predetermine the assignment of operational responsibilities for space systems which will be made on a project by project basis as a particular project approaches the operational stage, and which will take into account the competence and experience of each of the Services and the unified and specified commands.

We recognize that all the military departments, as well as other Defense agencies, may have requirements for the use of space equipment. The directive expressly provides that they will continue to conduct preliminary research to develop specific statements of these requirements, and provides a mechanism through which these requirements may be fulfilled.

Attached is a directive incorporating this decision. We expect all elements of the Department of Defense to support it fully and to help develop the military portion of the national space program in the most effective manner.

Robert S. McNamara

Encl. DOD Dir. 51GO.32

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[1]

March 6, 1961
Number 5160.32

Department of Defense Directive

SUBJECT: *Development of Space Systems*

References:

(a) Memorandum (Conf) from Secretary of Defense to Chairman, Joint Chiefs of Staff, subject: Satellite and Space Vehicles Operations, September 18, 1959

(b) Memorandum from Director, Advanced Research Projects Agency to Secretary of the Army, Secretary of the Navy, and Secretary of the Air Force, subject: Study Contracts for Projects Assigned to the Advanced Research Projects Agency, September 14, 1959

(c) Memorandum from Director, Advanced Research Projects Agency to Secretary of the Army, Secretary of the Navy, and Secretary of [2] the Air Force, and Director, Advanced Research Projects Agency, subject: ARPA Programs, June 11, 1959

I. Purpose

This establishes policies and assigns responsibilities for research, development, test, and engineering of satellites, anti-satellites, space probes and supporting systems therefor, for all components of the Department of Defense.

II. Policy and assignment of responsibilities

A. Each military department and Department of Defense agency is authorized to conduct preliminary research to develop new ways of using space technology to perform its assigned function. The scope of such research shall be defined by the Director of Defense Research and Engineering in terms of expenditure limitations and other appropriate conditions.

B. Proposals for research and development of space programs and projects beyond the defined preliminary research stage shall be submitted to the Director of Defense Research and Engineering for review and determination as to whether such proposals, when transmitted to the Secretary of Defense, will be recommended for approval. Any such proposal will become a Department of Defense space development program or project only upon specific approval by the Secretary of Defense or the Deputy Secretary of Defense.

C. Research, development, test, and engineering of Department of Defense space development programs or projects, which are approved hereafter, will be the responsibility of the Department of the Air Force.

D. Exceptions to paragraph C, will be made by the Secretary of Defense or the Deputy Secretary of Defense only in unusual circumstances.

E. The Director of Defense Research and Engineering will maintain a current summary of approved Department of Defense space development programs and projects.

III. Cancellation

Reference (a), except as to the assignments of specific projects made therein, and references (b) and (c) are hereby cancelled.

IV. Effective date

This directive is effective upon publication. Instructions implementing this directive will be issued within thirty (30) days.

ROBERT S. MCNAMARA, *Secretary of Defense*

Document II-18

[1] March 9, 1961

The President
The White House
Washington, D.C.

My dear Mr. President:

I am seriously disturbed by the persistency and strength of implications reaching me to the effect that a radical change in our national space policy is contemplated with some areas of the executive branch. In essence, it is implied that United States policy should be revised to accentuate the military uses of space at the expense of civilian and peaceful uses.

Of course, I am aware that no official statement to this effect has been forthcoming; but the voluminous rash of such reports appearing in the press, and particularly in the military and trade journals, is, it seems to me, indicative that more than mere rumor is involved.

Moreover, I cannot fail to take cognizance of the fact that emphasis on the military uses of space is being promoted in a quasi-public fashion within the defense establishment. Nor can I ignore the suggestion, implicit in the unabridged version of the Wiesner report, that the National Aeronautics and Space Administration role in the development of space systems will be predominant. Such an assertion not only seems to disregard the spirit of the law but minimizes the values of peaceful space exploration and exploitation.

I have hesitated to call this to your personal attention. However, since the National Aeronautics and Space Council, whose duty it is to advise on the formulation of United States space policy, remains unformed, I feel constrained to broach the matter directly.

May I point out that the National Aeronautics and Space Act of 1958 passed the Senate in which both you and the current Vice President so ably served without a recorded dissenting vote. It was unanimously approved by the House. In that Act Congress took great pains to declare that space activities "shall be the responsibility of, and shall be directed by, a civilian agency exercising control over aeronautics and [2] space activities sponsored by the United States. . ." Space activities "peculiar to or primarily associated with the development of weapons systems, military operations, or the defense of the United States" were quite properly made the responsibility of the Defense Department, but this was a literal "exception" to the proclaimed procedure.

As you know, I served twenty-two years on the House Armed Services Committee. I would be the last person to attempt to weaken our defense posture. But neither do I intend to sit by and, contrary to the express intent of Congress, watch the military tail undertake to wag the space dog.

The law makes it crystal clear that the prime American mission in space is toward peaceful purposes. It specifically enjoins NASA to promote space science and technology with a view to the "application thereof to the conduct of *peaceful activities* within and outside the atmosphere." The law not only does not limit NASA's functions to scientific research; it affirmatively directs NASA to make peaceful use of space and to develop operational space systems, manned and unmanned. This is a legislative requirement imposed. To place the prime operational responsibility for space exploration and use with the military, particularly when no military requirement for men in space yet exists, would be to disorient completely the space program as contemplated by Congress and as set forth in the law.

As Chief Executive of the United States charged with the conduct of foreign affairs and as a former member of the Senate Foreign Relations Committee, you are, I know, aware of the great importance of preserving the peaceful image of the United States within the international community. At the same time, few areas of national endeavor today serve better to reflect the American attitude in world politics than what we intend and how we behave in this new dimension of human activity. I do not see how we can square an exclusive, or even a predominant, military exploitation of space with our announced aspirations for peace and disarmament. To sublimate military operations in space would thus seem to be inconsistent with our foreign policy and, in my judgment, would serve to impede our future negotiations for world-wide disarmament.

There is another extremely important aspect of this picture, namely participation by private enterprise in the space venture. If we are to reap genuine economic pay-off through space exploration, we must find ways of eliciting and using the resources of private capital. While I recognize that the armed services have a legitimate interest in such space enterprises as communications, weather prediction, navigation and the like, I submit that these concepts have a predominant use for peaceful activities. In my judgment, we will lag seriously in any efforts to bring private enterprise into space if we turn control of research, development and operation of such endeavors over to the military whose [3] needs are highly specialized and whose research methods tend to be restricted in scope and concept.

To amplify: if we envision the military in control of world-wide space communications, it is difficult to understand in advance what basis would be provided for world-wide media of communications such as television, radio and telephone systems. If we concede military control of weather satellites, how shall such control be reconciled to the needs of farmers, merchants, and business generally? If we permit military domination of space navigation devices, are we fulfilling our obligations to the merchant marine and the commercial air fleets operating on and above the high seas? I think not. In fact, many of the benefits which humanity could expect to reap from the exploration of space may easily be lost unless they are made available on a non-military basis. If the fruits of our efforts to conquer space are to enrich people's lives and raise standards of living throughout the world, they must be handled through a civilian peace-time agency, not by the military which necessarily is governed by its particular objectives.

In conclusion, I feel obliged to point out that in view of the recent Defense Department decision to concentrate all military space research in a single service, this question of civilian preeminence in space exploration becomes paramount. Space exploration involves much research, basic and applied, and it is axiomatic that the rate of research pay-off is accelerated many times when a variety of approaches, ideas and concepts are explored simultaneously. Testimony before our Committee permits no doubt whatever that the United States space effort, civilian and military, has achieved what it has during the past three years only because of an imaginative and *diversified* approach.

If NASA's role is in any way diminished in favor of a space research program conducted by a single military service, it seems unlikely to me that we shall ever overtake our

Soviet competition—a competition which, by the way, has been peculiarly effective because of its public emphasis on scientific and peaceful uses of space.

It is my hope that you will find it feasible to clear up this matter, and, coincidentally, to reassure me in the very near future.

Very sincerely yours,

OVERTON BROOKS
Chairman

Document II-19

[1] March 23, 1961

Dear Overton:

Recently you wrote to me concerning my attitude toward the conduct of our national space effort. I appreciate your comments and have given considerable thought to the problems of this program which you have raised. I hope that this letter will serve to reassure you that there is no basic disagreement between us.

It is now, nor has it ever been, my intention to subordinate the activities in space of the National Aeronautics and Space Administration to those of the Department of Defense. I believe, as you do, that there are legitimate missions in space for which the military services should assume responsibility, but that there are major missions, such as the scientific unmanned and manned exploration of space and the application of space technology to the conduct of peaceful activities, which should be carried forward by our civilian space agency. Furthermore, I have been assured by Dr. Wiesner that it was not the intention of his space task force to recommend the restriction of the NASA to the area of scientific research in space. One of their strongest recommendations was, in fact, that vigorous leadership be provided by NASA in the area of non-military exploitation of space technology.

As you have pointed out, there are programs which have strong implications in both the military and civilian fields. In making policy decisions on such programs, I intend to rely heavily on the advice of the Vice President, based on his invaluable experience with the Senate Committee on Aeronautical and Space Sciences. We are also moving ahead with plans to reactivate the Space Council, and to make it an active and effective organization. As [2] you know, I have nominated Dr. Edward C. Welsh to be executive secretary of the Space Council. I believe that he, working under the Vice President, can assemble a top-flight staff that will make the Space Council more than just a box on an organization chart as it has been heretofore.

I agree wholeheartedly with you that there are highly important benefits to be realized from the civil applications of space technology and that private enterprise must play an important role. I am confident that with the help of the Vice President, the Space Council, the Senate Committee under Senator Kerr, and the House Committee under your able leadership, we can assure that the proper policy decisions will be reached.

Again, may I thank you for your comments and also express my appreciation for the outstanding job you are performing as Chairman of the Committee on Science and Astronautics.

Sincerely yours

John F. Kennedy

Document II-20

Document title: "Summary Report: NASA-DOD Large Launch Vehicle Planning Group," September 24, 1962, pp. ii-iv, I-1–III-13.

Source: NASA Historical Reference Collection, NASA History Office, NASA Headquarters, Washington, D.C.

After President Kennedy's May 25, 1961, speech to Congress, which committed the United States to a lunar mission, there was an attempt to establish military and civilian requirements for large launch vehicles, with the hope of establishing a single national launch vehicle fleet. On July 7, 1961, NASA Associate Administrator Robert Seamans proposed a joint study to determine mission models and requirements affecting the selection of large launch vehicles; the study was headed by NASA's Nicholas Golovin. As the study progressed, the different requirements and institutional interests of NASA and the Department of Defense (DOD) became clear and both agencies quickly distanced themselves from the contents of the report. By the time this report was released on September 24, 1962, almost a year after the group had completed its work, it had been obvious for some time that there would be very little cooperation between NASA and the DOD on large launch vehicles.

[ii]

Foreword

Early in 1961 numerous studies relative to our space programs were undertaken under a variety of auspices. In one of the initial efforts the Space Exploration Program Council of NASA revived in detail the various aspects and approaches to manned lunar landing including both rendezvous and direct ascent. This review culminated in the decision that NASA would proceed toward the manned lunar landing on a broad base. Accordingly, studies were initiated to aid in formulating an approach to the task. At about the same time, the Secretary of Defense requested a comprehensive study by his staff of our total national space program and a comparison of these with what was known of Soviet undertakings in this field.

Early in May 1961, NASA presented its plans for accomplishing a manned lunar landing and estimates of the cost to the Department of Defense for the purpose of coordinating the resources and efforts of these two agencies to accomplish this mission. These discussions culminated in a NASA-DOD report submitted to the Vice President, in his capacity as Chairman of the National Aeronautics and Space Council, entitled "Recommendations for Our National Space Program: Changes, Policies, Goals." This report, dated 8 May 1961, was submitted jointly by the Administrator of NASA and the Secretary of Defense.

The most important of these recommendations was that the achievement of manned lunar landing before the end of the decade be established as a national goal. In addition, it was recommended that scientific exploration of space be intensified; that operational communications and meteorological satellite systems be developed at the earliest reasonable time; that large scale boosters be developed for potential military use as well as to support the civilian space program; and that an increased effort be placed on advanced technology, particularly with regard to the development of chemical and nuclear rocket propulsion. It was recognized, of course, that further analysis would be required to develop more detailed program plans in each of the recommended areas. It is important to note, however, that the basis for such planning was clearly [iii] specified in the 8 May 1961 report; it was recognized that long-range planning, especially for launch vehicles (which account for more than half the cost of space programs), must first be successfully accomplished, and that such planning was essential to insure that national resources would be properly harnessed to national tasks on a national scale.

The 8 May 1961 report gave renewed support to the "building block" concept. It was stated in this connection: "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 resources, on the essential building blocks."

The budgetary and policy recommendations of the 8 May report were adopted by the President and presented to the Congress in his message of 25 May. Subsequently, virtually all the recommended authorizations and appropriations were passed by the Congress.

Simultaneously with these acts, NASA and DOD continued an intensified effort to define mere explicitly and explore more thoroughly the actions that would have to be taken to implement these recommendations. New studies were begun in both agencies and the talents of specialists were harnessed in organizations in many parts of the country.

Within NASA the first of a series of major study efforts was begun on 2 May 1961, initiated to define in greater detail the feasibility, schedule, and costs of accomplishing manned lunar landing, giving attention to the various possible approaches for accomplishing the mission. An ad hoc task group was then established and assigned the responsibility for defining in detail a feasible approach for accomplishment of an early manned lunar landing. A second ad hoc group was assigned the task of conducting a broad survey of the feasible ways for accomplishing manned lunar landing.

One of the results of these studies was establishment of the need for further information on the rendezvous approach to manned lunar landing and the associated launch site planning and resources required. Accordingly, two [iv] additional ad hoc task groups were established. One group established on 20 June 1961 was assigned responsibility for studying in detail the plans and supporting resources needed to accomplish manned lunar landing by the rendezvous technique. The other group established 23 June 1961 conducted a joint NASA-DOD study of national launch site planning and of the resources required to accomplish the manned lunar landing mission—as it was defined by the earlier studies.

Early in July it became apparent that a very major effort was necessary to aid in defining the large launch vehicles which would be needed for the Manned Lunar Landing Program. Numerous mechanisms were considered for this purpose. The idea of establishing a committee of scientists and technologists somewhat analogous to the Von Neuman Committee, which in 1954 recommended the initiation of our ICBM program, was considered. The possibility of establishing a contractor or a group of contractors charged with responsibility for this analytical and planning effort was also considered. From such considerations emerged the concept of the Large Launch Vehicle Planning Group (LLVPG). This group was to be comprised of representatives from both NASA and DOD reflecting equally the experience, viewpoints and special knowledge of both agencies. The group was to be responsible jointly to a senior official in each agency and empowered to draw upon scientific and technological resources wherever they might be found and needed. . . .

[I-1]

Chapter I
Summary and Recommendations

I. Introduction

A. *Formation of the Large Launch Vehicle Planning Group*

The Secretary of Defense and the Administrator of NASA, in an exchange of correspondence on 7 July 1961, established the DOD-NASA Large Launch Vehicle Planning Group (LLVPG), to provide the necessary joint planning leading to future specification and development of large launch vehicles required as a result of the expansion of the national space effort outlined by the President on 25 May 1961.

The LLVPG was headed by Dr. Nicholas E. Golovin of NASA, and by Dr. Lawrence L. Kavanau of OSD [the Office of the Secretary of Defense], who served as Deputy Director of the group. They reported jointly to Dr. Robert C. Seamans, Jr., Associate Administrator of NASA, and Mr. John H. Rubel, Assistant Secretary of Defense (Deputy Director, Defense Research and Engineering) of DOD. A total of nine DOD representatives and ten NASA representatives made up the membership of the LLVPG. Their names appear in Appendix A, which also describes the assistance the group secured from other agencies, such as the Marshall Flight Test Center, Aerospace Corporation, Jet Propulsion Laboratory, and industrial contractors. As noted in Appendix A, the LLVPG commenced its operations in July and continued through the month of November 1961, and utilized the equivalent full-time services of approximately 150 people during this period.

Representatives from many NASA and DOD components served as members of the LLVPG. Although it was desired and necessary to insure that organizations charged with on-going responsibilities for the execution of space programs would have the opportunity to participate in this planning effort, the principal criterion used in selecting members of the LLVPG was their personal technical ability and experience. The objective was not to attain a compromise between the preconceived notions of DOD representatives on the one hand and NASA representatives on the other, but to harness, through cooperative study, the best capabilities available for the task of laying out a long-range plan for a National Launch Vehicle Program.

[I-2] The initial instructions to the LLVPG were comprised [sic] in a memorandum dated 7 July 1961 to the Administrator of NASA from Dr. Seamans. This document was approved by the Administrator of NASA and the Secretary of Defense. While these documents served as the important starting point and the principal framework for LLVPG deliberations, the LLVPG was responsive to considerable detailed guidance furnished by Dr. Seamans and Mr. Rubel, immediately following its establishment, and from time to time during the course of its deliberations. Since the objective of the LLVPG was to formulate plans, it was natural to expect that ideas and concepts would be changed as their studies and analyses evolved. This was indeed the case, and some of the notions with which this undertaking began were significantly modified before the completion of the group's effort.

Based on the direction received by the LLVPG, the following frame of reference for the study was adopted:

a. The launch vehicle configurations and the operational procedures to be developed and recommended by the LLVPG were to take into account the current and anticipated needs of DOD and of NASA and be guided by the following national objectives for large launch vehicles:

(1) Early successful landing of manned spacecraft on the moon to return to earth.

(2) Manned scientific missions in earth orbit and circumlunar flight as well as on the lunar surface.
(3) Launch vehicle developments for advanced military missions.
(4) Increased reliability and economy of effort achieved by multiple use of vehicle components, vehicle stages, and complete launch vehicles.

b. The principal specific allegation of the LLVPG was the explicit development, in useful detail, of a technically well-established planning basis in which coordinated action could be taken leading to the development [I-3] and use of the recommended launch vehicles and the necessary facilities for their test and launching. The group was charged with the identification and preparation of preliminary specifications for long lead time items for which development should be initiated immediately, and was directed to review and recommend a suitable balance between early achievement of major goals, over-all costs, and growth potential of large launch vehicles.

c. Guidelines provided the LLVPG included the following:
(1) Both direct ascent and rendezvous operations with respect to the lunar landing were to be considered.
(2) Plans were to be based on components within the present state-of-the-art but not restricted to on-the-shelf items. When the scheduled development of a new component appeared questionable, a duplicate approach was to be included.
(3) Although only liquid and solid motors were to be employed, proposal designs should facilitate exploitation of nuclear and electric propulsion for follow-on systems if feasible.
(4) The group was to concern itself only with large launch vehicle systems. The word "large" was to mean those vehicles whose capability to accelerate payloads on spacecraft to escape velocity would be greater than the capability of the Atlas-Agena B system. (This guidance was subsequently modified as a result of the booster requirements arising in connection with the NASA Gemini program, and the group was reconvened by a memorandum dated 18 November 1961, from the Associate Administrator of NASA and the Assistant Secretary of Defense (Deputy Director of Defense Research and Engineering) to extend its study of vehicle systems with the range of payloads down to 5000 pounds.) The term "vehicle system" was to include not only propulsion elements, but guidance, control and those instrumentation, telemetry, and command/communication subsystems which are normally physically part of the vehicle system and are employed for maneuvering the payload or spacecraft into a desired sequence of position and velocity coordinates.

[I-4] B. *Approach*

The general approach followed by the group was that of defining stage and vehicle combinations which could reasonably be expected to become available within the next 5 to 8 years: executing a systematic quantitative analysis of their relative performance, schedule, cost and reliability characteristics; and comparing resultant launch vehicle capabilities, with the projected national missions requirements. In developing national launch vehicle requirements for the period 1962 - 1970, the LLVPG utilized forecasts of launch needs prepared by DOD and NASA reflecting programmed and anticipated mission needs.

It was not considered an assignment of the LLVPG to establish preferred mission modes where alternative operational concepts were involved as, for example, in the case of various approaches to accomplishment of manned lunar landing. However, it was the aim of the group to define the launch vehicle configurations (and their availability, cost, reliability and performance characteristics) associated with such alternative mission modes and thereby provide inputs which could be used for decisions by DOD and NASA.

In defining building block combinations of boosters and upper stages, consideration was extended to major subsystems including guidance systems, control systems, power supplies, telemetry and the like. Quantitative preliminary design analyses were made by Aerospace Corporation and/or the Marshall Space Flight Center (MSFC), and were carried through to a sufficient depth of technical detail to substantiate the operational feasibility of each prospective launch vehicle. These studies included: propulsion system performance characteristics; controllability; structural behavior in typical trajectories; detailed development schedules for the engines, stages, and vehicles, structured in the form of PERT diagrams incorporating all significant milestones throughout the development cycle up to first vehicle availability for flight test, and detailed cost estimates for each phase of the development process for each stage of every vehicle, including manufacturing facilities, static and dynamic testing facilities, as well as the necessary launch complexes.

[I-5] In this effort one of the early decisions of the LLVPG was that no recommendation, consistent with the guidelines given to the group was likely to be of practical utility as a basis for management decisions in NASA or DOD unless the prospective reliability of the vehicle systems involved was estimated. Accordingly, arrangements were made for detailed reliability analysis of each stage, each major subsystem, and each over-all vehicle system.

In view of the fact that durations of testing programs, both static and flight, are dependent on the engineering and testing philosophies employed in the development process, substantial attention was also given by the group to these matters. The experience of qualified staffs at MSFC and Aerospace Corporation, as well as of members of the LLVPG, were melded in sharpening the concepts involved and in applying them, to establish vehicle development and flight schedules for various mission-vehicle combinations later considered by the group.

Further details of the participation of the LLVPG, the manner in which the group proceeded in its activities, and the contents of the final report are included in Appendix A.

As stated previously, it was the objective of the LLVPG to develop recommendations for a National Launch Vehicle Program that would satisfy NASA and DOD flight mission requirements for the remainder of the decade. Therefore, one of the initial steps taken by the group was to obtain the mission requirements of the two agencies and analyze them with a view to developing a systematic mission requirement base to serve as a foundation for the vehicle studies to follow. Spacecraft development and mission attempt schedules were assumed to be paced by the availability of vehicles, the derivation of vehicle types and their development schedules.

For convenience in analyzing the characteristics of the various vehicles considered, the mission requirements were divided into four classes. These mission classes are:

Class I - Unmanned NASA and DOD missions plus early manned flight

Class A - Low earth orbit missions for large manned spacecraft systems (Apollo, Dyna-Soar, Orbiting Laboratory)

[I-6] Class B - Manned lunar missions involving lunar circumnavigation, lunar orbit and lunar landing by earth orbit or lunar orbit rendezvous

Class C - Manned flight to the moon by direct ascent

The launch vehicles studied were correspondingly divided into four classes. The performance characteristics, reliability and development schedules for these vehicles are summarized in Appendix B.

A total of over 800 missions was projected for NASA and DOD to the end of the decade. These missions were distributed among the four mission classes as follows:

	NASA	DOD	Total
Class I			
Class A	277	523	800
Class B	69	Undefined	69
Class C	10		10
Total	356	523	879

[II-1] II. Principal Recommendations

A. *Recommendations*

The following are the principal recommendations of the LLVPG with a brief discussion of each.

1. *Class A Launch Vehicle Development*

Recommendation: *Development of the Saturn C-1 should continue.*

The Saturn C-1 is the only vehicle (A-1) available in time to meet the present development schedule of the Apollo program. Therefore, the Saturn C-1 vehicle (A-1) should be developed, flown, and man-rated as soon as possible as a matter of high priority. Such development will not only allow initiation of Apollo spacecraft tests at the earliest possible date, but will also generate experience in the operation of large hydrogen-oxygen stages and will provide definition of the problems and the potential of multiple engine clusters for such stages.

2. *Titan Launch Vehicle System*

At the conclusion of the LLVPG studies in October 1961, the following recommendation was made by the group with regard to the Titan III:

Recommendation: *The 120-inch diameter solid motor and the Titan III launch vehicle should be developed by the Department of Defense to meet DOD and NASA needs, as appropriate in the payload range of 5000 to 30,000 pounds, low earth orbit equivalent.*

Of the various considerations taken into account in evaluating the advisability of proceeding with development of the Titan III system, the principal arguments leading to the conclusion of the group were: (1) the anticipated large number of DOD missions during this decade justify the development of the Titan III family because of its substantially lower cost per launch than for Saturn based vehicles; (2) the importance to DOD of having a launching system not dependent on the use of cryogenic propellants; (3) the Titan III, by virtue of the way its building blocks can be combined, permits greater flexibility; [II-2] (4) the Titan III uses DOD experience with Titan II, making logistics and training easy for DOD; and (5) development of large solid motor technology would be part of the development effort and cost of this vehicle system. Such development would be in accord with prior governmental policy decisions that advancement of large solid rocket technology would be vigorously pursued.

Following the adjournment of the LLVPG in October 1961, unresolved questions still remained relative to the role of the Titan III. The LLVPG had given little or no attention to the Titan II-1/2, the Department of Defense had initiated a Phase I development on the Titan III, and NASA was soon to make a decision on Gemini and was considering the Titan II-I/2. To assist the pending decision by DOD and NASA relative to these vehicles, the LLVPG was reconvened for analysis of the National Launch Vehicle Program in the 5000 to 30,000 pound low earth equivalent range.

At the termination of this reconvened session of the group. the recommendation on the Titan III was as follows:

Recommendation: *The Titan III space launching system should be developed by the Department of Defense providing that the Phase I study now under way confirms the technical feasibility and desirability of the system.*

The further review of the Titan III by the group did not result in the introduction of any additional factual evidence either for or against the prior recommendation. Thus, the arguments outlined above in favor of Titan III suggest again the recommendation to proceed with development of the vehicle should the Phase I study confirm the technical feasibility.

3. *Saturn Upper Stage*

Recommendation: *Develop the S-IVB stage as promptly as possible using it as an alternate stage for the 5-IV in the Saturn C-1. This stage is necessary for the Class B vehicle recommended and its combination with the S-I stage (A-2 vehicle) will constitute another potential Class A vehicle.*

[II-3] An examination of the various Class B vehicles considered shows that all of the interesting versions have as their third stage the S-IVB which is powered by one J-2 engine. In view of its almost certain use in Class B vehicles it is considered extremely desirable that plans be made for early flight tests of the S-IVB on the S-I stage in order to build up its reliability as rapidly as possible.

4. *Class 13 Launch Vehicle*

Recommendation: *Develop as promptly as possible a Class B vehicle (B-8, B-10, or B-15) consisting of a four or five F-l engine first stage, a four or five J-2 engine second stage and a one J-2 engine third stage (S-IVB). This vehicle should be designed for use as a two-stage vehicle for low earth orbit missions and a three-stage vehicle for escape missions with a minimum performance capability of 180,000 pounds in a low earth orbit and 70,000 pounds to escape.*

It is felt that a Class B vehicle can be developed with relatively little delay and that this development should be pursued with the highest priority. This conclusion results from recognition that both earth orbit rendezvous and lunar orbit rendezvous are attractive mission concepts and that they can be achieved with Class B vehicles. Furthermore, lunar orbit rendezvous offers the chance of the earliest accomplishment of manned lunar landing. It is quite likely that the pacing item for any rendezvous approach is development of the Class B vehicles, hence the high degree of urgency recommended.

5. *Use of Solid Motors in Class B Launch Vehicles*

Recommendation: *The design of the second and third stages of the Class B vehicle recommended (B-8, B-10, or B-15) should, if practicable, provide potential for economical and early substitution of a solid motor first stage for the four or five F-1 engine first stage. Substitution of such a solid motor stage may permit the construction of a vehicle (B-5 or B-14) of comparable but somewhat lower capability than the recommended all-liquid Class B vehicle.*

[II-4] The group examined the question as to whether a solid first stage should be developed for the Class B vehicle in parallel with the recommended liquid first stage. It was considered that while LOX/RP is a familiar propellant combination and the F-1 engine appears to be progressing satisfactorily thus far, there is considerable merit in a backup development that exploits large solid rocket motors. This is particularly the case if the manned lunar landing program is to be considered a high priority program aimed at accomplishing the mission at the earliest possible date. Therefore, it was recommended that the upper stages of the all-liquid Class B vehicle should be designed for possible substitution of a solid first stage. Such a solid first stage vehicle appears to be attractive in terms of a low cost, high reliability and operational simplicity if there are sufficient continuing needs for Class B vehicles in the late 1960's and early 1970's.

6. *Rendezvous Operations Techniques*

Recommendation: *A major engineering effort should be made to develop rendezvous operations techniques in both earth and lunar orbits as possible approaches for accomplishing the manned lunar landing mission at the earliest possible date.*

The Class B vehicle required for manned lunar landing by rendezvous operations will be available earlier than the Class C vehicle necessary to carry out the mission by direct ascent. Thus, if the development of rendezvous operations are not the pacing item, use of the Class B vehicle offers the earliest possibility of a manned lunar landing.

It is therefore important to determine the feasibility of rendezvous at the earliest possible date. Accordingly, efforts should be initiated as soon as possible to develop techniques for both earth and lunar orbital rendezvous. A detailed discussion of these rendezvous techniques is included in Chapter VI, Volume III.

[II-5] 7. *Class C Launch Vehicles*

Recommendation: *Since it is by no means certain that the development of rendezvous operations will advance rapidly enough to provide earliest accomplishment of manned lunar landing, it is recommended that the direct ascent capability be developed on a concurrent basis.*

For that purpose the following specific steps are recommended:

a. On a concurrent and urgent basis a thorough engineering analysis should be made of attractive Class C vehicles (C11, C-16, C-20, C-24, C-25), their constituent building blocks and other related possible configurations to enable selection of the most desirable NOVA vehicle for manned lunar landing.
b. The large solid rocket motor and the large hydrogen/oxygen engine development also recommended should be pursued in a manner that will permit their potential use in a NOVA configuration for planetary missions.

The group felt that a Class C vehicle program must be carried forward on an urgent basis and concurrent with development of orbital rendezvous. Nevertheless, the group also felt that initiation of Class C stage and vehicle development at this time was inappropriate because of the lack of sufficient information to select a specific Class C vehicle.

The initial step that the group felt should be taken is to analyze in detail the potential Class G vehicles. This analysis should take into consideration the large solid motors, the M-l engine, and the stages of the recommended Class B vehicle (B-8, B-10, B-15) that would potentially be available as building blocks. It was also considered important to study in greater depth the technical problems and schedule implications involved in producing very large solid motors.

8. *Large Liquid Hydrogen Engine for Class C Launch Vehicles*

Recommendation: *Initiate promptly the development of a hydrogen-oxygen engine having a nominal thrust of 1.5 million pounds.*

[II-6] Studies made by the group to date do not support a specific thrust level recommendation at this time but do suggest that a level above 1.2 million pounds is necessary to provide for follow-up programs after a manned lunar landing.

Although it had been concluded that insufficient information was available to initiate development of a specific Class G vehicle it was recommended by the group that development be initiated or continued on certain components of attractive Class G vehicles that might prove useful in the development of a Class G vehicle. One such component on which the group felt development should be initiated was a large hydrogen-oxygen engine, the M-1.

9. *Large Solid Motors for Class C Vehicles*

Recommendation: *Initiate promptly a program aimed at the development and production of solid propellant motors up to 300 inches in diameter and 3,000,000 pounds in weight. The program should be associated initially with a thorough study of the advantages and disadvantages of the* *segmented type assembly, with particular attention given to clustered motor configurations.*

Emphasis in the initial phase of the program should be to produce an early test firing of a unitized motor of at least 240-inch diameter and to utilize to a maximum the existing solid motor facilities for the development of 156-inch diameter segmented motors for test firing as promptly as possible. This solid motor program should be conducted concurrently with development of the Class C liquid propellant vehicle.

The effort should be incrementally funded so as to reduce the total funds that must be committed before definitive engineering information is available on the suitability of large solid motors of various dimensions and before the requirements are established for the number of motors needed in each size class. These recommendations are made in full awareness of the fact that a new facility on water for case fabrication, propellant mixing, casting and curing and for static firing purposes must be committed at the beginning of this development effort.

[II-7] 10. *Launch Facilities*

Recommendation: *The following launch complex plans should be implemented:*

a. *The complex for the Saturn C-1 should be built so that it is compatible for use with the S-1 and S-IVB stage versions of Saturn (A-2).*

b. *Develop an Integrate-Transfer-Launch (ITL) complex for solid-boosted Class A vehicles.*

c. *Construct an ITL complex to handle the all-liquid Class B vehicle (B-8, B-10, or B-15) and initiate the A and E work necessary to permit use of the complex for launch of a solid-boosted Class B vehicle (B-5 or B-14).*

d. *Initiate A and E studies on a Class C vehicle launch complex designed to accommodate either liquid or solid first stage boosters and using all or part of the ITL concept.*

Consideration has been given to the launch facilities required for all three vehicle classes. In general, where new facilities are to be constructed, the group favors an ITL type complex. This type of complex provides for an integration building near, but not on, the launch pad in which the launch vehicle and spacecraft integration and checkout are performed. After completing the checkout, the vehicle is moved to the pad, where it is fueled and launched. By utilizing this technique, the on-pad time can be cut drastically and overall cost reduced while high launch rates are simultaneously achieved.

For Class A vehicles it is clear that the Saturn configuration should be launched from the existing pad and others of similar design. An ITL is not worthwhile for these vehicles because of the urgent program schedule. On the other hand, for a workhorse Class A vehicle, which would have a solid first stage, the ITL concept should be used.

[II-8] B. *Discussion of Recommendations*

The basis for the principal recommendation, briefly discussed above are [sic] amplified in the following paragraphs.

1. *Class A Vehicles*

Considerations of the group relating to the Class A vehicles led to a study in some detail of the reasons for supporting development of a Titan III-C vehicle in addition to the Saturn C-1. It was projected that during this decade there would be over 200 missions, largely for DOD, in which 12,000 to 30,000-pound payloads will be required in low earth orbit. In addition to the Titan III-C there are two versions of the Saturn that have this payload capability. These vehicles are the Saturn C-1 and a possible variation of Saturn (A-2) using the S-1 and the S-IVB stages. The Saturn C-1 is already in the National Launch Vehicle Program and the A-2 version of Saturn was recommended to provide early flight development of the S-IVB stage.

Although the two versions of Saturn have performance capabilities that are comparable or superior to the Titan III-C, the Saturns are likely to have a somewhat higher cost; they do not have the militarily desirable feature of employing solid and storable propellants, which permit fast reaction times, or, stated differently, permit long waiting periods on-pad; and they do not contribute to the development of large solid motor technology. On the other hand, the two Saturn vehicles appear to offer more growth capability than members of the Titan III family for a general program of space exploration. In this regard the Saturn permits larger diameter payloads than the Titan III-C. The Saturn can accommodate payloads of up to 20 feet in diameter, which also makes them suitable for launching a nuclear stage. This will be an important advantage if it is eventually desirable to use them for the development of such stages or to provide increased payload capabilities for future missions by the use of a nuclear upper stage. It was after weighing these factors that the LLVPG recommended that the Saturn C-1, which is scheduled for use in Apollo manned orbital flights prior to completion of Titan III development, should be improved (Recommendation 1) for the purpose of its continued use in support [II-9] of Apollo. Furthermore, the Titan III should be developed primarily for support of other scientific and military missions (Recommendation 2).

In considering the Titan III vehicle family it was noted that the Titan III-A and the Titan III-B, which are closely associated with the Titan III-C development, have payload capabilities that can he provided by the second generation Centaur on an Atlas. There was, therefore, some question as to whether the Titan Ill-A and III-B should be developed. However, development of the Titan BI family will enable the economical introduction of the Titan III-A and III-IS; also those versions of Titan III will serve as backup to cryogenic based boosters or as a substitution for them in cases where fast reaction time is needed.

2. *Class B Vehicles*

In connection with the development of the Class B vehicle, it was recommended that development of the upper stage, the S-IVB stage, be initiated immediately with a view toward flight testing it on an S-1 stage (Recommendation 3). This procedure would insure most rapid development of the Class B vehicle.

The Class B vehicle recommended (Recommendation 4) will provide a minimum payload capability of 180,000 pounds in low earth orbit and 70,000 pounds to lunar escape velocity. This capability is sufficient to enable manned circumlunar flight using the Apollo spacecraft and with a single rendezvous operation in earth orbit, to perform the manned lunar landing mission. It was strongly recommended that the rendezvous approach be pursued vigorously.

An item that received particular attention with relation to the Class B vehicles was whether a large solid rocket motor should be developed in parallel or as backup to the liquid first stage booster. Two configurations were examined, both of which utilized 156-inch diameter solids on the first stage and J-2 engines on the second and third stages.

[II-10] It was concluded that a vehicle such as these might be attractive in terms of low cost high reliability and operational simplicity if there are sufficient continuing needs for Class B vehicles in the late 1960's and early 1970's (Recommendation 5). By reducing the size of the solid motor first stage and thus significantly reducing vehicle cost, a useful vehicle can be provided that will cover the payload range between 30,000 and 180,000 pounds in a low earth orbit. While the total cost of the solid motor rocket development program cannot be justified on the basis of this application alone, there are other applications for solid motors in the development of Class C vehicles.

3. *Class C Vehicles*

The principal reason for recommending development of direct ascent capability concurrently with rendezvous, and thus the development of a Class C vehicle was so that success of the manned lunar landing mission is not solely dependent on the timely success of rendezvous techniques (Recommendation 7). It is also important to recognize that the national space program should be projected beyond the initial manned lunar explorations to the problems of a more thorough exploration of the moon, possible establishment of a moon base and the initiation of a manned planetary exploration program. Aside from the obvious direct importance of early attainment of U.S. capability for planetary exploration there is also the consideration that failure to develop a Class C vehicle at an early date could, if our rendezvous capability is delayed, leave this country in a particularly difficult posture if the USSR should be first to achieve a successful manned lunar landing.

After reviewing the various configurations for the Class C or NOVA vehicle it was concluded that insufficient information exists to permit selection of a specific NOVA configuration to be developed or to support a recommendation that development of a specific stage be initiated. It was felt that more must be known about the performance and design feasibility of the various vehicles considered and about the development risk of such important elements as the very large solid rocket motors. Another consideration was recognition of the cost and management difficulties of undertaking development of a Class IS and C vehicle simultaneously and with equal urgency.
[II-11] The best approach appeared to he initiation and continuation of component development which may be applicable to the NOVA vehicle. It would also be desirable to intensify detailed engineering studies of the most promising Class C configurations. One component that should be developed is the large hydrogen/oxygen engine, the M-1, which is visualized as having a thrust between 1 and 2 million pounds (Recommendation 8). Such an engine could replace the five J-2 engines of the S-II stage with a single engine. It would also permit the design of two or four engine stages considerably larger than the present S-II stage, thus providing greater payload capability.

The other major component possibly useful for NOVA class vehicles is a very large solid motor, and thus the recommendation that development be initiated on solid motors up to 300 inches in diameter and weighing up to 3,000,000 pounds (Recommendation 9). From the study of the various vehicle configurations it appears possible to make a Class C vehicle by clustering 4 to 10 solid motors in the first stage on top of which would be placed a complete Class B all-liquid vehicle (B-8, B-10, or B-15). The Class B vehicle would require suitable modifications to the first stage to provide for altitude starting of the F1 engine and increased strength to withstand the structural loads that it would experience as a second stage. If such a vehicle is not feasible, two other approaches are offered. One is to be a cluster of solids for the first stage and new upper stages based on the M-1 and J-2 engines (C-16 and C-21). The other approach is to make an all-liquid vehicle with all of the stages different from those of the Class B vehicle. The C-11 is an example of such a vehicle.

The development of large solid rocket motors was examined quite thoroughly by the group. Of course, the generally claimed advantages of solids are high reliability, low cost, and short development time. The group, however, found it very difficult to establish any clear superiority in reliability or development time for the solid over the liquid rocket booster. From the standpoint of cost, the solid motors appear relatively most attractive in the Class A vehicles, less attractive in the Class B, and least attractive in the Class C. Since the Class A vehicles require smaller diameter solids [II-12] (100 to 120 inches), which present the least development risk and earliest availability, the group favors the development of a solid first stage Class A vehicle as a workhorse. A solid first stage Class B vehicle appears attractive from the viewpoint of operating convenience, cost and perhaps reliability (based on the use of 156-inch diameter clustered solids). However, this vehicle is not sufficiently attractive in itself to justify development of solid motors larger than 120 inches in diameter. For Class C vehicles, the 240 to 280-inch diameter solids are considered the most attractive size.

If solid motors are selected for use in large vehicles, it therefore appears that the two most attractive sizes are 156 and 240-inch diameter. The 156-inch diameter motors are favored because, if segmented, they can be fabricated, tested and shipped with presently existing facilities and transportation methods. The basic factor limiting the size of a segmented motor is the limit for railroad transportation. Present manufacturing facilities permit research and development motors to be made in the 156-inch diameter size but they are inadequate to supply production quantities. Development of the capacity to supply production demands for this size motor would require a new propellant mixing, casting and curing plant. One unattractive feature of the 156-inch diameter motor is the fact that as many as 7 to 10 motors must be clustered together to provide the first stage of a Class C vehicle. This means that the reliability of each motor must be very high and of each segment even higher if the over-all stage reliability is to be satisfactory.

The advantage of going to larger diameter solid motors, those in the range of 240 to 280-inch diameter, is that only a few motors need be clustered in the vehicle first stage. For example, four motors of this size appear to be adequate for the first stage of a Class C vehicle. Fewer motors favor higher stage reliability and also simplify the intrastage structural design and vehicle bending load analysis.

There are three principal disadvantages of the larger motors. The first is that a greater chance exists for the occurrence of developmental problems, although at this time no such problems can be identified by scaling [II-13] analysis. The second disadvantage is that production of even the early test motors must await construction of new plant facilities. In order to facilitate transportation to the launch site such facilities should be located on navigable waterways. Thus, it would require from 6 to 18 months longer to develop these motors than those of 156-inch diameter. Finally, such large motors, particularly if unitized, are extremely heavy, weighing about 2,500,000 pounds. Thus, new problems in handling, transportation and assembly must be faced.

Whether large solid motors will actually provide the advantages of early availability, flexibility of configuration, simplicity of operation and high reliability in Class C vehicles cannot yet be predicted with any assurance. However, the importance of developing a Class C vehicle at the earliest possible date is so great that initiation of a large solid motor program, including development of integrated motors up to 300-inch diameter, is called for. Furthermore, the design studies of various Class C vehicles with solid propellant first stages should be intensified. It is felt that such an effort will insure availability of a Class C vehicle at the earliest possible date with a relatively modest additional development effort.

In connection with the possibility of using large solid motors, a NOVA vehicle comprised of all solid stages was considered. The most carefully investigated vehicle in this class was conceived by the Jet Propulsion laboratory and proposed for the manned lunar landing program in JPL-TM33-52, "A Solid Propellant Nova Injection Vehicle System," 3 August 1961. The report proposed a four-stage vehicle consisting entirely of solid propellant motors with a liftoff gross weight of 25,000,000 pounds, and an estimated capability of placing 130,000 pounds in a lunar escape trajectory. This design was considered sufficiently interesting to warrant careful review by qualified and disinterested organizations. Accordingly, it was requested that Space Technology Laboratories and the Boeing Company review the JPL report. After completion of these studies, the group arrived at the conclusion that the all-solid NOVA development constituted a very high risk program and thus should not receive further consideration.

[II-14] 4. *Future Decisions*

There are three major future program decisions that are implied by the conclusions and recommendations of the group. These are:

a. Whether or not the S-I stage - S-IVB stage version of Saturn, which is recommended to provide early flight testing of the S-IVB stage, should be fully developed as another Class A vehicle.
b. Selection of the Class C or NOVA vehicle design.
c. Establishment of the diameter and other pertinent specifications of the large solid rocket motors to be developed, and definition of the stages in which the large solids are to be used.

Replacing the S-IV stage of the Saturn C-l with the S-IVB stage will provide a substantial increase in performance capability. In addition, the single engine of the S-IVB stage offers the potential for greater ultimate reliability than does the six engine S-IV stage.

Even though the S-IVB stage is successfully flown on an S-I stage for test purposes, considerable additional design and development effort would be required to fully develop such a vehicle for operational use. Therefore, the decision as to whether the development of such a vehicle should proceed must be based on the degree of success achieved in developing the Saturn C-l and the Titan III and on their ability to fulfill the mission requirements for Class A vehicles.

The decisions on the Class C vehicle design and the selection of the large solids to be developed can interact strongly. The first opportunity for a decision on Class C vehicle configurations will occur when the recommended design studies are completed in about mid-1962. Probably a better decision can be made if it is postponed until late 1962, by which time significantly more should be known about the performance of the F-1, the J-2, the cluster of eight H-1 engines in the S-1 stage, and about 156-inch diameter solid motors. More may also be known about the feasibility of orbital operations. If the solid motor development program and stage engineering studies [II-14] proceed as recommended, probably no appreciable time will be lost in the Class C vehicle operational date by delaying the configuration decision for a year. This viewpoint is based on the premise that the final configuration selected would use a large solid motor first stage and the modified upper stages of the Class B vehicle based on the M-1 engine. If the configuration chosen is the all-liquid Class C vehicle (C-11), some time will probably have been lost.

If the solid motor diameter decision is not made as part of the vehicle configuration choice, but is kept open among 156, 240 and 280-inch or greater, it will probably be an additional six months to a year before enough is known from actual tests of the large solid motors to enable selection of a diameter with confidence.

[III-1] III. Supplemental Recommendations

In addition to the primary recommendations there were several supplementary recommendations made by the group. One subject of particular importance, which NASA requested the group to consider at the end of its study efforts, was a possible launch vehicle for the Gemini spacecraft. Other supplementary considerations and recommendations concern largely technical problems which stand out as requiring further detailed study to maximize vehicle system usefulness and to minimize time and costs. These supplemental recommendations of the group are summarized in the following paragraphs.

A. *Supplemental Launch Vehicle for NASA's Gemini Program*

Recommendation: *A minimum modification version of the Titan II ballistic missile should be used for the Gemini program.*

In the studies of launch vehicle requirements for Gemini it was found that there were four alternative vehicles that might be used. These four vehicles are the Titan II, Titan II-1/2, Titan IIIAJ, and the Saturn C-1. The development schedule indicates that the Titan IIIAJ will not be available until a year later than the two versions of the Titan II. In addition the need for all of the Saturn C-1 vehicles scheduled for production to support the Apollo program, as well as launch facility scheduling problems associated with an increased Saturn C-1 launch rate, indicate that consideration of this vehicle is purely academic, since it would not be available for use in the Gemini program. Thus the only useful alternatives are the Titan II and Titan II-1/2. The principal difference between these two vehicles is that the Titan II-1/2 provides subsystem redundancy leading ultimately to higher reliability but with a penalty in payload weight.

Since the performance differences between these two vehicle configurations are not striking. vehicle reliability and development schedules were the areas of consideration in making a choice between them. Safety of the crew will be insured by malfunction detection and abort systems in either vehicle. Thus the greater reliability offered by additional redundancy of the Titan II-1/2 is a factor that can be supported principally as a need on the basis [III-2] of launch vehicle economy. However, the initial planning of the Gemini program calls for only about 18 flights and the Titan II will have attained a reasonable reliability by the time this program begins. Therefore, little weight can he given to possible economic gains that might be realized with the Titan II-1/2. In addition, the inherent uncertainties in reliability estimates as well as uncertainties in projected reliability growth during the brief life span of the Gemini program suggest that even the economic arguments based on greater reliability of Titan II-1/2 may not be well founded.

Other major factors that were weighed in determining the relative suitability of these two vehicles are: (1) availability in 15 to 18 months after program go-ahead; (2) the degree to which either may interfere with DOD programs; and (3) relative cost.

Considering the many factors pertinent to a choice between these two vehicles, it was the judgment of the group that use of the Titan II ICBM with minimum modifications in the Gemini program would provide greatest assurance of timely availability of a vehicle that has adequate reliability and performance, best utilization of DOD engineering and management resources associated with the Titan II weapon system, and minimum vehicle cost for the program.

B. *Reliability and Reliability Growth*

Recommendation: *A vigorous theoretical study and experimental program must be implemented to determine the degree to which redundancy, engine-out and manned monitoring and control should be used in each vehicle and subsystem. The LLVPG believes that, in the size booster vehicles considered for the Apollo missions, it is practical and desirable to use such techniques to a far greater extent than was possible in previous booster systems.*

The reliability to be expected in early flights of vehicles used for the manned lunar landing program has an extremely important bearing on the time required to accomplish the mission and on the cost of the over-all program. In addition, reliability will have an effect on crew safety and on the [III-3] possibility of program stretch-out or cancellation. Indeed, it might be said that the chances of being first to the moon are very small indeed, unless a significant step forward can be made in obtaining high reliability earlier in the life of the vehicles than has been experienced to date.

From an examination of the results of the calculation of mission success data analyzed by the LLVPG, it was found that it would take two to three years of flight test and about 25 to 60 launchings to man-rate a Class B or C vehicle using the reliability growth estimates of this study. As previously indicated, it is important to note that "man-rate," as used in this entire study, refers to a vehicle having an absolute reliability of 50 percent or more. This level of reliability should not be confused with "man-safety" which is sought to be maintained at a relatively much higher level by providing abort subsystems for crew escape in case of catastrophic malfunction.

If a significant improvement in early reliability were achieved, the date for mission accomplishment could be advanced about a year. In addition, 20 to 30 flight vehicles could be eliminated from the program at a cost savings of the order of one billion dollars.

The reliability growth curves used in the analysis were based on past experience primarily with ballistic missiles and space adaptations thereof. The data from previous flight test programs were smoothed and interpreted in terms of the number of such systems, stages, restarts, etc., involved, and in terms of the number of redundant and nonredundant elements such as engines, thrust vector control systems and the like. The fundamental assumption underlying the argument is: It will be possible to obtain about the same early reliability on an absolute basis with the new, large launch vehicles as we have done in the past on smaller, primarily ballistic, missiles (Atlas, Titan, Thor, Jupiter, Polaris).

It could be argued that the reliability growth should be much better because so much has been learned from past failures and mistakes, and because weight and performance are not quite as critical as they were for such vehicles as the Atlas. Conversely, it could be argued that the reliability growth will be [III-4] worse because of the greatly increased size of these new vehicles, the use of a new propellant (hydrogen), the clustering of 4, 5, and even 8 liquid engines per stage, and the simultaneous development of so many large stages and multi-stage vehicles by the same organization. In the group's deliberations it was agreed that these two sides of the argument just about offset one another and that reliability growth about equal to that of past vehicle development programs might reasonably be expected. Nevertheless, it was recognized that there is a very wide range of uncertainty in reliability growth projections.

It is important to examine very carefully the question as to whether, and how it might be possible, to improve significantly the reliability growth rate of the new vehicles to be developed. In order to be somewhat more specific about the major problems, the LLVPG had specific studies made in the technical areas of redundancy, the role of man in complex systems, and engine-out capability.

C. *Reliability Budgeting*

Recommendation: *The iterative use of the "reliability budget" during the design phase is probably the most practical means of achieving an optimum approach in reliability engineering of complex systems.*

Because of the large number of stages involved in the total lunar mission, the requirement for a much higher level of redundancy should be anticipated than has been normal in the past. This redundancy will vary from conservative design margins and state-of-the-art engineering to the use of completely redundant subsystems in some cases. The iterative use of reliability budgeting provides a basis for establishing the amount of redundancy to be employed in a given system or subsystem.

Reliability budgeting is a general approach toward reliability which has been used on some programs and which can be extended and improved for application to the manned lunar landing program. It is an iterative approach which must be run repeatedly until the design converges or is frozen for other reasons. Underlying the whole process is a recognition and an acceptance of the fact that there are gains to be made by the judicious employment of [III-5] redundancy but that such employment in no way diminishes the need for a sound analytical approach to design.

The process of reliability budgeting begins with the system engineer. The first step is for the system engineer to block out the total system design and translate it into a reliability budget. Each subsystem is assigned a level of reliability which in combination with those of the other subsystems will produce the desired system reliability. Where the assumed reliability is not feasible with the simplest system configuration, redundancy is added judiciously until it is attained. Costs and schedules must be evaluated in parallel to assist in weighing the merits of the particular design choice.

The reliability budgeting task is then given to the subsystem designer who carries through the same processes for his subsystem against the assigned reliability target given to him by the system engineer. Should the subsystem designer find the reliability target impossible to meet, even with optimum redundancy, he must obtain a new target from the system engineer, thus requiring that the system engineer rebudget the reliability requirements among the various subsystems. Conversely, if the subsystem designer finds ways of obtaining reliability higher than the target value, the system engineer can likewise take this information into account together with the cost and schedule implications to rebudget his reliability among the various subsystems.

By carrying this process on through to the lowest level of component design and by maintaining the over-all design relatively fluid in its early stages and freezing it as late as possible, the maximum number of iterations can be made and thus the optimum use of redundancy can best be approached.

D. *The Role of Man in System Operation*

Recommendation: *It is recommended that prompt steps be taken to initiate further detailed studies concerning the role of man in system operation employing well-definitized systems and subsystems of the launch vehicles intended to be used for future manned missions. Furthermore, launch vehicle systems designs compatible with crew participation in vehicle control, but not solely dependent on it, should be investigated in detail. It would be desirable* [III-6] *for these studies to be conducted by organizations having experience and capability in the manned aircraft and missile design field.*

The problem which is of concern here is the establishment of the role of the flight crew during the launch phase of manned flight operations. That is, whether the crew should be given an active role in the control and management of the launch vehicle systems or whether they should maintain a completely passive role with all functions being programmed automatically. Because of man's inherent ability to perceive, reason, and judge in even unrehearsed situations, it is believed that the idea of a completely passive role for the crew is unreasonable.

There are several modes of manned participation which could be considered, namely:

a. Direct control
b. Monitor, switching, and override
c. Monitor, adjustment, and maintenance

The direct control mode would provide the crew with the primary path for control inputs to the given system in much the same manner as our present day aircraft are designed. In this mode, the automatic controls would be provided for crew convenience for use during reasonably uneventful periods. The second mode—monitor, switching, and override—would provide the crew with a generally subordinate control approach with the option for primary control. In this mode, the crew would normally monitor a system and, in the event of some malfunction, they could exercise direct control by manually switching to a redundant system or by manually overriding the automatic system. The third mode provides for the lowest degree of crew participation. In this mode, the crew would monitor certain function displays and would make only minor adjustments, such as gain settings, gyro realignment, etc. In addition, the crew could perform certain maintenance functions, such as changing fuses and small components.

[III-7] Of the three modes of participation cited, it is believed that the direct control mode is probably too drastic in view of our present, very limited experience in this area. On the other hand, some real gains in the over-all reliability, or mission success achievement, are likely to be made by the judicious adoption of the second and third modes of crew participation for certain launch vehicle systems.

After reviewing this problem and the various possible approaches, the following general conclusions were reached:

a. From an environmental standpoint, no evidence exists indicating that the vehicle control task cannot be handled by man as an integral control element.
b. Considerable evidence exists to show that man, having been given adequate instrumentation and training, has the capability of successfully completing booster trajectory control during launch.
c. It is believed that appreciable gains in mission success can be achieved through crew participation, particularly during the early development stages, where the demonstrated reliability of launch vehicles is generally quite low.

In the light of the foregoing, it is believed that the role of the spacecraft crew should he one of active participation during the launch phase of flight. The exact degree of crew participation cannot, of course, be definitely specified at this time. However, available evidence suggests that the crew should be provided with more than merely monitor capability.

E. *Engine-Out Capability*

Conclusion: *While engine-out capability appears attractive on the basis of the engine and control system redundancy considerations, a detailed engineering study of the implications on the remaining portions of the vehicle system is required.*

1. *Performance Degradation Versus Reliability Increase*

The LLVPG has made some estimates of the losses in payload that would result from stage designs with engine-out capability. The major points revealed by this study are as follows:

a. For a given number of engines, the performance loss with one engine out is about one half as great in a second stage as in a first stage.
b. Engine-out performance loss is serious in the first stage, particularly if the number of engines is small (four or five compared to eight) and engine shutdown occurs early in the stage burning time.
c. Engine-out penalties in first and second stages are a non-linear function of time; one engine shutdown at the halfway point results in about one-fourth to one-fifth as much performance loss as when the engine shutdown occurs just after ignition.
d. Operation with an engine out does not result in a significant performance loss in a third (escape) stage.

These performance degradation results are based upon reasonably well-designed vehicles and therefore should not be assumed as applying to off-optimum or unique vehicle designs.

Another approach to engine-out redundancy would be to add extra or spare engines. The performance loss for the Saturn C-4 class vehicles using such an approach has been examined and found to be acceptably low. It would be possible to design a stage carrying a true spare engine which would not be started unless required; however, this "delay-until-needed" design philosophy would appear undesirable in the lower stages.

Preliminary analyses of the over-all problem by the LLVPG has led to the following stage-by-stage design philosophy:

a. First Stage—the design should probably be based upon hold-down and engine-out. One engine out in this stage could extend to two if a large number of unreliable engines are used. Similarly, if a stage [III-9] contains a small number of very reliable engines, the engine-out design approach should not be used.

All engines should be started before liftoff and should be able to operate through the thrust/weight instability and high q regions. The use of hold-down aids the reliability since over one-half (68 per cent) of the engine failures occur in the first few seconds of engine operation.

b. Second Stage—all engines in this stage should be started. The q problem is not important in this stage since staging occurs at a very high altitude. Engine-out capability should be provided for in all multiple engine stages. The performance reliability "map" is attractive in this stage since engine-out performance losses are about one-half to one-third as severe as in the first stage and the improvement in reliability with one engine out capability is attractive.

c. Third Stage—a two-engine stage seems attractive here from a reliability point of view. The reliability of a two-engine stage is typically raised from 0.90 to 0.95 by the use of one engine redundancy.

The third stage problem is somewhat unique. First examinations seem to indicate that a two-engine system should be used by starting just one engine, with the second engine started only if the first should fail. The guidance control problems in the third or higher stage, if both engines are initially started, seem to be quite severe. Therefore, the delay-until-needed approach is suggested.

2. *Effect on Other Systems*

The previous suggestions are based upon considerations of the reliability of engine and control systems and their associated failures and performance. For a stage to have engine-out capability a number of modifications of other subsystems may be required. These modifications will affect system reliability and performance. The autopilot, for instance, may be required to have provisions for automatic reprogramming when an engine is shut down. Similarly, the control system may be required to have faster [III-10] response and to operate with larger gimbal angles and increased actuation forces. Vehicle structure will be subjected to new load distribution which may necessitate a different design. The implications of engine-out operation will vary between stage designs. It is anticipated that, in some cases, significant modification (by present standards) of autopilot and/or structure and control systems will be required to accommodate the engine-out feature. Other stages may conceivably require little or no change in these systems.

F. *Automatic Vehicle Checkout and Countdown Considerations*

Conclusion: *The significance of the considerations concerning automatic checkout and countdown of vehicles is twofold:*

a. *A most intimate relationship is needed among design criteria of the vehicle and its subsystems, of ground support equipment and the launch complex of the spacecraft, its propulsion and other subsystems, and of the payload. The extent of this relationship, and the amount of preplanning needed cannot be fully envisioned at this time.*

b. *The necessity to standardize specifications of interrelated components will require a level of systems engineering, both in comprehensiveness and in detail, far surpassing in complexity previous technological undertakings of any kind.*

Among the factors strongly influencing the probability of mission success is the efficacy of checkout procedures used just prior to launch. The checkout procedures may require the testing of all essential components, subsystems and systems and thus involve measurement of up to 1500 functions in research and development vehicles. The concept of automatic checkout has been advanced primarily for two reasons: (1) to reduce the amount of time required in using launch facilities; and (2) to enhance the reliability of the entire checkout operation.

No figures can be quoted on time savings or operational vehicle reliability improvements achievable with automatic checkout procedures, since numbers and types of measurements, amount of data processing, manner of [III-11] presentation and use of processed data are not currently defined. It has been estimated, however, that manual operations for a large vehicle might require two to three weeks as contrasted with three days for an automatic system.

The employment of automatic checkout equipment will require a high level of advance planning effectiveness and good over-all system engineering, in the following areas:

a. Design criteria of the vehicle, the ground support equipment and the launch complex must contain automatic checkout requirements so that the automatic checkout concept is extended back to, and properly accounted for, at the stage and subsystem manufacturing level.
b. Management arrangements between contractors involved in development of the vehicle, the ground support equipment and the launch complex.
c. The planning and stocking of spares, up to and including individual stages.
d. Equipment modification and change control. The potential conflict between research and development or operational changes and automatic checkout compatibility requires that the changes be carefully scheduled.

Even with effective preplanning, 30 to 40 flights may be needed to perfect the launch vehicle automatic checkout system. It is possible that the spacecraft checkout system can be perfected in fewer flights, since it is in some ways less complex than the vehicle system, but this implies extensive systems engineering coordination at the earliest stages between spacecraft and vehicle contractors. In this view, conceptual separation between spacecraft and launch vehicles is largely artificial and has significance or convenience principally for administrative rather than substantive engineering purposes.

The difference between automatic checkout of solid and liquid motors is not entirely clear due to unknowns affecting solid motor design and assembly. Checkout procedure on solid motors may be shorter and less complex but the [III-12] loading process may be longer, since by some estimates the motors must be perhaps assembled at the launch area instead of the assembly area. The estimated installation and checkout time required for solids may be as long as several weeks. There is little doubt, however, that the advantages of automatic checkout will be required for solids as well as liquids.

The high level of design unification which will be required for the launch vehicle, ground support equipment and launch complex must also be extended to include the spacecraft and all of its essential subsystems. Since the demands on the crew in flight should be minimized, the spacecraft system must incorporate design provisions permitting not only automatic checkout on demand but also containing continuous reliability and damage assessment checks. These checkout provisions must naturally be compatible with the ground-based launching checkout system. In addition, limited but effective and compatible provisions must be included for in-flight maintenance, based on modular design, at least for those components with the lowest reliability and for those most subject to in-flight damage.

G. *Technical Manpower Requirements*

Recommendation: *Because the preliminary study of technical manpower requirements for DOD and NASA programs during the remainder of the decade suggests that a potential shortage of technical manpower may be in store, becoming critical in CY 64, it is recommended that a more thorough and complete inquiry in this area be initiated by DOD and NASA as expeditiously as possible. It may also be desirable to begin developing plans promptly for appropriate action by DOD and NASA in case the difficulties predicted by the LLVPG are confirmed.*

In view of the large scale and long duration of the research and development efforts needed to accomplish the manned lunar landing mission, and the need to superimpose them on the already large and growing requirements of the Department of Defense for scientific and technical manpower, a study was undertaken by the group to provide information on whether such [III-13] manpower resources might be a limiting factor to early accomplishment of national apace exploration objectives.

This study compared an estimate of the supply of scientists and engineers for each year through 1967 with three estimates of the need for such manpower. The supply for any year was computed by beginning with an inventory for 1960 (as reported by the National Science Foundation), increasing it by the number of college graduates and non-degree personnel entering the field each year, and decreasing it by losses due to retirement because of age or death and transfers to other fields.

Three estimates for manpower need were developed in an effort to insure realism in the final comparisons of supply with demand. One estimate was based on the projections by industry of the ratio of scientists and engineers to total employment, the latter itself being estimated from gross national projections. The other two estimates were based on building up the total national need for scientists and engineers from estimates of total research and development and other dollar expenditures using "experience" ratios for numbers of scientists and engineers per million dollars for various types of such expenditures.

The conclusion of the study is quite clear. No matter what projection of the national needs for scientists and engineers is chosen as the probably correct one, the supply does not appear adequate; the lowest reasonable estimate of requirements approximates the projected supply. This lowest reasonable estimate includes, however, a substantial number (many tens of thousands) of scientists and engineers engaged in writing proposals and brochures, and in advancing state-of-the-art through engineering overhead, and may, therefore, be subject to adjustment if appropriate national policies and implementation procedures are developed.

It is also of interest that the most stringent problem in adjusting demand and supply for scientific and technical manpower will probably occur during 1964 if LLVPG estimates for program growth turn out to be valid.

Document II-21

Document title: James E. Webb, Administrator, to The Honorable Robert S. McNamara, Secretary of Defense, January 16, 1963.

Document II-22

Document title: James E. Webb, Administrator, Memorandum for Dr. Robert Seamans, Associate Administrator, January 18, 1963.

Document II-23

Document title: James E. Webb, Administrator, NASA, and Robert S. McNamara, Secretary of Defense, "Agreement Between the National Aeronautics and Space Administration and the Department of Defense Concerning the Gemini Program," January 21, 1963.

Source: All in NASA Historical Reference Collection, NASA History Office, NASA Headquarters, Washington, D.C.

As an Earth-orbiting program that would develop capabilities for in-orbit rendezvous and human observation of the Earth from space, the Gemini program was of high interest to the Department of Defense as well as the program's sponsor, NASA. In late 1962, Secretary of Defense Robert McNamara, with the support of Presidential Science Advisor Jerome Wiesner, attempted to seize control of the program from NASA, or at least share in its management. This initiative set off an intense conflict between NASA and Department of Defense (DOD) top management. Several documents give a sense of the issues at stake. The January 16, 1963, letter from James Webb indicates the depth of NASA concern, while the January 18 Webb memorandum to Associate Administrator Robert Seamans suggests Webb's desire to find a way to settle the dispute. The January 21 NASA-DOD agreement resolved the conflict. NASA would retain management control over the Gemini program, but a joint NASA-DOD Program Planning Board would ensure that the program's activities were responsive to DOD's interests and requirements. Mentioned are Deputy Secretary of Defense Roswell L. Gilpatric, Director of Defense Research and Engineering Harold Brown, Deputy Director of Defense Research and Engineering John H. Rubel, and NASA Deputy Administrator Hugh Dryden.

Document II-21

[1] January 16, 1963

The Honorable Robert S. McNamara
Secretary of Defense
Department of Defense
Washington 25, D.C.

Dear Bob:

I cannot agree that your proposed version of an agreement would set up management arrangements suitable to a national Gemini program. Nor do I consider its basic pattern one which can be made acceptable through a series of negotiated changes.

In the recent discussion in which you, Mr. Gilpatric, Dr. Brown, and Mr. Rubel participated, with Dr. Dryden, Dr. Seamans and me, I presented in detail the reasons why we here in NASA consider it a serious mistake to proceed with any plan to transfer the Gemini program to the jurisdiction of the Department of Defense as raised by Dr. Wiesner. Following the subsequent receipt of your suggested agreement, Dryden, Seamans, and I have consulted with our senior associates involved in the manned space flight program. We are unanimous in the view that for us to proceed with the arrangements you suggest would jeopardize our ability to meet our manned lunar landing target dates, would disrupt or certainly impair the effectiveness of an organization that is functioning in a magnificent way on a very tight schedule, and would raise a public and Congressional storm of protest that the language and intent of the National Aeronautics and Space Act of 1958 was being violated.

The scientific knowledge and technologies we, as a nation, need are being rapidly accumulated. An effective capability to continue this activity has been created. It is operating in close co-operation with the military services, and we have recently, through the establishment of a Deputy Associate Administrator for Defense Affairs, strengthened our effort to make available all that is of use to them. We should not risk this hard-won progress.

The policies we have been following in this agency have been directed toward the establishment of a broad national participation by and stimulation of the utilization of increased resources in the universities to meet present and future national requirements. Similarly, increasingly important programs of international cooperation involving both governmental and scientific agencies have been successfully established and are a valuable asset to the Nation's space program, both operationally and scientifically. To mix military and civilian activities to the extent proposed would appear to us to have the most serious implications for the future success of these important national and international activities.

Further, the clear and repeated pronouncements which have been made by the President, the Vice President, the Secretary of State, and [2] other leaders concerned with space, would be compared here and abroad with the action taken, with the inevitable conclusion drawn that there had been a major change in policy with regard to the objectives and purposes of the United States in space activity. Such a conclusion could have a far-reaching influence upon this country's relationships with both the neutral and hostile blocs and upon their policies.

As an alternative to your suggestion, I enclose a brief agreement with an attached suggested plan for increased Air Force participation in Project Gemini. It is about as far as we in NASA feel we can go at this time.

Permit me to close with the suggestion that the agreement I enclose will retain for the President a flexible military program including manned space flight, with the ultimate growth of that program dependent on the knowledge both NASA and the Department of Defense gain as we go along. It facilitates the closest co-operation in obtaining and utilizing this knowledge. The President can as a matter of policy increase this military program or decide not to go forward with it. Likewise, the proposed agreement, taken with the program which he is recommending to Congress in his 1964 budget for NASA, gives him a civilian program to develop the scientific and technological base for pre-eminence in space with a vigorous program to make the manned lunar landing and the incident gaining of experiences in extended manned space flight on a fast schedule. Here again the President retains the flexibility, dependent on the needs of the Nation, for speeding up or slowing down the NASA program. To join the DOD and NASA programs in a monolithic effort would inevitably cause the total program to be characterized as military with substantial loss of flexibility in our international posture.

Sincerely yours,

James E. Webb
Administrator

Document II-22

[1] January 18, 1963

Memorandum for Dr. Seamans—AA

After thinking overnight about the suggestions made by Secretary McNamara, it seems to me that in reality he is coming back with the same pattern of joint management. I do not see how this is possible under the law. However, I think it is essential that we explore every possibility of working with him and retaining his support. Further, we certainly must go into the question very carefully of why he feels he needs a voice in our management to be sure we accomplish the things that are required in the interest of the Department of Defense.

Further, it seems to me that when he says he does not know what is going on in these programs, we could suggest some way that he could find out and keep abreast without having to actually participate in the decisions. Somehow, we must convince him that we can operate this program better as it is now being operated, producing more value for the total national interest, including the military, than under any other system, but are perfectly prepared to have any system that helps identify the things that are in the national interest and facilitates their accomplishment.

I got the impression last night that somehow the clause about extending the arrangements we now have about launch vehicles—that neither of us will start another one without a sign-off by the other—to the manned space flight field is of great importance. It may be that he feels his situation would be seriously impaired if we should start a manned orbiting station, and that he would then be expected to support it as having value for the military services.

On the other hand, I do not see how we can discharge our responsibilities and give him a veto over this. We could do it with respect to the launch vehicles because each of us was [2] developing some, each of us had authority to develop others, and we needed some device to insist on a national program. It may be that there are some elements of this situation in the manned orbital problem, and if so we should explore them with great care.

It may be that he will tell the Bureau of the Budget what he has not yet told us—his real reasons for wanting a jointly-managed effort.

While I believe the instructions to the Bureau of the Budget should be as I mentioned them to Harold Brown—that the last paper drawn by McNamara represents something on which he and I would like to try to find agreement, provide there is a basis without destroying fundamental values for either of us or impairing the President's position, requirements and responsibilities. I think there are many elements in the draft that do not correspond with this. However, it seems to me that some agency experienced in handling Presidential problems must put these forward perhaps more forcefully than I have been able to do so.

It seems to me that you, Hugh, and I should bear in mind that we have signed, as you said last night, and sent over a paper that truly represents our views. While we want to go just as far as we can to meet Mr. McNamara, we must not recede from this position except as we reach a settlement that all of us can live with.

I wonder if Harold Brown would be willing to list what it is they want from Gemini?

I have no doubt whatever that McNamara is underrating the problems that will be created with Congress if he insists on the participation in our management or that we participate in the management of the development of military equipment such as weapons systems. We can contribute a great deal, but when it come [sic] to the actual development, this is not our function under the law.

There is another element which we must consider. Under the proposed arrangement, we would lose control of the research which we will do. The basic policy from NACA days is that we would determine the research which was necessary, would fund it, and would do it. This made us independent of those who wanted us to undertake contract research, but of course, we were always [3] sensitive to their needs. I believe this principle is one that has made for advance, has given the nation strength, and that even though Mr. McNamara does not seem to be able to understand it today, we must not lightly put it aside. After all, we do not know how long he or I or any of the principal actors will be on the stage, and we must keep a system that others can operate under.

These are just early morning thoughts as I leave for the airport.

James E. Webb
Administrator

Document II-23

[1]

Agreement Between the National Aeronautics and Space Administration and the Department of Defense Concerning the Gemini Program

This document defines the policy agreement for arrangements to insure the most effective utilization of the GEMINI Program in the national interest.

1. Objectives of the GEMINI Program

The GEMINI Program constitutes a major portion of the current near-earth manned space program in the United States. It is the intent of this agreement to assure that the scientific and operational experiments undertaken as a part of the GEMINI Program are directed at the objectives and requirements both of the DoD and the NASA manned space flight program.

2. Establishment of the GEMINI Program Planning Board

A GEMINI Program Planning Board is hereby established reporting jointly to the Administrator of the NASA and the Secretary of Defense. The Associate Administrator of the NASA and the Assistant Secretary of the Air Force for Research and Development will serve as Co-Chairmen of the Planning Board. The Board will include two additional representatives of each of the two agencies. Members will be named by the Co-Chairmen and approved by the Administrator of the NASA and the Secretary of Defense.

3. Functions of the GEMINI Program Planning Board

The Board hereby created is intended to assure that the GEMINI Program is planned, executed, and utilized in the over-all national [2] interest, in accordance with policy direction from the Secretary of Defense and the Administrator of the NASA, so as to avoid duplication of effort in the field of manned space flight and to insure maximum attainment of objectives of value to both the NASA and the DoD. The functions of the Board in carrying out this responsibility shall include the delineation of NASA and DoD requirements and program monitoring to insure that they are met in:

1. The planning of experiments.
2. The actual conduct of flight and in-flight tests.
3. The analysis and dissemination of results.

Should actual project plans fail to meet the requirements specified by the Board, or should competing requirements produce resource or schedule conflicts, the Co-Chairmen shall so inform the Administrator of the NASA and the Secretary of Defense.

4. GEMINI Project Management
NASA will continue to manage the GEMINI project. It is, however, agreed that the DoD will participate in the development, pilot training, pre-flight check-out, launch operations and flight operations of the GEMINI Program to assist NASA and to meet the DoD objectives.

5. Funding
In recognition of its interest in the program, the DoD will contribute funds to assist in the attainment of GEMINI Program [3] objectives. The amount of such support will be determined on the basis of recommendations submitted by the Board.

6. Additional Programs
It is further agreed that the DoD and the NASA will initiate major new programs or projects in the field of manned space flight aimed chiefly at the attainment of experimental or other capabilities in near-earth orbit only by mutual agreement.

James E. Webb	Robert S. McNamara
Administrator, NASA	Secretary of Defense
Date: January 21, 1963	Date: January 21, 1963

Document II-24

Document title: Robert S. McNamara, Secretary of Defense, Memorandum for the Vice President, "National Space Program," May 3, 1963.

Source: NASA Historical Reference Collection, NASA History Office, NASA Headquarters, Washington, D.C.

In April 1963, President Kennedy asked Vice President Johnson to conduct, as chairman of the National Aeronautics and Space Council, an overall review of the national space program, published as Document III-17 in Volume I of Exploring the Unknown. *Secretary of Defense McNamara's reply suggests the many ways in which the programs of NASA and Department of Defense had become intertwined.*

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[1] 3 May 1963

Memorandum for the Vice President

SUBJECT: National Space Program

This memorandum will respond to Dr. [Edward C.] Welsh's memorandum to me of April 10, requesting information on which to base replies to the questions in the President's memorandum to you of April 9. I should point out first that most of the points raised by the President deal with matters for which NASA has primary or exclusive responsibility. My comments will, therefore, be confined to the military aspects to questions 2 and 3, and to question 5.

Question 2: What specifically are the principal benefits to the national economy we can expect to accrue from the present, greatly augmented program in the following areas . . . military technology?

I have attempted to measure these benefits by estimating the extent to which [the] DoD budget would be increased, in each of the DoD budget categories corresponding to the major NASA budget categories, if the present greatly augmented program had not been undertaken by NASA. It should be borne in mind that a part of the augmented program, including, for example, the TITAN III development, has been undertaken directly by the Department of Defense. The military justification for this portion of the program is such that it would have been undertaken without regard to the other objectives of the National Space Program. The great bulk of the augmented program, $4,388 million out of $4,696 million, is in the NASA budget; the Department of Defense space program for FY 1964 is about 7% higher than the 1 January 1961 projection for FY 1964, after adjustment for comparability. A comparative tabulation of DoD and NASA budgets for the National Space Program appears at Table I.

Research. Although it is difficult to assess the direct military value of space research, it appears likely about $20 million of NASA's $100 million research budget proposed for FY 1964 would be undertaken by DoD in the absence of a NASA program.

[2] *Exploratory and Advanced Development* (corresponds to NASA's Supporting Research and Technology). While the military value of this category of expenditures is almost equally difficult to determine in advance, I estimate that some $100 million of NASA's augmented program might be supported by DoD if NASA were not supporting it. In addition, the Department of Defense would probably support the entire NASA "base" program in this area under like circumstances.

Engineering Development

Launch Vehicles. The major NASA development activity in this field is focused on the use of liquid hydrogen to lift the extremely large payloads required for the lunar mission. This technology is probably not of much military value because of severe operational restraints on its handling and storage. Some of this development work will undoubtedly have incidental military benefits, but they cannot be estimated in advance, and would not merit DoD expenditures in the absence of the NASA program. Primary DoD reliance is on the TITAN III as the standardized workhorse building block for military applications in space. It is important to point out, however, that the concept of a single National Launch Vehicle Program dates back to the first agreement between NASA and the DoD signed in the new Administration, by Mr. Webb and Mr. Gilpatric, in February 1961, and that the Department of Defense includes in its consideration of launch vehicles for new military missions any vehicles under development by NASA for non-military space missions.

Manned Space Craft. The APOLLO space craft, designed for the lunar mission, has no predictable military applications. The GEMINI space craft, however, is in a different category, and if it were not under development, the Department of Defense would probably undertake a GEMINI-type program. The NASA GEMINI program has a critical early flight date as a part of the over-all lunar project. This condensed scheduling cannot be supported as a military requirement, and, therefore, an additional Defense program of $150-$200 million in FY 1964 might be justified in lieu of the $300 million level of effort proposed by NASA for FY 1964.

Unmanned Space Craft. In part because DoD was active in this area before the organization of NASA, there are no vehicles under development by NASA which would have been undertaken or would be taken over by DoD in the absence of the program.

[3] *Mission Applications.* A number of the special mission applications of NASA space vehicles, such as meteorological satellites and communication satellites are of military interest. If they were not undertaken by NASA, the Defense budget might be increased by $25-$50 million in these particular mission application areas. Most of these applications

stem from the pre-1961 NASA program, and their present level of effort cannot easily be apportioned between the "base" program and the augmented program. These essentially experimental mission applications, however, do not include the necessity for extensive military development activity, since the technology for military operations is increasingly distinct from the technology for experimentation.

Other. Most of the increase in the augmented NASA effort classified in Table I as management and support reflects the lunar program directly and has no demonstrable military value. We have found, for example, that military use of GEMINI could very likely be fitted into our existing DoD tracking facilities for current classified programs, without major increases in funds. Of course, if space becomes very much more important from a military standpoint—if many more laboratories, tracking sites, launch facilities and the like were needed over and above what we already have in the Defense Department[—]then NASA's extensive facilities could be combined into indirect military assets. On the other hand, based upon what we presently foresee, the Defense Department would not pay for the large augmented management and support effort, or any appreciable fraction of it, if NASA did not.

Summary

The NASA budget estimate for FY 1964 totals approximately $5.7 billion. It is about $4.5 billion larger than the NASA budget for FY 1962 as of January 1961. The NASA budget for FY 1964, as projected at that time was somewhat less than the present amount.

In the foregoing paragraphs, I have identified approximately $600-$675 million of NASA effort which appears to have direct or indirect value for military technology. Of that amount, about $275-$350 million stems from the augmentation of NASA programs since January 1961.

Question 3: What are some of the major military problems likely to result from continuation of the National Space Program as now projected in the fields of . . . government. . . ?

[4] While the detailed answer to this question will come more appropriately from NASA, some comments from the special vantage point of the DoD may be appropriate.

The concerns suggested in this question were foremost in our minds two years ago when Mr. Webb and I submitted our report to you of 6 May 1961. On page 10 of that document, urging the importance of planning at the national level, we noted that the decade of 1950-1960

> "has witnessed a great expansion in U.S. government sponsored research and development especially for large scale defense programs. Enormous strides have been made, particularly in our space efforts and In the development of related ballistic missile technology on a 'crash' basis. We have, however, incurred certain liabilities in the process. We have over-encouraged [sic] the development of entrepreneurs and the proliferation of new enterprises. As a result, key personnel have been thinly spread. The turnover rate in U.S. defense and space industry has had the effect of removing many key scientific engineering personnel from their jobs before the completion of the projects for which they were employed. Strong concentrations of technical talent needed for the best work on difficult tasks have been seriously weakened. Engineering costs have doubled in the past ten years.
>
> "These and other trends have a strong adverse effect on our capacity to do a good job in space. The inflation of costs has an obvious impact, and they are still rising at the rate of about seven per cent [sic] per year. This fact alone affects forward planning. It has often led to project stretch-outs, and may again in future years. The spreading out of technological personnel among a great many organizations has

greatly slowed down the evolution of design and development skills at the working level throughout the country."

Earlier in the same report we also stated again in connection with planning, that

> "it is absolutely vital that national management be equal to the task of focusing resources, particularly scientific and engineering 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."

[5] The concerns expressed in the report of 8 May 1961 were related to the impediments to and opportunities for success in undertaking an expanded space program. The concerns implicit in Question 3 of the President's memorandum relate to impact of this program on the non-government sector. These two concerns are opposite sides of the same coin. Moreover, the same trends that were of concern two years ago are, in many cases, of equal or greater concern today.

For example, it turns out that federal expenditures for research and development, although they exhibit fluctuations from year to year, seem to have been following a long-range trend for the last fifteen years, at least. This trend rises much more steeply than the total federal budget or total [gross national product]. In fact, if extrapolated, federal expenditures for research and development can be predicted to equal the entire gross national product by about the year 2000. It is obvious, therefore, that the slope of the curve must flatten out over the next few years.

The Department of Defense, along with every other agency of government and the private sector of the economy, is in increasingly sharp competition for the research and development dollar. The elimination of waste and inefficiency in the National Space Program, whether it occurs in NASA, in DoD, or in overlaps between the two agencies, is essential to our national security.

Question 5: Are we taking sufficient measures to insure the maximum degree of coordination and cooperation between NASA and DoD in the areas of space vehicles development and facility utilization?

The adequacy of coordination and cooperation between NASA and DoD must be measured by the extent to which such efforts support the policy of creating and maintaining a single National Space Program. That policy has governed our actions since the beginning of this Administration. In our report of 8 May 1961, Mr. Webb and I stated, in summary:

> "Clearly, then, the future of our efforts in space is going to depend on much more than this year's appropriations or tomorrow's new idea. It is going to depend in large measure upon the extent to which this country is able to establish and to direct 'an Integrated National Space Program'."

[6] We pointed out then (page 12) that:

> "It will be necessary, therefore, to find a way to formulate and apply plans and policies aimed at insuring the success of an Integrated National Space Program. Top level scientific and policy direction must be forthcoming from the top management echelons. The mere statement of broad objectives will not be enough. Periodic budget reviews and their intensification in the spring of each year will not suffice. It will be necessary to impose policy and management actions which will alter many of the trends of the past ten years, particularly in the management of research and engineering resources on a national scale."

In my view, it is essential that all major space programs be integrated with military requirements in the early stages of their development. This integration has been fostered through the organization and operation of the Aeronautics and Astronautics Coordinating Board and its six panels. A series of written agreements between NASA and DoD spells out this general policy in such fields as development of launch vehicles and space craft, administration of range facilities, and planning for communications satellites.

I am not satisfied, and I am sure that Mr. Webb is not satisfied, that we have gone far enough to eliminate all problems of duplication and waste in administration. We are engaged in a continuing joint effort in this area. But I am more concerned with the potential dangers in the divergence of our efforts in the study and planning of potential new large projects.

Take, for example, the proposed space station being considered by NASA and DoD, and still in the planning phase. While it is not yet clear that the project is justified, either on a military or nonmilitary basis, it is clear that it should be undertaken only as a national program, which meets the requirements of both NASA and DoD, and that it must be jointly planned from its inception.

Coordination and joint planning of our efforts must extend to all so-called "advanced studies." Experience has demonstrated that if many or sizeable [sic] studies are supported throughout industry, the expectation of a new project grows rapidly until such expectations are translated into public debate and controversy. Mr. Webb and I agreed on this matter in recent discussions.

In the National Launch Vehicle Program, to take another example, we must be constantly alert to consider new vehicles for inclusion as standard "building block" vehicles meeting the requirements of both agencies. We must refrain from undertaking unnecessary new developments, and we must limit the scope of adaptations of standard devices to unique projects. Both NASA and DoD continue to be exposed to proposals for additional launch vehicles or modifications of those that are already a [7] part of the National Launch Vehicle Program. It is even conceivable that within a year or two pressures will arise to develop vehicles using new materials and techniques on the sole ground that "no new launch vehicle projects have been undertaken" in a long time. This is not to say that we should abandon the continuing examination of new technological achievements in these areas. But development projects must be jointly planned and development decisions jointly taken.

Coordination and joint planning of our efforts must extend to all so-called "advanced studies." Experience has demonstrated that if many or sizeable [sic] studies are supported throughout industry, the expectation of [a] new project grows rapidly until such expectations are translated into public debate and controversy. Mr. Webb and I agreed on this matter in recent discussions.

I am also concerned with the potential dangers in the divergence or unnecessary duplication of our efforts in fields where technology and other factors are rapidly changing. Communications and meteorological satellites are two examples. I have already canceled some major programs in the communications area, and I do not propose to launch any additional projects until the roles of NASA, DoD and the Communications Satellite Corporation have been clearly defined.

The heads of the two agencies must constantly be sensitive to the dangers of duplication and waste. The problem is of sufficient importance to require continuous monitoring at a level above that of the agencies themselves. I suggest that responsibility for this monitoring be assigned to the Bureau of the Budget and to the Director of the Office of Science and Technology. Only by assigning specific responsibility in this fashion can the integrity of the National Space Program be protected.

Robert S. McNamara

[8]

TABLE I

SPACE AND SPACE RELATED PROGRAMS

BREAKDOWN BY DOD RESEARCH AND DEVELOPMENT PROGRAM CATEGORY OF AMOUNTS APPEARING ON PAGE 404 OF BUREAU OF THE BUDGET SPECIAL ANALYSIS G, "Research and Development and Selected Scientific and Technical Activities of the Federal Government," January 1963.[1]

NEW OBLIGATIONAL AUTHORITY (MILLIONS OF DOLLARS)

DOD R&D Program Category	DOD FY 1962 (act.)	DOD 1963 (est.)	DOD 1964 (est.)	NASA 1962 (act.)	NASA 1963 (est.)	NASA 1964 (est.)
Research	4	4	6	23	65	99
Exploratory Dev.	140	159	166	-	-	-
Advanced Dev.	535	509	405	-	-	-
Supporting R'sch. & Technology	675	668	571	236	439	647
Engineering Dev.	112	382	437	845	1,858	3,297
Operational Sys. Dev.	26	39	40	-	-	-
Mgt. & Support	467	525	614	692	1,261	1,621
TOTAL	1,285	1,618	1,668	1,796	3,623	5,664

[1] Special Analysis G states: "The amounts show for the National Aeronautics and Space Administration cover all the activities of that agency except those specifically identified with aircraft technology. The estimates for the Department of Defense include all the principal amounts identifiable with the Department's space programs, but exclude certain amounts which cannot be feasibly separated from other military expenses, such as the development of missiles which are also used in the space programs, military personnel costs, and various other operating costs."

Document II-25

Document title: W.F. Boone, to Mr. Webb, Dr. Seamans, Dr. Dryden, "DOD-NASA Relations," July 12, 1963.

Source: NASA Historical Reference Collection, NASA History Office, NASA Headquarters, Washington, D.C.

NASA's Office of DOD Liaison, headed by retired Admiral W. Fred Boone, performed the difficult task of attempting to keep communications open between NASA and the military when Secretary of Defense McNamara and NASA Administrator Webb were at odds. Boone's July 12, 1963, memorandum to top NASA officials attempted to place in perspective NASA's views of the military intentions and the military's view of NASA intentions. It highlights the problems of developing collaborative programs with such widely differing needs.

[no pagination] July 12, 1963

A/Mr. Webb
AA/Dr. Seamans
AD/Dr. Dryden
AAD-3

DOD-NASA Relations

In response to your desire expressed at a recent staff meeting, the attached paper is submitted.

The paper has been prepared with the thought that it would be used as a "talking paper" rather than one to be given to Mr. McNamara.

The whole paper has been coordinated with [D. Brainerd] Holmes and has his concurrence.

The section on GROUND SUPPORT OPERATIONS has been coordinated with [Edmond C.] Buckley [special assistant to the administrator] and has his concurrence.

If the DOD agrees that NASA and the DOD should work together primarily on the basis of coordination rather than joint action, I suggest that we might want to ask the AACB to agree on the meaning of "coordinate" in this context.

It is suggested that this be held on an "eyes only" basis among Dr. Dryden, Dr. Seamans, and yourself, until all or part of the paper is released by you.

W.F. Boone

2 Enclosures
DOD-NASA Relations
Definition

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[1] *PRIVATE—Eyes Only for Mr. Webb, Dr. Dryden, and Dr. Seamans.*

DOD-NASA Relations

1. The purpose of this paper is to bring into focus the divergent philosophies, attitudes, and interpretations of the Department of Defense and the National Aeronautics and Space Administration with respect to the implementation of the National Aeronautics and Space Act of 1958. Delineation of certain differing points of view may suggest guidelines for their resolution, and closer agreement as to principles involved will permit the two agencies to work more harmoniously, economically, and effectively together in the national interest.

2. This discussion will be presented under the headings of *NATIONAL POLICY, PLANNING,* and *GROUND SUPPORT OPERATIONS* as these pertain to space activities, and *AERONAUTICAL RESEARCH.* These are the areas in which the principal problems appear to lie.

NATIONAL POLICY

3. A difference of opinion exists as to the proper function and status of the Space Administration under the Space Act of 1958.

NASA Position

4. The National Aeronautics and Space Act was responsive to national requirements in two categories: (1) general welfare, and (2) security. The objectives set forth in the Act were formulated after thorough deliberation by the Executive and Legislative Branches, and extensive correlation with the scientific community. The Act provided that the scientific exploration and exploitation of space shall be the responsibility of and directed by an independent *civilian* agency, while stating the major exception that "activities peculiar to or primarily associated with the development of weapons systems, military operations or the defense of the United States (including the research and development necessary to make effective provision for the defense of the United States) shall be the responsibility of, and shall be directed by, the Department of Defense. . . " Thus, the Congress clearly recognized the need for two mutually supporting but separately directed space programs. The Act established a liaison mechanism (the Civilian-Military Liaison Committee, later superseded by the Aeronautics and Astronautics Coordinating Board) through which the DOD and NASA were required to "advise and consult with each other on all matters within [2] their respective jurisdictions relating to aeronautical and space activities" and to "keep each other fully and currently informed with respect to such activities." The Act provided that the President shall determine which agency shall have responsibility for the direction of a space activity.

5. In drafting the Act, the Congress stressed the peaceful purposes of our space activities. It was apparently recognized that the exploration of space was more than an area of future significance to the defense of the United States, and that the scientific, political, and economic benefits to be derived from a space program might be subordinated if space exploration were conducted solely under military auspices.

6. NASA sees the national space effort as a spectrum encompassing three areas: (1) acquisition of basic scientific knowledge and the development of basic technologies and operating techniques; (2) the application of space knowledge, technologies, and techniques to the development of prototype space systems; (3) the production and operation of commercial and military space systems to meet national requirements. A necessary adjunct to this total effort is the establishment of a government in[-]house capability supported by a broad industrial base competent in the space field.

7. NASA's assigned functions lie primarily in category (1) above. The DOD has research and development responsibilities in this category to the extent that such research and development pertains to the defense of the United States. NASA's responsibilities do not extend to the area of category (3). Category (2) is a gray area in which the responsibilities of DOD and NASA overlap to a considerable extent. NASA of necessity becomes an operating agency in those cases where basic subsystems and operating techniques can best be developed by means of an experimental operational flight system, and where NASA is called upon to furnish operational services to another agency. NASA recognizes that some

programs to meet the requirements of DOD and NASA in category (2) are of such magnitude as to require that a single program serve the needs of both agencies; i.e., a manned orbiting laboratory. Where predominant interest is at issue in such cases, a Presidential decision as to management responsibility would be needed. Presumably, the decision, in addition to the matter of relative interest in terms of experiments to be accommodated, would take into account additional factors such as management competence, operational experience, and political impact.

8. Consideration of national policy and national interests dictates that the civilian space program under NASA should be an "open" program with maximum dissemination of derived information "for the benefit of all mankind," whereas these same considerations require that a military space program be conducted essentially under security restrictions.

[3] *DOD Position—as it appears to NASA*

9. The attitude of the DOD with respect to the roles of the two agencies in the national space effort differs from that of NASA in that the DOD sees the civilian and military space programs as one program which should be jointly conducted to attain both civilian and military objectives. They believe that the military requirements in space were not as well foreseen when the Space Act was passed in 1958 as they are now. In the intervening years, it has become apparent that the Soviet space program is directed primarily toward the gaining of a military advantage through space operations, forcing the United States to build a military defense in space. Because of this increasing role, the military should have a stronger voice in shaping and direction of the total national space program than was recognized and provided for in the Space Act.

10. This attitude has led to efforts on the part of the DOD to have segments of the NASA program transferred to the DOD (i.e., Gemini, bio-astronautics, training of astronauts, MILA). The desire to control is especially strong within the Air Force, as the Service of primary interest in the field of space, is disproportionately small and has not received the proper public recognition. The Air Force considers that space operations are simply an extension of flight operations in the atmosphere, and therefore that they should be under Air Force control. Lacking greater support for this position at the DOD level, the Air Force has made an "end runs" [sic] to members of Congress and the White House staff, and has launched an intensive and well organized public relations campaign to convert the public to the Air Force point of view. The Air Force is inclined to look upon NASA as a competitor rather than a partner in the field of space.

Proposed Basis of Agreement

11. The Secretary of Defense and the Administrator should agree in principle along the following lines, and should join in a vigorous effort to indoctrinate subordinate staffs and agencies in acceptance of these principles:

(a) It was the intent of Congress, and remains in the national interest so far as possible without jeopardizing national security, that the United Sates maintain in the eyes of the world the peaceful image of our space program.

(b) As a corollary to (a), NASA should remain a fully independent, civilian agency.

[4] (c) There are certain advantages to the national space effort, and in the long run specifically to the Department of Defense, which accrue the virtue of civilian agency management of a major portion of the total space effort; i.e., international cooperation; and relations with the research and development organizations of industry, with the civilian scientific organizations, and with the university community.

(d) At the same time, the unfolding military requirement in space demands an expanding role for the Department of Defense in the total space effort.

(e) For the present, this increasing role will be accommodated by earlier and stronger concerted DOD-NASA action on the basis of *coordination* rather than *joint control,* and in a manner which will not compromise the civilian character of NASA's activities.

(NOTE: "Coordination" as used in this paper, will have the following meaning: An agency having responsibility to "coordinate" with another agency on a specified project (1) will recognize the interest of the other agency in the project, (2) will initiate a full exchange of information and consultations early in the conceptual phase, (3) will encourage the active participation of the other agency in the planning from the very outset, and (4) will make an earnest effort to meet the requirements and objectives of the other agency. Concurrence of the other agency will be sought in the planning and execution of the project. Concurrence is not required as a pre-condition to further action. However, matters on which agreement is not reached may be referred for resolution to the next higher authority in which both participants have a voice.)

(f) It is expected that the decision as to management responsibility for a major new program will be made by the President primarily on the basis of predominance of interest, but also taking into account other factors such as capability to conduct the program, relation to other major programs, international aspects, security considerations, etc.

[5] (g) There will be maximum cross-servicing in the use of support resources and technical know-how.

(h) Except in unusual cases, joint management responsibility is not favored on the basis that the requirement for concurrence at every step [is] inefficient, uneconomical, and tends to impede rapid progress.

PLANNING

12. A difference of opinion exists as to the desirability of joint versus coordinated planning.

NASA Position

13. NASA's assigned mission is to maintain a national position in the vanguard of space exploration. In its quest for scientific knowledge and its efforts to develop the basic techniques necessary for space operations, NASA must constantly seek to advance man's space frontier further into the unknown. In pursuing this mission, NASA should not be restricted by a limitation that its advanced exploratory studies must be related to established operational requirements of either a military or commercial nature. At the same time, NASA should ever be alert to discern those areas of research which appear to offer the most promising potential for the solution of military problems and for otherwise contributing to the national welfare, and be prepared to orient its efforts responsively to these objectives.

14. There should be a thorough, inter-agency exchange of ideas and information as to requirements and problems early in the process of formulating advance studies in an area of mutual interest, but to impose the restriction that the formal concurrence of another agency is required before NASA may proceed with such a study would seriously obstruct NASA's ability to discharge its statutorily assigned functions.

15. Major future progress in space are [sic] likely to be so costly that the nation will be able to afford only one program in each category. Consequently, each such program should be designed to meet, in so far as possible, the requirements of all government agencies for space research and development.
16. Once the decision is made to embark upon a multi-interest project, the agency responsible for its direction should be designated. Thereafter, the planning and execution should be coordinated between interested agencies to assure that in so far as practicable the requirements of all agencies are fulfilled in the national interest. The primary responsibility for that coordination should reside with the agency directing the project.

[6] *DOD Position—as it appears to NASA*

17. The DOD view with respect to planning differs from that of NASA in that the DOD feels all planning relating to NASA programs or projects which are of interest to DOD should be jointly conducted from inception. This view has led DOD to seek inflexible agreements concerning the manner in which NASA's advance exploratory studies may be initiated, including sign-off authority for DOD.

Proposed Basis of Agreement

18. (a) Requirements and objectives in any particular area of space research and development will, as a general rule, be developed unilaterally by DOD and NASA. Subject to security restrictions, general knowledge of each other's requirements and objectives must be assumed.
(b) Prior to the approval by either agency of a study project in an area of mutual interest, inter-agency coordination will be accomplished. This will take the form of a free exchange of information concerning requirements, objectives and plans for the study, and an earnest attempt to cast the study in such manner as to be responsive to the requirements and objectives of both agencies in so far as practicable. Provisions will be made so that in the event an agency feels that its needs are not being adequately met in formulating the study, recourse may be had to higher authority for resolution of differences, initially to the Co-chairmen of the [Aeronautics and Astronautics Coordinating Board].
(c) Results of studies in an area of mutual interest will be made available to both agencies.
(d) Upon approval of a new major project of mutual interest, the agency responsible for its direction will also be charged with insuring that adequate arrangements for coordinated planning and coordinated monitoring of execution are made. Again, provision will be made for recourse to higher authority to resolve differences.

GROUND SUPPORT OPERATIONS

19. There are some conflicting views in the matter of control of ground support operations.

[7] *NASA Position*

20. NASA fully subscribes to the concept of national launch ranges operated by the DOD for the benefit of all government user agencies. NASA has levied known requirements on the ranges for over 140 future launches, over 40 of which involve tracking ships. However, the requirements which NASA must place on the ranges have become so large, complex,

and exacting that NASA feels it must actively participate in planning the manner in which the ranges are to be equipped and operated to provide the project-peculiar services required by NASA.

21. The magnitude and nature of the Manned Lunar Landing Program are such as to require that the assembly, check-out, and launch area (Merritt Island) be under NASA control.

22. The world network of land-based orbital tracking and data acquisition stations should, to the maximum practical extent, be under NASA control for NASA missions. This applies to planning of facilities, specification and installation of instrumentation, training and maintenance of proficiency activities, communication links, and operational control during a flight. As high a degree as possible of standardization among stations is necessary in order to permit the most effective operational flexibility and casualty control during an operation. Exceptions to this doctrine can be accepted in the case of a few DOD stations that are already in existence, strategically located, and responsive to NASA requirements. This doctrine is made necessary by the indivisible relationship between program management and the operations control organization.

23. If and when stations of the NASA world network are utilized to track DOD missions, NASA would be willing to place these stations temporarily under DOD operational control if DOD considers this necessary to the mission and to the extent permitted by international agreements. (Nearly half of the spacecraft being tracked by the NASA satellite network are DOD spacecraft.)

24. Arrangements for the procurement, preparation, and operation of the project peculiar tracking ships required to occupy the critical stations for insertion into orbit and injection into the moon transfer in the Apollo operation must be such as to give NASA a high degree of control through relatively direct administrative channels.

25. To this end, NASA's present intention is to employ MSTS [Military Sea Transportation Service (NAVY),] a DOD agency experienced in the operation of special purpose ships, to prepare the hulls and machinery and to operate the ships themselves as differentiated from the instrumentation installed therein. In the interest of standardization, NASA plans to use the same contractor for installation and operation of the instrumentation as is used in the case of other NASA stations in the net. [8] While these ships will be required nearly full time for the Apollo mission, NASA has no objection to adding general purpose instrumentation to the extent this will not compromise the project peculiar instrumentation, and to make the ships available for general purpose use when not required in connection with Apollo. Generally speaking, these ships should basically be special purpose ships, with a general purpose secondary mission, rather than vice versa.

26. The priority assigned to the Apollo program and considerations of safety are such that where other agencies are depended upon to furnish facilities or perform essential services in the loop, NASA must have the prerogative of monitoring the provisions for rendering such services to the extent necessary to assure itself that all recognizable potential limitations which might delay the schedule or increase the risk of the mission are eliminated.

DOD Position—as it appears to NASA

27. The DOD takes the position that the launch ranges are a national asset which would be used to capacity by other agencies of the government, and on which requirements should be levied without voice as to the manner in which these requirements are to be met. The range facilities, including tracking ships, should be primarily "general purpose" in nature, with "project peculiar" provisions added. The DOD fears that NASA, by establishing the Merritt Island Launch Area and seeking to acquire its own project-peculiar

tracking ships, wishes to depend less and less upon the DOD ranges for services, becoming a range operator instead of a range user.

Proposed Basis of Agreement

28. The differences in this area stem more from a lack of mutual trust than from differing concepts. Each agency sees the other as seeking control of segments of its operations. This has at times inhibited a free exchange of information. In order to dispel any such fears, it is proposed that DOD and NASA agree in principle to the following, and that all subordinate organizations be informed accordingly:

(a) The concept of national launch ranges operated by the DOD is to be fully accepted and implemented. NASA will depend upon the facilities and services of these ranges to the extent that they can meet NASA requirements.

[9] (b) The principle of "primary assignment" will be applied in accordance with priorities established by mutual agreement or by higher authority.

(c) Where NASA specialized requirements exceed the capacity of the national range, the range will be given an opportunity to augment its capacity if desired, before NASA proceeds to make its own provisions to meet the excess requirements.

(d) NASA will continue to be responsible for operating the world networks required for tracking NASA spacecraft in orbit and in lunar and planetary transfers. In the interest of avoiding unwarranted duplication, the DOD will utilize these NASA networks for DOD orbital missions where feasible.

(e) Generally speaking, the point of demarcation between the ranges and the world tracking nets will be the point of insertion into orbit.

(f) Each agency will participate actively on a coordination basis in the other's plans for equipment development and facilities with the objectives of achieving the maximum practicable degree of standardization and permitting such facilities and equipments to meet the needs of both agencies to the maximum practicable extent.

(g) All tracking [of] the data acquisition ships, once ready for service, will be assigned to the national ranges who will utilize MSTS to operate and maintain the ships generally under the same arrangements that currently govern the MSTS to operation and maintenance of special purpose ships for various agencies of the government. Under this arrangement, there will be a mutually agreed upon scheduling authority who will assign the ships to the operational control of the user agency on a prime assignment basis as necessary to meet the requirements of the user agency as to training, calibration check-out, minor modifications to instrumentation, and tracking and data acquisition operations.

(h) Operation of instrumentation aboard each ship will be contracted for directly by the user having primary interest.

[10] *AERONAUTICAL RESEARCH*

29. There is a difference of opinion as to the relative importance time-wise of aeronautical research programs utilizing new prototypes and the flight test programs of these prototypes.

RS-70 Program

30. In a letter dated May 3, 1962, the Administrator proposed to the Secretary of Defense that one of the three XB-70 prototypes be made available to NASA for use in conducting an advanced aeronautical research program in the area of supersonic cruise flight. NASA considers that this program is essential to our country's progress in the field of aeronautics, and that the information desired cannot be obtained by any other means. No official response to this request has been received. Recently, after an elapse of over a year, the proposal has been revived by NASA in the [Aeronautics and Astronautics Coordinating Board].
31. NASA considers it to be of the utmost importance that the opportunity presented by the XB-70 for flight research in the supersonic range be fully exploited as early as practicable. The data to be gained thereby will have special application in the development of the supersonic transport now advocated by the Administration.
32. A proper flight research program cannot be conducted simultaneously with and as a part of the flight tests of this aircraft. Since the instrumentation for the research program should be installed during the fabrication of the designated aircraft, an early decision by the Secretary of Defense to make one of the XB-70 prototypes available on loan to NASA is required if the valuable data to be derived from such a research program is to be available in time to be used in designing the supersonic transport.

TFX Program

33. By letter dated January 15, 1963, the Administrator requested that one of the early TFX prototypes be made available on loan to NASA to be used in conducting a flight research program to obtain basic data concerning the variable swept wing concept incorporated in the aircraft. This concept originated at the Langley Research Center, and much of the supporting ground research data were gathered there. On 1 March 1963, the Secretary of Defense responded by disapproving the request, making the alternate suggestions that:

(a) NASA participate jointly with the Air Force by combining the research program with the flight test program,

[11] (b) NASA acquire one of the prototypes upon completion of the flight test program, or

(c) NASA purchase an additional prototype at a cost of about $10 million.

Alternative (c) appeared to involve unwarranted duplication, and neither alternative (a) nor (b) would permit the accomplishment of an adequate flight research program in a timely manner.
34. Following personal negotiations with the Secretary of the Air Force by the Deputy Associate Administrator for Defense Affairs, discussions were commenced between NASA and the TFX Project Office at Wright-Patterson Air Force Base to find ways and means of meshing an adequate flight research program under NASA control with the flight test program on the TFX prototypes. It is too early to say whether satisfactory arrangements for meeting the requirements of both agencies will evolve from these negotiations. The Secretary of Defense and the Administrator should agree to review this matter again about six months hence.

Proposed Basis of Agreement

35. In layout [of] a program for the acquisition of a new military aircraft type incorporating a new concept or a substantial projection of a current design concept, provision will be made to make an early prototype available to NASA for the purpose of accomplishing an "in-flight" research program designed to obtain advanced technical data in the field of aeronautics.

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[no pagination]

Definition of
"Coordination With" and "In Coordination With"

This expression means that agencies coordinated with shall participate actively; and concurrence shall be sought; and that if concurrence is not obtained the disputed matter shall be referred to the next highest authority in which all participants have a voice.

(The above information from JCS Publication "Dictionary of U.S. Military Terms for Joint Usage" and Army Regulation 320-5)

Document II-26

Document title: James E. Webb, Administrator, NASA, and Robert S. McNamara, Secretary of Defense, "Agreement Between the Department of Defense and the National Aeronautics and Space Administration Covering a Possible New Manned Earth Orbital Research and Development Project," August 17, 1963, with attached: "Procedure for Coordination of Advanced Exploratory Studies by the DOD and the NASA in the Area of Manned Earth Orbital Flight Under the Aegis of the Aeronautics and Astronautics Coordinating Board."

Document II-27

Document title: Robert S. McNamara, to Honorable James E. Webb, NASA Administrator, September 16, 1963.

Source: Both in Administrators Files, NASA Historical Reference Collection, NASA History Office, NASA Headquarters, Washington, D.C.

Among the more important areas on which NASA and the Department of Defense (DOD) agreed to cooperate was the development of future orbital space stations. This agreement, signed on August 17, 1963, was to cover the development of a joint national space station. Although Secretary of Defense Robert McNamara signed the agreement, in a September 16, 1963, letter to Administrator Webb, he expressed his reservations, focusing particularly on the need for both agencies to concur on, not just coordinate, their future activities related to future station design and development.