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A CONCEPT OF MILITARY OPERATIONS IN SPACE

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ABSTRACT

The United States has divided the management of its space activities between two agencies in the Executive Branch of the government; the National Aeronautics and Space Agency and the Department of Defense. There have been many controversial discussions by both military and civilian personnel concerning the desirability and effectiveness of this split in responsibility.

In order to develop a Concept of Military Operations in Space it was necessary to investigate and attempt to answer the following questions: Why did the United States adopt a national policy of space for peaceful purposes only? What is the present government organization for management of space activities? Of what do the present United States' space programs consist (civilian and military), and what are their goals? Will this program, within the scope of national policy, permit the military to provide for the adequate defense and security of the nation?

After tracing the evolution of the present space management and organization system and understanding the reasons for this evolvement, it was determined that the government's decision to make a distinction between the peaceful and military use of space was necessary.

The scientific research, application, and exploration of space covers so many fields and new technologies that it is essential for all nations to participate. Internationalized space programs will permit the most eminent scientists and engineers of the world to address themselves to common goals rather than fragmenting their efforts into individual national programs. Further, the

international legal problems resulting from satellites over-flying other countries must be clarified and an agreement made by all nations on a code of international law. Because of the international involvement in the space program, it would be neither practical or desirable for the Department of Defense to control and manage the entire effort.

The NASA and unclassified military space programs were reviewed to determine where the actual split in responsibility occured and how comprehensive their programs were. It was found that there is considerable overlap in responsibilities between NASA and the Department of Defense. In most cases, a clear definition cannot be made and an arbitrary assignment is made for each individual project. However, if a philosophy of close coordination and joint participation is adopted, it is the opinion of this writer that the present space management system and organization will satisfy the immediate requirement.

The civilian and military space programs in being and in planning will, if applied to future requirements, provide the Department of Defense with the necessary space technology and capability to develop the operable weapon systems necessary to insure the security of the nation.

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INTRODUCTION

The primary effect of the rapid advancement in missile and space technology has been organization and reorganization of government agencies responsible for the programs. The missile gap in the mid-nineteen fifties caused President Eisenhower to assign the highest national priority to the inter-continental ballistic missile program. The Department of Defense geared to discharge its responsibility first by decentralizing control, then recentralizing and finally by again decentralizing.

Sputnik I, launched 4 October 1957 by the Soviet Union, caused another round of reorganizations. Space for peaceful purposes manifested itself by the enactment of the National Aeronautics and Space Act of 1958 which assigned the responsibility for space development to a civilian agency. For nearly two years, any discussion of the military and space was taboo.

Major Yuri Gagarin's orbital flight, 12 April 1961, dispelled all doubts about the existance of a space gap with Russia. The nation's number one priority became the man on the moon program and the new administration publically recognized the importance of space to the military security of the country.

A review of organizational changes and the assignment of responsibilities within agencies of the government and a review of current civilian and unclassified military space programs provide the background to develop, in Chapter III, a Concept of Military Operations in Space.

A CONCEPT OF MILITARY OPERATIONS IN SPACE

CHAPTER I

SPACE: A MEDIUM FOR PEACE OR POWER

> We should, certainly, make provisions for inviting together the scientists of other nations to work in concert on projects to extend the frontiers of man and to find solutions to the troubles of this earth.
>
> Our President, holding as he does the esteem of men throughout the world, has a rare opportunity to lead in this labor boldly and forcefully, for in the vigorous pursuit of peace he will find the Nation undivided in his support.
>
> Further, it would be appropriate and fitting for our Nation to demonstrate its initiative before the United Nations by inviting all member nations to join in the adventure into outer space together.
>
> The dimensions of space dwarf our national differences on earth. (87:15)
>
> --Senator Lyndon B. Johnson

The eyes of the people of the United States have been jolted open twice in the past fourteen years; the first time when the USSR exploded her first nuclear device and secondly the day of Sputnik I. The threat of devastation by nuclear weapons has dictated a continuing and urgent effort by the United States, through the United Nations, to negotiate an agreeable disarmament policy with the USSR and other Nations possessing nuclear weapons.

The reality of satellites orbiting the world and the realization that manned space flight, within and out of the solar system, is possible in the foreseeable future has led to many private and public discussions of whether space should be used for improving national security and world power, or for peaceful purposes to the benefit of all mankind.

The problem of solidifying a clearly understandable and adequate space activities policy was a highly debated subject. Mr. Robert Dechert, General Counsel of the Department of Defense, summarized the dilemma by stating that we are faced with two major problems: "(1) We must say that this vast area of our universe is not to become the battleground for future generations [and provide] completely adequate safeguards to insure such an aim; and (2) Until such time as that goal is achieved with certainty, we must continue to develop defensive weapons and vehicles which will meet this new threat." (26:16) President Kennedy (then Senator) stated, "If the Soviets control space, they control the world." (38:21)

As a result of the extensive hearings by the House Select Committee on Astronautics and Space Explorations, the Hon. John W. McCormack, chairman of the committee, resolved the basic problem of space activities. He introduced House Concurrent Resolution 326 on the Peaceful Exploration of Outer Space. The resolution as passed by Congress declared that space would only be utilized for peaceful purposes. (87:17) (See Appendix B)

The declaration of the United States Congress that outer space would only be utilized for peaceful purposes catalyzed a chain of events that have not been completed as of this date.

Management of Space Activities Prior to 29 July 1958. It is not the intention of this writer to trace and analyze all the actions and inter-action associated with the development of the present day Department of Defense and Civilian Space Agency organizations. However, it is essential to have a general understanding of the significant events that led to the enactment of the National Aeronautics and Space Act and the Defense Reorganization Act of 1958. This is necessary to fully appreciate the complexity of the space-for-peace vs. the space-for-military problem.

The National Security Act of 1947 was the first in a series of National Military Establishment organizations and reorganizations that have been prompted, in part, by the development of new weapons systems and the rapid development of technology. Throughout the many Congressional hearings related to the formation of a Department of Defense organization, Congress was principally concerned with the role of the Secretary of Defense, the safeguarding of individual status of the three services, and preventing a supreme military high command. (67:5) In addition to establishing the specific roles and missions for each of the three services, the National Security Act of 1947 recognized the need for research and development and provided for the following functions to be common to all of the services:

> To conduct research, to develop tactics, techniques, and organization, and to develop and procure weapons, equipment, and supplies essential to the fulfillment of the functions hereinafter assigned, each service coordination with the others in all matters of joint concern. (88:39)

The above section of the National Security Act of 1947 set the stage for the many accusations of inefficiency, duplication, rivalry, waste, etc., that have been levied against the Department of Defense since that time. Individual service research and development was dictated not only by the requirement to fulfill their responsibilities but also to further their individual claims to be the predominant service in developing the National War

Strategy. Decentralization of controls, hazy functional responsibilities, and closely guarded research and development activities were the rule of the day.

The organizational changes necessary for centralized planning and control of the military's research and development programs were slow in coming. However, it is significant that by 1953, major changes to the Security Act had been made that took cognizance of the vital need for close monitoring and coordinating of the Department's research and development programs. The Secretary of Defense's functions were strengthened and, in part, were stated to be:

> Preparation of a complete and integrated program of research and development for military purposes.
> Note trends in scientific research and assure continued and increasing progress.
> Coordinate research and development among military departments and allocate responsibilities for specific programs.
> Formulate policy for the Department of Defense in connection with research and development matters involving agencies outside the Department of Defense. (88:20)

The tempo of the nation's missile and astronautic research and development activities have increased from mere conjectures by Buck Rogers fans, to a four billion dollar annual budget program. Organization changes and functional realignments in the Department of Defense have continually been made to keep pace with the rapid advances in weapon systems development and technological breakthroughs. (See Appendix A for a compilation of selected missile and astronautic events for the period 1946 to date)

Resolving the Space Responsibility Problem: By late 1957, the complexity of the nation's missile and space programs, in terms of diversification, identification, scientific resources, control and functional management had reached the point that it was difficult if not impossible to determine of what the United States space program consisted or where it was going. A report published by the House of Representatives stated the problem as follows:

> The record shows a bewildering kaleidoscope of directors, committees, special assistants, assistant secretaries and other offices and officers, seeking in one way or another to influence the nature and direction of the National missile effort.
>
> The specter of a vehicle orbiting the earth introduced space to the American public as a new dimension in strategy. The race for space on the grand scale is between the United States and the Soviet Union. But there are contests as well on the National scene. Military and civil agencies compete for prestige and projects, and the military services struggle for ascendancy in space, competing with each other for jobs and budgets....(76:7&127)

During 1958, President Eisenhower took three major steps to resolve the missile and space organizational and functional problems. These steps were: (1) The advanced Research Projects Agency (ARPA) was established within the Department of Defense with jurisdiction over research and development of space projects, the antimissile missile, and other special projects not clearly the responsibility of a single military department; (2) The Defense Reorganization Act of 1958 was signed creating the post of Director of Defense Research and Engineering with authority to issue instructions to military departments, to approve or disapprove programs and projects in the interest of eliminating unpromising or unnecessary duplicative programs, and to initiate or support promising programs and projects for research and development; (76:19) and (3) the National Aeronautics and Space Agency was created by Congress (Public Law 85-568, 29 July 1958) and provided an organization with the responsibility of managing all U. S. Government aeronautics and space programs except activities peculiar to or primarily associated with development of weapon systems, military operations, or the defense of the United States. (91:1)

Each of the above acts created many misgivings and on occasion outright criticism by both military and civilian personnel. However, the die had been cast; missile weapon systems and space weapon systems were separated within the Department of Defense and control of peaceful space scientific exploration programs had been given to a civilian organization in the Executive Branch of the Government.

Why a National Aeronautics and Space Administration?

The decision by Congress to resolve that the nations of the world should join in the establishment of plans for the peaceful exploration of outer space; and that the broadening of man's knowledge of space should be for the good of all mankind stemmed from two basic principles: (1) That without international agreement and control, the arms race between the East and West would be projected into the space medium to the detriment of United States' security; and (2) That the basic space scientific research and development field was so broad and complicated that only through the combined efforts of all nations and their scientists could the world progress toward interplanetary space travel at the desired rate.

In 1955, both the United States and the Soviet Union stated that they had plans for investigating outer space as part of the International Geophysical Year. Russia implied willingness to cooperate with other countries in the collection and dissemination of information about space. However, the rapid improvement of thermo-nuclear bombs and the development of long range missile techniques gave cause for President Eisenhower to suggest in his 10 January 1957 State of the Union message that the international community should seriously consider a plan to mutually control the outer space missile and satellite development. The President's suggestion was incorporated into a United States disarmament proposal on 14 January 1957. The Soviets have refused to participate. (82:2)

It was apparent to Congress that if exploration of outer space was to be accomplished in a peaceful environment, the United States must again be the world's spokesman advocating adherence to a principle. The U. S. House Select Committee on Astronautics and Space Exploration reported their thoughts as follows:

> The inability to depend on Soviet cooperation and the lack of governmental space effort in most other countries offers a peculiarly good chance for the United States to mobilize the researches of most of the world's scientists in this field.
>
> The opportunity now exists, therefore, for the United States to accept the leadership of an international space effort in the infancy of the art. We can thereby insure this effort starts and remains truly peaceful and productive. (83:2)

The declaration of Congress that the United States should be the proponent of international cooperation and control of outer space, gave rise to many difficult questions. Could an organization directed and controlled by the Defense Department effectively coordinate with international space research agencies? Would the military overtones of such an organization, even though headed by a civilian, negate to the avowed position that space exploration would be for peaceful purposes only? Would military security practices prevent free and unrestrained intercourse of ideas and technology between scientists of the world? Would it be possible within the Defense Department to differentiate between those programs of a sensitive nature to the National security and those of a purely scientific nature? Could there be a division of programs on the basis of peaceful scientific exploration vs. militarily significant programs? Could the military effectively coordinate with the State Department and the United Nations in the development of International Space Law doctrines? These and many other questions were considered by Congress in their deliberations preceding enactment of the National Aeronautics and Space Act. The Senate Special Committee on Space and Astronautics had the following to say about the problem of transferring space programs from the Department of Defense to NASA:

> This is a far more complicated task than that of transferring the Manhattan Project to the newly organized Atomic Energy Commission in 1946. The AEC deals both with military and non-military nuclear projects. It is easier, on the basis of scientific and technical facts, to draw a line between the military and peaceful uses of nuclear energy than is the case with the uses of space vehicles. The National Advisory Committee for Aeronautics had both peacetime scientific and defense missions which are retained in NASA. But NASA's space mission is oriented to meet scientific and peaceful needs. Simultaneously, however, the Department of Defense has a need for scientific research projects which are related to military uses but are not exclusively military in nature, while scientific space knowledge which can be used for peaceful purposes also has military implications. (87:9)

President Eisenhower solved at least temporarily, the problem of control and use of outer space when he proposed and subsequently signed the bill establishing the National Aeronautics and Space Administration, 29 July 1958. The law was very general in its dealing with division of responsibilities between NASA and the Department of Defense, and the mechanics for coordination and control of space programs at governmental level. However, the declaration of policy and purpose of the law leaves no doubt as to the intention of Congress that the United States' activities in space should be devoted to peaceful purposes for the benefit of all mankind. (87:33) (See Appendix C)

The United States has attempted to foster international cooperation in space activities through the United Nations. Yet, the United Nations has been slow in obtaining any productive results either in the area of international space law or international cooperation in space science. The National Aeronautics and Space Agency has actively participated in UN activities, such as they are, but has been forced to deal unilaterally in making most agreements with friendly nations. NASA has initiated programs wherein scientist of other nations have and will participate with the United States in space projects. Specific examples are (1) Preparation of an ionospheric research satellite (Top Side Sounder) by Canada to be launched by the United States. (2) A complex of satellite experiments is being prepared in England to measure cosmic rays, ion mass spectra, electron densities and temperatures, and solar radiation. These experiments will be flown from American sites in 1962. (3) Twenty-six outstanding scientists from thirteen countries are engaged in basic research at NASA laboratories under its Postdoctorate Research Associate program. (4) NASA has assisted other countries with a start in the launchings of space vehicles by cooperating with them in their sounding rocket programs. (33:24M:1-5)

The concept of international cooperation that was contained in the National Aeronautics and Space Act of 1958 has given rise to the problem of Space and International Law. The United Nation's efforts to lay the foundation for starting a space code has met with little success. Even the international lawyers in the United States cannot agree on what is needed or best for the country.

There have been many volumes published dealing with all aspects of international space law. There are as many ideas, as international lawyers concerning the urgency of the need for an over-all code for outer space. An over-simplified summary of the differences in views can be stated as follows: (1) There is an urgent need to identify all possible areas, develop the laws, and obtain approval of all nations either through the auspices of the United Nations or the International Court of Justice. This can be done with or without Soviet participation. (Past Soviet actions indicate that if the program is started and is favorably received by the majority of the nations, Russia and the Satellite Nations will join. (2) Past efforts of the United Nations in dealing with controversial subjects such as disarmament and Berlin have been anything but satisfactory. An introduction of specific international space law codes at this time would only aggravate existing controversies. Rear Admiral Chester Ward in a statement to the House Committee on Science and Astronautics expressed serious concern over efforts to establish space law. "A premature, over-optimistic, unsafeguarded plunge into space law through international agreements restricting the freedom of space will seriously threaten the survival of the United States." (81:99) When specific cases are encountered, present National and International laws can be interpreted to adequately deal with the immediate situation. The United States should expend its efforts in attempting to get all nations to cooperate in the development of space science rather than introduce another controversial subject for debate and Soviet propaganda.

Although there is disagreement as to what should be done, when, and by whom, there is complete agreement that the legal problems of space are numerous, complicated and in most cases without precedence. Mr. Clark C. Abt, Missile and Space Division, Raytheon Company, Bedford, Massachusetts, published a comprehensive list of legal problems dealing with the utilization of space. (See Appendix D)

Organizing for the Defense Department's Space Activities:

Until the enactment of National Aeronautics and Space Act in July 1958, practically all guided missile and space activities had been planned, researched and developed by the services in the Department of Defense. Much of the criticism of the Department's missile program was directed against the complexness of the orginization within the Department to conduct the program. There was no one individual or agency below the Secretary of Defense who could be held responsible for the program. On 15 November 1957, Secretary of Defense Neil H. McElroy issued a directive establishing the Office of Director of Guided Missiles with authority to direct all activities in the Department of Defense relating to research, development, engineering, production, and procurement of guided missiles. (85:43)

By January 1958, Secretary McElroy concluded that the guided missile program had developed to the point that it was no longer feasible or economical to maintain the guided missile, anti-missile and space exploration programs in one big operating agency. A new agency was needed to act as a single manager for research, development and testing projects of an advanced scientific nature. He created the Advanced Research Projects Agency to be responsible under the Secretary of Defense for the research and development phases of advanced science projects, the development of an anti-ballistic-missile system, and such other projects as designated by the Secretary of Defense. (85:46)

Congress expressed approval of the Department of Defense's action by authorizing the Secretary to engage in non-military advanced space programs as designated by the President. This authority was only granted for one year in order to give Congress time to decide upon long range outer space legislation.

When ARPA was established, it was not known what authority and responsibility the then proposed civilian-controlled space agency would have, or for that matter, what ARPA's future in the Defense Department would be. However, the Director of ARPA took immediate action to draw under his control all advanced research and development programs that were to be conducted by the services. (76:138) ARPA gradually lost its advanced projects responsibility to NASA and the services. By November 1960, ARPA was concerned only with basic advanced research that could not be identified with a specific military requirement or department. (30:96)

The Department of Defense Reorganization Act of 1958 abolished the position of Assistant Secretary of Defense (Research and Engineering) and created a Director of Defense Research and Engineering. The new Director was given specific delegated authority to issue instructions to the military departments and other Defense agencies in the interest of eliminating unpromising or duplicative programs; and to initiate or support promising programs and projects for research and development. (76:19) Further, he was given authority to supervise the activities of ARPA. In April 1959, the office of the Director of Guided Missiles was abolished and its duties absorbed by the Director of Defense Research and Engineering. Thus, the Director of Defense Research and Engineering became the focal point, with directive and contractual authority, for all research and development activities in the Department of Defense.

The centralization of research and development control at the Secretary of Defense level caused a new round of research and development reorganizations within each of the services; the Army and Navy trending toward centralization, the Air Force, with its tightly controlled Ballistic Missile Division, toward decentralization.

In March 1961, the Defense Department made two major changes in its evolving space age organization: (1) Secretary of Defense, Robert S. McNamera announced that the Air Force would be the Department's single manager for the development of military space systems (See Appendix E) and (2) The Air Force re-named and functionally realigned its Air Research and Development Command (ARDC) and its Air Material Command (AMC). ARDC was re-named, Air Force Systems Command (AFSC). AMC was re-named, Air Force Logistics Command (AFLC). The new AFSC was given the resources and responsibility for development and test through procurement and production, installation, and checkout delivery to the using command for all system programs. The AFLC was given the responsibility for providing supply and maintenance support for systems in service and to insure that they remained operational after delivery to the using agency. (97:40)

Is the Resolution of the Space Responsibility Compatible with the Military Requirement? The primary effect of Sputnick I on the Nation's space age research and development effort was organization and reorganization. Centralized control to promote efficiency in planning, decision making, development, and testing has been the predominate trend. Reduction of the drawing board-to-user development time has been stressed as the vital factor in the attempt to catch up with the Soviets. Mr. A. Blagonarov, a member of the USSR Academy of Sciences, stated in 1958, "It is easy to see that precisely the time element is the decisive factor which should be grasped in the competition with the capitalist countries in the field of technology." (56:62)

The enactment of the National Aeronautics and Space Act and the Defense Reorganization Act of 1958 provided for centralized control of the entire space effort at Executive level (National Aeronautics and Space Council); centralized control of the civilian managed space-for-peace effort (NASA); centralized control of the military effort at Department of Defense level (Director of Defense Research and Engineering); and a coordinating agency between NASA and the Department of Defense (Aeronautics and Astronautics Coordinating Board).

The evolution of the present day space management organization, functions and coordination has not been smooth nor is there unanimity in agreement that the present organizations and relationships are adequate or desirable. In April 1961, Representative Daddario summed up the effectiveness of the nation's space management as follows:

> Under the previous Administration, [President Eisenhower] this legislation expressing the intent of Congress in space matter was thwarted. The Space Council was seldom convened; its director and staff never appointed. The President delegated his function to the Administrator of NASA who was essentially free to pick and choose as he saw fit in the administration of the civilian space program.
>
> The military, not relieved of its responsibility for protecting the National Security, went on its own way. Its activities on the fringes of

> space continued; occasionally it defended its plans as necessary to the National Security, but mostly it carefully disavowed any claims to the space arena, deferring to the primacy of NASA, under the law. Thus, in effect, under a veneer of words and documents, the groundwork was laid for unnecessary conflict in what should have been regarded as a broad-spectrum program in search of National Objectives. (25:1)

President Kennedy has taken action to improve the degree of executive control over the nation's space program by making the National Aeronautics and Space Council an operating and effective agency under the chairmanship of the Vice President. (79:1) (See Appendix F) However, the Services in the Department of Defense have expressed varying degrees of concern over the present research and development organization and functional alignment, and in the assignment of responsibility for operational employment of some space systems.

The Army states that its participation in the national space effort is but a small part of the overall effort. But, it is concerned over the possibility that a single service will be given overall responsibility. During a recent Congressional hearing, Lt. Gen. Arthur G. Trudeau, Chief of Research and Development, Department of the Army, stated:

> Now we have a new environment - space - erroneously considered by some to be a completely separate entity and as erroneously by others to be integral with the atmosphere. While a thoughtful appraisal of this situation reveals that it certainly is neither, space can be considered as a medium in which, or through which, military systems of the various services can operate to achieve military objectives in support of currently assigned roles and missions. Thus, space is not to be considered unique as the exclusive territory of operations of a particular service, but it is indeed a most useful and potent new environment to better support recognized military missions for each and all services. (78:50)

The Navy is adamant in their belief that the tri-service approach in research and development is best and that the three services, in committee action, can agree on working requirements for test vehicles and programs. Admiral Hayward, testifying before the House Committee on Science and Astronautics, expressed his feelings about attempts to justify Air Force responsibility of military space programs because they are getting most of the money.

> I personally take exception to the discussions about the Air Force being responsible for 91 percent of the effort. If you relate effort to dollars, why, nuclear propulsion would have been given to the Air Force years ago, because Admiral Rickover got operating submarines, he got everything going for less than a third of the price that you put into the aircraft nuclear propulsion program. Every time you relate effort to dollars percentage-wise this is when I take exception. I think we have competent people and have demonstrated competence. We might have only nine percent of money, total money, but I feel we have ninety percent of the accomplishments. (78:113)

The establishment of NASA and ARPA and their relationship with the Air Force caused a reaction from that service. The Air Force's principle of single agency management and control from research and development to operational employment was being violated by this split in responsibility. A report by the House of Representatives Committee on Oranization and Management of Missile Programs had the following to say about the Air Force's position on management of space programs.

> As the service responsible for operational control of landbased strategic missiles, the Air Force considers that it should control the major work in military space technology to further its strategic requirements. Offensive weapons, missile early warning and other missile defenses, reconnaissance satellites, and supporting systems, are space related matters which the Air Force considers as properly within its sphere. General Schriever said: "...unless the Air Force is clearly given the responsibility to do these missions in space, we might very well end up by being a transport or logistical service."

According to Gerneral Schriever, eighty percent of ARPA's dollars are spent through the Air Force. In his view, ARPA well could be abolished as an operating agency, in order to "bring the operator and developer together under the same tent" - - Flying The Air Force Flag. (76:147)

The above statements selected by the writer were the most radical views that could be found, in print, by, or concerning the heads of the services' research and development departments. They are in no way intended to indicate the degree of animosity over the Department of Defense's space organization and assignment of responsibility. Rather, they are an exaggeration to indicate that there will probably always be some animosity between the services as long as there is control exercised over their research, development and operational programs.

Based on the preceding material and other readings, it is this writers firm conviction that the United States' space management, organization, and assignment of responsibilities is evolving toward a good end. The present civilian-military split in the nation's space and science programs is proper and necessary. There are many space studies and projects with overlaping civilian and military interests, but the field is so broad and complex that it would be impractical, if not impossible, for one operating agency to attempt to manage and control the entire effort.

President Eisenhower's early, strict policy of not allowing the military to plan, manage or control any part of the nation's space program has been modified considerably by President Kennedy. Vice President Johnson, as Chairman of the National Aeronautics and Space Council, voiced the position of the present administration when he stated, "Space programs have benefits which can apply to both civilian and military space efforts. It is not useful to pretend that arbitrary distinctions can or should be made between the two." (9:14)

The present national space organization and assignment of functional responsibilities, civilian and military, provide the means to effectively manage the program. It is up to the leaders of NASA and the Department of Defense, including the services, to see that the system works.

CHAPTER II

UNITED STATES NASA AND MILITARY SPACE PROGRAMS

The United States' space programs and technology are expanding rapidly. The country expects to spend approximately fifty billion dollars in the 1960s. By 1970, the goal is to move ahead of Russia, master space with men and instruments, and land men on the moon. Congress has been asked to provide five and one-half billion dollars for civilian and military space programs in the fiscal year 1963. (3.8 billions for NASA; 1.5 billions for DOD; 200 million for AEC and the Weather Bureau) NASA indicates that it will need almost six billion dollars a year after 1963 for its program alone. (69:38)

The National Aeronautics and Space Agency has developed and published its general space program and objectives. The Department of Defense space program is of necessity classified; however, there is sufficient unclassified information available to review specific areas of interest. To develop a comprehensive and objective concept of military operations in space, it is essential that significant space science programs and projects be reviewed from the standpoint of their military application. NASA and military efforts must be considered complimentary. Dr. Edward Welsh, Executive Secretary of the National Space Council, in speaking of the national space program stated. "In my view, we do not have a division between peaceful and non-peaceful objectives for space. Rather, we have space missions to help keep the peace and space missions to help increase our ability to live well in peace." (9:14) It is in this context that each of the NASA and Department of Defense space programs are reviewed.

National Aeronautics and Space Agency's Mission, Objectives and Program. During recent hearings before the United States Senate Committee on Aeronautical and Space Sciences, NASA representatives defined their mission as follows.

1. Formulate specific national objectives and develop a comprehensive program for the study and peaceful utilization of space.
2. Conduct research leading to practical solutions of problems of Aeronautics and space flight.
3. Develop and operate appropriate vechicles for the scientific investigation and practical utilization of space for peaceful purposes.
4. Arrange for participation by the scientific community in planning and conducting scientific flights of aircraft and space vehicles.
5. Provide for the widest practicable and appropriate dissemination of information concerning these activities and results. (88:9)

The fulfillment of this mission resulted in NASA developing broad objectives encompassing three specific areas: (1) Production of scientific data on the environment of the solar system and galaxy essential to space utilization, and a better understanding of the physical universe and its relation to man, (2) Studying the practical applications of earth satellites to weather research and forecasting, communications, navigation and other similar tasks, and (3) the exploration of problems of man in space including at first, manned orbital flights around the earth, and later flights to the moon and beyond. (86:10)

Basic research and scientific investigation is an important part of NASA's space program. Although their program is directed primarily toward the investigation of man's relation to space, it is extensive and widely diversified with a minimum of control as to the direction of any particular project. NASA's research program can be catagorized into three basic areas: (1) Flight Medicine and Biology encompassing man-machine intergration, stress tolerance, weightlessness, crew performance, protection-including radiation shielding, life support systems, ground crew and public health aspects; (2) Space Medical and Behavioral Sciences in areas of weightlessness, isolation, nutrition, artificial life support, radiation, acceleration, vibration, effects of confinement on man's behavior, respiratory physiology, endocrinology, radiology, metabolism and cardiovascular physiology; and (3) Space Biology dealing with ground based scientific studies of the effect of extraterrestial environments on living organisms, including decontamination techniques for space craft which are designed to impact or land on extraterrestial bodies. (86:61)

It is not practical or necessary to discuss any of the above programs in this paper. It is sufficient to note that those areas involving man's flight into space must be thoroughly investigated and all problems solved prior to his launching.

The large majority of NASA's flight projects are oriented toward supporting the Man-in-Space program and the development of useful (public and private) applications for space satellites. The following is a brief review of those projects that are related or complimentary to the country's military space needs. (See Appendix G)

<u>Communications Satellites:</u> ECHO--The first communications satellite to be launched was ECHO I on 12 August 1960. It was launched to demonstrate the possibility of using large inflatable spheres as passive communications reflectors and to study the behavior of these large lightweight structures in a space environment. In addition to demonstrating the feasibility of using this type of system for radio transmission relay, ECHO I, proved the theory that solar radiation exerted pressure on a sphere in space. Severe solar flares

on 12 November 1960 and on 5 December 1960 gave increased drag on the satellite by a factor of two and caused a change in its orbit, altitude and period. The reflector type communications relay system would be highly reliable as it contains no moving parts, nor does it require an airborne power source. It does have the disadvantage of requiring very high powered transmitters and large receiving antennas on the ground for wide band communications. An advanced program is expected to commence in 1962. (86:301)

REBOUND--A follow-on program to ECHO, that would use a number of passive communications satellites (at least 12) spaced around the globe in 1,700 mile orbits. The REBOUND program is not firm at this time, but if it materializes, launchings will take place during the 1963-1965 time period. (70:127)

RELAY-A NASA study on the practicality of an active transponder communications satellite system utilizing a large number of light weight vehicles, approximately eighty-five pounds, for commercial application. The satellites will be placed in random 3,000 to 4,000 mile orbits with an inclination of forty-eight degrees to the equator. It is estimated that as many as forty satellites will be required for world wide coverage. (53:17)

SYNCOM--A NASA study on a commercial communications system utilizing active transponder satellites in a 22,300 mile stationary orbit inclined thirty-three degrees to the equator. These satellites will not be truly stationary, relative to a point on earth, due to the inclination to the equator. However, three satellites evenly spaced around the globe will provide world wide coverage at all times. (53:17)

The American Telephone and Telegraph Company is actively participating in the development of the NASA communications satellite program and has been given authority to build a test satellite to be launched by NASA. The government has not resolved the problem of private business participation. However, the National Aeronautical and Space Council has drafted a bill (awaiting Presidential approval) to be presented to Congress that would allow private companies to operate the global communications system at a profit, but would impose federal controls. This is a compromise between private and public ownership. (96:20)

The NASA SYNCOM communications system is very similar to the Department of Defense's ADVENT program, except that ADVENT is planned to be placed in an equatorial orbit. The commercial aspect of NASA's program necessitates some duplication in this field. Proper coordination and free exchange of information (less classified material) between NASA and the Department of Defense is essential and should accelerate both programs.

Weather Satellites: (See Appendix G) TIROS (Televison Infra-red Observation Satellite)--TIROS is the NASA research and development program being conducted prior to initiating an operational United States Weather Bureau meteorological satellite system. TIROS I was launched 1 April 1960 using two television camera systems. One camera had a wide angle lense and took pictures of an area seven-hundred miles on a side. The other camera coverage was seventy miles on a side. Stored data was passed to the acquisition stations at Fort Monmouth, New Jersey and Kaena Point, Hawaii. TIROS I had a useful life of only seventy-eight days due to a system failure. During its life, TIROS I made 1,302 orbits and provided 22,952 pictures. Sixty percent of the pictures were considered to be of meterological interest. TIROS II, was launched 23 November 1960. The differnce between TIROS I, and TIROS II, was the installation of infra-red sensors to measure the radiation from the earth and atmosphere, and a magnetic coil to partially control the attitude of the satellite. The results of the wide angle camera in TIROS II, were a partial failure for it produced pictures that were out of focus. However, some useful data was obtained. The Air Force was particulary pleased with the nephanalyses (storm origination) coverage provided by TIROS and stated that fifty percent of the nephanalyses transmitted met its criteria of timeliness and coverage in the areas of interest. Navy comments from the fleet were most enthusiastic; but, they are highly desirous of a direct readout capability for their fleets. (86:270) Subsequent TIROS satellites will be launched to improve techniques and perfect the system to be used in NIMBUS.

NIMBUS--NIMBUS is the operational follow-on program to TIROS. It will be a family of satellites with many common components (data storage, camera direction controls, satellite stabilization, data transmission, physical structure,ect.). NIMBUS will be placed in a polar orbit. The satellite will be earth stabilized so that the cameras will be pointed toward the earth at all times. Plans call for data to be sent, in real time, from the data acquisition station at Fairbanks, Alaska, to the National Meteorological Center of the United States Weather Bureau at Suitland, Md.. There the data will be analyzed and the resulting weather information distributed to both civilian and military weather stations. (86:291)

AEROS--In addition to the polar orbiting NIMBUS weather satellites, there is a requirement for a capability not only to detect storm centers, but also maintain continuous surveillance of the storms. NASA proposes to accomplish this by using a stationary weather satellite orbiting at 23,000 miles in the earth's equatorial plane. The satellite will be stabilized with the television cameras oriented toward the earth. The cameras will have variable focus and wide angle lenses controlled from the ground. Further, the direction of the cameras (area of coverage) will be controllable from the ground. AEROS is a supplemental program to NIMBUS. (3:47)

The Navy has expressed the need for a tactical weather satellite program (using TIROS type cameras and sensors) that will provide direct read out weather photographs to ships at sea. Their project, RENAE, is in the proposal state. The probable future of RENAE will hinge on the adequacy and timeliness of NASA's NIMBUS and AEROS programs.

NASA's weather satellite program will effectively utilize a correlative and interacting world-wide net of ground-based, lower atmosphere data collecting, processing and distributing facilities. A sophisticated electronic screening process will be required to evaluate the usefulness of the thousands of weather photographs that will be taken by the weather satellites. (6:10)

Orbiting Observatories: NASA's Observatory program consists of three basic projects - OAO (Orbiting Astronautical Observatory), OGO (Orbiting Geophysical Observatory), and OSO (Orbiting Solar Observatory). The project of most interest to this paper is NASA's OAO which will eliminate the effects of the atmosphere on visual observation of the stars, sun, moon and earth's sister planets.

The OAO satellite will weight about 3,500 pounds, contain telescope mirrors up to thirty-six inches in diameter and will be placed in a five-hundred mile orbit inclined thirty-two degrees to the equator. Stability of the satellite is a very critical item if satisfactory acquisition and observation of the astronomical body is to be accomplished. The OAO satellite is designed to be stablized in space to plus or minus one tenth of a second of circular arc. (70:127)

Rocket Propulsion Engines and Booster Vehicles: (See Appendix H) Power to accelerate a vehicle or satellite into space, plus power to control its trajectory is the biggest problem facing the space scientist. The propulsion systems available at the present time provide relatively large amounts of thrust for very short duration, and in most cases are one-shot systems, i.e., once initiated, burn until cut-off with no restart capability. The type of rocket engines and booster vehicles developed in conjuntion with the missile program have not satisfied the requirements of the country's space program. The spectacular success of the Soviet Union's space accomplishments have caused the development of large and versatile rocket booster systems to become the key word in the United States space effort.

The rocket engines used by NASA in accomplishing their space program have in the most part been variations of existing military ballistic missile engines. However, they have, in close coordination with the Department of Defense, been pursuing the development of a wide variety of new engines that will provide the thrust and versatility needed. Those of primary interest in the developing of this paper are discussed below.

Liquid Propellant Rocket Engines: The latest and, probably the last large liquid oxygen-kerosene engine that will be developed is the Rocketdyne F-1, 1,500,000 pound thrust single chamber engine. NASA's present plan is to use this engine in a cluster of five to provide the first stage of Saturn C-5 launch vehicle.

The use of liquid hydrogen as a propellent appears to be the key to the success of NASA's launch vehicle program. Two liquid hydrogen-liquid oxygen rocket engines are being built; the Pratt and Whitney RL-10 which develops 15,000 pounds of thrust and the Rocketdyne J-2 which develops 200,000 pounds of thrust. Combinations of the large LOX-kerosene and the new LOX-LH appear to be able to satisfy the large thrust requirement for launch vehicles. If hydrogen engines do not prove satisfactory, virtually all existing space-booster plans will have to be reoriented. For example, if hydrogen is used in every stage except the first stage of a Nova-type vehicle designed to fly direct to the moon and return without rendezvous, it would weight less than ten million pounds. If kerosene had to be substituted for hydrogen, the vehicle's weight would go up to about fifty million pounds. (18:96)

Nuclear Rocket Engines: NASA and the Atomic Energy Commission are pursuing a nuclear rocket engine program, ROVER, that will provide a medium thrust engine for use on the last stage of advanced Saturn and Nova launch vehicles. The present design uses reactor heat to accelerate and expel hydrogen that is carried on board the spacecraft in liquid form. The amount of liquid hydrogen stored will limit the time that thrust will be available. However, this time will far exceed that of any propulsion system in development today, except the electro-magnetic type engines.

Electro-Magnetic Rocket Engines: A large number of

American electonics companies, under contract to NASA and the Department of Defense, have been studying the feasibility of electrically powered space engines using the principle of expelling highly accelerated ions. There are several types of electro-magnetic engines under development; ion engine, plasma engine, plasma pinch engine, etc. However, the characteristics of all electro-magnetic engines are similar to those of the United Aircraft Research Laboratories' ion propulsion system: (1) Exhaust gas velocity-55,500 miles per hour; (2) Thrust-0.4 pounds; (3) Powered time-4 months; (4) Total fuel weight-4,000 pounds. Ion engines will have to be launched into orbit by high-thrust vehicles. Once in orbit or space they can provide power for maintaining and changing orbits, or provide acceleration and deceleration thrusts for long periods. Practical ion systems should be available by 1970. (61:7)

Solid Propellent Rocket Engines: Solid propellent boosters have been used extensively for military missile weapon systems and for upper stages of orbital flight and space probe vehicles. It has only been recently that very large thrust solid propellent engines have become practical. Although NASA has turned over the responsibility for development of large solid propellent rocket engines to the Department of Defense, it is appropriate to discuss them in this portion of the paper. The smaller 115,000 pound thrust and less, solid rocket engines have demonstrated a high degree of reliability. The Thiokol Chemical Corporation states that, "the in-flight reliability of Thiokol-produced solid propellent engines has been 99.9-plus percent. More specifically, in some 6,500 flights, only six failures attributable to propulsion have been encountered." (27:18) Solid propellent booster engines with thrusts up to five million pounds are practical and can be made to operate with the same reliability as the smaller solid propellent engines. At the present time, NASA is not considering the use of large solid propellent boosters for its man in space program. However, with the development program being conducted by the Department of Defense, this type of booster will be available.

Anti-gravity Systems: The dream of anti-gravity belts is as old as history. It is still a dream and a long way off unless there is some important technological breakthrough. Both the Soviet Union and the United States are slightly active in the study of anti-gravity. (12:27)

Space Launch Vehicles: The success of the United States space effort from the standpoint of success versus failures leaves something to be desired. The ratio of space vehicles put into orbit versus attempts is about fifty percent in over eighty launches. Dr. Harold Brown, Director of Defense Research and Engineering, Department of Defense claims that the practice of building a separate vehicle and control system for almost every payload plus the tendency to try to get every last possible performance out of each component is the major reason for the poor record. (16:54)

NASA is in the process of standardizing their launch vehicles. Through this process NASA hopes not only to increase the over-all reliability of the systems, but to reduce the cost of production. The present cost per pound in a three-hundred mile orbit is $3,500. By 1965 this should be cut to $1,000 per pound primarily from greater experience in manufacturing and launch operations, the use of larger and more advanced vehicles, and the use of more efficient hydrogen fuel. (20:101)

One of the major cost factors in launching satellites today is the loss of the booster hardware after each staging. The boosters are the most expensive part of the rocket. Development of a system to recover launched boosters has a high priority with both NASA and the Department of Defense. Dr. Werner Von Braun, in an address to the Explorer's Club stated that a booster recovery system is possible. He outlined a plan to use controllable paragliders (a parachute that takes the form of a glider when deployed) for the recovery of the Saturn first stage. (93:6) With such innovations it should be possible to reduce the cost per pound in orbit to as little as $100. (20:101)

NASA plans to use standard launch booster systems in the conduct of their earth satellite experiments and space exploration programs. (See Appendix I)

Auxillary Electric Power Systems: The increased complexity of space vehicles has required more and more electrical auxillary power. Solar energy, converted to electricity (solar cells) and stored in satellite borne batteries, has been the primary method of providing electricity to satellites. Nuclear reactor heat energy appears to be the next technological advance in the production of electrical power for satellites and space ships. Application of the first thermo-electric generator was announced to the world by President Eisenhower on 16 January 1959. The SNAP-3, atomic battery had provided the first atomic power to be used in a satellite. (91:32) The SNAP (Systems for Nuclear Auxiliary Power) program is investigating two different methods of electrical generation; thermo-electric and the turbogenerator.

SNAP 1-A: A thermo-electric plant designed to produce two hundred and fifty watts continuously for one year. This type of plant converts the heat generated by the nuclear reactor into electrical energy by use of thermo-electric elements. The automatic reactor controls are the only moving parts involved in this type of system. Final tests for SNAP A-1 are scheduled for early 1962. (90:30)

SNAP 2: A five kilowatt mercury vapor turbogenerator plant. This plant uses the heat from the nuclear reactor to vaporize mercury which in turn drives an electric generator. The third phase of testing for the SNAP 2 is scheduled for 1963. (90:31)

SNAP 8: A larger version of SNAP 2. This plant is programmed to produce sixty kilowatts of electrical power. The entire unit will weigh some three-hundred pounds. It is anticipated that SNAP 8 will be ready for flight test in 1966 and will provide power for the first ion engine tested in orbit. (90:34)

SNAP 10: A completely static thermo-electric power unit that will provide three hundred watts of electric power. SNAP 10 will be particularly practical for manned space use, as it will be designed to start after it is in orbit. Shielding will not be required until the spacecraft is in orbit or outer space, thus simplified methods of shielding such as shadow shields and trailing the reactor may be used. (91:34)

SNAP 10-A: A large SNAP 10 plant designed to produce five hundred watts of electrical power. (90:34)

Project Sunflower: A project to develop a spaceborne solar power plant that will generate three killowatts of electricity continuously for one year. NASA expects to have two proto-types ready for flight testing in 1964. (70:128)

<u>Manned Space Exploration: (See Appendix J)</u> The heart of NASA's overall space effort is its man-in-space program.

Nearly every NASA project is directly related to this program.

On 1 August 1958, Dr. Hugh Dryden, then Director of the National Advisory Committe for Aeronautics, now Deputy Administrator of NASA, presented a program to the Select Committees of Congress on Astronautics and Space Exploration, which he called, Technology of Manned Space Flight Vehicles. At that time he implied that manned orbital flight could be accomplished some time in 1961. (86:146) The Soviet Union fulfilled Dr. Dryden's prediction; the United States did not.

NASA's space exploration program consists of several specific and inter-related projects. The program is designed to provide for an orderly and systematic progression of landing man on the moon; then further exploration of the solar system. A review of this program follows.

Project Mercury: The first step in NASA's manned space exploration program is their project to place a man in an earth orbit: Project Mercury. All portions of the project have been completed except the final act of manned orbital flight. The sub-orbital unmanned and manned flights were completed after Commander Allen B. Shepard, Jr. and Captain Virgil I. Grissom made their flights in May and July, 1961 respectively. The unmanned orbital flight series were completed when Enos, a chimpanzee successfully completed two orbits of a scheduled three orbit flight on 29 November 1961. Project Mercury will be completed when a man is placed into orbit more than a hundred miles above the earth, has circled the earth three times, and been returned safely to earth.

The day this paragraph was written, 27 January 1962, Lt. Col. John H. Glenn, Jr. was in his Atlas boosted Mercury capsule, "Friendship 7", ready to attempt the first American orbital flight. The flight was postponed due to weather in the launch area. Flight MA-6 has been rescheduled for February 1962. Upon successful completion of the one man Mercury flights the project named will be changed to Gemini and expanded to a two man orbital program. (69:38)

Project Ranger: Being conducted concurrently with Project Mercury. Ranger is one of the steps that must be accomplished prior to landing a manned vehicle on the moon. Ranger III was launched 26 January 1962. The object of Ranger III is to make a semi-soft landing on the moon. During the last two thousand to twenty miles from the moon a vidicon telescope will take approximately one hundred pictures. The first pictures will cover an area twenty-five miles on a side, while the last pictures will cover an area two thousand feet on a side with a resolution between ten and twenty feet. At twenty miles altitude, the scientific capsule (a fourteen inch sphere) will be separated from the vehicle, allowed to stall-out by a spin retro-rocket, and then impact on the moon at a velocity of approximately one hundred and fifty miles per hour. The scientific capsule contains a single axis seismometer that is to remain active for one to three months. Ranger III will test the Atlas Agena-B booster system, the vehicle guidance system and obtain scientific information to help determine the origin and structure of the moon. (86:259) At the time of this writing, Ranger III is approximately half way to the moon. The success of the launch appears doubtful as the Agena-B velocity at nose cone separation was too high. Ranger III is predicted to miss the moon by twenty to thirty thousand miles. The next step in the Ranger program has not been announced.

Project Surveyor: A continuation of the Ranger program. The unmanned Surveyor will make the first fully controlled soft landing on the moon. The landing vehicle will contain approximately two hundred and fifty pounds of scientific instruments, including television cameras with variable magnification and color-stereo. In addition it will carry drills and spectrometers to determine the moon's soil composition. The purpose of Surveyor is to test techniques for guidance, control, communications, and landing technology for later manned missions. (86:259)

Project Prospector: A continuation of the Surveyor program. The primary purpose of Prospector is to soft land a mobile truck on the moon. The truck will be controllable from the earth and equipped with cameras, soil sampling equipment, etc. The truck will be capable of traveling fifty miles from the landing point. Later versions of Surveyor will provide for rockets to return a lunar soil sample back to earth. Further, it is anticipated that the truck could be used to collect and segregate supplies and equipment landed on the moon prior to the arrival of a manned expedition. (86:261)

Project Voyager: The Voyager spacecraft will be designed to orbit Mars and Venus. The spacecraft will contain television cameras and normal radiation, thermo, magnetism, etc. equipment aboard. The spacecraft will eject capsules for scientific measurements during their atmospheric penetration and after impact. Project Voyager will be started as soon as the state of the art permits. Completion of Ranger, Surveyor and Prospector are not prerequisites to Voyager. (86:261)

Project Apollo: NASA's manned lunar landing program.

The initiation of Apollo flights is keyed to the completion of Mercury and sufficient Ranger, Surveyor and Prospector flights necessary to test all the techniques required to land men on the moon and return them to earth. The Apollo spacecraft will be built to carry two or more men. The steps in the project call for extended earth orbits and return; circum-lunar flights and return to earth; and finally, a lunar landing and return to earth. (86:146)

NASA recently made the decision to use the rendezvous orbit concept to accomplish the Apollo project. (19:41) This decision is extremely important to the Department of Defense. Establishing an earth orbiting space station has long been a major goal of the military. Development of space planes capable of rendezvousing with orbital vehicles, and the development of the necessary support equipment will be required before placing a space station in orbit. Although NASA has not decided whether the Apollo rendezvous will be accomplished in an earth orbit or a moon orbit, the development problems will be the same. The combined efforts of NASA and the Department of Defense can now be directed toward a common goal.

<u>Department of Defense Space Interest and Activities</u>:

The high ideals and hopes for the peaceful use of space exploration, as expressed by the Congress in their enactment of the National Aeronautics and Space Act in 1958 are gradually being modified. The Soviet Union's subtle threats that the engines that carried Major Titov around the world could also carry super atomic weapons; and their resistance to participation in the United Nations' Committee on Peaceful Uses of Outer Space have led to a general disenchantment with space for peace. Senator Stuart Symington has remarked that Congress had made some errors in writing the Space Act and that he for one, was willing to take his share of the blame. (42:65)

The lessening of restraint on the military is permitting freer planning, discussion, and investigation of the use of space for the security of the nation. The following discussion of the unclassified aspects of the Department of Defense's space programs is broken down into four areas: (1) Intelligence gathering; (2) Command and Control; (3) Defensive systems; and (4) Offensive deterrant systems.

Intelligence Gathering Space Systems: The gathering of intelligence is a broad field. It encompasses all programs designed to obtain data that is useful in furthering the capability of the military to accomplish its mission.

Project Discoverer: The first active satellite launching program conducted by the Department of Defense. The Discoverer program is basically a scientific investigation program designed to gather data on satellite attitude stabilization techniques, environmental information for biomedical studies, payload recoverability, infra-red missile detection equipment, visual observation techniques, orbit control,etc.. (70:128) The Discoverer program has demonstrated the feasibility of several important theories. (1) That standardization of a booster system will improve reliability. The Thor-Agena booster has been used for all Discoverer launches. Its reliability, satellites in orbit vs. attempts, is approximately seventy percent. This is considerably better than the United States' all over space system reliability of fifty percent. (2) That the Agena-B engine can be stopped and restarted in flight upon command from the ground. This procedure was used in the injection of Ranger III into its trajectory to the moon. (3) That an orbiting vehicle can be returned to earth with a relatively accurate prediction of the landing point. (4) Demonstrated the capability to air-snatch a ballistic capsule descending by parachute after re-entry. (5) That living cells can survive in space using existing state of the art shielding against radiation.

SAMOS: (See Appendix K) The so-called spy in the sky program. Samos is a program to place a series of visual observation satellites into polar orbit to provide visual reconnaissance of the entire earth's surface. (70:128) Although details are classified, it is known that Samos will have the capability to take pictures of the earth's surface and transmit them to data collecting centers where they will be analyzed for intelligence purposes.

The problem of making effective use of the vast numbers of photographs by Samos and follow-on reconnaissance vehicles was pointed out by the time required to analyze the 23,000 pictures taken by TIROS I. The analysis of Samos photographs is estimated to require thousands of man hours for each hour the satellite spends over an enemy area of interest. Recent Office of Naval Research tests of a machine designed to scan large quantities of pictures for pre-determined types of objects such as ships, missile sites, cloud formations, etc., indicate that this problem can be solved. (40:32)

Short term observation satellite systems: The military commander has always been plagued with a lack of knowledge of his enemy's position and capability. The availability of current, accurate tactical intelligence has many times been the contributing factor to the success or failure of a military action. All three services in the Department of Defense view the orbiting satellite as a means to gain this intelligence.

The Navy's Yo-Yo- program is a study of the possibility of employing satellite vehicles, sea launched, to make single orbital passes over desired areas for quick reconnaissance. The Navy program will use NASA's Scout booster for this program. (70:128)

The Air Force is studying a short term manned reconnaissance system (SR-178) which will have the capability of obtaining quick observational data. (70:128) Although the Army has not disclosed a similar project, it is readily apparent that such an observation system would also be very useful to them.

Project VELVA HOTEL: A satellite system for detection of nuclear explosions in space. Velva Hotel contains detectors that are sensative to bursts of X-rays. The satellite will weigh about three-hundred to four-hundred pounds, be forty inches in diameter and be placed in a 50,000 mile orbit by an Atlas Agena-B booster. Probably twelve satellites, launched in pairs, will be used to provide reliability against false alarms from bursts of solar emitted X-rays. The detectors are sensitive enough to detect 1/100th of the burst of X-rays that would be emitted from a one megaton weapon detonated twice the distance from the earth to the sun (3×10^{8} KM). (50:12)

Command and Control Systems:

> The over-riding factors [of command and control] have become; the capability to apply controlled response under competent national authority; the compression of time; the expanded theater of operation; the increasing importance of decisions that are right the first time; the lessening of the commander's ability to see and actively direct the battle; and the need for systems which can survive to function in a post-attack period. The weapons of war have indeed made it increasingly difficult for the commander to carry out his functions. (75:5)

Communications Satellite Systems: Adequate, reliable and flexible communications have always played an important part in the successful accomplishment of military missions. Survival of the country's deterrent force and its subsequent employment against the enemy is tied directly to the nation's communications capability. The successful deployment and control of the nation's conventional war forces are tied directly to the nation's communications system. Communications are the heart of a command and control system. The Army's Advent and Courier communications satellite programs are designed to provide the advanced technology necessary to make an adequate, reliable and flexible world wide communications net a reality. Advent is a twenty-four hour instantaneous repeater communications satellite system using a number of satellites in a 22,300 mile equatorial stationary orbit. Advent will be similar to NASA's Syncom project. (80:6) Courier is a low orbiting delayed-repeater satellite communications system that will provide for insertion of a message that will be stored until called for by a command on the ground. For example: a message could be inserted as the satellite passes over Washington and called out as the satellite passes over a commander in the western pacific area. (70:128) The Air Force Osar project is an investigation of a passive lens reflector communications satellite system similar to NASA's Echo project. This satellite would have the same reliablility as Echo but by use of stabilized lens reflectors would not require the high powered ground transmitting and receiving equipment. (52:23)

Navigation Satellite System: The Navy managed Transit program is the major active navigation satellite project in being today. Transit utilizes the doppler frequency shift principle to provide surface receiving stations with the necessary information to locate their geographic position. Transit will enable surface ships and submarines, especially Polaris, to fix their positions with an accuracy of one tenth mile.

The operational Transit system will consit of four satellites; two in polar orbit and two in equatorial orbit. All four satellites will be at an altitude of approximately five-hundred miles. (3:47) The Navy has stated that Transit has demonstrated its ability to meet designed and operational requirements. The weight of the operational satellite will be reduced to permit use of the standard Scout booster, and will cost approximately one million dollars per launch. The first operational satellites are planned to be launched in late 1962. (58:8)

Defense Systems: The major indefensible threat to the United States is the Soviet Union's Inter-continental Ballistic Missile. The only active anti-missile program being pursued by the United States today is the Army's Niki Zeus. Niki Zeus is a terminal system based on radar acquisition, tracking, discrimination, launching of the interceptor missile, and interception of the incoming war head. The system is complicated, expensive, and completely automated from detection to kill. The Niki Zeus system is still in the development phase and has not been ordered into production. The results of tests to be conducted in 1962 will undoubtedly determine if Niki Zeus is to be the country's weapon system to combat the ICBM. (6:29)

There are several other approaches to the anti-ICBM that are being studied. The most desirable time to "kill" an ICBM would be during the boost phase. However, the problems are tremendous. Within the two to five minutes the missile is in this phase, the defense system must detect, lockon, make the decision to kill and then intercept the missile. It is also possible to intercept an ICBM during its mid-course flight phase. This is the longest period of time available, but it is the time that the war head is the most difficult to detect and lock on with radar. Unless there is a break through on a means of sensing the war head, use of the mid-course phase is impractical. (23:9)

Air Force project Bambi was initiated to determine the feasibility of using orbiting satellites to provide the platform for an anti-ICBM booster phase defense system. The name Bambi was officially dropped by the Air Force to emphasize that the program is a techniques study rather than a weapons system effort. (8:23) Because of the complexity and cost of a satellite booster-phase kill system, high defense officials feel that the follow-on to Niki Zeus will be a terminal system and probably fairly simple. (23:42)

Tied closely to the anti-missile program is the Air Force project MIDAS. (Missile Defense Alarm System) Midas is designed to detect aggressive missile launches using infra-red sensors aboard polar orbiting satellites. (70:128) Midas will assist in providing the maximum possible time for making national decisions and launching the country's deterrent force.

It is generally conceded that an anti-ICBM system requires a higher state of technology than an anti-satellite system. Successful development of Niki Zeus will provide the basis for an anti-satellite capability. However, it would not be in the nation's interest to destroy a suspected threatening satellite unless it could be inspected and the intent or capability of the satellite to harm the

United States positively determined.

SAINT is an Air Force project to develop a satellite rendezvous and inspection system. (70:128) The military and the NASA Apollo rendezvous requirement are closely related. Close collaboration in these programs will be beneficial to both agencies.

Offensive Systems: At the present time unmanned satellites do not appear to be practical for use as an offensive military weapon system. Although it is possible to place atomic weapons in orbit, and the technology is available to direct their re-entry into a desired area; the cost of the system and its probable unreliability make it much less attractive than the proven surface based ballistic missile systems. Development of a controllable manned orbital vehicle could prove to be an effective bombing platform. However, as discussed previously, unless the vehicle is in an extremely high orbit, it would be relatively vulnerable to enemy action from the ground..

DYNA SOAR (Dynamic Soaring) is an Air Force project to place a man into low controllable orbital flight. The vehicle must be capable of withstanding the heat generated by the outer atmosphere during orbit, maneuvering in the outer atmosphere, and re-entering to a controlled landing. The Dyna Soar program calls for its initial flights to be orbital rather than sub-orbital as originally planned. (2:8) The Titan II missile was selected as the booster for the initial Dyna Soar flights; however, the change from sub-orbital flight to orbital flight requires a larger booster. Titan III, a Titan II with two, one hundred and twenty inch five segment solid rocket motors attached to the first stage has been selected to boost Dyna Soar into orbit. (41:26)

Combining the aircraft with the space vehicle is a requirement that must be eventually fulfilled. The full advantage of either the atmosphere or space will not be fully realized until this is accomplished. The Space Plane must be capable of taking off from an earth runway; accellerate to 18,000 miles per hour and go into orbit; decelerate for re-entry into the atmosphere; and maneuver to a landing on a normal runway. Best indications to date are that the Space Plane is practicable and can be flown before 1970. Much of the information gained in the X-15 and Dyna Soar programs will contribute to the development of the Space Plane. (21:48)

This chapter has briefly reviewed the current and active space programs of NASA and the Department of Defense that are important to military operations in space. Chapter III will attempt to combine all the technological advances that should be realized by the early 1970s as they apply to projected military needs. It will develop a general concept of military operations in space for that time frame.

CHAPTER III

MILITARY OPERATIONS IN SPACE

> But tomorrow's space systems may use an altogether new kind of armament. Perhaps they will employ principles we haven't yet discovered - and won't discover until we get into space and learn in detail about the environment. Weapons which would be very limited in the atmosphere may not be so limited in space. Perhaps, they will be weapons that enable us to neutralize earth-bound ICBMs. If a new gerneration of armaments operated in space can neutralize an agressor's ICBMs, the world will enter a new era in warfare.
>
> General Curtis E. LeMay. (42:78)

The nineteen seventies will not only see man firmly established on the moon, reconnoitering Mars and Venus, and on their way to Jupiter and Saturn; but will see the United States and the Soviet Union expending every effort to utilize space as the means to gain decisive military superiority.

The application of space to military operations is a subject that has been widely discussed by civilians and military planners alike. Discussions have ranged from, space not being practical for military use, to hiding huge forces of space ships in outer space. The rapid advances made in space technology gives credulance to even the wildest schemes. It is the purpose of this chapter to develop a general, but objective, concept of military operations in space. This concept will be based on existing and projected space science capabilities and divided into four areas; exploration, defensive systems, reconnaissance systems, and offensive systems.

<u>Exploration</u>: The exploration and conquest of new territory has historically been the task of the military. The conquest of space is not following this pattern. NASA, a civilian agency, has been given this responsibility. The

reasons for this assignment of responsibility were adequately covered in Chapter I. However, it is important to note here that military participation in the exploration program is essential if the nation expects to derive the most out of its expenditure of effort and money. If there is close coordination between NASA and the military, NASA's goal of landing a man on the moon will provide all of the technology and hardware needed by the military to accomplish their initial requirement for manned orbiting vehicles and space stations. Further, joint participation will allow the military to take immediate advantage of any technological discoveries and new applications of space sciences to fulfill military requirements. The personnel manning NASA's exploration spacecraft will be primarily military with a few civilian scientific personnel participating. Continuation and expansion of the astronaut training program is essential to the over-all military and space exploration programs.

Defensive Systems: The country that develops an anti-missile/satellite weapon system sufficiently effective to prevent an enemy from delivering an unacceptable amount of nuclear weapons will, in reality, have broken the nuclear stalemate. General LeMay emphasized this point when he stated, "It stands to reason that it must be our technology which is first capable of disarming an aggressor's nuclear weapons. Because, if an aggressor nation bent on world domination should be first to acquire this capability, I don't think we would be permitted to develop an equal defense against his nuclear weapons or space armament." (43:78)

The outlook for the development of an economical and effective anti-missile/satellite weapons system is not promising. The one-for-one point defense principle used in the Niki Zeus system appears to be the only practical approach available in the foreseeable future. The cost, complexity and reliablity of Niki Zeus will prevent the United States from installing weapon complexes in sufficent numbers to meet the nineteen seventy threat. Future development of anti-missile/satellite weapon systems should be oriented toward meeting a surprise mass missile attack rather than develop ing an individual missile/satellite kill capability. The United States would not arbitrarily shoot down an unidentified orbiting satellite without first inspecting it to determine if it actually threatened the security of the country. To inspect such satellites requires developing the capability to detect, rendezvous, dock and physically inspect unidentified orbiting vehicles. (This will be done in conjuction with NASA's Apollo program) It is obvious that if the United States can intercept and inspect unidentified vehicles,it can also neutralize the vehicle without use of surface based anti-satellite weapons. The anti-missile problem presents the greatest defense weapon need. It is imperative that every advance in space technology be thoroughly investigated for application to an advanced anti-missile defense weapon system.

Reconnaissance Systems: At the present time, NASA and military space programs call for launching numerous unmanned orbiting vehicles designed to perform specific single functions. Each satellite system will require periodic replacement, vehicle recovery or specialized data read-out equipment, detailed tracking, etc.. As the space technology advances, the number and types of satellites required to effectively utilize the technology will increase to the point that it will be economically impossible to support the program. Low altitude and stationary high altitude manned space stations must be developed to permit consolidation and simplification of the equipment. It is anticipated that properly placed high altitude manned stationary space stations will provide consolidated facilities for alternate national command and control centers, world wide communications terminal/relay points, constant selected area weather observation, astronomical and geophysical observations, nuclear detonation detection devices, satellite monitoring and cataloging centers, and platforms for many other scientific observation equipment.

Highly sophisticated multi-purpose reconnaissance and surveillance satellites will evolve from the Samos, Midas and Nimbus programs. Data from this system of polar orbiting satellites will be collected, screened and analyzed electronically and automatically distributed to the using agencies. The system will be serviced and repaired by using manned interceptor vehicles. The effectiveness of the system will obviate the need for major unified commanders to use short period reconnaissance vehicles as a primary source for tactical intelligence information. However, they will be maintained in the inventory for back-up in the event the primary system is disruped or destroyed during hostilities.

Low altitude orbiting manned space stations will be strategically located to provide a base of operations for interceptor vehicles and storage space for logistical support of the satellite system. Space planes using assist take-off devices will be utilized to shuttle personnel and equipment from earth to the space station and return. All in-orbit transportation requirements will be met by nuclear powered interceptor vehicles. The nuclear powered interceptor vehicles will be initially launched into orbit by large booster engines. Their nuclear engines will be started after they are in orbit. They will not return to earth due to the radiation hazard.

All space stations and orbiting vehicles will be equipped with small nuclear or electromagnetic engines to maintain or adjust their orbits.

Offensive Systems: Moral principles and world opinion will prevent the United States from placing unmanned nuclear weapon carrying vehicles into orbit. This restriction is not significant in respect to the nation's deterrant capability as surface based missiles will be more accurate, easier maintained and considerably less expensive. The same conditions apply to the Soviet Union. However, the Soviet Union will very likely place a limited number of nuclear weapons in orbit to propogandize superior technological development and military strength. The accuracy of these weapons will not be important, but the weapons will pose a threat that must be countered.

The United States, through its Dyna Soar program, will develop an offensive orbital weapon system that will provide an effective airborn-alert capability. The Dyna Soar orbits will be nearly equitorial to prevent over-flight of Russia and to make them less vulnerable to Soviet interception. The vehicles will be pre-targeted and have sufficient propulsive power to drop down from a 150 mile orbit into the outer fringes of the atmosphere, change orbit to over-fly their target, and continue to a landing in the United States.

The concept of military space operations contained in this chapter is far from being comprehensive or all-encompassing. However, it is sufficient to point out two factors:

that space has become an extremely important medium in the development of the nation's military strength; and that the application of space for new and advanced weapon systems is limited only by the initiative and imagination of the nation's military planners.

CHAPTER IV

CONCLUSIONS AND RECOMMENDATIONS

The United States government's decision in 1958 to advocate space for peace was in the final analysis an appropriate and astute move. The criticisms voiced against the NASA/military responsibility split have, in the most part, stemmed from two basic conditions: (1) During the Eisenhower administration the space for peace policy was so adamantly adhered to that governmental officials lost sight of the provision in the law that provided for the development of weapons systems for the defense of the country, and (2) The NASA and military space needs are so closely related and overlapping that it has been virtually impossible to determine which agency should be given the prime responsibility for specific programs.

The first of the above problems has been solved by the change in administration. Solution to the second problem will only be the result of effective management and close coordination from the highest level of government down to the lowest inter-agency coordinating group. The national space organizations, as they exist, provide the means to exercise good management.

The space for peace policy has provided several advantages to the United States. (1) The free exchange of technical information with allied countries and their active participation in space activities has broadened the collective scope of basic scientific research and channeled the participating scientific community toward common goals, (2) Open declaration of the nation's space goals has permitted the United States to take maximum advantage of the facilities of the United Nations and other international organizations to further the doctrine of freedom and self determination, (3) Announcing to the world that the United States is spending 5.5 billion dollars in the futherance of space for peaceful purposes is considerably more acceptable to the world and the United States' public than an announcement that the money is to be spent by the Department of Defense. It could be conjectured that Congress might be very critical of adding this amount to the already prohibitive military budget. (4) It is impossible to launch orbiting earth satellites without overflying another country's territory. The space for peace policy permits the United States to pursue, in good faith, a code ofr international law for space that is compatible with the free world ideology.

NASA's major short term objectives of landing a man on the moon, making soft instrument landings on Mars and Venus, and launching orbital probes to all planets of the solar system will necessitate their developing most of the basic space technology required by the military to accomplish their space goals. Time will not permit the military to wait for NASA to develop this technology before adapting it to military space systems. Consequently, it is essential that the military and NASA identify their common space goals and insure that the technology and hardware developed are compatible with both agency's requirements. An example of this type of cooperation is NASA's recent decision to use an orbiting space station as the launching and recovery platform for their man on the moon program. This will require placing a space station in orbit, developing manned space vehicles capable of rendezvousing and docking, and ferrying large quantities of equipment from the earth to the space station. All of the above projects are common and vital to military requirements. Benefits in economy, time, and quality of equipment will be realized by NASA and the military if proper joint planning and cooperation are affected.

Recommendations:

1. That every effort be made to determine common NASA and Department of Defense space technology and systems requirements, and that research and development projects be allotted based on capability and work load. Further, that a comprehensive policy to this effect be jointly established by the Director of NASA and the Secretary of Defense. This policy should be in sufficient detail to provide guidance to the lowest level of management and inter-agency coordination groups.

2. That the United States accept the fact that negotiations with the Soviet Union to establish acceptable international space laws are not practical. Based on this, the United States must be prepared to take advantage of the propoganda value of Russia's first attempt to destroy an orbiting American satellite. This writer assumes that the United States will not be prepared to reciprocate in kind as an anti-satellite program is not in development at this time. Also, it will not be likely that the Soviet Union will have satellites in orbit suitable for the United States to attack. Two actions that the United States should take as soon as possible are:

a. Immediately establish a cover for Samos and Midas launches and place Tiros/Nimbus and Advent type vehicles in polar orbit.

b. Develop contigency plans to take reprisals against the Soviet Union for hostile acts against peqceful satellites. Reprisal action could be based on the monetary value of the satellite (no human lives are involved) and could be preceeded by public announcements of the actions the United States intends to take.

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APPENDIX A

A Chronology of Missile and Space Events
(77:1 and various periodicals)

1946

Mar. - Army Air Force established Project Rand.
12 May - Rand report on "World Circling Space Ship."
6 Oct. - New York Times report on Space Travel to Other Planets.

1947

Oct. - Committee on Guided Missiles of Research and Development Board assigned responsibility of coordinating earth satellite programs scattered among the separate services.

1948

15 Jan. - General Hoyt S. Vandenberg approved policy for development of earth satellites.
21 Aug. - General Spaatz called for development of 5,000 mile missile
15 Sept. - Committee on Guided Missiles initiated Army "Hermes" project study for development of earth satellite.

1949

9 Feb. - Department of Space Medicine established at Randolph Field.
22 Mar. - Navy multichannel telemetering system devised.
11 May - Bill signed establishing Air Force Missile Test Center (Atlantic Missile Range).

1950

23 Jan. - Air Research and Development Command established.
15 Mar. - USAF given sole responsibility for Strategic Missiles.
1 Apr. - Dr. Von Braun moved from White Sands to Redstone Arsonal.
22 Apr. - Igor Sikorsky predicts manned space flight by 1970.
10 May - President created National Science Foundation.
13 June - Department of Defense assigned White Sands Proving Ground to Army; Point Mugu Naval Missile Test Center to Navy; Atlantic Missile Range to Air Force.
30 Sept. - First International Congress on Astronautics.

1951

25 June - Arnold Engineering Development Test Center dedicated.
7 Sept. - H. H. Koehle of Redstone Arsonal reported the Soviet Union is racing to set up military space station.

1952

22 Mar. - Colliers Magazine published first space symposium.

Apr. - National Advisory Committee for Aeronautics (NACA) directed laboratories to begin study of space flight.

June - Navy's Johnsville, Pa., Human Centrifuge went into operation.

Dec. - Dr. Von Braun published "The Mars Project."

1953

Feb. - The United States National Committee for the International Geophysical Year (IGY) established by National Academy of Sciences.

9 Sept.- Mr. Trevor Gardner appointed by Secretary of Defense Wilson to head Committee to Eliminate Interservice Competition in Development of Missiles.

1954

6 Feb. - The Soviet Union stated that United States Science Fiction Publications was forerunner to United States imperialism in conquering other planets.

25 June - In a secret session, the Navy and Army first proposed Project Orbiter, a satellite using a Redstone Missile for a first stage and a LOKI second stage. The Air Force was invited to participate, 20 Jan. 55.

30 Nov. - American Rocket Society (Milt Rosen) urged the the United States to construct an Earth Satellite.

21 Dec. - Department of Defense asknowledged a United States Space Satellite Program.

1955

14 Mar. - United States National Committee for the IGY completed feasibility study and recommended development of Earth Satellite.

15 Apr. - Soviet newspaper announced creation in the USSR of a permanent interdepartmental Comission for Interplanetary Travel.

July - Satellites were stated to have no foreseeable military value according to "informed" American Government Sources.

2 Aug. - Premier Khrushchev reported that the USSR would cooperate with the United States if Space Projects were "In the Interests of Man."

8 Sept. - President assigned highest national priority to ICBM Program.

13 Sept. - President approved development of IRBM, both land and sea-basing to be considered.

8 Nov. - Secretary of Defense authorized Army and Navy to develop IRBM in addition to Air Forces' Thor..

17 Nov. - Secretary of Navy created the Special Project Office to handle ship-launched Jupiter Weapon System.

1956

13 Jan. - Mr. Trevor Gardner resigned as Assistant Secretary of the Air Force for Research and Development as a protest against Pentagon Policies for missiles.

20 Mar. - Department of Defense Ballistic Missile Committee approved Navy Solid Propellant Program.

27 Mar. - Secretary of Defense Wilson appointed Edger Murphree as "Missile Czar."

8 Dec. - Secretary of Defense authorized Navy to terminate participation in Jupiter and to proceed with Polaris.

1957

10 Jan. - President Eisenhower in his State of the Union Message declared that "We are willing to enter any reliable agreement which would *** mutually control the outer space missile and satellite development."

May - Andrew Stone of Metro-Goldwyn-Mayer offered to pay the price for launching a satellite if we could beat Russia.

4 Oct. - The USSR launched Sputnik I /The United States was working on Project Vanguard for its first satellite launch/

3 Nov. - The USSR launched Sputnik II, carrying a dog, Laika. No recovery was attempted.

8 Nov. - Secretary of Defense McElroy directed the Army to prepare to launch a satellite with Jupiter-C, thus supplementing the existing Vanguard Program.

21 Nov. - The Rocket and Satellite Research Panel proposed creation of a Civilian National Space Establishment in the executive branch of the government.

25 Nov. - The Preparedness Investigating Sub-Committee began extensive hearings on the nation's satellite and missile programs.

5 Dec. - An Advanced Research Projects Agency (ARPA), planned to be created in Department of Defense to direct defense space projects.

6 Dec. - First United States Satellite (Vanguard) launch attempt fails.

10 Dec. - A Directorate of Astronautics established by Air Force to manage satellite and anti-missile work.

13 Dec. - Order creating an Air Force Directorate of Astronautics was suspended as creation of ARPA had been proposed.

1958

9 Jan. - President Eisenhower in State of the Union Message recognized need for single control of satellite and anti-missile programs within the Department of Defense.

13 Jan. - Secretary of Defense McElroy established Advanced Research Projects Agency.

16 Jan. - National Advisory Committee for Aeronautics adopted resolution that the National Space Program be a cooperative effort with all agencies and that NACA be responsible for Research and Scientific Operations in Space.

22 Jan. - Premier Khrushchev, in a speech stated the Eisenhower proposal to dedicate outer space to peaceful purposes was an attempt of the United States to ban weapons it did not possess and to protect itself from those weapons which would harm its own territory.

31 Jan. - The first United States Satellite, Explorer I was successfully launched.

4 Feb. - President Eisenhower directed Mr. Killian to study and make recommendations on the Government Organization of the Nation's Space and Missile Programs.

6 Feb. - The Senate created a Special Committee on Space and Astronautics.

7 Feb. - Advanced Research Projects Agency established by Department of Defense. Mr. Roy Johnson named director.

10 Feb. - NATO urged to take inititive in exploring space on a cooperative basis.

27 Feb. - The Air Force announced that plans were well advanced for a Reconnaissance Satellite weighing in excess of 1,300 pounds.

5 Mar. - The House established a Select Committee on Astronautics and Space Exploration.

14 Mar. - General Medaris said that only the military services had the experience to run a successful space program.

15 Mar. - The USSR proposed that banning the use of outer space for military purposes be coupled with the liquidation of foreign military bases.

15 Apr. - The House Committee on Astronautics and Space Exploration opened hearings on outer space toward formulating a National Space Program

17 Apr. - Lt. Gen. Gavin and Maj. Gen. Medaris testified that the appearance of a reconnaissance satellite over the United States should be treated as invasion, but urged the early development of a capability to operate such devices ourselves.

1 May - The Van Allen radiation belt discovered as a result of two Explorer shots.

1 May - Project Vanguard transfered from Navy to ARPA.

15 May - Sputnik III launched.

28 June - Space Science Board formed to assist in formulation of United States post-IGY space research.

25 July - The Air Force awarded Rocketdyne a contract to begin work on a million pound thrust liquid rocket engine.

28 July - Scientists from east and west recommend that satellites be used to detect any violations of agreements to suspend nuclear tests.

29 July - President Eisenhower signed Bill (Public Law 85-568) establishing the National Aeronautics and Space Agency.

15 Aug. - ARPA initiated Project Saturn-assigned to Redstone Arsonal.

31 Aug. - First colloquium on space law at the Hague.

2 Sept. - Ambassador Lodge announced the United States would propose to the United Nations a plan for international cooperation in the field of outer space.

12 Sept. - Wallops Island was announced as a future satellite station for NASA.

1 Oct. - NASA is activated. DOD space activities transfered to NASA.

7 Oct. - NASA formally organized project to orbit and recover manned capsule.

11 Oct. - Pioneer I launched. First successful space probe.

14 Oct. - NASA asked that both the jet propulsion lab and the space team and facilities at the Arm Redstone Arsonal be transferred to NASA.

13 Nov. - United States proposed appointment of a United Nations study committee to consider problems of outer space.

15 Nov. - COSPAR (Committee on Space Research) ended first meeting begun 14 Nov. 58.

17 Nov. - Senator Johnson appeared before United Nations Political Committee for support of United States plan for study of outer space problems.

18 Nov. - USSR withdrew its demand that the problems of outer space study be coupled with withdrawal of the United States from forward bases.

1 Dec. - Los Alamos Laboratory announced it was working on propulsion system using small nuclear explosions rather than an atomic reactor.

3 Dec. - DOD announced a long-range program to put man into orbit.

3 Dec. - President Eisenhower decided to put JPL and Redstone under NASA.

13 Dec. - United Nations voted to set up an eighteen nation study committee on outer space.

17 Dec. - NASA assigned code name Mercury to man in space program. Awarded contract to Rocketdyne for 1.5 million pound thrust engine.

18 Dec. - USAF for ARPA launched an Atlas into orbit. (Project Score)

21 Dec. - House Committee on Astronautics and Space Exploration released report on space law.

27 Dec. - President Eisenhower established a new Federal Council for Science and Technology to head off creation of a new Department of Science.

1959

2 Jan. - USSR launched successful rocket to moon.

10 Jan. - House Astronautics and Space Exploration Committee released final report, "The U.S. and Outer Space."

11 Jan. - Vice President Nixon relayed informally to newsmen the view that the United States is ahead in the ballistic missile race and is catching up fast in other phases of the space race.

12 Jan. - Senator Symington disagreed with Vice President Nixon's remarks.

12 Jan. - McDonnell to construct Mercury capsule.

16 Jan. - AEC revealed new five pound atomic generator called SNAP III.
27 Jan. - Moscow Radio suggested an international cooperative effort in carrying out interplanetary exploration because the costs might be too great for a single nation.
2 Feb. - President Eisenhower released first annual report of space progress.
12 Feb. - Secretary of Defense McElroy issued directive defining duties of new Director of Research and Engineering (Dr. Herbert F. York).
28 Feb. - USAF fired first ARPA Discoverer.
1 Mar. - NASA announced details of Scout satellite launching vehicle.
14 Mar. - United States offered to carry the experiments of scientists of all nations in our space vehicles.
18 Mar. - Army Signal Corps and RCA developed micromodule electronic devices (500,000 componets per cubic inch).
19 Mar. - New York Times broke story on project Argus.
2 Apr. - NASA selected seven candidates for Project Mercury training.
14 Apr, - Speculation that Russia recovered Discoverer II capsule.
18 Apr. - USSR announced development of atomic battery with a 24,000 volt output.
26 Apr. - USSR plans to build surveillance satellites.
26 Apr. - USAF and Westinghouse announced a new discovery in the field of molecular electronics. An entire radio circuit can be reduced to the size of a match head.
4 May - Bureau of Standards released information about radio blackouts caused by nuclear detonations in space.
6 May - NASA awarded contract to Convair for Vega rocket combination.
9 May - House Science and Astronautics Committee released report on international control of outer space.
11 May - House Science and Astronautics Committee released report on communication by satellite.
26 May - DOD told Congress that it had no long-range program for space research but that Dr. York was in charge of its military space research.
10 June - First report from the working group of the Legal Subcommittee of the United Nations on peaceful use of outer space.
20 June - The Kiwi-A nuclear rocket tested at Jackass Flats, Nevada.
1 July - The President expanded the authority of the Civilian Military Space Liason Committee to settle disputes between DOD and NASA (CMIC).
29 July - NASA agreed to supply Scout Launcher to the UK.
7 Aug. - DOD announced Navy project Tepee, space nuclear detonation detection.
11 Aug. - USSR formally accepted Geneva plan for using satellites to detect nuclear explosions at high altitude.
17 Aug. - Naval Research Laboratory in Washington DC may have found the route to a breakthrough in taming thermonuclear power.
23 Sept. - DOD reorganized its space program again.

24 Sept. - Reported that the Navy had before the Joint Chiefs of Staff a plan for a unified command for military space and missile development. It was turned down.

17 Oct. - Roy W. Johnson announced he was resigning as head of ARPA.

18 Oct. - USSR announced that it had taken pictures of the far side of the moon.

21 Oct. - The President transferred Army's space rocket team and Saturn booster to NASA.

26 Oct. - USSR released first pictures of back side of the moon.

9 Nov. - USAF announced development contracts for Dyna-Soar (Boeing and Martin).

11 Nov. - USSR discovered 62,000 mile long tail of air escaping from the earth.

1 Dec. - Twelve nations signed treaty making the Antarctic continent a preserve for scientific research.

7 Dec. - A new charter for the Committee on Space Research was approved at the Hague.

8 Dec. - ARPA put under control of Dr. York, Director of Defense Research and Engineering.

15 Dec. - NASA released report on assessment of the United States and USSR space science programs.

19 Dec. - USSR released information on how its moon satellite was stablized and on how its cameras operated.

28 Dec. - Dr. Wallace R. Brode, science advisor to the Department of State advocated creation of a cabinet Department of Science.

1960

20 Jan. - NASA presented its ten year plan of space activities to Congress.

25 Jan. - The Bioscience Advisory Committee of NASA filed its report.

2 Feb. - General Power criticized by President Eisenhower concerning remarks about USSR capability to knock out United States strategic forces.

17 Mar. - The United States called for a system of advance notice for all missile and space launchings to minimize the chances of war by accident.

1 Apr. - NASA launched Tiros I weather satellite.

4 Apr. - USSR refused to join in an agreement to prohibit launching of nuclear bombs into orbit unless the United States agreed to give up military bases abroad.

8 Apr. - Dr. Vannevar Bush stated plans to put a man into space were little more than a stunt and that instruments could do as good a job.

13 Apr. - Navy launched Transit I-B navigation satellite.

18 Apr. - NASA selected Avco and General Electric to study development of an electric rocket motor.

1 May - United States U-2 shot down over USSR

24 May - Midas II placed in orbit by Air Force (Midas I unsuccessful).

1 July - George C. Marshall Space Flight Center officially opened. (Directed by Dr. Von Braun)

29 July - NASA announced Apollo will succeed project Mercury (a three man capsule) for sustained orbital flight or circumlunar flight).

12 Aug. - NASA successfully launched Echo I (100 ft. diameter aluminized mylar balloon).

31 Aug. - A joint NASA-AEC nuclear propulsion office established.

14 Sept. - Executive order established a new Aeronautics and Astronautics coordinating board. (Dr. York as head)

1 Oct. - Harvard Business Review published article showing majority of business men supported a vigorous space program.

4 Oct. - Satellite Courier I-B developed by the Army Signal Corps successfully launched.

7 Oct. - The Federation Aeronautique Internationale accepted the first rules to govern the establishment of official records for manned space craft.

12 Oct. - NASA offered to launch at cost communications satellites developed by private companies.

19 Oct. - NASA announced award of preliminary design contracts for solid fuel rockets with thrusts between two and fifteen million pound thrust to Aerojet-General, Grand Central and Thiokol.

25 Oct. - NASA announced award of feasibility studies for Apollo three-man space ship to Convair, General Electric and Martin.

14 Nov. - The Soviet magazine International Affairs stated that the USSR has the ability to stop any espionage by SAMOS, Midas, or Discoverer satellites. G. Zhukov insisted that surveillance from any altitude was illegal.

23 Nov. - Tiros II launched.

3 Dec. - Senate Committee on Aeronautical and Space Sciences charged that the United States lagged in establishing a comprehensive policy for developing space communications even though the need was pressing.

10 Dec. - The New York Times made public excerpts from the Secretary of the Air Force to commanders concerning probability of battle with NASA for dominant role in space.

19 Dec. - Westinghouse Electric Dorporation announced new ultraviolet space communication system called "Ultracom." Potential of fifty times as great as present radio and radar.

21 Dec. - STL selected by NASA to build OGO (orbiting geophysical observatory).

23 Dec. - Announced that solar storm of November 12 made a substantial change in orbit of Echo I.

1961

11 Jan. - President elect Kennedy released report calling for a sweeping reorganization of the national space program and criticized past leadership and direction.

18 Jan. - House Science and Astronautics Committee released staff report on space launching vehicles.

31 Jan. - Samos II successfully placed in orbit.

1 Feb. - Bell Telephone Laboratory announced development of a new supermagnet using niobium three-tin wherein an ordinary storage battery would produce a field with a strength which formerly took millions of watts of power.

7 Feb. - The X-15 with Major Robert White flew at 2,275 miles per hour, a new record, and reached 77,000 feet over Edwards Air Force Base, Calif..

10 Feb. - The Rockedyne F-1 liquid-fueled rocket engine was tested for a few seconds at Edwards Air Force Base, Calif., at a power output of 1,550,000 pounds of thrust.

15 Feb. - Dr. Hugh L. Dryden confirmed the view of Representative Overton Brooks that the Soviet Union probably possessed the ability to direct bombs from orbit to targets on earth; however, he doubted the practical significance of such a capability when ICBM's, in his view, could do the same job more easily.

17 Feb. - Richard S. Morse, Director of Research and Development, Department of the Army, reported to the House Science and Astronautics Committee a new reason for urgency in pursuing Nike Zeus for anti-ICBM purposes in the "very large effort", the Soviet Union was making in the field of such defenses.

18 Feb. - The Air Force launched at Vandenberg AFB, Discoverer XXI which was successfully placed in polar orbit. Sometime during the first orbit, the Agena B engine was restarted in space for the first time, and the orbital period was lengthened.

21 Feb. - The NASA selected Lt. Col. John E. Glenn, Jr., USMC; Capt. Virgil I. Grissom. USAF; and Comdr. Alan B. Shepard,Jr., USN, to begin final training for the first Redstone ballistic flight.

Mar. - USAF given responsibility for development of military space systems.

7 Mar. - Major White flew X-15 to 136,000 feet and 2,905 miles per hour.

Apr. - Two study contracts awarded by Air Force to investigate Bambi anti-missile defense concept.

1 Apr. - USAF, ARDC, and AMC re-named Air Force Systems Command and Air Force Logistics Command, respectively.

12 Apr. - Major Yuri Gagarin made man's first orbital flight in Vostok I. He completed one orbit: perigee, 109.5 miles; apogee, 187.75 miles. The orbit was in a sixty-five degree inclination to the equator.

19 Apr. - USAF nuclear powered aircraft program cancelled by the Department of Defense.

5 May - Comdr. Allen B. Shepard made first American sub-orbital space flight.

7 June - Research Analysis Corporation formed as a non-profiting defense research organization for the Army.

26 June - ARPA picked a four company team headed by Raytheon to devise an anti-missile method other than Niki Zeus. (ARPAT-Advanced Research Projects Agency Terminal)

July - Two Air Force Captains breathed almost one hundred per cent pure oxygen for seventeen days.
12 July - Tiros III sucessfully launched using two wide angle cameras.
21 July - Major Virgil Grissom became the second American to accomplish sub-orbital space flight.
6 Aug. - Major Gherman Titov orbited the earth for over twenty-four hours, eighteen orbits in Vostok II .
1 Sept. - USSR resumed nuclear testing.
9 Sept. - The first full-scale test of Niki Zeus ended in an explosion six seconds after lift-off; twenty-five minutes later, a Samos missile exploded on its pad. Both mishaps occured at PMR's Point Arguello.
24 Oct. - Midas IV satellite detected the exhaust of a Titan missile launched from Cape Canaveral.
27 Oct. - First Saturn (SA-1) successfully launched to an altitude of 84.8 miles and traveled 214.7 miles downrange.
7 Nov. - Kiwi B-1A hydrogen system exploded at Jackass Flats, Nevada. The reactor was not damaged.
9 Nov. - Major Robert White piloted the X-15 to 4,093 miles per hour at an altitude of 95,800 feet.
29 Nov. - America's first life carrying Mercury capsule successfully launched into orbit. A chimpanzee (Enos) made two orbits of the earth and was successfully recovered. The next Mercury flight will be manned by Lt. Col. John Glenn.

1962

15 Jan. - An Echo satellite sub-orbital flight failed. The semi-rigid sphere burst apart about twenty-five minutes after launching.
26 Jan. - Ranger III was successfully launched for first attempt to take close-up pictures of the moon, and to make a semi-soft landing on the moon. The Agena-B engine gained too much velocity and Ranger III missed the moon by 22,000 miles.
27 Jan. - First American manned orbital flight by Lt. Col . John Glenn postponed due to weather at Cape Canaveral. Countdown was at T-30 minutes.
7 Feb. - President Kennedy asked Congress to charter a huge corporation to build and run a worldwide space network for radio, television and telephone. The corporation to be a profit making organization with shares to be sold to the public.
8 Feb. - Tiros IV successfully launched into orbit from Cape Canaveral.
20 Feb. - Lt. Col. John H. Glenn, USMC, became the United States' first man to be placed in an earth orbit. Lt. Col. Glenn, flying his Mercury capsule Friendship-7, was launched by an Atlas booster, MA-6, at 0947 EST from Cape Canaveral. He completed 3 orbits for a total flying time of 4 hrs. 56 min. He landed at 1443 EST and was picked up by the US Destroyer Noa. The 4 hrs. and 45 min. of weightless flight had no ill effects on Col. Glenn. It is important to note that the capsule's automatic control system malfunctioned in the same manner as the capsule on the Chimpanzee flight, 29 Nov. 1961. That flight was terminated after 2 orbits. Col. Glenn was able to take over manually and complete his flight. The need for manned space flight cannot be questioned.

APPENDIX B

Extract from Senate Resolution 256

Whereas man is standing upon the threshold of a new era of space exploration; and

Whereas it is the devout wish of all peoples everywhere, in every nation, in every environment, that the exploration of outer space shall be by peaceful means and shall be dedicated to peaceful purposes; and

Whereas the United States as a nation and as a people favors the peaceful solution of all international problems: Now, therefore, be it

"Resolved by the House of Representatives (the Senate concurring)", that the Congress of the United States believes that the nations of the world should join in the establishment of plans for the peaceful exploration of outer space, should ban the use of outer space for military aggrandizement, and should endeavor to broaden man's knowledge of space with the purpose of advancing the good of all mankind rather than for the benefit of one nation or group of nations;

That it is the sense of the Congress:

That the United States should strive, through the United Nations or such other means as may be most appropriate, for an international agreement banning the use of outer space for military purposes;

That the United States should seek through the United Nations or such other means as may be most appropriate an international agreement providing for joint exploration of outer space and establishing a method by which disputes which arise in the future in relation to outer space will be solved by legal, peaceful methods, rather than by resort to violence;

That the United States should press for an international agreement providing for joint cooperation in the advancement of scientific developments which can be expected to flow from the exploration of outer space, such as the improvement of communications, the betterment of weather forecasting, and other benefits; and

That the Congress respectfully requests the President to effectuate in every way possible the objectives set forth in this resolution. (87:17)

APPENDIX C

Extract from Public Law 85-568

. . . . .

Sec. 102. (b) The Congress declares that the general welfare and security of the United States require that adequate provision be made for aeronautical and space activities. The Congress further declares that such activities shall be the responsibility of, and shall be directed by, a civilian agency exercising control over aeronautical and space activities sponsored by the United States, except 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; and that determination as to which such agency has responsibility for and direction of any such activity shall be made by the President in conformity with Section 201 (e).

(c) The aeronautical and space activities of the United States shall be conducted so as to contribute materially to one or more of the following objectives:

. . . . .

(4) The establishment of long-range studies of the potential benefits to be gained from, the opportunities for, and the problems involved in the utilization of aeronautical and space activities for peaceful and scientific purposes;

(5) The preservation of the role of the United States as a leader in aeronautical and space science and technology and in the application thereof to the conduct of peaceful activities within and outside the atmosphere;

. . . . .

(7) Cooperation by the United States with other nations and groups of nations in work done pursuant to this Act and in the peaceful application of the results thereof; (87:15)

. . . . .

APPENDIX D

Legal Problems of the Utilization of Space

a. National sovereignty or territorial rights in space.

b. Responsibility for damage caused by return of spacecraft to earth. (On 5 December 1956, a SNARK guided missile was fired from Cape Canaveral, went out of control, flew without external control to South America. It was lost somewhere over the Brazilian interior)

c. Definition of "peaceful purposes" of various space operations presuming that the use of space for other purposes is outlawed (particularly with respect to reconnaissance or weather surveillance and control vehicles).

d. Filing of flight plans and inspection of launch together with advance notice of intent to launch.

e. Guaranteed safe passage of scientific or other peaceful craft where notice of launch and inspection, if it is agreed upon, has been accomplished.

f. Surrender of downed or apprehended spacecraft to the originating nation. Do such vehicles, together with their equipment and accumulated data, remain the property of the launching nation or of the recovering nation? [Example] One only needs to imagine Soviet employment of submarines to recover Mercury and Discoverer capsules before they can be reached by U.S. vehicles.

g. Piracy in space and unauthorized interference with or intercept of peaceful vehicles.

h. Use of radio transmission frequencies (the Soviet Sputniks in their use of the 20 and 40 megacycle frequencies were in violation of treaty regulations promulgated through the International Telecommunications Union).

i. Cooperation on navigational problems and specific prohibitions of electronic radiation tending to degrade the quality of various electronic navigation systems with fatal results.

j. Distribution of scientific data.

k. Registration and identification of spacecraft. (1:2)

APPENDIX E

Extract from DoD Directive on Space Responsibilities

Purpose:

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

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 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. (97:40)

APPENDIX F

Letter from President to House of Representatives

10 April 1961

Hon. Sam Rayburn
Speaker of the House of Representatives
Washington, D.C.

Dear Mr. Speaker:

I transmit herewith, for the consideration of the Congress, a draft of a bill relating to the National Aeronautics and Space Council.

I contemplate making the Council an active and useful instrumentality. To achieve that end it is necessary, in my view, to amend existing law providing for the Council.

As you know, it is now the duty of the President to preside over meeting of the Council. As had been previously announced, I desire to place the Council under the chairmanship of the Vice President. The primary effect of the attached amendatory bill, if enacted, will be to make that possible.

I believe that the Vice President can contribute importantly to, and give me valuable counsel and assistance with respect to, space programs, and that the chairmanship of the National Aeronautics Space Council will materially enhance his opportunity and capability to render maximum service.

I therefore recommend that the Congress enact legislation along the lines of the attached draft bill.

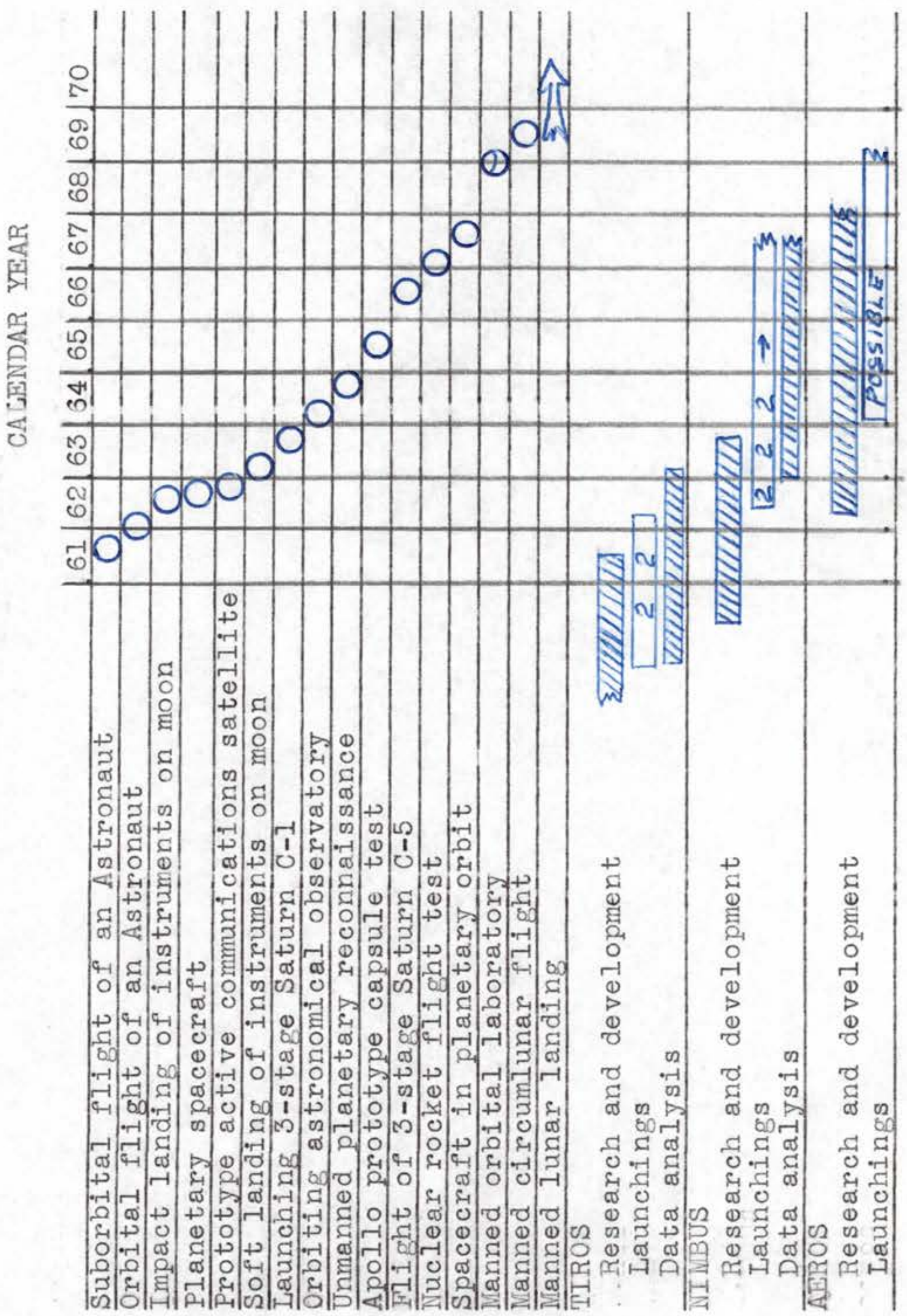
Sincerely,

John F. Kennedy (79:1)

APPENDIX G

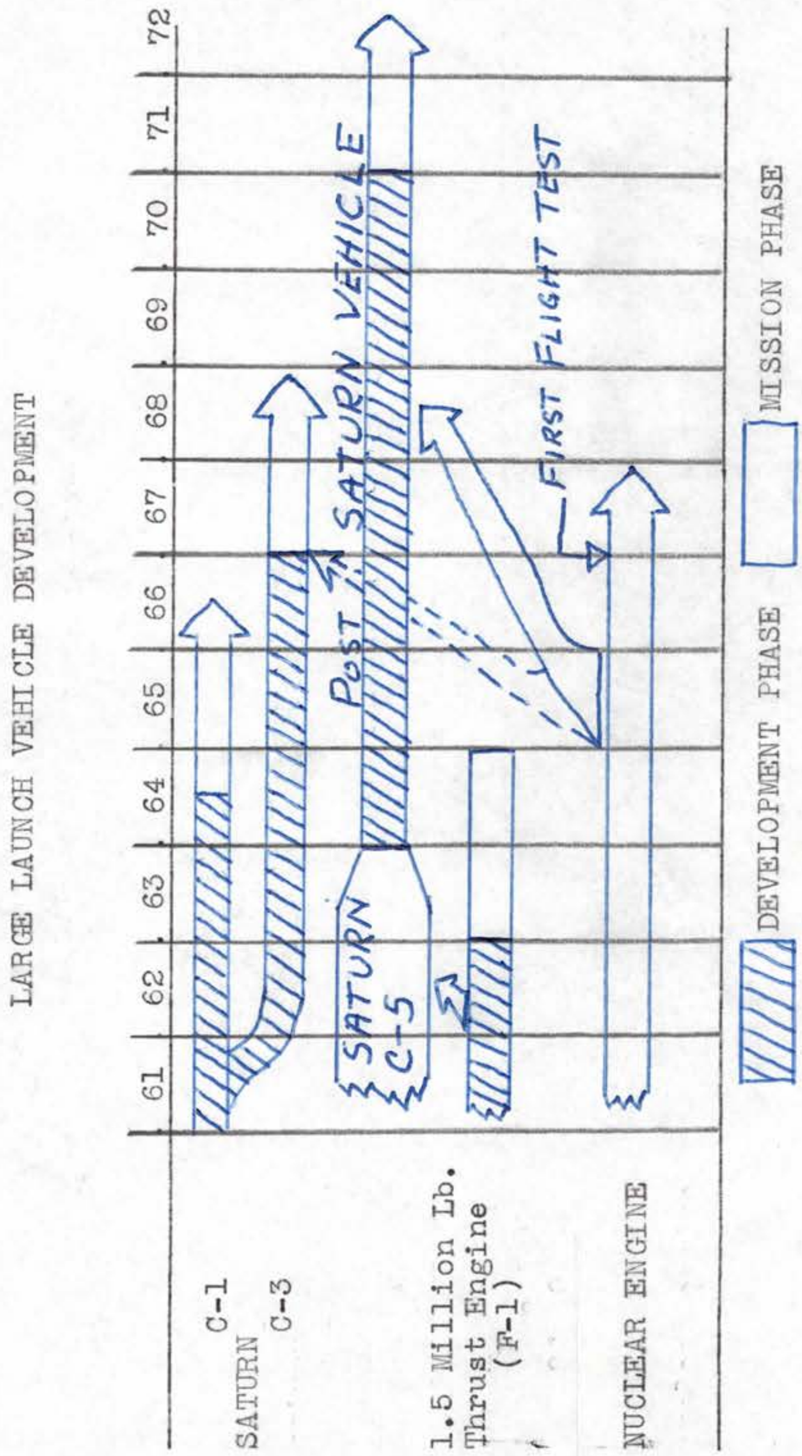
NASA Mission Milestones
(86:162 & 294)

NASA MISSION MILESTONES



APPENDIX H

Large Launch Vehicle Development
(86:167)



APPENDIX I

Space Launch Vehicle Specifications

Atlas-Agena B
1st Stage - Modified Atlas D - 360,000 lbs thrust.
2nd Stage - Agena B - 15,000 lbs thrust.

Agena B has an inflight restart capability. This vehicle will place 5000 pounds in a 300 mile earth orbit or lift 750 pounds to the Moon.

Thor-Agena B
1st Stage - Modified Thor - 150,000 lbs thrust.
2nd Stage - Agena B 15,000 lbs thrust.

This vehicle will place 1600 pounds in a 300 mile earth orbit.

Scout (Four solid propellant stages)
1st Stage - Aero Jet Gen. (Algol) - 115,000 lbs thrust.
2nd Stage - Thiokol (Castor) - 55,000 lbs thrust.
3rd Stage - Allegany Bal. Lab. (Antares) - 13,600 lbs thrust.
4th Stage - Allegany Bal. Lab. (Altair) - 3,060 lbs thrust.

This vehicle will place 150 pounds in a 300 mile earth orbit or lift 150 pounds to a probe altitude of 8000 miles.

Saturn (The Saturn launch vehicle has several configurations. Only two will be listed as NASA has not decided which configurations will be used)

Saturn C-1
1st Stage - 8 Rocketdyne H-1 engines-1,500,000 lbs thrust.
2nd Stage - 6 RL-10, LH/LOX engines - 90,000 lbs thrust.
3rd Stage - 2 RL-10, LH/LOX engines - 30,000 lbs thrust.

This vehicle will place 80,000 pounds in a 300 mile earth orbit, or accelerate 30,000 pounds to escape velocity, or land 20,000 pounds on Mars. It is estimated that an 8,000 to 15,000 pound payload is required to place a three man crew on the moon and return the crew to earth. (88:81)

Saturn C-5
1st Stage - 5 Rocketdyne F-1 engines-7,500,000 lbs thrust.
2nd Stage - 5 J-2 LH/LOX engines -1,000,000 lbs thrust.
3rd Stage - 1 J-2 LH/LOX engine - 200,000 lbs thrust.

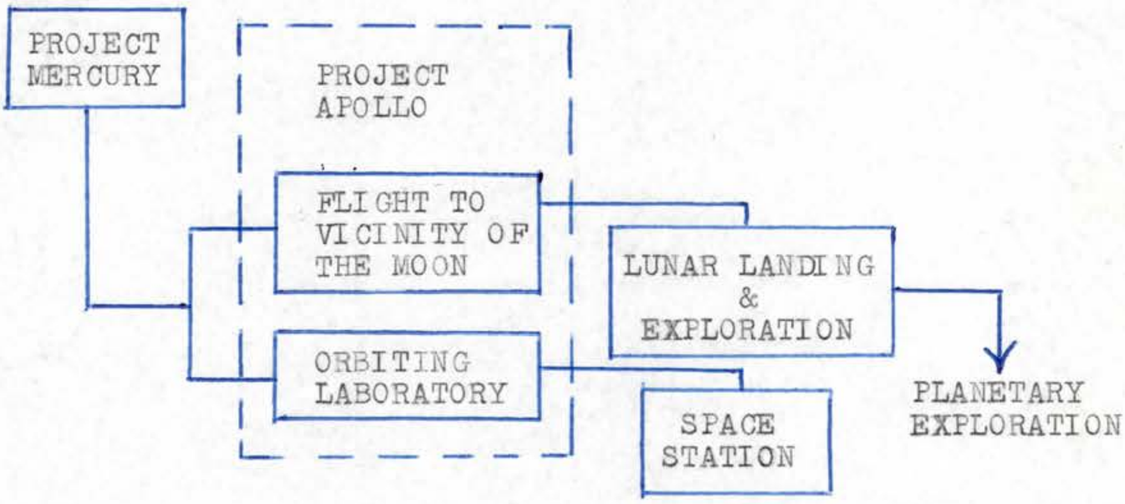
This vehicle will be capable of placing 200,000 pounds in a 300 mile earth orbit.

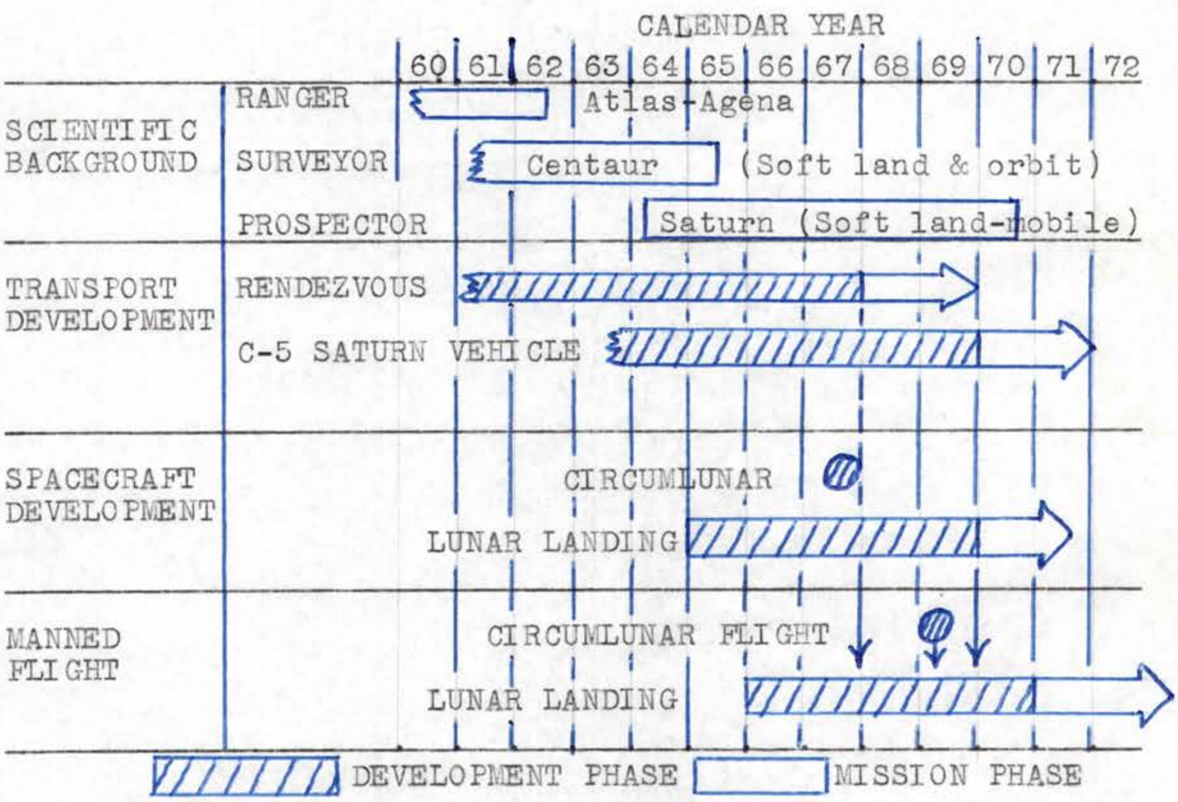
Nova (Nova is not a specific vehicle but merely a concept for additional use of the large F-1, 1.5 million pound thrust engine. One suggested configuration of Nova is:) (88:81)
1st Stage - 8 F-1 engines - 12,000,000 lbs thrust.
2nd Stage - 8 J-2 engines - 1,600,000 lbs thrust.
3rd Stage - 1 J-2 engine - 200,000 lbs thrust.

This vehicle could place 400,000 pounds in a 300 mile orbit.

APPENDIX J

Organization and Timetable for Manned Lunar Landing
(86:147 & 169)





APPENDIX K

Observation Satellite Combinations
(17:226)

OBSERVATION SATELLITE COMBINATIONS

BASIC BOOSTER COMPONENT	TYPICAL WT. IN ORBIT. POUNDS	TYPICAL ALTITUDE. MILES	TYPICAL SENSOR	TYPICAL GROUND RESOLUTION. FEET[1]	Useful Life: SHORT[2]	Useful Life: LONG[3]	Data Recovery: PHYSICAL RECOVERY	Data Recovery: VIDEO LINK	Purpose[5]
IRBM	300-500	150	Photo	60	X		X		Coverage of millions of square miles. (Level A)
		150	Photo	20	X		X		Higher resolution search over limited areas. (Level B)
ICBM	2,000-10,000	300	Photo-TV	200-500		X		X	Weather reconnaissance.
		150	Photo	20	X		X		Higher resolution coverage of millions of miles. (Level B)
		300	Photo-TV	8-12		X		X	Cyclic surveillance of selected areas - intelligence gathering. (Level C)
		300	Infrared			X		X	Warning (ICBM firings).
		300	Electronic			X		X	Electronic and communications intelligence, communications relay, etc.
NUCLEAR OR LARGE CHEMICAL ROCKET	20,000-100,000	500-25,000	All types	(4)		X	X	X	All missions listed above plus - Level D

1 Ground resolution figures apply only to photographic and television sensors.
2 Week or less.
3 Month or more.
4 One foot at 500 miles
5 Levels - A 50 to 200 ft. B 10 to 40 ft. C 2 to 8 ft. D 0.5 to 2 ft.