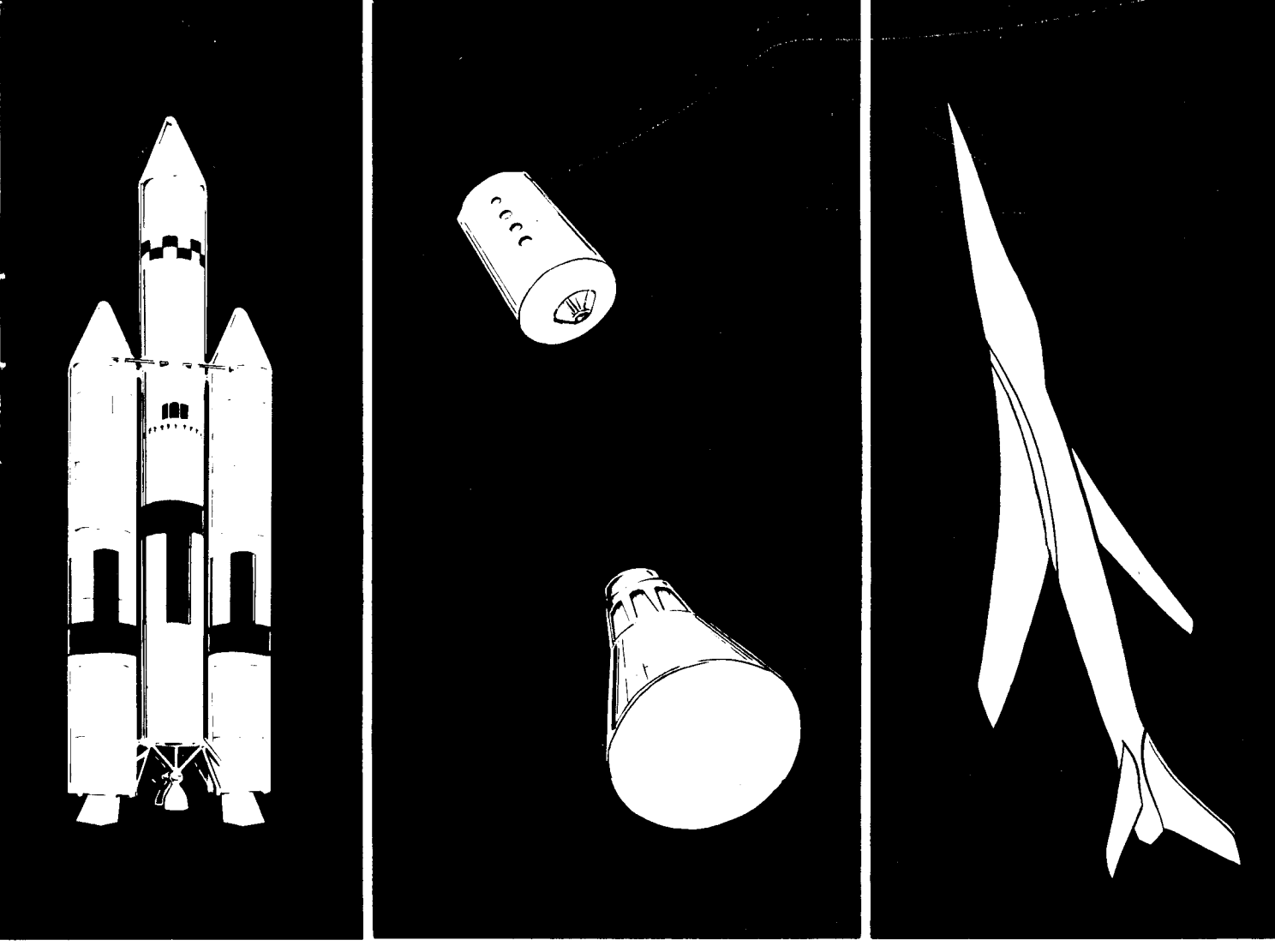

REPORT TO THE CONGRESS FROM THE PRESIDENT OF THE UNITED STATES

UNITED STATES AERONAUTICS AND SPACE ACTIVITIES

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REPORT TO THE CONGRESS FROM THE PRESIDENT OF THE UNITED STATES

UNITED STATES AERONAUTICS AND SPACE ACTIVITIES 1963

THE WHITE HOUSE

WASHINGTON

January 27, 1964

TO THE CONGRESS OF THE UNITED STATES:

In accordance with Section 206 (b) of the National Aeronautics and Space Act of 1958, as amended, I transmit herewith a report for the calendar year 1963, on this nation's aeronautics and space activities.

The year 1963 was a period of constructive development of our increasing space competence. It was also a period of searching evaluation of the national space program -- an evaluation which resulted in broad acceptance of the policy of our attaining and maintaining space leadership, with due regard for our national security.

Our space program, in both its civilian and military aspects, is peaceful in purpose and practice. Moreover, it combines such objective with a policy of international cooperation based upon a mutuality of participation and benefits as well as the wide dissemination of knowledge.

Space progress is essential if this nation is to lead in technology and in the furthering of world peace. Such progress requires the use of substantial resources, which must be employed efficiently and effectively in order that we obtain the maximum benefits with a minimum of waste.

In summary form, the accompanying report depicts the contributions of the various departments and agencies of the Government to the national space program during 1963.

Lyndon B. Johnson

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EXECUTIVE OFFICE OF THE PRESIDENT
NATIONAL AERONAUTICS AND SPACE COUNCIL
WASHINGTON

Chapter I
U.S. Aeronautics and Space Activities 1963

SUMMARY

Nineteen sixty-three was a significant year for the United States in its arduous effort to achieve broad space competence for peaceful purposes, including both civilian and military projects.

The past six years have been productive ones in overcoming competitive disadvantages, which derived directly from a relatively late start and from initial lack of enthusiasm for space achievements. In this process, there have been numerous positive accomplishments, not the least of which has been the marshalling of valued resources into a viable national effort. Leadership among spacefaring nations is now a discernible goal. Our chief competitor has in the meantime not stood still, and in fact continues to lead in some respects. Through their greater ability to rocket heavier payloads into space, the U.S.S.R. could, for example, score new "firsts" in maneuvering, rendezvousing, and space docking. However, our encouraging progress in the development of large rockets and in sophisticated spacecraft gives strong indication that the United States will cut any "lag-time" appreciably as it proceeds toward new space successes.

While many achievements are recorded for the year 1963, the record forms no basis for complacency. If the goal of being first in space is to be achieved and maintained, there can be no slackening of effort and no dampening of enthusiasm for space achievements.

The United States adheres firmly to its policy of "space for peaceful purposes" as expressed in the basic legislation and as espoused by this country's leadership. Furthermore, as a corollary to that policy, we are cooperating with some 60 nations in various aspects of the space program. Such cooperation, in intent and in proposals, extends to the Soviet Union on a mutually beneficial and peace-creating basis.

Although many specific accomplishments will be described in more detail throughout this report, special notice should be given to the improved cooperation between agencies with space responsibilities, to the reorganization of NASA's management, and to the coordinated decision for the Defense Department to develop and use a manned orbiting laboratory.

The United States has made outstanding progress in improving the reliability of its rockets. For example, during the year, NASA had 14 launch successes out of 15 attempts, including the successful launching of 10 earth satellites out of the 10 tries made. The launching record of the Defense Department has also been impressive, both in the number of successes and in the reliability of its launch vehicles.

The peaceful applications of space competence were furthered, during the year, in the continuing improvements to the weather, communications, and navigational satellite systems.

In order to maintain this country's lead in the field of commercial aviation,

decision was made to proceed toward the development of a supersonic transport for commercial use.

Of particular note during 1963 were the following events and accomplishments.

... A U. S. astronaut was orbited 22 times for a period of 34 hours, 20 minutes, and was accurately landed within four miles of a predicted point while under manual control. This MERCURY shot (MA-9) completed the first U. S. manned space flight program with a perfect record.

... The successful launch of CENTAUR, the first known successful flight of a high energy rocket fueled by liquid hyrdrogen was accomplished.

... The first synchronous satellites, SYNCOM I & II,were orbited. SYNCOM II was also the first truly maneuverable station-keeping satellite, the first space link from North America to Africa, the first 24-hour a day space communications link. It was also the first satellite to employ a satellite ship-to-shore link, and conducted the longest (7, 700 miles from California to Nigeria) space communication link.

... Twin satellites capable of detecting nuclear explosions in the atmosphere or in outer space by radiation measurements were launched. The operation included dual injection of the two satellites into different 60, 000 mile orbits.

... A navigation satellite was stabilized in a low (500 mile) earth orbit by passive means using only the earth's gravity field and a damping mechanism.

... The X-15 research rocket-aircraft set new records in flight on the fringes of space.

... The decision was made to revise and enlarge the Department of Defense space-flight program. Redirection included establishment of a Manned Orbiting Laboratory (MOL) program; extension of the NASA-developed GEMINI spacecraft to defense missions; cancellation of the X-20 program; and expansion of Project ASSET to accelerate lifting body technology development.

... The President ordered the development of a supersonic transport. Forty five tentative orders had been placed by the world's airlines for the proposed aircraft. Three airframe and three engine companies are completing design proposals to be submitted this January.

... TELSTAR II joined RELAY in orbit to provide two operational low orbit communications satellites, both furnishing television, phone, voice and teletype communication demonstrations.

... The first two spacecraft powered entirely by nuclear units were orbited this year. The power is supplied by the SNAP-9A 25-watt plutonium-fueled radio-isotope thermo-electric generator.

Two weather satellites, TIROS VII and TIROS VIII were successfully launched, and weather satellites launched to date have supplied over 300, 000 useful pictures. TIROS VIII contained an automatic picture transmission (APT) system to provide daily weather pictures to relatively inexpensive ground stations throught the world.

... In cooperation with other member nations, the United States participated in the drafting and acceptance of a United Nations resolution calling upon all nations to refrain from stationing weapons of mass destruction in outer space.

...An agreement to ban nuclear testing in outer space, the atmosphere and underwater was drafted by the United States, the United Kingdom, and the Soviet Union, and ratified by over 100 nations.

... The United States played a leading part in developing a Declaration of Legal Principles to guide states in the exploration and use of outer space, which was unanimously adopted by the United Nations General Assembly.

... The United States entered into a cooperative agreement with the Soviet Union envisaging an exchange of data from coordinated launches of weather satellites, joint experiments in space communications with passive United States satellites, and an exchange of data from satellites equipped with magnetometers.

... The Extraordinary Administrative Radio Conference convened at Geneva, Switzerland, in October 1963 to allocate bands of frequencies for research and development in the field of space communication and radio astronomy. An agreement was concluded in November with a good measure of acceptance of the U.S. proposals.

... New astronauts were selected, and began training for the eventual lunar landing mission.

... Suborbital test flights were conducted of the ASSET winged reentry vehicle and the LITTLE JOE II APOLLO boilerplate version of the vehicle to be used for the manned lunar mission.

... The scientific satellite EXPLORER XVII was placed into orbit and is furnishing significant information on atmospheric structures.

... LOFTI 2A conducted a dual frequency study of the propagation of very low-frequency radio waves in and through the ionosphere.

... The 120-inch solid rocket to be used with the TITAN III was successfully tested.

... EXPLORER XVIII, the Interplanetary Monitoring Probe (IMP) afforded scientists with the first comprehensive study of radiation hazards in cislunar space to a distance of 150,000 miles from the earth.

... A narrow belt of tiny electric dipoles (WEST FORD) was established around the earth, which had the communications ability and the decay characteristics which had been planned.

... The HITCHHIKER scientific satellite was launched into orbit from another satellite which had already been in orbit several days.

... The planets Mars and Venus were successfully contacted by radar.

... Another in the series of the large SATURN boosters was successfully tested, to provide 1,500,000 pounds of thrust, the largest first stage yet tested.

... The United States placed about 60 satellite payloads into orbit.

Chapter II
National Aeronautics and Space Council

Nineteen Hundred and Sixty-Three was a year of accelerated effort and accelerated learning as the national space program of the United States reached higher levels of competence and performance. The year's program included a 34-hour manned orbital flight, the launching of the world's first successful synchronous satellite, the world's first all-nuclear powered satellite, the first high energy hydrogen rocket stage, the first satellite stabilized by the earth's gravity field, the orbiting of a belt of reflective communications dipoles, the orbiting of nuclear test detection spacecraft, and the achievement of critical milestones in the development of large-thrust rocket engines.

During this year, the United States was successful in placing about 60 satellite payloads into earth orbit, raising the Nation's total from the beginning of the space age to approximately 180. The Soviets put about one-third as many payloads into earth orbit during 1963, although they were sufficiently heavier than ours to keep their lead in total weight orbited. The over-all country-to-country orbital payload ratio numerically is more than 3 to 1 in favor of the United States. In the light of available information, it also appeared that the ratio of successes to failures was approximately comparable for both countries as the launching vehicles of each showed a trend toward improved reliability.

By the end of 1963, the United States had under development more powerful rockets than any the Soviet Union had in operation. This country remained well ahead of the U. S. S. R. in putting space competences to direct use in improving man's living on earth by weather, communications, and navigation satellites. Although the U. S. S. R. must be credited with potential ability to do so, it has not developed comparable programs for the benefit of mankind. At the same time, however, the Soviets maintained their lead in large operational rockets, near-rendezvous experiments, and the life sciences aspects of space. They launched more weight into space, their astronauts spent more time flying outside the atmosphere, and their interplanetary effort was significantly greater. Their accumulation of data and experience made plain that they have an orderly, step-by-step program which has impressed the world with their accomplishments.

The National Aeronautics and Space Council has been guided by the premise that the United States will become the world's leading spacefaring nation and that it will dedicate its space competence to improving and maintaining the peace. To this end, our national space program has been designed to increase our knowledge of the space environment and the fundamental facts of nature; to master the technology of manned and unmanned space flight; to explore the solar system; to increase our national security; and to utilize the results of space technology and discovery to achieve a broad range of economic and social benefits. Our goals include increased international cooperation in the use of outer space for peaceful purposes, the development of the regime of law for outer space for peaceful purposes, the development of the regime of law for outer space, and the orderly and open conduct of space-related activities.

More critical and detailed examination of the space program characterized the Congress's approach to budgetary requests for FY 1964, particularly regarding the funds for NASA. Although the net result was less than the amount of appropriations needed, it is significant and encouraging that the Congress favored a substantial increase over the preceding year and hence supported a broad-based accelerated program.

In discharging its responsibilities, the Council directly and through its staff engaged in a wide range of policy and coordinating activities. Among such activities were:

a. formulated and recommended to the President that the United States initiate a supersonic transport prototype development program at the earliest possible date, with the objective of obtaining a safe, economically sound, and superior aircraft.

b. supervised the preparation and conducted the editing of the President's Annual Report to the Congress on aeronautics and space activities for 1963.

c. testified on space and aeronautical activities before committees of the Congress.

d. increased the public understanding of the national space program through speeches, articles, public appearances, and interviews.

e. participated in the analysis and development of the FY 1965 budgets for space.

f. coordinated efforts leading to the launch of an orbiting dipole belt and the release of information to the world scientific community in accordance with the President's policy on Project WEST FORD.

g. participated in continuing review of the major policy and planning issues confronting the Communications Satellite Corporation.

h. coordinated procedures for the placing of nuclear auxiliary power devices in spacecraft and made positive recommendations to the President regarding such launches.

i. initiated coordination on space projects, such as space stations for military and non-military missions.

j. participated in the development of United States positions with respect to bilateral arrangements with the Soviet Union in the field of weather, communications, and geomagnetic satellites.

k. visited space installations, examined facilities, and discussed space developments and problems with managerial and technical specialists.

l. engaged in numerous interagency, as well as Government-industry, meetings and briefings on new developments in space technology and space benefits.

m. participated in analyses leading to the decision to initiate a Manned Orbiting Laboratory (MOL) project.

n. developed internal analyses on nuclear rocket propulsion, nuclear auxiliary power, reliability of space launching vehicles, lunar and earth orbital rendezvous, range instrumentation ships, post-lunar missions, high velocity space probes, and space station program decisions, and

o. maintained a current record of United States and Soviet space launches, developed comparisons between U. S. and U. S. S. R. space activities, and reviewed space accomplishments and potential of other nations.

The Space Council held formal meetings on such subjects as: formulation of supersonic transport program recommendations; review of policy issues relating to the national space program; and coordination of Defense-NASA space projects, such as GEMINI and space stations.

The United States space program is designed to maintain our position of leadership in the Free World. Cooperating with other nations in many areas of space technology, and pressing for ever-widening participation and distribution of space benefits, the United States has led the world effort in this area. It is in the national interest -- economically, technologically, scientifically, militarily, and internationally -- to carry this program forward in an accelerating fashion so that the United States will obtain for mankind every one of its many benefits as soon and as efficiently as possible.

Chapter III
National Aeronautics and Space Administration

INTRODUCTION

During 1963, the National Aeronautics and Space Administration made significant advances in all of its programs in the continuing effort to assure preeminence in space for the United States.

The MERCURY manned space flight project culminated in the 22-orbit flight of Astronaut L. Gordon Cooper, Jr., May 15-16. Other important achievements included the orbiting of SYNCOM and TELSTAR communications satellites, the TIROS VII and VIII meteorological satellite, and the EXPLORER XVII, XVIII, and XIX geophysical satellites. And on November 27 NASA launched the hydrogen-fueled CENTAUR rocket into orbit. The first stage of the powerful SATURN I launch vehicle was successfully tested for the fourth time. Progress also continued in all other aspects of the drive to complete a manned lunar-landing-and-return mission during this decade.

MANNED SPACE FLIGHT

In 1963, NASA concluded Project MERCURY and substantially advanced the work on Project GEMINI and Project APOLLO; the Agency also took concurrent steps to provide the essential manned space flight support.

Project MERCURY

The outstanding event of the United States space program in 1963 was the successful flight of Astronaut L. Gordon Cooper, Jr. It began on the morning of May 15, 1963; 34 hours and 20 minutes later, after completing 22 orbits, Astronaut Cooper's spacecraft Faith 7 reentered the atmosphere and splashed down in the Pacific Ocean. The primary mission of the flight was to evaluate the effects of weightlessness and extended orbital flight on man.

The launch phase was normal; the spacecraft was inserted into a near-perfect orbit. Its systems performed well until the 18th orbit, when the automatic control system failed. For the rest of the flight, retrofire, and reentry, Astronaut Cooper manually controlled the spacecraft, landing it within four miles of the predicted point. The astronaut performed his tasks in an outstanding manner and provided further evidence of the essential role of man in space exploration.

The effectiveness of NASA's flight operations planning was underscored during this mission. Ground controllers quickly diagnosed the problem encountered in the automatic control system of the spacecraft during the 19th orbit and subsequently relayed new instructions, enabling the astronaut to make a manually controlled retrofire and reentry. The successful termination of this flight confirmed the soundness of the operational techniques.

This flight also enabled NASA to conduct such scientific and engineering experiments

as medical studies, radiation measurements, photographic and visibility studies, and experiments in TV communications.

In the area of space medicine, the Project MERCURY flights were completed with no prolonged ill effects upon the astronauts; also, there were no significant deficiencies in the life support system or personal protective equipment developed for this project. Particularly noteworthy is the fact that the MERCURY life-support system, originally designed for short duration missions, was modified during the course of the project to support man for more than 34 hours. Improvements in equipment and techniques were characteristic of each succeeding flight.

In Project MERCURY, the United States learned:

a. how to design, build, and test the necessary spacecraft.

b. how to adapt launch vehicles, never intended for manned flight, so that they are sufficiently safe and reliable for manned flight.

c. how to operate a worldwide network of radio and radar to keep track of the spacecraft and remain in communication with the pilot.

d. how to recover spacecraft from the ocean in a very short period of time.

e. how to select and train astronauts.

f. how to develop and operate life-support systems, pressure suits, and biomedical instrumentation systems.

Perhaps most important of all, the United States has learned that man can contribute materially to the exploration of space. He can make scientific observations in space and perform and assess scientific experiments. As an engineer and test pilot, he can function as a primary system of the spacecraft, and he can cope with the unexpected in a space mission. These demonstrations of man's ability to judge, to reason, and to cope with the unexpected enable the United States to proceed with confidence that man can assume the role of explorer in space just as he has been an explorer on earth.

The objectives of Project MERCURY, as laid out in 1958, were to take the first step in the manned exploration of space, to determine man's capabilities in space, and to develop the foundation for the technology of manned space flight. With successful completion of the Cooper mission, these objectives have been more than met.

Project GEMINI

Project GEMINI is the second major step being taken by the United States in manned space systems development and manned space exploration. Closely following MERCURY, GEMINI will provide a two-man spacecraft; the objectives of the project are to increase operational proficiency and to gain more knowledge of the technology of manned space flight. Specific areas within these objectives include long duration flight, rendezvous and docking, post docking maneuvers, controlled reentry, extra-vehicular activity, and ground and flight crew training.

Production design of the GEMINI spacecraft structure was completed in February; in October, GEMINI Spacecraft No. 1 was delivered to Cape Canaveral (now Cape Kennedy). Spacecraft No. 1 together with the first GEMINI Launch Vehicle, also delivered in October, will be used in the first unmanned developmental flight scheduled during the first half of 1964.

To test the final design of the spacecraft and various subsystems, 10 non-flight spacecraft were in the process of being fabricated. These will be used to evaluate the various individual subsystems of the spacecraft such as the life support system, the ejection seats, and the parachute recovery system; they will also be used to test structural design and astronaut training.

Typical structural tests include pressurization, flotation, and landing impact. Seven successful parachute drops were conducted during the summer months to qualify the recovery system. Two of these were dropped in the water to determine impact loads.

Effort was devoted to the development of the paraglider recovery system for a series of air drops. More than 100 ground tow tests were made with a half-scale model to determine landing characteristics.

Electronic systems tests were conducted to determine the intercompatibility of the spacecraft electronics and guidance systems. A complete test of all the subsystems which make up the flyable spacecraft for mission No. 2 was underway by the end of the year.

The GEMINI Launch Vehicle (GLV) is a modified TITAN II being procured by NASA through the Air Force Space Systems Division. A total of 15 such launch vehicles are to be procured. The first of these was delivered to Cape Kennedy in October following checkout of all subsystems, qualification testing of components, and correction of certain deficiencies noted by the vehicle acceptance team.

Critical components of the GLV, such as the malfunction detection system, were flight tested on Air Force TITAN II ICBM's to gain flight reliability data. Three of the planned six such tests were flown before the end of the year. Also, prior to the first GEMINI flight, flight data from many standard Air Force TITAN II's were being obtained.

The target vehicle for the GEMINI rendezvous and docking missions consists of the ATLAS standard launch vehicle and a modified AGENA D. The AGENA is being modified to give it maneuverability in orbit and to provide for actual docking with the spacecraft.

During the year, work on the target vehicle centered on development and test of the AGENA propulsion system. The system was repeatedly fired under simulated orbital altitude conditions; the results were satisfactory. Design and development of other aspects of the AGENA are proceeding according to schedule, with the first delivery planned for early 1965.

Operational concepts and procedures were being developed for Projects GEMINI and APOLLO, using the experience gained from Project MERCURY. A new ground control site, the Integrated Mission Control Center (IMCC), was under development at the Manned Spacecraft Center in Houston. This Center will maintain operational

control over the manned flights now planned for both GEMINI and APOLLO. The ground crews underwent intensified training for the early GEMINI flights.

Project APOLLO

NASA continued progress with the development of the Project APOLLO spacecraft, the launch vehicles and propulsion systems, and the associated mission planning.

Systems Engineering -- During 1963, continued progress was made in the overall engineering of the system for manned lunar flight. Additional detailed specifications of the hardware were completed. The computation of the detailed flight path was begun. Special attention was paid to natural environmental problems, including the earth's radiation belts, solar flares, meteoroids, and the surface of the moon. The value of a lunar orbiter was established, and mission assignments for the APOLLO flight tests were established.

Spacecraft -- During the past year, NASA completed selection of the APOLLO spacecraft industrial team, the first test spacecraft were delivered, and the first developmental flights were made.

Three boilerplate APOLLO Spacecraft Command and Service Modules were constructed and delivered by October 1963. A total of nine were delivered in Calendar Year 1963, with six of the boilerplates for unmanned flight testing and three for various ground tests.

(A boilerplate spacecraft has the same shape, but is heavier structurally than the spacecraft that will make the mission. Some boilerplate spacecraft are highly sophisticated items of equipment, containing elaborate instrumentation and actual spacecraft systems and components.)

Three of the flight tests of these boilerplates are to demonstrate the mission abort emergency escape systems. Of the other three flight tests, two are to measure the micrometeorite density in near earth space, and one is to obtain information on conditions of vibration, temperature, pressure, and noise at launch.

Manufacturing was also begun on three prototype spacecraft (similar to those planned for the lunar mission). Two of these spacecraft are to be used for ground tests to check out the spacecraft structure and systems under simulated mission and space conditions. The third is to be a production air-frame for unmanned flight testing of the spacecraft systems, including the heat shield.

Nearly half the ground tests of boilerplate spacecraft were completed. Basic design approaches were confirmed in water recovery and handling operations, land and water impact tests, parachute recovery tests, and dynamics tests conducted in combination with a prototype SATURN launch vehicle.

At the White Sands Missile Range (WSMR), N. Mex., a LITTLE JOE II launch vehicle facility was completed and made operational in July. In August, a LITTLE JOE II launch vehicle with a dummy spacecraft payload was flight tested at White Sands to qualify the launch vehicle for forthcoming APOLLO spacecraft emergency escape system tests. In a flight at WSMR in November, the launch escape system of the APOLLO was tested in a launch pad abort situation. This flight successfully simulated a mission abort resulting from a launch vehicle failure on the pad.

In January, NASA signed a contract for the Lunar Excursion Module (LEM). The Lunar Excursion Module is used to transport two astronauts from the mother spacecraft in lunar orbit to the lunar surface and back again to the mother spacecraft. During 1963, more than a dozen subcontracts were let to form the Lunar Excursion Module industry team.

A preliminary configuration of the LEM was "frozen" in the middle of the year, and the first of a series of mockups was reviewed in September. Plans were drawn and construction started to permit the first test firing of the LEM rocket engines at White Sands, N. Mex., in mid-1964. The descent engine of the LEM will represent a technological advance in that it must be capable of a thrust level variation ranging from one-tenth to maximum thrust. Two parallel development efforts were underway; these will provide the basis for selecting the final descent engine design.

Small bi-propellant control engines which are capable of thousands of starts were in the advanced stages of development for the reaction control systems of the APOLLO Spacecraft Command and Service Modules. These engines are used for controlling the attitude of the spacecraft in space and during reentry.

The 22,000-pound thrust service module propulsion system engine, also with multiple start capability, underwent altitude testing at the Arnold Engineering Development Center (AEDC) facilities at Tullahoma, Tenn. This program is directed toward attaining the highly reliable spacecraft engine necessary to assure flight safety and mission success. This engine is the prime means of returning the astronauts to earth once the spacecraft leaves the near-earth environment.

Construction was initiated on the APOLLO Propulsion Development Test Facilities at White Sands Missile Range, N. Mex. Also included at this site are the Control Center, the Propellant Storage and Transfer System, a Preparation Building and the Project Control Area.

At the Manned Spacecraft Center in Houston, Tex., contracts were awarded for construction of two major test facilities. One of the buildings is the Environmental Testing Laboratory; the other is the Flight Acceleration Facility. Thirteen other laboratory and administrative facilities were near completion.

Launch Vehicles and Propulsion -- The development of more powerful engines and launch vehicles required for the APOLLO project progressed significantly in 1963. The SATURN I, the SATURN I-B, and the SATURN V are the launch vehicles under development.

The configuration of the SATURN I consists of two stages: (1) the S-I booster stage, powered by eight H-1 engines (liquid oxygen and kerosene) developing 1.5 million pounds of thrust; and (2) the S-IV second stage, propelled by six RL-10 A-3 engines (liquid oxygen-liquid hydrogen), generating 90,000 pounds of thrust. The SATURN I is slated for use in earth orbital tests of two of the three modules of the APOLLO spacecraft.

The fourth unmanned developmental flight of the SATURN I was successfully completed in March. The flight configuration was similar to the first three successful flights, consisting of a live first stage and dummy upper stages.

Uprating of the H-1 engine from 165,000 to 188,000 pounds of thrust was nearing

successful completion and further uprating of the engine to 200,000 pounds of thrust for SATURN I-B flights was approved. Two improvements to the engine were developed: (1) a stainless stell thrust chamber of increased durability and (2) a new injector capable of damping out artificially induced combustion instability.

The first S-IV flight stage was successfully static fired for its full mission duration in August and was delivered to Cape Kennedy for final pre-flight checkout in September.

In November, fabrication of hardware began on the SATURN I-B, an improved version of the SATURN I. The I-B will be used for manned earth orbital flights and rendezvous operations of the complete APOLLO spacecraft, including the Command Module, the Service Module, and the Lunar Excursion Module. This launch vehicle will comprise a first stage (S-IB) which will be a modified version of the SATURN I first stage, and a second stage (S-IVB) propelled by one J-2 engine generating 200,000 pounds of thrust. The S-IVB second stage is essentially the same as the third stage of the SATURN V vehicle. Flight testing of the SATURN I-B vehicle is scheduled for 1965.

The J-2 engine, which also powers the S-II second stage of SATURN V, underwent successful tests and the first production engine for use in ground testing of stages was delivered.

The SATURN V, the most powerful launch vehicle now under development, will provide the launch power required to land two men on the moon. The vehicle will stand 281 feet high (without payload) and will weigh approximately six million pounds. It will have the capability to place 240,000 pounds (the equivalent of 80 MERCURY capsules) into earth orbit, and 90,000 pounds into a translunar trajectory.

The vehicle has three stages. The first or booster stage (S-1C) will have five F-1 engines (liquid oxygen and kerosene) producing a total of 7.5 million pounds of thrust. Work was begun on the fabrication and assembly of the first ground test stage--the All Systems stage--at the Marshall Space Flight Center. In addition, a full scale mock-up of the thrust structure assembly, measuring approximately 20 feet in height, and 33 feet in diameter, was built there.

In the F-1 program, substantial progress was made in developing an injector which will produce stable combustion. Continued progress was made in developing the nozzle extension, improved turbopumps, vehicle interconnects, and a heat exchanger for heating vehicle tank pressurizing gases. Gimballing capability of the engine was also demonstrated. The progress in solving the combustion instability problem was largely the result of the work of a NASA-Industry-University research task force which was formed for the purpose.

At the close of the year, three new F-1 production test stands at Edwards Air Force Base were nearing completion and the first production engine for ground testing by the Marshall Space Flight Center and vehicle manufacturers was completed.

The second or S-II stage is equipped with five J-2 engines (liquid oxygen-liquid hydrogen); these will yield a total of one million pounds of thrust. The S-II is the most powerful stage under development using liquid oxygen and liquid hydrogen as propellants. The total thrust of this stage is 11 times greater than that of the S-IV, which is the second stage of the SATURN I.

The S-II is being assembled at Seal Beach, Calif. Components are being manufactured at Downey, Calif., and Tulsa, Okla. Fabrication of hardware for the battleship and the structural test stages was initiated during 1963.

The third stage of the SATURN V vehicle is an S-IVB stage powered by a single 200,000 pound thrust J-2 engine. This stage will carry the APOLLO spacecraft to earth orbit and, after a predetermined coast period, it will be re-ignited to provide the propulsion to place the spacecraft on its lunar journey. NASA made significant progress with the S-IVB stage over the past year. The initial design effort was in the final phase of completion; the ground test stages, forerunners of the flight stage, were being fabricated; and the test facilities were progressing on schedule.

The Instrument Unit is the uppermost part of the SATURN V vehicle. It is a 3-foot cylindrical section 260 inches in diameter. The Instrument Unit serves as the brain and nerve center for the vehicle and determines the optimum trajectory to achieve the desired flight mission requirements through its guidance and control systems supported by its measuring, telemetering, and radio frequency systems.

In the past year, most of the preliminary design was completed for the components of the Instrument Unit, and the contractor was selected for the assembly and checkout of the Instrument Unit. Also contracts were awarded for the stabilized guidance platform and for the guidance computer and associated data adapter.

In 1963, a program was instituted to assure the compatibility of mission requirements and vehicle capabilities, using performance and weight as an index. In addition, high-speed computational capabilities were developed for studies to investigate vehicle systems and designs which critically affect the weight-performance relationships.

Basic design concepts of the computer-controlled checkout systems for the APOLLO spacecraft and SATURN launch vehicles were approved, and stringent reliability and quality requirements were established.

NASA continued constructing the facilities necessary for the fabrication and testing of more powerful launch vehicles. The Marshall Space Flight Center's S-I static test stand was completed, and construction undertaken of SATURN V static test facilities for the engines and vehicles. The Michoud Plant at New Orleans, La., which provides 1.8 million square feet of space for the manufacture and assembly of the SATURN I and SATURN V vehicles, assumed operational capability.

The construction of a large vertical assembly and hydrostatic test structure for the SATURN V first stage was carried through to completion, and erection of a new engineering building was initiated.

At the Mississippi Test Facility, site for ground testing of large launch vehicle stages, the acquisition of 13,000 acres for the construction area was completed, and easements on about 128,000 acres of land (necessary buffer zone) were approximately 40 percent complete. Facilities valued at $150 million were placed under design; construction contracts were awarded for support structures, test stands, waterways and utilities. Approximately $70 million of construction contracts had been awarded by the end of the year.

Other facilities for manufacutre, assembly, and test of the SATURN engine and the

second and third stages were in various stages of construction at Seal Beach, Santa Susana, Edwards Air Force Base, Huntington Beach, and Sacramento, all in California.

NASA acquired most of the approximately 87,000 acres comprising the Merritt Island Launch Area at the Launch Operations Center, Fla. An extensive construction program was initiated at the industrial area and Launch Complex 39 within the Merritt Island Launch Area.

A causeway across the Banana River between Cape Kennedy and the new area was readied for limited operation. Spacecraft facilities supporting the APOLLO program (Operations and Checkout Building and the Fluid Test Complex) were nearing completion.

The major items of the APOLLO-SATURN V Launch Complex 39 were designed and construction was started. In March, a contract was awarded for the design, manufacture and erection of two crawler-transporters. In July, a contract was awarded for the fabrication and erection of three launcher-umbilical towers. The fill for the 524 foot-high Vertical Assembly Building (VAB) was completed in August and construction of the foundation was started. The contract for the structural steel framing was awarded in July, and erection began in December.

On January 17, 1963, NASA and the Department of Defense signed a new agreement covering the management relationships between the Atlantic Missile Range of Department of Defense and the NASA Launch Operations Center. Under the agreement, Department of Defense is the single manager of the Atlantic Missile Range and the Air Force is the host agency responsible for the Cape Kennedy area. However, NASA will manage and serve as host agency for the Merritt Island Launch Area to the north of Cape Kennedy.

Space Medicine -- Achievements in personal protection during 1963 included the successful testing of a light weight net couch; beginning development of a multi-directional force attentuation device for crew restraint and support systems; and advancing development of a partial wear, quick donning suit for use inside a spacecraft.

A configuration mock-up and a prototype of the APOLLO portable life support system, to be used in entrance/egress and wearability studies, were developed.

A significant problem with respect to flights of more than two weeks duration is the uncertainty about the physiological effects of a pure oxygen cabin atmosphere. Extensive reviews of cabin atmosphere were initiated early this year and work in this area is continuing. Also, a prototype for a flight instrument capable of accurately measuring contaminants in a spacecraft was developed.

A series of studies to determine human tolerance limits to impact stress was initiated. These studies are being carried on at Air Force and Naval medical research facilities. Other studies in tolerance to stress include the investigation of subaudible noise associated with the APOLLO-SATURN booster.

Flight Crews

Based on experience provided by Project MERCURY astronauts, NASA established crew requirements for forthcoming flights and selected an additional 14 flight crew

candidates who will report for duty early next year.

Response of applicants to this third selection was again enthusiastic. The average age of the 14 new candidates is lower than that of their predecessors when selected. They possess a higher educational level and have comparable outstanding flying records. At time of selection, seven of the new candidates held advanced degrees--one was a Ph. D., and another was completing his doctorate work. Selection of scientific crew members at a future date is now under study.

For GEMINI and APOLLO, operational training equipment, such as mission simulators, part task trainers, and docking trainers, were being developed. Astronauts underwent basic training in science and engineering subjects. Jungle, desert, water survival, and environmental training on centrifuges and in zero "g" environment was conducted. GEMINI systems trainers were used. A large portion of the astronauts' time was spent in assisting the engineering personnel in the space vehicle design.

Advanced Planning

NASA continued to conduct studies of possible future missions, looking to the time when the nation will have the capacity to undertake more advanced programs. Primary emphasis was placed on studies of the feasibility of extended scientific and exploration missions to the moon, manned planetary missions, manned earth-orbiting laboratories, and on research into advanced launch vehicles.

The M-1 engine was being developed as a 1.5 million pound thrust liquid oxygen-liquid hydrogen engine for use with post-SATURN class launch vehicles. Progress was made in the design, development and testing of major engine components of the M-1, and work on construction of M-1 facilities was advanced. Since rocket engine development precedes and sets the pace for launch vehicle design and development, the M-1, on which development was started in 1962, will make it possible for the Nation to undertake the development of a vehicle with a significant space capability beyond that of the SATURN V, should such be required.

The joint NASA-Air Force Large Solid Propellant Booster Program was initiated during 1963. Based on agreement between NASA and the Department of Defense, a program to build and test 156-inch and 260-inch diameter solid boosters was defined. The purpose of the program is to demonstrate the feasibility of very large solid fuel motors, and to advance their technology to such a point that they will be readily available for post-SATURN vehicle stages if a decision should be made to proceed in that direction. Initial motors will generate thrusts of from 1,000,000 to 3,000,000 pounds; a later design will deliver 6,000,000 pounds of thrust.

SCIENTIFIC INVESTIGATIONS IN SPACE

The past year proved to be one of steadily increasing knowledge of the earth's environment, earth-sun relationships, planets, and outer space, as the universe yielded more of its secrets under the persistent probing of instrumented spacecraft.

For example, astronomers made greater use of the newest space vehicles to observe the sun and the stars from far above any disturbance of the atmosphere of the globe, as they awaited the development of an Orbiting Astronomical Observatory which will enable them to study the sky through a telescope mounted on a revolving platform.

The first Orbiting Solar Observatory, launched in 1962, discovered nearly instantaneous X-ray flashes and fadeouts from the sun and detected a puzzling coronal response to solar flares.

MARINER II in its four-month lifetime transmitted over 90 million scientific data points, and determined the mass of Venus to be 0.815 that of the earth.

FLIGHT PROGRAMS

EXPLORER XVII

On April 2 NASA launched the 17th in the EXPLORER series of geophysical satellites which detected a layer of neutral helium only 160 miles above the earth at the spacecraft's perigee, while it was studying the physics and chemistry of neutral gases making up the atmosphere.

EXPLORER XVII, a 410-pound stainless steel sphere, 35 inches in diameter, represented the first gas-tight satellite designed to prevent its discharges from contaminating the region that it was investigating (at an altitude of between 160 and 570 miles).

The fact that the spacecraft was able to examine the atmosphere's neutral atoms and molecules, marked a substantial advance over earlier craft that were generally limited to measuring electrically-charged ions and electrons.

EXPLORER XVIII

On November 26, the 138-pound EXPLORER XVIII (IMP) was launched by NASA into an earth orbit to measure magnetic fields, cosmic rays and solar winds in cislunar space (the region between the earth and the moon). The satellite, the first in a series of interplanetary EXPLORERS, was sent out to a maximum distance of 122,800 miles from the earth--more than twice as far as any other earth satellite has gone.

EXPLORER XVIII contains nine scientific instruments contributed by scientists from the Universities of California and Chicago, the Massachusetts Institute of Technology, and two NASA centers. In its present orbit the satellite will spend about 60 percent of each orbit outside the earth's magnetic field in cislunar space. Measurements will be made of the charged particle radiation emanating from the sun and sources beyond the sun during a solar cycle and are expected to provide important data for the manned lunar flight program.

EXPLORER XIX, an inflatable sphere, was launched from PMR on December 19, into polar orbit. Its purpose is to study behavior and electron content of the ionosphere and particularly those conditions which can disrupt communications.

RANGER A

The sixth and latest in the RANGER series of unmanned spacecraft designed to collect data about the moon and cislunar space is scheduled to be launched from Cape Kennedy early in 1964. This Ranger mission is expected to obtain high resolution TV pictures of the lunar surface prior to impact--data that should be of great benefit to the lunar science and manned lunar programs.

A review of the RANGER program by a board of inquiry of experts from industry and NASA to determine causes of previous RANGER failures was concluded during 1963. This detailed examination led to a major reorientation of the program that promises a high degree of success with future RANGER spacecraft.

MARINER II

MARINER II, which flew within 21,648 miles of Venus in December 1962, completed its first orbit of the sun on August 1, having traveled about 540 million miles. Communication was lost with the spacecraft on January 3, 1963, when it was 53.9 million miles from the earth and 5.7 million miles beyond Venus.

Making an orbit around the sun every 346 days, MARINER II is calculated to be moving at 54,200 m.p.h.

PIONEER

In the fall of 1963, NASA awarded a contract for the design and development of four PIONEER spacecraft for the exploration of interplanetary space.

PIONEER A, planned for launching early in 1965, is being designed to provide scientific measurements of interplanetary space. Data on this environment are vitally needed for the lunar exploration of Project APOLLO and future advanced interplanetary projects.

Lunar Orbiter

In August, the Agency embarked upon a program for a lunar orbiting satellite able to provide the photographic coverage needed to select suitable sites for SURVEYOR to soft-land on the moon. (The craft would later help SURVEYOR find a landing site for manned Project APOLLO spacecraft.

Preliminary plans are for the first lunar orbiter launch early in 1966. This will be the culmination of NASA's two years of extensive studies to determine the most feasible, yet most economical, method of carrying out this exceedingly difficult, important mission.

Sounding Rockets

Seventy sounding rockets were successfully launched this year. Some studied atmospheric motions in the ionosphere 100 miles above the earth; others worldwide circulation patterns. Continuing investigations of high noctilucent (bright nighttime) clouds revealed meteoric dust particles coated with ice in polar regions at an altitude of about 50 miles.

For the first time sounding rockets were used to measure atmospheric temperatures and other conditions during overhead passes of spacecraft. Such measurements were made for EXPLORER XVII and the Canadian geophysical satellite ALOUETTE, orbited by NASA in September 1962.

In addition, sounding rockets carrying instruments high above the earth's atmosphere made unobstructed observations of the sun and stars and searched for sources of X-rays from outer space.

Data from Earlier Spacecraft

During the year substantial amounts of data were transmitted by the five satellites launched in 1962--ARIEL, ALOUETTE, EXPLORERS XIV and XV, and Orbiting Solar Observatory (OSO-I). In addition, the now useless ECHO I communications satellite was studied to determine the atmospheric density at its orbital altitude.

BIOSCIENCE PROGRAMS

Detecting Extraterrestrial Life

The Space Science Board of the National Academy of Sciences, after a thorough study of the Nation's space program, concluded that investigations of extraterrestrial life should be assigned top priority in NASA's space explorations. Accordingly, the Agency responded to this recommendation by expanding its space biology program and is able to report substantial progress in this field.

Noteworthy advances were made in developing four of the more promising devices to search for life on other planets and in interplanetary space. The radioisotope biochemical probe (Gulliver), designed to detect growth and metabolism of microorganisms on Mars, was modified so that it will be able to also detect photosynthetic organisms on the planet and work efficiently even though it may not land "right side up" on the Martian surface.

Another instrument is being perfected that will be able to detect living matter through the unique ability of organic forms to rotate polarized light.

In research related to investigations of extraterrestrial life and the development of life-detection instruments, significant progress was made in studies on the laboratory synthesis of primitive lifelike organisms.

Further, in March, a balloon carrying a 36-inch telescope and an infrared spectrometer flew to an altitude of 77,000 feet and observed that the atmosphere of Mars contained traces of water vapor (essential to all types of life).

Biosatellites

Beginning late in 1965, NASA plans to orbit biosatellites in systematic studies of the biological effects of weightlessness, high energy cosmic radiation, and other outer space stresses on a wide variety of life forms including primates, mammals, eggs, cell cultures, plants, and bacteria.

The Agency's advisory Space Science Steering Committee has reviewed and screened 175 biological experiments proposed by life scientists for these laboratories in space and has selected about 40 of the best scientific experiments to be developed for final selection for flight in biosatellites.

THOR-type boosters, with specially designed recoverable spacecraft containing life support systems, will be used in the 3- to 30-day circular near-equatorial orbits of the biosatellites.

Superior Diet for Astronauts

A synthetic, chemically-defined liquid diet for astronauts has been developed by a NASA contractor. One cubic foot of the diet (including 50 percent water) will supply 2,000 calories a day for a month, and at the same time reduce fecal waste by 90 percent.

As part of a continuing two-year study, volunteer prisoners were fed the diet for two months with excellent results.

Medical research into possible use of the diet for surgical and other patients, and dietary and nutritional studies were continued.

SATELLITE APPLICATIONS PROGRAM

As of December 10, 1963, four spacecraft were orbited by NASA in its satellite applications program--TIROS VII (June 19); TELSTAR II (May 7); SYNCOM I (February 14); and SYNCOM II (July 26). Significant advances were also made in research and development in the program.

METEOROLOGICAL SYSTEMS

TIROS

On June 19, TIROS VII was launched by a Delta vehicle from Cape Kennedy, marking an unbroken series of seven successful launches of these efficient meteorological satellites. Since the fifth and sixth TIROS continued to perform longer than anticipated, the original date of orbiting TIROS VII was twice postponed to assure its maximum contribution during the 1963 hurricane season.

TIROS VII detected and warned of the formation of Hurricane Flora before any conventional detection devices. The sixth TIROS supported the orbital MERCURY flight in May, and later observed sand storms in Saudi Arabia and ice conditions in both hemispheres.

Since the launch of TIROS I on April 1, 1960 and as of December 9, 1963, about 290,000 pictures have been transmitted by these spacecraft, approximately 80 percent of them meteorologically useful.

Although the lifetime of the TIROS satellites was originally estimated to be three months, all but the first in the series have exceeded this time. TIROS I performed for two and one-half months; TIROS II, ten months, TIROS III and IV, four and one-half months; TIROS V, ten and one-half months; TIROS VI, thirteen months, and TIROS VII is still in operation.

TIROS VIII, launched December 21, contains an experimental Automatic Picture Transmission (APT) subsystem designed to continuously transmit pictures of local cloud conditions to weather stations near the track of the satellite.

Meteorologists with relatively simple ground equipment costing less than $50,000 a set will be able to obtain direct cloud pictures of their local areas when the satellite passes within 1,700 miles of them.

A design study for another TIROS, planned for launching next year, was completed and hardware was being fabricated. This satellite, referred to as the cartwheel configuration, is basically the same as the standard TIROS, but its cameras will be lined up to view out through its rim. The spacecraft will be oriented so that its axis will be perpendicular to its orbital plane. Thus, as the TIROS spins on its axis in space, the cameras will be able to view the earth almost all the time.

NIMBUS

The NIMBUS meteorological satellite designed to overcome some of the limitations of the original TIROS, is scheduled for its first launching early in 1964. NIMBUS in a near polar orbit will cover the entire globe daily. This earth-oriented satellite will also provide a test bed for developing sensory devices to be used on more advanced satellite systems.

Two phases in the development of NIMBUS were scheduled for 1963--a research and development vehicle and the initial spacecraft in the operational system sponsored by the Weather Bureau. The Bureau has discontinued support of an operational system using the present NIMBUS configuration as the basis for the operational system. NASA is continuing with the research and development vehicles.

About 150 small sounding rockets carrying chaff, sphere, or parachutes with telemetry package were launched (some for the Navy) to provide atmospheric data for altitudes between 20 and 40 miles.

A program was established to develop a self-sufficient sounding system (motor, sensors, and data acquisition) for these generally experimental single-stage solid propellant rockets. The system will assure reliable routine operation of the rockets in a network or in support of research.

About 15 larger two-stage solid propellant rockets, using acoustical grenades, sodium vapor, and pitot tube techniques, were also launched during the year to make basic meteorological measurements between 40 and 70 miles.

COMMUNICATIONS SYSTEMS

Two types of communications satellites were under development during 1963--active satellites carrying their own power supply for receiving, amplifying, and transmitting signals (TELSTAR, RELAY, SYNCOM) and passive satellites or communications reflecting stations (ECHO).

Operating altitudes for the active satellites are classified as low or medium, up to 12,000 miles or synchronous, 22,300 miles. When in orbit the angular speed of the synchronous type of satellite (SYNCOM) corresponds to the rotational velocity of the earth around its axis.

TELSTAR

TELSTAR II was launched by NASA for the American Telephone and Telegraph Co. on May 7. This communications satellite performed successfully until July 6 when it stopped operating for an unknown reason. It resumed operation on August 13 (again for an unexplained reason).

TELSTAR I operated from its launch date on July 10, 1962 until November 23, 1962 at which time it failed to respond to ground commands. In January 1963 the satellite came to life again and performed until February 21 of this year when it went dead a second time and remains silent.

Demonstrating the feasibility of using a low-altitude active repeater satellite as a communications device, TELSTAR has transmitted transatlantic TV in color, and black and white. In addition, transatlantic telephone conversations were held and teletype messages sent via the satellite, as were data and facsimile transmissions.

RELAY

Another highly successful active communications satellite launched by NASA (December 13, 1962) is RELAY. The spacecraft has performed communications experiments between the U.S. and Europe, this country and South America, and between Europe and South America.

RELAY, in various engineering tests in television and via telephone during 1963, transmitted "brain waves" (electroencephalograms) from England to the U.S. and transmitted the diagnosis from the U.S. to England within the same 15-minute pass of the satellite. The spacecraft also telecast to Europe pre-launch activities of Astronaut Cooper's orbital space flight and provided European viewers with on-the-spot coverage of the White House ceremony conferring honorary American citizenship on Sir Winston Churchill. At the requests of the TV networks NASA made RELAY available for coverage of the events following President Kennedy's assasination. Three telecasts to Japan and eight to Europe were transmitted.

In addition, when ionospheric conditions prevented the use of normal radio communications between the U.S. and South America, RELAY was successfully used as a ground station link.

Difficulties with a power supply voltage regulator immediately after its December 1962 launch caused a loss in power preventing the use of the satellite. However, by January 3, 1963, RELAY's batteries were sufficiently charged to be able to turn on a duplicate communications system carried on board, and the spacecraft again became operative. Except for three days in March, when this trouble reoccurred, RELAY has performed continuously.

A timer aboard RELAY is set to disconnect the main power supply from all electronics one year after launch.

SYNCOM

SYNCOM II, on July 26, became the world's first satellite to be placed into synchronous orbit and successfully maneuvered into position. Reorientation was accomplished after injection, the drift rate and direction adjusted through a series of jet pulses, and the satellite stationed over Brazil and the North Atlantic Ocean--a final maneuver placing it at 55^{o} West Longitude.

Tracing out an elongated figure 8-type path on the earth, SYNCOM has an orbital period the same as that of the rotational period of the globe 22,235 miles below. In its relatively short lifetime the satellite has logged as much communications time as have all other active satellites.

SYNCOM II was used to establish the first North America-to-Africa link employing an Army transportable ground station at Lakehurst, N.J., and the Navy satellite communications ship in Lagos Harbor, Nigeria. Other ground stations were established at Fort Dix, N.J., Camp Roberts, Calif., and the Goddard Space Flight Center, Md. A U.S.-to-Europe link was established by moving the Kingsport to Rota, Spain in the fall of 1963. The conclusion of the International Telecommunication Union conference was transmitted via SYNCOM II from Geneva, Switzerland, to the U.S.

The first SYNCOM was successfully launched from Cape Kennedy on February 14. However, soon after the firing of its apogee motor the satellite became silent and contact was lost. Visual sightings (February 24 and 25, and March 2) by a Bloemfontein, South African observatory affiliated with Harvard College Observatory indicated that SYNCOM I is in orbit nearly at its planned synchronous altitude.

ECHO

ECHO I completed its third year in orbit. It is typical of NASA's passive communications satellites that reflect signals transmitted by one ground station to be received by another. Now wrinkled and no longer an effective communications device, the 100-foot diameter, 135-pound balloon has probably been seen by more people throughout the world than any other man-made object.

Progress was made in 1963 toward developing its larger, stronger, and heavier successor, ECHO II (135 feet in diameter, weighing 500 pounds). Successful inflation and radio reflectivity tests of the sphere--made of a laminate of aluminum and mylar plastic 0.00075 inch thick--were conducted at Lakehurst, N.J. and at the Goddard Space Flight Center in Greenbelt, Md.

ECHO II is scheduled to be used by Russian scientists to transmit radio signals between observatories in the U.S.S.R. and England. These limited joint communications experiments are the result of a cooperative agreement on space projects between the U.S. and the Soviet Union announced on August 26.

LIGHT AND MEDIUM LAUNCH VEHICLES

NASA presently makes use of five launch vehicles for unmanned missions. These are CENTAUR, ATLAS-AGENA, THOR-AGENA, DELTA, and SCOUT. Of these only CENTAUR is in the development stage.

Planned for SURVEYOR and MARINER missions, ATLAS-CENTAUR is the Nation's first launch vehicle using high energy liquid hydrogen as a fuel. After significant difficulties and delays, NASA made a substantial number of design changes to improve the launch vehicle's reliability and increase its payload capability. The Agency also initiated and substantially executed an intensive ground test program.

On November 27, the first successful ATLAS-CENTAUR was launched from Cape Kennedy in a test of vehicle performance. The CENTAUR stage was placed in orbit by two RL-10 A-3 liquid hydrogen-liquid oxygen engines with a thrust of 15,000 pounds each.

NASA and the Air Force revised the management agreement on the ATLAS-AGENA and THOR-AGENA vehicles to permit greater participation by NASA in the USAF vehicle improvement and development programs. The ATLAS D, used in previous space launches, was redesigned into a Standard Launch Vehicle for improved reliability and increased economy. The USAF, in a program monitored by NASA, has improved the THOR performance with no apparent penalties to reliability to gain greater vehicle cost effectiveness. These vehicles will be used to launch NASA's scientific satellites such as the Geophysical and Astronomical Observatories and the lunar and planetary probes such as RANGER and MARINER.

THOR-DELTA continued to be a very reliable launch vehicle; after an initial failure in May 1960, this vehicle has scored 20 consecutive successes. Plans to procure additional quantities in FY 1964 are underway for additional launchings of such satellites as TIROS and RELAY.

The all solid propellant 4-stage SCOUT launch vehicle developed by NASA has been utilized by the NASA, USAF, Navy and the AEC for research experiments and orbital missions. NASA continued its efforts to increase the payload capability of the SCOUT by up-grading the 4th stage motor. Reliability studies recently completed for SCOUT are expected to lead toward assurance of increased performance.

ADVANCED RESEARCH AND TECHNOLOGY

BASIC AND APPLIED RESEARCH

NASA continued to conduct a wide variety of advanced studies in areas that will provide the new knowledge necessary to assure success of current missions and to pave the way for future vehicles and equipment.

Applied Mathematics

To determine a stable space vehicle orbit around both the earth and moon, it is necessary to solve what is known as the three body problem--bodies under mutual gravitational forces. During the year, NASA mathematicians developed an improved approach to solving this problem; it will aid significantly in programing and planning for deep space probes.

Fluid Physics

Planetary Entry Fluid Physics -- NASA gained additional knowledge concerning the flow field and heat transfer around bodies entering planetary atmospheres at speeds ranging from 25,000 to 45,000 feet per second. This knowledge considerably improves the accuracy with which the effects of gas ionization on flow properties, heat transfer, and radio blackout can be estimated.

Additional research increased understanding of the ablative behavior of relatively slender-nosed shapes. This knowledge should lead to designs that will reduce the heat load of spacecraft entering the atmospheres of the earth and other planets at speeds corresponding to those of deep space travel.

Plasma Physics

Plasma physics research increased the basic understanding of the physical processes involved in electromagnetic propulsion, space power conversion, and radio communication in space. Progress was achieved in developing new methods of plasma diagnostics, in investigating the propagation of radio waves through various plasmas, and in developing principles and apparatus for greater efficiency in plasma acceleration. Magnetohydrodynamic research has shown that it may be feasible to control MHD drag and MHD heat transfer.

Electrophysics

Two independently stabilized infrared lasers were utilized by researchers to detect the presence of an ether wind. No such effect was noted thereby confirming the results of previous optical experiments.

Materials

Supersonic Transport Materials -- In late 1960, NASA started an evaluation program of the approximately 30 different alloys being considered as the structural materials for the national supersonic transport project. The candidate alloys were observed for property change after exposure lasting 10,000 hours and longer to stress, temperature, and other elements of the operational environment of a supersonic transport. Results of this work are now available to U.S. airframe companies to aid them in the selection of the best structural alloys.

Reciprocal Stiffness Materials -- Normally, a polymeric shock mount becomes too soft to operate as the temperature is raised to 210° F. NASA researchers developed a graft polymer which becomes stiffer as the temperature is raised and softer as the temperature is lowered.

Electrical Conductive Polymer -- A polymeric sheet material, commonly used as an insulator, was made electrically conductive by including iodine in the polymer matrix. This gives the material many more possible applications.

Passive Communication Devices -- A rigidized inflatable polymeric material (developed and reported last year) can remain spherical even after the inflation gas has leaked out. This material was incorporated into a space structure and is scheduled to be placed in orbit as ECHO II in 1964.

Thermal Control Coatings -- A spacecraft coating experiment carried by the Orbiting Solar Observatory (OSO) I detected no evidence of erosion, showing that ultraviolet radiant energy was the only cause of coating damage. Test coatings for the APOLLO space radiators are to be orbited on the OSO-B satellite, currently undergoing prototype environmental tests.

BIOTECHNOLOGY AND HUMAN RESEARCH

Significant progress was made in developing a physical-chemical regenerative life support system capable of operating for a minimum of one year (with expendables resupplied at 90-day intervals). A research project on physiological effects of low magnetic fields was completed; research on physiological effects of high magnetic

fields was started.

Manual Flight Control Research

NASA investigators derived mathematical descriptions of man's performance in rapidly changing control situations. The descriptions permit designers to insert the man's performance characteristics in analytical studies of flight control system designs. These studies and others in progress will aid in improving pilot work and performance levels.

Rendezvous

Using the recently completed moving-base GEMINI docking simulator, a number of the astronauts participated in studies to test the pilot's ability to visually guide his spacecraft during the docking phase of rendezvous. The tests confirm results of earlier studies on stationary simulators; these results indicated that precise docking can be accomplished visually under daytime visibility. In addition, the tests demonstrated that advance training enabled the pilot to handle a number of situations in which simulated failures were introduced into portions of the control system. Nighttime operations pose considerably more difficulty and continued under study.

Monitoring Vital Human Functions

Prototypes of extremely small, light microelectronic units, which monitor and transmit merged electrocardiographic and respiratory data, were tested successfully on human subjects. All working parts and a power supply cell for these devices are contained within a volume of 1/16th cubic inch. Units powered by impinging electromagnetic beams were under development; such units are needed to replace present units which have a 36-hour limit on power cell life.

ELECTRONICS AND CONTROL PROGRAM

Microelectronics

NASA expanded its research and development program in microelectronics to achieve higher reliability, lower power consumption, and greater immunity to the radiation environment.

Speech Compression

Because of problems in communication with astronauts at planetary distances, NASA continued basic studies to determine whether speech compression techniques can be applied to voice communications in deep space.

Antenna Arrays

A feasibility study is underway on the array of large dish antennas to increase antenna size for deep space communications and thereby increase communication capability for the transmission of data from space.

Flight Path Control During Rendezvous and Docking

Additional research has demonstrated that the pilot can efficiently effect the docking

maneuver with a minimum of instrumentation, and the requirements for a flight control system have been defined.

Cryogenic (Superconductive) Inertial Sensors

Continuing research on the problems inhibiting the performance of the cryogenic gyro led to improvements in both design and magnetic shielding. Rotors of ceramic material on which superconductive films are deposited offer promise of providing a capability for operation in high-g launch environments.

Horizon Sensor

Project SCANNER, a small flight program, seeks precise knowledge of the earth's horizon gradient in portions of the electromagmagnetic spectrum. This information is of interest to designers of the horizon scanners for use in NASA and Department of Defense earth orbiting spacecraft.

Computer Memory Studies

The heart of a modern digital computer is that portion of the data storage system usually called the "random-access memory" because information can be stored anywhere within it or retrieved from it rapidly and relatively directly. Advances were made in new magnetic and electrostatic techniques which should substantially increase the ability of such systems to store large amounts of information with no compromise in speed.

Launch Checkout and Countdown System

Elaborate, multi-computer systems completed at NASA field centers markedly advanced the technology of automated, rapid checkout of electronic and other systems in SATURN vehicles. Duplication at launch sites will ensure rigid control of all vehicle characteristics at launch time.

Television Improvements

NASA scientists designed, constructed, and tested a television system in which such characteristics of TV pictures as line structure, amount of detail, noise levels, and contrast range can be precisely controlled. Extensive studies with this equipment yielded very useful data on requirements for transmission of such images over interplanetary distances.

CHEMICAL PROPULSION AND POWER GENERATION

Launch Vehicle Engines

Analytical and experimental work continued on nozzles, engine cycles, combustion chambers, high pressure pumps, and high pressure cooling for future large launch vehicle engines in the 3- to 40-million-pound thrust range.

Spacecraft Engines

NASA undertook extensive investigations of problems associated with the reliable

operation of liquid propulsion systems in deep space. The effects of the environment on propellants, on engine components, and on operating characteristics were evaluated and progress was made in solving related problems. Also, work continued on advanced high energy propellants particularly suitable for use in space and on advanced engine construction concepts.

Solid Propulsion Systems Technology

Hybrid Hover Motor -- A design study of a solid propellant hybrid hover motor was conducted to understand the methods of operation, propellant selection and characterization, and system designs. This research will aid engine development by pinpointing key problem areas in need of further study.

Start-Stop-Restart Motor -- NASA started a program to design, fabricate, and test a start-stop-restart solid propellant rocket motor for use in various space applications.

Space Power Generation

NASA made further progress in the development of solar power systems. Tests of the service life of the solar thermionic system converters pressed the 2,000 hour mark, and the mercury rankine (liquid metal) solar engine completed 4,300 hours of testing. A developmental program was started on a solar engine using gas as the working fluid.

In chemical power research, NASA developed a rechargeable sealed battery with a third electrode. Its advantages: long life, increased reliability, and reduced weight.

AERONAUTICS RESEARCH

In addition to its investigations in space technology, NASA conducted aeronautical research on the supersonic transport, on V/STOL aircraft, and on hypersonic vehicles.

Supersonic Transport Aircraft (SST)

NASA concentrated effort on studies to determine the feasibility and practicability of four promising aircraft design concepts for the SST. The studies defined the following problem areas for further analysis: sonic boom influence on airplane design; advanced propulsion system research and development; benefits of using titanium as the basic structural material.

V/STOL Aircraft

In this research area, NASA stressed the flying and handling qualities of short takeoff and landing (STOL) aircraft. Evaluations were made of deflected-slip-stream vehicles, and work began on a boundary-layer control airplane. This system has potential value in the very low speed landing-approach condition. The aerodynamic characteristics of the tilt-wing airplane were assessed in wind tunnel investigations.

X-15 Research Airplane Program

This program, conducted in cooperation with the Department of Defense, provided additional data on aerodynamic and structural heating, structural dynamics,

supersonic and hypersonic aerodynamics, stability and control, and on the physiological aspects of manned flight in a maneuverable hypersonic vehicle.

During 1963 the X-15A-2 airplane was modified to give it a capability for a Mach 8 mission at an altitude of 100,000 feet. Increased performance will result from the addition of two external propellant tanks, and improving the windshield configuration, landing gear, and instrumentation. The X-15 number 3 was flown to an altitude of 354,200 feet, an unofficial world record, on August 22, 1963. The flight obtained data on stability and control in the extreme flight ranges, and on reentry without the ventral fin.

Aerodynamics

Research in aircraft aerodynamics contributed additional data applicable to the supersonic transport program. The information related to the wave drag of complex configurations at supersonic speeds, exploitation of wing warp and favorable interferences to optimize supersonic performance, the skin friction forces of very large supersonic aircraft, and stability characteristics of such aircraft.

Structural Studies

Research on metal fatigue in the titanium alloys and steels indicates that their properties are not significantly changed by exposure to heat representative of that encountered by advanced aircraft such as the supersonic transport.

SPACE NUCLEAR PROPULSION

During 1963, steady advances were made in the AEC-NASA program in developing nuclear systems capable of propelling spacecraft for manned explorations of the planets and for prolonged instrumented probes of deep space.

Key projects in this research and development were nuclear rockets (Project ROVER), nuclear electric power generation, and electric rocket engines.

Nuclear Rockets

The program to provide the earliest, most practical use of nuclear rockets in space consists of three projects and the research and technology needed to support them. The projects include: KIWI to develop the basic technology for the first generation nuclear rocket reactor; NERVA (Nuclear Engine for Rocket Vehicle Application) to develop a flight engine for nuclear rocket-powered upper stage vehicles; and RIFT (Reactor-In-Flight Test) to provide flight verification of the NERVA nuclear rocket propulsion system.

KIWI -- The KIWI-B4A nonflyable reactor was redesigned to prevent mechanical vibrations of its core that occurred in tests. Non-power producing reactor tests were conducted to further evaluate this problem. Principles used in modifying the reactor's design and a different design were also evaluated. Components and subassemblies underwent flow and mechanical tests to assure their satisfactory operation in full-scale tests.

NERVA -- The NERVA project, conducted under contract to the AEC-NASA Space

Nuclear Propulsion Office, has as its objective the development of flight engines for operational nuclear rocket-powered upper stage vehicles. The KIWI-B4 design was selected as the basis for developing the flyable reactor.

Laboratory and full-scale mechanical testing are underway prior to adapting this design for power demonstration. Major emphasis continued on the reactor itself. However, non-nuclear component work is underway to evaluate the critical long lead time between the design and operating problems of the engine. Large numbers of flight components to be developed to high reliability will not be procured until the reactor is operated successfully.

Two reactor test cells are operating at the Nuclear Rocket Development Station, Jackass Flats, Nev. Major construction was completed on an engine test stand and construction is proceeding on an engine maintenance and disassembly facility.

RIFT -- Major hardware and facility commitments for the RIFT project are being delayed pending further development of the NERVA engine reactor. The present RIFT program emphasizes the development of necessary technology in fabrication and structures, cryogenic insulation, and radiation effects.

Supporting the radiation effects program, the Georgia Nuclear Reactor was reactivated. NASA arranged with the Navy to use the metal dirigible hangar at Moffett Field, Calif., for the RIFT stage fabrication and assembly facility. Two acceptable routes to transport this stage from Moffett Field to the Nuclear Rocket Development Station in Nevada were surveyed. Conceptual design of the stage, including preliminary definition of all its subsystems, was completed.

Nuclear Electric Power Generation

The joint AEC-NASA SNAP-8 electric power system is intended to propel lunar stations or orbit space platforms and provide power for interplanetary communications, as well as to investigate problems of long-lived nuclear turbomachinery as a guide for future systems.

During 1963 SNAP-8, a compact experimental reactor that will use the heat from the decay of radioisotopes as energy, underwent a series of low power tests of its performance and operating characteristics. The power conversion system design was completed and released for fabrication and component tests.

Isotope generators ranging from 25 to 500 watts were also under design or development to determine their feasibility for a number of NASA missions, including the Interplanetary Monitoring Probe, SURVEYOR, Orbiting Astronomical Observatory, NIMBUS, and manned space exploration. (The research and development version of NIMBUS is scheduled for a nuclear power tack.)

ELECTRIC PROPULSION

Electric Rocket Engines

NASA's electric propulsion program is planned to develop, test, and evaluate laboratory engine models; provide the technology to develop high-power prime propulsion systems and low-power attitude control and station keeping engine systems; and investigate advanced concepts.

Electric engines for prime propulsion are being designed to provide up to 30 megawatts of power with a lifetime of 10,000 to 30,000 hours. Such engines will have a specific weight of 10 to 20 pounds per kilowatt for manned flight and up to 30 pounds per kilowatt for unmanned flight. High reliability will be essential. Station keeping spacecraft will require rocket engines with power levels of 200 watts to several kilowatts, 10,000 to 50,000 hours of life, and 15 to 40 pounds per kilowatt specific weight for the entire power thrustor system.

Three general categories of electric propulsion engines are being investigated: electrothermal (arc jet and resistojet); electrostatic (ion); and electromagnetic (plasma or MHD). Fifty-five contracts cover supporting research and technology.

Electrostatic (Ion) Engines -- NASA is investigating and demonstrating a small ion engine (200 watts to 1 kilowatt) to determine its feasibility for satellite position control. This engine is presently undergoing long duration laboratory tests.

Good performance was demonstrated on two types of 3-kilowatt ion engine modules. These will be scaled and clustered into higher power engines using the building block technique to attain large megawatt power engines (those with hundreds of pounds of thrust. High efficiencies--60 through 80 percent for specific impulse range of 6,000 to 9,000 seconds--were obtained on these modular units. Emphasis is being placed on attaining long life, high performance, and techniques for scaling and clustering these units.

Electrothermal (Arc Jet and Resistojet) Engines -- Small (up to 8 kilowatts) and large (up to hundreds of kilowatts) arc jets are being investigated for position control of satellites and prime propulsion for spacecraft. The arc jet promises to perform well for the specific impulse range of 800 to 2,500 seconds. Ion engines appear attractive for the impulse range of 4,000 to 10,000 seconds.

During the past year the arc jet was redesigned to provide good performance at specific impulses of 1,000 to 2,200 seconds. A 31-day life test was completed on a 30-kilowatt (0.5 pound thrust) engine with specific impulse of 1,300 seconds. Emphasis is being placed on attaining a 250-kilowatt arc jet engine of high efficiency and long life.

Electromagnetic (Plasma or MHD) Engines -- Progress was made in determining the feasibility of and defining problem areas for four different types of MHD accelerators. Good performance was obtained on a coaxial plasma gun for propulsion which showed the most promise to date. Improvements on thrustor efficiencies and better thrustor component design are being emphasized.

SPACE VEHICLE SYSTEMS

Space Vehicle Aerothermodynamics

A model piloted spacecraft able to generate much greater lift than the Apollo lunar exploration craft was built and successfully flown subsonically at NASA's Flight Research Center. Its low speed handling and landing characteristics are being determined.

Experimental radiative heating data obtained on similar spacecraft models entering

the simulated atmospheres of Mars and Venus at about 15,000 m.p.h. indicated a large increase in radiative heating over those entering the earth's atmosphere at similar speeds. However, recent theoretical studies show that this effect may diminish at hypervelocity speeds.

The Project FIRE reentry flight test experiment to investigate aerodynamic and hot gas radiative heating on an APOLLO-shaped body at 25,000 m.p.h. is in the final stages of preparation for launch.

Progress was also made in adapting retro-rockets to gliding parachutes to provide a steerable spacecraft landing and recovery system with very low or zero landing impact.

Space Vehicle Structures -- Major advances were made in reentry thermal protection schemes, self-sealing micrometeoroid protection methods, cushioning against environmental vibrations, and techniques for measuring atmospheric wind shear layers having a substantial effect on space vehicle loads during launch. Noteworthy progress was also made on improving propellant tanks to handle ultra-cold liquid oxygen and hydrogen.

High Energy Radiation

Theoretical and experimental techniques are supplying precise nuclear data to determine how high energy charged particles in space (such as electrons and protons) pass through spacecraft materials. This information will help gauge the effects of electrons on materials and spacecraft components, and thereby aid in designing more adequate shielding for thin-walled spacecraft.

Meteoroid Hazard

Results obtained from the EXPLORER XVI micrometeoroid satellite showed that damage to the spacecraft's thin skin from penetrations by 50 meteoroids was not as great as expected. However, meteoroids must be considered in designing spacecraft.

Zero Gravity Fluid Behavior

Initial drop tower and space probe rocket-powered tests were completed to determine how liquids in tanks behave under zero gravity conditions. Results indicated that specially designed tanks could position fuels so that they can be pumped and vented when in a weightless state.

Solar Radiation and Temperature Control

MARINER II on its Venus fly-by in December 1962 was heated by solar radiation beyond expectations and also beyond established pre-flight tolerances. Accordingly, work is proceeding on improving test facilities able to simulate this type of radiation in order to develop shielding to protect against it.

Also, experiments in the laboratory and in space determined that surfaces which normally reflect solar radiation degrade and become more absorbent when exposed

to ultraviolet solar radiation. More stable materials are being developed to withstand this damaging effect.

In addition, during the year significant progress was made in the broad program aimed at solving advanced systems problems and developing the technology for these systems. Valuable data (for both turboelectric and thermionic conversion systems) were obtained on materials, heat transfer, liquid metal bearing design, environmental effects, and electron emission.

TRACKING AND DATA ACQUISITION

During 1963, NASA's three tracking and data acquisition networks were expanded and modified to meet the increasing and changing requirements of current flight missions.

Manned Space Flight Network

The support of the 22-orbit MA-9 mission on May 15-16 ended one phase of the Manned Space Flight Network's operations. To prepare the network for the GEMINI and later programs, tracking and data acquisition equipment was purchased, construction was started on a new Australian facility, and long-range plans were formulated for ground support of the APOLLO missions. An agreement was reached with the Department of Defense for the provision of ship support to monitor APOLLO insertion, injection, and recovery operations.

Satellite Network

This network, which consists of the optical and electronic stations, including Minitrack, used in tracking and acquiring data from scientific, communications, and weather satellites, was expanded with the completion of the 85-foot diameter antenna facility at Rosman, N. C. Detailed plans were prepared for a second 85-foot antenna system at Rosman and for a similar system near Canberra, Australia. In addition, NASA completed a second 85-foot antenna system in Alaska for use in the Nation's weather satellite program.

For the Project SYNCOM synchronous communications satellites, the network provided the intricate command and control functions required to put the satellite into a synchronous orbit.

Deep Space Network

Several steps were taken to give this network the capability to support future deep space flight programs. Construction started on an 85-foot parabolic antenna system in Southeast Australia, and related S-band electronic equipment was contracted for. In addition, a contractor was selected for the 210-foot advanced antenna facility at Goldstone, Calif. It will have the potential of receiving high quality television pictures in real time from lunar distances.

UNIVERSITY PROGRAMS

The Sustaining University Program was established in 1962 to expand university research and training in the space sciences and technology to help meet the needs of our expanding space effort. During the second year of the program, NASA made 22 special purpose research grants to augment and complement its major sponsored

research projects in space science and technology.

In addition, 786 graduate students entered training in space-related science and engineering programs under pre-doctoral training grants to 88 universities, and essential national space research capabilities were expanded by grants to 9 selected universities for urgently needed research facilities.

INTERNATIONAL PROGRAMS

At the close of 1963, 65 political jurisdictions had joined with NASA in flight, flight-support, ground-based support, or personnel exchange programs in the peaceful uses of outer space. A bilateral agreement was reached with the Soviet Union for limited coordinated U.S.-U.S.S.R. launchings of geomagnetic and weather satellites, and experiments with the ECHO II communications satellite. Cooperative arrangements were explored with two European space organizations--the European Space Research Organization and the European Launcher Development Organization.

Satellite Projects

The second cooperative U.S.-U.K. satellite (ARIEL II) is scheduled for launching early in 1964. Like ARIEL I, the first international satellite launched by NASA in 1962, the U.S.-built spacecraft will contain experiments designed and built by British scientists. ARIEL II will measure atmospheric ozone, galactic radio noise, and micrometeoroid flux.

ALOUETTE, the Canadian-built topside sound satellite, also launched by NASA (September 1962), continued to perform well and to transmit valuable data.

In view of the successful ALOUETTE cooperative project, the Agency and the Canadian Defence Research Telecommunications Establishment held technical discussions to develop a follow-up program--ISIS (International Satellite for Ionospheric Studies). Under this arrangement four satellites will be built by Canadians and launched by NASA at intervals during the next period of increasing solar activity--1965 to 1970.

Work continued on the U.S.-Italian San Marco program. The project is expected to culminate, in 1965 to 1966, in the launching of an Italian-built satellite into equatorial orbit from a towable platform (like a Texas tower) in the Indian Ocean. The satellite will be used to determine the local density of the upper atmosphere in the equatorial plane.

NASA and the French National Center for Space Studies agreed that the Agency should launch a French-built satellite in 1965 to study very low frequency (VLF) radio propagation.

During 1963, NASA also selected six experiments submitted by foreign scientists to be flown on the Agency's astronomical, geophysical, and solar observatory satellites from early 1964 through 1966. Selected in competition with U.S. proposals, the experiments are to be prepared at the expense of the cooperating foreign agencies.

In August, NASA and the Soviet Academy of Sciences approved a memorandum of understanding to implement the 1962 U.S.-U.S.S.R. technical agreement for limited

coordinated meteorological and geomagnetic satellite programs with data exchanges and long-distance experiments in telecommunication.

The Agency and the Soviets agreed to an exchange of weather data received from each country's experimental meteorological satellites using a fulltime data-transmission link between world weather centers in Washington and Moscow, and to subsequent coordination of launchings of operational meteorological satellites for maximum coverage of worldwide weather conditions. The two also agreed to joint experiments in telecommunication using the U.S. passive reflector satellite ECHO II, and to satellite launchings by each country, in 1965, to measure the earth's magnetic field, with free exchanges of resulting data.

Sounding Rockets

During 1963 sounding rocket experiments to collect data on cosmic rays, the ionosphere, and geomagnetic and auroral phenomena were conducted from ranges in this country and abroad in cooperation with Australia, Canada, India, Japan, New Zealand, Norway (with Denmark participating), Pakistan, and Sweden.

In two special sounding rocket experiments launched from Wallops Island, Va., in the summer, Italian technicians tested the drag-balance mechanism for the San Marco project payload, and French technicians tested the payload for their very low frequency satellite. As in previous years, NASA and the cooperating countries divided responsibilities for rockets, experiments, and ground facilities--each financing its own share of the work.

The Agency also concluded agreements with Argentina for a sounding rocket study of the ionosphere, and with Indian and Pakistan for their participation in a developmental meteorological sounding rocket program in connection with the International Indian Ocean Expedition of 1964.

Support for Satellite Projects

In 1963, 40 weather services were participating in ground-based meteorological studies coordinated with passes of the TIROS satellites. These meteorological studies included cloud photography, radar, and radio, and sounding rocket experiments. Fourteen countries have started to assemble or are planning to buy ground receiving equipment for NASA's new satellite-borne Automatic Picture Transmission (APT) subsystem to be orbited in 1964. Allowing direct readout of weather photographs as the satellite passes overhead, this relatively simple and inexpensive ground station equipment is within the means of many nations.

Arrangements were made for scientists in 26 countries to cooperate in ionospheric investigations through ground-based studies of radio emissions from NASA's Polar Ionosphere Beacon Satellite (S-66) scheduled to be launched from the Pacific Missile Range in 1964. Laser specialists from France and the United Kingdom plan laser tracking experiments associated with this satellite.

Fourteen countries took part in ground ionospheric studies synchronized with the passes of the Canadian geophysical satellite ALOUETTE.

Canada, Denmark, Norway, and Sweden were added to a growing list of nations

agreeing to cooperate with NASA in testing experimental communications satellites by providing major ground terminals at their own expense.

In August the first telephone and radio transmissions between Africa and the U.S. were made via NASA's SYNCOM communication satellite.

Tracking Network Stations -- International arrangements were made for new stations at Carnarvon and Canberra, Australia and Majunga, Malagasy as part of NASA worldwide tracking network. Agreements for existing network stations were renewed for Bermuda; Canton Island; Grand Canary Island; and Guaymas, Mexico.

Support for Project MERCURY Flight

The Agency cooperated with the Department of State in arranging for the entry of U.S. search and recovery teams into the territory of 80 countries should the MA-9 spacecraft have landed outside planned recovery areas during its orbital space flight in May. Approval was also secured for staging additional contingency recovery units overseas.

Personnel Exchanges

In 1963, 66 scientists from 23 countries participated in the post-doctoral theoretical and experimental research program at NASA centers. During the same period, under an Agency program 41 graduate students, co-sponsored and supported by their national or regional space committees, were enrolled at American universities in space research studies.

Some 140 technicians from 13 countries are also being trained at NASA centers in payload engineering, telemetry, tracking, radar, meteorology, launch procedures, and range safety operations.

Fourteen foreign students, sponsored by their national or regional space committees, attended a summer institute in space physics at Columbia University.

During 1963, about 2,400 visitors, representing foreign scientific and technical organizations, other governments, and overseas news media, toured NASA Headquarters and the Agency's field installations.

ORGANIZATIONAL CHANGES

During 1963, NASA made major organizational changes to obtain better coordinated planning and quicker reactions to new and unexpected developments, and to strengthen lines of authority and responsibility between Headquarters and field installations.

The Associate Administrator was relieved of direct responsibility for general operation of NASA's field installations. Responsibility for management of NASA's major programs and the field installations primarily required to carry out these programs have been assigned to three officials reporting to the Associate Administrator.

An Associate Administrator for Manned Space Flight will direct this program and the three centers primarily involved in the manned space flight program--George C. Marshall Space Flight Center, Manned Spacecraft Center and Launch Operations Center. An Associate Administrator for Space Science and Applications will execute these programs primarily through the direction of the Goddard Space Flight Center,

Wallops Station, Pacific Launch Operations Office, and the contractor-operated Jet Propulsion Laboratory. An Associate Administrator for Advanced Research and Technology will be responsible for carrying out this program primarily through the Ames Research Center, Langley Research Center, Lewis Research Center, and Flight Research Center.

Other Headquarters elements were realigned. A Deputy Associate Administrator for Industry Affairs was appointed and given responsibility for procurement policy and overall direction of procurement activities. A Deputy Associate Administrator handles agency-wide organizational and managerial matters as an "assistant general manager." A small Secretariat, headed by an Executive Secretary, is responsible for assisting the members of general management particularly in maintaining a flow of information among them and the major elements of NASA's Headquarters. The public affairs function was transferred from the Assistant Administrator for Technology Utilization and Policy Planning to an Assistant Administrator for Public Affairs who reports directly to the Administrator. The Office of Plans and Program Evaluation was abolished and its policy planning functions transferred to an intra-agency Policy Planning Board. Responsibility for coordinating plans for advance missions and projects was transferred to the Associate Administrator in order to relate more effectively NASA's planning for future projects to the status of programs and projects currently underway.

PROCUREMENT

The Office of Procurement, formerly the Procurement and Supply Division, was reorganized as a staff office reporting directly to the Deputy Associate Administrator for Industry Affairs. NASA is planning greater emphasis on incentive type contracts rather than cost-plus-fixed-fee contracts to stimulate more effective and economical performance by its contractors.

TECHNOLOGY UTILIZATION PROGRAM

This program carries out one of the primary responsibilities of the Associate Administrator for Technology Utilization and Policy Planning. Through it, NASA has taken the lead in a government-wide effort to translate and transfer the results of federally financed research to business, commerce, and related segments of the Nation's economy. Under the program the Agency employed industrial research organizations, universities, and publications to assist in the transfer of space research information.

Chapter IV
Department of Defense

INTRODUCTION

During 1963 the Department of Defense (DOD) sustained a comprehensive effort to advance and exploit those space and aeronautics technologies important to national defense posture. Over 20 percent of the funds spent for all Defense research and engineering programs were spent on military space activities.

About half of the military space effort - measured in dollar expenditures - is directed toward the development of hardware to meet firm military needs. The remainder is devoted to the development and maintenance of a base of supporting technology, techniques, and experience intended to sustain a flexible, responsive capability to move rapidly into future system development programs as future needs evolve.

This year was marked by a substantial growth in the reservoir of military space flight experience. Accompanying this experience is a growing inventory of space-proven hardware on which flight data are available and from which components, systems, and subsystems can be drawn for application to future programs. The space environment has become well enough understood to permit spacecraft design with confidence. Test and simulation techniques, equipments, and facilities have been developed which permit a greater emphasis and reliance on ground, aircraft, and other test and evaluation programs before commitment to orbital flight. With the fundamentals increasingly well in hand, greater attention is being directed to putting space technology to work and the balance of emphasis is shifting from the past need to explore to a growing competence to exploit. Continuing progress is being made with program management techniques, and with cost estimating. There is a growing expertise in cost-effectiveness analysis as it applies to military space systems and a firmly seated conviction that to merit support, space programs must compete favorably when weighed impartially against other feasible alternatives in the context of overall military needs for the present and the future.

Finally, there is wide recognition that the nation's space activities must be measured from a national rather than a departmental standpoint. Just as there are many Defense programs providing direct support to other agencies, so are the research and development efforts of the National Aeronautics and Space Administration, as well as those of other agencies such as the Atomic Energy Commission and the Weather Bureau of the Department of Commerce, providing hardware and know-how of importance to military needs. Prime examples are the NASA GEMINI program where the DOD and NASA are engaged in a joint manned space flight enterprise as well as the space nuclear power programs of the AEC and the Weather Bureau's weather satellite program. Undoubtedly, the scope and magnitude of the Defense Department's space efforts would be substantially larger if it were not for the programs of other agencies.

The year 1963 witnessed both progress and delays in achieving military space capabilities. During the year a DOD satellite was stabilized, for the first time, by utilizing gravity gradient techniques. Also, the first satellites entirely powered by nuclear energy were placed in orbit. With the launch of two identical satellites in the

fall of this year, significant steps were taken toward the development of the equipment and techniques for the detection of nuclear tests in space by satellite-borne instruments. The feasibility of voice, teletype, and high speed digital communications by passive relay via a belt of orbiting dipoles was successfully demonstrated. On the other hand, rendezvous with, and inspection of, unidentified satellites still appears technically difficult and there still remain unanswered questions regarding the technical feasibility, complexity, and cost-effectiveness of a spaceborne ballistic missile alarm system.

A significant step toward future manned space flight capabilities was taken in December with the decision to proceed with the development of a Manned Orbiting Laboratory (MOL). The MOL program will exploit equipment and facilities already under development in the DOD's TITAN III and NASA's GEMINI programs to provide an early, straightforward approach to the problems of exploring and developing man's potential for performing military missions in space. In corollary actions taken to provide a more economical and effective allocation of efforts and resources, the X-20 (DYNASOAR) program was terminated and the unmanned vehicle program for the research and development of the techniques and technology of advanced reentry and precision recovery was substantially augmented, both in emphasis and scope.

Continuing progress was made in strengthening inter-agency ties at both the management and operating levels in DOD and NASA and several important agreements were reached which establish terms of reference for further collective effort. Among these are agreements covering the GEMINI, Navigational Satellite, AGENA D and Thrust-Augmented THOR programs, a possible new manned earth orbital research and development project, the management and operation of the Atlantic Missile Range (DOD/Merritt Island Launch Area (NASA)), and ship support for APOLLO. Such agreements will further facilitate the conduct of a fully integrated national space program properly addressed to all national needs.

Although not accorded the public attention focussed on space activities, aeronautics programs continue to figure importantly in Defense interests and capabilities. Continuing, and significant, progress was also made in this area during the past year.

Accordingly, selected elements of the DOD program in both of these areas are highlighted in the following sections:

SPACE DEVELOPMENT ACTIVITIES

TITAN III

The TITAN III Standardized Space Launch System is being developed by the Air Force as a part of the National Launch Vehicle Program of the DOD and the NASA. This booster uses a modified TITAN II missile as the basic building block. A pair of 120-inch diameter segmented solid motors give over two million pounds of lift-off thrust. A new pressure-fed upper stage, capable of multiple restarts after long coast periods in space, will provide the propulsion versatility needed for very high orbits, escape missions, and precise control of orbital plane or altitude changes. The low altitude payload weight capability of the TITAN III configurations ranges from 5,000 to 25,000 pounds. Over a ton of payload can be injected into a stationary orbit.

After more than a year of program definition effort, the development phase was started on 1 December 1962. The first full-size five-segment solid motor was test-fired on

schedule in July 1963. The performance of the liquid injection thrust vector control exceeded expectations. The new twin engine propulsion unit for the upper stage was successfully tested, also in July, in a long duration firing with programmed shut-downs and restarts. A new facility at Edwards Air Force Base for testing the solid motors has been completed. At Cape Kennedy, billions of cubic yards of fill were pumped to create new islands in the Banana River. On these, construction of the new Integrate-Transfer-Launch facility is well on the road. In addition to the new complex, a conventional ICBM launch pad has been modified to support the early test flights of TITAN IIIA. The first flight is scheduled to take place in the third quarter of 1964.

Manned Orbiting Laboratory (MOL)

In December the Secretary of Defense assigned to the Air Force a new program for the development of a near-earth Manned Orbiting Laboratory (MOL).

The MOL system will consist of a modified GEMINI capsule coupled to a pressurized laboratory cylinder of approximately 1500-2000 cubic feet of volume configured as an orbiting laboratory, to be launched integrally on a TITAN IIIC. Astronauts will be seated in the GEMINI capsule during launch and will move into the laboratory after injection into orbit. After completion of their tasks in space, the astronauts will reenter the GEMINI capsule, detach, and deorbit, leaving the laboratory cylinder in orbit. The GEMINI capsule being developed by NASA for use in the Lunar Program will be appropriately modified to provide in-orbit access to the laboratory as well as to perform other functions necessary to support the MOL. While not required in the early stages of the program, rendezvous provisions will be designed into the MOL so that the laboratory could later be resupplied and reused if justified by progress made in defining man's military role in space.

The MOL program will be directed specifically to fulfilling the need for an early, effective demonstration of man's utility in performing military functions in space. This must be accomplished before realistic specifications can be drawn for any potential operational manned system.

The MOL program is not aimed at a military operational system, or even to an orbiting manned space station capability in the context usually attributed to that term. Rather, it will be designed to provide a minimal but substantive assessment of the feasibility and effectiveness of manned operations in orbit which may later be used to specify operational design characteristics and performance parameters. The first manned flight of the MOL is expected late in 1967 or early in 1968.

In initiating the MOL program, it was decided to terminate the X-20 (DYNASOAR) program because of its limited utility as an in-space test facility and because the exploration of the hypersonic flight regime and the development of maneuverable reentry and recovery techniques - which X-20 was primarily designed to do - are of lesser priority and can be more economically conducted in a program of unmanned lifting reentry vehicles. X-20 was directed to demonstrating the feasibility of a specific design of a radiative-cooled structure with a hypersonic lift-to-drag ratio of about 1.7. The development of a weapon system, or prototype of a weapon system, was not one of the X-20 objectives.

It is planned to broaden the DOD's unmanned vehicle program (ASSET) for the research and development of reentry and recovery techniques and technology to embrace a wider range of reentry conditions, materials, structures, and techniques than previously

included in either X-20 or ASSET. Much of the X-20 development experience - particularly the wind tunnel testing, aerodynamics, structures design, and materials improvements - will be directly applicable to this augmented effort.

As the development for the MOL proceeds, continued joint participation by DOD and NASA will be involved: in assessing compatible scheduling between DOD and NASA manned space flights, to facilitate the common usage of range and ground support equipment and launch tracking and control facilities, to incorporate NASA experiments in the MOL while meeting priority military requirements, and in planning and conducting a mutually interdependent effort for the exploration of hypersonic reentry characteristics and subsonic landing and handling qualities of representative lifting reentry vehicles.

Communications Satellite Programs

The immediate objective of the Defense Communications Satellite Program (DCSP), as reoriented by the Secretary of Defense in May 1962, is to provide a worldwide communications system utilizing active medium-altitude random-spaced satellites in polar orbits, with ground stations so located as to satisfy the operational requirements of the Defense Communications System. Under the integrating direction of the Defense Communications Agency, the Air Force has responsibility for the satellites and launch vehicles and the Army is responsible for the surface environment to be comprised of fixed and transportable terminals.

In January 1963 a request for proposal for the Program Definition Phase of the Medium Altitude Communication Satellite Development Program was distributed to 36 potential contractors. Seven contractors responded. The names of the two successful bidders were released on 13 May 1963. The purpose of the Program Definition Phase was to determine feasibility and acceptability of continuing with the development program. The study was completed on 30 July 1963.

The medium altitude system would involve four series of six to eight satellites, weighing approximately 100 pounds each, in random polar orbits. Approximately 24 satellites in four orbital planes, spaced 45° apart, will provide global communication coverage. Initial launches will employ spin stabilized satellites. Studies are now being conducted on the feasibility of phasing in gravity gradient stabilized satellites at a later date.

The DOD TRADE POST test program was continued in order to determine: The technical capabilities of a ground station complex which is compatible with at least two different concepts of communications satellites; the requirements for operation, maintenance, personnel, and logistic support; and the operational data to aid in planning future military communication satellite systems. Both military and commercial ground terminals and all available communications satellites - SYNCOM, TELSTAR, RELAY - were employed in carrying out this evaluation.

In addition, a continuous program of supporting development is being conducted to advance the design of satellite communications surface complexes as the state of the art progresses. These efforts generally lead from studies through component and subsystem development to actual hardware fabrication and integration. Included are investigations in such areas as multiple access, anti-jamming, communication vulnerability, improved radio frequency components, optimized antenna designs,

computer programming for satellite communications scheduling, and transportable terminals.

Project WEST FORD

Project WEST FORD is a communications experiment designed to place 50 pounds of copper hair-like filaments (dipoles) into orbit in a belt around the earth for the purpose of:

a. Investigating the technical feasibility of utilizing orbiting dipoles as passive reflectors for relaying communications.

b. Providing an opportunity for an objective assessment of the possible effects of the dipole technique on space activities or any branch of science.

The WEST FORD package was launched on 9 May 1963, and injected into orbit from the parent satellite on 10 May. The first observation of belt dispersal was made on 12 May. The dipole belt closed on 18 June 1963. Its width is about ten miles wide and 20 miles thick at an altitude of approximately 2,000 miles.

This experiment was very successful. Voice, teletype, and high speed digital data communications were transmitted between Camp Parks, Calif., and Westford, Mass. Observations and measurements are continuing in order to provide a detailed analysis and evaluation of this experiment.

In accordance with the Presidential Policy Statement of August 1961, the U.S. will plan no further launches of orbiting dipoles until after the results of the first WEST FORD experiment have been analyzed and evaluated. The scientific community will be advised of the government's plans before conducting further experiments of this nature.

Inspector

Work continued this year on various aspects of the satellite inspection problems. DOD/NASA detailed plans for performance of selected experiments on GEMINI flights are nearing completion. Conceptual preliminary design studies are under way to define a spacecraft capable of co-orbital inspection of non-cooperative satellites. Further efforts toward an unmanned prototype co-orbital demonstration have been suspended pending the completion of those studies.

ICBM Alarm

The objective of this program is the research and development of a space-based attack alarm system intended to maintain continuous surveillance over ballistic missile launches on a global basis. Such a system would consist of unmanned satellites carrying infrared sensors which can detect ballistic missiles in powered flights as they emerge from the atmosphere. During 1963, several technical advances were made in furthering this development as the flight test program was directed toward the actual detection of live ballistic missile launches. Two flights were conducted on which a number of in-space detections were made of both liquid-fueled and solid-fueled ICBM launches from AMR and PMR.

ANNA 1B

The ANNA 1B Geodetic Satellite launched on 31 October 1962 experienced early equipment failures that affected the power supply and by January 1963 the intensity of the flashing light experiment was reduced to about 25 percent of original level. The original observation program had to be abandoned in favor of a small camera network operating in the United States only. In July 1963 the power supply trouble disappeared and the light intensity came back to normal if used for about eight to ten flash sequences per day. With the limited revival of the light, a program has been formed to use ANNA 1B to determine the accuracy of long base-line surveys by satellite light techniques. The analysis of doppler and other data is continuing and the ANNA satellite has contributed materially to a better definition of the earth's gravitational field and to the improvement of world mapping accuracies.

On 13 December 1962 the DOD and NASA executed an agreement on Project ANNA which prescribed the division of responsibility which obtains from ANNA I as well as for a follow-on ANNA program. Overall project management for such follow-on programs as may be required rests with NASA. The DOD will participate as necessary to provide and operate certain ground tracking equipment to assist with data processing and analysis.

Large Solid Propellant Motor Program

In accordance with an agreement between the DOD and the NASA, the Air Force is carrying out a program to advance the technology and demonstrate the feasibility of very large solid motors. With segmented motors 120 inches in diameter already under development for TITAN III, this program has progressed in the past year to larger sizes, specifically 156-inch and 260-inch diameters. The practical limit for overland transportation by road or rail is 156 inches. There is no current DOD interest in a solid motor larger than this size.

A monolithic motor approximately 260 inches in diameter may have application to first stage use in very large NASA launch vehicles capable of orbiting payloads weighing hundreds of thousands of pounds; a motor of this size would require water transportation from the manufacturing plant to launch site. The two-year program initiated by the Air Force in mid-1963 should result in static firing tests of motors in both of these sizes from early in 1964 to mid-1965.

In support of NASA's interests, the DOD program includes four half-length 260-inch motors firings at new contractor-owned fabrication and test facilities on waterways in the Southeast convenient to Cape Kennedy. Should NASA's requirements dictate, successful demonstration of these sub-length motors at the three-million pound thrust level could subsequently lead to development of flight-qualified full size motors delivering about seven million pounds of thrust. In direct support of the 260-inch effort, a two-segment 156-inch motor will be used to test a three-million-pound nozzle and simulate the propellant grain design of the larger motor. Single segment 156-inch motors will be used in tests of mechanical thrust vector control methods at the one-million-pound thrust level. One of these methods uses a single large movable nozzle; the other, jet tabs. Concurrently with these tasks a general technology effort is being conducted which includes work on nozzle and case materials, fabrication processes, alternate methods of thrust termination and thrust vector control, ground handling equipment, high burn rate propellants, and high chamber pressures.

Navigational Satellite Program

The Navigational Satellite Program proceeded as planned during 1963. Ground based tracking, computation, and injection stations are in place and operating. Operational prototype satellites are being launched. Shipboard navigational equipment has been installed and operational evaluation of the system is under way. In February 1963 a DOD/NASA agreement was reached which provides that responsibility for governmental determination of the suitability of Navy-developed navigational equipment to meet non-military requirements, as well as responsibility for the development of non-military navigational equipment, rests with NASA. The DOD (Navy) retains responsibility for the development, technical direction, and operation of the satellite system per se, its associated ground environment, and for the development of military navigational equipment.

Spaceborne Nuclear Detection

The nuclear detection satellite program is a joint AEC-DOD research and development effort concerned with the detection of nuclear tests in space by satellite-borne instruments. The satellites developed under this program are designed to provide data on the operation of nuclear test detection sensors in space, and information on the natural radiation environment in which the sensors must function.

The first launch of this program occurred during the fall of 1963. Two identical experimental satellites, equipped with X-ray, gamma-ray and neutron detectors, were launched in tandem and placed into virtually identical near-circular orbits beyond most of the particle trapped in the earth's magnetic field. The two satellites were injected into their final orbits to maintain an almost constant separation of about 100,000 miles.

A large amount of data on radiation background has been received. These data will be used to design improved worldwide test detection systems of the future. In addition, the satellites are providing data of considerable general scientific value for the study of solar and galactic radiation.

Additional launches, each with two satellites, are scheduled in this series.

SPACE GROUND SUPPORT

Space Detection and Tracking System (SPADATS)

This system is under the operational control of the North American Air Defense Command (NORAD) and consists of three major elements. SPACETRACK, operated by the USAF Air Defense Command (ADC) is a globally dispersed system of long range radars and optical device plus a computer center at Colorado Springs. SPASUR, and interferometer fence across the southern U.S., is operated by the Navy. The third element, a full computer backup for Colorado Springs, is located at L. G. Hanscom Field and manned by a detachment of ADC.

During the past year SPACETRACK has been improved by the addition of a tracking radar in Diyarbekir, Turkey, and the completion of BMEWS Site III at Fylingdales, United Kingdom. Significant progress has also been made in automating the data processing throughout the entire system.

DOD National Ranges

The Department of Defense's National Range complex consists of the Atlantic Missile Range (AMR), Pacific Missile Range (PMR), and the White Sands Missile Range (WSMR). The capabilities of this complex continue to grow at a pace set by the ever-increasing data needs of the DOD missile programs and the nation's expanding space program. Capabilities added during the past year include highly instrumented new tracking ships, improved radars and precision tracking systems, additional communications capacity, and various minor improvements. Global satellite tracking and control facilities have been expanded and are now capable of simultaneous control of multiple orbiting vehicles. DOD space operations have increased to the extent over the past year that one or more active satellites requiring active control is now in orbit at all times.

In November the Secretary of Defense directed a number of changes regarding management of the DOD's missile test ranges and space launch and tracking facilities. The principal changes include:

a. The establishment of a single manager, within the Air Force, to coordinate and conduct the planning of ICBM and space vehicle tracking activities at: AMR, Point Arguello and Vandenberg AFB, and the Air Force Satellite Control Facility, Sunnyvale.

b. Transfer of the Navy-managed facility at Point Arguello to the Air Force.

c. Clarification of the responsibilities for on-orbit control of DOD satellites by assigning this function to the Air Force.

d. The initiation of action to transfer the anti-missile test support facilities at Kwajalein from the Navy to the Army, and the transfer, from the Navy to the Air Force, of the PMR space tracking stations.

These and other related changes are expected to improve the overall management of the facilities involved since responsibilities which previously overlapped have been clarified and ICBM and space support facilities are now to be managed by one central authority.

At AMR two new ships (modified C-4 hulls, renamed the General H. H. Arnold and the General Hoyt S. Vandenberg) have been added, augmenting the United States' already extensive mobile, seaborne radar tracking and telemetry capability. The ships will be used in support of the missile development programs and could be used in support of space projects. Also at AMR the electronic tracking capability has been enhanced with the installation of new, large, hi-power tracking radars with a greatly increased range and accuracy performance. A tracking system of extremely high precision, the Missile Trajectory Measurement (MISTRAM) has been put into operation up-range. It is supplemented by another new system, Global Tracking (GLOTRAC) which is mobile and has extensive coverage. A new submarine cable has been installed between Grand Turk Island in the Bahamas and Antigua. This provides an extension of high density wide-band communication capability over the critical first 1500 miles of the range. This increased capacity permits much greater flexibility of operation. Better range control results, but more importantly, project support is enhanced because of the ability to transmit real time tracking and telemetry

data back to Cape Kennedy as well as the transmission of vehicle control signals down-range.

Launch rates of large space boosters and missiles from the Point Arguello/Vandenberg complex of PMR tripled during this year. An important element of the PMR increase overall was the NIKE ZEUS AICBM tests which reached a peak level of activity. Highlighting over one hundred and forty other programs supported by the PMR were the successful launching of a DOD satellite containing an AEC-developed nuclear power plant, and the support of the MERCURY MA-9 flight. The MA-9 capsule and astronaut Cooper were recovered by the aircraft carrier Kearsarge in an area near Midway Island. Land tracking, instrumentation, and telemetry facilities at Canton Island, Kokee Park, Hawaii, and at Point Arguello, California provided the necessary support for the MA-9 operation. The USNS Wheeling, T-AGM-8 is being converted to an instrumentation ship and next year will join the group of PMR ships which are now assisting in obtaining data from satellites and missiles over wide ocean areas. Other important additions to communications, tracking, range safety, and multiple countdown facilities at PMR continue to be made.

At WSMR design and construction of the NASA-operated APOLLO Propulsion Development Facility was initiated. Modification of test stands and other support facilities for tests of APOLLO abort systems was completed permitting initial flight tests of the SATURN booster simulator (LITTLE JOE II). By the end of the third calendar quarter, WSMR was planning or providing range support for a total of 159 air, space, and missile project programs.

Rocket Engine Test Facility

In December 1963 the Air Force Systems Command completed construction at Arnold Engineering Development Center of the largest simulated altitude rocket test facility in the free world. This facility will permit testing of 500,000-pound thrust rocket engines under simulated altitude environments. The facility, which supports national booster programs, has the potential of being modified to permit testing of boosters developing 1.5 million pounds thrust.

AERONAUTICS DEVELOPMENT ACTIVITIES

Helicopter and V/STOL Development

Fixed-wing aircraft currently in the inventory have good characteristics for landing and taking off from short, unimproved surfaces. Currently available helicopters are comparatively efficient in vertical take-off, hovering and at low speeds. However, the flexibility of fixed-wing aircraft is still limited by their dependence on landing areas, and the helicopters are limited in stability, lift capability, range and speed. Therefore, the DOD is pursuing a development program with the twin goals of improving the helicopter and developing vertical and short landing and take-off (V/STOL) aircraft which are completely responsive to combat area requirements of the ground combat forces.

Helicopter development has included flight or wind-tunnel tests of rigid, semi-rigid and teetering rotors in speed ranges up to 160 knots. In 1962, the Navy, in cooperation with the Army, initiated a rigid rotor research helicopter program. The purpose of this effort was to determine if a simplification could be made in the helicopter program. The purpose of this effort was to determine if a simplification could

be made in the helicopter rotor hub without loss in current helicopter performance, stability and control. This program resulted in the construction of two experimental helicopters designated the XH-51. Flight evaluations were completed in 1963. The results indicate that the rigid rotor concept has merit in that hub mechanisms can be considerably simplified without a decrease in helicopter handling characteristics. In addition, an increase in helicopter performance is probable since the simplified hub has lower air drag than current rotor hubs.

Extrapolation from other tests completed this year indicates that, by 1968, it will be feasible to construct reasonably stable helicopters capable of speeds in excess of 200 knots. Tests were initiated with heavy lift, turbine-shaft driven helicopters with 8 to 10 ton lift capabilities and investigation of hot cycle and tip-turbine rotors continued with the objective of determining the feasibility of lighter weight heavy lift systems.

The Army conducted three V/STOL development programs directed towards a surveillance aircraft; one, as U.S. project manager, for development with the British and Germans, of a single engine, deflected jet V/STOL aircraft. Tests were initiated on and improved engine for this aircraft, capable of developing 15,200 pounds of thrust. A second program resulted in both conventional and hovering flight of a U.S. designed and fabricated twin-engine aircraft employing an augmented jet ejector principle for vertical flight. The third program has resulted to date in static tests of vertically oriented, turbine-driven fans which will provide over 15,000 pounds of vertical thrust to lift and propel a U.S. designed fan-in-wing aircraft.

The three military services continued three additional V/STOL programs funded equally by each Service directed toward development of a transport aircraft. Since the tilt-wing configuration was considered the lowest risk approach, five four-ton payload prototypes are being constructed under Air Force management. The first aircraft of this type, designated the XC-142A, is scheduled to fly in July 1964. Two half-scale research aircraft programs, one of a tandem tilt-propeller and one, a tandem rotating ducted propeller, are also being pursued. Design and component testing of the tilt-propeller version, designed the X-19A, were completed under Air Force management early this year. The first of two X-19A's was completed and the roll-out ceremony was held on 23 July 1963. First flights of the X-19 occurred late in 1963.

The rotating ducted propeller VTOL research aircraft, designated the X-22A, is now in the design phase under Navy management with first flights expected in early 1965. Two aircraft are scheduled for construction and evaluation.

Laminar Flow Control Demonstration Aircraft

The two X-21A Laminar Flow Control (LFC) demonstration aircraft began their flight tests this year. These aircraft, which are extensively modified WB-66's, have the so-called "wing that breathes." Suction through a large number of very fine slots in the surface removes the boundary layer air before it becomes turbulent, thereby reducing the friction drag.

Refinements in the system since the first flight in April 1963 have gradually increased the area of the wing over which laminar flow is maintained to about 70% at low Reynolds numbers. If it can be perfected for the expected speed-altitude regime, it could be applied to a subsonic airplane of optimized configuration with an expected increase in

range or endurance of up to 50%.

X-15 Research Aircraft

One of the X-15 Research Aircraft is being modified to increase its speed capability from Mach 6 (4100 mph) to Mach 8 (5400 mph). This will be accomplished by increasing fuel and oxidizer capacity in order to provide longer rocket engine burning time. At the same time other modifications are being made to provide greater heat resistance at the increased speed for the wing and tail leading edges, fuselage nose section, and cockpit windshields. Improved instrumentation to acquire aerothermodynamics, structures, and materials test data should add measurably to the value of the future flight program.

XB-70 Development

The objective of the XB-70 program is to preserve the option of developing a new manned bomber weapon system through exploration of the problems of flying at three times the speed of sound with an airframe potentially useful for a bomber. The program plan provides for the design, development and fabrication of three experimental prototype (XB-70) aircraft and a limited flight test program. The third aircraft will contain a prototype bombing-navigation system.

The XB-70 program is also of interest to the FAA and NASA as support for the National Commercial Supersonic Transport program and the supersonic aeronautical research activity conducted by NASA. Agreements have been reached among the FAA, NASA, and DOD (USAF) to provide for FAA and NASA participation in the program. FAA and NASA funds have been applied toward gathering information of specific value to those agencies from the SB-70 flight test program.

Work on the first aircraft approached completion as the year ended. Fabrication of the second and third aircraft was under way. The flight test program is scheduled to begin during 1964.

F-111 Tactical Fighter Aircraft

The F-111A is being developed as a fighter weapon system for Air Force tactical air missions in either limited or general war. The F-111B will perform fleet air defense missions for the Navy. The F-111 will combine high performance, long ferry range, and operational flexibility.

The Air Force is the program manager for this Joint Air Force/Navy Weapon System and the program has progressed well into the development cycle.

A full scale mock-up of the aircraft was reviewed by the two services in August 1963 and the configuration established. The commonality of configuration and equipments in the Air Force and the Navy aircraft has been retained with a high degree of success. The Development Engineering Inspection, a significant milestone in the development cycle, was completed in September 1963. The program is on schedule and milestones are being achieved effectively.

The development approach stresses total weapon system integrated performance to achieve the tactical demands of future air operations. The development cycle includes design and manufacture of the test articles, development flight test program, static

and fatigue test program, ground equipment development, and test program, together with the determination of spare parts and generation of technical data. This program will capitalize on the developments from other programs, and, as a result, the weapon system should have high reliability and operability characteristics.

F-5A Tactical Fighter for Military Assistance Program

Two prototype models of the F-5A have been undergoing initial testing at Edwards Air Force Base, California, during 1963. The first production model F-5A tactical fighter began flight test in October 1963.

This F-5A is the first of 85 fighters currently on contract and being built for use by nations participating in the Military Assistant Program. Seventy-one of the aircraft will be single place F-5A's. the remaining 14 will be F-5B two-place trainer versions.

Both versions of the F-5 are powered with General Electric J85-13 turbojet engines with afterburners. The F-5 reverses a trend toward heavier and more complex fighter aircraft. It is designed as a lightweight aircraft to provide high performance and reliability, low initial and operating cost, and minimum logistics requirements. It is suitable for a variety of missions, including air superiority, reconnaissance, interception, close support for ground troops, and interdiction of enemy targets behind enemy lines.

Both the F-5A and F-5B will carry SIDEWINDER missiles and auxiliary fuel tanks on their wing tips, plus a variety of bombs, rockets, chemical stores, and pylon fuel tanks on their five stations beneath the wings and fuselage. In addition to the aforementioned armament, the F-5A will carry two 20MM cannons mounted in its nose for aerial and ground attack missions. Its light overall weight, high thrust engines, leading and trailing edge wing flaps, parachute braking system, and special design "sod field" landing gear make the F-5 capable of operating from dispersed air strips less than 5,000 feet long. The F-5 sister aircraft, the T-38, is currently in use by the Air Force as a supersonic trainer.

C-141A Transport Aircraft

The C-141A was conceived as a modern, high speed, jet powered, cargo transport aircraft. It is being developed and produced for both military and commercial use. FAA certification, scheduled for January 1965, will be facilitated by continuous close coordination between the Air Force and the FAA in order to assure maximum compatibility with civil requirements.

The C-141A will be capable of worldwide, all-weather operations. The design of the aircraft will permit routine operation, at maximum gross weight, from air fields with runways measuring less than 6,000 feet. Significant features include four separately mounted 21,000 pound thrust turbofan engines, a high wing with a 25 degree sweep, a fuselage mounted landing gear, truck bed height level cargo compartment and a high T-tail empennage. It will have an excellent aerial delivery capability for personnel, equipment and supplies, as well as the capability for aeromedical evacuation.

The first C-141A was rolled out of the factory, on schedule, on 22 August 1963 and the first flight took place in December 1963. The introduction of this aircraft into the military - civilian transport fleet will greatly extend the speed, range, and

versatility of the nation's airlift capability.

COIN Aircraft

The DOD is currently following dual approaches to attainment of an improved counter-insurgency aircraft.

The Air Force is modifying T-37 and T-28 airplanes to determine the degree to which these aircraft can be successfully reoriented toward counterinsurgency use.

At the same time the Navy is undertaking the development of an entirely new "state-of-the-art" primitive area, STOL aircraft which is to be a combination weapon delivery and limited logistic vehicle. The combination of Air Force and Navy effort will provide both a short range program and a moderate risk, maximum improvement, longer term program. Contractor proposals were solicited by the Navy during the last quarter of 1963.

Airlift Requirements Studies

Extensive studies are currently in progress on the overall subject of Defense logistic support, examining the relative requirements for airlift, sealift, and prepositioning. In these reviews a new heavy-lift transport, the CX-HLS, is being considered which would have the additional capability for transporting outsize cargo. The studies are incomplete at this time and final requirements for airlift have not been determined.

Short Airfield for Tactical Support

After several years of effort, the Navy-developed Short Airfield for Tactical Support (SATS) is approaching operational status. The basic requirement that resulted in the development of the SATS system is that of the need for air support of the Marine assault and landing forces. With the SATS system, first line fighter and attack aircraft can be operated from areas close to the combat area without the need for expensive and time consuming construction of airfields. The SATS system is designed to be air transportable and quickly assembled and disassembled. Technical evaluation of the system is completed and operational evaluation is currently in progress. It is expected that first delivery of the operational system will commence in calendar year 1964.

SUPPORTING RESEARCH AND TECHNOLOGY

Vehicle Flight Control

The Air Force is conducting an in-house flight research program to develop solutions to the critical control/display problems associated with letdown, approach, landing, and take off of advanced high performance vehicles under "blind" flight conditions. The results of this program have direct application to the National Supersonic Transport program. FAA is actively involved with the Air Force and is contributing both personnel and funds. While far from complete, this program has aroused international as well as national interest in both military and commercial aviation fields.

In Phase I, 1200 successful blind landings and take offs were completed, forty-one Air Force, commercial and FAA pilots participated. In Phase II, two T-39 aircraft at the Instrument Pilot Instructors School, Randolph Air Force Base, Texas, have

been equipped for blind landings. A grossly larger cross section of pilots is being used to demonstrate the operational applicability of the system. Foreign pilots are being included in the program.

ASSET

The first of a series in the Aerothermodynamic/Elastic Structural Systems Environmental Test (ASSET) Program was successfully launched from the Atlantic Missile Range (AMR) on 18 September 1963. The basic objective of the ASSET program is to obtain data necessary to understand the glide reentry environment. With these non-orbiting, unmanned, glide-reentry vehicles, the Air Force conducts multiple experiments under true conditions of temperature, density, and velocity to obtain relatively steady-state data in aerothermodynamics, structures, and aerothermoelasticity.

The first ASSET, an aerothermodynamic/structural vehicle, was launched by a single stage THOR booster. Actual trajectory was almost identical with the planned trajectory. Booster separation and start of glide occurred at 200,000 feet and 16,000 fps. The vehicle impacted approximately 1,000 nautical miles down range. Although the vehicle was not recovered as planned, all data were gathered through telemetry and delayed playback.

As mentioned previously in connection with the MOL program, the purpose and scope of the ASSET program is being broadened to include a wider range of reentry conditions, materials, structures, and techniques than now planned for the initial flight program. It is expected that this augmented effort will produce the data needed to define design and performance parameters for an operational reusable space ferry vehicle, should that operational requirement evolve from the MOL program.

Variable Camber Propeller

In 1960, the Navy initiated a research and development program on a variable camber propeller. The purpose of this program is to provide more efficient propeller operation over a wider aircraft operating range. Since conventional propellers must be designed for maximum efficiency for one operating condition such as takeoff, climb, cruise, etc., they suffer efficiency degradation at other conditions. The first full scale static tests of the variable camber propeller were conducted in the spring of 1963. The results of these tests are promising and indicate that the program is proceeding satisfactorily toward the desired goal. Present plans are for the 50 hour preliminary flight rating test (PFRT) to be completed in early 1964 and flight tests on a modified B-17 to commence by mid-1964.

Tilt Float Program for Open Ocean Stabilization

In 1957, the Navy initiated a research and development program on a tilt-float system as the most promising means of providing on-the-water stability for helicopters and seaplanes against violent wave motions of the open ocean. Successful development of such a system could improve the effectiveness of airborne anti-submarine warfare operations as well as allow for more effective air sea rescue operations. On open sea tests of a seaplane test vehicle conducted this year, the pitching motion of the aircraft was reduced by as much as 96 percent by the application of the tilt-float system. These and other model tests on both seaplanes and helicopters have convincingly demonstrated the effectiveness of this system in providing a stable platform.

Regenerative Turboprop Engine

Development of a regenerative turboprop engine of approximately 4200 horsepower has been initiated. This engine will use the principle of recirculation of the hot exhaust gases to preheat the intake airflow. This makes possible a more efficient engine and will require less fuel use for the same output horsepower. It is expected that this new engine development will improve efficiency and effectiveness of aircraft weapon systems that are required to operate at low altitudes for long periods of time; for example: anti-submarine warfare and cargo delivery.

Jet Engine Thrust Measuring

As a result of a research and development program initiated in 1957, a more reliable method for determination of the thrust output of jet engines has been devised. This method utilizes the swinging probe technique and measures the temperature and pressure of the engine exhaust gases. The method and the developed equipment can be used on after-burning as well as non-after-burning jet engines. During this year, extensive flight testing of this method has been conducted using an A-5 aircraft with very encouraging results. The development of this method is of considerable importance in that it will (1) enable a more accurate determination of the flight characteristics of new military aircraft, and (2) provide a more positive identification of any deficiencies that must be corrected.

Sounding Rockets and Space Probes

Several sounding rockets were launched during 1963. Types of vehicles included the NIKE-CAJUN, the AEROBEE, the ASTROBEE, the BLACK BRANT, and others carrying payloads of up to about 100 pounds to altitudes of approximately 300 miles.

a. In June 1963, and AEROBEE launched at Eglin Air Force Base, Florida found a peak in the positive ion distribution in the ionospheric D region that correlated strongly with solar X-radiation in the one to ten Angstrom wave length band.

b. In July 1963, two Air Force-launched BLACK BRANTS at the Fort Churchill, Canada Rocket Research Facility, made the first direct ion density measurements in the ionosphere during and after a total eclipse of the sun.

c. Using NIKE-CAJUN sounding rockets, the compound trimethyl aluminum has been demonstrated to be a potent agent for exploring the upper atmosphere. When released in small quantities under pressure from a rocket in flight above about 55 miles, it yields a visible, artificial trail not dependent on sunlight for activation. Analysis of the behavior of the visible chemical provides information on upper atmospheric physical and chemical reactions, wind, and turbulence.

A space probe was launched by the Air Force on 30 July 1963 to measure extra-terrestrial radio noise at two and four megacycle frequencies. Boosted by a BLUE SCOUT, JR. the probe achieved an altitude of 7000 miles. The data showed that the noise level is essentially constant above 900 miles. Ionospheric absorption at these frequencies is thus negligible above that altitude.

Tactical Probes

Studies and development tests were completed during the past year involving the application of high altitude ballistic trajectory probes to military tactical requirements. Tests were completed proving tactical feasibility in the application of high altitude probes to long range communications and tactical area weather reconnaissance. Probes launched from aircraft, land and the sea itself for this application have proven successful.

Hydra Launch Technique

The Hydra technique involves the launch of rockets from the sea by appropriately water proofing the missile, floating it vertically like a spar buoy and initiating under water ignition. During the past year, development tests have been completed for the Hydra concept application to high altitude rocket probes. Standard land launched and air launched missiles have been modified and successfully fired from a floating position to carry instrumentation packages for the Lawrence Radiation Laboratory to altitudes of over a hundred miles. The attractiveness to this application of Hydra involves the very large flexibility in the selection of launch locations for obtaining synoptic information on the earth's atmosphere and near space environment.

Space Technology Satellites

The Air Force continued with an active launch program of Space Technology Satellites during 1963. Propulsion, guidance systems, and components used in various United States space projects were tested in a space environment. The data were obtained from telemetry and through recovery of the capsules.

During 1963 the total payload capability was somewhat increased through the use of an improved booster. However, the increment of payload capacity available for scientific experiments was less than in previous years. A total of 12 experiments was carried on in 1963 on micrometeorite detection, cosmic radiation, ionization density, and galactic radio noise. In addition, 20 packs of sensitive materials such as emulsions and metal transmutation samples were carried on recoverable vehicles for determination of particle radiation energies and total radiation doses received in the orbits of the spacecraft. Throughout 1963, results of experiments flown in 1962 continued to be analyzed. Four experiments on ionization density flown on Space Technology Satellites in 1962 have yielded unique data on electron fine structure in the auroral regions.

STARAD

The STARAD Air Force Special Radiation Measuring Satellite launched in October 1962 continued to function until January 1963, fulfilling its designed lifetime to within six days. The data on electron and proton energies, fluxes, and directional variation continue to be analyzed. Five scientific papers from the data have been published. The information from this satellite has been an invaluable contribution to the knowledge of the radiation effects from the high altitude weapon test of 9 July 1962.

Radiation Monitoring Satellite

A Radiation Monitoring Satellite was launched from an Air Force Space Technology Satellite while in flight in July 1963. This sub-satellite powered itself into an

independent polar orbit of 180 x 2240 nautical miles and carried a payload to measure magnetically trapped electrons and protons at all significant energy levels. The subsatellite yielded stored data read-out on two full orbits each day until September 1963 when the stored data read-out system failed. Since then the data have been read-out on real-time. All instruments have functioned perfectly and the data are of unprecedented high quality and resolution. Preliminary results of analysis show new relations between solar flares and low energy particles in the space plasma. Also, for low energy electrons and high energy protons, there seems to be no clear zone of separation between the inner and outer Van Allen belts, but rather only a gradual transition.

Geophysical Research Satellites

An Air Force Geophysical Research Satellite was launched using a Scout Booster from the NASA Wallops Island Station in June 1963. This small research satellite orbited between 260 and 800 miles, and operated perfectly until telemetering was lost, on the thirteenth orbit. The experiments consisted of a mass spectrometer sensitive to atoms and molecules of all weights from atomic hydrogen to molecular oxygen for the determination of space gas composition, and a retarding potential analyzer sensitive to photoelectronis up to 60 electron volts, positive ions up to 20 electron volts, and free electrons up to 30 electron volts. The data are in process of analysis and are regarded as especially valuable because of their clarity, the orbit dimension, and the day-night transition region collection process.

Space Power Equipment

The DOD continued to examine various concepts for meeting the anticipated high electrical power requirements of future satellites. For possible requirements of more than several hundred watts, careful consideration has been given to both nuclear and solar powered generators. In 1962, joint inter-agency management action was accomplished to undertake the development of a nuclear power unit to generate several hundred kilowatts of electrical power. Further progress was made in 1963, with agreement between the Chairman, AEC, and the Secretary of the Air Force on the use of Air Force capabilities by the AEC in the development of SNAP-50/SPUR (300 kw to 1,000 kw) nuclear reaction electric space power unit. The construction of major experimental test equipment for the turbine experiments and for heat transfer experiments commenced with Air Force funds and per agreement will be placed in operation using AEC FY 1964 funds.

In September 1963, the Department of Defense launched the nation's first satellite powered solely by nuclear (radio isotopic) power. This AEC-developed power unit, designated the SNAP 9A, delivers 25 watts of power and is expected to provide electrical power to the satellite systems for a period in excess of five years.

A new program was started this year to develop and demonstrate a solar powered electrical system capable of producing 20 kw of power continuously for a year. This is the only non-nuclear system under development capable of these power levels. It is expected that it could be available for space missions late in the decade. Five years of research work on component technology preceded this decision. One such task was accomplished this year; the orbital flight testing of solar mirror. Efforts this year were also directed to fabricating a 44.5 foot Solar Collector and installing it with a heat storage device to obtain ground test data.

Electrical Propulsion

In 1963, efforts continued to develop electrical propulsion engines which can be used for space missions around the 1970 time period. The performance and lifetime of the Contact Ion Engine was successfully increased. New concepts such as the Oscillating Electron Engine in the lower specific impulse range have also shown promise. The program to flight test the most promising engines included a flight test of the Contact Ion Engine late this year. In preparation for this flight, extensive flight simulation tests were conducted in the environmental chambers at the Arnold Engineering Center, Tullahoma, Tennessee, and at the Aeronautical Systems Division in Dayton, Ohio.

Gravity Gradient Stabilization for Satellites

During this year the Department of Defense successfully stabilized a satellite using gravity gradient techniques. After the satellite was placed in orbit a long boom was erected with a weight on the end and the resulting torques due to the decreasing strength of the gravitational field with altitude caused the satellite to align itself vertically within a few degrees. Damping forces were provided by a "lossy" spring at the end of the boom. Gravity gradient stabilization is a passive method of attitude control with inherent reliability for those types of long-lived functional satellites which are required to have their antennas, cameras, or other satellite instrumentation always pointed earthward.

Infrared

Recent developments in infrared detector technology have resulted in the development of a detector material consisting of mercury, cadmium, and telluride, with a sensitivity in the 8-14 micron region comparable to that of mercury-doped germanium which is currently the best detector in that band. The new tertiary detector offers the advantage of less severe cooling requirements (-196°C vs -243°C) to achieve the same performance as the mercury-doped germanium. This lesser cooling requirement will result in significantly less weight and power required to support these detectors when used for horizon scanners, satellite rendezvous, reconnaissance, and other space-borne applications.

LASER Technology

Several electronic projects in the exploratory development area had some type of LASER (Light Amplification by Stimulating Emission of Radiation) investigation under way in 1963. The research objectives include propagation studies, effects on materials, device configurations, modulation and demodulation schemes, materials research, medical and biological effects, improvement of efficiency, pumping and power supplies, improved detectors, aiming and beam deflection, and improvement of optical components.

It was realized quite early that LASER applications would, to a large extent, depend on a good fundamental understanding of the devices and major advancements in those areas previously mentioned. Accordingly, thoughts on applications have been used merely as guides to research.

In August 1962, ODDR&E formed the Special Group on Optical MASER's (Molecular Amplification by Stimulating Emission of Radiation). This group has the function of

reviewing existing and proposed programs of the Services and advising the Department of Defense and the Services on these programs. Membership consists of representatives from the three Services and ARPA. All NASA projects have been submitted as information items. Over the past year, the Group has effected considerable inter-agency and intra-departmental coordination and has been instrumental in reorienting a number of efforts down more useful lines.

General Support, Research and Development

The DOD's basic and applied research program in materials, ballistics, solid state physics, fuel cells, night vision, and upper atmosphere investigations, continues to contribute to the advancement of space technology. Some of the major activity during 1963 and progress associated with this effort is as follows:

Studies and investigations of the performance of solid and liquid lubricants and of the vaporization and outgassing characteristics of other materials in a hard vacuum were continued. While designed primarily to permit improvement of military missile and vacuum tube components, this effort is applicable to the solution of problems being encountered in the pursuit of space technology.

The results of military high temperature materials programs designed to improve nuclear reactors, gas turbines, gun liners and electrical devices are applicable in orbiting vehicle structural and power source parts.

Research into the energy absorption and dissipation characteristics of materials is being conducted for application to the development of protective armor and of shielding against nuclear weapons effects. This activity also has application to the problem of protecting personnel and equipment in space from the hazards of meteorite bombardment and natural high energy radiation.

The Department of Defense is continually looking for high strength-to-weight ratio structural materials for its weapons and other equipments. This research is significant to efforts designed to reduce the weight of spacecraft.

Investigations of the operating characteristics of available batteries which is important to satellite designers who use such power supplies as well as to manufacturers who are seeking to improve their designs.

COOPERATION WITH OTHER GOVERNMENT AGENCIES

General

Much of the Department of Defense space and aeronautics activity reported on herein was carried out in close coordination with other government agencies. Important examples already cited include the Large Solid Propellant Motor Program, the navigational and geodetic satellite programs, the X-15, and XB-70 programs, and spaceborne nuclear detection.

The Department of Defense's support to MERCURY launches and recoveries has been extensive and represents a major contribution to the success of this program during the past year. Other examples requiring emphasis include the DOD's participation in the Joint Meteorological Satellite Advisory Committee and continued cooperation with the AEC in the development and use of space nuclear power units.

DOD/NASA Agreements

Major DOD/NASA formal agreements were concluded during the year concerning the following:

a. Management and Operation of the Atlantic Missile Range (DOD) and the Merritt Island Launch Area (NASA)

b. The GEMINI Program

c. The TRANSIT Navigational Satellite Program

d. The AGENA D Program

e. The Thrust Augmented THOR-DELTA Launch Vehicle Program

f. A possible joint program for a manned orbital space station

g. The DOD Manned Orbiting Laboratory (MOL) Program.

DOD Participation in the GEMINI Program

On 21 January 1963, NASA and DOD entered into the agreement cited above designed to insure the greatest national benefit from the GEMINI Program. A joint GEMINI Program Planning Board was formed to administer the agreement. In May, the Board recommended to the Secretary of Defense and the Administrator of NASA a plan for DOD experiments to be performed on NASA's flights. In June the Secretary of Defense approved: (1) A program of "piggyback" experiments on NASA flights along the lines recommended by the Board; (2) the manning of an Air Force Field Office at Houston to manage the integration of DOD experiments into the NASA program; and (3) the assumption by DOD of the costs associated with improving the TITAN II booster for the GEMINI program. A development plan for the experimental program has been prepared by the Air Force, working with the Army, the Navy, and NASA's Manned Spacecraft Center.

Active DOD participation in the NASA GEMINI Program facilitates the flow of information between DOD and NASA, insures more complete use of experience gained in manned space flight activities, and minimizes the possibility of duplication within the National Space Program. Data derived from this program are expected to be useful for the MOL development and operation.

Orbital Space Station

On 16 September 1963 Secretary McNamara and Administrator Webb signed the agreement concerning a possible new project in the area of manned earth orbital research and development vehicles.

As pointed out in the agreement, since a large orbital space station would be a major technical and financial undertaking, the requirements of all government agencies should, insofar as practicable, be met in a single national program.

Both NASA and DOD will continue advanced and exploratory studies to develop data on agency requirements, possible new design concepts, feasibility, and costs. These

studies are to be coordinated through the Aeronautics and Astronautics Coordinating Board (AACB) which will evaluate the various advanced space station concepts. Acting upon the evaluations of the AACB, and in the light of the experience gained in GEMINI, MOL, and APOLLO, the Secretary of Defense and the Administrator of NASA will, at an appropriate time in the future, address a joint recommendation as to whether to proceed with a new national program in this area.

Manned Orbiting Laboratory (MOL) Program

DOD and NASA worked together in defining the MOL program and NASA concurred in the DOD decision to proceed. It was agreed that the MOL is not a national space station program in the context of the Webb/McNamara agreement of September 1963, but, rather, is a specific experimental test bed for certain potential military space applications not within the scope of NASA's activities. It was agreed, however, that NASA projects would be considered for test in the MOL on a non-interference basis in order that NASA might take full advantage of the research and development opportunities presented by the program.

Both agencies have agreed that a joint coordinating board should be established to advise and pass on recommendations to DOD and NASA top management concerning such GEMINI/MOL interagency interfaces as: common use of launch facilities, checkout equipments, control centers, and range support, as well as the accommodation of NASA experiments in the MOL.

Both agencies have agreed that major savings could be realized in the next year by terminating the DOD's X-20 program and orienting effort in the MOL direction. To provide the technical data needed for the design of possible future operational lifting reentry vehicles, DOD and NASA have agreed to coordinate in the planning and conduct of an accelerated program for the exploration of hypersonic reentry characteristics and subsonic handling and landing characteristics of representative reentry spacecraft.

Life Sciences/Bioastronautics

The Bioastronautics/Life Sciences programs of the Air Force and the National Aeronautics and Space Administration (NASA) were involved in several joint management actions during the past year.

The Manned Space Flight Panel of the Aeronautics and Astronautics Coordinating Board (AACB) completed a "Report on Air Force/NASA Space Station Coordination" in July 1963, in which Air Force and NASA representatives put forth a jointly approved plan for effective participation.

The Supporting Space Research and Technology (SSRT) Panel of the AACB has established a Life Sciences Sub-panel. This group, with members from the three military departments and the NASA, has formally addressed the problem of achieving effective coordination of Life Sciences/Bioastronautics effort with specific emphasis on eliminating duplication of effort. In achieving these goals, the sub-panel has arranged for the exchange of project data cards and task descriptions between the Office of Advanced Research and Technology (NASA) and the Aerospace Medical Division at Brooks Air Force Base, Texas, the latter of which has management responsibility for the Air Force Bioastronautics/Life Sciences program. This exchange will result

in computer-accessible information in both agencies, regarding the exact efforts being conducted in-house and on contract.

Another important agreement reached during the year was one between the Office of Manned Space Flight in Hq NASA and the Deputy for Manned Space Flight in Hq AFSC, Andrews Air Force Base, Maryland. This agreement entitled "Plan for NASA/AF Coordination of FY 1964 Space Medicine/Bioastronautics Design, Development and Test Programs to Support Approved Flight Program Requirements" resulted in a meeting this year between representatives from the Manned Space Flight Center, Houston, Texas, and selected Air Force technical specialists. At this meeting bench-level scientists from both agencies reviewed each task in detail and considered such matters as validity, priority, duplication, and redundancy. Each surviving task was then assigned to one agency or the other. Specific laboratories were designed and task scientists were identified. This method of detailed cross-examination will help assure that Air Force and NASA facilities and capabilities in this important area are being optimally utilized in the National Space Program.

SYNCOM I

DOD and NASA operations have been fully integrated in NASA's SYNCOM I effort, which resulted in the first synchronous-altitude communications satellites experiment. Since the launch of the SYNCOM satellite in July, the Army, as agent for the DOD, has directed the communications test operations and public demonstrations and is thoroughly evaluating the system to determine its true capabilities. The DOD has provided a total of five Satellite Communication Terminals for the SYNCOM network: a shipboard terminal, USNS Kingsport; two fixed terminals, Fort Dix and Camp Roberts; and two transportable terminals.

General Support, Construction

The Army Corps of Engineers continued to support the national space program by providing real estate acquisition and management services, and design and construction of facilities. Construction of the Manned Spacecraft Center at Clear Lake, Texas was continued and NASA occupied some of the buildings by the end of the year. Real estate was acquired and construction was started at NASA's Mississippi Test Facility. Additional land was acquired at Merritt Island for the expansion of NASA's launch facilities. Construction was initiated at Cape Kennedy on the SATURN V launch facilities including the large Vertical Assembly Building. Also at Cape Kennedy construction began on the Air Force TITAN III Integrate - Transfer - Launch complex.

Chapter V
Atomic Energy Commission

INTRODUCTION

Throughout 1963 the Atomic Energy Commission continued to pursue its efforts to develop: (1) a family of compact nuclear devices and nuclear reactors to provide power for spacecraft and satellites (Project SNAP); (2) the technology basic to the development of a nuclear rocket engine for accomplishing operational space missions in advanced launch vehicles (Project ROVER); (3) an advanced-type reactor which can be used as a heat source in ramjet propulsion systems designed to propel missiles of very long cruising range at high-speeds and sea-level altitudes (Project PLUTO); and (4) satellite-based instruments and associated systems to detect and identify nuclear explosions in space (formerly called Project VELA HOTEL).

PROJECT SNAP

SNAP Radioisotope Units

Compact devices which use the heat from the decay of radioisotopes as the energy source are being developed to meet space power requirements of up to several hundred watts.

Two of these small devices, plutonium-238-fueled 25-watt SNAP-9A generators, were launched into space aboard Navy navigational satellites the latter part of 1963. They are designed to supply the total power requirements of the satellites. These are the first launchings of nuclear powered satellites. They are designed to last five years, and are functioning properly.

Additional SNAP-9A-powered navigational satellites are scheduled for later launch. The SNAP-9A generators had been readied for use in 1962 but because the launchings of the satellites for which they were intended were delayed, they were subjected to additional ground testing in 1963. These tests led to improvements which were incorporated into the generators. Thus the SNAP-9A units which were delivered to the Navy during the last half of 1963 were, in effect, second-generation units which had been developed without an intervening flight test.

During 1963, a detailed design was completed of the SNAP-11 thermoelectric generator, and electrically heated prototype generators were fabricated and put under test. The SNAP-11 units being developed will have the capability of powering instruments in NASA's unmanned SURVEYOR soft lunar landing spacecraft. Half-scale SNAP-11 fuel capsules were tested during the year to assure no fuel leakage upon their impact with the surface of the moon.

Two SNAP-13 electrically-heated prototype thermionic generators were removed from life-testing in December 1962 because of a steady degradation in their power output. The power drop, caused primarily by oxidation of the external lead connections, was overcome by cleaning the connector pins and replacing the leads. Life-testing of the units, which are also adaptable to NASA's SURVEYOR lunar

landing program, was reinstituted in March, and completed in late, 1963. A demonstration SNAP-13 unit is scheduled to be fueled with curium-242 and ready for ground testing by mid-1964.

A detailed design was completed during the year of a radioisotopic power system for use in a satellite whose primary mission will be to chart the magnetic field between earth and the moon. Two plutonium-238 fueled thermoelectric SNAP generators, each of which will produce approximately 20 watts of electric power, are to be used to power the Interplanetary Monitoring Probe -- IMP -- satellite under development by NASA. Electrically-heated mockup generators are currently being fabricated.

A program was initiated during 1963 to develop an advanced, low-powered strontium-90 fueled thermoelectric generator for use on long-lived operational satellites such as the Air Force's medium altitude communications satellite. This program is the first step toward exploiting the use of abundant fission product radioisotopes for space power sources. Late in the year, two contractors were selected to perform separate but competitive design approaches.

SNAP Reactor Units

To initially provide space power in the range of .5 to 100 kilowatts, a family of compact, lightweight, long-lived, reliable, zirconium-hydride moderated, enriched-uranium fueled, nuclear reactors is under development.

By mid-1963, two complete SNAP-10A flight qualification systems, one non-nuclear and the other nuclear, had been assembled, checked out, and successfully subjected to a series of simulated launch environmental tests. The non-nuclear system operated satisfactorily at full power on October 12. The ground test nuclear qualification system is scheduled for full power operation early in 1964.

Another non-nuclear ground system, designed as a confirmatory test of flight-qualified hardware identical to the components which would make up a final flight system, is being assembled for scheduled 1964 full power operation.

Late in December the SNAP-10A flight test was cancelled because of the lack of firm space power requirements in the low kilowatt range. The associated ground system testing will continue as planned, and subsequent to endurance testing of the two complete non-nuclear mockups and one nuclear ground system, the SNAP-10A program will be completed. The development of thermo-electric technology will be continued under a separate thermo-electric material and generator development program.

Since the SNAP-10A reactor, with static thermoelectric power conversion system has been scheduled to be the first nuclear power reactor system to be placed in orbit, major 1963 effort was devoted to assuring its safe operation into, in, and back from, space. On May 22, an unfueled but otherwise complete SNAP-10A reactor was launched on a SCOUT vehicle from NASA's Wallops Island Complex in Virginia to obtain experimental evidence to support theoretical studies of reactor heating, disassembly, and melt down during re-entry into the earth's atmosphere. When the inert reactor reached an altitude of approximately 80 miles, its re-entry vehicle was turned and powered back into the atmosphere to simulate the reactor re-entering the atmosphere from a decaying orbit. A preliminary evaluation of data obtained by

optical tracking networks and special telemetry systems indicates that the major test objectives were achieved.

Late in the year, as the result of the lack of a firm requirement by a user agency for a nuclear-powered 3 electrical kilowatt generator for space use, the SNAP-2 development program was reoriented. Rather than being a system flight test demonstration program, the technology developed to date under the SNAP-2 program will be incorporated into a broadly based technical program designed to provide improved space nuclear power technology, including turboelectric power conversion, when systems are needed.

The SNAP-8 Experimental Reactor commenced nuclear operation using liquid metal coolant in May 1963. After successfully undergoing a complete system checkout and completing a program of low-power experiments, the reactor began its approach to full 450-thermal-kilowatt power operation in August. Upon reaching the 10 thermal kilowatt power level, however, an inadequacy in the instrumentation required that the reactor be shut down. During the shut down, a leak was detected in the cooling coils within the reactor containment vessel. Repairs were completed and the reactor was restarted in October. By mid-November, the SNAP-8 Experimental Reactor had attained its full power level, and during December it was started on a 60-day endurance run at full power.

The SNAP 50/SPUR power plant is being designed and developed for future space applications which call for hundreds of kilowatts of power with a high rate of power production for each pound of system weight. To meet the specified high performance goals, a high temperature, refractory metal system will be used with lithium serving as the reactor coolant and potassium as the working fluid for the Rankine cycle energy conversion loop.

During 1963, a working agreement was reached with the Air Force to combine several tasks in the power conversion area, being developed under the Air Force's SPUR program, with the reactor and power plant design work underway in the AEC's SNAP-50 Program. All of this work, currently in the component design and development phase, is now being funded and centrally administered by the AEC.

PROJECT ROVER

The most probable choice of basic reactor design for later flight engine development, the KIWI-B4A, was initially tested at the Nuclear Rocket Development Station in Nevada on November 30, 1962. The test was cut short when flashes in the exhaust jet indicated that material was being ejected from the core of the reactor. Subsequent disassembly and examination of the reactor revealed that most of the fuel elements in the core had broken or cracked, apparently the result of mechanical vibrations within the reactor. Consequently, major effort during 1963 has been directed to conducting an extensive program of component, subassembly, and full-scale mechanical and cold-flow (non-power producing) testing in order to examine, understand, and resolve the phenomena which may have caused the damage in the November power run. These design evaluation experiments have been conducted on an extensively instrumented reactor assembly identical to the KIWI-B4A except that it did not contain fissionable material. The data and camera records from these tests confirmed that excessive mechanical vibration was the primary cause for the failure of the "hot" test of the KIWI-B4A.

In August, a KIWI-B4B cold flow reactor core test indicated that modifications incorporated into the design of its core would prevent it from experiencing, at least under cold-flow conditions, the vibration difficulties which its predecessor KIWI-B4A core had experienced.

The KIWI-B2 reactor concept, whose core support design is distincly different from that of the B4 concept, was cold-flow tested in July. No mechanical vibrations were observed.

The development of critical non-nuclear components for the NERVA (Nuclear engine for rocket vehicle application) engine such as the nozzle, the liquid hydrogen turbo-pump system, and the engine controls and actuators, has been initiated. Preparations also have begun for conducting engine system tests on a mockup NRX (NERVA Reactor Experimental) reactor. The cold-flow experiments on NRX reactors are scheduled to begin late in 1963.

The Los Alamos Scientific Laboratory has been devoting an increasing share of its capabilities to the PHOEBUS Program, which is expected to provide the technology for developing rocket reactors with higher power levels, longer operating times and increased restart capability. Paralleling this effort, the Argonne National Laboratory is investigating various alternate core concepts which use uniquely different core materials. The total effort is aimed at providing an improved reactor technology for the development of advanced propulsion systems.

Despite labor difficulties with the crafts which slowed construction progress, modifications were made to some, and design services and conceptual studies are in progress on other, Nuclear Rocket Development Station Facilities at the AEC's Nevada Test Site. These facilities are being readied for testing the series of progressively higher power test reactors which will evolve into the flight reactors to be incorporated into the presently planned and the future envisioned nuclear rocket engines.

PROJECT PLUTO

During 1963 the AEC's PLUTO project to develop nuclear reactors for the DOD for possible use in low altitude supersonic ramjet missiles was reduced to development of the TORY IIC reactor only. In the absence of a specific DOD requirement, work leading to higher performance reactors was discontinued early in the year.

Assembly of the TORY IIC reactor, the second in a series of reactors designed to lead to the eventual development of a flyable nuclear power plant, was completed during the first half of 1963. Its design power, temperature, and size are the minimum required for a propulsion system to permit low altitude supersonic flight. On July 19, this flight-type reactor successfully achieved its initial criticality, i. e., a self-sustaining chain reaction. From then until the middle of September, neutronic measurements and evaluations were performed which, to within small acceptable tolerances, confirmed design predictions.

Following the completion of these criticality tests at the Lawrence Radiation Laboratory, the reactor was to be shipped to the AEC's Nevada Test Site where ground-testing was scheduled to begin during December.

The facilities at the Nevada Test Site which were used to test the TORY IIA initial engineering test reactor have been expanded and modified to accommodate the testing of the TORY IIC. This major construction project, completed in June, gives the test facility a capability of providing a five minute test run delivering air at about 2,000 pounds per second and 1,000° F, conditions which simulate the environment that a vehicle traveling at supersonic speeds at low altitude would encounter.

Late in October, after the TORY IIC test facility had undergone several trial runs, an inspection revealed certain deficiencies in the expansion joints. Although a repair and modification procedure was promptly initiated to restore the facility to sound operating conditions, shipment of the TORY IIC reactor from the Lawrence Radiation Laboratory to the Nevada Test Site is being withheld until the repairs and subsequent facility checkout are completed. Initial nuclear testing of the TORY IIC reactor is consequently now expected to commence early in 1964 rather than late in 1963.

SATELLITE-BASED DETECTION OF NUCLEAR EXPLOSIONS IN SPACE

In October, the successful launch of an ATLAS-AGENA rocket by the Department of Defense placed in orbit in space two AEC-instrumented detection satellites. The satellite-based instruments, consisting of X-Ray, gamma-ray, and neutron radiation detectors, were developed, designed, and fabricated by the Los Alamos Scientific Laboratory. The Sandia Laboratory was responsible for the associated data processing electronic systems placed in the satellites, and for special equipment to test the performance of the systems in the satellites.

The October launch was the first of several authorized rocket launchings to place detection satellites in orbit; instruments and associated systems developmental work is continuing.

Chapter VI
Department of State

INTRODUCTION

Brought to fruition in 1963 were the protracted negotiations of a number of international agreements of worldwide interest and great importance. Particularly noteworthy were the approval by acclamation by the United Nations of a resolution which welcomed the expressions of the United States and the Soviet Union of their intentions not to station any objects carrying nuclear weapons or other kinds of weapons of mass destruction in outer space and a second resolution, also adopted by the General Assembly, which called upon all States to become parties to the treaty, signed in Moscow on August 5, 1963 banning nuclear weapon tests in the atmosphere, in outer space and under water.

Many of the objectives proposed by the Department of State in past years also were brought to international agreement during 1963. Many of the proposals and recommendations tabled in the Outer Space Committee of the U. N. by the United States, i. e. scientific and technical cooperation and legal principles, were adopted unanimously by the General Assembly of the United Nations.

The final actions of the Extraordinary Administrative Radio Conference on Space Communications, held under the auspices of the International Telecommunications Union, were in considerable measure responsive to United States desires on the allocation of frequency bands for space communications. Successfully negotiated at this conference were frequency bands for radio astronomy, meteorology, navigational satellites, aeronautical amateur services, scientific research, and most important, communications satellites.

Negotiated or in the process of negotiation on behalf of NASA, are the renewal of tracking station agreements with Mexico, Nigeria, Spain, the U. K. and Zanzibar.

U. N. RESOLUTIONS ON DISARMAMENT

RELATED QUESTIONS INVOLVING OUTER SPACE

On September 19, 1963, the Soviet Foreign Minister stated before the General Assembly that "the Soviet Government deems it necessary to reach agreement with the United States Government to ban the placing into orbit of objects with nuclear weapons on board," and expressed awareness that the United States took a positive view toward a solution of this problem. The following day President Kennedy, in his address to the Assembly, said: "We must continue to seek agreement, encouraged by yesterday's affirmative response to this proposal by the Soviet Foreign Minister, on an arrangement to keep weapons of mass destruction out of outer space."

On October 16, 1963 Committee I of the General Assembly, while considering the question of disarmament, approved by acclamation a resolution, cosponsored by all of the participants in the 18-Nation Committee on Disarmament, which (a) welcomed

the expressions by the United States and the Soviet Union of their intention not to station any objects carrying nuclear weapons or other kinds of weapons of mass destruction in outer space, and (b) called upon all States to refrain from placing such objects in orbit. The U. S. Ambassador, speaking before Committee I, recalled that this resolution set forth a policy which had already been adopted by the United States, and said that he was glad the intentions of the Soviet Union in this regard were the same as our own. While reaffirming the intentions of the United States, he made clear that "if events as yet unforeseen suggest the need for a further look at this matter, we would acquaint the United Nations with such events." The General Assembly adopted the resolution by acclamation in plenary session on October 17, 1963.

On November 27, 1963, the General Assembly adopted, by a vote of 104 in favor, one against (Albania) and three abstentions, a resolution which called upon all States to become parties to the treaty banning nuclear weapon tests in the atmosphere, in outer space and under water, which was signed on August 5, 1963 by the United States, the United Kingdom and the Soviet Union.

ACTIVITIES WITHIN THE UNITED NATIONS

Guidelines for United Nations activity in outer space for 1963 were laid down by General Assembly Resolution 1802 (XVII), adopted unanimously on December 14, 1962, on the initiative of the United States.

The Scientific and Technical Subcommittee of the United Nations Committee on the Peaceful Uses of Outer Space, which met in Geneva from May 14 to 29, agreed upon a number of recommendations, including the following: (1) preparation by the U. N. Committee of a working paper on the activities of the United Nations and its specialized agencies relating to the peaceful uses of outer space and of a summary of national and co-operative international space activities based upon voluntary submissions; (2) compilation, in cooperation with the United Nations Educational, Scientific and Cultural Organization (UNESCO), of information on facilities for education and training in basic subjects related to the peaceful uses of outer space in universities and other places of learning; (3) recommendation to Member States to give favorable consideration to requests of countries for training and technical assistance; and (4) establishment, at the request of the Government of India, of a group of scientists, to visit the sounding rocket launching site at Thumba and to advise the Committee on the acceptance of United Nations sponsorship. In addition, the Subcommittee reviewed reports of the International Telecommunication Union on space communications and the World Meteorological Organization (WMO) on its program involving satellite meteorology.

The Legal Subcommittee, which met in New York from April 16 to May 3, was unable to record any progress at that time. The United States and other members of the Committee urged the adoption of general legal principles to guide the conduct of States in outer space upon which there was already wide agreement. The Soviet Union, however, opposed any recommendation on a set of principles that did not include four provisions to which the United States and other countries strongly objected. These were provisions (a) banning war propaganda in space; (b) restricing space activities to States; (c) requiring advance international consultation and agreement on national activities which might in any way hinder the exploration or use of outer space; (d) and condemning the use of satellites "for the collection of intelligence information." The Soviet Delegation also insisted that a declaration on general principles must take the form of an international treaty or agreement,

whereas the United States and others, believing a treaty to be premature, wished to see the general principles incorporated into a General Assembly resolution.

The full committee met from September 9 to September 13 to consider the reports of its two Subcommittees. It approved the recommendations of the Scientific and Technical Subcommittee. It also noted that as a result of the work of its Legal Subcommittee and subsequent exchanges of views, there had been a narrowing of differences on legal questions and expressed the hope that a wider consensus might be achieved by the time the General Assembly considered the Committee's report.

In accordance with the request of the U. N. Committee, the United States continued negotiations with the Soviet Union and with other Members of the Committee on legal matters. The negotiations yielded agreement on a declaration of legal principles and on the desirability of preparing international agreements on liability for damage caused by objects launched into outer space and on assistance to and return of astronauts and space vehicles. The Soviet Union abandoned its insistence that the declaration of legal principles include the four provisions which had obstructed agreement in the spring and also agreed that the declaration should be in the form of a General Assembly resolution rather than a treaty. The Outer Space Committee on November 22, 1963 unanimously decided to submit to the General Assembly an agreed text.

The Political Committee of the General Assembly adopted by acclamation the resolution containing the declaration of legal principles on December 5, 1963. The resolution was subsequently adopted unanimously in plenary session on December 13, 1963.

The United States and all other members of the U. N. Space Committee except Albania co-sponsored in the General Assembly a second resolution approving the recommendations endorsed by the Space Committee on scientific and technical cooperation; encouraging the programs of the World Meteorological Organization and the International Telecommunication Union in the fields of satellite meteorology and communications, respectively; and calling upon the Committee to arrange for the preparation of draft international agreements on liability and assistance and return. The Political Committee adopted this resolution by acclamation on December 5, 1963, and the General Assembly approved the resolution unanimously in plenary session on December 13, 1963.

The U. S. Ambassador to the United Nations opened the Political Committee's discussion of the two resolutions on December 2, 1963 with a major address. In this address he outlined progress toward freedom, peace, law and cooperation in the field of outer space. The Ambassador recalled that "President Kennedy proposed before the General Assembly last September to explore with the Soviet Union opportunities for working together in the conquest of space, including the sending of men to the moon as representatives of all of our countries." The Ambassador stated: "President Johnson has instructed me to reaffirm that offer today."

In response to General Assembly Resolution 1721 (XVI), the United States has continued to register with the U. N. Secretariat all United States objects launched into orbit or beyond since mid-February, 1962. In a letter of June 6, 1963 to the Secretary-General of the United Nations, our Ambassador called attention to the failure of the Soviet Union to include in its registration data submitted to the United Nations a number of Soviet space vehicles launched into earth orbit.

The World Meteorological Organization undertook several significant steps to implement General Assembly Resolutions 1721 (XVI) and 1802 (XVII) at its Fourth Congress in Geneva in April. A comprehensive study was initiated looking toward the improvement of the worldwide weather system, including the use of both satellite and conventional data. Member States were urged to cooperate in this study. In addition a WMO Advisory Committee of twelve highly qualified scientists and experts was established on operations, research and training aspects of meteorological activities and the atmospheric sciences.

The Extraordinary Administrative Radio Conference on Space Communications held under the auspices of the International Telecommunication Union in Geneva in October and November allocated frequency bands for space communications. The work and results of this conference are dealt with below. Following the completion of this Conference, President Kennedy issued a statement observing that "This Government and the United States Communications Satellite Corporation can now take practical steps, in cooperation with other governments and foreign business entities, to develop a single global commercial space communications system. It continues to be the policy of the United States that all countries which wish to participate in the ownership, management and use of this system will have an opportunity to do so."

BILATERAL AGREEMENTS AND OTHER INTERNATIONAL ACTIVITIES

In the spring of 1963 a senior NASA official met again with a senior representative of the Academy of Sciences of the U. S. S. R. to develop the broad steps to be taken to implement the bilateral technical agreement on cooperative space projects which had been reached between NASA and the Soviet Academy in 1963, i. e.: (1) the coordinated launching of meteorological satellites and the exchange of weather data from them; (2) a joint effort to map the magnetic field of the earth by means of coordinated launchings of geomagnetic satellites and related ground observations; (3) cooperation in the experimental relay of communications via an ECHO satellite.

These meetings resulted in a Memorandum of Understanding which was approved by NASA and the Soviet Academy on August 1, 1963. The U. S. representative on August 23, 1963, advised the Soviet representative that NASA was ready to proceed with the implementation of these projects and urged early action. He designated the American officials who would serve on working groups to bring the projects to fruition, and suggested detailed courses of action for each of the three projects. Further progress awaits action by the Soviet Academy.

In his address to the eighteenth General Assembly of the United Nations the President proposed to explore with the Soviet Union opportunities for working together in the conquest of space, including the sending of men to the moon as representatives of all our countries. As a means of accomplishing this objective he further suggested that scientists and astronauts of all the world band together to eliminate duplications of research, construction and expenditures necessitated by lunar exploration.

The Department undertook bilateral negotiations with a number of countries on items ranging from support of NASA programs to arrangements for communications satellite demonstrations.

In support of NASA programs the Department commenced negotiations with Spain for a deep space instrumentation facility to be located near Madrid. At the close of the

year negotiations for this facility were still underway. The State Department negotiated with Nigeria for the stationing of a ship, the USNS Kingsport in Lagos Harbor which was used in connection with the Project SYNCOM communications satellite. The Department also made arrangements with Japan for the first trans-Pacific television transmission using the RELAY communications satellite. Arrangements were made with Spain for a European demonstration of the SYNCOM communications satellite involving the stationing of the USNS Kingsport in Rota, Spain, after its departure from Lagos, Nigeria, with terminal facilities at Geneva, Switzerland and Washington and New York. This latter demonstration was held during the meeting of the Extraordinary Administrative Radio Conference of the ITU.

International agreements were signed in 1963 with Japan, Sweden, Norway and Denmark for joint participation in intercontinental testing of experimental communications satellites. An international agreement was also signed with France for a cooperative program to investigate the propagation of very low frequency electromagnetic waves in the earth's upper atmosphere. The Department continued to facilitate the work of Project SAN MARCO, in which the Italians will place a satellite into an equatorial orbit using a SCOUT launch vehicle from the "Texas tower" type platform in the Indian Ocean.

An officer of the Department served as a member of a committee chaired by USIA for international program demonstrations via communications satellites which were by RELAY and SYNCOM. He helped to formulate and institute Procedure Guidelines for the conduct of the demonstrations.

In 1959 and 1960 the Department negotiated agreements with Australia, Mexico, the United Kingdom and Spain providing for the establishment and operation within their jurisdictions of satellite tracking stations in support of the U. S. manned spaceflight program. A number of these agreements were scheduled to expire in 1963. The Department undertook steps to insure the continued use of the facilities by negotiating extensions, as appropriate, of the relevant agreements. Negotiations for the extension of the agreements with Mexico, Spain and the U. K. have been completed. Arrangements for the Zanzibar and Nigerian facilities are still under consideration.

Extensive preparatory work and contingency planning was done prior to the May 15-16, 22-orbit flight of Major Leroy Gordon Cooper which was the last flight in the MERCURY series. The Department's planning contemplated every possible contingency that could occur in the event of an unplanned emergency landing. More than 85 embassies, 17 consulates and 8 regional telecommunications centers were on the alert throughout the course of the flight to facilitate, if necessary, search and rescue operations. The planning, which was developed in close cooperation with NASA, also included thorough coordination with 16 major military commanders. Throughout the flight the Department maintained a special coordinating center and watch office which advised the Secretary of State and other principal officers as to the exact location of the astronaut at any given time and was prepared to inform them of the probabilities of an unplanned contingency landing in a foreign territory or at sea.

SPACE COMMUNICATIONS

In January and February of 1963 the 10th Plenary Assembly of the International Radio Consultative Committee (CCIR) met in Geneva to study technical and scientific problems affecting space radio communications and radio astronomy. The findings

of the conference are important as they have a direct bearing on the technical characteristics of future communications satellites. The Department organized the preparation of the U. S. proposals and a Department officer was chairman of the U. S. delegation.

The 18th Session of the Administrative Council of the International Telecommunication Union (ITU) which was convened on March 23, 1963, supported the U. S. proposals which were determining factors in establishing the agenda for the October frequency allocation conference. U. S. proposals were designed to enable the orderly development and operation of the space programs of the United States and other nations. The U. S. representative on the Administrative Council was also a Department of State officer.

Planning for the Extraordinary Administrative Radio Conference (EARC) convened in Geneva October 7, 1963, for the purpose to allocate frequency bands for space communications, telemetry, radio astronomy, meteorology, navigational satellites, aeronautical and amateur services and scientific research was coordinated by the Department in conjunction with the Inter-Departmental Radio Advisory Committee (IRAC), industry and scientific groups. To make the necessary allocations, the Conference amended the existing international Radio Regulations to the extent necessary to make the desired frequency bands available on an exclusive, shared or joint user--non-interference basis. The preparatory work started in 1960 and was intensified in 1963 when teams of experts were sent to numerous foreign countries to explain the U. S. allocations proposals. These proposals had been given wide and earlier distribution. Allocations obtained at the space radio communications conference, although not in all cases those proposed by the United States, are believed to be of sufficient quantity and quality to accommodate the presently projected U. S. requirements in the services mentioned.

Although the conference was technical in nature and the agenda limited to frequency allocations and related technical matters, the opportunity was seized to impress upon the delegations the policy of the U. S., established by the President and reflected in the Communications Satellite Act of 1962 that a commercial communications satellite service should be organized as a single global system with non-discriminatory access to all nations. The fears of a number of smaller countries that the major space powers of the world would pre-empt allocated frequencies for space communications by prior utilization, thus precluding small-nation participation in the development of a global communications satellite system, were largely allayed.

Progress was made in the implementation of the Communications Satellite Act of 1962. Starting late in the fall of that year, preliminary discussions were held with a number of foreign countries to explain the United States policy of a single global system for commercial satellite communication, with opportunities for participation in ownership, management and use by all interested countries. Following the organization of the Communications Satellite Corporation and the appointment of its principal executives, the Department established close liaison with the Corporation. Thereafter Corporation officials, assisted by the Department, held a series of meetings with the representatives of a number of foreign telecommunications agencies with the result that a satisfactory groundwork has now been established permitting actual negotiations, for the orderly development of a global system, to start during the early months of 1964. The negotiations will be conducted as a collaborative effort between the Executive Branch of the United States Government and the Communications Satellite Corporation.

Chapter VII
National Science Foundation

INTRODUCTION

The principal efforts of the National Science Foundation are directed toward the stimulation and support of basic research and education in the sciences. Most of this activity is conducted at universities and non-profit institutions.

Significant research is also carried out at three National Research Centers, federally owned and supported by the National Science Foundation. They have been established to provide essential research facilities, so large and expensive that it would have been impractical for most individual universities to have constructed them. The Centers also constitute nuclei for planning and executing research endeavors so broad in scope that the cooperative efforts of a number of institutions are required to execute them. Research at the Centers is carried out both by the resident staff and by visiting university scientists.

The National Radio Astronomy Observatory (West Virginia)

The new 300-foot radio telescope has been used almost continuously for a number of research programs primarily conducted by an impressive list of visiting astronomers. Examples of investigations carried out in 1963 are: study of 120 radio sources for possible polarization of their radiation; measuring the distribution of hydrogen gas in the Andromeda galaxy and in our own galaxy; exhaustive survey of all the radio sources in a strip of the sky at +40° declination.

Construction of a 140-foot precision telescope, after long delays, is now going forward, with the expectation that fabrication and erection of the major aluminum and steel components will be completed in December, 1964.

Work has started on the addition of a second 85-foot radio telescope to be used in conjunction with the existing 85-foot dish as a two-element interferometer. The new telescope will be mounted on wheels so that it can be moved along a runway to distances of up to 9,000 feet from its twin.

The Kitt Peak National Observatory (Arizona)

The new 60-inch solar telescope is the largest instrument of its kind in the world. Although the chore of debugging and testing has continued throughout most of the year, the instrument has been used part-time for research programs and soon will be in full-time operation. Its great light-gathering power and variety of spectrographic dispersions may make it the first optical telescope to be used around the clock. In addition to providing photographs of the solar spectrum and of sunspot velocity fields, it has been used at night to photograph stars, planets and the moon.

A new 84-inch stellar telescope is essentially completed by still undergoing tests. The mirror gives evidence of being extremely accurate. Some magnificent photographs of star clusters have already been obtained with it, and photoelectric

photometry has also started.

In the Space Division, work is continuing on the remotely-operated 50-inch telescope. Space research programs have been initiated, including the firing of two Aerobee rockets equipped with spectrometers to measure dayglow in the upper atmosphere. Studies of the glow of the night sky are also being carried out with special photometers on Kitt Peak.

Cerro Tololo Inter-American Observatory (Chile)

The major effort during the past year has been the completion of a 14-mile road linking the observatory site with the nearest existing road. Research is already underway on Tololo with one of Kitt Peak's two 16-inch reflecting telescopes which is used to set up photoelectric standards in the southern hemisphere. With the mountain now accessible, construction of the required buildings and telescopes can be started at a rapid pace. It is expected that a 60-inch and a 36-inch telescope will be in operation in mid 1965.

The E. O. Hulbert Center for Space Research (Washington, D. C.)

A grant to the Naval Research Laboratory (NRL) in Washington, D. C. for the establishment of this Center is permitting university faculty members and post-doctoral fellows to reside at the Center and to participate in astrophysical research from space platforms with the distinguished NRL team. This support will supplement the existing NRL effort by the addition of a number of major space experiments each year for the guest investigators, and is expected to greatly strengthen U. S. research in space physics.

Stratoscope II

The first scientific balloon flight of Stratoscope II (a balloon-borne 36-inch telescope operating by remote control at an altitude of about 80, 000 feet) took place on March 1, 1963 from the newly completed launch facility at Palestine, Texas. The purpose was to determine the amount of water vapor in the atmosphere of Mars by scanning the infrared spectrum of the planet in the wavelength region 1 and 7 M. Although the launch went perfectly the scientific results were marginal because of several malfunctions such as interference and electronic failures. Further scientific flights are planned for 1964.

The International Year of the Quiet Sun (IQSY)

The International Year of the Quiet Sun is a concerted 24-month effort to study the geophysical and interplanetary environment of the earth during the period of sunspot minimum. As such, it is a space activity, particularly since the earth and its atmosphere form the most sensitive probe of the space environment available to us so far. We have much to learn about the operation of this probe and how it responds to the varying inputs of solar particles and radiation. In doing this we add to our basic understanding of the earth, the atmosphere and exosphere, space, and solar radiation. These interlocking goals are the purpose of the IQSY.

The program for the IQSY consists of internationally coordinated research projects in meteorology, geomagnetism, aurora, airglow, ionospheric physics, solar radio

astronomy, solar activity, the interplanetary medium, cosmic rays, trapped particles, and aeronomy. The cooperative observations are geared to a calendar of world days and special intervals so as to assure appropriate simultaneity and dispersion. Results are brought together in World Data Centers which assure international dissemination of data for analysis and interpretation. More than sixty countries are involved, each supporting its own activities. The United States program consists of researches by a number of Federal and private agencies, and of a number of special projects, funded through the National Science Foundation, which are undertaken to enhance or to exploit the coordinated aspects of IQSY.

In calendar year 1963, the major United States efforts were planning, and the initiation of projects with long lead times for the construction of equipment. Grants were made in FY 1963 for projects to study the stratosphere, ionosphere, aurora, magnetic field, whistlers (sounds heard over voice radio generated by some lightning discharges) cosmic rays, and solar flares. The equipments are all expected to be in operation by January 1, 1964, as the IQSY begins.

High Temperature Gas Dynamics

Continuing support is being given to a research program at Harvard University on the properties of gases at high temperatures. While the data being obtained are not oriented toward a particular application, a knowledge of gas properties at elevated temperatures is fundamental to the solution of such problems as heat transfer from space vehicles upon entry into the atmosphere of a planet, spacecraft power production and spacecraft propulsion by ionized gases. This research team has published theoretically determined data on the high temperature thermal and electrical properties of helium and has recently completed an attempt at experimental verification of these data. The results of theory and experiment differ by a factor of 2, and an effort will be made by the group to resolve this discrepancy before proceeding to the study of the properties of hydrogen, which is a major constituent in the upper atmosphere.

The aerodynamic behavior of an ablating body is being studied under an NSF grant at the University of Florida. This work is of potential interest to space technology since the problem of heating of a space vehicle on re-entry is currently solved by ablation.

The drag and heating of meteors, satellites and space vehicles moving through low-density atmospheres at high speeds can be simulated using a hypersonic molecular beam developed under a research grant at the University of California, Los Angeles.

Chapter VIII
Department of Commerce

INTRODUCTION

The Department of Commerce both supports and makes use of the nation's space program through activities of the Weather Bureau, Coast and Geodetic Survey and the National Bureau of Standards. Applications of satellites to the operations of ships at sea are under review in the Maritime Administration.

WEATHER BUREAU

Space activities of the U. S. Weather Bureau are carried out through its National Weather Satellite Center (NWSC), Suitland, Md. During 1963 NWSC operations were highlighted by:

a. the continued use of TIROS-derived data for operational weather analysis and forecasting;

b. implementation of TOSS (TIROS Operational Satellite System);

c. cancellation of plans for a Nimbus-based operational system and initiation of steps to provide an interim and then long-term substitute;

d. continuation of meteorological support to NASA manned space-flight programs;

e. interim completion and dedication of the NWSC Data Processing and Analysis Facility;

f. progress in Meteorological Satellite Laboratory research programs; and

g. furtherance of the international distribution and use of weather satellite observations.

Use of TIROS Data for Analyses and Forecasting

The beginning of the year found two satellites---TIROS V and VI---in operation. On June 19 a third, TIROS VII, was orbited. TIROS V had ceased functioning in May, however, and TIROS VI did the same in October after 320 and 388 days of operating life respectively. TIROS VIII was successfully launched on December 21 and began operations that date.

Throughout 1963, at least one, and sometimes two, TIROS spacecraft were in orbit and operation. Their combined observations provided 3,052 useable picture sequences and 82,687 useable individual pictures.

On the basis of this coverage, 179 adjustments were made to the weather analyses of the National Meteorological Center, 79 Satellite Storm Advisories were transmitted to foreign countries, and 129 Satellite Storm Advisories were issued to Weather Bureau activities in the continental United States. Similar advisories, 325 in number, were provided to U.S. Navy Weather Centrals and U.S. Air Force Weather Centrals and U.S. Air Force Weather Detachments overseas.

Out of 41 named tropical storms, TIROS cameras were instrumental in locating or positioning 17.

During 1963 a number of picture-taking sequences were programed to support specific projects or operations. These included:

a. the International Indian Ocean Expedition;

b. experimental ice reconnaissance;

c. Project MERCURY (flight MA-9);

d. observation of the solar eclipse;

e. sea swell studies (University of California);

f. Antarctic resupply;

g. tropical research (Florida State University); and

h. U.S. Navy and Air Force Research and experimental programs.

The opening in September of a third Command and Data Acquisition Station, located at Fairbanks, Alaska, to complement the readout capabilities of the existing stations at Wallops Island, Va., and Point Mugu, Calif., greatly facilitated TIROS operations during the remainder of the year.

Automatic Picture Transmission (APT) Test

The entry-into-operation of TIROS VIII (December 21) was noteworthy for the APT system which it carried aloft. Using a so-called "sticky vidicon" camera, this system enabled cloud cover pictures to be scanned slowly for automatic direct readout to ground stations equipped to receive them. Test pictures, taken every 208 seconds for approximately 30 minutes of each orbit, proved the feasibility of APT and laid the groundwork for use of the system in follow-on spacecraft.

Implementation of TOSS

Essentially TIROS is a NASA research and development program. The operationally valuable information obtained from its flights has been a by-product or outgrowth of its prime experimental usage. As NASA plans further TIROS flights and experiments, these operations are expected to involve schedules and orbits not necessarily conducive to the production of data operationally useful to the Weather Bureau.

Recognizing this, the Bureau in late 1962 began discussions with NASA intended to

help maximize the continuity of weather satellite data by interspersing operational Weather Bureau-funded TIROS launches among NASA's research and development flights. This plan to deploy operational TIROS spacecraft was assigned the name TOSS (TIROS Operational Satellite System).

On May 23, 1963, TOSS was formally implemented when the Weather Bureau issued a $9,132,000 Purchase Order to NASA providing for three TIROS spacecraft, two THOR-DELTA launch vehicles, plus associated launch, data acquisition, programing and data analysis services. The first two TOSS spacecraft would be identical to TIROS VI with its two wide-angle cameras. The third would embody a "cartwheel" configuration, producing vertically oriented pictures taken by cameras looking out from the spacecraft rim.

The first NASA launching of a Weather Bureau TOSS satellite is expected in calendar 1964.

Cancellation of Plans for a NIMBUS-Based Operational System

When Congress in September 1961 appropriated funds to the Weather Bureau to establish and operate a National Operational Meteorological Satellite System (NOMSS), the national inventory of weather-reporting spacecraft consisted of only two models: TIROS and NIMBUS. The first was in a flight status. The other was under development.

Because TIROS has severe performance and observation limitations, it was decided to base NOMSS initially upon the NIMBUS vehicle. It was expected that this second-generation weather satellite would provide the earth-oriented global coverage required.

During 1963 the National Weather Satellite Center (NWSC) undertook a series of operational analyses and cost effectiveness studies for use in planning the further implementation of the operational system. From these resulted the conclusions that (a) for reason of its cost and projected lifetime, NIMBUS was not well suited for routine operational usage and (b) other satellite concepts seemed better adapted to meeting Weather Bureau requirements.

Ensuing Department of Commerce/NASA discussions reached the following conclusions (in late September and early October):

a. that further Weather Bureau funding of NIMBUS would be discontinued and plans terminated for a NIMBUS-based operational system;

b. that the cooperative program which had existed between the Weather Bureau as the user and NASA as the spacecraft system developer would be continued;

c. that this program would be re-oriented to provide for the development of an Operational Meteorological Satellite (OMS) which would possess the cost, reliability, lifetime, and other requisites recommended by the NWSC analyses and studies;

d. that because this OMS would require three years or more to develop, an Interim Operational Meteorological Satellite (IOMS), based upon TIROS technology, would be evolved and placed in operational service to fulfill Weather Bureau needs; and

e. that the NASA NIMBUS research and development effort would be continued for the space technology advances and experience benefits which such continuation would provide, particularly to the IOMS and OMS programs.

It is estimated that the first IOMS will be launched early in calendar 1965, the initial OMS, in the 1968 period.

Meteorological Support to NASA Manned Spaceflight Programs

To provide meteorological assistance to NASA's MERCURY, GEMINI, and APOLLO programs, NWSC's Spaceflight Meteorology Group utilized the services of its detachments at Miami, Cape Kennedy, and the Manned Spacecraft Center in Houston, in addition to its own headquarters staff at Suitland.

During the year the Group achieved the following:

a. continued studies of the weather problems for MERCURY recovery operations for all ocean areas beneath the MERCURY track;

b. provided operational forecasting services for the last MERCURY flight (MA-9);

c. expanded its general climatological studies to include all water and potential terrestrial landing areas for follow-on manned spacecraft;

d. began providing forecasts to the Manned Spacecraft Center for use in connection with GEMINI and APOLLO systems testing, primarily in the Gulf of Mexico and Texas; and

e. conducted instruction in meteorology to the second group of astronauts, stressing not only weather as it affects their operations but also what they as spaceborne observers and experimenters might do to advance meteorological knowledge.

NWSC Data Processing and Analysis Facility

The National Weather Satellite Center, created by the Weather Bureau as its management tool for the establishment and operation of NOMSS, is an operational as well as administrative headquarters. Into NWSC will come television and infrared data sensed by weather satellites and transmitted to Suitland and the Center by wideband communication links. There this information concerning the earth's atmosphere will be used (a) to generate TV pictures with latitude and longitude grid lines superimposed and (b) to provide computer-produced digitized and rectified mosaics and other products. These products will then be interpreted by NWSC analysts and

communicated, together with their analyses, to the world meteorological community.

The fulfillment of this task requires considerable data processing capability. On September 6, this capability, represented by recording, formatting, digitizing, and computing equipment, was declared to be in a state of interim readiness and the NWSC Data Processing and Analysis Facility officially dedicated by the Chief of the Weather Bureau.

Meteorological Satellite Laboratory (MSL) Research

MSL comprises a major activity within NWSC. By analytical studies, research investigations, and experimental programs, it seeks (1) to extract the maximum possible weather information from satellite observations and (2) to find new ways to obtain and apply such observations to the betterment of the various services provided by the Weather Bureau.

During the year, MSL continued its work on cloud picture and infrared data analysis. The development and movement of storms and weather phenomena were studied in search of new information concerning their behavior and how to predict them accurately.

Of particular interest among the fifty or so projects under way was the work carried on (1) to test the feasibility of improving the Numerical Weather Prediction model using satellite data, (2) to determine or devise methods for inferring atmospheric motions from satellite cloud pictures, (3) to investigate the possibility of using reflection patterns of the sun on the sea surface and radiation data from satellites to estimate wind speeds over water surfaces, and (4) to experiment in viewing the earth's cloud cover using the near-infrared portion of the spectrum. For this last project, a hand-held camera containing infrared film and three separate filters was used by the MA-9 astronaut to obtain photographs in the 6600 to 9000 A^{o} range. These pictures revealed that the strong emission from vegetation tended to decrease the contrast between clouds and land surfaces as compared with photographs made in the visible range. Film definition and contrast between land and sea areas were termed "excellent."

International Distribution and Use of Observations

June 1963 saw the beginning of the first full year of overseas facsimile broadcasts of satellite-derived meteorological information. These took the form of standard facsimile and photofacsimile transmissions beamed toward Manila, Frankfurt, San Juan, and, at times of significant Australian information, toward Melbourne.

The past twelve months additionally saw certain nations--specifically Argentina, Ireland, Israel, and, on a part-time basis, the United Arab Republic-- start re-transmitting pertinent standard satellite cloud analyses (nephanalyses) received via these international broadcasts. The willingness of these countries to relay the information to other local users is an important step toward achieving optimum utilization of the weather data which these nephanalyses contain.

Special interest was attached to the agreement dated March 20, 1963, between the U.S.S.R. Academy of Sciences and NASA. This laid the future basis (1) for exchange

of satellite-derived meteorological information (cloud photos and nephanalyses) over a communication link between Moscow and Washington (Suitland) and (2) for the coordinated launchings of operational weather satellites in the future.

Weather Satellites and the World Meteorological Organization (WMO)

The Quadrennial Congress of the World Meteorological Organization was held in April 1963. One of the major items considered was peaceful uses of outer space, including developments in meteorological satellite programs. The WMO, led largely by United States interests and proposals, had responded to United Nations Resolution 1721 calling for extensive international activity in meteorology, with its "First Report on the Advancement of Atmospheric Sciences and Their Application in the Light of Developments in Outer Space." This report called for extensive research and operational effort in the atmospheric sciences and developed the concept of the "World Weather Watch" to assist in reaching these objectives. The WMO Congress, again responding to United States proposals, considered the new United Nations Resolution 1802 which requested the WMO to develop in greater detail its plans for an intensive program to strengthen meteorological services and research with particular emphasis on artificial satellites, education, and training. The United States proposed the establishment by the WMO of a new Development Fund to assist in implementation of the "World Weather Watch." This concept was adopted unanimously. The United States also introduced proposals for system study on a worldwide basis of requirements for improvement in data availability and facilities for research, operations, education, and training. The United States announced and described the newly developed automatic picture transmission system for use on meteorological satellites which will permit suitably equipped ground stations to acquire pictorial data of meteorological conditions in their local area.

Other

Establishment of a National Meteorological Rocket Network (NMRN) under overall management responsibility of the Weather Bureau--see Report to the Congress from the President on United States Aeronautics and Space Activities, 1962--did not materialize during 1963 owing to lack of funding.

Project SKYWATCH was undertaken in the summer and again in the fall of 1963. This program made use of the help available from students in the Washington, D.C., area to record observations of clouds and weather conditions. Assisted by local newspapers which published the times that TIROS would overfly the area, these school children observed and sketched the clouds, using specially-prepared SKYWATCH observation forms. They recorded also wind speed and direction, humidity, temperature, and precipitation where school-owned weather instruments were available. The data thus recorded by these youngsters--a thousand from over 200 schools participated in the October experiment--were forwarded daily to NWSC for subsequent research analysis. In addition to the eventual value of correlating these high-density ground observations with the pictures taken by the passing satellite, the impetus given to student and teacher interest in meteorology made this program a major achievement of the year.

COAST AND GEODETIC SURVEY

The Coast and Geodetic Survey has been active in the development of photogrammetric satellite tracking systems to be used primarily for establishing a world geometric geodetic control net. The Survey has also been active in support of other space projects.

Geodetic Triangulation Apparatus and System Planning

The Coast and Geodetic Survey has completed the technical development of three precision photogrammetric satellite tracking systems for use in geodetic satellite triangulation using passive (sun-lit) satellites. The first evaluation phase has been completed satisfactorily. This consisted of photographing ECHO-1 simultaneously with the three cameras side by side to establish that the position of the satellite, photographed against a stellar background, was the same for all cameras. The second consists of photographing ECHO-1 and ANNA 1B with the three cameras located at the corners of a triangle, one each in Maryland, Mississippi, and Minnesota. Many simultaneous photographs of ECHO 1 and several of ANNA 1B have been obtained and computations of the results are in progress. Preliminary results are very encouraging and indicate that it will be possible to define, for the first time, a network having an accuracy commensurate with increasingly rigorous civilian and defense requirements. Present plans are to extend the present satellite triangulation to Bermuda, Puerto Rico, and the Canal Zone.

A system study is in progress to provide a comparison between sun-lit and incandescent satellites for measurement of the worldwide geodetic reference system. The study will also be used for determining the ground operations that would provide the necessary data at least cost.

Missile Range Measurements

Extensive geodetic surveys have been made during the year at both Atlantic and Pacific Missile Ranges. These were done to provide essential data for the tracking of test missiles over the ranges and for the launching phases of earth satellites and space vehicles.

Magnetic Field Studies

NASA has continued to use the Coast and Geodetic Survey's large-coil facility at its Fredericksburg, Md., Observatory during the past year for the test and calibration of a number of instrument packages designed for satellite installation. This is the only facility known in the United States having fully automatic controls and capable of maintaining near-zero magnetic field intensities for the duplication of outer space magnetic conditions. Special equipment has been used at times in these coils for producing wide ranges of temperatures and high vacuum conditions as well as the controlled magnetic fields.

The analysis and interpretation of magnetic measurements made in orbiting vehicles and space probes must be correlated with the distribution of the magnetic field at the earth's surface, the latter portrayed by C&GS "world magnetic charts." But vast oceanic areas have inadequate magnetic measurements and the U. S. Naval Oceanographic Office through its Project MAGNET is attempting to supply these through

airborne magnetic surveys. The Navy has used the Fredericksburg Observatory to calibrate its airborne magnetometers.

The C&GS has a cooperative project with NASA and the National Science Foundation for the study of geomagnetic data from an array of observatories throughout the world. The study will produce a mathematical description of the temporal changes in the magnetic field which will be used in the evaluation and analysis of magnetic measurements made with satellite and space probe vehicles.

Seismic Studies

The C&GS has monitored the seismic effects of several vehicle launches at the Atlantic Missile Range. These included the Moon Probe of April 23, and the Saturn 4 launch of April 28. The objective of the C&GS seismic monitoring program was to obtain data on seismic conditions generated within the Cape Kennedy Missile Test Complex and vicinity by missile launches, and to provide consequently an estimate of the probable seismic conditions to be generated by launches of larger vehicles.

Analysis of the seismic data obtained made possible the prediction of the seismic effects from vehicle launches with engines of .075 to 1.3 million pounds of thrust with possible extrapolation to much larger vehicles.

Special Maps for Space Activities

The C&GS has prepared and furnished two maps to Aracon Laboratories, Concord, Mass., (under contract to Meteorology Research Laboratories, AFCRL, Bedford, Mass.). The two maps portray that portion of the earth as seen from an altitude of 500 miles, and are printed in 8 tones from black to white as depicted on photographs taken from the TIROS Satellite. They are to be used to index and interpret future photographs relayed from other satellites.

Also under preparation by C&GS for the Navy are three charts of the Pacific Missile Range for "Official Use Only."

NATIONAL BUREAU OF STANDARDS

Because the national space program ranges across the broad spectrum of science and engineering, many NBS projects contribute substantially, although sometimes indirectly, to the national space effort. The Bureau's efforts to provide leadership in measurement techniques, the properties of materials, in radio propagation, and cryogenic engineering are frequently spurred in by the exacting demands of the space program.

Basic Measurement Standards and Techniques

For several years the Bureau has been conducting a research program for calibrating master gage blocks in order to meet the stringent calibration requirements imposed by increasingly small tolerances in industry. Many of these requirements are associated with the guidance systems of space vehicles. Two types of gage blocks have now been developed which are dimensionally stable to better than one 10-millionth of an inch per year.

The accurate measurement of spectral irradiance has assumed increasing importance in connection with studies of the irradiance to which space vehicles will be subjected. During the year a new standard of spectral irradiance was developed in the form of a 200-watt quartz-iodine lamp with a coiled tungsten filament operating at about 3000°K.

Research continued on atomic standards of frequency and time which are vital to the space program. A new cesium beam frequency standard was constructed which promises to have a precision about twice that of the cesium standard now used to maintain the United States Frequency Standard with an accuracy better than one second in 3000 years. In addition, a thallium beam standard was evaluated and it appears that it may provide an improvement of one order of magnitude in accuracy over that of cesium.

Standard Reference Data -- Basic Properties of Matter and Materials

Basic information on the properties and behavior of matter and materials is fundamental to the design and execution of experiments, the design of systems and components, and the reliability of complex equipment which is typical of the space program. In addition to existing experimental programs in materials research and fundamental physical constants, the Bureau launched a new program in 1963 which should go far toward insuring that reference data needed by scientists and engineers is available when and where it is required.

A National Standard Reference Data System is now being set up which will consist of a National Standard Reference Data Center at NBS, and various other Standard Reference Data Centers in other government agencies and at universities, research institutes, and other non-government organizations.

Under the sponsorship of the Advanced Research Projects Agency, the Bureau continued its comprehensive program of research on the thermodynamic properties and high temperature chemistry of simple light-element substances that are important in rocket propulsion. Microwave spectra have been detected and analyzed for such molecules as aluminum monofluoride and aluminum monochloride, which do not exist at room temperature but which are important constituents in rocket combusion systems.

New information of interest to space scientists on the atomic energy levels of the rare gases helium, neon, and argon was also obtained in a series of independent experiments which utilized both electron and photon interactions.

Radio Propagation Studies

The Bureau's Central Radio Propagation Laboratory (CRPL) in Boulder, Colorado, is concerned with the collection, analysis and dissemination of information on the propagation of radio waves at all frequencies along the surface of the earth, in the atmosphere and in outer space. The very broad research program conducted by the CRPL contributes in numerous ways to improved understanding of upper atmosphere and solar phenomena in addition to improved space telecommunications. The following examples cover only a very few of the CRPL activities which directly support the national space program.

During 1963 ground-based studies of the inonosphere in the vicinity of the earth's equator were made by a scatter radar technique at the Jicamarca (Peru) Observatory of CRPL and of the Instituto Geofisico de Huancayo (Peru). This observatory, located on the magnetic equator near Lima, employs a 6-million-watt transmitter and a 22-acre antenna to transmit a very high frequency radio wave of extremely short duration to great heights. The primary function of the installation is to study the distribution of electron density with height out to 6000 miles or more above the earth's surface.

In cooperation with the Instituto Geofisico de Hyancayo, the Jicamarca Observatory made a series of measurements of the synchrotron radiation that was emitted by the man-made belt of high-energy electrons which formed as a result of the high-altitude nuclear detonation occurring above Johnson Island in the Pacific on July 9, 1962. From these measurements, made at 30 and 50 megacycles per second, the number, energy spectrum, and decay rate of the electrons were derived -- information that will help improve understanding of the physics of the upper atmosphere. The extremely high radar sensitivity available at Jicamarca also made possible the detection of radar echoes from Venus when the planet was observable from Lima during the first week of December 1962.

During the orbital flights of Astronauts Shirra and Cooper, special efforts were made by the staff at the North Atlantic Radio Warning Service located at Ft. Belvoir, Va., to keep Project MERCURY headquarters informed of current and anticipated radio propagation conditions. Special forecasts of radio propagation conditions were issued previous to the flights and at every hour during the flights, specifically for the high frequency circuits which comprise the Project MERCURY ground communications network.

CRPL participated with NASA and the Defense Research Telecommunications Establishment of Canada in the analysis of data from the ALOUETTE topside sounder launched in September 1962. The sounder has produced more than a quarter of a million ionograms in an orbit which permits almost pole-to-pole analysis of the topside of the ionosphere.

Other CRPL studies included predictions of the limitations on radio tracking of rocket launch trajectories imposed by the atmosphere, experimental studies of distance and angular position errors in long-baseline tracking systems, studies of the effects upon space communication systems of forward scatter interference from thunderstorm cells, and theoretical calculations of the interaction of solar plasma thrown out by the sun during magnetic storms with the outer portion of the earth's magnetic field.

Cryogenic Engineering

This continuing program provides information on the physical properties of materials at extremely low temperatures, methods of measuring these properties, and the characteristics of cryogenic systems. The emphasis is on practical applications, and the program includes experimental work as well as the operation of a data center. Space programs, relying on cryogenic liquids as propellants have markedly increased the demand for information in this field.

The Cryogenic Data Center's documentation unit searches the world literature for

technical information pertinent to the cryogenic engineering field and provides such literature to the Bureau staff and the cryogenic industry.

A study of the bulk density of boiling liquid oxygen stimulated by the needs of rocket propulsion programs, was completed with NASA support. Satisfactory agreement between the theoretical analysis and the experimental research to determine the mass and volume of propellant aboard a vehicle at any time was obtained. The theoretical analysis was also applied to boiling liquid hydrogen.

Cryogenic instrumentation studies were continued with particular emphasis during the past year on the evaluation of liquid level point sensors for hydrogen. The dielectric behavior of dense parahydrogen also was studied to meet urgent demands of design engineers who are interested in determining density, liquid level and quality of the fluid by capacitance measurements.

Assistance is being given to Projects CENTAUR, ROVER, and NERVA. The CENTAUR first space vehicle to use liquid hydrogen as a propellant, will be followed by the nuclear rocket programs, ROVER and NERVA, that are planning more extensive use of liquid hydrogen. The physical properties of hydrogen are sufficiently different from other propellants to present many new problems to the industry. Principal contractors of these programs receive Bureau support in the areas of ground support equipment, insulation, instrumentation, thermodynamics, and plans, specifications, and equipment review.

Economic Analysis of Supersonic Transport

The Operations Research branch of the Bureau conducted a parametric cost and benefit analysis of various alternatives facing the United States in the field of long-range, high-speed transport. The analysis assumed various levels of costs for each of the alternative strategies, and a range of fares, traffic, and operating conditions. The results indicated the rate of return on invested capital that could be anticipated under a series of assumed strategies, including the rapid development of a supersonic transport to compete with the Anglo-French Concorde SST. This study was made available to the National Aeronautics and Space Council during its consideration of the national policy on the SST.

Chapter IX
Space Science Board

INTRODUCTION

The work of the Space Science Board of the National Academy of Sciences has been devoted, domestically, to advising the government on the scientific aspects of the national space program and to the promotion of discussion of advances and opportunities in sapce research. Internationally, the Board, on behalf of the Academy, represents the U.S. scientific community on, and has collaborated closely with, the Committee on Space Research (COSPAR) of the International Council of Scientific Unions (ICSU). This committee serves to encourage and guide international cooperation in space research, to facilitate the exchange of information and to elicit the interest and participation of scientists throughout the world.

In the account which follows, the activities of the Board are discussed under three heads: the national space program, international activities, and the effects of space projects on other branches of science.

THE NATIONAL SPACE PROGRAM

Space Science Summer Study

The formal report of the 1962 Summer Study of the space research program (A Review of Space Research, NAS Publication 1079) was transmitted to the government early in the year and at the same time made available to the public. More than 4000 copies of this report have been distributed.

Committees

The Board has continued its advisory work through its regular meetings and those of its Executive Committee and a small number of standing committees; viz., Surfaces and Interiors of the Moon and Planets, International Relations, Life Sciences, Geodetic Uses of Navigational Satellites, High Altitude Rocket and Balloon Research, Potential Contamination and Interference from Space Experiments, and several ad hoc groups. In addition, the Board has maintained continuous and close liaison with the scientific subcommittees of the NASA Space Sciences Steering Committee.

Lunar Orbiter

Further consideration, in the light of the Summer Study, of the plans for exploration of the moon led to the conclusion that an unmanned lunar orbiting spacecraft should be included in addition to the unmanned lunar spacecraft already projected. Such a spacecraft was originally included in the lunar program, but execution had been deferred. The Board therefore adopted and forwarded to the government a resolution which strongly recommended proceeding with a lunar orbiter project in order to facilitate the planning and execution both of the investigation of the moon by other unmanned spacecraft and of the manned lunar landing programs. A spacecraft of this type should provide photographic coverage of the lunar surface and equally essential measurements

regarding the gravitational and geometric constants of the moon. The Board's recommendation on this question has been accepted and preparations have been made by NASA for the construction of a lunar orbiting spacecraft.

Scientist-Astronauts

In consequence of one of the recommendations of the Summer Study, the Board has been requested by NASA to assist in the selection of scientist-astronauts to participate in future space flights. In preparation for this, a representative has participated as an observer in the selection of the most recently appointed group of astronauts.

Biology and Man in Space

In the life sciences, several reports have been completed covering the work of study groups established earlier to investigate problems both in pure biology and in the development of manned space flight. The following subjects are covered: fundamental radiation biology, weightlessness, nutrition, magnetic and radiofrequency effects, impact acceleration stress, and gaseous environment. A synopsis of these reports follows.

The need for applied radiobiological studies with reference to manned flight programs is recognized, but work on radiation biology should not be confined to the solution of immediate problems, since, in the long run, the successful exploration of space will be aided by the contributions of basic research. Studies in fundamental radiobiology of relevance to the space program are discussed. Biological effects of radiation in space are not expected to differ significantly from those on earth but this expectation can be very easily verified experimentally.

The environment of space flight may, in the future, involve radical departures from terrestrial biological experience of magnetic field strengths and radiofrequency energy levels; it is therefore of interest to ascertain whether marked biological effects are to be expected. Present evidence indicates that further laboratory work is needed to establish the existence of definite and reproducible effects; in the meantime there are no clear grounds for concern with respect to the development of manned space flight.

A detailed report of the contributions to a Symposium on Impact Acceleration Stress has been published (NAS Publication 977). It contains discussion of the effects of impacts (such as may be encountered in space flight) on humans and the means whereby they may be controlled.

The requirements for self-sufficiency, compactness and minimization of weight pose severe problems in planning for the feeding of astronauts on flights of more than a few days. Approaches to practical solutions consistent with the special requirements are outlined, both for short and long duration flights.

Although of small significance in short flights, exposure of humans to weightlessness for two weeks or more can be expected to produce definite physiological effects (e.g. calcium loss from the bones). Investigations which will help to improve present knowledge of the phenomena involved are discussed, including some which require experimentation in spacecraft. Physiological research on the effects of exposure to weightlessness must be a fundamental part of future manned space flight development

if these effects are to be well enough understood for the devising of proper corrective measures.

The atmosphere provided in manned spacecraft must satisfy human physiological requirements without adding unnecessary engineering difficulties or contributing to the risks of space flight (as ordinary air may do). The physiological aspects of this problem are reviewed, on the basis of current knowledge. Criteria for the selection of composition and pressure of the cabin atmosphere are recommended together with specific measures to verify suitability and to minimize difficulties which may arise in flight.

The scientific support for programs in space biology and man in space is under continuing study and a symposium on nutrition in space flight was sponsored in order to stimulate interest in this field. At the request of the government, the Board is organizing a working conference on nutrition to be held early next year.

Congressional Testimony

At the request of the Senate Committee on Aeronautical and Space Sciences, the Chairman of the Board provided a Board statement on the scientific goals of the space program in connection with the Committee's review of the NASA authorization request for fiscal year 1964.

Space Science Symposium

On the occasion of the Spring Meetings of the National Academy of Sciences during its centennial year, the Board organized a symposium on developments in space research. The symposium included addresses reviewing progress in several scientific fields which are important in the space program: energetic particles and fields, solar phenomena, lunar and planetary studies, the interplanetary medium and the life sciences.

INTERNATIONAL ACTIVITIES

Sixth Meeting of COSPAR

As in previous years, the Space Science Board organized, on behalf of the National Academy of Sciences, the attendance by U.S. scientists at the sixth meeting of COSPAR in Warsaw, June 1963 and prepared and presented the summary report of the year's activities in this country in space research. The working meetings at Warsaw reflected the increasing variety and growth of interest in space research. This is particularly apparent in the case of the smaller countries which have more recently embarked on the use of sounding rockets for scientific research. Among special topics discussed were:

a. plans for participation during the IQSY in coordinated sounding rocket investigations of the upper atmosphere;

b. establishment of a new working group on the physics and chemistry of near space; and

c. establishment of a new working group on space biology.

The COSPAR Consultative Group on Potentially Harmful Effects of Space Experiments met several times; its field of interest is described in the last section of this report.

International Years of the Quiet Sun (IQSY)

A working group of COSPAR for international planning of space research activities for the period of minimum solar activity had met earlier in the year in conjunction with the International Committee on Geophysics in Rome. At this meeting and at Warsaw research programs appropriate to the study of the sun and the effects of solar phenomena were devised. These involve the use both of satellites and sounding rockets. In the former case continuous monitoring of solar activity is the main purpose. In the latter, it is proposed to arrange synoptic or cooperative investigations of the following kinds:

a. upper atmosphere winds and temperatures;

b. atmospheric circulation in the mesosphere;

c. height profiles of atmospheric density;

d. composition of the upper atmosphere;

e. electron density and temperature;

f. electric currents in the ionosphere;

g. coordinated studies of the D- and E-regions of the ionosphere;

h. changes in the hydrogen concentration of the upper atmosphere; and

i. synoptic meteorological observations by sounding rockets.

Manuals which describe the relevant experimental techniques are in process of publication.

COSPAR Fourth International Space Science Symposium

On the occasion of the Sixth Meeting of COSPAR in Warsaw, an International Space Science Symposium was held involving the presentation of more than 160 papers by scientists from 14 countries. The U.S. delegation to this meeting was organized by the Space Science Board and contributed more than 70 papers to the total. Recent advances were reported in a wide range of physical fields, including the upper atmosphere, ionosphere and magnetosphere of the earth; solar radiation; the interplanetary medium; the planets and cosmic radiation. Among noteworthy spacecraft which contributed useful results were the deep space probes MARINER II (U.S.) and MARS I (U.S.S.R) and the first international cooperative satellites ARIEL I (U.K. and U.S.) and ALOUETTE (Canada and U.S.).

Interests in the life sciences were centered on a special symposium on space biology. This included review papers on extraterrestrial organic chemistry and biology and particular attention was given to methods for the detection of extraterrestrial life and the biological effects of the space environment. The leading role in this symposium was played by the U.S. delegation which presented discussions on the effects of space on terrestrial organisms, problems of manned space flight, biological contamination and sterilization, and exobiology.

U.S.-U.S.S.R. Bilateral Discussions

In response to a request from the National Aeronautics and Space Administration, the Space Science Board recommended appointment of scientists as advisors to the U.S. members of the working groups which were designated to devise plans for cooperation between this country and the Soviet Union in space research. The fields of particular interest were meteorology, communications and the World Magnetic Survey. These working groups met in Rome in March 1963.

World Data Center A for Rockets and Satellites

In the discharge of its commitment to COSPAR, the Board continued to support the operation of the World Data Center which collects and exchanges the results of research with spacecraft and sounding rockets. In addition to its normal activities in archiving and distributing of data, two catalogues have been prepared. An annual bibliography of over 2000 reports and papers in the space sciences was compiled and incorporated in the Space Science Board report to COSPAR.

EFFECTS OF SPACE PROJECTS ON OTHER BRANCHES OF SCIENCE

One of the chief concerns of the Board is the preservation and improvement of scientific standards and opportunities in space research. In this connection it is considered necessary to examine projects which may seriously interfere with work in other branches of science, or other human activities.

WEST FORD Experiment

The WEST FORD experiment involves the creation of an orbital belt of many fine wire dipoles and the testing of its properties as a reflector in a radio communications system. This experiment was designed so as to avoid causing interference to astronomers and, in any case, to produce a belt with limited lifetime. However, some scientific workers feared that errors or uncertainties in estimation might lead to unexpected and harmful results, once the belt was formed, and that the belt might remain much longer in orbit than intended. A special Board committee has therefore followed this project from its inception in order to verify the expectation that the presence of the belt would cause no difficulties to observations in either optical or radio astronomy. It has advised astronomers both at home and abroad of the important characteristics of the experiment so that calculations and observations could be made which would assist in assessing the amount of astronomical interference which orbital belts of wire dipoles would cause. These steps were taken well in advance of the establishment of the WEST FORD belt. After the belt was successfully formed in May 1963, the committee continued in touch with the astronomical community and was instrumental in assisting observers and in the compilation of the results. A report has been prepared which incorporates the observations made to date and compares them with the results expected on the basis of calculations. It verifies the expectation that the experimental belt has produced no significant interference with optical or radio astronomy and will have the limited lifetime intended. Estimation of the effects of denser belts of dipoles, should these become of practical concern, can be made with confidence. This report has been forwarded to the government, COSPAR and to the WEST FORD Committee of the International Astronomical Union. Calculations and observations of the belt by interested astronomers have been and will

continue to be published in the open literature.

Space Probe Decontamination

The Board has long been concerned with the problems which might arise from the landing of unclean spacecraft on the moon and the planets before an adequate study of the existence of life or the chemical precursors of life on these bodies could be made. Mindful of the practical difficulties of sterilization and decontamination of interplanetary spacecraft and on the basis of the most recent information, the Board has adopted a new statement of policy with respect to:

a. lunar probes; and

b. Mars probes.

This statement discusses the particular considerations which apply to each of these bodies and explains the steps which should be taken with regard to decontamination of spacecraft intended for lunar and Martian investigations, respectively.

Conditions on the lunar surface are felt to be sufficiently hostile to the survival and reproduction of terrestrial living organisms to permit some relaxation of the rigorous standards of cleanliness which are required in the biological studies of Mars. In the latter case, and because of its unique character, every reasonable measure should be taken to avoid contamination of the Martian environment until the critical investigations of the possible existence of Martian life and of its characteristics have been conducted.

The recommendations contained in this statement of policy have been accepted by the National Aeronautics and Space Administration and embodied in the latest instructions for the carrying out of lunar and Martian investigations.

COSPAR Consultative Group on Potentially Harmful Effects of Space Experiments

Problems involving space projects which may have deleterious effects on other branches of science are dealt with internationally by a special Consultative Group of COSPAR. The Space Science Board has provided this group with information from its studies of the two topics mentioned above. This group considers also other aspects of space activity where undesirable effects may arise, e.g. the pollution of the atmosphere by rocket-exhaust gases.

Space Science Board Committee on Potential Contamination and Interference from Space Experiments

In order to carry on its work on subjects such as those described above and to provide a domestic counterpart to the COSPAR Consultative Group, the Board has established a Committee on Potential Contamination and Interference from Space Experiments. This committee includes members representing both the physical and biological sciences. It will maintain interest in space activities which may have harmful effects and has the power to co-opt additional specialists as required. The government has indicated its desire to consult the Board on potentially harmful space projects and the new committee is expected to play a key role in these matters.

Chapter X
Smithsonian Astrophysical Observatory

INTRODUCTION

The Smithsonian Institution Astrophysical Observatory in Cambridge, Massachusetts, pursues a broad program of research in astrophysics and related space sciences, funded both from its own resources and from contracts and grants from the National Aeronautics and Space Administration and other government agencies.

The Observatory maintains a highly accurate and extremely productive network for optical tracking of artificial earth satellites; is engaged in the design and operation of two experiments to be flown as part of NASA's Orbiting Observatory Program; is establishing a network for photographing meteors and recovering newly fallen meteorites; is developing a program for injecting into the high atmosphere particles to simulate meteoric phenomena; conducts with the Harvard College Observatory a Radio Meteor Program and, under a contract from the Air Force, a related study of the velocity and direction of winds in the lower ionosphere; is reducing gamma-ray data from the first orbiting solar observatory; continues radioisotopic and other analyses of meteoritic and recovered satellite materials; is investigating the possibilities of a cometary probe; and is conducting laboratory experiments to simulate the primitive terrestrial and other planetary environments.

Closely integrated with these projects are the theoretical investigations and studies by the more than fifty Observatory scientists whose research has yielded new information and theories concerning the earth, interplanetary matter, the solar system, and the stars, galaxies, nebulae, and interstellar matter.

In 1963, as in previous years, scientists from many parts of the world have visited the Observatory to cooperate with its staff in both consultation and research on various space problems.

As in every year since the launching of the first artificial satellite, the number of major scientific papers written by members of the staff has increased. In 1963 nearly 40 Special Reports were issued in the Observatory's Research in Space Science series, and 150 other papers were published in leading scientific journals.

Finally, the Observatory continues to supply services on request from other agencies. An outstanding example was the photographing of Syncom by the Observatory's satellite-tracking camera in South Africa. Another has been the surveillance observation of several satellites at the Air Force's request.

OPTICAL SATELLITE TRACKING PROGRAM

The Observatory's optical tracking program consists of the 12 Baker-Nunn camera stations located in Argentina, Australia, Curacao, Florida, Hawaii, India, Iran, Japan, New Mexico, Peru, South Africa, and Spain; 190 volunteer Moonwatch teams, 97 of them in 28 foreign countries; and service groups in Cambridge for the communication, recording, reduction and scientific use of the resultant data.

In 1963 the Baker-Nunn cameras, still the most accurate means of measuring satellite positions in space, made more than 30,000 observations, and the photoreduction group in Cambridge precisely determined the time and position recorded on approximately 24,000 of the films. The station operations division continues to improve the Baker-Nunn system and has developed a new EECo precision timing system now being installed in the stations.

The Baker-Nunn stations made simultaneous observations of light flashes from the ANNA geodetic satellite, and Observatory scientists used the resultant data for refining the geometric determination of the station positions.

The Baker-Nunn cameras are also being used for cometary and flare-star studies, the latter in cooperation with the Jodrell Bank and the CSIRO radio telescopes.

The Moonwatch teams made approximately 7000 observations of more than 125 satellites in 1963. In addition, Moonwatch is developing a program for the prediction of the reentry of satellites, with the objective of recovering satellite material, and a correlative program of observing meteors and transmitting to Cambridge data that might result in meteorite recovery.

Data supplied by the tracking stations and the Moonwatch teams and reduced by the photoreduction division, and programs developed with the computations division enable Observatory scientists to continue their analyses of the earth's atmosphere, geopotential field and the geodetic data. The temperature and density of the upper atmosphere, and their response to electromagnetic and corpuscular radiation have been more precisely defined. Extensive computer programs have been written to permit the analysis of many optical observations in order to determine the coefficients of higher-order tesseral and sectorial harmonics in the earth's gravitational field and to establish whether those coefficients have seasonal variations.

In addition to the geodetic studies resulting from ANNA, the Observatory has used the deviations between observed and predicted values to improve the coordinates of the Baker-Nunn stations, as one more step toward the fuller use of satellites for geodetic studies. Another such step has been the development of an inexpensive satellite-tracking camera, now in experimental operation, to expand the network's geodetic capabilities.

SPACE OBSERVATORIES

The Celescope experiment, to be launched in a NASA Orbiting Observatory in 1965, will make a complete survey of ultraviolet stellar radiation between 1000 and 3000 A. Four specially designed telescopes will make programmed observations of the stars for one year. Telemetry equipment will send the resultant data to ground stations, where they will be used for the preparation of a map recording the position and brightness of at least 50,000 stars. While the project has suffered the inevitable delays and disappointments attendant on the development of any new observing system, prototypes of the following pioneering instrumentation and techniques have been designed and built: the Uvicon, an ultraviolet-sensitive television camera tube; Schwarzschild telescope systems; lamps for calibrating ultraviolet radiation; a digital television system; and means for automatic identification and cataloging of stars. For the last, project scientists will use the SAO catalog of more than 250,000 stars prepared for the rapid and accurate reduction of Baker-Nunn films.

A joint project of the Smithsonian Astrophysical and Harvard College Observatories is the preparation of the instrumentation for the second Orbiting Solar Observatory, to be launched early in 1964. The experiment will scan the solar spectrum and obtain monochromatic images in the wavelengths between 500 and 1500 A. Both the prototype and the flight models have already been delivered for integration into the spacecraft. Meanwhile, research and development are under way for an improved spectrometer-spectroheliograph for the fourth OSO.

The Observatory is reducing data from the first Orbiting Solar Observatory, launched in March, 1962; making theoretical calculations of the sun's possible production of gamma rays; and planning experimental instrumentation for a survey of gamma rays from solar and other stellar origins.

METEORITIC STUDIES

The director of the Observatory has made a new estimate of the meteoroid hazard to space vehicles. The data indicate that a spacecraft 10 feet in diameter will be able to travel for about 28 months before being impacted by a meteoroid--in contrast to his 1957 estimate of once every six hours.

By the end of 1963, seven of the 16 camera stations of the meteorite recovery program were photographing the trails of extremely bright meteors in order to determine the possible impact points of corresponding meteorites and to initiate searches for them. The instrumentation of the stations, including the cameras and photoelectric and control systems, is being improved as experience suggests.

The Observatory is cooperating with Harvard College Observatory in the radio meteor project, which utilizes radar techniques to gain information concerning the speed and trajectory of particles entering the earth's atmosphere. The project operates a multistation radar system capable of detecting meteors down to a limiting magnitude of +12 on the visual scale. Data derived from the system indicate that there is a difference in the populations of large and small meteors, that between magnitudes +6 and +9 the average velocity of meteors changes by 5 km/sec as a consequence of the smaller orbits of the fainter meteors, and that the faint meteors show total fragmentation as they enter the upper atmosphere.

In conjunction with this project, the Observatory has undertaken a study of the velocity and direction of winds in the lower atmosphere by measuring the Doppler shifts in radio returns from meteor trails.

In cooperation with NASA's Langley Research Center, the Observatory is participating in a meteor-simulation project that will inject into space small particles of predetermined mass, density, composition and shape, and then measure the trails and ionization they produce on reentry into the earth's atmosphere.

A number of Observatory scientists are devoting their attention to the composition, distribution, and history of micrometeoritic particles in space, in orbit around the earth, and in the earth's atmosphere. The results of this research are gradually building up a detailed picture of cosmic dust produced by comets, by meteors colliding with one another and with the moon, and by other sources. Extraterrestrial particles collected by the earth are being examined microscopically and their physical and chemical properties studied, the latter particularly by means of electronprobe

techniques.

The Observatory's program for the analysis of meteorites also continues. In addition to tritium and argon radioactivities, staff scientists have now measured carbon-14 and gamma-ray radioactivity from such isotopes as aluminum-26, manganese-54, sodium-22, and cobalt. The Potter, Estacado, and Farmington meteorites, as well as the recently fallen Peace River, have been measured for tritium, argon-37, and argon-39 in order to determine ages, relevant to physical processes in space. Concentrations of tritium in stony and iron meteorites and in recovered satellite material constitute a special field of study. Tentative hypotheses have been advanced for the loss and retention of tritium in various materials. A high-sensitivity mass spectrometer is being completed for the study of noble gases in meteorites. The temperature-pressure history of meteorites is also being approached through a study of their mineralogy and petrology, and the chemical composition of the microstructures of chondrites is being analyzed for determination of the thermal history of meteorites. All of these programs lead to increased knowledge of the experience of these objects in the solar system and therefore of the evolution of that system.

OTHER SPACE STUDIES

Of the other dramatic research programs at the Observatory, only a few can be highlighted here. The study of the evolution of the solar system has been continued, the age of which has now been established as near 4.6 billion years, positing the hypothesis that the Cameron model of a collapsing interstellar cloud forming the planets may also lead to the development of a stable belt of cometesimals near the planetary plane beyond the orbit of Neptune. Not visible optically, this belt may produce the observed disturbances to the motion of Neptune's latitude previously attributed to Pluto.

Studies are being made on methods for detecting extraterrestrial life, including simulation of a possible Martian environment and a rigorous analysis of the panspermia hypothesis. Preliminary results emphasized that microorganisms from terrestrial soil would probably survive on Mars and that therefore Mars-impacting space vehicles must be rigorously sterilized before launch.

The possibility that decay of cometary nuclei can provide evidence of the brightness and deterioration of periodic comets is used to calculate the lifetimes of certain comets. Laboratory techniques are being developed for simulating cometary conditions and to aid in recommending specifications for cometary studies in space.

A theory developed to account for the motion of an artificial satellite about its center of mass has been confirmed from Baker-Nunn observations. One group at the Observatory is investigating the excitation of the metastable states in O_2, N_2 and O by electron impact, and the subsequent reactions of the states with other gases, as one phase in the development of a model of the atmosphere that will take into account atomic collision processes. Another group has concluded that the red lines of atomic oxygen 6300-6364 A are almost certainly excited by heated electron in low-altitude auroral forms.

A theoretical study being made of the expected limb-darkening in planetary atmospheres indicates distinct Cytherean limb-darkening in the 10-micron region and no clear breaks in the Venus cloud layer.

Studies of the rings of Saturn continue in a search for a more accurate scattering theory for solar illumination.

The orbits of both the major and the minor planets are being more exactly defined through the development of new computer programs.

In the lunar sciences, the Observatory has developed an approximate analytical study of the motion of a body orbiting the moon, and shown that radiation pressure could sufficiently change the orbit of a "balloon" spacecraft to effect a lunar capture from an initially geocentric orbit. Finally, studies are being continued of the nature, force, and consequences of the impact of meteorites on the moon surface.

The Observatory continues to publish the results of statistical analyses of precisely reduced photographic meteor data from Super Schmidt cameras, and to determine more precisely the orbits of meteor streams.

Measurements have been made of the activity of a cometary tail as a means of developing a hypothesis to account for the interaction of solar winds and comets.

Theoretical studies of stellar atmospheres continue, including extensive calculations concerning the structure of stellar convection zones and the nature of the perturbations they produce in the stellar atmosphere; the structure of shock fronts in atomic hydrogen; and perturbation-iterative procedures for solving the structure equations for nongray stellar atmospheres.

Finally, the Observatory is correlating these many researches and opening new lines of study as part of its preparation for participation in the United States program for the Year of the Quiet Sun.

Chapter XI
Federal Aviation Agency

INTRODUCTION

In this the 60th year of powered flight, civil aviation continued to grow in importance as a vital element of national life and as one of the world's major economic, political, and social forces. Throughout 1963, the Federal Aviation Agency pointed its efforts to both sustaining momentum and imparting new impetus to this urgent national enterprise. Solid and distinct progress was made in major programs looking toward the development of an integrated National Aviation System to meet tomorrow's needs. Meanwhile the Agency sought and achieved immediate improvements in its complex mission of promoting aviation safety, assuring efficient utilization of airspace, fostering civil aeronautics and air commerce, and supporting defense and other national policy requirements. At the same time FAA continued to refine its organizational structure and administrative processes in the never-ending effort to improve management effectiveness.

AIR SAFETY PROGRAMS

Promoting safety of flight is FAA's most important mission. It is the single purpose of many Agency programs and a desired derivative of countless others. Although the air safety record will never satisfy FAA until an accident-free situation is attained, preliminary statistics reveal that the airways were never busier nor safer than during 1963. The steady improvement in the safety record of commercial airlines is encouraging more and more Americans to take advantage of the speed and convenience of air travel.

Throughout the year FAA placed particular emphasis on improving air safety through better maintenance practices and procedures. To bring greater recognition to the aviation mechanic and his vital role in safety of flight, 1963 was designated "maintenance year" and an aviation mechanic safety-award established.

With the goal of eliminating potentially disastrous in-flight engine failures FAA inaugurated in 1962 a program to improve the reliability of aircraft propulsion systems. Steady gains in engine reliability were reported by air carriers during 1963. Participation in this program, in which 22 operators representing 75 percent of the U.S. air carrier fleet are cooperating, produced first-year savings of $1.2 million for one airline by reducing flight delay and unscheduled maintenance costs. FAA is planning to extend the reliability control concept and use of automatic data processing methods to programs covering all the complex systems and components of modern transport aircraft.

In related safety and airworthiness programs the Agency:

a. encouraged wider use of turbine-engine vibration-monitoring devices to permit early detection of malfunctions.

b. approved use of contract maintenance to assist small air carriers to attain highest safety standards.

c. continued to take positive action to improve supplemental carrier operations.

d. evaluated the regulatory material governing the training of the 49,000 maintenance employees of U.S. scheduled and supplemental air carriers.

e. updated and standardized maintenance and overhaul specifications for certain aircraft not presently monitored by maintenance review boards.

Effective measures to prevent air catastrophes depend also on accurate determinations of their probable cause. To aid accident analysis FAA has undertaken the development of voice recording equipment capable of preserving crew conversation and other sounds occurring in the cockpit up to 30 minutes before an accident. During the year feasibility tests were completed and technical specifications written. FAA is now seeking comments from the aviation industry and the public on its proposal to make use of such devices mandatory.

A parallel project aims at devising improved flight data recorders that are better able to withstand crashes and more easily recovered thereafter. Equipment presently required by FAA for all air carrier jets and certain other commercial piston-driven aircraft records time, altitude, airspeed, heading, and vertical acceleration. New recorders under development will provide accident investigators with additional information concerning aircraft and engine performance. Evaluation of such a prototype is scheduled for late 1964.

The report year also witnessed the establishment of a joint FAA-CAB school to train personnel of both agencies and keep them current in the most modern techniques of aircraft accident investigation. Located at the FAA Aeronautical Center, Oklahoma City, the school is called the National Aircraft Accident Investigation School. The first NAAIS course began in September.

Since 1933 six accidents in the United States have resulted from explosives placed aboard commercial aircraft, claiming the lives of 173 passengers and crewmembers. FAA in concert with other government agencies has continued to actively explore numerous techniques for combating such warped enterprises. In October at Dulles International Airport an experimental bomb-detection device was tested and proved feasible. Engineering evaluation is now underway at FAA's National Aviation Facilities Experimental Center (NAFEC), Atlantic City, N. J. Other portions of the program are proceeding on schedule.

Experience continues to show that human errors and limitations are the greatest single cause of air accidents. The human factor in the air-ground equation of civil aeronautical activity was the object of special FAA attention during 1963. Progress was made in studies to refine selection criteria for air traffic controllers, to determine relationships between an individual controller's physical condition and his resistance to stress, and to evaluate the effects of antihistamines and other over-the-counter drugs on his judgment and efficiency. Intended primarily for use by FAA-designated medical examiners in counseling pilots and other airmen in the use of drugs whose side effects could make flying a hazard, an exhaustive compilation of such drugs--the first comprehensive guide of its kind in aeromedical pharmacology--

was published.

Other studies focused on better escape methods for crews of all-cargo aircraft; the characteristics of vertigo, a little understood but critical factor in many general aviation fatal accidents; and toxic hazards associated with crop-dusting operations. Impact tests with new seats being readied for airline use enabled FAA to specify design changes which will help passengers survive crashes that would otherwise be fatal.

Perfection of a pocket-size electroencephalographic device during the year makes it possible for FAA researchers to secure for the first time recordings of a pilot's brain-wave activity under in-flight conditions where he may be subject to stress. Data thus obtained is being used in the Agency's pioneering aeromedical project exploring man's aging process and its relation to chronological age and pilot proficiency.

FAA also began tests in which two large transport aircraft, remotely controlled, will be deliberately crashed and five others burned to examine and find means to combat the hazards presented by aircraft crashes and resulting fires. To determine their relative resistance to fire, over 100 materials used in aircraft cabins were laboratory-tested. In a related safety program, FAA is proceeding with full-scale fire tests of modern turbine engines--a project made possible through a cooperative arrangement with the Navy for use of its engine test facility at Trenton, N. J.

ADVANCES IN AIRSPACE USE AND CONTROL

Related closely to its safety mission are FAA programs which aim at insuring the efficient utilization of national airspace to serve the need of both U.S. civil and military aviation.

Increased use of improved radar and radar beacon equipment is a key element in the Agency's plan for modernizing the Nation's air traffic control system. This follows the recommendation of the Project BEACON task force, established by the President to review the system as it existed in 1961 and to chart a course for future progress.

Extensive tests at NAFEC during the year proved the engineering soundness of the air traffic control radar beacon system (ATCRBS), which adds a third dimension--altitude--to the information now automatically available to the air traffic controller. Suitable altitude-reporting transponders are now available commercially for large and medium aircraft. Development of similar light-weight equipment for small airplanes neared completion at year's end. Work on ground devices to decode and process altitude data received from the airborne transponders also moved ahead, with prototype models scheduled for delivery in 1964. To assure that the highest standards of reliability are achieved and maintained in the ATCRB system, the Agency accelerated programs to develop tools and techniques to monitor ground-station performance, to suppress undesired transponder replies, and to determine accurately the center of target-aircraft appearing on radar displays.

Full cooperation is being received from the armed services in steps to implement the beacon system. Agreements between FAA and the Department of Defense during the year defined the use and technical standards of the ATCRB system along with the characteristics of the airborne equipment which will be used.

To safely yet efficiently separate jet aircraft flying in the world's busiest high-altitude airspace, FAA provides radar area positive control (APC) service. In these

positive control areas, which extend upwards from 24,000 feet, all aircraft must operate under instrument flight rules, regardless of weather, and be equipped with a two-way radio and a coded beacon transponder that identifies the aircraft on ground radarscopes. Although lack of certain special equipment and problems related to radar remoting produced some delays in 1963, at year's end FAA neared its program objective, having blanketed with APC service well over 90 percent of the area embraced by the 48 contiguous States.

More and faster aircraft with greater numbers under positive control continue to heighten requirements for radio communications and air navigation facilities. At the same time, the available radio frequency spectrum is a rapidly dwindling natural resource. To lessen frequency congestion and to improve its communications equipment and techniques, FAA during 1963:

a. established a policy and formulated plans to pursue an active ground-air data link program which looks also toward expanded use of computer techniques to supplement present ground-air-ground voice communications for control of air traffic.

b. developed for overall application to the U.S. airways system more exacting standards for the geographical separation of VHF/UHF (very high frequency/ultra high frequency) navigation aids.

c. installed and began evaluation of log-periodic and wire-grid Luneburg lens antennae to improve the reliability of high-frequency point-to-point circuits that link vital communications between the continental United States and overseas locations.

d. prepared, for submission by the Interdepartmental Radio Advisory Committee, U.S. proposals to the International Telecommunications Union Space Conference to permit wider use of space communications techniques for aeronautical services.

e. initiated extensive tests using two new tropospheric communications facilities located near Cape Cod and San Juan, Puerto Rico. Year-end results indicate that it may be economically feasible to provide reliable air-ground communications over distances more than triple that spanned by conventional equipment in use at other major gateways to the United States.

f. contracted for the development of electronic equipment to process radar information for transmission over ordinary telephone lines. Such equipment could eliminate the need for expensive microwave transmitter and repeater facilities now used to send radar data from field sites to FAA control centers.

The FAA-Department of Defense plan which last year called for joint use of three SAGE direction centers underwent modifications during the year as the result of revised defense requirements and the decision to close the centers at Minot and Grand Forks, N. Dak. In the third center--at Great Falls, Mont.--FAA began air traffic control operations during December. With expanded radar coverage this center is serving the western part of the "Northern Tier" area, while FAA's air route traffic control center at Minneapolis, with similarly augmented radar capability, covers the

eastern portion.

Despite these changes in the planned air traffic control structure for the Northern Tier, FAA's program to consolidate air route traffic control centers (ARTCC's) and realign area boundaries proceeded on schedule during 1963. Phaseout of the ARTCC's at Norfolk, Spokane, and El Paso was completed--their services taken over by the Washington, Seattle, and Albuquerque centers, respectively. When consolidation-realignment actions are completed, FAA centers in the contiguous 48 States will have been reduced from the present total of 25 to 21, including the joint-use SAGE center at Great Falls, Mont. Intended to lighten both cockpit and controller tasks by requiring fewer air-ground-air communications and radar handoffs from center to center, this program is calculated also to produce substantial economies through better use of equipment and personnel.

A large stride towards FAA's objective of eliminating control by two separate agencies of aircraft in the same airspace was taken during the year as the result of an FAA-Continental Air Defense Command (CONAD) agreement concerning airborne interceptor operations. Under the cooperative arrangement, scheduled to take effect in early 1964, air defense activities will be conducted within the same FAA traffic control system which controls all other aircraft operating under instrument flight rules. Although military control will be exercised over certain special missions and the most critical phases of interceptor operations, the new procedures will reduce materially the potential collision factor and increase safety margins for both civil and military air operations.

Significant developments took place this year in FAA's Project FRIENDSHIP. In keeping with the intent of the Federal Aviation Act to establish a common civil-military system of air traffic control, Project FRIENDSHIP designates the plan under which FAA has taken over or would assume responsibility for (1) military flight services, (2) flight inspection of military air navigation facilities, (3) training of military air traffic controllers, and (4) operation of military air traffic control facilities. To assure responsiveness to military requirements in emergencies, FRIENDSHIP also visualized creation of a Federal Aviation Service to operate military air traffic control facilities. Military flight services were transferred to FAA in 1961. And during 1963, the Agency assumed complete worldwide responsibility for flight inspection of all military NAVAID's.

To establish guidelines for future actions under Project FRIENDSHIP a high-level FAA-Department of Defense-Bureau of the Budget steering committee was formed in February 1962 and a senior task force organized to work under the committee's direction. Reporting in the spring of 1963, the task force concluded that general worldwide operation of U.S. military air traffic control facilities by FAA cannot be justified on the basis of cost or operational efficiency. It recommended that future transfers of activities and facilities be continued on a selective, mutually agreed basis. In view of this finding the Interagency Steering Group has concluded that the proposed Federal Aviation Service is not necessary. A special staff led by FAA, however, is reexamining the Agency's special personnel needs. Continuing studies are exploring the feasibility of joint training for military and civil air traffic controllers.

AIRCRAFT DEVELOPMENT PROGRAMS

Important decisions and decisive actions taken during the year imparted fresh impetus to the Supersonic Transport Program (SST). Highlighting these activities was the President's determination in June that the government, in partnership with private industry, must undertake development of an SST aircraft "which is safe for the passengers, economically sound for the world's airlines and whose operating performance is superior to any comparable aircraft." The President's decision, following comprehensive program review, guided by the Chairman of the National Aeronautics and Space Council, climaxed two years of intensive and careful study regarding the technical feasibility of such an aircraft, its marketability, efficiency, and safety. Research projects also probed into high-altitude hazards, sonic-boom effects, and other problems related to the physical and social environment in which the SST will operate.

In this feasibility-research phase, completed with appropriations of $31 million, FAA provided program leadership, NASA basic research and technical support, and DOD administrative and technical collaboration. To head the administrative and technical organization charged with overall management responsibility for the development program the FAA Administrator established in July the post of Deputy Administrator for Supersonic Transport Development. Other agencies of government will continue to contribute technical assistance as needed. In August FAA established SST performance objectives to serve as a basis for the design competition in which three major airframe builders and three major engine manufacturers have indicated their intent to participate. Scheduled for submission by January 15, 1964, the manufacturers' design proposals will be evaluated by FAA, other government agencies, and U.S. airlines.

Under the current timetable, this U.S. bid for continued leadership in the field of aircraft development and air transportation will be carrying passengers safely by mid-1970 at between two and three times the speed of sound. Furthermore it will demonstrate, in the Chief Executive's words, the "technological accomplishments which can be achieved under a democratic free enterprise system."

Despite a marked growth rate over the past several years, air cargo transportation has failed to realize its full potential--primarily for want of suitable commercial all-cargo aircraft. Jet propulsion, which found extensive employment in military and passenger-carrying civil airplanes, lagged far behind in its application to civil aircraft engineered expressly for cargo operations. To meet civil needs for an efficient and economical jet cargo aircraft, FAA is participating in the Air Force's C-141 development program. Designed from the start to meet civil certification criteria as well as military requirements, the C-141 prototype advanced during the year through the final stages of fabrication to "roll-out," with initial flight tests planned for late December. A better airplane both for defense and commercial purposes is resulting from this cooperative development endeavor.

Double duty from the defense dollar and greater flexibility in the national air transportation system of the future are likewise two prime objectives of FAA's participation in military projects to develop helicopters and other vertical or short-takeoff-and-landing air vehicles (V/STOL). Prototypes offered by three different manufacturers competing in the Army's light observation helicopter program underwent initial flight tests during the year. FAA's schedule calls for completing certification of these aircraft for civil use by the end of 1964. During this year FAA was also

engaged in 13 other joint military projects to develop new kinds of V/STOL aircraft. These cooperative efforts are building an essential core of operational data, engineering information, and related technical knowledge for subsequent application to civil aircraft in these categories.

During the year FAA accelerated its efforts to stimulate development and production of a small, modern transport to replace the venerable but aging DC-3, which, after 27 years of service, still dominates the short-haul market in this country and abroad. Following release of design objectives for such an aircraft, FAA proposed in October a cooperative government-industry program calling for limited design competition to produce detailed specifications and cost data for a practical short-haul transport. Under the present timetable, a number of competitive aircraft designs will be ready for evaluation during 1964. Besides meeting an acute need of local-service airlines and certain mission requirements of potential military users, an efficient, short-haul transport could become also an important dollar earner in foreign markets.

Launched in 1962, Project LITTLE GUY aims at developing simplified flight control apparatus and instrument displays for light aircraft such as those used in general aviation--the largest and fastest growing segment of U.S. civil aviation. General aviation includes all aviation other than commercial and military. A less-complex and more efficiently designed cockpit will make flying easier and safer for the non-professional pilot and enhance the utility of light planes for the general public.

Completed this year was a report containing major recommendations and an experimental mockup that could evolve into the light plane instrument panel of the future. Work is progressing on the construction of a dynamic model of this instrument panel. It will undergo extensive tests in a general aviation flight simulator, installed during the year at FAA's National Aviation Facilities Experimental Center. Actual flight-testing of LITTLE GUY equipment and systems is scheduled to get underway next year.

OTHER ACTIVITIES FOSTERING CIVIL AVIATION

Extensive all-weather landing tests were completed, using an Agency aircraft equipped with a radio altimeter and airborne computer to make over 1,100 automatic landings at some 50 different airports. Built around an improved version of the present instrument landing system (ILS), this first-generation system is expected to be available for airline use by 1966. Looking toward a second-generation system to provide aircraft with a fully automatic, "hands-off" landing capability in conditions of low airport visibility, FAA in July awarded a development contract. Such a system could become available for operational use in the 1970's.

In September FAA sponsored the Second International Aviation Research and Development Symposium, bringing together representatives from the aviation community and scientific and educational groups from the United States and to discuss progress in all-weather landing systems and plans for their introduction into commercial service.

To evaluate procedures for segregating controlled from uncontrolled aircraft in the vicinity of high-activity airports--a Project BEACON recommendation--FAA conducted a test program at the Atlanta Airport between November 15, 1962, and June 1 of this year. Results indicated that positive separation service is sound and generally applicable to high-density terminal areas. Although such service improves airport acceptance rates and contributes to safety of operations, adequate ground facilities must be provided commensurate with traffic volume.

Another procedure, initiated late last year at the world's busiest airport, Chicago's O'Hare International, has resulted in substantial reduction in arrival delays. It involves the use of parallel ILS approaches to the airport's dual runways during peak traffic periods. Experience at O'Hare has provided a basis for establishing national standards for implementing such procedures at other selected airports.

Recognizing the seriousness of noise nuisance to neighbors of many of the Nation's major air terminals and its potentially adverse effect upon the growth of U.S. civil aviation, FAA continued during 1963 to direct special attention to this complex problem. Within the limits imposed by safety in aircraft operations, the Agency made further use of preferential runways and developed, in cooperation with the aviation industry, refinements in landing and takeoff procedures to lessen the noise imposed on communities adjacent to busy runways. To supplement such procedural methods, FAA provided updated technical guidance for use by other Federal agencies, airport authorities, zoning boards, and other local officials for evaluating the compatibility of land use around airports. Continuing a cooperative FAA-NASA-Department of Defense effort, the Agency in June awarded a research contract to develop valid measurements of aircraft-noise annoyance. FAA also continued to support, in conjunction with the engine-development portion of the SST program, a substantial research effort aimed at reducing noise at its source.

Mounting concern that long-standing American leadership of world aviation was threatened by an outmoded U.S. international air transportation policy led to the establishment in September 1961 of a Presidentially appointed Interagency Steering Committee, charged with the task of conducting a comprehensive policy review. Early in 1963 this committee, chaired by the FAA Administrator, submitted its report to the President. Accepting many of the report's key recommendations, the Chief Executive in April issued a statement of basic policies as a guide for future actions to strengthen U.S. aviation in its international role. To assure that this and related U.S. policies stay ahead of swift-moving developments in international aviation and consistent with overall national objectives, the President directed the Secretary of State to organize an International Committee on International Aviation Policy (ICIAP), designating the FAA Administrator as its Vice Chairman.

Chapter XII
Federal Communications Commission

INTRODUCTION

Among its many responsibilities under the Communications Act of 1934, as amended, the Federal Communications Commission is required to "study new uses for radio, provide for the experimental uses of frequencies, and generally encourage the larger and more effective uses of radio in the public interest." In the discharge of its duties under this Act and the Communications Satellite Act of 1962, which later provided for the establishment of the Communications Satellite Corporation, the Commission has been called upon to assume an important regulatory role in the development of a space satellite communication system. Through the cooperative efforts of the Commission, the National Aeronautics and Space Administration, the Department of State, other government agencies and private industry, the year 1963 has seen significant strides made with respect to space telecommunications. The Commission played an important part both leading up to and in the Extraordinary Administrative Radio Conference convened in Geneva in October 1963 principally for the purpose of allocating, on an international basis, bands of frequencies to be used in space communications research and development and commercial operations. With respect to the field of aeronautical communications, the Commission's regulation thereof is a continuing one, the importance of which, to the safety of lives and property, cannot be overemphasized.

TECHNICAL DEVELOPMENTS IN SPACE COMMUNICATION

The Communication Satellite Act of 1962 charges the Commission with the responsibility of approving the technical characteristics of the operational communications satellite system as well as the ground stations. In order to perform its duties properly the Commission maintains close liaison with NASA, with the Department of State and with the Corporation and private industry. The progress of the TELSTAR, RELAY, and SYNCOM experiments (described elsewhere) were followed in specific detail. Using these satellites, since January 1963, experimental television, record data and two-way telephone transmissions have been made internationally on an almost daily basis through the use of one or more of the communications satellites placed in orbit either as U.S. Government or joint industry-government projects.

The experiments with TELSTAR series, RELAY and SYNCOM have been conducted through the joint efforts of the United States and certain foreign governments whose cooperation was obtained by the Department of State in coordination with NASA, the FCC and private industry. Pursuant to these cooperative efforts ground stations have been or are being established in England, France, Brazil, West Germany, Italy and Japan. The past coordination of activities by the United States and these foreign countries has laid the groundwork for continued cooperative efforts necessary to the establishment of a truly global satellite communication system.

The Communications Satellite Corporation is engaged in experimental and developmental work necessary for a determination of the technical characteristics of the initial system. In August 1963 the Corporation let contracts for multiple access studies and is preparing for further technical studies which must be conducted before

such a determination can be made. The Commission and other concerned government instrumentalities maintain particularly close liaison with the Corporation in this area.

STATUTORY AND REGULATORY RESPONSIBILITIES

The Satellite Act gives the Commission comprehensive regulatory authority over the Corporation. Its responsibilities in this regard include, but are not restricted to: approving of all corporate borrowing and stock issues, except the initial capital stock offering; granting authorization to those communications common carriers who desire to own capital stock in the corporation; insuring of effective competition in the procurement of equipment, apparatus and services required by the communications satellite system, common carriers with equitable opportunity for small business firms to participate; licensing of satellite terminal stations; and insuring that all present and future authorized carriers have equitable and nondiscriminatory access to the system; and on just and reasonable terms and conditions.

Because of the fact that existing communications satellites are being operated as part of an experimental program and are not designed to render a commercial service, no basis presently exists for action by the Commission in connection with certain of its statutory responsibilities partially listed above. However, with respect to those duties which can be discharged at this time, the Commission has taken the actions listed below.

CORPORATE FINANCING AND ISSUANCE OF CAPITAL STOCK

Section 201(c)(8) of the Satellite Act empowers the Commission to authorize borrowings by the corporation whey they are deemed consistent with the purposes and objectives of the Act. The Commission has several times authorized the corporation to borrow sums against line of credit entered into, with Commission consent, by the corporation with 10 commercial banks. Such loans have been necessary to provide interim financing of the corporation's operations pending the completion of the initial issue of capital stock.

CARRIERS AUTHORIZED TO OWN STOCK IN THE SATELLITE CORPORATION

After appropriate rule making proceedings, the Commission adopted rules and regulations, effective December 3, 1962, setting forth the procedures to be followed by communications common carriers desiring to apply for Commission authorization to purchase stock in the corporation. Of the 142 applications for such authorizations filed by carriers as of December 31, 1963, 127 have been granted by the Commission. The remaining applications are being processed in accordance with the applicable rules and regulations.

PROCUREMENT

In addition to requiring the Commission to insure effective competition in the satellite procurement program the Satellite Act provides that the Commission shall consult with the Small Business Administration (SBA) and solicit its recommendations on measures and procedures which will insure that small business concerns are given an equitable opportunity to share in the supplying of property and services. As an initial step in the performance of its duties in this connection, the Commission

promptly established an employee group charged with the duty of maintaining close liaison with the SBA.

On July 17, 1963, the Commission proposed to issue rules which would implement the procurement provisions of the Satellite Act. A report and order promulgating final rules in this connection will be issued by the Commission when it has completed its consideration of the comments filed by interested parties. Pending the adoption of such rules, the corporation and communications common carriers are keeping the Commission informed of their procurement activities in the satellite communications field in accordance with the request of the Commission.

ALLOCATION OF FREQUENCIES FOR SPACE COMMUNICATION AND RADIO ASTRONOMY

The first major event of the year relating to the allocation of frequencies for the space services was the Xth Plenary Assembly of the International Radio Consultative Committee (CCIR) which convened in Geneva in January 1963 for a one month meeting. FCC representatives were very active, together with many U.S. scientists and engineers, in the work of the U.S. committee of the CCIR dealing with space communication matters, and excellent progress was made in the development of sound technical principles for use in the special International Telecommunication Union (ITU) conference on the allocation of frequencies for the space services held in October and November of 1963. The agenda for this conference, referred to as an Extraordinary Administrative Radio Conference (EARC) of the ITU, was limited to the allocation of frequencies for the various space communications services and for radio astronomy.

The preparation for the 1963 EARC constituted a major effort for the Commission in the field of space communication. Recognizing the importance of this conference, the Commission, since 1960, was deeply engaged in extensive preparatory work as part of a coordinated effort with other government agencies, with great weight being given to the representations and advice of the communications industry.

As part of its preparatory work the Commission issued Notices of Inquiry soliciting views of all interested parties on the subject of frequency allocations for space communications and radio astronomy. In addition, the Commission participated, with representatives of other government instrumentalities, in visits to various other countries to discuss proposals for the EARC. As a result of this extensive preparatory work, the Commission, in coordination with the Interdepartment Radio Advisory Committee (IRAC), submitted recommended proposals to the Department of State. These were adopted as the formal U.S. proposals for the EARC and forwarded to the ITU for conference purposes.

Subsequent to submission of the U.S. proposals, the Commission, in recognition of radio astronomy's potential for adding significantly to our knowledge of the universe, adopted a Report and Order reserving UHF-TV channel 37 for the exclusive use of radio astronomy for a period of ten years. On the recommendation of the Commission, the U.S. proposals to the EARC for radio astronomy frequency allocations were expanded to include worldwide reservation of this channel for the aforesaid purpose and period.

General agreement was reached at the space EARC on all of the essential allocation objectives in the area of space radiocommunication and radio astronomy. This was

accomplished with a minimum of impact upon existing (terrestrial) radio services, by employing a number of technical devices developed earlier in the year by the Xth Plenary Assembly of the CCIR. The conference made allocations for a communication-satellite service, meteorological-satellite service, radio-navigation satellite service, space research service and the radio astronomy service. It also agreed to the application of space techniques in the amateur service, the aeronautical mobile (R) service and the aeronautical radionavigation service. Provision was made for the support functions of space telemetering, tracking and telecommand. The conference established procedures for the international notification and registration of individual frequency assignments which will be made to stations in the several categories of service. It also established the technical criteria necessary to control frequency sharing between terrestrial and space radio communication services with a minimum impact on each.

The work of the space conference (Geneva, 1963) constitutes a major step forward in a technical but essential area, because it provides frequency allocations which appear reasonably adequate to support space and radio astronomy programs in this country and abroad for a considerable number of years. On December 16, 1963, the Final Acts of the space conference, which constitute a partial revision of the international Radio Regulations (Geneva, 1959) were transmitted to the Senate with a view to receiving the advice and consent of that body to ratification (Senate Executive "S," 88th Congress 1st Session).

The Commission completed rule making proceedings intended to improve the domestic allocation of frequencies for radio astronomy in the national table of frequency allocations (Docket No. 14475) and to adopt rules to enable domestic radio astronomy observatories to make annual reports to the ITU for worldwide information pooling (Docket No. 14476). Space frequency problems of a domestic nature continue to increase with the expansion of the U.S. space effort. There is continuing close cooperation between the FCC, private industry, NASA, the Department of State and other government instrumentalities concerned with space communications. The Commission has cooperated to the fullest extent in arranging for frequencies to meet the needs of the various U.S. space projects.

AERONAUTIC DEVELOPMENTS

The Commission has the statutory responsibility of regulating the non-government use of radio for aviation. It prescribes the manner and conditions under which frequencies may be assigned for aeronautical telecommunication purposes such as air safety and operational control as well as command and telemetry functions in the development of missiles, rockets and satellites. Stations to which frequencies are assigned include, among others, aircraft, aeronautical enroute, radionavigation, flight test, airdrome control and aeronautical advisory.

One area of the Commission's responsibility relates to the loading of aviation communication frequencies in the various aeronautical bands. For example, due to the normal growth of aviation and the increase in aircraft speeds, communication capability may be required in excess of that provided by 50 kilocycle channel spacing in the 118 - 136 megacycle band. In order to meet the increasing need within the limited frequency space available, the Commission has initiated rule making which, if adopted, would require increased frequency stability for the majority of transmitters operating in such band. This would allow more efficient utilization of the

channels available, looking toward a possible increase in the number of usable channels.

The Commission is and has been, cooperating with the FAA and the Department of Commerce in the direct pilot-to-forecaster weather service test. Indications are that a requirement for this service will be established on a regular basis with a permanent frequency.

A Special Communications Conference of the member States of the International Civil Aviation Organization was held in April and May 1963 in Montreal to coordinate the views of aviation interests on revision of the ITU Radio Regulations (Appendix 26) relating to the high frequency aeronautical mobile (R) frequency allotment plan. The material developed at the Conference is being used in preparation for the Aeronautical Extraordinary Administrative Conference of the ITU, which is scheduled to be convened in two sessions with the first, or preparatory session, to be held early in 1964. U.S. proposals, prepared by a group of representatives from government and industry, working under the aegis of the Department of State, include, among other things, technical and operational criteria, guidance for use of the Conference on collection of aircraft operation statistics, and amendments to Appendix 1, Articles 7 and 9 of the Radio Regulations, Geneva, 1959.

Chapter XIII
United States Information Agency

INTRODUCTION

In 1963 the United States moved steadily towards its goal of becoming the leading spacefaring nation. As the space events of the year unfolded, USIA employed the resources of its five media--Press, Radio, Television, Motion Pictures, and Information Center Service--in its 239 posts abroad, to tell the story to world audiences.

The Agency employed an unprecedented network of communications to retail the principal space event of the year--the flight of Astronaut Gordon Cooper. This and other steps towards achieving a manned lunar landing within the decade, together with other U. S. achievements in space, were conveyed to the world in a steady stream of information and reports. In 105 countries where the U. S. Information Service operates, American officers and their staffs prepared these materials for further dissemination. The story of the U. S. in space was translated for the local press, made known to government officials and scientific circles, placed on local radio, shown on movie and television screens, translated into books; and, through wall newspapers and comic strips, carried still further to the people.

Communist bloc countries learned of American space developments primarily through the Voice of America. But America Illustrated, the USIA Russian and Polish-language illustrated monthly that is distributed in the Soviet Union and Poland by reciprocal arrangement, carried important articles on U. S. developments and space science.

GUIDELINES

USIA employed the following guidelines in its coverage:

a. Emphasized that the U. S. is determined to lead in space and that U. S. space achievements flow from American leadership in science and technology.

b. Emphasized that the U. S. favors peaceful development of outer space. United States activities in this regard--the common scientific benefits flowing from communication, weather, and other satellites, cooperation extended for U. S. tracking stations abroad, NASA assistance to foreign space programs--were fully publicized.

c. Underlined the desire of the U. S. to cooperate in space, as signified by the U. S. -Soviet Rome agreement on exchange of satellite information, the offer to the Soviets to participate in the lunar landing program, and the effort at the UN to reach a joint agreement on legal principles for exploration and use of outer space.

ASSETS

These factors emerge on the credit side, in depicting the U. S. space effort abroad:

Breadth and Scope of U. S. Program

The U. S. has a balanced, well conceived, orderly space program of very broad scope. It provides a continuing flow of data to meet human needs through satellites for global communications, weather forecasting, navigation and mapping. The U. S. S. R. has announced no such programs.

International Cooperation

The U. S. has working partnerships in space experimentation with 61 nations--including cooperative projects in meteorology, exchanges of scientific personnel and joint launchings of sounding rockets and satellites. The U. S. S. R. has no comparable cooperative programs.

Openness of Operations and Sharing of Results

Manned space operations are conducted in full view of the world's television cameras, and NASA's launchings are announced in advance. Scientific findings are made available, unfiltered, to the scientific and industrial community as soon as practicable. The U. S. S. R., on the other hand, conducts manned space operations behind a curtain of secrecy, and announces launchings and scientific findings selectively.

LIABILITIES

Influencing the U. S. negatively in the reception of our space effort abroad:

Soviet Manned Space Flight Feats

The Soviets continued to mount manned spacecraft larger than those of the U. S. for longer periods and to display space techniques beyond present U. S. capability. Part of this was due to superior Soviet booster power, which permits larger payloads. The Soviet edge in manned flight performance continued to be the largest negative factor affecting the picture overseas of the U. S. in space.

USIA TREATMENT

Manned Space Flight

No other phase of space activity so influences the U. S. space image abroad. For this reason, manned flight received major emphasis. The flight of Astronaut Gordon Cooper in May was given fullest treatment as a rare opportunity to counter the impression, widely held abroad, that the Soviets lead the U. S. in space.

Communications Satellite

Communications satellites emerged as probably America's greatest asset in conveying to other nations the practicable possibilities in peaceful space development.

USIA worked with other government agencies and with private enterprise in the broadcast of a wide variety of events through the calendar year. The broadcast arrangements were in direct support of American foreign policy in the areas concerned. SYNCOM, newest of U. S. communication satellites, was used in a telephone and radio demonstration with Nigeria between President Kennedy and the Nigerian Prime Minister, to broadcast a U. S. press conference concluding the Extraordinary Conference on Communications Frequencies at Geneva, and for transmission of the first TV broadcast to Japan. RELAY was used to carry simultaneously a three-language, four-media demonstration between the U. S. and Brazil, and later for transmission of President Kennedy's funeral and President Johnson's inaugural address to Europe and the Soviet Union. Both RELAY and TELSTAR broadcast a large number of news events, including the launch of Astronaut Cooper, while TELSTAR reported President Kennedy's trip to Ireland and Germany.

Weather Satellites

The Agency continued to distribute pamphlet and press material covering the operations of the TIROS satellite system. These satellites have continued to excite interest abroad, probably because of its established capacity to detect hurricanes and storms in advance.

Lunar and Planetary Experiments

The story of MARINER II is still gaining scientific credit for the U. S. For example, USIA's account of it was the Agency's first TV export to Rumania. It was also seen by four million Swedes at peak evening time, and in Morocco was hailed as the telecast of the year.

ASSISTANCE TO NEWS MEDIA

Press and Publications

The Agency's daily wire service gave full coverage to all space events while its features service published in-depth articles on the U. S. in space. The Agency transmitted 77 flight reports, totalling over 24,000 words, by radio-teletype on the two days Gordon Cooper was in orbit. Advance material on the flight had been shipped to all overseas posts, for translation and local placement on the launching date, as early as February. The Agency's printing plants in Manila, Beirut, and Mexico City, along with many individual posts, produced leaflets and pamphlets dealing with the flight. The Agency dispatched advance photographs to 148 posts, supplied 3,000 newspapers with plastic plates of a Cooper portrait. According to the responses from posts, few events in postwar history made such an impact.

Television

Through Science Report, an Agency television newsreel program produced in four languages for 52 countries, the space events of the year received wide exposure on foreign screens. In addition to providing world news coverage to networks and stations on the Cooper flight, the Agency's TV service preshipped, for showing with the flight, a half-hour TV program, "Profile: Gordon Cooper," to posts abroad.

Radio

The Voice of America provided continuing and full coverage of all American space events, reaching many parts of the world not available to other USIA media. For the Gordon Cooper flight, the Voice was on the air continuously for 36 hours. The largest network of radio transmitters ever assembled fed the story to the largest overseas radio audience in history. A Voice team in Washington interviewed Congressional leaders and NASA officials, while at Cape Kennedy. Voice reporters broadcast live coverage in English, Russian, French, German, Spanish and Malay.

Motion Pictures

Coverage of important U. S. space developments was provided by newsreels, which carried the message to movie audiences. "The John Glenn Story," a half-hour film on the astronaut's life, was distributed in 27 languages to 97 countries. The half-hour film, "Profile: Gordon Cooper," in three languages, went to movie houses in 58 countries.

Exhibits

USIA has used original MERCURY spacecraft and scale models of satellites, in addition to photo-panels and other materials, to carry the story of the U. S. in space to large and small communities abroad through exhibits. Closest cooperation with NASA was maintained.

The Sigma 7 MERCURY capsule of Astronaut Wally Schirra, set up by USIS in Sao Paulo, Athens and Tokyo during a world tour sponsored by NASA and the Departments of Commerce and Agriculture, was viewed by more than a million people. Its public impact can only be described as tremendous.

Models of satellites and MERCURY spacecraft, including five life-size of the latter, with dummy astronauts, are circulating more widely.

An exhibit on U. S. Progress in Space Sciences, distributed to all regions of the world, has reached over 1,500,000 people. Recently 1,000 poster-size sheets carrying this exhibit in condensed form were distributed worldwide.

In anticipation of Astronaut Cooper's flight, world charts of the orbit paths to be followed were distributed for display at flight time. In conjunction with the fifth anniversary of NASA, all areas received world maps of the U. S. tracking network.

Books and Libraries

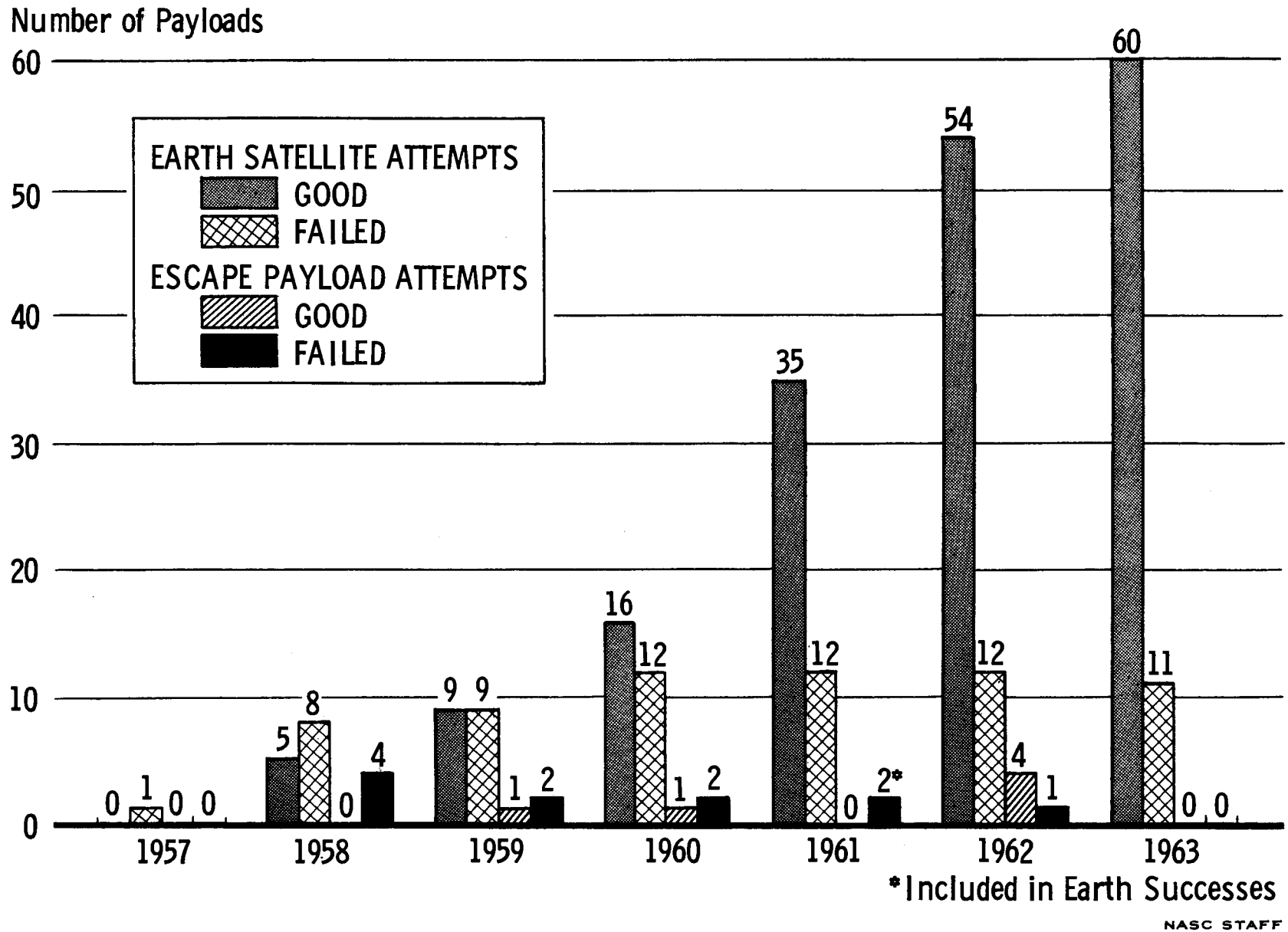
In 341 U. S. Information Service libraries and binational centers, a vast variety of materials on the U. S. space effort was made available to readers. Included were official NASA reports, Congressional and Senate hearings, and a continuing selection of the best available books and publications.

USIA-NASA COOPERATION

Supported by a full-time USIA liaison officer at NASA, the two agencies have worked together in publicizing the space program. The USIA/NASA - sponsored seminar, "The United States in Space," brought ranking administrators and technicians from government and industry to the Agency for a full-dress review of all phases of the subject. USIA and NASA have cooperated in getting NASA's significant photos to the field, in planning exhibits, in preparing space books useful to USIA, in arranging lectures by travelling NASA scientists, and in drawing on space scientists and technicians at NASA installations for Voice of America and USIA-TV interviews.

NASA-supplied Spacemobiles-- mobile lecture-demonstration units equipped to explain U. S. space science and programs by models and experiments--are carrying the space story to cities, hamlets, and colleges abroad. Two spacemobiles in charge of USIA officers are operating in English-speaking Africa and French-speaking Africa. Five more in Europe, Mexico, Venezuela, Brazil and South Asia are sponsored by NASA and the local scientific-space agency, and are captained by a local scientist or teacher.

U.S. LAUNCHING RECORD -- EARTH SATELLITES



UNITED STATES LAUNCHING RECORD

Year	Earth Satellite Attempts		Escape Payload Attempts	
	Good	Failed	Good	Failed
1957	0	1	0	0
1958	5	8	0	4
1959	9	9	1	2
1960	16	12	1	2
1961	35	12	0	2*
1962	54	12	4	1
1963	60	11	0	0
Total	179	65	6	11

Notes:

1. Information contained in this table is drawn from unclassified sources and is believed to be complete and accurate in keeping with the definitions given below.

2. Numbers are given in terms of identified separate payloads placed in Earth orbit or sent to the Moon or into solar orbit. A few launchings have put up more than one payload. If these payloads were intended to separate from each other in flight, they are counted individually even though in a limited number of cases such separation failed to occur. A payload is defined as an object put into orbit or sent away from the Earth to accomplish some specific research or application purpose and to return data to Earth. Typically, a payload transmits telemetry, but not always (e.g. ECHO which carried only a radio beacon). Some rocket casings may carry radio beacons, but limited data return incidental to putting up a payload does not classify these as payloads in their own right.

3. The sole criterion of success or failure used for the purpose of this table is that of attaining Earth orbit, or escape to the Moon or solar orbit as appropriate to the column indicated. Some payloads reached orbit or escaped without returning as much data as planned; other payloads failed to reach orbit or escape, yet returned useful data at least briefly.

4. The corresponding data for number of launchings attempted (the count without reference to multiple payloads) are the same as given above except in the Earth orbital category for 1959 (8 failures), 1960 (15 successes and 11 failures), 1961 (29 successes), 1962 (48 successes and 6 failures), 1963 (38 successes and 8 failures), making totals of 144 orbital launch successes, 6 escape launch successes, 54 orbital launch failures, and 11 escape launch failures, for a grand total of 213 launch attempts (2 escape failures were orbital successes).

5. Minor adjustments in some figures quoted previous years follow a continuing detailed review of records in an attempt to apply a uniform standard of statistical definition.

*These failed to go to escape as intended, but did attain Earth orbit and are in those totals.

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Appendix A-2

SUCCESSFUL U. S. LAUNCHES -- 1963

[See explanatory notes at end of table]

Launch Date Name Designation Vehicle	Payload Data	Apogee and Perigee (in statute miles) Period (minutes) Inclination to Equator (degrees)	Remarks
Jan. 7 DEFENSE 2A Thor Agena D	Total weight: Not stated. Objective: Development of space flight techniques and technology Payload: Not stated.	244 130 90.5 82.00	Decayed January 24, 1963.
Jan. 16 DEFENSE 3A Thor Agena D	Total weight: Not stated. Objective: Development of space flight techniques and technology Payload: Not Stated.	322 297 94.7 81.97	
Feb. 1 Probe Blue Scout, Jr.	Total weight: Not stated. Objective: Not stated. Payload: Not stated.	Orbit not intended.	
Feb. 11 Probe Argo D-8	Total weight: 104 pounds. Objective: To return data on the Van Allen natural radiation belts and on the after effects of nuclear tests in space. Payload: Not stated.	Orbit not intended.	Reached an altitude of 990 miles, then fell in the ocean 1250 miles away after returning 27 minutes of useful information.

Feb. 14 SYNCOM I 4A Thor Delta	Total weight: 150 pounds at separation from third stage; 86 pounds after firing of apogee motor. Objective: Place communications satellite in near-synchronous orbit; test communications capability of satellite and new transportable ground stations. Payload: 28" (diameter) x 15-1/2" cylinder, plus apogee motor on one end and antennas on the other; 2 transponders, command systems; attitude and orbit control systems; 3,840 solar cells.	22,953 21,195 1,426.6 33.51	Near-synchronous orbit was achieved; satellite transmitted during launch, but then all transmission failed; orbit confirmed by visual photographic means on Mar. 4, 1963.
Feb. 19 DEFENSE 5A Blue Scout	Total weight: Not stated. Objective: Development of space flight techniques and technology. Payload: Not stated.	496 304 97.8 100.50 **	
Mar. 13 Probe Blue Scout, Jr.	Total weight: Not stated. Objective: Not stated. Payload: Not stated.	Orbit not intended.	
Mar. 28 SA-4 Vehicle Test Saturn I	Total weight: Not stated. Objective: Development of Saturn I booster. Payload: Jupiter nosecone, with Q-ball angle-of-attack device; accelerometers, attitude control system, and transponder as those to be used in later Saturn tests; 95 tons water ballast.	Orbit not intended.	Fourth consecutive successful development flight of Saturn I; 2nd and 3rd stages inert, carried water ballast; one of eight engines in 1st stage deliberately cut off after 100 sec. of flight; last of Block I (only the first stage live) tests. Climbed 80 miles, fell 232 miles away.

April 1 DEFENSE 7A Thor Agena D	Total weight: Not stated. Objective: Development of space flight techniques and technology. Payload: Not stated.	254 129 90.6 75.37	Decayed April 26, 1963.
April 3 EXPLORER XVII 9A Thor Delta	Total weight: 405 pounds. Objective: Measure atmospheric density, composition, pressure, and temperature at altitudes from 155 to 580 miles. Payload: 35" sphere containing 2 neutral mass spectrometers, 4 vacuum gauges, 2 electrostatic probes; aspect control system; telemetry system; 2 radios; 150 pounds of silver-zinc batteries.	568 158 96.4 57.63	Obtained first measurements of the neutral helium belt surrounding the Earth; confirmed day and night temperatures, fluctuations of electrons. Stopped transmitting July 10, 1963.
May 7 TELSTAR II 13A Thor Delta	Total weight: 175 pounds. Objective: Continued research on low-to-medium-altitude active communications satellites; study radiation effects and means of extending useful life of satellite; check performance of new ground station equipment. Payload: 34-1/2" sphere, containing communications receivers and transmitters; tracking beacons; electron detector; 10 semiconductors to measure radiation damage; mirrors for optical tracking; 3,600 solar cells; batteries.	6,694 538 225.0 43.73	Second AT&T-owned satellite launched by NASA; efforts to minimize radiation damage suffered by TELSTAR I by putting this one in more elliptical orbit, evacuating gas from around transmitters--were successful; satellite went silent from July 15 to Aug. 12, reasons unknown, but resumed operation again.
May 9 DEFENSE 14A Atlas Agena B	Total weight: Not stated. Objective: Development of space flight techniques and technology. Payload: Not stated.	2,290 2,249 166.6 87.44	
May 9 TRS I 14B Atlas Agena B	Total weight: 1 1/2 pounds. Objective: Measure solar cell radiation damage. Payload: Tetrahedron 6.5 inches on a side, solar power and test cells, telemetry system.	2,297 2,241 166.5 87.43	

May 9 TRS I 14C Atlas Agena B	Total weight: 1 1/2 pounds. Objective: Measure solar cell radiation damage. Payload: Tetrahedron 6.5 inches on a side, solar power and test cells, telemetry system.	2,282 2,238 166.5 87.34	
May 9 WEST FORD None Atlas Agena B	Total weight: 50 pounds. Objective: To establish a ring of metal fibers in a belt around the earth for communications experiments, by passive reflection of signals. Payload: 400 million fibers.	Belt about 2,275 about 166.6 about 87.44	Ejected from 14A on May 10, 1963. Experiment completely successful, and natural decay of belt expected as planned.
May 15 FAITH 7 (MA-9) 15A Atlas D	Total weights: (approx.): 4,000 pounds at launch, 3,000 pounds in orbit, and 2,640 pounds on recovery. Objective: Orbit and recover manned spacecraft after extended orbital flights; study the effects of extended orbital flight on astronaut; verify that man can function in space as primary spacecraft system. Payload: Bell-shaped 9 1/2' x 6' (diameter at base) capsule, containing, in addition to astronaut, still and TV cameras; life-support equipment; attitude control systems; radio and telemetry equipment; drag balloon; radiation experiment; HF antenna experiments.	166 100 88.7 32.55	Fourth U.S. manned orbital flight exceeding combined flight time of other flights, with 22 orbits lasting 34 hrs., 20 min. Astronaut L. Gordon Cooper, Jr., made manual reentry May 16, landing 7,000 yds. from USS Kearsarge, located 80 miles SE of Midway Island.
May 15 FLASHING LIGHT None Atlas D	Total weight: 10 pounds. Objective: To provide the astronaut with an object in nearby orbit on which he could practice observations. Payload: A balloon and flashing light.	166 100 88.7 32.55	After the astronaut released the balloon and light on third orbit, he was able to spot them from time to time during orbits 5 and 6.
May 17 Probe Blue Scout, Jr.	Total weight: Not stated. Objective: Not stated. Payload: Not stated.	Orbit not intended.	

May 18 DEFENSE 16A Thor Agena D	Total weight: Not stated. Objective: Development of space flight techniques and technology. Payload: Not stated.	Elements not stated.	Decayed May 27, 1963.
May 22 Reentry Test Scout	Total weight: 480 pounds. Objective: Put mockup nuclear reactor into suborbital trajectory and reentry to test whether reactor would disintegrate on reentry. Payload: Reentry vehicle containing nonradioactive mockup of SNAP 10A reactor with dummy fuel rods.	Orbit not intended.	RFD-1 (Reentry Flight Demonstration-1), first of series of AEC-NASA flight tests of space reactor design and flight safety; Scout was launched from Wallops Island on 800-mi. suborbital trajectory, re-entered SW of Bermuda; payload not recovered but telemetry received for 90% of flight and optical viewing indicated breakup of reactor components on schedule.
June 12 DEFENSE 19A Thor Agena D	Total weight: Not stated. Objective: Development of space flight techniques and technology. Payload: Not stated.	263 127 90.7 81.45	Decayed July 12, 1963.
June 15 LOFTI IIA 21B Thor Agena D	Total weight: Not stated. Objective: To conduct low frequency communications experiments. Payload: Not stated.	550 109 95.2 69.87	Decayed July 18, 1963.
June 15 SOLARAD IV 21C Thor Agena D	Total weight: Not stated. Objective: To measure solar radiation. Payload: Not stated.	546 109 95.1 69.87	Decayed August 1, 1963.

June 15 DEFENSE 21D Thor Agena D	Total weight: Not stated. Objective: Development of space flight techniques and technology. Payload: Not stated.	549 109 95.2 69.87	Decayed July 30, 1963.
June 15 DEFENSE 21E Thor Agena D	Total weight: Not stated. Objective: Development of space flight techniques and technology. Payload: Not stated.	541 109 95.0 69.87	Decayed July 27, 1963.
June 15 DEFENSE 21F Thor Agena D	Total weight: Not stated. Objective: Development of space flight techniques and technology. Payload: Not stated.	533 114 94.9 69.86	Decayed July 5, 1963.
June 16 DEFENSE 22A Blue Scout	Total weight: Not stated. Objective: Development of space flight techniques and technology. Payload: Not stated.	528 463 100.7 90.00	
June 19 TIROS VII 24A Thor Delta	Total weight: 297 pounds. Objective: Continue development of hardware and techniques for operational weather satellite; obtain global weather data during tropical storm season; obtain infrared heat-balance data and electron temperature measurements. Payload: 22" x 42" cylindrical 18-sided polygon, containing 2 wide-angle-lens TV cameras; 5-channel medium resolution scanning infrared radiometer; omnidirectional infrared experiment; electron temperature probe; 4 transmitters and 2 tracking beacons; 9,260 solar cells; 63 nickel-cadmium batteries.	404 384 97.4 58.22	Orbited with all equipment functioning; sighted Hurricane Flora before any other weather sensor, enabling the warning that saved lives and property in the Caribbean.
June 27 DEFENSE 25A Thor Agena D	Total weight: Not stated. Objective: Development of space flight techniques and technology. Payload: Not stated.	255 126 90.1 80.79	Decayed July 26, 1963.

June 27 RADIATION MONITOR 25B Thor Agena D	Total weight: 176 pounds. Objective: To measure magnetically trapped electrons and protons at all significant energy levels. Payload: Octagonal, 3' in diameter. Proton detector, plasma probe, electron detector, electrostatic analyzers, Geiger counter, magnetometers; solar cells, command receiver, tape recorders and telemetry equipment.	2,561 201 132.6 82.13	Hitchhiker separated from 25A on July 1, 1963, and fired to attain a higher apogee. Unusually high performance of instrumentation in quality and resolution showed relation between solar flares and low energy particles in space plasma; showed no sharp division between inner and outer Van Allen belts, but a gradual transition.
June 28 GEOPHYSICS RESEARCH 26A Scout	Total weight: Not stated. Objective: Measure space gas composition. Payload: Mass spectrometer, retarding potential analyzer.	808 267 102.1 49.75	Telemetry returned for 13 orbits.
June 29 DEFENSE 27A Thor Agena B	Total weight: Not stated. Objective: Development of space flight techniques and technology. Payload: Not stated.	360 311 94.9 82.36	
July 2 Probe Argo D-4	Total weight: 50 pounds. Objective: To calibrate and verify data being returned by Canadian satellite, ALOUETTE, on ion and electron temperatures and densities. Payload: Not stated.	Orbit not intended.	Launched vertically 590 miles to reach vicinity of ALOUETTE as it passed nearby; established that ALOUETTE data interpretations were valid.

July 12 DEFENSE 28A Atlas Agena D	Total weight: Not stated. Objective: Development of space flight techniques and technology. Payload: Not stated.	124 111 88.2 95.36**	Decayed July 18, 1963.
July 18 DEFENSE 29A Thor Agena D	Total weight: Not stated. Objective: Development of space flight techniques and technology. Payload: Not stated.	206 120 89.8 82.85	Decayed August 13, 1963.
July 18 DEFENSE 30A Atlas Agena B	Total weight: Not stated. Objective: Development of space flight techniques and technology. Payload: Not stated.	2,316 2,274 167.9 88.40	
July 18 TRS I 30B Atlas Agena B	Total weight: 1 1/2 pounds. Objective: Measure solar cell radiation damage. Payload: Tetrahedron 6.5 inches on a side, solar power and test cells, telemetry system.	2,319 2,276 167.9 88.40	
July 18 DEFENSE 30D Atlas Agena B	Total weight: Not stated. Objective: Development of space flight techniques and technology. Payload: Not stated.	2,326 2,270 168.0 88.41	
July 20 Reentry Test Scout	Total weight: 175 pounds (at start of reentry). Objective: Test charring ablator heat shield material in reentry at 18,600 m.p.h. Payload: Nose cone 4' long, 20 1/4" in diameter, tapering to less than 12" at blunt heat shield end; heat shield experiment; 25 thermocouples; 2 telemetry transmitters.	Orbit not intended.	Scout launch vehicle veered off course and was destructed seconds after launch from Wallops Island.

July 26 SYNCOM II 31A Thor Delta	Total weight: 147 lbs. at separation; and 86 lbs. after apogee motor firing. Objective: Place communications satellite in near synchronous orbit and gain experience in its operation; test new attitude and period control system. Payload: 28" (diameter) x 15 1/2" cylinder, plus apogee motor on one end and antennas on the other; 2 transponders, command system; 3,840 solar cells.	Initial: 22,750 22,062 1,454.1 33.05 Later: 22,192 22,184 1,436.0 33.09	Launch put satellite in good initial position; series of maneuvers culminated on Aug. 15 in achieving definite synchronous figure-8 orbit over Brazil and South Atlantic Ocean. Wide range of communications experiments were conducted with SYNCOM II, including voice, teletype, data relay transmissions; also TV was relayed by the satellite, a capability not designed into its transponders. SYNCOM II would have enough gas fuel for minor orbital corrections to remain on station about 2 years.
July 30 Probe Blue Scout, Jr.	Total weight: 50 pounds. Objective: To measure extraterrestrial radio noise (and total radio energy input). Payload: Four tuned radio frequency receivers on 2.2, 4, 1, and 3 megacycles and two 30-foot dipoles; FM telemetry link.	Orbit not intended.	Climbed 8,000 miles, fell 9,000 miles away, returning 3.5 hours of data.
July 31 DEFENSE 32A Thor Agena D	Total weight: Not stated. Objective: Development of space flight techniques and technology. Payload: Not stated.	288 99 90.6 74.70	Decayed August 11, 1963.

Aug. 2 Payload Test SHOTPUT II	Total weight: 178 pounds. Objective: To test Italian satellite instrumentation, and the despin mechanism of SHOTPUT. Payload: A SAN MARCO satellite package.	Orbit not intended.	Climbed 183 miles.
Aug. 25 DEFENSE 34A Thor Agena D	Total weight: Not stated. Objective: Development of space flight techniques and technology. Payload: Not stated.	202 104 89.5 75.00	Decayed September 12, 1963.
Aug. 28 Payload Test LITTLE JOE II	Total weight: Not stated. Objective: To verify performance of LITTLE JOE II. Payload: Boilerplate APOLLO capsule.	Orbit not intended.	Climbed 5 miles, impacted 9 miles away, achieving 5 of the 6 test objectives.
Aug. 29 DEFENSE 35A Thor Agena D	Total weight: Not stated. Objective: Development of space flight techniques and technology. Payload: Not stated.	202 183 90.8 81.90	Decayed November 7, 1963.
Aug. 29 DEFENSE 35B Thor Agena D	Total weight: Not stated. Objective: Development of space flight techniques and technology. Payload: Not stated.	262 195 92.0 81.90	Decayed September 28/29, 1963.
Sept. 6 DEFENSE 36A Atlas Agena D	Total weight: Not stated. Objective: Development of space flight techniques and technology. Payload: Not stated.	Elements not stated.	Decayed September 13, 1963.

Sept. 18 ASSET Reentry Test Thor	Total weight: 1,100 pounds. Objective: Test of gliding reentry from space. Payload: Delta-winged reentry body, 68.7" long, 58.9" wide; instrumentation and telemetry equipment.	Orbit not intended.	Climbed 35 miles, fell 1,150 miles away, attaining speed of 10,900 m.p.h. and 4000° F. temperature. Good telemetry received on temperature and pressures, but vehicle not recovered.
Sept. 24 DEFENSE 37A Thor Agena D	Total weight: Not stated. Objective: Development of space flight techniques and technology. Payload: Not stated.	274 100 90.6 74.85	Decayed October 12, 1963.
Sept. 28 DEFENSE 38B Thor Able Star	Total weight: Not stated. Objective: Development of space flight techniques and technology. Payload: Not stated.	714 676 107.4 89.90	
Sept. 28 DEFENSE 38C Thor Able Star	Total weight: Not stated. Objective: Development of space flight techniques and technology. Payload: Not stated.	705 667 107.4 89.89	
Oct. 17 DEFENSE 39A Atlas Agena D	Total weight: Not stated. Objective: Development of space flight techniques and technology. Payload: Not stated.	68,905 63,301 105 hours 38.30	
Oct. 17 TRS II 39B Atlas Agena D	Total weight: 3 pounds. Objective: Measure charged particle intensity in Van Allen belts. Payload: Tetrahedron 9 inches on a side, solar cells, proton and electron detectors, telemetry system.	64,388 129 39 hours 36.69	

Oct 17 DEFENSE 39C Atlas Agena D	Total weight: Not stated. Objective: Development of space flight techniques and technology. Payload: Not stated.	Elements not stated.	
Oct. 25 DEFENSE 41A Atlas Agena D	Total weight: Not stated. Objective: Development of space flight techniques and technology. Payload: Not stated.	Elements not stated.	Decayed October 29, 1963.
Oct. 25 DEFENSE 41B Atlas Agena D	Total weight: Not stated. Objective: Development of space flight techniques and technology. Payload: Not stated.	Elements not stated.	Decayed October 28/29, 1963.
Oct. 29 DEFENSE 42A Thor Agena D	Total weight: Not stated. Objective: Development of space flight techniques and technology. Payload: Not stated.	218 172 90.9 89.90	
Oct. 29 DEFENSE 42B Thor Agena D	Total weight: Not stated. Objective: Development of space flight techniques and technology. Payload: Not stated.	349 193 93.4 89.94	
Nov. 27 EXPLORER XVIII 46A Thor Delta	Total weight: 138 pounds. Objective: Measure interplanetary magnetic fields, solar wind, and cosmic radiation in area between Earth and the Moon. Payload: 28" x 12" octagon, with 6' telescoping boom rising out of the center to support a rubidium-vapor magnetometer; two 7' booms extending from the sides of the octagon and mounting flux-gate magnetometers; 4 paddles mounting solar cells; 13 silver-cadmium batteries; transmitter; telemetry; 4 energetic particle sensors; 3 solar wind sensors.	122,522 119 96 hrs., 26 min. 33.30	Interplanetary monitoring probe (IMP) was successfully launched into highly elliptical orbit, although apogee was some 50,000 miles less than hoped for; was sending important data that would be of significance for Project APOLLO.

Nov. 27 CENTAUR II 47A Atlas Centaur	Total weight: None except for the weight of the vehicle and ballast, amounting to about 10,500 pounds. Objective: Test-fly Atlas-Centaur vehicle, principally testing structural integrity, stage separation, in-space ignition of Centaur's liquid-hydrogen engines, and accuracy of Centaur guidance system. Payload: None, other than diagnostic instruments.	1,093 303 107.7 30.40	Second attempt, first success in flight-testing Centaur; first ignition of liquid hydrogen in space and on time. Centaur stage was put into orbit, its 10,500 pounds being heaviest single weight yet orbited by U.S.
Nov. 27 DEFENSE 48A Thor Agena D	Total weight: Not stated. Objective: Development of space flight techniques and technology. Payload: Not stated.	236 109 90.1 70.02	Decayed December 15, 1963.
Dec. 5 DEFENSE 49B Thor Able Star	Total weight: Not stated. Objective: Development of space flight techniques and technology. Payload: Not stated.	690 665 107.2 89.98	
Dec. 5 DEFENSE 49C Thor Able Star	Total weight: Not stated. Objective: Development of space flight techniques and technology. Payload: Not stated.	689 666 107.2 89.97	
Dec. 17 Probe Blue Scout	Total weight: Not stated. Objective: Not stated. Payload: Not stated.	Orbit not intended.	
Dec. 18 DEFENSE 51A Atlas Agena D	Total weight: Not stated. Objective: Development of space flight techniques and technology. Payload: Not stated.	Elements not stated.	Decayed December 20, 1963.

Dec 19 EXPLORER XIX 53A Scout	Total weight: 138 pounds, including 17.8 pounds for the inflated balloon satellite; 77 pounds for cannister prior to satellite ejection. Objective: Using tracking of air density satellite, obtain measurements of atmospheric density fluctuations in the high latitudes and extending over a large portion of the solar cycle; engineering test of new X-258 4th stage of Scout booster. Payload: 12' (when inflated) sphere of 4 alternating layers of 1-mil aluminum foil and Mylar, painted with white polka dots for temperature control; tracking beacon, solar cells, and nickel-cadmium batteries attached to skin of balloon satellite.	1,487 366 115.9 78.61	Orbit achieved, but signal from tracking beacon was so weak that optical tracking was necessary to define orbit and confirm inflation of balloon satellite; EXPLORER XIX would provide for the high latitudes the kind of atmospheric density data that EXPLORER IX did for the lower latitudes.
Dec. 21 TIROS VIII 54A Thor Delta	Total weight: 265 pounds. Objective: Continue development of hardware and techniques for operational weather satellite; test new APT (automatic picture transmission) subsystem and its related ground equipment. Payload: 22" x 42" cylindrical 18-sided polygon, containing one 104° wide-angle-Tegea-lens TV camera, picture storage, and transmission system; one 108° wide-angle-Tegea-lens camera and its slow-scan transmitting system; 2 tracking beacons; 9,260 solar cells; 63 nickel cadmium batteries.	473 430 99.3 58.49	APT transmits on call pictures of local cloud conditions to inexpensive ground stations on a real-time basis. System performed as planned. About 44 ground stations are involved in the current experiment.
Dec. 21 DEFENSE 55A Thor Agena D	Total weight: Not stated. Objective: Development of space flight techniques and technology. Payload: Not stated.	189 107 89.3 64.87	
Dec. 21 DEFENSE 55B Thor Agena D	Total weight: Not stated. Objective: Development of space flight techniques and technology. Payload: Not stated.	245 196 91.7 64.52	

Dec. 21 DEFENSE 55C Thor Agena D	Total weight: Not stated. Objective: Development of space flight techniques and technology. Payload: Not stated.	Elements not stated.	
Date not stated DEFENSE Not stated Thor Agena D	Total weight: Not stated. Objective: Development of space flight techniques and technology. Payload: Not stated.	Elements not stated.	A minor pickaback carried on the principal payload already reported.
Date not stated DEFENSE Not stated Atlas Agena B	Total weight: Not stated Objective: Development of space flight techniques and technology. Payload: Not stated.	Elements not stated.	A minor pickaback carried on the principal payload already reported.

NOTES: Successful launches are judged solely by the criterion of whether orbit of Earth was achieved when so intended. Additionally, the table includes listings of important probes and vehicle tests not intended to orbit, but in these cases, no criterion of success has been applied; some achieved their purposes, others did not. Eight additional Earth-orbital launchings with eleven payloads not in this table failed to achieve orbit.

Launch date is based on Greenwich Mean time.

Name is the payload identification.

Designation is the international COSPAR astronautical name of orbital objects.

Vehicle is the launch craft type.

Total weight refers to the orbital weight of the object containing the payload; it does not include the weight of any separate miscellaneous burned-out rocket casings, protective coverings, etc.

Objective and Payload are self-explanatory.

Orbital elements are those filed with the United Nations as available; otherwise they are taken from the NASA Goddard Satellite Situation Report or other official public releases.

Apogee and Perigee refer to the greatest and least distances respectively from the Earth of geocentric orbiting objects.

Period refers to the time in minutes (unless otherwise marked) required to complete one Earth orbit.

Inclination refers to the tilt of Earth orbits in relation to the Equator, measured in degrees of latitude at the points of the orbit farthest away from the Equator. Inclinations in excess of 90 degrees carry double asterisks (**), indicating some amount of retrograde flight, i.e., somewhat westerly instead of the normal easterly.

Remarks are self-explanatory.

NASC Staff

UNITED STATES SPACE LAUNCH VEHICLES

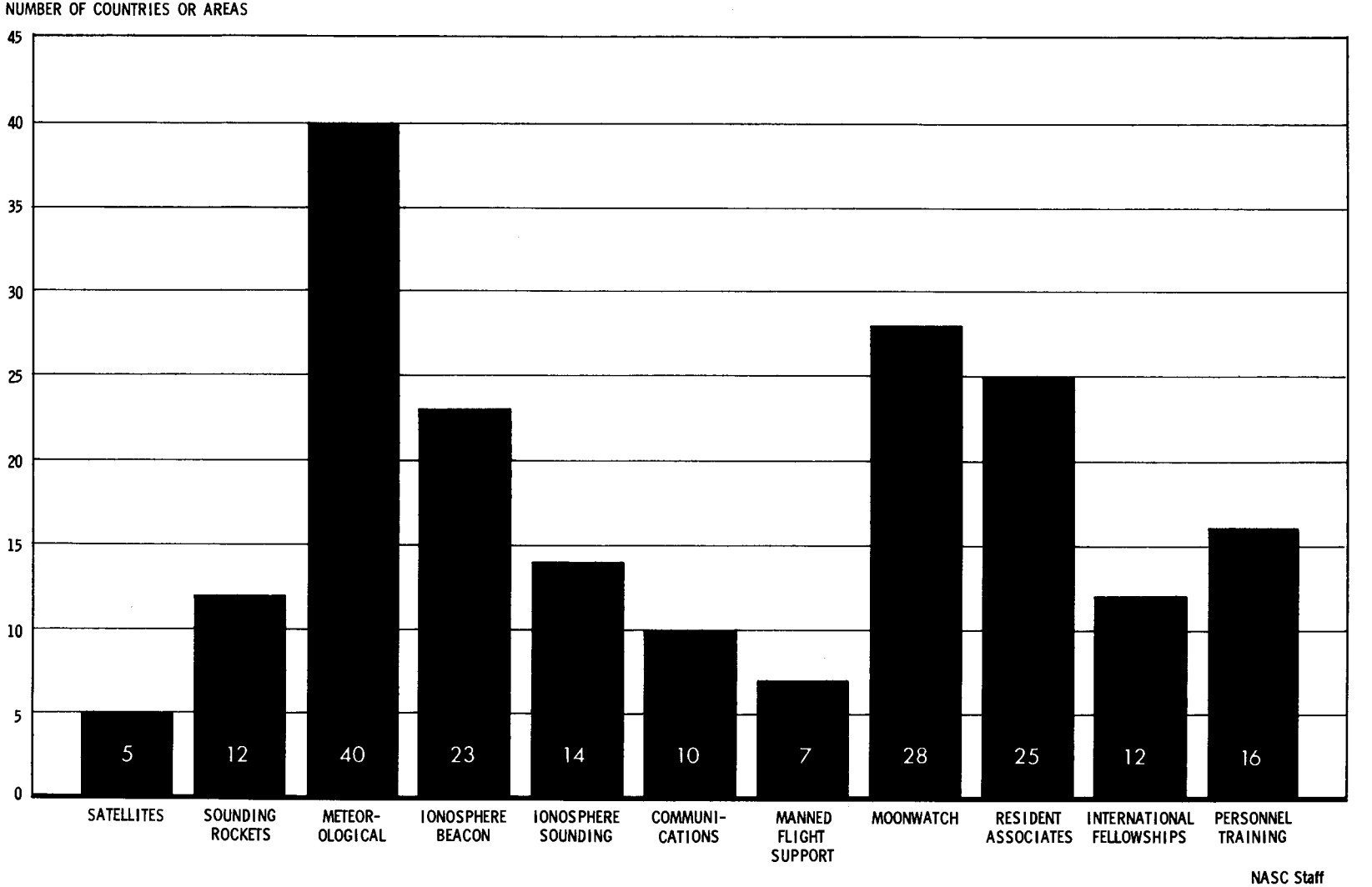
Vehicle	Stages	Propellant	Thrust (in thousands of pounds)	Max. Dia. (feet)	Height less Spacecraft (feet)	Payload (pounds) 100 NM orbit	Escape	Stationary orbit	First Launch
Scout and Blue Scout	1. Algol (IIA)	Solid	87	3.3	72	345	80		1963 (60)*
	2. Castor (XM-75)	Solid	64						
	3. Antares (XM-93)	Solid	23						
	4. Altair (ABLX-258)	Solid	3						
Thor Delta	1. Thor (DM-21)	LOX/RP	172	8	87	800			1963 (60)
	2. AJ-10-118	IRFNA/UDMH	7.5						
	3. Altair (ABLX-248)	Solid	3.0						
Thrust augmented Thor Delta	1. Thor (DM-21)	LOX/RP	172	11	87	1500 +	150		1964 (60)
	(3 TX 33-52)	Solid	55 each						
	2. AJ-10-118	IRFNA/UDMH	7.5						
	3. Altair (ABLX-248)	Solid	3						
Thor Able Star	1. Thor (DM-21)	LOX/RP	172	8	79	900			1962 (60)
	2. AJ-10-104	IRFNA/UDMH	7.9						
Thor Agena D	1. Thor (DM-21)	LOX/RP	172	8	76	1600			1962 (59)
	2. Agena D	IRFNA/UDMH	16	5					
Thrust augmented Thor Agena D	1. Thor (DM-21)	LOX/RP	172	11	76	2500			1963 (60)
	(3 TX 33-52)	Solid	55 each						
	2. Agena D	IRFNA/UDMH	16						
Atlas SLV-3	1. Atlas D (improved)	LOX/RP	400 +	10	75	2700			1963 (59)
Atlas Agena D	1. Atlas D (improved)	LOX/RP	400 +	10	91	5000 +	750		1963 (60)
	2. Atlas D sustainer	LOX/RP	60						
	3. Agena D	IRFNA/UDMH	16						
Titan II (GLV)	1. 2 LR-87	Storable liquid	430	10	90	7000			1963
	2. IR 91	Storable liquid	100						

Titan III	1. Two 5-segment	Solid	2000 +	10,10	110	25,000	5000	2100	1964/65
	2. 2 LR-87	Storable liquid	430	10					
	3. LR-91	Storable liquid	100	10					
	4. Upper Stage	Storable liquid	16	10					
Centaur	1. Atlas D	LOX/RP	367	10	105	8500	2300	1300	5/8/62
	2. Atlas D (sustainer)	LOX/RP	80						
	3. Centaur (Two RL-10)	LOX/LH	30						
Saturn I	1. S-I (8 H-1)	LOX/RP	1500	21.6	125	15,000	--	--	1st stage 10/27/61
	2. S-IV (6 A-3)	LOX/LH	90						2nd stage 1964
Saturn I-B	1. S-IB (8 H-1)	LOX/RP	1500	21.6	141	28,500	--	--	1965
	2. S-IVB (1 J-2)	LOX/LH	200						
Saturn V	1. S-IC (5 F-1)	LOX/RP	7500	33	275	220,000	90,000	70,000	1966-67
	2. S-II (5 J-2)	LOX/LH	1000						
	3. S-IVB (1 J-2)	LOX/LH	200						

NOTES: Definitive data are difficult to compile. Payload capacity data vary according to the place and direction of launch as well as intended orbital altitude. Vehicles still under development may fall short of or exceed their projected capacities, both in payload and in engine thrust. Modifications of existing vehicles have already raised their performance, and future modifications may be expected in several cases. In general, these data apply to the latest versions now under development. *The date of first launch applies to this latest modification with a date in parentheses, for the earlier version.

Propellant abbreviations used are as follows: Liquid Oxygen and a modified Kerosene -- LOX/RP; Solid propellant combining in a single mixture both fuel and oxidizer -- Solid; Inhibited Red Fuming Nitric Acid and Unsymmetrical Dimethylhydrazine -- IRFNA/UDMH; Nitrogen Tetroxide and Aerozene 50 -- Storable liquid; Liquid Oxygen and Liquid Hydrogen -- LOX/LH.

SELECTED PROGRAMS FOR COOPERATION IN OUTER SPACE



NASC Staff
December 1963

SNAP RADIOISOTOPE ELECTRICAL POWER UNITS FOR SPACE

SNAP NO.	Power electrical (watts)	Life (years)	Application	Fuel	Status
3	2.7	5	Navigation Satellite (Navy)	Plutonium-238	Launched twice: in June and November 1961.
9A	25	5	Navigation Satellite (Navy)	Plutonium-238	Launched twice: in September and December 1963.
11	25	1/3	SURVEYOR (NASA)	Curium-242	Scheduled delivery 1965
13	12.5	1/3	Thermionic Demonstration Unit	Curium-242	Electrically heated units under test.
IMP	20	1-5	Interplanetary Monitoring Probe	Plutonium-238	Under development.
COMSAT Generator	35	5	Military Communications Satellite	Strontium-90	Under development

Source: Atomic Energy Commission

Historical Summary and 1965 Budget Recommendations January 21, 1964

NEW OBLIGATIONAL AUTHORITY

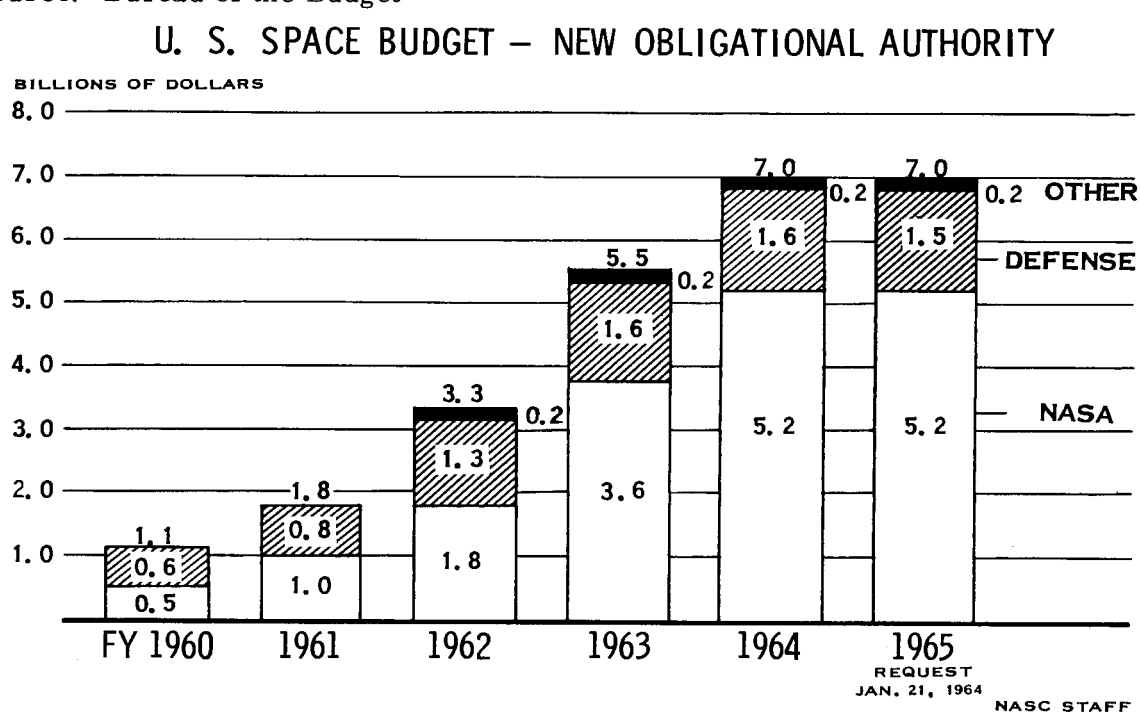
(In millions of dollars)

	NASA Total	NASA Space 1/	Dept. of Defense	AEC	Weather Bureau	NSF	Total Space
Historical							
1955	56.9	56.9	3.0	-	-	-	59.9
1956	72.7	72.7	30.3	7.0	-	7.3	117.3
1957	78.2	78.2	71.0	21.3	-	8.4	178.9
1958	117.3	117.3	205.6	21.3	-	3.3	347.5
1959	338.9	338.9	489.5	34.3	-	-	862.7
1960	523.6	523.6	560.9	43.3	-	.1	1,127.9
1961	966.7	926.2	813.9	67.7	-	.6	1,808.4
1962	1,824.9	1,796.0	1,298.2	147.8	50.7	1.3	3,294.0
1963	3,673.0	3,626.0	1,579.3	213.9	43.2	1.5	5,463.9
1965 Budget							
1964	5,241.0 2/	5,189.5 2/	1,615.8	227.6	2.7	2.4	7,038.0
1965	5,304.0	5,230.8	1,474.1	212.7	20.8	2.9	6,941.3

1/ Excludes amounts for aircraft technology in 1961 and succeeding years. Amounts for NASA-NACA aircraft and space activities not separately identifiable prior to 1961.

2/ Includes recommended 1964 supplemental appropriation of $141.0 million.

Source: Bureau of the Budget



SPACE ACTIVITIES OF THE UNITED STATES GOVERNMENT

Historical Summary and 1965 Budget Recommendations January 21, 1964

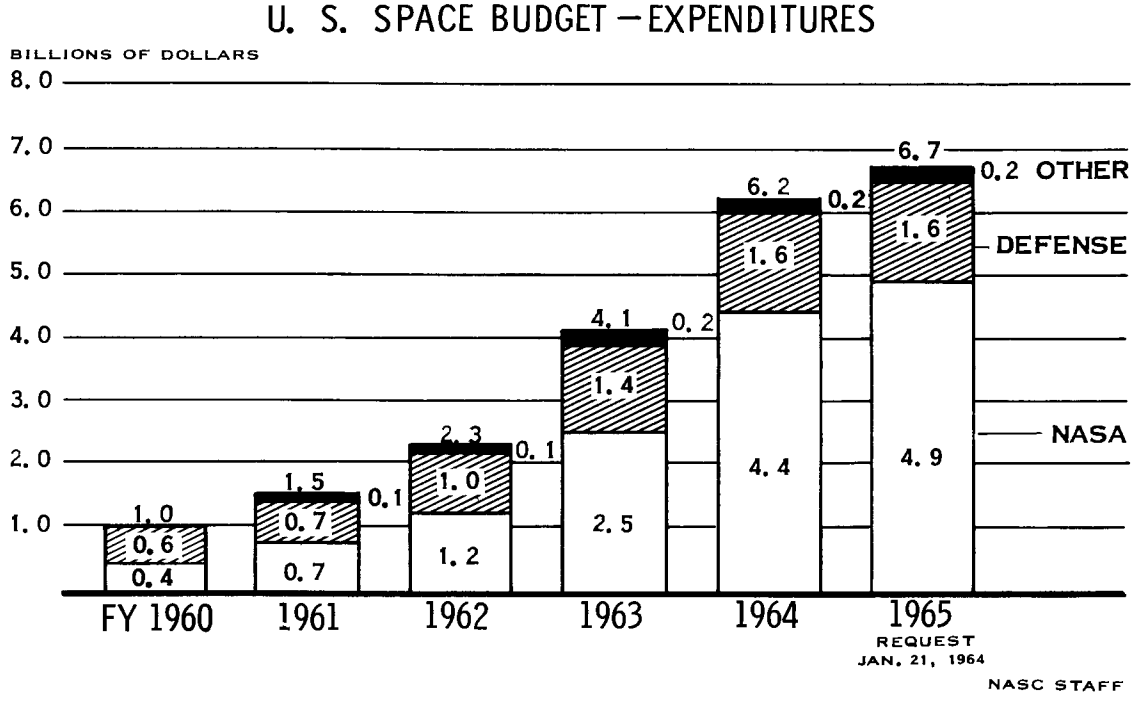
EXPENDITURES

(In millions of dollars)

	NASA Total	NASA Space 1/	Dept. of Defense	AEC	Weather Bureau	NSF	Total Space
Historical							
1955	73.8	73.8	1.5	-	-	-	75.3
1956	71.1	71.1	16.5	6.3	-	6.2	100.1
1957	76.1	76.1	47.5	19.2	-	7.3	150.1
1958	89.2	89.2	135.5	20.2	-	4.0	248.9
1959	145.5	145.5	341.0	32.6	-	1.5	520.6
1960	401.0	401.0	518.1	41.1	-	-	960.2
1961	744.3	694.0	710.0	64.3	-	-	1,468.3
1962	1,257.0	1,229.0	1,028.8	130.0	1.0	.9	2,389.7
1963	2,552.3	2,515.3	1,367.5	181.0	12.2	1.1	4,077.1
1965 Budget							
1964	4,400.0	4,354.8	1,583.0	217.7	19.0	1.5	6,176.0
1965	4,990.0	4,939.1	1,548.0	220.4	21.7	1.8	6,731.0

1/ Excludes amounts for aircraft technology in 1961 and succeeding years. Amounts for NASA-NACA aircraft and space activities not separately identifiable prior to 1961.

Source: Bureau of the Budget



SPACE ACTIVITIES BUDGET

1965 Budget Document

January 21, 1964

(In millions of dollars)

	New Obligational Authority			Expenditures		
	1963 (Actual)	1964 (Estimated)	1965	1963 (Actual)	1964 (Estimated)	1965
Federal Space Programs						
NASA*	3626.0	5189.5**	5230.8	2515.3	4354.8	4939.1
Department of Defense	1579.3	1615.8	1474.1	1367.5	1583.0	1548.0
Atomic Energy Commission	213.9	227.6	212.7	181.0	217.7	220.4
Department of Commerce:						
Weather Bureau	43.2	2.7	20.8	12.2	19.0	21.7
National Science Foundation	1.5	2.4	2.9	1.1	1.5	1.8
TOTAL	5463.9	7038.0	6941.3	4077.1	6176.0	6731.0
NASA Program						
Manned space flight	2244.8	3535.1**	3580.4	1533.4	2898.3	3369.6
Space applications	106.8	116.6	98.0	89.7	105.0	97.3
Unmanned investigations in space	588.3	687.6	732.5	484.1	645.2	670.4
Space research & technology	492.1	491.6	457.8	272.5	443.6	453.9
Aircraft technology	47.0	51.5	73.2	37.0	45.2	50.9
Supporting operations & other	216.9	375.0	362.1	135.7	262.7	347.9
Adjustment to NOA basis	-22.9	-16.4	-	-.1	-	-
Total	3673.0	5241.0**	5304.0	2552.3	4400.0	4990.0

* Excludes amounts for aircraft technology.

** Includes proposed 1964 supplemental estimate of $141.0 million.

Source: Bureau of the Budget.

Appendix E-3

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