U.S. AERONAUTICS AND SPACE ACTIVITIES,
JANUARY 1 TO DECEMBER 31, 1959

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2d Annual
REPORT TO CONGRESS

FROM

THE PRESIDENT OF THE UNITED STATES

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THE WHITE HOUSE

TO THE CONGRESS OF THE UNITED STATES:

In accordance with Section 206(b) of the National Aeronautics and Space Act of 1958, I am transmitting herewith the second annual report on the Nation's activities in the fields of aeronautics and space.

During 1959, the Nation's space effort moved forward with purpose and its accomplishments were many, as this report recounts. In the short period of a single year, a program of great complexity and scope was aligned so that the scientists of many organizations in and out of Government could pool and coordinate their knowledge and skills. Much information of far-reaching significance was acquired on the frontiers of science and technology; substantial gains were made, ranging from advances in aircraft and space vehicle design to greatly improved understanding of the environment in which our planet exists and by which its natural forces and life are conditioned.

The year was also one of transition. The national space program grew in breadth and depth -- benefiting greatly from the tremendous efforts of the American scientists, engineers, and technicians who, in the short space of the past five years, have performed miraculously in developing United States rocket technology.

This Report details the steps taken during 1959 to establish a firm foundation for a dynamic program of space exploration, and it summarizes the contributions of Federal agencies toward the paramount goal: the conquest of space for the benefit of all mankind.

DWIGHT D. EISENHOWER

THE WHITE HOUSE,

February 22, 1960.

TABLE OF CONTENTS

U.S. AERONAUTICS AND SPACE ACTIVITIES

INTRODUCTION

SECOND ANNUAL REPORT

- - 1959 - -

Nineteen fifty-nine witnessed substantial accomplishments in the United States space exploration program and revealed with increasing clarity the nature and dimensions of major problems confronting the effort.

During the year, extensive changes in organization and in program responsibility were effected, resulting in consolidation of the nonmilitary space program under the National Aeronautics and Space Administration.

The United States carried out a vigorous operational space program by means of earth satellites, space probes, and sounding rockets. Immediate focus of the national space program was upon Project Mercury, first phase of the manned satellite program, which gained considerable momentum during the year.

Progress was made in the development of a small family of high-thrust vehicles, with emphasis on increased thrust and improved reliability and guidance; they will be used first for lunar missions and ultimately to power missions to the planets. Tracking and data-collection networks are being constructed in support of earth-satellite, Project Mercury, space-probe, and sounding-rocket programs.

In aeronautics, research went forward across the entire speed range from hovering aircraft, ground-effect systems, and VTOL (Vertical Take-Off and Landing) and STOL (Short Take-off and Landing) to experimental aircraft capable of near-satellite speeds and altitudes.

Underlying the entire effort are basic and applied research programs in space sciences and technology.

During the year, United States activities toward achieving international cooperation in space affairs increased markedly.

In summary, the Nation's aeronautics and space activities -- both military and nonmilitary -- gained in momentum, scope, and positive direction during the year under review.*

U.S. Space Program Milestones

During calendar year 1959, the National Aeronautics and Space Administration (NASA) successfully launched four satellites and one space probe in 10 attempts. The Department of Defense (DOD) successfully launched six satellites in nine attempts.

These experiments, together with the earlier Explorers, Pioneers, and Vanguards, have provided a vast quantity of valuable data on such phenomena as the Great Radiation Region surrounding the earth, the earth's magnetic field, micrometeoroid density in space, and other factors involved in problems of space travel.

Knowledge gained from these experiments has enabled NASA to prepare more realistic and comprehensive short- and long- range (nonmilitary) space goals than had been possible during the early phases of the Nation's space drive.

The following experiments and activities highlighted the U.S. space year in the nonmilitary realm.**

Seven astronauts for Project Mercury were selected and began intensive training. All military test pilots with engineering backgrounds, the astronauts are contributing their knowledge and experience in design and construction of the Mercury capsule and supporting equipment.

An Atlas booster propelled a Mercury capsule model to an altitude of 100 miles and a range of 1,300 miles, a flight that culminated in a successful test of capsule instruments, stability, and heat shielding.

The Pioneer IV space probe achieved its primary mission, an earth-moon trajectory, and traveled on to orbit the sun.

Two monkeys, Able and Baker, survived a space flight at speeds as great as 10,000 mph and to a peak altitude of 300

* This report does not include activities of the Federal Aviation Agency and the Civil Aeronautics Board which are concerned primarily with operational civil aviation matters, nor does it cover details of the research and development accomplishments of the Department of Defense.

** Details of the NASA year are to be found in Chapter 1; the Department of Defense program is in Chapter 2.

miles. The monkeys were part of a biomedical experiment carried in a Jupiter nose cone in a flight conducted by the Army under NASA sponsorship.

The X-15 rocket-powered research airplane completed successful initial glide- and powered-flight tests.

Explorer VI, the "paddlewheel satellite" (so-named because of its solar vanes or paddles), was successfully launched into orbit, relaying a crude photograph of the earth's cloud cover and transmitting valuable new data on radiation, micrometeoroids, radio waves and earth's magnetic field.

Vanguard III, last of the Vanguard satellite experiments, was launched successfully; it has supplied information on solar X-rays and has transmitted other valuable data.

Explorer VII, a highly instrumented 91.5-pound satellite, was launched into predicted orbit, all equipment working as programmed. From its transmissions, scientists are learning new facts about the trapped solar radiation and cosmic radiation near the earth.

In addition to numerous sounding rocket and upper-atmosphere wind velocity experiments, NASA successfully launched a test vehicle carrying a 100-foot-diameter inflatable sphere on a suborbital flight over the Atlantic Ocean. The sphere, which was seen throughout a wide area of the Atlantic Seaboard, is a prototype of spheres that will be used in passive communications satellite experiments.

Military Space Activities

The Department of Defense placed special emphasis on its Discoverer Satellite Program in 1959. Its objective: the testing of components, propulsion and guidance systems, and techniques for several U.S. space projects. A capsule recovery operation, so far unsuccessful, is a principal technique being tested in the program.

Eight of the nine military space launchings were of Discoverer vehicles (six attained orbit); the ninth, in the Transit navigation satellite program, failed to achieve orbit but yielded useful operational data.

Also included among key Defense Department projects were the following: Project Argus, in which the effects of nuclear explosions in the exosphere are being studied; Project Notus, a communications satellite system for long-range radio communication; Project Shepherd, a combined Minitrack-Doploc fence to serve as a space surveillance system for defense purposes; and Project Longsight, a research study concerned with military needs in space technology.

Consolidation of the Nonmilitary Space Program

A fundamental achievement of 1959 was further consolidation of the nonmilitary space program under NASA with the transfer to that agency of several projects and research and development organizations from the Department of Defense.

As specified in the National Aeronautics and Space Act of 1958, NASA's mission is to conduct U.S. aeronautical and space research and development, apart from military projects. (In aeronautics, as a matter of practice, NASA restricts itself to research.) The legislation stipulates, however, that NASA should cooperate with the military in defense-related space research and development. As a result, NASA scientists and engineers are at work on problems connected with many military launch vehicles

On April 13, Project Tiros, a meteorological satellite, was transferred to NASA from the Department of Defense. And on June 1, Project Centaur, a high-thrust, Atlas-based booster, was shifted to NASA from the Advanced Research Projects Agency (ARPA) of the Defense Department.

Most notable expansion and consolidation of NASA's mission came in the field of super-boosters. In late 1959 the President announced his intention of transferring to NASA the Development Operations Division of the Army Ballistic Missile Agency at Redstone Arsenal, Huntsville, Ala., along with Saturn, the 1.5-million-pound-thrust (clustered) rocket engine under development by the Division.

Subject to Congressional approval, the transfer will become effective 60 days from formal notification of the Congress on January 14, 1960 (after the period of this report). The transfer will include the 4,300 scientific and technical positions from the present Development Operations Division and a provision enabling NASA to recruit up to 815 individuals from ABMA or Redstone Arsenal supporting personnel. The total supporting personnel requirement of 1,200 for the Saturn group cannot be filled entirely from the Redstone personnel because the Army requires their continued service in military programs.

In a message to the Congress discussing the Saturn transfer, and recommending changes in the Space Act, the President emphasized that the assignment of super-booster development to NASA was being made regardless of the vehicle's ultimate military or nonmilitary uses.

In order to speed development of super-boosters, NASA decided to divide its Office of Space Flight Development into two offices -- the Office of Space Flight Programs and the Office of Launch Vehicle Programs. The former will be responsible for mission planning, payload design and in-flight research and operation; the latter will direct booster development and launchings.

Other NASA divisions under the reorganization include: the Office of Advanced Research Programs (formerly the Office of Aeronautical and Space Research) which is charged with advanced research in aeronautics and space; and the Office of Business Administration which continues with the same name and functions.

International Cooperation in Space

The National Aeronautics and Space Act of 1958 states:

> "...The Congress hereby declares that it is the policy of the United States that activities in space should be devoted to peaceful purposes for the benefit of all mankind..."

The Act further states:

> "...The aeronautical and space activities of the United States shall be conducted so as to contribute materially to cooperation by the United States with other nations and groups of nations in work done pursuant to this Act and in the peaceful application of the results thereof..."

Looking toward implementation of these provisions of the Space Act, the United States has taken initiative in the United Nations, and NASA has found that the spirit of cooperation engendered during the International Geophysical Year (IGY) had carried over into 1959 with numerous positive results. Furthermore, U.S. requirements for worldwide tracking and data-acquisition networks increased the opportunity for international cooperation in space affairs.

The Department of State and NASA began discussions with other governments leading toward the acquisition of sites for eight Project Mercury tracking stations abroad. Preliminary site surveys have been made.

Discussions with both the United Kingdom and the Canadian Defence Research Board were initiated regarding cooperative space research programs.

In September, Dr. Hugh L. Dryden, the Deputy Administrator of NASA, took part in discussions with a number of scientists and officials of the European scientific community. His mission had a twofold purpose: to assess space-connected activities in Europe and to indicate NASA's interest in discussing potential cooperative space research programs.

On December 7, the Administrator of NASA offered the services of the U.S. worldwide tracking network in support of any manned space flight the USSR might have under way or plan to undertake.

Summary Evaluation; Problem Areas and Goals

While NASA's operational goals continue to expand, its fundamental mission remains constant. As broadly expressed in the Space Act (sec. 102), the agency must pursue aeronautical and space research and development for "...the expansion of human knowledge of phenomena in the atmosphere and space" -- for mankind's benefit.

Following this objective during the 15 months of its operational life, NASA has carried out its mission across a broad research and development front. Already on the horizon are practical benefits in the fields of meteorology, communications, navigation and geodetics, while unforeseen rewards of today's basic research undoubtedly lie still further in the future.

As it has simultaneously built up its organization, carried out an operational space program and set goals, NASA has uncovered and isolated many major problem areas. For example, the nonmilitary space program has been plagued by a lack of high-thrust, reliable boosters designed specifcally for space missions. The experiments have been launched, for the most part, by rockets originally designed and developed for military purposes.

Lack of reliability has been a corollary problem of equal magnitude. During both military and nonmilitary space experiments in 1959, there was all too often little or no margin for even the slightest deviation from planned performance.

In 1960 and the years immediately ahead, NASA will concentrate upon:

...Development of a small family of highly reliable medium and high-thrust boosters.

...Development of midcourse and terminal guidance equipment and techniques.

...Research into the performance of materials and fuels in the temperature extremes and stresses of space flight.

...Communications experiments over interplanetary distances.

...A substantial program of scientific research using earth satellites and space probes, with increasing emphasis upon lunar missions to develop technology for later, more advanced flights to the planets.

...Associated tracking and data-collection networks.

In the coming months, areas of concentration will inevitably be affected in both DOD and NASA programs as unforeseen problems -- and opportunities -- arise in this highly fluid technology. Both programs are subject to continuing review and re-evaluation. But the year-end stocktaking reveals that, in sum, United States achievements in space during 1959 add up to a substantial base upon which to build for the future.

CHAPTER 1

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

The mission of the National Aeronautics and Space Administration (NASA) is to conduct the government's nonmilitary activities in aeronautics research and in space research and development, and to cooperate with and support Department of Defense activities in these fields. The basic objectives of the Nation's space program are exploration of space to extend knowledge of the solar system and the universe, to use this knowledge for peaceful ends, and to share its benefits with all mankind.

Initial steps toward these goals are the continuing series of scientific satellites and the probes dispatched into space to transmit basic information on conditions that coming generations of spacecraft and, eventually, human crews will encounter and must cope with.

Essential to the key objective is Project Mercury, to which NASA has given high priority. Mercury will place a manned satellite in orbit around the earth, recover the astronaut-pilot and make possible the study of human capabilities under the stresses of acceleration, weightlessness, deceleration, and landing.

Beyond Project Mercury, it is planned to dispatch highly instrumented robot devices to the moon, followed by manned expeditions. Further still in the future are deep space probes to Mars, Venus, and eventually to more distant planets. Sustaining NASA's space flight operations are extensive programs in space sciences and technology. From these fields is emerging knowledge for designing and developing more powerful and more reliable space vehicles, and more accurate guidance for them.

Accomplishments and developments in major NASA programs during 1959 are summarized below.

OPERATIONAL MISSIONS

NASA's achievements in operational space flight were substantial during the period January 1, 1959, to December 31, 1959. Of 10 attempts to launch spacecraft into orbit or on deep space trajectories, five have attained a large proportion of the objectives set for them.

These United States experiments have yielded data of great importance to science in general and vital to the future of man's venture into space -- such as findings on the range and intensity of dangerous radiation in space, the makeup of the earth's magnetic field, and micrometeoroid density.

Except where otherwise noted, all launchings were from the Atlantic Missile Range, Cape Canaveral, Fla.

Major Satellite and Space Probe Experiments

...February 17 -- Vanguard II, a meteorological "Cloud Cover" satellite, was successfully launched into orbit. The 20.74-pound sphere contained photocells to produce images of the earth's cloud formations. Although the payload developed a precession (wobble) that scrambled the transmitted images, Vanguard II proved the feasibility of the weather satellite concept.

...March 3 -- Pioneer IV, a conical instrument package of goldwashed fiberglass, was successfully launched by a Juno II rocket. Pioneer IV achieved its primary mission, an earth-moon trajectory, yielded excellent radiation data, and provided valuable tracking experience. It is now orbiting the sun.

The 13.40-pound probe passed within 37,300 miles of the moon on March 4, 1959. It reached its perihelion (nearest point to the sun) -- 91,700,000 miles -- on March 17, 1959, and its aphelion (farthest point from the sun) -- 106,100,000 miles -- on October 1, 1959.

The probe was tracked for a total of 82 hours and four minutes to 407,000 miles, the greatest distance a man-made object had been tracked up to that time.

...April 13 -- An attempt to launch a Vanguard satellite, containing a magnetometer experiment and an inflatable sphere, failed when the second stage did not operate properly.

...June 22 -- An attempt to launch a Vanguard satellite, containing a heat-balance experiment, failed because of a faulty second-stage pressure valve.

...July 16 -- The range safety officer destroyed a Juno II rocket, bearing an Explorer satellite, after 5½ seconds when it tilted sharply because of a power supply failure to the guidance system. The satellite contained a radiation balance and Lyman-Alpha X-ray experiments.

...August 7 -- Explorer VI -- the "paddlewheel satellite," so-called because of its four vanes or paddles studded with solar cells -- was launched into orbit by a Juno II rocket. Explorer VI contained 14 scientific experiments and was the most advanced U.S. experiment to date. It reported a new region of high-energy protons in the Great Radiation Region, and enough new measurements to show considerable variations in radiation intensity and distribution. Equipped with a photocell scanner also, Explorer VI transmitted a crude picture of the earth's cloud cover from a distance of 20,000 miles.

...August 14 -- An attempt to launch an inflatable satellite of micro-thin Mylar plastic film and aluminum foil with a modified Juno II failed because of premature fuel depletion in the booster and a malfunction in the attitude control system for the upper stages.

...September 18 -- Injection of Vanguard III into planned orbit marked the end of the Nation's first scientific earth satellite program. Although the launching phase of Project Vanguard has been completed, the personnel, techniques, and hardware developed during the program are continuing to contribute substantially to the U.S. space effort.

Vanguard III, weighing 50 pounds, consists of a magnesium sphere 20 inches in diameter with a 26-inch tapered tube attached. The payload includes twin ionization chambers (responding to radiation in the range between one and 10 angstroms) to measure solar X-rays. It has revealed valuable data which are being analyzed.

...October 13 -- Explorer VII, a 91.5-pound satellite containing radiation balance, Lyman-Alpha X-ray and heavy primary X-ray experiments, was successfully launched by a Juno II rocket. The satellite went into predicted orbit, all equipment working as programmed. It has revealed valuable data about trapped radiation and cosmic radiation near the earth, indicating a possible correlation with solar events and geomagnetic storms.

...November 26 -- An attempt to launch a Pioneer lunar probe with an Atlas-Able 4 rocket failed when, about 45 seconds after launching, the plastic shroud covering the probe fell off. With the shroud gone, the payload was torn off and, at 104 seconds, all telemetry was lost.

Other Experiments during 1959

During the year, NASA carried out numerous sub-orbital experiments with sounding rockets, sodium flares, inflatable spheres, and scientific and biomedical instrument packages.

On March 3 and June 4, six-stage rockets were fired from Wallops Station, Va., to study the effects of extremely high temperatures on a vehicle reentering the earth's atmosphere. Three stages are employed on the upward leg and three on the downward leg of the trajectory. The vehicle reaches a maximum speed of 16,000 mph on the downward leg. The first shot malfunctioned; in the second, all stages fired as programmed. On December 22, a 48-foot, four-stage Javelin sounding rocket was fired from Wallops, carrying a joint U.S.-Canadian experiment to measure the intensity of galactic radio noise. Another purpose of the experiment was to test operation of the X-248 rocket engine (to be used in the Delta vehicle) in the space environment.

U.S. Satellites, Lunar Probes, and Space Probes, 1959

Name	Lifetime	Dimensions	Shape	Weight (lbs.)	Type	Altitude	
						Perigee (miles)	Apogee (miles)
Vanguard II	Feb. 17, 1959 (10 or more years)	20 inches in diameter	Spherical	20.74	Satellite	347	2,064
Pioneer IV	Mar. 3, 1959 (Lifetime unknown)	20 inches long; 9 inches in diameter	Conical	13.40	Planetoid in solar orbit	91.7* million	106.1** million
Discoverer I	Feb. 28 - Mar. 5, 1959	19.2 feet long; 5 feet in diameter	Cylindrical	1,300	Satellite	99	605
Discoverer II	Apr. 13-26, 1959	Do	Do	1,610	Do	142	220
Vanguards 3A and 3B	Apr. 13, 1959 (0)	Vanguard 3A: 13-inch diameter sphere topped by a 17⅛ x 2⅛ inch cylinder; Vanguard 3B: 30-inch diameter inflatable sphere	See dimensions	23.3	Do	0	0
Discoverer III	June 3, 1959 (0)	19.2 feet long; 5 feet in diameter	Cylindrical	1,600	Do	0	0
Vanguard	June 22, 1959 (0)	20 inches in diameter	Spherical	22.5	Do	0	0
Discoverer IV	June 25, 1959 (0)	19.2 feet long; 5 feet in diameter	Cylindrical	1,700	Do	0	0
Explorer	July 16, 1959 (0)	28 inches long; 30 inches in diameter	Bi-conical	91.5	Do	0	0
Explorer VI	Aug. 7, 1959 (Over 1 year)	39 inches in diameter and 55 inches deep	Spherical with flattened bottom and four solar vanes	142	Do	156	26,357
Discoverer V	Aug. 13, 1959 - Sept. 16, 1959	19.2 feet long; 5 feet in diameter	Cylindrical	1,700	Do	136	450
Beacon	Aug. 14, 1959 (0)	12 feet in diameter when inflated	Spherical	10	Do	0	0
Discoverer VI	Aug. 19, 1959 - Sept. 16, 1959	19.2 feet long; 5 feet in diameter	Cylindrical	1,700	Do	139	537
Transit I	Sept. 17, 1959 (0)	36 inches in diameter	Spherical	265	Do	0	0
Vanguard III	Sept. 18, 1959 (30-40 years)	20-inch-diameter sphere from which 26-inch tapered tube extends	See dimensions	50	Do	319	2,329
Explorer VII	Oct. 13, 1959 (20 years)	30 inches in diameter; 30 inches long	Bi-conical	91.5	Do	342	680
Discoverer VII	Nov. 7- 26, 1959	19.2 feet long; 5 feet in diameter	Cylindrical	1,700	Do	104	550
Discoverer VIII	Nov. 20, 1959 (estimated at several months)	19.2 feet long; 5 feet in diameter	Cylindrical	1,700	Do	120	1,000
Pioneer	Nov. 26, 1959 (0)	39 inches in diameter; 55 inches deep	Spherical with flattened bottom and four solar vanes	372	Lunar probe	Unknown	

*Perihelion
**Aphelion

The Javelin rose to an altitude of 650 miles and went down in the Atlantic, 600 miles from Wallops Island. The 48-pound payload contained a 3-mc radio receiver which telemetered the galactic radio signals to the earth.

On October 28, NASA launched a test vehicle carrying a 100-foot-diameter inflatable sphere on a sub-orbital flight over the Atlantic Ocean.

The sphere -- Mylar plastic, coated with micro-thin vaporized aluminum -- reached an altitude of 250 miles and traveled 500 miles across the Atlantic Ocean. Weighing 130 pounds, the sphere provided a high degree of reflectivity to light and radio signals. It was seen from Maine to Florida and as far west as Ohio.

The sphere was launched by a two-stage test vehicle, producing an initial thrust of about 130,000 pounds. The first stage consisted of a cluster of three solid-fuel rockets. The second stage was a solid-fuel rocket developed under the Vanguard program. Similar 100-foot spheres will be used in a passive communications system in future experiments.

On May 28, an Army Jupiter launched a nose-cone package carrying two living passengers -- Able, a seven-pound rhesus monkey, and Baker, a one-pound South American squirrel monkey, both females. Among purposes of the mission were recovery of the nose-cone and obtaining physiological and psycho-physiological data on animals of primate level under the stresses of space flight. The nose-cone package also contained specimens of low-order life.

Medical portions of this cooperative, NASA-sponsored experiment were carried out by the Army Medical Service and the Army Ballistic Missile Agency, with the assistance of the U.S. Naval School of Aviation Medicine and the U.S. Air Force School of Aviation Medicine.

After a 15-minute flight at altitudes up to 300 miles, the nose cone and its payload were lowered by parachute -- as programmed -- into the South Atlantic, 40 miles north of Antigua, West Indies Federation, some 1,500 miles from the Florida launch site. Ninety-three minutes after liftoff, the nose cone was hoisted from the ocean by the crew of the U.S. Navy tug Kiowa.

NATIONAL LAUNCH VEHICLE PROGRAM

Goals: Greater Simplicity, Reliability, and Payload Capabilities

Emphasizing maximum practicable simplicity, greater payload capabilities, and increased reliability, the National Launch Vehicle Program made significant gains during 1959. Vega, a two- and three-stage vehicle, was cancelled on December 11.

A modified version of the Agena, the highly successful second stage used in the Air Force Discoverer program, has been substituted for Vega. The Atlas-Agena will be ready about the same time that the Vega would have been ready.

The vehicle program consists primarily of Scout and Delta, "workhorse" vehicles for launching small-to-medium payloads in the near future; Atlas-Agena; Centaur, a general-purpose vehicle for later and more advanced experiments; Saturn, a cluster of boosters designed to deliver 1.5-million pounds of thrust; and the F-1, a 1.5-million-pound-thrust, single-chamber rocket engine.

Scout is a four-stage, solid-rocket vehicle that will be capable of launching payloads of about 200 pounds in circular west-east orbits at altitudes of 300 miles, and of launching probes with 100-pound payloads to altitudes of 6,000 miles. Because of its relatively simple components, launching, and handling requirements, it does not need an elaborate launching complex, but can be fired from a number of sites, including NASA's Wallops Station. Development and procurement contracts for Scout components were awarded early in 1959 and most of these have now been fabricated and are being tested.

Delta is a modified three-stage Thor-Able that will be capable of placing 100-300 pounds into circular orbits of 1,040 miles and into highly elliptical orbits (between 156 and 46,100 miles). It will also be able to reach the moon with a 65-pound payload. Delta will be used to launch the 100-foot sphere for communications experiments (Project Echo), a meteorology experiment (TIROS II), radiation and spectroscopy experiments, a deep space probe, and several atmospheric and ionospheric experiments. All major elements of the Delta are on schedule, with first launching to take place early in 1960; other firings will continue through 1962.

Centaur is a two-stage vehicle consisting of a modified Atlas booster and a second stage powered by the XLR-115, a two-barrel, turbopump-fed, rocket engine which may be fueled with high-energy liquid hydrogen. The engine, producing 30 percent more thrust than present engines using kerosene and liquid oxygen, was recently test-fired at full thrust. This powerful second stage will enable the Centaur to accomplish missions now requiring more stages, such as placing a communications satellite in an equatorial "fixed" orbit about 22,300 miles above the earth. The vehicle will also be employed for earth-satellite and lunar and planetary scientific missions. The first Centaur launching is scheduled for mid-1961.

Saturn is a clustered rocket intended to produce 1.5-million pounds of thrust, to lift a 30,000-pound satellite

into a 300-mile-high orbit, or land a 7,000-pound payload on the moon. This vehicle, still in the early design phase, will use the XLR-115 as one of its upper stages.

F-1 Engine, also in an early design phase, is an extremely powerful single-chamber engine, intended to produce 1.5-million pounds of thrust.

MANNED SPACE FLIGHT PROGRAM

Project Mercury

Goals -- One of the top-priority goals of the U.S. space program, this is the first phase of a continuing effort to demonstrate that manned space flights is feasible. Three-fold in purpose, Project Mercury is designed to place a man in orbit around the earth, to recover him, and to test human capabilities under the stresses of acceleration, weightlessness, deceleration, and landing. The Department of Defense is assisting NASA in several areas, including capsule launching and recovery and biomedical studies.

Astronauts Selected -- Much progress was made on the program during 1959. Seven Mercury astronauts, all volunteers and all highly trained, superbly fit military test pilots, were selected early in the year and have been intensively training ever since. Contracts for the capsule and related equipment were signed, and development is well under way.

Mercury Capsule -- The capsule, constructed by McDonnell Aircraft Corp., St. Louis, Mo., will have a nickel-cobalt outer shell and a titanium inner shell separated by insulation to protect its passenger from heat, cold, and noise. The astronaut, clad inaa pressure suit, will recline on a specially fitted couch that will absorb much of the stress of launching and reentry accelerations. The capsule will be fitted with communications and navigation devices, equipment to provide oxygen and remove carbon dioxide, attitude control jets, an ablation heat shield to protect against severe reentry heating, three solid-fuel retrograde rockets to reduce the speed of the capsule in orbit, and main and emergency parachutes for landing.

At launch, the capsule will be topped by a pylon-like arrangement containing an escape system. If the booster malfunctions at any time from pad to staging, and escape rocket can be triggered to carry the capsule away from the booster. Parachute release and recovery will then take place.

Tests of Capsule and Components -- Tests have been made of the escape system, the parachutes, and the aerodynamic qualities of the capsule. One of the important tests was a launch termed "Big Joe," held on September 9, when an Atlas booster lifted a full-scale instrumented boilerplate model of the capsule to near-orbital speed and to an altitude of

about 100 miles. The purpose was to test reentry capabilities; chiefly, performance of the heat shield, flight characteristics of the capsule and its instruments, and capsule recovery. The capsule was picked up by a Navy destroyer in the Atlantic Ocean north of Puerto Rico. The test was successful, even though the capsule's flight deviated from the planned trajectory.

"Little Joe" is the name given to a fin-stabilized, clustered, eight-rocket booster made up of four solid-fuel Sergeant and four solid-fuel Recruit engines. The system was designed to test boilerplate models of the Mercury capsule in ballistic flight.

Little Joe is capable of boosting a full-scale capsule to a distance of nearly 130 miles at speeds up to 4,000 mph. Little Joe has 250,000-pound-thrust capability at liftoff. The system provides an economical means of testing the capsule escape system over a wide range of dynamic pressures.

A successful test of the Little Joe launching system was carried out on October 4. Atop the booster was a boilerplate capsule model with an escape rocket system. Neither the capsule nor the escape system was instrumented for this launch.

The next Little Joe booster launching took place on November 4, at Wallops Station. In a successful test of the escape system, the booster-capsule combination and operation of recovery parachutes, the Mercury capsule model was fired to an altitude of 35,000 feet and to a distance of five miles.

The escape rocket was actuated 30 seconds after launch, carrying the capsule several thousand feet away from the booster. After a 20-second coasting period, the escape tower was jettisoned; 10 seconds thereafter, the drogue parachute was deployed. Three minutes after liftoff, at an altitude of 10,000 feet, the main parachute deployed and eased the one-ton capsule into the Atlantic Ocean.

The Navy salvage ship Preserver recovered the capsule 45 minutes after launch.

On December 4, a seven-pound rhesus monkey survived a 55-mile flight into space in a third successful test of the Little Joe emergency escape mechanism.

Attached to the outside of the container was a package of biological specimens including barley seeds, molds, and tissue cultures to provide data on radiation and weightlessness in space flight.

At 100,000 feet the emergency escape rocket was fired, carrying the capsule away from the booster; the capsule

coasted to an altitude of 150,000 feet where the escape tower was jettisoned. The capsule continued to coast to an altitude of 55 miles, some 20 miles short of the original test objective. Recovery was successful.

Mercury Tracking and Communications Network -- Project Mercury tracking and ground-instrumentation stations will provide complete radio tracking, communications (including voice), and data acquisition during launching, flight, and recovery of the Mercury capsule. The Project Mercury network will comprise 16 stations (some of them existing military facilities) located between latitudes 35° North and 35° South in the path of the manned capsule. NASA's Space Task Group will manage the network. Langley Research Center, Hampton, Va., is responsible for establishing the tracking network and monitoring contracts. Western Electric Co., Inc., New York, N. Y., has been selected as the prime contractor to equip and manage construction of the NASA stations in the network. For most ground communications, existing military links and commercial facilities will be utilized.

Astronaut Engineering and Training Activities -- On April 27, the astronauts reported for full-time duty with the NASA Space Task Group at Langley Research Center. Each is specializing in and contributing to a different aspect of the project -- communications and navigation, control systems, cockpit layout, life-support system, tracking and recovery, Redstone booster, or Atlas booster. Each man is responsible for assuring, within his particular area, that the Mercury system is suitable for manned operation.

In addition to their specialty assignments, the pilots as a group attend lectures on rocket propulsion, space mechanics, gyroscope theory, stable platforms, space navigation, communications, meteorology, astronomy, and physics of the upper atmosphere. They also receive status briefings from the NASA Mercury Project engineers and visit the various contractor and service facilities. Individually, the pilots visit the sub-contractors within their own specialty areas. During these visits, they are briefed on the Mercury systems and on advanced programs that are under study and development.

Pressure Suit Selected -- A modified U.S. Navy Mark IV pressure suit was selected on July 24 as the closest approach to the type of life-support garment which the astronauts will need in suborbital and orbital flights. NASA scientists are conducting developmental work on the suit, which is made by B. F. Goodrich Co., Akron, Ohio. Factors in the decision were comfort, mobility, compactness, reliability, impermeability, resistance to temperature, pressure, ease of donning and removing, and noise reduction. The suit will serve as a back-up safety feature; it will automatically inflate should the capsule pressure system fail. A coating of silver spray will act as an additional heat buffer and radiation shield.

X-15 Research Airplane

X-15 program objectives are to determine intensity and effect of aerodynamic heating on aircraft materials, to obtain stability and control data regarding aircraft performance in the upper atmosphere, and to observe effects of weightlessness on the pilot. The Air Force and Navy provide contract funds for the X-15 program while NASA provides technical direction.

During 1959, the X-15 was still under test by the contractor, North American Aviation, Inc., Los Angeles, Calif. The airplane is designed to reach altitudes of 250,000 feet or more and a 4,500 mph speed. It is launched from a B-52 "mother" plane. Tests were conducted at Edwards Air Force Base, Calif.

The X-15 made its first captive flight on March 10 and on June 8 successfully completed a glide flight from an altitude of 38,000 feet and at a speed of Mach 0.8. On September 17, the X-15 reached a speed of Mach 2 and altitude of 50,000 feet on its first powered free flight.

SPACE SCIENCES PROGRAM

Research in the NASA Space Sciences Program is devoted to learning more about the fields of geophysics and astrophysics, making use of the data-gathering capabilities of such space research tools as satellites, space probes, and sounding rockets. Principal areas of research are: 1) atmospheres -- including daily, geographical, and seasonal variations in composition and behavior; 2) ionospheres -- study of the origin of electrically charged (ionized) particles of air beginning about 35 miles above the surface of the earth, to learn their origin and how they vary with altitude, time of day, and latitude; 3) energetic particles -- including those forming the Great Radiation Region* surrounding the earth, cosmic rays, and the particles involved in the aurora borealis and aurora australis; 4) electric and magnetic fields -- the strength and direction of the earth's magnetic fields and its changes, some slow and gradual over periods of several years, others very abrupt, lasting for hours or days; 5) gravity fields -- obtaining precise geodetic data over a long period of time; 6) astronomy -- including gamma ray astronomy, relativity investigations, orbiting astronomical observatories, radio astronomy, solar probes, and a solar observatory; and 7) lunar science -- including a variety of planned missions to the moon, such as probes and satellites, instrumented "hard" and "soft" landings, instrumented circumnavigations with return to earth, and eventually, manned versions of these missions.

* Belts of high-energy, charged particles, trapped in the earth's magnetic field, first reported by James A. Van Allen, of the State University of Iowa.

Perhaps the most important discovery in the space sciences field during 1959 was that the structure of the Great Radiation Region is more complex than was previously supposed. A new region of high-energy protons was reported by Explorer VI, the "paddlewheel" satellite, and enough new measurements were obtained to show considerable variations in intensity and geographical distribution of the radiation. The new proton layer is about 310 miles thick, (centered at an altitude of about 1,250 miles) and extends for about 20 degrees on either side of the geomagnetic equator.

It now appears that the Great Radiation Region may be an extensive area of energetic particles, rather than the two rather distinct "doughnuts" or bands indicated by earlier experiments. A possible hazard to astronauts will be pockets of radiation that fade in and out, probably as a result of solar disturbances; the entire region varies considerably in intensity of radiation and geographical distribution over relatively short periods of time.

SATELLITE APPLICATIONS*

The goal of the satellite applications program is to apply space research to practical, beneficial uses. As the program advances, it is expected to improve weather forecasting, make navigation for air and sea travel more exact and timely, and provide worldwide television and telephone services.

Meteorological Satellite Program

NASA has established this program to determine the effectiveness of weather satellites in observing and reporting to ground stations worldwide weather patterns as they generate and develop. Execution of the program is the responsibility of Goddard Space Flight Center. Payload development and fabrication is carried out by contractors. Military participation and coordination are through the Joint Meteorological Satellite Advisory Committee, having representation from the three military services, ARPA, Weather Bureau, and NASA. Substantial research by the Weather Bureau for utilizing satellite data is being supported by NASA.

On April 13, 1959, the meteorological satellite, Project TIROS, initiated by DOD, was transferred to NASA. The first TIROS experiment will carry two television-type cameras to take clearer, more comprehensive pictures than could the

* For current progress in these fields, see Operational Missions.

photographic devices in Vanguard II and Explorer VI. A later version of TIROS (TIROS II) will include both scanning and non-scanning infrared detectors to report detailed radiation information and gross radiation picture.

Geodetic Satellite Program

In this program, NASA will develop specialized geodetic satellites, and conduct extensive ground observations and analyses leading to use of these satellites as precise tools for mapping, geodetic, and other geophysical investigations.

A preliminary design for a geodetic satellite has been prepared: a sphere 36 inches in diameter, weighing about 150 pounds, the satellite will be equipped with a very intense flashing light system. By photographing the light flashes against the stellar background, it will be possible to determine the satellite's position within about 50 to 100 feet, at an altitude of 1,000 miles. Three separate techniques may be used with a satellite of this type to obtain geodetic data: 1) observing the flashing light simultaneously from a number of ground stations; 2) using the satellite orbit as an interpolation device to connect non-simultaneous observations from ground stations; 3) using purely dynamical methods, based on analysis of the perturbations (disturbances) of the orbit.

Communications Satellites

To test the feasibility of passive reflecting satellites as global teleradio-transmission links, NASA has set up Project Echo, managed by the Goddard Space Flight Center.

On October 28, NASA launched a 100-foot diameter inflatable sphere of the type to be used in Project Echo. Purpose of the experiment was to test ejection and inflation mechanisms. Results of the test were satisfactory. The big sphere, made of micro-thin aluminized Mylar plastic, rose to an altitude of 250 miles. It was visible throughout most of the Eastern Seaboard.

Later one of these spheres will be launched by a Delta vehicle and placed in orbit at an altitude of about 900 miles. On entering orbit, the container will separate from the third stage and open, and the sphere will inflate.

Plans call for communications to be established via the satellite between the Jet Propulsion Laboratory's facility at Goldstone, Calif., and the Bell Telephone Laboratories at Holmdel, N.J. The Naval Research Laboratory will participate in the experiment. The Project Echo satellite will also afford industrial and private scientific research organizations the opportunity to conduct communications and related experiments of their own.

SOUNDING ROCKETS

Two Prototypes Being Developed

NASA space science investigations require a family of sounding rockets to carry scientific payloads of numerous types to different altitudes. Prototype rockets of a projected series are "Arcon" and "Iris." Initially, they were projects of the Naval Research Laboratory (NRL) and the Navy Bureau of Ordnance. Transfer from the Navy to NASA was arranged in January 1959, after a transfer of personnel working on them. The program is directed by NASA's Goddard Space Flight Center.

Arcon

The Arcon solid-fuel rocket, six inches in diameter and eight and one half feet long, is topped by a 40-pound instrumented payload. Over-all weight of the vehicle with payload is 254 pounds. Arcon is designed to lift its payload to an altitude of 70 miles. NASA has improved rocket chamber insulation and fuel-charge design, and is planning further development to increase power.

Iris

The Iris, solid-fuel rocket, one foot in diameter and 13 feet long, is designed to lift its 100-pound payload to an altitude of 185 miles. Over-all weight of the vehicle with payload is 1,290 pounds. Tower-launched, Iris will be given extra initial thrust by a small clustered booster. Aims of current NASA work are to increase engine reliability and to improve the fuel charge. Engine ground tests are scheduled for early 1960 and actual flights are planned for spring at Wallops Island.

INTERNATIONAL COOPERATION

Tracking Network Negotiations

NASA and the Department of State began discussions with other governments toward acquiring sites for eight Project Mercury tracking stations abroad. Preliminary site surveys have been made.

Space Research Arrangements

Discussions with the United Kingdom regarding cooperative space research programs are in an advanced stage. It is expected that the United Kingdom will provide several instrumented satellites for launching by U.S. vehicles. This country may furnish some two or three vehicles for the cooperative program which will probably extend over two to three years. Selection of scientific experiments will be subject to joint agreement. No exchange of funds is involved.

Other negotiations with the Canadian Defence Research Board have resulted in arrangements for a satellite project for "top-side" sounding of the ionosphere. Thus far, ionosphere sounding has been conducted from the ground; this would be the first instance of sounding from above. Laboratories in the participating countries will develop suitable instrumentation for the experiment by joint agreement. Again, no exchange of funds is planned.

In addition, NASA recently initiated several small grants or contracts for tracking and data analysis services in the United Kingdom, West Germany, and Japan.

Several grants were made to foreign scientists under a NASA-sponsored, post-doctoral Resident Research Associates Program administered by the National Academy of Sciences. These are for basic space-connected research in the United States and afford recipients opportunities to take part in NASA's scientific programs.

In September, Dr. Hugh L. Dryden, the Deputy Administrator of NASA, participated in discussions with various scientists and officials of the European scientific community. The purpose was to inform NASA of space-connected interests and activities in those countries and to indicate NASA's willingness to discuss possibilities of cooperative space research programs.

NASA is supporting preparations for the First Annual Space Science Symposium, sponsored by COSPAR, scheduled to be held in France in January 1960. Its purpose is to present and discuss scientific results obtained by rockets, satellites, and space probes during and after the International Geophysical Year.

On December 7, the NASA Administrator made clear America's willingness for international cooperation in space activities by offering the services of the United States worldwide tracking network in support of any Soviet manned space flight program. The NASA Administrator also announced that the United States would launch three inflatable spheres into orbit during 1960 in communications satellite experiments and invited world scientists to participate in the experiments. The first of these spheres is scheduled to be sent aloft from Cape Canaveral in late spring, 1960. The purpose of this very early announcement was to afford scientists of other nations an opportunity to set up equipment to take advantage of the experiment.

NASA officials took part in meetings of the International Telecommunications Union in order to cooperate in assignment of satellite and space-probe tracking frequencies and other telecommunication matters. They also were active in meetings of the NATO Science Committee.

TRACKING AND DATA SYSTEMS

During 1959, the Minitrack system, established for the International Geophysical Year (IGY), was being expanded to high-latitude coverage; a network of deep space stations was begun; and preparations for the Mercury network were inaugurated. Each of these spacecraft tracking stations has a specific function. Minitrack can track earth satellites. Mercury will be used for maintaining communication with the Mercury capsule and its astronaut-pilot. The deep space network will track vehicles traveling into the far reaches of space. All networks have stations located both in this country and abroad. Site surveys were made, some construction began, and diplomatic arrangements for sites were under way during the year.

A new tracking frequency of 135-136 mc was assigned nationally to the Minitrack stations to replace the 108 mc tracking frequency assigned for IGY.

The Goldstone, Calif., receiver -- currently, the only deep space station -- is being enlarged to send as well as to receive signals. All deep space stations will have both receiving and transmitting capabilities.

In addition to these tracking systems, NASA has use of the Baker-Nunn Optical Tracking Network which is under the technical direction of the Smithsonian Astrophysical Observatory. No new Baker-Nunn stations were established or contemplated during 1959.

ADVANCED RESEARCH PRIMARILY IN SUPPORT OF SPACE ACTIVITIES

Propulsion

To the forefront of space exploration requirements is propulsion, an area in which NASA is conducting a comprehensive program of research and development. Future space propulsion systems under NASA study include chemical, nuclear, and electrical systems. Nuclear systems -- as visualized at present -- and chemical systems are capable of generating enormous power. These systems can lift heavy payloads from the earth but are exhausted in a short time.

Electrical Engines -- Electrical rockets are incapable of lifting heavy payloads from the ground into orbital velocity. Yet rockets of this type have potentially long lives and -- in current theory -- are capable of sustaining the movement of a vehicle that is already moving at high velocity through space. Other uses of electric rockets are for attitude orientation or stabilization, for position control or orbital correction of satellites, and as vernier rockets to control the velocities and trajectories of lunar or interplanetary vehicles. Electricity to power spacecraft equipment and instrumentation may be generated by nuclear systems. (See Chapter 3, U. S. Atomic Energy Commission.)

NASA is investigating three electrical engines: an ion rocket in which ions rush rearward toward an electrostatic field; a plasma rocket in which electromagnetic fields propel a mixture of ions and electrons rearward; and an electro-thermal rocket in which electrically-heated gas is ejected rearward. Two experimental ion engines have been operated for a total of 70 hours at the NASA Lewis Research Center, Cleveland, Ohio, without component failure. The Center has procured five vacuum tanks in which conditions approaching those in space can be simulated in order to conduct research on electric rockets.

F-1, 1.5-Million-Pound-Thrust Single-Chamber Engine -- The F-1 has been under development at the Rocketdyne Division, North American Aviation, Inc., since January 1959. This

single engine will develop as much power as the eight-engine cluster known as Saturn. Because the engine is so large, suitable test facilities and measurement facilities are a problem. This problem has been emphasized both by the lack of adequate test stands at Edwards Air Force Base and suitable measuring facilities at the National Bureau of Standards in Washington. These problems are in process of solution.

The need for propellants in great quantity is being solved partially by the construction of a new oxygen-generating plant in the vicinity of Edwards Air Force Base.

A thrust chamber has been modified so that the engine can start reliably, and operate under relatively limited conditions. Other components are still in the design and fabrication stages.

Advanced Liquid Rockets -- NASA is seeking to learn more about using such high-energy propellants as hydrogen (with oxygen or fluorine as the oxidant) in space vehicles. It is also studying combustion, pumping, cooling, and other factors involved in increased rocket performance. As a combination of liquid fluorine and liquid hydrogen shows promise of high performance among chemical systems, exhaustive work is centered in this area. Separate thrust-chamber and turbopump tests have demonstrated that a pump-fed, hydrogen-fluorine engine should be feasible at the present stage of technology.

Liquid Hydrogen-Oxygen Rocket Engine -- An exceptionally high-powered engine being studied is fueled by liquid hydrogen and oxygen in combination. Successful test runs of this engine at full power have been made by the Pratt & Whitney Division of United Aircraft Corporation. Known as the XLR-115, the engine has 30 percent greater thrust than present engines using kerosene and liquid oxygen. Research is also in progress on individual components of hydrogen-oxygen vehicle systems (lines, valves, controls, etc.). Program aims are to obtain basic answers to flow-system and other problems of interest in the Centaur project, which involves utilization of the XLR-115 engine. Two methods have proved successful in igniting hydrogen-oxygen engines: electric spark plugs and spontaneously combustible chemicals.

Solid-Propellant Rocket Engines -- Solid-propellant rockets have advantages of reliability, simplicity, and economy. In addition, they have the potential for very high percentage of propellant to over-all rocket weight, and for developing exceptional thrusts (one million pounds or more). Present disadvantages are poor thrust-level control

during burning and poor thrust-direction and cut-off qualities. NASA has awarded research and development contracts to several companies for improved solid-propellant motors.

Thrust cut-off is a standard feature of many solid-propellant rocket motors, but control of thrust level and re-start is largely unexplored. Acoustica Associates, Inc., Plainview, N.Y., has a NASA contract to determine if the thrust level of a solid rocket can be controlled satisfactorily by sound waves (acoustical energy). Experience has shown that the combustion rate in solid rockets can be radically affected by energy waves generated in the combustion chamber. If research is successful, a variable sonic energy generator -- a whistle or siren of special design -- will be emplaced in the solid rocket chamber to control burning rates.

NASA is also conducting research aimed at developing superior high-impulse solid fuels for space flight. A radically different fuel system being developed under contract by the Callery Chemical Company, Callery, Pa., has been shown to be feasible. Most details of this work are classified.

Auxiliary Power Units

Space vehicles must have a self-contained power supply for radios, research instruments, environmental control systems, and the like. To meet weights, packaging, and life requirements, such a source must be efficient, long-lasting, light, and compact.

Present-day electrochemical and solar batteries are too bulky and heavy for space requirements. Therefore, research on improved power sources must be continued. Nuclear power sources (described in Chapter 3, United States Atomic Energy Commission) appear most practicable for very high systems demands.

Another type of power unit being considered is called a "solar collector." This is a device -- folded before launch -- which opens like an umbrella once the vehicle is in orbit. This collector -- 300 square feet in area -- will capture solar radiation to be converted into electric power by thermal or direct processes. NASA has requested proposals for a 3-kw collector (called Sunflower-I).

ADVANCED RESEARCH PRIMARILY IN SUPPORT OF AERONAUTICS ACTIVITIES

Typical Advanced Aeronautics Research

Research to make aircraft faster, safer, and more efficient continued to be an important NASA activity during 1959. Most research went forward at Langley Research Center, Hampton; Va., Lewis Research Center, Cleveland, Ohio; and Ames Research Center, Moffett Field, Calif. Even in this, the Space Age, conventional aircraft powered by air-breathing engines and operating solely within the atmosphere continue to be the chief means of rapid passenger and cargo transport.

Langley and Ames are studying a wide variety of Vertical Take-off and Landing (VTOL) and Short Take-off and Landing (STOL) aircraft, including helicopters and ground-cushion machines, the latter being unique new vehicles capable of hovering a few feet above ground or water, supported by the lift of a jet of air directed downward.

During the year, experimental studies were made to develop improved designs for airplanes that cruise at supersonic speeds (2 to 4 times the speed of sound). Progress was made in reducing aerodynamic skin-friction drag, and a method was evolved that gives promise of reducing the extremely high temperatures generated on the surfaces of the aircraft by this friction. Incorporating these advances into practical plane designs would improve performance in military aircraft, as well as help bring in an era of supersonic transports.

Research on air-breathing engines at Lewis and Ames was primarily devoted to problems of supersonic inlets for turbojets and ramjets.

Prime attention was also being given to ways of insuring the safety of high-performance aircraft and their crews; special flying techniques have been developed for landing these aircraft with and without power. Also in the field of flight safety, NASA is carrying on a long-range cooperative effort with major airlines of the United States and with some foreign operators. Instruments have been installed that record the accelerations, airspeeds, and altitudes of airplanes during entire flights from take-off to landing. Records are returned to Langley for evaluation and analysis; information already passed on to the airlines and manufacturers has brought about corrections that will aid in maintaining and improving flight safety records.

NASA ORGANIZATIONAL CHANGES

Saturn Transferred

On October 21, the President announced his intention to transfer the Development Operations Division, Army Ballistic Missile Agency, Huntsville, Ala., to NASA, subject to the approval of Congress.

The action is being accompanied by transfer of responsibility for Project Saturn, the 1.5-million-pound-thrust engine cluster, which will be capable of placing a 30,000-pound payload into a 300-mile earth orbit or landing 7,000 pounds on the moon. Also to be transferred are 4,300 employees of the Division, 815 supporting personnel, and 1,200 acres of the Arsenal.

The transfer of the Development Operations Division and the Saturn Project concentrates within NASA responsibility for development of all high-thrust boosters, civilian or military.

Pending formal transfer, NASA was assigned technical direction of Saturn under a memorandum of understanding endorsed by NASA and the Department of Defense on November 18. As part of this understanding, a Saturn Committee made up of representatives of NASA, ARPA, ABMA, and the Air Force was established. Under the agreement, the Director, Defense Research and Engineering, will provide a statement of military interest to NASA for guidance in technical direction.

The Saturn is being developed by a team of scientists and engineers under the direction of Dr. Wernher von Braun.

NASA Headquarters Reorganized

A NASA reorganization announced December 8 and effective January 1, 1960, divided space flight development responsibilities to place great emphasis on development of launching vehicles. An Office of Launch Vehicle Programs was established and given responsibility for development and launching of all space vehicles.

Major General Don R. Ostrander, U.S. Air Force, was appointed Director of Launch Vehicle Programs. General Ostrander has been detailed to NASA by the Air Force. He was Deputy Director of the Advanced Research Projects Agency, Department of Defense. The Development Operations Division and its Saturn project will be placed under General Ostrander's office as a field center of NASA.

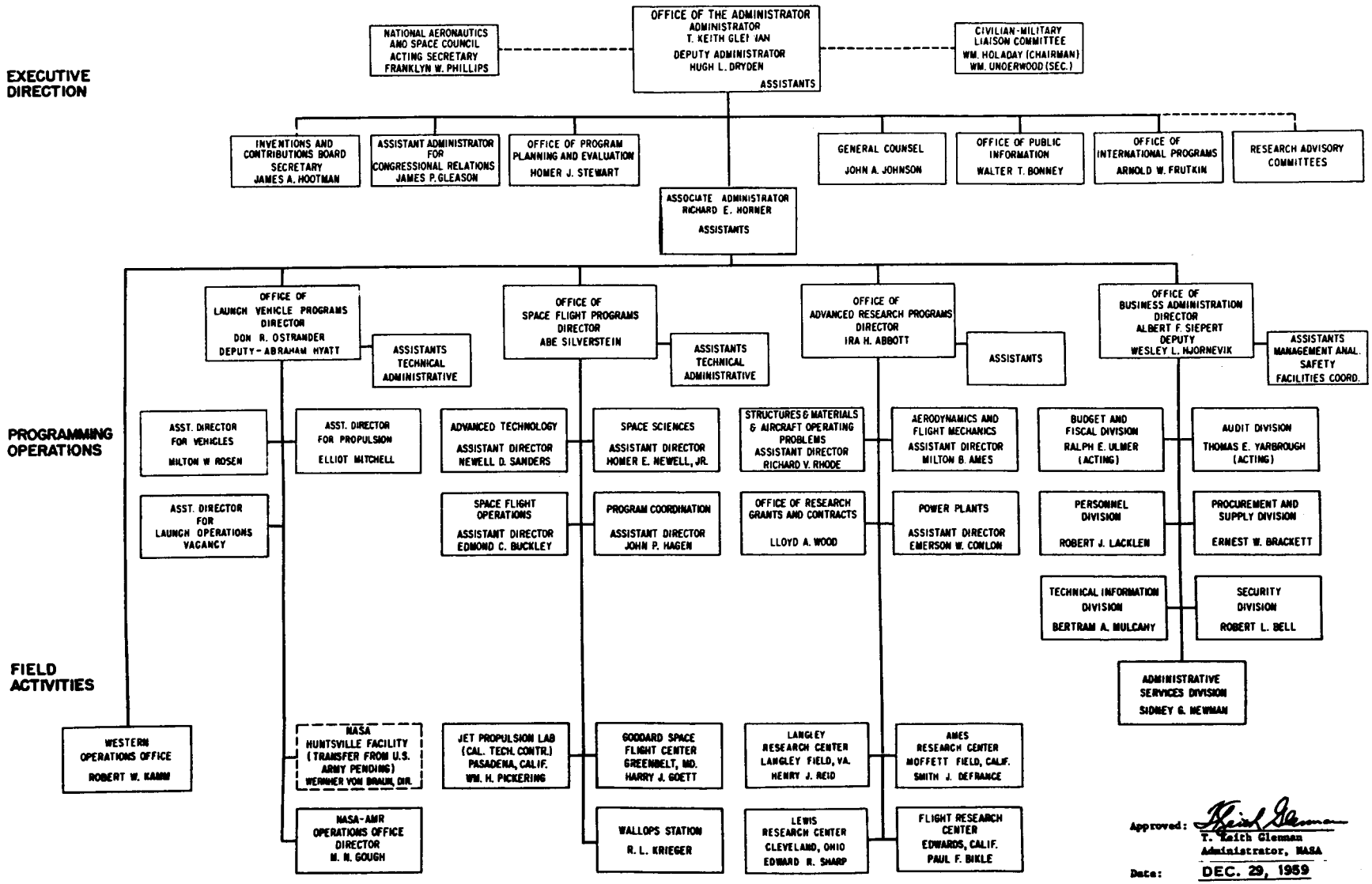
The former Office of Space Flight Development has been redesignated the Office of Space Flight Programs and is charged with mission planning, payload design and development, and in-flight research and operation. Abe Silverstein is Director of Space Flight Programs.

The Office of Advanced Research Programs (formerly the Office of Aeronautical and Space Research) will continue advanced research in aeronautics and space. Its director is Ira H. Abbott.

No change of name or function was made in the Office of Business Administration, which is directed by Albert F. Siepert.

The acquisition of the Development Operations Division has made it possible to begin centralizing at Huntsville major responsibility for the bulk of launch vehicle system development and operation. Establishment of the Office of Launch Vehicle Programs evidences the increased emphasis NASA attaches to developing and launching boosters for which estimated obligations for fiscal year 1961 are more than $250 million.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION



Approved: T. Keith Glennan
T. Keith Glennan
Administrator, NASA

Date: DEC. 29, 1959

DEPARTMENT OF DEFENSE

The primary space interest of the Department of Defense is in the application of the new capability for flight in space as a means toward achieving a more effective military posture for the United States and its allies, rather than space flight and exploration as ends in themselves. Therefore, the space efforts of the Department of Defense are an integral part of our over-all military program and will complement or supplement other military capabilities. Applications of space technology appear to provide foreseeably better means of achieving certain military requirements. Space technology is being developed with the intention of more effectively achieving certain military functions by complementing or extending non-space capabilities. In addition, as space technology and resulting uses of outer space expand, new military requirements and opportunities for development of new military capabilities are likely to materialize. Thus, the major objectives of the Department of Defense efforts are development, production and operation of systems where it can be demonstrated with reasonable certainty that the use of space flight will enhance the over-all defense program, or the development of components which would be needed in such systems which cannot be clearly defined at this time.

The military space projects conducted by the Department of Defense moved ahead at a rapid pace during 1959. Strides were made in all programs on payloads design and development, boosters, guidance, telemetry, instrumentation, tracking, and ground support activities. Nine launch attempts were made, with six successfully attaining orbit. A brief summary of each major program, with the exception of certain classified projects, follows:

MAJOR PROGRAMS

DISCOVERER

Particular emphasis was placed on the DISCOVERER Satellite Program which has as its objective the testing of components, propulsion and guidance systems and techniques to be utilized in various United States space projects. Foremost among the techniques being tested is the capsule recovery operation. Although no successful recovery has been effected to date, much has been learned concerning the many complex problems associated with the technique which is so vital to military space efforts. In the near future, biomedical specimens will be carried in the DISCOVERER satellite for the purpose of gaining more knowledge on the effects of space travel.

Eight of the nine military space launches made during 1959 were DISCOVERER vehicles. Six of these successfully attained orbit. The first DISCOVERER satellite successfully achieved orbit on February 28, 1959. Propulsion and guidance performance was satisfactory and test of capability for polar launch from the Pacific Missile Range was assured. DISCOVERERS II, V, VI, VII, and VIII also achieved orbit. However, due to malfunction of various recovery aids, the capsules ejected while in orbit were not recovered. Only one of the above DISCOVERER vehicles (DISCOVERER VIII) remains in orbit.

TRANSIT

One other military space project, the navigation satellite, TRANSIT, progressed to the point where a launch could be attempted in 1959. This program is designed to provide, through use of an instrumented satellite and modified doppler technique, a highly accurate global all-weather means of fixing precisely the position of ships and possibly aircraft.

On September 17, 1959, the launch of TRANSIT I, the first navigation satellite, was attempted at the Atlantic Missile Range. In spite of failure to achieve orbit due to malfunction of the THOR-ABLE third stage, sufficient data were attained from this shot and other study to date to give strong indication that this program will establish the correction factors for refraction of signals through the ionosphere, thus enhancing the entire art of satellite communications. The next launch in the TRANSIT series is scheduled for early 1960.

MIDAS

The Missile Defense Alarm System (MIDAS) project is aimed toward establishing a reliable, operational satellite-borne missile alarm capability. The MIDAS project will place in orbit payloads with infrared detection scanners capable of keeping watch over large areas of the upper atmosphere.

In 1959, the MIDAS project was reoriented to provide more research and development data and to achieve higher altitudes in earlier flight tests. The first infrared scanner has been tested successfully and has been mated with the first flight vehicle. Modification of the scanner is planned to increase the operational altitude capability of an early unit.

The first research and development flight is scheduled for early 1960.

ARGUS

The effects of nuclear explosions in the exosphere are being studied under Project ARGUS.

The current program of investigation includes theoretical studies to devise new kinds of laboratory and space experiments, utilizing means other than nuclear explosions. These will be examined for feasibility and coordination with the theoretical program to insure selection of experiments which yield the greatest return per dollar.

Tests have indicated that high altitude nuclear explosions can affect long distance communication systems. Further studies are in progress to determine the extent to which this phenomenon could affect military communications.

NOTUS

The objective of the communication satellite project (NOTUS) is the development of a communication system, utilizing satellites to provide long range radio communication links. This system is expected to relieve presently over-crowded trunking facilities and to improve reliability of global communication.

The goal of Project NOTUS is the development of instantaneous repeater satellites. These will lead to the development launching in 1962 of the so-called "fixed satellite." These devices will maintain a fixed position over a given point, revolving at the same speed as the Earth and will provide broad-band, point-to-point communication and ground-to-aircraft communication.

SHEPHERD

In February 1959, elements of the Active Minitrack fence became operational on a 24-hour basis. This system functions to detect, identify and predict orbits of non-radiating objects in space. The objective of this program is to obtain at the earliest practicable date a space surveillance tracking system capable of satisfying military and other requirements.

The first definite occurrence of passive detection took place on January 22, 1959, on Sputnik III, at the Forest City Station. Since that time, the satellites which have been repeatedly detected by this system include DISCOVERER, VANGUARD, and LUNIK vehicles.

In 1959, decision was reached to reorient the effort of this project toward improved second generation tracking systems. Plans were formulated for phasing out some aspects of the interim "fence" and for implementing the reoriented program. These plans include the closing down of some interim stations and increasing the operational capabilities of other stations.

LONGSIGHT

Project LONGSIGHT has as its objectives the finding and remedying of serious short and long term gaps in study and research relating to foreseen military needs in space technology.

In 1959 work was continued on a feasibility study dealing with a nuclear-pulse-propelled space vehicle concept (Project ORION). In contrast to earlier effort, the current effort is directed primarily to engineering feasibility studies.

Progress is also continuing on research and development projects in the areas of power sources and collection, power conversion, energy storage and heat rejection. Primary emphasis is on numerous approaches to conversion of solar and nuclear energy to electrical energy in the space environment.

In the space propulsion area of Project LONGSIGHT, progress is being realized in research projects dealing with electrical propulsion methods. These projects in propulsion complement related work sponsored by other agencies.

PROJECT TRANSFERS TO NASA

Certain projects were transferred from the Department of Defense to the National Aeronautics and Space Administration in 1959. The first of these was Project TIROS, the meteorological satellite designed to provide weather information on a global basis. This transfer became effective April 13, 1959. In view of the continued interest of the Department of Defense in the results attained by TIROS, a joint DOD-NASA advisory group has been formed.

On June 30, 1959, Project CENTAUR was transferred to the National Aeronautics and Space Administration. This project will provide a liquid-hydrogen-oxygen upper stage for placing heavy payloads -- military and civilian -- in space.

Plans were made in the last quarter of 1959 to transfer Project SATURN, the 1.5-million-pound-thrust engine cluster to the National Aeronautics and Space Administration. Pending Congressional approval of the transfer of that portion of the Army Ballistic Missile Agency developing SATURN, the National Aeronautics and Space Administation is exercising technical management and the Department of Defense administrative management. The SATURN static tower at the Army Ballistic Missile Agency is essentially complete and the launch complex at the Atlantic Missile Range has been designed and work initiated. Four of the eight engines for the first vehicle have been successfully hot-fired at the Army Ballistic Missile Agency.

VEHICLE DEVELOPMENT

The only satellite vehicle development project remaining in the Department of Defense at this time is the AGENA upper stage development. The AGENA is currently used as a satellite vehicle for DISCOVERER and certain other military programs. The AGENA is also planned to be used by NASA as a replacement for the VEGA upper stage development, which has recently been cancelled. It is probable that other upper stage developments will be required for Department of Defense application in the future but these requirements cannot be clearly defined at this time.

DYNA SOAR AEROSPACE DEVELOPMENT

DYNA SOAR is expected to consist of a manned, aerospace test vehicle which in its first tests will be boosted by a TITAN ICBM booster. These tests on the Atlantic Missile Range will first be unmanned and then manned, and will explore and solve the problems of flight at near orbital speeds. It will be able to make a controlled re-entry into the atmosphere and to make a normal landing.

The major effort during the past year was expended in studies, preliminary design and tests. Material and structural testing was accomplished. Samples of nose caps and wing leading edges were tested in wind tunnels to define temperature and heating rates, which will be encountered in actual flight. Results to date look very promising; however, careful evaluation is preceding developmental effort to insure an adequate technical approach.

The Department of Defense and NASA are cooperating in the DYNA SOAR development but it is funded and managed by the Department of Defense.

SPACE FLIGHT SUPPORTING RESOURCES

During Calendar Year 1959, nineteen (10 NASA and 9 DOD) space vehicles were launched from the National Missile Ranges. To a substantial extent these launchings were supported by existing facilities and equipment which were initially provided for missile requirements.

Procedures such as joint use of facilities are being actively implemented to obtain maximum effectiveness of space flight support resources.

CHAPTER 3

UNITED STATES ATOMIC ENERGY COMMISSION

Contributions of the Atomic Energy Commission (AEC) to the National Space Program center about Project ROVER and Project SNAP, two concepts for attaining nuclear rocket propulsion and nuclear-generated auxiliary electric power systems for spacecraft, respectively.

PROJECT ROVER

Reactor development in Project ROVER is under the technical direction of the Los Alamos Scientific Laboratory (LASL). The first objectives of the program are to: 1) develop test reactors to explore the problems involved in achieving high-power density; 2) develop reactor materials capable of withstanding high temperatures; and 3) investigate concepts for conversion of nuclear energy into useful propulsion forms.

During 1959, the first facilities at the Nevada Test Site were completed, and on July 1, the first test reactor (Kiwi-A) was tested to full power. Kiwi-A is a heat-exchanger device in which the propellant, heated in the reactor core, is expended to the atmosphere through a nozzle. The second reactor in this series is being fabricated, and construction of additional test facilities for subsequent experiments is being initiated.

PROJECT SNAP

The SNAP (Systems for Nuclear Auxiliary Power) program has been developing compact, lightweight nuclear-electric auxiliary power units for space vehicles. Two approaches have been followed: one, the development of radioisotope-powered units and, two, the development of small reactor powered units.

The radioisotope units are being developed by the Martin Co., Baltimore, Md. The reactor units are being developed by Atomics International, a Division of North American Aviation, Inc., Canoga Park, Calif.

Advanced Heat-to-Electricity Conversion Systems

In addition to developing compact sources of nuclear power, the SNAP Program also sponsors the development of advanced heat-to-electricity conversion systems capable of operating in the space environment. The SNAP Program has demonstrated a unique Rankine cycle, using mercury both as the working fluid and machinery lubricant, and utilizing solid-state thermoelectric elements and thermionic devices. Extensive work will be necessary to provide the long-term reliability essential to operation in space.

Companies participating in the energy conversion portion of the SNAP program are Thompson Ramo-Woolridge, Inc., Cleveland, Ohio; Minnesota Mining and Manufacturing Co., St. Paul, Minn.; Thermo-Electron Engine Corp., Cambridge, Mass.; United Electronics Co., Newark, N.J.; and Westinghouse Research Laboratories, Pittsburgh, Pa.

Thermoelectric Generators

The first complete SNAP 3 thermoelectric generator, delivered to the AEC by the Martin Company in January, weighed five pounds, had no moving parts, and produced 2.5 watts of electricity from 1495 curies of Polonium-210. SNAP 1A, a 125-watt extension of the SNAP 3 concept, is being developed as a ground-demonstration unit only. An electrically heated unit will be completed this year.

Nuclear Reactor Space Power Systems

The SNAP 2 space power system is based on a small Zirconium hydride moderated reactor, homogeneously fueled with 3 kg of U-235. The reactor weighs approximately 220 lbs. and produces 50 kw of reactor power at 1200°F outlet temperature. It was tested at design power and temperature on November 9. Development of advanced turboelectric machinery to convert reactor heat to electricity is proceeding at a rate to permit the first integrated reactor and power conversion system tests during the first or second quarter of FY 1961. The over-all weight of SNAP 2 is expected to be about 500 lbs., exclusive of shielding. A test facility is under construction at the AEC's site in Los Angeles County which will provide for testing the complete SNAP 2 unit. This facility is scheduled for completion early in FY 1961.

SNAP 8, a joint AEC-NASA program has been initiated this year. The reactor developed will be handled by the AEC as an extension of the SNAP 2 reactor concept. NASA is proceeding to negotiate a contract with industry to develop the

energy conversion equipment. This space power plant (producing 30-kw of useable power) is expected to include a reactor weighing approximately 250 lbs., and associated power conversion equipment for a total of approximately 900 lbs., exclusive of shielding.

Thermoelectric Generator Systems

SNAP 10, an AEC project to produce a completely static, reactor-powered, thermoelectric generator producing 300 watts of electricity, has been designed. Disc-shaped fuel elements of the SNAP-2 material are being manufactured. The construction of a thermoelectric generator is being negotiated with industry. A nuclear test is planned for the first quarter of FY 1961 in the new environmental test facility.

PLASMA-THERMOCOUPLE

A method of directly converting nuclear energy to electrical energy was demonstrated in April at the Los Alamos Scientific Laboratory. The experimental thermocouple device was composed of two "legs" -- one a cesium plasma (an electrically neutral gas of ions and electrons), and the other a high-temperature, enriched uranium fuel element. When the device was placed in the LASL Omega West research reactor, fission reaction in the uranium of the fuel element leg raised the uranium to a high temperature. The temperature difference between the uranium and the cesium (which was kept relatively cool) produced the Seebeck (thermocouple) effect, resulting in a short circuit current of 30 to 40 amperes and an open circuit voltage of about 3.8 volts.

While it is recognized that the work on this device is still in a very early phase, the experiment appeared to demonstrate a potentially valuable means of producing electric power for space vehicles and for possible use in small mobile nuclear power plants in remote areas.

In seeking the establishment internationally of a sound framework for the exploration and use of outer space, the United States has recognized two basic aspects of the opportunities and problems arising from outer space activities.

First, the United States has expressed its willingness to participate in a study of the possibility of assuring that outer space be used for peaceful purposes only. In this regard, the United States has said that if there is general agreement to proceed with such a study on a multilateral basis, this country would be prepared to join in examining the matter without awaiting the conclusion of negotiations in other substantive areas related to the reduction and control of armaments. During 1959, the United States reemphasized the importance it attaches to this aspect of outer space considerations.

Second, as Secretary of State Christian A. Herter stated in an address before the Fourteenth Session of the United Nations General Assembly, September 17, 1959: "Recognizing that progress in disarmament might be slow, however, the United States has urged that peaceful uses of outer space be considered as a separate step toward constructive change." During 1959 significant steps forward were taken in this area.

ACTIVITIES OF THE UNITED NATIONS GENERAL ASSEMBLY

In a statement of December 11, 1959, in the United Nations, Ambassador Lodge called attention to the fact that events in outer space during the past two years have challenged man's political as well as his technological inventiveness. Ambassador Lodge stated: "It is a prime task of governments and of the United Nations to see to it that political progress keeps pace with scientific change. Unless this is done, the world runs the serious risk of relying on political institutions and arrangements that are outmoded and inadequate."

With the objective of providing an informed basis for consideration of outer space matters by the United Nations, the United States participated in and strongly supported the work of the United Nations Ad Hoc Committee on the Peaceful Uses of Outer Space, which had been established by the General Assembly at its Thirteenth Session in 1958 and which met at United Nations Headquarters during May and June, 1959. The work of the Ad Hoc Committee represented the first international effort to survey comprehensively the opportunities and problems arising in connection with the peaceful exploration and use of outer space.

Although five members, including the Soviet Union, did not participate as a result of disagreement over membership, the Ad Hoc Committee completed its task in an objective manner, drawing on the assistance of scientific and legal experts from the thirteen participating countries. The Ad Hoc Committee's report has provided the General Assembly with a useful introduction to current activities of international bodies in the field of outer space, the area of international scientific cooperation which might appropriately be undertaken under the auspices of the United Nations, the nature of the legal problems which may arise from the exploration and use of outer space, and future organizational arrangements to facilitate international cooperation in this field within the framework of the United Nations.

With respect to the question of future United Nations organization, the Fourteenth Session of the General Assembly established on December 12, 1959, a new Committee on the Peaceful Uses of Outer Space to follow-up the exploratory work of the Ad Hoc Committee by studying practical and feasible means for giving effect to programs in the peaceful uses of outer space which could appropriately be undertaken under United Nations auspices, and by continuing the study of legal problems. An early task of the new committee will be to work out proposals with respect to convening a scientific conference for the exchange of experience in the peaceful uses of outer space. The United States has welcomed the opportunity to take part in such a conference.

The new committee consists of the following members, who will serve for the years 1960 and 1961: Albania, Argentina, Australia, Austria, Belgium, Brazil, Bulgaria, Canada, Czechoslovakia, France, Hungary, India, Iran, Italy, Japan, Lebanon, Mexico, Poland, Romania, Sweden, Union of Soviet Socialist Republics, United Arab Republic, United Kingdom, and United States.

Co-sponsorship by twelve countries of the resolution calling for establishment of the new committee and the unanimous

approval of the resolution by the General Assembly have laid the groundwork for an increasingly effective consideration of outer space problems by the United Nations. Furthermore, this successful outcome of the protracted negotiations between the United States and the Soviet Union respecting this matter represents a signal achievement from the point of view of the ability of the two countries to reach useful agreement in areas of major interest.

Success of organizational efforts in the United Nations was paralleled during 1959 by the agreement reached among members of the international scientific community on a charter for the Committee on Space Research (COSPAR) of the International Council of Scientific Unions. The charter provides for broadly based membership of interested national scientific institutions and interested international scientific unions. The United States has regarded as encouraging this development outside of governmental channels of the traditional methods of communication and cooperation among the world's scientists.

OTHER INTERNATIONAL ACTIVITIES

Discussion of outer space matters in the United Nations has emphasized the desirability of conducting the exploration and use of outer space in an orderly and open manner. These principles have been given practical effect by the United States in initial international consultation regarding specific regulatory problems, in the conduct of this country's outer space effort, and in the dissemination of scientific results of this effort.

Allocation of radio frequencies represents the first practical problem of a regulatory character which has arisen in the outer space field and constitutes an important element in the provision internationally of a basis for the orderly conduct of outer space activities. Meeting with over eighty other countries in the International Administrative Radio Conference of the International Telecommunication Union, which was held in Geneva, August through December, 1959, the United States called attention to the need for reserving radio frequencies for space communications and radio astronomical research. The Conference accorded some recognition to this problem and made minimal provision for frequencies for these services. However, the results of the Conference can be regarded as only a first step toward resolution of a problem which will become increasingly pressing in the future.

With respect to cooperation in the conduct of outer space activities, the United States has regarded the extension of its space vehicle tracking operations as essentially a cooperative effort of this country and the other countries involved. Where practical, provision is made for active participation by other countries both in the special tracking operations required in connection with specific scientific activities as well as in the case of the radio and optical tracking stations which comprise the basic tracking network. Major activities in this area during 1959 included negotiations to place on a more permanent basis many of the tracking stations established during the International Geophysical Year, to establish new stations for tracking deep space probes, and to establish the special tracking network required in support of Project Mercury. The number of countries with which arrangements have been made or are currently under discussion on the governmental or technical levels is approaching twenty.

Similarly, the United States has actively sought the cooperation of other countries in the planning and conduct of scientific space activities. Offers of cooperation have been extended to the international scientific community through the Committee on Space Research and to scientists of NATO countries through the NATO Science Committee in recognition of the fact that the common interests of NATO countries go beyond military matters. On a bilateral basis, the possibilities of scientific cooperation have been discussed with a number of countries which possess scientific and technical competence bearing on the conduct of outer space activities, but which are not themselves engaged in the launching of earth satellites or deep space probes.

Looking to the future, the United States played a leading role during 1959 in bringing to the attention of the World Meteorological Organization the operational as well as the research potentialities of meteorological satellites. The United States has thus recognized the interest of all nations in sharing the benefits which may ultimately result from service activities of this type.

NATIONAL SCIENCE FOUNDATION

One of the principal objectives of the National Science Foundation (NSF) is to support basic research of a pioneering nature in all areas of science. In the main, this is done through grants to non-profit institutions for the support of research projects proposed by staff scientists of the institutions involved. A few special grants and contracts have been let for the development of special instrumentation or facilities which are deemed particularly important for the advancement of research in particular fields. A substantial part of these efforts is devoted to the support of scientific investigations that seek an understanding of the fundamental laws of the physical universe.

BASIC SCIENCE PROGRAMS RELATED TO SPACE

NSF Encourages Work in Underemphasized but Important Areas

In the areas of space science, NSF activity consists primarily in supporting basic research which contributes to an understanding of the physical and biological processes occurring in the space environment.* An effort is made by NSF to give particular encouragement to needs of the fundamental sciences for scientific observations and experiments which can only be met by use of space vehicles such as satellites, space probes, high altitude rockets, etc. In specific cases, the Foundation provides support to study the character and feasibility of experimental equipment suitable for research in outer space, recognizing that research for space exploration as such, and provision of vehicles and their scheduling are essentially an NASA responsibility.

The more basic a research result, the wider is the area of its potential application. For this reason, it is difficult to set down exact criteria for determining whether a particular project has "close" relation to space science. The problem is most apparent in the case of physics research projects, where it is difficult to think of an area of investigation which does not have some application to space science or technology (consider, for example, mechanics, nuclear physics, fluid dynamics, plasma physics, low temperature research, and solid state research). Similarly, in

* NSF-Grants for Space-Related Basic Research Program are in Appendix A.

the biological and medical sciences programs, difficulties are presented in determining a "close" relationship with space science. The Foundation, however, supports a very substantial program of research in the biological and medical sciences, much of which will find important application and use in space science. In constructing the tabulation given in Appendix A, the rule has been to include among the projects active as of November 20, 1959:

(a) All projects in the Astronomy Program.

(b) Only those projects in the Atmospheric Sciences Program which deal with the effects of objects outside the earth's atmosphere (such as the sun) upon the earth's atmosphere, or which employ extra-terrestrial vehicles in the research procedure.

(c) Only those projects in the Chemistry Program which deal specifically with the behavior of substances at extremely high or extremely low temperatures.

(d) Only those projects in the Earth Sciences Program which deal with geophysical properties affecting the earth as a whole or with properties which are detectable at great distances above the surface, such as the magnetic field.

(e) Selected projects from the Engineering Sciences Program dealing directly with meteoroids, materials at high temperature, combustion, and electrohydrodynamics.

(f) No projects in the Mathematical Sciences Program, although the Foundation's support of computers for research will find application and use in many phases of space science - orbit computation, aerodynamics, and the like.

(g) Only those projects in the Physics Program concerned with primary cosmic ray phenomena.

(h) No projects at present in the Biological and Medical Sciences Program although, as noted, much of the supported research will find application and use in space science.

In some instances a project will be listed under one program when the name of the project would imply that the research is in the area of another program. In these cases, it should

be assumed that the background, interests, and special techniques of the investigators stem from an area of the Program under which the listing is made.

Several of the projects in the regular programs in support of basic research are of sufficient interest to warrant special mention.

The National Radio Astronomy Observatory

This facility is located at Green Bank, West Virginia. The location has been especially selected because of the low level of the local radio noise interference. The instrumentation includes one 85-foot equatorially mounted radio telescope (now in full operation) and one 140-foot telescope similarly mounted (planned to go into operation in 1961). Both telescopes are or will be usable over the entire range of wavelengths employed in radio astronomy down to 3 centimeters. At present receivers are operating at 3.75 centimeters (broadband traveling-wave tube type), 21 centimeters and 68 centimeters. The Observatory is being constructed and operated under contract by the Associated Universities, Incorporated. All qualified U. S. astronomers have access to these facilities, with priorities determined by the scientific merit of their respective projects.

The Kitt Peak National Observatory

This observatory has been established on Kitt Peak, Arizona, 40 miles southwest of Tucson. Extensive site surveys indicated that Kitt Peak appears to offer the most promising site in the southwestern part of the United States for research with very large astronomical telescopes. The instruments now planned include a 36-inch reflector and an 80-inch telescope (scheduled for completion in 1960), and a 60-inch solar telescope (planned for completion in 1961). The solar telescope will be several times larger than the largest instrument of this kind now in existence. The Observatory is being constructed under contract by the Association of Universities for Research in Astronomy. All qualified United States astronomers will have access to these facilities, with priorities determined by the scientific merit of their respective projects.

In response to a proposal from this Observatory, special additional funding has been provided to enable it to undertake very long range conceptual and preliminary design studies on a moderately large space telescope.* Apertures of the order of 50 inches are being considered. The intention is to design an instrument which would be useful for a wide variety of research problems involving spectroscopy, direct photography and photometry in the ultraviolet region and with an optical

* See also Chapter 8, Smithsonian Astrophysical Observatory

resolution as close as possible to the theoretical limit determined by the aperture. It is hoped that the telescope might be placed in a twenty-four hour orbit and remain operable for at least a year, perhaps for 10 years. If successful it is contemplated that the telescope would be available for use by all qualified U. S. astronomers. No time schedule for completion or launching has been set. It is intended that the work proceed for as long a period of time as possible free from the pressure of launching schedules. Close liaison is being maintained with NASA, and it is believed that when a workable instrument can be produced, perhaps five or ten years hence, vehicles capable of placing it in orbit will exist.

Photoelectric Image Tubes

At the present time the best available method for recording the information which a telescope collects from an extended area of the sky (such as that occupied by a galaxy or a star cluster) is by means of a photographic plate. The fastest available photographic emulsions have a very low efficiency, however. It is generally found that only one photon in every thousand which strike the plate forms a distinct blackened image. The result is that it takes approximately 1,000 times as long to photograph a faint galaxy as is theoretically necessary.

A number of photoelectric devices which give promise of greatly increasing the efficiency of the photographic procedure have been developed during the postwar years. They all depend on the fact that a photon, when striking an appropriate type of photoemissive surface, will cause an electron to be emitted with an efficiency of one electron for approximately every ten photons. Each electron can then be given a high energy by means of accelerating electrodes, so that it subsequently produces a distinct blackened image on a photographic plate.

The purpose of the Image Tube project is to develop simple, inexpensive, efficient light amplifiers for astronomical purposes. If successful (as appears likely), these devices would effectively multiply the aperture of any existing large telescope by a factor between 5 and 10. This project is being administered by the Carnegie Institution of Washington.

High Altitude Astronomy

The angular resolution obtainable in astronomical photographs taken from ground-based observatories is limited by the fluctuations in the refraction of the earth's atmosphere. These are the same fluctuations which are responsible for the twinkling of the stars and produce the condition known as poor astronomical "seeing". In the case of photographs taken at night with present

telescopes, the angular diameter of a point image (such as a star) is never less than 0.3 seconds of arc.

The most promising means of obtaining better resolution in astronomical photographs is to mount a telescope on a platform which is at an altitude well above most of the earth's atmosphere. The Princeton investigators have already successfully taken photographs of the sun with a 12-inch reflector suspended from a balloon at an altitude of 80,000 feet. The resultant photographs revealed for the first time the detailed polygonal structure of the convective currents (granulations") which bring much of the internal solar energy to its surface.

During the summer of 1959, a series of successful flights obtained photographs of unprecedented clarity showing the filamentary structure of the penumbra of sunspots and turbulent elements within the umbras.

An extension of this program is now in progress involving the design and construction of a 36-inch balloon-borne telescope. This instrument would be used for observations of objects in the night sky. The technique opens up the prospect of greatly increasing our detailed knowledge of the surface features of the moon, Mars, and similar extended objects.

This project is being supported by the Foundation cooperatively with the Office of Naval Research.

Rocket Observations of Solar Flare Emission in Ultraviolet and X-Rays

This project, which is under the primary cognizance of the Naval Research Laboratory, received substantial financial support from the Foundation. It is one of a relatively small group of experiments thus far carried out from extra terrestrial vehicles which have resulted in the acquisition of high grade astronomical observations. In a recent series of flights it was discovered that X-Rays of energies as high as 80,000 electron volts are emitted by the sun during the most active phases of some solar flares.

Automatic Measuring Machine

Modern astronomical cameras are now available which can photograph large areas of the sky and record very faint stars and galaxies in a short period of time. In order that the data thus obtained may be analyzed quickly and economically it is essential that fast automatic measuring methods be developed. The equipment being developed at the Lick Observatory will automatically perform all the needed operations except those where the judgment of the astronomer is required with

regard to the choice of objects to be measured. It is anticipated that this equipment, or minor modifications thereof will find wide use in other fields of astronomy, missile tracking, and perhaps in areas of physics.

Physics Program

Cosmic rays originate in outer space. Some also come from the sun or are influenced by it. The energy spectrum and particle spectrum of these rays are directly related to the physical processes occurring in outer space. Directional studies of cosmic rays at high energies are used to help determine the galactic origin of the cosmic ray particles. Information on the particle spectrum bears directly on the origin of the universe and its composition.

Neutron flux studies today are of special interest to physicists because of the information these flux measurements give on the sun and the magnetic fields between the earth and sun.

Balloon flights, rockets and satellites are used to get information on the cosmic ray particles in their virgin state before breakup in the earth's atmosphere. These high altitude studies are also tied in with the earth's magnetic field and solar activity. These flights may use emulsions, counters, or ionization chambers. Terrestrial telescopes which are sensitive to air showers are also employed to obtain informaon the cosmic source of very high energy particles.

Atmospheric Sciences Program

The atmosphere around us has been receiving increased study for decades. The problems today are not new, but unique facilities, such as satellites, offer a method of obtaining observations and hence improving research into atmospheric phenomena. The National Science Foundation has recognized the need for sponsoring increased atmospheric research and has recently organized an Atmospheric Sciences Program. This program consists of supporting scientific research in both the lower and upper atmosphere of interest to both aeronautics and space research. The investigations include such studies as the physics of atmospheric motions; the earth's planetary albedo; the effect of solar activity on atmospheric circulation and distribution of meteorological phenomena in the stratosphere; the space and time derivations of the variables in the stratosphere; and tidal oscillations in the stratosphere.

DEPARTMENT OF COMMERCE

THE NATIONAL BUREAU OF STANDARDS

Although most research programs of the National Bureau of Standards are related at least indirectly to the aeronautics and space technology programs of other agencies, there is a particularly direct relationship in the following general areas: standards and measurement methods; properties and behavior of materials; radio propagation research; cryogenic engineering; plasma physics and astrophysics research; and fluid dynamics.

Standards and Measurement Methods

One of the primary missions of the National Bureau of Standards is to provide the basis for a complete, consistent system of physical measurement of national scope adequate to the needs of science, commerce, and industry. With respect to space technology, some of the most important areas of research on new standards and more precise measurement techniques include the following:

1. Atomic standards of length and related measurement methods to facilitate the production of missile and space vehicle parts and devices to tolerances far beyond present capabilities.

2. Atomic standards of frequency and time interval to permit much greater precision in guidance and tracking systems.

3. Extension of the temperature scale into very high temperature ranges, as well as increasing the precision of measurement throughout the scale, to meet the needs arising in connection with new propulsion systems, novel materials, and nuclear technology.

4. Improvement of standards for extremely large forces to enable precision measurement of large loads, such as the thrust of rocket motors.

5. Extension of the pressure scale to meet increasing needs for greater precision of measurement at the very high pressures associated with modern synthetic materials research and at the very low pressures encountered in outer space.

6. Development of more accurate methods of measurement of all electrical quantities, especially at radio and microwave frequencies, to assure the adequacy and interrelatedness of electronic equipment used in guidance, control,and communication systems.

Properties and Behavior of Materials

The National Bureau of Standards is also involved in providing understanding of the behavior and properties of materials that are of great importance to science and industry and are not available with sufficient accuracy elsewhere. Current programs in this field involve three general areas of work:

1. A program of preparation of extremely pure and highly characterized materials for use, in other laboratories as well as in NBS laboratories, in studying the fundamental properties of matter. Chief initial emphasis of this program will be in the development of techniques for achieving high purity, for extremely precise analysis and characteristics of materials, and for the introduction of precisely known foreign atomic constituents or structural dislocations.

2. Expanded studies of the fundamental properties of matter, using available materials as well as the new pure substances described above to compile the basic data that is urgently needed to scientists and engineers.

3. A program to determine the engineering properties of certain critical materials, and provide engineering data on their behavior under a variety of environmental conditions and under static and dynamic load.

Radio Propagation Research

The Central Radio Propagation Laboratory has primary responsibility within the Federal Government for research on the propagation of radio waves through the atmosphere, and on the basic physics of such phenomena. In four broad areas the programs of the CRPL have an important and close relationship to current and future space programs: (1) transmission, propagation, and reception of electromagnetic radiation to and from space vehicles for communication, navigation, and guidance; (2) interaction of space vehicles

with their environment; (3) use of space vehicles as research instruments; and (4) characteristics of the various parts of the atmosphere. Some of the most important of these programs include:

(1) Observing the variations of wave polarization and analyzing the refraction effects of the ionosphere on radio signals from earth satellites.

(2) Studying the phase stability of radio waves propagated over point-to-point paths and the effect of climatological characteristics of the troposphere on radio propagation, to determine the effects on the accuracy of guidance systems.

(3) Making directional scintillation and refraction studies of the ionosphere to determine the navigational accuracy of radio signals for guidance of vehicles in and beyond the upper atmosphere.

(4) Investigating physics of the upper atmosphere, including the dynamics of the ionosphere, airglow emission, thermal structure, electron densities, and VLF emissions.

(5) Studying of the effects of solar activity on radio noise, the earth's magnetic field, and the state of ionization of the ionosphere.

Cryogenic Engineering

The Bureau's Cryogenic Engineering Laboratory conducts programs aimed at determining the properties of cryogenic fluids, measuring the physical and chemical properties of materials used in cryogenic equipment, and investigates phenomena associated with cryogenic processes. The continuing use of cryogenic fluids as rocket propellants creates a strong demand for the data and research results available from this laboratory. The programs in this area are aimed at obtaining understanding of the low-temperature effects on properties and compiling low-temperature properties of materials, to aid engineers and scientists in designing and developing new equipment.

Plasma Physics and Astrophysics Research

Progress in understanding the complicated processes in ionized gases (plasmas) is essential to the basic problem of the definition and measurement of high temperatures, and is important to a number of national programs in applied technology, such as space exploration, rocket propulsion, ultrasonic aerodynamics, thermonuclear power, and ionospheric communications.

Successful experimental research and adequate theoretical understanding in plasma physics and astrophysics requires precise measurement of the fundamental material involved, the hot plasma. Current NBS activities in the plasma physics and astrophysics fields are partially filling the need for a national astrophysical laboratory. Long range plans are for modernization and expansion of those programs to keep up with the new observatories and to develop a more realistic approach to the basic physics of the problems. The Bureau regards this new inter-laboratory program on measurement and standards in plasma physics and astrophysics as a major focus of NBS activity for the next several years.

Fluid Dynamics

Problems associated with the flow of fluids or the movement of bodies through them depend for their solution on a better understanding of the basic mechanisms of the flow phenomena, such as fluid friction within the fluid, at interfaces, and at solid surfaces. Fundamental research programs are conducted by the Bureau on interface stress, turbulence, boundary layer mixture, intermittent flow, surface shearing stresses, and the transition from laminar to turbulent flow in a boundary layer.

WEATHER BUREAU

The Weather Bureau works with the National Aeronautics and Space Administration and the Department of Defense in meteorological experiments involving use of satellites and sounding rockets. The Bureau also serves these agencies as consultant on meteorological problems. The meteorological satellite work of the Bureau is funded by NASA, and close coordination is maintained by the two agencies. A Joint Meteorological Satellite Advisory Committee composed of representatives of the Bureau, NASA, and DOD coordinates military and civilian requirements. The Bureau also works informally with the Naval Photographic Interpretation Center, the Geophysical Research Directorate, and the Air Weather Service of the U. S. Air Force. Weather Bureau meteorologists are represented on the Space Science Board of the National Academy of Sciences, and a Weather Bureau meteorologist is a member of a panel of experts in the World Meteorological Organization of the United Nations. This panel is concerned with the international dissemination and utilization of meteorological information obtained by satellites.

Observation of Cloud Formations and World Weather

Clouds are visual indicators of atmospheric motion; they reveal the location and many characteristics of most high and low pressure systems and storms. Meteorological satellites will present a comprehensive picture of cloud cover and movement, making possible better weather forecasting than that obtainable with current means of observation. As cloud observation becomes refined and meteorological satellite systems are developed, detailed observations of small-scale wind systems and phenomena such as hurricanes, squall lines, etc., will be possible. The Weather Bureau has participated in a number of weather satellite experiments, and more are planned. Vanguard II demonstrated that weather satellites are feasible. Explorer VI* was the next step, photographing and transmitting back to earth a rough picture of the earth's surface and cloud cover. While this photograph was quite crude, it demonstrated that picture-taking weather satellites could send cloud-cover photographs covering large areas. Refinements in picture taking and transmission should make satellite photographs of inestimable value in weather forecasting.

* Reported in more detail in National Aeronautics and Space Administration, Chapter I.

Project Tiros* is a means of televising cloud formations from satellites. For use in this project, the Weather Bureau has obtained high-altitude photographs taken from rockets and aircraft, to use in comparing, supplementing, and interpreting the Tiros transmissions. One 16mm motion picture film, taken during an Atlas Flight (August 24, 1959) at altitudes of 200 miles over the Bahamas and 700 miles over the mid-Atlantic, has already revealed important meteorological features, not evident from conventional data, that will significantly influence weather forecasting.

A program for cloud interpretation is being conducted jointly with the Radio Corporation of America. Results of the Weather Bureau-RCA experiments show that considerable cloud detail will be recognizable from Project Tiros. When the Tiros satellite begins operating, Weather Bureau meteorologists will interpret and summarize data from the pictures derived from satellite signals and send the data for immediate operational use to the National Meteorological Center, Suitland, Md., the Department of Defense, and international centers. After operational use, the Weather Bureau will make the data available to other Government agencies, universities, and research groups.

Other Research Utilizing Space Vehicles

The Weather Bureau coordinates with NASA and the Department of Defense in planning and conducting sounding rocket research on winds, radiation, and other phenomena of the upper atmosphere. Other Weather Bureau research has included: 1) a technical study of an infrared spectrometer for satellite use, to make alternate measurements of radiation from the earth and from space, using the latter as a reference; and 2) a preliminary study of the feasibility of operating radar on a satellite to measure the worldwide distribution of precipitation. Contract proposals for a detailed study and preliminary engineering design are being reviewed by the Weather Bureau, the Diamond Ordnance Fuze Laboratories of the Department of the Army, and NASA.

COAST AND GEODETIC SURVEY

The activities of the Coast and Geodetic Survey in space investigation stem from its work in the following related fields -- geodesy, geomagnetics, photogrammetry, and cartography.

During 1959 the Coast and Geodetic Survey made studies of possible uses of data obtained from satellite trajectories to determine more accurately the shape of the earth, the exact location of continental land masses, and variations in the gravity field. A plan was submitted, at the request of NASA, for using

* Reported in more detail in National Aeronautics and Space Administration, Chapter I.

the geodetic satellite of 1961 in further studies of this nature.

A study was also started of possible applications of geodetic satellite observations in navigation, and survey operations at sea.

Continuing investigations were made of equipment and techniques for precise satellite tracking, including optical and photographic systems, plate and film reading machines, and coordinated programming of analysis by high-speed computers and automation.

The magnetic observatory operations of this organization contributed monitoring services in many space research programs. Direct aid was given to NASA through the installation of special magnetometer test facilities at the Coast and Geodetic Survey's Fredericksburg, Va., Magnetic Observatory and Laboratory.

CHAPTER 7

SPACE SCIENCE BOARD

The Space Science Board* was established by the National Academy of Sciences in mid-1958 in response to national and international basic research interests. Domestically, the Board serves in an advisory capacity to the National Aeronautics and Space Administration, the National Science Foundation, and the Department of Defense. Internationally, the Board serves as the Academy's vehicle for cooperation with scientists of other countries, working through the Committee on Space Research (COSPAR) of the International Council of Scientific Unions (ICSU). The chairman of the Board's Committee on International Relations is the delegate to COSPAR.

The members of the Board serve as chairmen of 12 specialized subcommittees covering the various scientific disciplines and fields of activity associated with the U. S. space science program.

NATIONAL ACTIVITIES

Space Research Proposals

As soon as it was established, the Board asked for proposals and suggestions from the U. S. scientific community for new projects in space science research to follow the satellite and rocket program of the International Geophysical Year (IGY). The Board's committees assessed some 200 proposals and made recommendations to NASA and NSF in the fall of 1958 and early 1959. These studies helped provide guidance for the organization of post-IGY space research now being conducted, and helped

* Membership is listed in Appendix B. The Board and its committees are composed of approximately 140 leading specialists. Since its formation, the Board and its committees have had 23 formal meetings and an even larger number of informal sessions.

insure an orderly transition from the IGY period, directed by the Academy's IGY Satellite Panel, to the post-IGY effort.

The committees of the Board continue to advise with NASA as committees on scientific disciplines, reviewing projects in the NASA national space sciences program.

Review of Space Research Programs

During 1959, the Board held three major meetings: January 17-20 at the Atlantic Missile Range, Cape Canaveral, Florida; May 7-9, at NASA headquarters and the Advanced Research Projects Agency, Washington, D. C.; and October 23-24 in Philadelphia, Pa. These visits have helped orient Board members in current vehicle programs, launching facilities available to scientists, and various problems to be considered in launching space experiments.

Current and near-future research activities in space science were presented by officials of NASA, NSF, and agencies of the Department of Defense. The aim: to ascertain the state of the research being conducted, to single out major problems requiring solution, and to devise the best possible means of drawing broadly upon the talents of scientists throughout the nation in the conduct of the space research program.

Symposium Held

On April 29-30, 1959, a symposium was held in Washington on the exploration of space. Sponsored jointly by the Board, NASA, and the American Physical Society, the symposium reviewed space research findings to that time and discussed the broad objectives of future research programs in all fields of space science. Nearly a thousand scientists from all over the United States attended, and heard discussions of recent space science results, the current status of space science, and opportunities and objectives in space research.*

* Proceedings of the symposium have been published in the Journal of Geophysical Research, Vol. 64, No. 11, November 1959, and will soon be available in book form.

"Science in Space"

During 1959 the Board prepared a volume, "Science in Space," which broadly examines opportunities and objectives of space science for the coming years. This volume, the chapters of which are written by eminent American scientists in various fields, covers such subjects as the nature of gravitation, geodetic measurements and continental distances, meteorology, physics of the earth's upper atmosphere, the moon and planets, the solar system and galactic astronomy, physics of fields and energetic particles in space, and space biology. Scheduled for publication in early 1960, the volume outlines major areas of fundamental scientific research, indicates general objectives for the national space program, and suggests to scientists the opportunities and challenges implicit in this vast new area of study.

Special Problems

Under the auspices of the Space Science Board, a number of special ad hoc study committees were established to consider, on behalf of scientists, specific problems or neglected areas affecting space research. Among these have been: the consequences of contamination of extraterrestrial bodies by impacting space probes and recommendations for a program to prevent this contamination; the need for exclusive allocations of radio frequencies for use in space research (specific recommendations were provided to the U. S. delegation to the 1959 International Telecommunication Union conference in Geneva); ground-based radar astronomy to provide back-up support to the space sciences program; the photochemical aspects of space exploration; the chemical analysis of meteorites contributory to future space experimentation; and a study of sounding rocket research efforts.

Rocket and Satellite Data Center

Established during the IGY at the National Academy of Sciences, this Center provides a means for international exchange of scientific data resulting from rocket and satellite programs. The Center is part of an international data interchange program now under the auspices of COSPAR. Through the Center, launchings have been announced to observers throughout the world for tracking purposes; space programs have been described in summary; and two series of reports have been issued. One series deals with sounding rocket research results; the other, with satellite and space probe findings. To date, five reports have been issued in the Rocket Series and nine reports in the Satellite Series. Several others in both series are in final stages of preparation.

During 1959, the following rocket reports were issued:

No. 2, "Flight Summaries for the U. S. Rocketry Programs for the IGY", Part I, 5 July 1956 - 30 June 1958, 193 pages; No. 3, "Flight Summaries for the U. S. Rocketry Program for the IGY", Part II, 23 May 1958 - 31 December 1958, 129 pages; No. 4, "Magnetic Exploration of the Upper Atmosphere", 86 pages; and No. 5, "Upper Air Densities and Temperature from Eight IGY Rocket Flights by the Falling-Sphere Method", 102 pages.

During the same period, these satellite reports were issued:

No. 7, "Simplified Satellite Prediction from Modified Orbital Elements", 1 January 1959, 54 pages; No. 8, "Ephemeris of Satellite 1957 Alpha 2 and Collected Reports on Satellite Observations", 15 June 1959, 122 pages; and, No. 9, "Symposium on Scientific Effects of Artificially Introduced Radiations at High Altitudes", 15 September 1959, 87 pages.

Several additional volumes in each series will be issued early in 1960.

The Center has also maintained an archive of results and documents from other countries, acquiring some 1000 reports and published papers. These were collated during the last quarter of 1959, looking to preparation and issuance of a series of reports to provide orderly information on experimental results.

INTERNATIONAL ACTIVITIES

Committee on Space Research

The Space Science Board provides U.S. representation to the ICSU Committee on Space Research (COSPAR). COSPAR, organized in October 1958, affords a principal means for international scientific collaboration in space science. Dr. R. W. Porter, Chairman of the Board's Committee on International Relations, is the U.S. National Academy of Sciences representative to COSPAR. COSPAR provides an effective means for scientists to consider internationally the broad objectives of space research; it affords an effective forum for international discussion of these topics, and promotes international collaboration in operational space research programs.

The NASA has supported the Academy's Board and COSPAR as one of the channels for promoting international participation in the United States space science program. At the

March 1959 meeting of COSPAR, the National Academy of Sciences representative was authorized by NASA to invite international science to participate in its program. This offer included the launching of space experiments or complete payloads developed in other countries. NASA's offer to COSPAR has already contributed to increased interest by scientists of several countries in conducting space experiments.

COSPAR Rocket Week

On behalf of COSPAR, the Board and its staff encouraged the U. S. contribution to an internationally coordinated program of scientific rocket soundings of the upper atmosphere which took place November 16-22, 1959. The U. S. contribution included ten rockets launched by three scientific institutions in this country. The Board has also participated in development of plans for a COSPAR rocket week in 1960. It is anticipated that this program will become an annual event.

First International Space Science Symposium

COSPAR has scheduled its First Annual International Space Science Symposium for Nice, France, January 11-15, 1960. It will include approximately 100 papers contributed by scientists from many nations, with international participation numbering approximately 300 persons. Directed toward a review of space science achievements to date, the symposium will also examine possibilities in this field for the immediate future; it promises to be a significant and important scientific event. The Board and its staff have coordinated the U. S. effort -- some 50 scientific papers, and a delegation of approximately 75 U. S. scientists.

United Nations

The Board and its staff have cooperated with NASA and U. N. Secretariat in providing information and advice on space science activities during and after the IGY. At the request of the Department of State a member of the Board provided scientific advice and assistance to the U. N. Ad Hoc Committee on the Peaceful Uses of Outer Space during its deliberations.

CHAPTER 8

SMITHSONIAN ASTROPHYSICAL OBSERVATORY

The Smithsonian Astrophysical Observatory, under the sponsorship of the National Aeronautics and Space Administration, has successfully maintained its world-wide system of 12 stations, equipped with Baker-Nunn cameras, for the precise photographic tracking of earth satellites. With improved observing techniques, one camera was able to photograph the 6-inch sphere, Vanguard I, at a distance of 2500 miles—a feat equivalent to photographing a .30 caliber bullet in flight, at a distance of 200 miles. The Observatory has also directed the activities of more than 250 Moonwatch teams of satellite observers. As the recognized world communications center for optical observations of the satellites, the Observatory has regularly received and analyzed the observations, and calculated and distributed predictions of the time and place of expected satellite passage.

ACCOMPLISHMENTS AND PLANS

From analyses and computations of the accumulated satellite data, the Observatory has made significant discoveries in the theory and practice of satellite flight and space science. In particular, the research staff has:

1) Derived the necessary theory, and established computing programs that use electronic techniques, when the techniques of classical celestial mechanics are inadequate, to predict and analyze the motions of satellites.

2) Derived and improved numerical value for the earth's grativational field, which confirms the unexpected asymmetry in the North-South distribution of mass in the earth.

3) Derived a surprisingly small value for the amount of the earth's flattening at the poles.

4) Derived unexpectedly large values for the densities in the earth's high atmosphere, and shown that the densities apparently decrease as sunspot activity declines from its 1958 maximum.

5) Proved for the first time that the earth's high atmosphere swells as the sun's activity increases; and demonstrated that long-period fluctuations in the high atmosphere are associated with increased radiation from the sun in the far ultraviolet, while some short-period changes are associated with the ejection of corpuscles from the sun.

During the coming year, the Observatory expects to continue its progress in these areas of research. It also expects to make important contributions to our knowledge of the size and shape of the earth. By utilizing the geometrical interrelations among the optical tracking stations on the earth, and the satellite observations made by the stations, the Observatory plans to determine geodetic measurements with a precision at least an order of magnitude greater than any previously achieved.

SATELLITE TRACKING

The network of 12 optical satellite tracking stations regularly gathered photographic data on the positions of seven artificial satellites. Data resulting from the more than 6,000 photographs made during the year have formed the basis of precise determinations of the orbits. The Baker-Nunn cameras can photograph objects as faint as 12th magnitude, with an accuracy between 1 and 5 seconds of arc. The system produced as many as 3 photographs per day of a satellite, over a long period of time, in spite of bad weather and mechanical problems -- a rate about 50 percent better than expected.

DETERMINATION OF SATELLITE ORBITS

The computing section of the Observatory has made excellent progress in solving some of the problems raised by the unexpected behavior of the satellites. Research has shown that deviations from the predicted orbit occur, in part, because the drag exerted on the object of the earth's atmosphere is about 10 times greater than had been expected. An erratic fluctuation in the amount of drag, combined with inaccuracies in the early observations and in geodetic data, further complicated the precise determination of satellite orbits. Although the classical methods of celestial mechanics could not be successfully applied to so complex a problem, the computing section has now derived the necessary theory, and developed programming methods with electronic techniques, to yield good short-term predictions of satellite orbits. The construction of a library of computing programs for precise analysis has been nearly completed. The library embodies a differential-corrections program which performs an elaborate statistical study of the observations, compares them individually with an expected orbit and, by successive approximations, refines the orbit and rejects the more inaccurate observations.

This program has now reached the final stages of refinement, and represents an invaluable contribution to satellite theory. Employing this computing program, the Observatory prepares bi-monthly reports of observations and orbits, which it distributes in the series of Special Reports issued by the Observatory.

Geodetic Applications of Satellite Data

Analyses made by the Observatory staff during the year have confirmed the (unexpected) finding that a North-South asymmetry exists in the distribution of matter within the earth's sphere. This asymmetry contributes to disturbances of the predicted satellite orbit. These analyses have also led to a recalculation of the amount of flattening at the earth's poles, and yielded a surprisingly small amount of flattening.

The Observatory has made significant contributions to the theory of orbital dynamics. A theory has been developed to determine how the moon's gravitational attraction affects the satellite orbit. This theory was applied for the first time to Explorer VI, the "paddle wheel" satellite, and shows that the moon's presence will reduce the lifetime of the satellite from an expected 20 years to an actual two years. The theory of the perturbational effects of the moon is used also in selecting the optimum launching conditions for satellites that will be vulnerable to the moon's influence.

THE STRUCTURE OF THE EARTH'S ATMOSPHERE

In attempting to account for unexpected irregularities in satellite orbits, the Observatory has made significant discoveries about the structure of the earth's upper atmosphere. Analyses of the orbital path of the spherical satellite Vanguard I showed that the variations caused by atmospheric drag exhibited a periodic character. Following a suggestion that the periodicity was correlated with the varying intensity of radio noise from the sun, the Observatory has carried out intensive research to try to determine correlations between solar radiation and phenomena on the one hand and the atmospheric density, as deduced from satellite drag, on the other. The result has been that variations of both ultraviolet and corpuscular radiation from the sun affect the temperature and density profiles of the upper atmosphere. Although all the details of this relationship are not yet clear, some facts have been established.

At great heights above the earth, the atmosphere swells and contracts in synchronism with the rising and falling level at which ultraviolet and corpuscular radiation are produced in the solar hemisphere that faces the earth. The sun's rotational period of 27 days, and the fact that localized regions of high activity often persist in the outer layers of the sun, produce a corresponding periodicity of 27 days in the swelling of the earth's atmosphere and the consequent changes in density. Furthermore, as the earth rotates, the atmosphere of the night-side, not directly subjected to solar radiation, cools and contracts.

The shifting orientation of the satellite orbits in one sense simplifies, and in another sense complicates, the study of changing atmospheric densities. Correcting the data to allow for the irregular body-shape of the long cylindrical satellite has presented a more difficult problem.

The Observatory is therefore engaged in both theoretical and empirical studies of the aerodynamic and gravitational effects on the orientation of satellites. The full explanation of the somewhat puzzling observations will be a major contribution to the ballistics of satellites.

MOONWATCH OBSERVING TEAMS

The most spectacular achievement of the Moonwatch teams was the re-acquiring of the "lost" satellites, 1958 Beta 1 and 1958 Epsilon, so that they could again be the subject of routine tracking and photography. The "Stockpiling" of visual observations by Moonwatch teams is already supplying material for basic research, in addition to data for regular orbital predictions. The discovery at the Observatory of a correlation between solar radiation and the atmospheric drag of artificial satellites was based on observations of which Moonwatch provided more than 70 percent.

SPACE TELESCOPE *

Preliminary designs have been completed for a satellite telescope to be used in space, to make spectroscopic and photometric studies of the stars and nebulosities. A preliminary prototype optical and television system now operating in the laboratory shows that this experiment will produce valuable astrophysical information not otherwise obtainable.

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* See also Chapter 5, National Science Foundation.

OTHER ACTIVITIES

Attempts to track the Soviet lunar and interplanetary probes have not yet produced any definitely confirmed photographs. However, studies have further substantiated Soviet reports on their deep space probes.

An important function initiated by the Observatory in the past year is the provision of special predictions and orbital analyses for installations devoted to radio-tracking. A comparison of the optical observations with the radio data is providing a picture of a previously unobservable portion of the ionosphere -- the electron gas embedded in the earth's atmosphere.

FEDERAL COMMUNICATIONS COMMISSION

The Federal Communications Commission's activity in the fields of space and aeronautics increased significantly in 1959. In the relatively new field of space communications, much work was done in allocating and protecting radio frequencies for radio astronomy use and for earth-space and space communication. In aeronautics, the increased activity was the broad result of the advent of the jet age for commercial air transportation and its attendant requirements for improved aeronautical communication and navigation facilities, as well as the expansion of such facilities to better meet the further needs created by the normal growth of air transportation.

SPACE COMMUNICATIONS

The FCC had been active prior to 1959 in the selection and provision of frequencies for satellite and rocket control, telemetry (data relay), tracking and other related experimentation. Such frequencies, however, were selected on a case-by-case basis so that operations could be conducted without interference to radio services for which bands of frequencies had been allocated, nationally and internationally. In addition, since there were no frequencies allocated for "space," such operations received no interference protection from the radio services operating in accordance with the Table of Frequency Allocations.

FCC Participation in International Administrative Radio Conference

In 1959, under the auspices of the International Telecommunication Union, an international Administrative Radio Conference was held in Geneva between August and December to consider revisions to the International table of frequency allocations and other radio regulations applicable to all radio services, the first such conference since 1947. The Commission's very active participation in both the conference itself and the preparatory work leading up to it included giving consideration to the matter of providing international protection for frequencies to be used for space communication,

taking into account the known frequency requirements of all other radio services.

As a result of work by the conference preparatory groups, under the aegis of the Department of State and with representatives of the electronics industry participating, the Commission and the other Federal agencies concerned drafted a tentative proposed international frequency allocation table which included provisions for space and earth-space services. Appropriate definitions for these services were also proposed. The allocation table finally adopted at Geneva in December 1959, contained provisions for these services for the first time, and it is expected that appropriate national space allocations will follow through the initiation of rule-making proceedings by the FCC, one of which has already begun.

It should be noted that the frequencies adopted internationally for space services are intended for tracking control and telemetry functions for Research purposes. Separately, the Commission is giving attention to possible application of space vehicles for relaying various types of communication between fixed points on earth. One experimental authorization involving the use of inflatable satellites as passive reflectors of radio waves for transcontinental tests has already been granted by the FCC.

FCC Participation in Other Technical Meetings and Consultations

In April 1959, the FCC participated in the Ninth Plenary Assembly of the International Radio Consultative Committee (CCIR) at Los Angeles, held to obtain recommendations of leading international technical experts on all fields of radio, including space and radio astronomy. In addition, the Commission participated on the International Relations Committee of the Space Science Board, National Academy of Sciences. Space frequency allocation problems were also jointly considered by the FCC, the Office of Civil and Defense Mobilization (OCDM), and the Department of State.

RADIO ASTRONOMY

During 1959, FCC activities in the field of radio astronomy closely paralleled those for "space" described above. Although the FCC had previously completed a rule-making procedure providing the National Radio Astronomy Observatory, Greenbank, W. Va., with protection against radio interference, no frequencies were allocated, either nationally or internationally for radio astronomy at the beginning of 1959.

In addition, the U.S. proposals at the beginning of the International Radio Conference at Geneva, in August, 1959, proposed only one band for radio astronomy, the band 1400-1427 mc,

which corresponds to a characteristic spectrum line for hydrogen. However, a major change in the U. S. position was brought about during the course of the conference. This resulted largely from the intensive consideration given the matter of radio astronomy frequency requirements in a series of meetings held in Washington, D. C. in October, sponsored by the National Academy of Sciences in cooperation with all Government agencies involved. A member of the U. S. Delegation to the Geneva conference returned to Washington to participate in these meetings and to report on related developments at the international conference. These meetings led to U. S. adoption of a draft resolution which resulted in considerable additional provisions for radio astronomy in the new radio regulations adopted at Geneva in December 1959. Thus, for the first time in history, provisions were made to avoid and resolve interference to radio signals not generated by man.

AERONAUTICS

This field includes radio for aircraft communications (including telemetry) and navigation, and for control and telemetry in the development of missiles. The FCC prescribes the manner and conditions under which frequencies may be assigned for such uses by non-Government licensees. In addition, the Commission coordinates extensively through established procedures activities involving the Government use of non-Government frequencies and, conversely, the non-Government use of Government frequencies.

Increased Demands for Communication and Navigation Facilities

The advent of jet aircraft for commercial use has created increased demands for communication and navigation facilities geared to the substantially higher speeds involved. Expansion of such facilities has also been necessary to meet the increased volume of air traffic resulting from normal growth in air travel. These developments have brought about greater requirements for aeronautical communications that must be accommodated within the limited frequency space available. Meeting such requirements involves more effective administration in utilizing frequencies, and continued efforts to exploit technical advances which permit greater conservation of frequencies. As one step in this direction, the FCC has instituted 50-kc channeling in the 118-132-mc band, in lieu of the former 100-kc bandwidth.

Moreover, in 1959, the FCC proposed to amend its rules to make five megacycles of additional spectrum space available for air traffic control by aeronautical and aircraft stations. The FAA and the OCDM had recommended such a reallocation to permit implementation of FAA plans for augmenting its air traffic control facilities.

The phenomenal increase in flight-testing requirements for missiles, rockets, satellites, as well as for aircraft -- most of which are being developed by non-Government licensees -- has necessitated allocation of the 1435-1535-mc band for aeronautical telemetering.

In air-navigation, FCC made provision for use of the Doppler system of navigation in the 8750-8850-mc, 9750-9850-mc. and 12,250-13,400-mc bands.

LONG-RANGE FREQUENCY PLANNING

During 1959, significant progress was made in joint OCDM-FCC long-range frequency allocation planning to produce, as its first objective, an improved pattern of frequency allocations for all radio services, which could be implemented within the next 10 to 15 years. This continuing study is concerned with ways and means of providing frequencies to permit expansion of existing radio services, and to provide for new radio services such as space and radio astronomy.

Requires Extensive Data

New long-range plans require accumulation and analysis of data from many sources in order to evaluate frequency requirements of all radio services and to define the trends in these requirements that may indicate need for allocation changes over an extended period of time.

The joint conduct of this study on a continuing basis is a new approach in long-term Government planning for frequency allocations. Heretofore, such studies were conducted independently by the agencies concerned and conclusions coordinated thereafter.

CHAPTER 10

UNITED STATES INFORMATION AGENCY

The United States Information Agency (USIA) distributes information abroad regarding the civilian and military space activities of this country. USIA utilizes a variety of communications media to accomplish this, including news releases, magazine reprints, pamphlets, photographs, radio, television, motion pictures, and exhibits. Information for release is obtained from the National Aeronautics and Space Administration, the Department of Defense, the Atomic Energy Commission, and from other government agencies participating in aeronautics and space research and development.

WORLDWIDE DISSEMINATION

News Releases

USIA prepared and distributed more than 110 releases totalling more than 40,000 words on United States rockets and satellites during 1959. In addition, it transmitted news in connection with the special United Nations committee studying international space cooperation, eighty-four newspaper editorial reprints, fifteen reprints of selected space articles in American magazines, four special columns on space subjects (Vanguards I and II, Argus, and Explorer VI), and other appropriate material.

In addition to the information given world-wide distribution, the four regional wireless files (Europe, Far East, Near East, and Latin America) and two special wireless files (Eastern Europe and Rio de Janeiro) transmitted a total of 225 items totalling 85,000 words of special interest to the people in the areas covered.

Pamphlets and Posters

USIA translated into foreign languages where necessary and distributed throughout the world the following publications: "Space -- The New Frontier," 1,012,000 copies; "Man

and Outer Space" (a comic book depicting history and future of man in space), 190,000 copies; "IGY -- New Horizons for Science" (describing IGY findings), 160,000; "The Story of IGY" (comic book), 148,000; and "The Future in Space," 153,000.

USIA made seven mailings of "Space Notes," each a collection of brief features. These series has a larger distribution than any similar recurring publications. USIA also distributed 150 copies each of 50 "mailers," which include items such as texts of major addresses, press conference transcripts, and press kits.

Photographs

USIA distributed about 6,811 negatives, 16,804 prints, 2,542 lithographs, and 55,734 plastic printing plates covering 143 space subjects during 1959. In addition, it distributed nine picture stories containing a total of 110 photographs, which required preparation of 5,291 negatives and 15,682 prints, and six science photo briefs totalling 27 photographs which required preparation of 1,389 negatives and 3,974 prints.

Radio, Television, and Motion Pictures

USIA writes 16 daily news round-ups, in English and other languages, for broadcasts over the Voice of America and some foreign stations. United States space achievements are included in these round-ups. On the space program itself, USIA taped eighty special programs (launchings, interviews with United States space leaders, proceedings of American aeronautical and space society meetings, etc.) and prepared 58 scripts on special subjects including a 12-part series on "Man in Space." In addition, 35 "Science Notebook" scripts covered space activities.

For television stations, USIA made world-wide distribution of the following documentaries: "Horizons of Science," "Vanguard II," "Pioneer IV," "Student of the Stars," and "The Challenge of Space." Certain films were sent to specific nations upon their request. Among these were: "Able-Baker Space Biology Experiment" to the United Kingdom; "VTOL Aircraft" to the Federal Republic of Germany; interview of the X-15 test pilot by a Japanese aviation editor to Japan; "Space Medicine" and "Story of American Aviation" to Italy; and "Wings for Tomorrow" to ten Latin American nations.

World-wide distribution of motion picture reels has provided another avenue for USIA to tell the story of America in space. USIA's newsreel clips distributed to 33 countries contained 19 stories on space. "Today," a two-reel monthly

newsreel magazine distributed to 22 countries featured Explorer VI. "Atlas in Orbit," "Explorer in Space," "Space Pioneer," and "Vanguard I," produced in 1958, had been seen in 88 countries by the end of 1959. "X Minus 80 Days," also produced in 1958, had been distributed to 80 nations by December 31, 1959. "Exploring Space," another 1958 production, had been seen in 60 countries by 1959's close. Soundtracks for the films covered 14 to 24 different languages. USIA produced "Out Among the Stars" in 1959. It has been distributed in 24 languages.

Exhibits and Libraries

Outstanding among exhibits during 1959 was the full-scale model of the paddlewheel satellite, Explorer VI, at the American National Exhibition in Moscow. Visitors expressed wonder not only at the exhibit but also at the rapidity with which it was assembled after the Explorer launching. After the Moscow exhibition, Explorer VI was shown in Yugoslavia, Italy, and the United Kingdom.

Another popular exhibit is "Space Unlimited," a photo panel covering 1500 square feet which traces the conquest of space from the Wright Brothers' flight to the Vanguard satellite. Its 19 copies have been shown in Italy, Chile, Brazil, Uruguay, Bolivia, Spain, Pakistan, Afghanistan, Israel, Greece, Morocco, Mexico, Guatemala, Cuba, Finland, Denmark, the Netherlands, Laos, Malaya, Burma, the Philippine Republic, Thailand, Sweden, Norway, Japan, Switzerland, France, and Syria.

A model of the 12-foot inflatable satellite was shown at the Tangier Fair. "Space Research Instruments" has been and is still on exhibit in Poland. "Satellite Tracking Station" has been exhibited in Brazil, Chile, Ecuador, and Peru.

Lecture material, pamphlets, and books on space subjects have been sent to USIA libraries throughout the world. Three hundred sets of a film-strip brochure on Project Mercury, America's man-in-space project, and of an address by Dr. T. Keith Glennan on "A National Program for Space Research" have been sent to the libraries. Approximately 13,000 copies of 31 pamphlets on space have been similarly distributed. About 500 paperback books on space sciences were shipped. In addition, three books on American space exploration were published during 1959 under the USIA Book Translations Program. They are:

1. "Exploring Earth and Space," by Margaret Hyde -- Arabic, 10,000 copies; Chinese, 8,000; Gujerati, 2,000; Japanese, 17,000; Korean, 5,000; and Marathi, 5,000.

2. "The World in Space," by Alexander Marshak -- Arabic, 4,000 copies; Japanese, 17,000; and Spanish, 22,000.

3. "Rockets, Missiles, and Moons," by Charles Coombs -- Arabic, 10,000; and Spanish, 6,000.

APPENDIX A

NATIONAL AERONAUTICS AND SPACE COUNCIL

(As of December 31, 1959)

President Dwight D. Eisenhower, Chairman

Christian A. Herter
Secretary of State

Thomas S. Gates, Jr.
Secretary of Defense

John A. McCone
Chairman, Atomic Energy Commission

T. Keith Glennan
Administrator, National Aeronautics and Space Administration

Dr. Detlev W. Bronk
President, National Academy of Sciences

Dr. Alan T. Waterman
Director, National Science Foundation

Dr. John T. Rettaliata
President, Illinois Institute of Technology, Chicago, Illinois

Vacancy

Acting Secretary,

Franklyn W. Phillips

APPENDIX B

MEMBERSHIP OF THE CIVILIAN-MILITARY LIAISON COMMITTEE

(As of December 31, 1959)

William M. Holaday, Chairman

William J. Underwood, Assistant to the Chairman and Secretary

NASA MEMBERS

Dr. Hugh L. Dryden, Deputy Administrator
Abe Silverstein, Director of Space Flight Development
Homer J. Stewart, Director of Program Planning and Evaluation
Ira H. Abbott, Director of Aeronautical and Space Research

NASA ALTERNATES

DeMarquis D. Wyatt, Technical Assistant to the Director of Space Flight Development
Abraham Hyatt, Assistant Director for Propulsion

DEPARTMENT OF DEFENSE MEMBERS

John B. Macauley, OSD, Deputy Director, Office, Defense Research and Engineering
Maj. Gen. W. W. Dick, Jr., Army, Director of Special Weapons, Office, Chief of Research and Development Dept. of Army
Vice Adm. R. B. Pirie, Navy, Deputy Chief of Naval Operations (Air)
Brig. Gen. Homer A. Baushey, Air Force, Director of Advanced Technology, Office, Deputy Chief of Staff, Development

DOD ALTERNATES

A. G. Waggoner, Special Assistant for Missiles and Space Operations, Office, Defense Research and Engineering
Colonel Charles G. Patterson, Deputy Director of Special Weapons, Office, Chief of Research and Development, Department of the Army
Rear Admiral K. S. Masterson, Director Guided Missiles, Office, Chief of Naval Operations
Colonel John R. Martin, Jr., Air Force, Deputy Director of Advanced Technology, Office, Deputy Chief of Staff, Development

NATIONAL SCIENCE FOUNDATION GRANTS FOR SPACE-RELATED BASIC RESEARCH PROGRAMS

APPENDIX C

ASTRONOMY

Instrumentation for General Astronomy

Project Title	Supplementary Description	Participants	Amount	Date of Grant	Duration
Design of Equipment Consisting of an Automatic Machine for Measuring Astrographic Positions and Magnitudes	To be used to measure photographic plates taken with the Lick Observatory Astrograph. See text for additional information	University of California S. Vasilevskis	$341,550	12/57	5 years
Application of the Lallemand-Type Image Converter		University of California M. F. Walker	$ 8,600	12/58	1 year
Investigations and Construction of Photoelectric Image Tubes for Research in Astronomy	See text for additional information	Carnegie Institution of Washington M. A. Tuve	$385,000	5/58	3 years
New Ultraviolet Transmitting Objective Prism	To be used on the 24-36 inch Schmidt telescope of the Warner and Swasey Observatory	Case Institute of Technology J. J. Nassau	$ 10,500	12/58	1½ years
Image Converters for Astronomical Photography		University of Chicago W. A. Hiltner	$ 15,000	3/59	1 year
High Resolution Spectrograph	To be used with the Coronagraph of the High Altitude Observatory	University of Colorado W. O. Roberts	$ 80,000	12/58	2 years
Studies and Tests for Improvement of Feed Systems for Large Paraboloids	To be used with Radio Telescopes. Principal purpose is to obtain maximum illumination of the primary dish while reducing spillover at the edges	Jasik Laboratories A. Jasik	$ 35,000	8/58	1 1/3 years

Instrumentation for General Astronomy (cont.)

Project Title	Supplementary Description	Participants	Amount	Date of Grant	Duration
An All-Mirror Cassegrain Spectrograph for Astronomical Research	To be used with the Perkins Observatory 69-inch reflector.	Ohio State University P. C. Keenan	$ 30,000	7/56	4 years
The Application of Television Techniques to Astronomy	Primary purpose is to obtain image amplification coupled with low internal noise	Vanderbilt University J. H. DeWitt	$ 27,900	6/59	1 year
Modernization of a Long Screw Measuring Engine and its Application to Astrometric Research		Yale University D. Brouwer	$ 27,500	8/58	3 years

Facilities for General Astronomical Research

Project Title	Supplementary Description	Participants	Amount	Date of Grant	Duration
Establishment, Construction and Operation of a National Radio Astronomy Observatory at Green Bank, West Virginia	See Text for additional information	Associated Universities, Inc. L. V. Berkner	$10,380,000	11/56	5 years
Establishment, Construction and Operation of a National Stellar and Solar Optical Observatory at Kitt Peak, Arizona	See Text for additional information	Association of Universities for Research in Astronomy, Inc. R. R. McMath	$ 8,445,000	12/57	5 years
Preliminary Conceptual Design, and Experimental Studies for Large Aperture Orbital Telescopes	See Text for additional information	Association of Universities for Research in Astronomy, Inc. A. B. Meinel	$ 160,000	6/59	1 year
Studies Related to the Establishment of a Large Astrographic Telescope in the Southern Hemisphere	The principal activity is site testing in the Southern Hemisphere. Present activities are centered on the area around Santiago, Chile	Columbia University J. Schilt	$ 25,300	3/59	1 year
21-Centimeter Radio Astronomy	A maser receiver is being developed.	Harvard University B. J. Bok T. K. Menon T. Gold	$ 361,500	10/52	7½ years

Facilities for General Astronomical Research (cont.)

Project Title	Supplementary Description	Participants	Amount	Date of Grant	Duration
High Altitude Astronomy	Spectroscopic Observations are to be made from a manned balloon.	Johns Hopkins University J. D. Strong	$ 70,000	12/57	2 years
A Fixed Paraboloid and Tiltable-Flat Reflector for Radio Astronomy Research	This instrument is designed to combine very large collecting area with relatively low cost. It will be of the transit type.	Ohio State University J. D. Kraus	$297,950	2/56	5 years
High Altitude Astronomy	See Text for additional information.	Princeton University M. Schwarzschild	$950,000	5/58	3½ years
Radio Astronomy	Solar Observations at low frequencies.	Rensselaer Polytechnic Institute R. Fleischer	$ 38,000	3/57	3 years
Design of Infrared-Microwave Telescope	Steerable dishes having apertures in the range from 10 feet to perhaps 60 feet and surface tolerances of the order of a fraction of a millimeter are being studied.	University of Texas G. Kuiper	$ 40,000	3/59	1 year

Solar System Astronomy

Project Title	Supplementary Description	Participants	Amount	Date of Grant	Duration
Indirect Flare Detection	Effects of solar activity on radio propagation are monitored.	American Association of Variable Star Observers H. L. Bondy	$ 575	5/59	1 year
Spectrum of the Radio Frequency Radiation from Jupiter		American Museum of Natural History K. L. Franklin	$10,000	3/57	2 3/4 years
Physical and Statistical Studies of Asteroids	Continuation of research programs on motions and light variations of asteroids to gain knowledge of their shapes, sizes, and reflectivity.	University of Chicago G. Kuiper	$69,200	7/53	7 years
Solar System Studies	Photometry of moon and asteroids, planetary studies, observations of comet tails.	University of Chicago G. Kuiper	$15,600	6/57	3 years
The Calculation of Minor Planet Orbits	The computing facilities of the University are used to compute orbits of newly discovered minor planets and to improve other orbits, making use of planet positions observed at centers all over the world.	University of Cincinnati P. Herget	$24,850	6/57	3 years
Optical Solar Flare Patrol and Solar Activity Summaries	A photographic solar flare patrol program started under the IGY is being continued. This program makes possible a variety of studies of solar-terrestrial relationships. The High Altitude Observatory collects data from many IGC stations and prepares summaries.	University of Colorado W. O. Roberts	$26,200	5/59	1 year

Solar System Astronomy (cont.)

Project Title	Supplementary Description	Participants	Amount	Date of Grant	Duration
Solar Activity Related to Ionospheric Phenomena		Dartmouth College G. Z. Dimitroff	$ 7,300	6/57	2 2/3 years
Planetary Emissions at Radio Frequencies	A program on the nature and origin of radio-frequency emissions from the planets, including spectral analysis by simultaneous monitoring of four frequencies, and study of polarization of planetary emissions.	University of Florida A. G. Smith	$20,000	8/57	3 years
Radio Observations of Jupiter and Saturn from Chile	Since these planets now appear low in the Southern sky for observers in the northern hemisphere, a field station is being operated near Santiago in cooperation with the National Astronomical Observatory of Chile.	University of Florida T. D. Carr A. G. Smith	$41,000	12/58	2 years
Investigations of the Sun's Spectrum	High resolving power is used	Georgetown University C. C. Kiess W. F. Meggers	$52,800	3/58	3 years
Solar Activity Flare Patrol		University of Hawaii W. Steiger	$ 8,000	5/59	1 year
Observations of Asteroids		Indiana University F. K. Edmondson	$45,200	6/54	7 years
The Abundance of Certain Elements in the Solar Atmosphere		University of Michigan L. H. Aller	$13,600	8/58	2 years

Solar System Astronomy (cont.)

Project Title	Supplementary Description	Participants	Amount	Date of Grant	Duration
Hydrogen in the Solar Spectrum		University of Michigan O. C. Mohler	$ 19,600	6/58	2 years
Lyot Photoheliograph Flare Patrol		University of Michigan O. C. Mohler	$ 10,600	5/59	1 year
Terrestrial Magnetic Storm and Solar Activity		University of Michigan O. C. Mohler	$ 8,000	9/59	1 year
Solar Activity Data	Data are tabulated and Published	National Bureau of Standards (Boulder) F. W. Brown	$ 14,900	5/59	1 year
Rocket Observations of Solar Flare Emissions in Ultraviolet and X-Rays	See text for additional information	U. S. Naval Research Laboratory H. Friedman	$250,000	5/59	1 year
Solar Eclipse October 2, 1959	Transportation costs to eclipse site only	Office of Naval Research (for University of Minnesota) E. P. Ney J. R. Winkler	$ 15,000	9/59	1 month
Zodiacal Light in the Tropics	A specially designed Schmidt camera on top of a mountain in Bolivia makes accurate automatic recordings of the Zodiacal light. Observations are studied to learn distribution of interplanetary dust and electrons and its dependence on solar tivity.	University of New Mexico V. H. Regener	$22,900	5/59	2 years

Solar System Astronomy (cont.)

Project Title	Supplementary Description	Participants	Amount	Date of Grant	Duration
Photometric Atlas of the Solar Spectrum		Ohio State University W. E. Mitchell	$10,300	9/59	1 year
Indirect Flare Patrol	Effects on radio reception are monitored.	Rensselaer Polytechnic Institute R. Fleischer	$ 8,000	5/59	1 year
An Analysis of Solar Granulation		University of Texas F. N. Edmonds	$ 3,000	8/58	2½ years
Interferometric Study of Coronal Emission	Detailed study of line profiles of the solar corona to be made during solar eclipse of October 12, 1958, using interferometric methods combined with photo-multiplier detection.	University of Wisconsin J. E. Mack	$24,600	8/57	4 years
Investigation of Planetary Radio Emission	Observations and theory of radio emission from Jupiter and other planets. Simultaneous observations are made at different locations and at different frequencies.	Yale University H. J. Smith	$75,500	12/57	4 years

Extra-Solar System Astronomy

Project Title	Supplementary Description	Participants	Amount	Date of Grant	Duration
A Spectrographic Study of Eclipsing Binaries and of Beta Canis Majoris Variables		Brigham Young University D. M. McNamara	$10,400	6/58	2 years
Evolution of Close Binary Stars	Observational and theoretical studies are being made on spectroscopic binary stars and intrinsic variable stars.	University of California O. Struve	$34,400	6/57	3 years
A Search for Variable Stars in Galactic Clusters		University of California (O. Struve) C. R. Lynds	$ 4,800	12/57	2 years
Computation of Orbits in the Restricted Three-Body Problem	A theoretical investigation of the motion of gases which envelop close binary star systems.	University of California O. Struve	$20,000	3/59	2 years
Application of a Pressure-Scanning Fabry-Perot Interferometer to High Resolution Stellar Spectroscopy		University of California A. E. Whitford	$17,500	9/59	1½ years
Abundances of the Elements in High Velocity G Dwarf Stars		University of California G. Wallerstein	$ 5,000	9/59	2 years

Extra-Solar System Astronomy (cont.)

Project Title	Supplementary Description	Participants	Amount	Date of Grant	Duration
A Cooperative Supernova Search	The 48-inch Schmidt telescope at Mt. Palomar and telescopes at the University of Arizona are being used to search for supernovae in selected groups of galaxies. Observations of light variations and spectral characteristics are being made.	California Institute of Technology F. Zwicky	$ 7,400	3/59	1 year
Determination of the Radial Velocities of a Special Class of Blue Stars		California Institute of Technology F. Zwicky	$ 3,900	6/59	1 year
Infrared Studies of Faint Red Stars	Experiments are planned to produce faster stable infrared photographic emulsions, and to combine use of fast infrared emulsions with low dispersion objective prisms to study statistical distribution of M-stars near the galactic pole and in young globular clusters.	Case Institute of Technology V. M. Blanco	$16,900	6/59	2 years
Distribution of A-Type Stars in Selected Galactic Regions		Case Institute of Technology J. J. Nassau	$ 5,900	3/58	2 years
Spectroscopic Binaries in the nearest O-Associations	Photometric observations and radial velocity measurements of double stars in the associations of O and B stars in Orion, Cepheus and Scorpio.	University of Chicago A. Blaauw	$12,000	1/56	5 years
Program for Research on Galactic Clusters	Photometric and spectroscopic studies	University of Chicago W. A. Hiltner	$12,800	8/58	2 years

Extra-Solar System Astronomy (cont.)

Project Title	Supplementary Description	Participants	Amount	Date of Grant	Duration
Distribution of Interstellar Dust	Color excesses of B8 - F1 stars determined by narrow-band photoelectric photometry.	University of Chicago W. W. Morgan B. Strömgren	$18,600	6/57	2½ years
Problems of Theoretical Astrophysics	Theoretical investigations of the evolution of young stars, and the nature of the flow of superficial gas streams near binary stars.	University of Chicago K. H. Prendergast	$11,700	3/59	2 years
Simultaneous Three-Color Photometry of Faint O-B Stars	A three color spectrometer is used to determine reddening and spectral classes.	University of Chicago B. Strömgren R. H. Weitbrecht	$ 4,100	1/56	4 years
Astrometric Investigations	Observations of positions to obtain orbits of double stars, comets, asteroids, planetary satellites. Determination of luminosities of faint nearby stars.	University of Chicago G. Van Biesbroeck	$25,600	6/54	6 years
Faint Variable Stars in the Cygnus Cloud of the Milky Way	Photographic Methods are used.	Fordham University W. J. Miller	$10,900	6/58	3 years
Photometric Studies of Bright Galaxies		Harvard University G. de Vaucouleurs	$15,000	2/59	2 years
Theoretical Energy Levels and Transition Probabilities	A new theoretical scheme for describing atomic spectra has been developed.	Harvard University D. Layzer	$22,200	6/58	2 years
Henry Draper Spectral Types for the Southern Polar Cap	Spectral Classification of about 4,000 stars	Harvard University D. Menzel	$ 6,900	6/59	1½ years

Extra-Solar System Astronomy (cont.)

Project Title	Supplementary Description	Participants	Amount	Date of Grant	Duration
The Dynamical Evolution of Star Clusters		University of Illinois J. R. King	$ 4,200	6/58	2 years
Astrophysical Problems	Theoretical Studies of stellar atmospheres and interiors.	Indiana University M. H. Wrubel	$ 8,500	6/57	3 years
Photoelectric Photometry of A and F Stars		Institute for Advanced Study B. Strömgren	$19,800	10/59	2 years
Proper Motion Survey of the Northern Hemisphere	A Catalogue of proper motions is being published. Measurements of stars between magnitudes 8.0 and 16 or 17 are being made on 2 sets of homogeneous plates taken 30 years apart.	Lowell Observatory H. L. Giclas	$29,400	8/57	3 years
General Proper Motion Survey	Measurements of colors and positions of stars with large proper motions to locate blue stars and white dwarfs in the neighborhood of the sun. Two catalogues have been published. A third is in preparation.	University of Minnesota W. J. Luyten	$25,800	8/58	3 years
Relative Frequencies of G and K Giants with Weak and Strong CN Absorption	Distribution of Space Velocities is being studied. Continuation of a project started at Louisiana University.	Mount Holyoke College K. M. Yoss	$ 850	9/59	1 year
A Spectrographic Study of A-Type Stars near the north Galactic Pole		Ohio State University A. Slettebak	$ 3,500	10/57	2 1/6 years

Extra-Solar System Astronomy (cont.)

Project Title	Supplementary Description	Participants	Amount	Date of Grant	Duration
Astronomical Research in the Infrared	Observations of the variations of infrared light during eclipses of eclipsing binary systems.	University of Pennsylvania W. Blitzstein F. B. Wood	$13,600	8/58	2 years
Determination of the Parallaxes of Dwarf Stars		University of Pittsburgh N. Wagman	$ 6,000	3/59	4 years
The Scattering of Light by Small Particles	An analogue method is used employing microwave techniques.	Rensselaer Polytechnic Institute J. M. Greenberg	$43,400	6/58	2 1/3 years
Astrometric Study of Nearby Stars	Continuation of a program of measurements of stellar positions to determine trigonometric parallaxes and to increase knowledge of masses and luminosities of stars.	Swarthmore College P. Van de Kamp	$27,000	12/57	2 years
Search for Spectrum Lines in Radio Astronomy	A parametric amplifier is being developed for this purpose. It is to be used on the U. of Michigan 85-foot radio telescope.	University of Toledo R. Chipman	$22,800	6/59	2 years
An Investigation of the Structure of the Galaxy Through the Study of the nearer association of OB Stars		Vanderbilt University C. K. Seyfert	$14,000	12/57	2 years
Astrochemical Research	Investigation of Chemical properties of matter at low temperatures and densities.	Wayne State University B. Donn	$13,500	8/57	2 1/3 years

Extra-Solar System Astronomy (cont.)

ASTRONOMY

Extra-Solar System Astronomy (cont.)

Project Title	Supplementary Description	Participants	Amount	Date of Grant	Duration
Determination of Systematic Errors and new Plate Constants of Northern Hyderabad Zone of the Astrographic Catalogue	Continuation of a project started at Georgetown U.	Wesleyan University H. K. Eichhorn	$ 6,700	10/59	1 year
Three-Color Studies of Eclipsing Binaries		University of Wisconsin C. M. Huffer	$ 5,600	6/59	1 year
Absolute Calibration of the Energy Distribution of Astronomical Radiation Sources		University of Wisconsin A. D. Code	$16,700	3/58	2 years
Constitution of the Late-Type Stellar Atmospheres and Interiors		Yale University R. Wildt	$ 7,500	12/57	2 years

General Support of Science in Space

Project Title	Supplementary Description	Participants	Amount	Date of Grant	Duration
Space Science Board	This is a consultative and advisory group of scientists. Support is being provided jointly by the National Science Foundation and the National Aeronautics and Space Administration. See text for additional information.	National Academy of Sciences S. D. Cornell	$220,800	8/58	10 months Renewal is being negotiated.

Project Title	Supplementary Description	Participants	Amount	Date of Grant	Duration
Large Air Shower Detector	Continuation of IGY program to measure cosmic ray showers.	University of California P. H. Barrett	$ 6,900	5/59	1 year
Time Variations of Neutron, Hard and Soft Cosmic Ray Components	IGY	University of California W. B. Fretter	$ 5,000	5/59	1 year
Primary Cosmic Radiation	IGY Balloon flights to measure proton and alpha particle intensity during a solar flare.	University of Chicago P. Meyer	$ 20,100	5/59	1 year
Cooperative Emulsion Flight for High Energy Events	Studies of cosmic Primary Particles. To fly three stacks of sheet emulsion in a balloon at high altitudes to carry out studies in high energy range. Will give information on recent galactic theories of cosmic origins.	University of Chicago M. Schein	$625,000	5/58	3 years
Primary Cosmic Ray Studies Using Nuclear Emulsions	Cosmic ray studies of particles at high altitudes.	College of Puget Sound M. E. Nelson	$ 7,100	2/58	2 years
Cosmic Ray Shower and Particle Study	To measure energies of μ mesons entering magnetic spectrometer from the air and observe their interactions in matter.	Cornell University K. I. Greisen	$ 31,800	6/59	1 year
Asymmetry of Extensive Air Showers		University of Denver M. Iona	$ 12,600	3/55	2 years
Structure of Solar Magnetic Fields	Optical telescopsic methods are used to get information about the sun's magnetic fields.	De Pauw University M. Correll	$ 23,100	9/59	3 years

Project Title	Supplementary Description	Participants	Amount	Date of Grant	Duration
Low Energy Primary Cosmic Rays at Thule	Continuation of IGY to study cosmic rays of low energy that come in through a "magnetic window". Measurements are to be continued through a solar cycle.	The Franklin Institute M. A. Pomerantz	$ 10,600	5/59	1 year
Cosmic Ray Studies at High Altitudes	Six or eight long-duration high altitude balloon flights near the north magnetic pole to study radiations of low energy from the sun, the daily variation of cosmic ray intensity, etc.	State University of Iowa K. A. Anderson	$ 40,400	5/59	1 year
Elementary Particles Reactions in Photographic Emulsions	Balloon flights on nature of high energy cosmic ray particles and particles from accelerators.	Marquette University A. G. Barkow	$ 15,600	9/59	2 years
Cosmic Ray Telescope at Thule	A cosmic ray telescope is being operated at Thule, Greenland to measure solar variation, cosmic ray storms and forbush decreases, solar flare increases, annual variation of cosmic radiation.	University of Maryland W. Webber	$ 6,400	4/59	1 year
Cosmic Ray Air Shower Research	Deals with galactic origins of very high energies.	Massachusetts Institute of Technology B. Rossi	$134,300	9/57	2+ years
Continuous Balloon Monitoring of Cosmic Rays and Solar Phenomena	Balloon flights to maintain aloft at all times instruments for recording cosmic ray events and variation of total intensity of cosmic rays with solar phenomena.	University of Minnesota E. P. Ney J. R. Winckler	$350,000	5/59	1 year

Project Title	Supplementary Description	Participants	Amount	Date of Grant	Duration
Cosmic Ray Monitoring	A monitoring station will be operated to the next sunspot minimum.	University of Nebraska R. L. Chasson	$17,200	5/59	1 year
Variations in Cosmic Ray Intensities	Information about earth and sun to be obtained by studying correlations of intensities with solar and terrestrial changes.	Nebraska Wesleyan University W. R. French, Jr.	$ 7,300	10/58	2 years
Forbush-type Decreases in Cosmic Rays	Solar effects on neutron flux	University of New Hampshire J. A. Lockwood	$ 3,200	4/59	16 months
Heavy Nuclei Component of Cosmic Radiation		New Mexico College R. E. McDaniel	$ 4,800	12/57	2 years
Time Variations of Cosmic Radiation at High Altitudes	Related to origin of cosmic rays. Terrestrial or solar effects.	University of New Mexico V. H. Regener	$33,900	9/58	3 years
Cosmic Ray Neutron Monitor in Alaska		New York University S. A. Korff	$34,600	4/59	2 years
Emulsion Investigations of Primary Cosmic Rays		Ohio University C. A. Randall	$17,500	6/57	2 years
Heavy Primaries in Cosmic Radiation		St. Benaventure University Z. O'Friel	$ 6,600	2/57	2 years
Primary Cosmic Ray Studies Using Nuclear Emulsions		Seattle Pacific College D. D. Kerlee	$12,000	2/58	2 years

Project Title	Supplementary Description	Participants	Amount	Date of Grant	Duration
Planetary Earth Albedo	Theoretical and observational study of radiation emerging from the top of the atmosphere toward outer space.	University of California Z. Sekera	$ 58,700	11/58	2 years
Interdisciplinary Studies in Solar-Upper Atmosphere Relationships	Solar-terrestrial relationships with emphasis on cross-connections among auroral, airglow, ionospheric and geomagnetic phenomena. An effort to define the nature of solar emissions and their influence on geophysical phenomena.	University of Colorado W. O. Roberts	$125,000	8/59	3 years
All-Sky Camera Operation	Continuation of IGY program. One of 13 locations.	Cornell University C. Gartlein	$ 11,500	6/59	6 months
Visual Auroral Observations in the United States		Cornell University C. Gartlein	$ 8,000	5/59	1 year
Visual Auroral Observations in the Antarctic		Cornell University C. Gartlein	$ 5,500	5/59	1 year
Effect of Variable Solar Activity on Atmospheric Circulation	Interrelation of solar data with climatic data.	Massachusetts Institute of Technology H. Willett	$26,000	9/58	2 years
An Experimental Study of Photodetachment Cross Sections for Negative Halogen Ions	Measurements of changes in photon flux and electron density have important applications in upper atmosphere work.	Pennsylvania State University H. D. Rix	$59,800	11/59	2 years

Project Title	Supplementary Description	Participants	Amount	Date of Grant	Duration
Preferential Adsorption of Orthohydrogen and of Paradeuterium		University of Arizona D. Chapin	$ 36,500	3/59	3 years
High Pressure-High Temperature Studies		Brigham Young University H. T. Hall	$ 85,000	8/58	3 years
Low Temperature Chemistry		California Institute of Technology G. W. Robinson	$ 45,800	10/59	3 years
Thermodynamic and Magnetic Properties at Low Temperatures		University of California W. F. Giauque	$207,300	10/56	3 years
Fast Gas-Phase Reactions		University of California H. Johnston	$ 54,300	2/59	3 years
Properties of Matter at Low Temperatures		University of Chicago E. A. Long	$ 56,500	3/57	3 years
Preparation and Reactions of Free Radicals		Georgetown University F. O. Rice	$ 32,300	9/59	1 year
Unstable Intermediates in Gas Reactions		Harvard University G. B. Kistiakowsky	$ 15,000	8/57	2 years
High Temperature Molecular Spectroscopy		Harvard University W. Klemperer	$ 40,000	9/58	3 years

Project Title	Supplementary Description	Participants	Amount	Date of Grant	Duration
Oxidation of Hydrocarbons and Related High Temperature Reactions		Ohio State University E. W. Malmberg	$18,600	8/59	2 years
Low Temperature Research in Chemistry		Pennsylvania State University J. G. Aston J. J. Fritz	$33,200	9/59	2 years
High Temperature Inorganic Chemistry		Temple University A. V. Grosse	$54,300	10/58	2 years
Vaporization Reactions		University of Washington N. W. Gregory	$24,800	9/58	3 years
Gas-Solid Interactions at High Temperatures		University of Wisconsin J. L. Margrave	$44,500	2/59	3 years

ENGINEERING SCIENCES

Project Title	Supplementary Description	Participants	Amount	Date of Grant	Duration
Gaseous Radiation	Study of radiant heat transfer in gases at elevated temperatures.	University of California J. T. Gier R. V. Dunkle A. K. Oppenheim	$11,700	12/58	1 year
Effect of Ultrasonic Vibrations on Liquid Heat and Mass Transfer	Study of conditions which influence the nature of boundary layers to attempt to correlate resulting heat transfer data with mass transfer data.	University of California E. E. Petersen	$12,700	11/58	2 years
Plastic Strength of Structures under Repeated Loads	Study problems of alternating plasticity and incremental collapse.	University of California E. P. Papov	$21,800	8/58	2 years
Jet Reactor Concentration and Temperature Fluctuations	Experimental studies to obtain data on concentration fluctuations, temperature fluctuations, and their correlation which will advance understanding of mixing process in jets, hydrodynamics of reacting fluids, combustion phenomena, and turbulent flames.	University of California J. M. Prausnitz	$11,800	10/58	2 years
Stability and Transition in Fluid Flow	Study of circular Couette flow between concentric rotating cylinders with emphasis on spiral turbulence, stability criteria, and non-linear interaction.	California Institute of Technology D. Coles	$57,000	10/58	3 years
Equilibrium Measurements in Reactive Metal Systems at High Temperatures	Systems to be studied are Zr-Mo binary system and the Zr-Mo-H ternary system. For melting, levitation technique will be used.	Carnegie Institution of Technology C. L. McCabe	$47,400	2/59	3 years

Project Title	Supplementary Description	Participants	Amount	Date of Grant	Duration
Heat, Mass and Momentum Transfer in Rotating Systems	To study in further detail the influence of fluid rotation in a stationary tube.	University of Colorado F. Kreith	$52,400	2/59	3 years
Solar Bursts at Meter Wave Lengths	Investigation of Faraday rotation in the corona, statistical study of linearly polarized bursts, study of position and polarization of spectral type IV bursts.	Cornell University M. H. Cohen	$29,500	11/58	19 months
IGC-1959, Whistlers-East Project	Study of atmospheric, low frequency, radio signals whose origin is attributed to lightning flashes.	Dartmouth College M. G. Morgan	$39,800	5/59	1 year
Thermal Forces in Materials of High Thermal Conductivity	Investigation to obtain experimental data on theories of thermal repulsion.	Georgia Institute of Technology C. Orr, Jr.	$19,000	1/59	2 years
High Temperature, High Speed Gas Dynamics	Theoretical and experimental studies of electromagnetic acceleration and magnetic confinement of high temperature gases.	Harvard University H. W. Emmons	$28,300	12/58	1 year
Electrohydrodynamics and Related Phenomena	Investigation of forces and torques produced by electric fields and currents in dielectric fluids.	Harvard University H. W. P. King	$17,200	12/57	2 years
Production of Uniform High Intensity Ultrasonic Fields	Study of high intensity ultrasonic fields to produce larger uniform fields, to further reduce variations in focused and unfocused fields, and to find materials more suitable for producing high intensity fields under continuous operation.	University of Illinois W. J. Fry F. S. Brunschwig	$44,800	2/59	2 years

Project Title	Supplementary Description	Participants	Amount	Date of Grant	Duration
Thermal Stresses in Plates and Shells		Illinois Institute of Technology F. Essenburg	$15,700	6/59	2 years
Adsorption of Gases and Vapors at Elevated Temperatures and Pressures	Adsorption of gases like nitrogen, oxygen, carbon dioxide, hydrogen at pressures up to 1000 psi at room and higher temperatures.	State University of Iowa K. Kammermeyer	$27,700	9/58	2 years
A Study of Phase and Volumetric Behavior at Extremely Low Temperatures	Study of phase and volumetric behavior of normally gaseous systems in the temperature range from 20° to 150° R and up to 100 atmospheres.	University of Kansas F. Kurata	$54,000	7/59	2 years
Interdepartmental Research Program on Ionized Plasmas	Study of gaseous electronic processes, plasma statics, magnetohydrodynamics of compressible and incompressible fluids and ionospheric physics.	Massachusetts Institute of Technology W. P. Allis	$500,000	7/59	2 years
Ignition and Combustion of Fuel Sprays		Massachusetts Institute of Technology C. F. Taylor A. R. Rogowski	$37,500	10/58	2 years
Cryogenic Chemistry	Research centered around the stability of organic free radicals (produced by thermal or photochemical means) and the properties of liquid carbon monoxide.	Massachusetts Institute of Technology R. C. Reid	$19,300	2/59	2 years

Project Title	Supplementary Description	Participants	Amount	Date of Grant	Duration
Oxidation Kinetics in Porous-Walled Tubes	Study of hydrocarbon oxidation kinetics in a reaction vessel whose walls are made of a finely porous material through which an inert gas can be passed to eliminate diffusion of reacting species.	Massachusetts Institute of Technology C. N. Satterfield R. C. Reid	$11,400	10/58	2 years
Study of Basic Mechanism of Flame Stabilization in a Boundary Layer	Theoretical study of interactions between a flame and a flow field, and theoretical and experimental studies of the structure and propagation of a two-dimensional laminar flame near a heat sink at reduced pressures.	Massachusetts Institute of Technology Tau-Yi Toong	$29,800	1/59	2 years
Origin of Meteorites		Massachusetts Institute of Technology H. H. Uhlig	$22,400	8/56	3 years
Analog for Transient Thermal Stresses	An analogy between thermal stresses in an elastic material and stresses set up in photoelastic plastics. Will permit transient stress analysis.	University of Michigan S. K. Clark	$10,700	10/58	1 year
Theoretical Investigation of Ram Jet Buzz		University of Minnesota C. C. Chang	$27,800	2/59	2 years
Effect of High Temperatures on Engineering Materials		New York University G. Gerard	$10,000	6/57	1 year

Project Title	Supplementary Description	Participants	Amount	Date of Grant	Duration
Titanium-Aluminum and Titanium-Manganese Alloys	Study of thermodynamic properties of titanium-aluminum and titanium-manganese alloys.	New York University K. Komarek	$18,800	8/57	2 years
Condensation Shock	An analytical investigation of the condensation in a polyphase system and the calculation of the speed of condensation and increase of entropy through condensation shock by statistical mechanics.	North Carolina State College J. F. Lee	$22,800	8/57	2 years
Diffusion Coefficients of Gases at High Pressure	Measurement of diffusion coefficients of mixtures of carbon dioxide and argon as a function of pressure up to 1000 atmospheres by means of radioactive tracer techniques.	Purdue University C. O. Bennett	$20,000	10/58	2 years
Characteristics of Structural Elements at Elevated Temperatures		Purdue University H. Lo R. J. H. Ballard	$50,000	11/58	3 years
Thermodynamic Properties of Titanium Alloys	Development of a general method of measuring thermodynamic properties of alloys by measuring hydrogen solubilities as a function of alloy composition and temperature by a modified Sieverts technique.	Purdue Research Foundation R. Schuman, Jr.	$17,000	4/55	2 years
Viscosities of Hydrocarbon Mixtures at High Pressures	Correlation for the viscosity of light hydrocarbon mixtures based on corresponding theories of state involving the actual viscosity at one atmosphere, the compressibility factor, the reduced temperature, and the reduced pressure.	Rice Institute R. Kobayashi	$17,800	4/59	3 years

Project Title	Supplementary Description	Participants	Amount	Date of Grant	Duration
Thermodynamic Properties of Hydrocarbon and Hydrogen Mixtures	Study of the volumetric behavior of gaseous hydrocarbon mixtures over a range of temperatures between 100°F and 300°F, and at pressures to to 10,000 atmospheres.	Rice Institute R. Kobayashi T. Lenand	$13,100	10/58	3 years
Effect of Kinetics on Forced-Convective Heat Transfer to Reacting Gases		Stanford University D. M. Mason	$25,600	2/59	3 years
The Kinetics of Reactions Between a Single-Component Gas and a Single-Component Liquid		Syracuse University R. V. Gill W. N. Jelinek	$20,200	6/59	2 years
A Study of Combustible Mixture Formation with Liquid Fuels	Investigation will use a unique photographic technique utilizing fluorescent dyes which cause the fuel droplets in the spray to fluoresce and become primary sources of light when excited by means of short duration, high intensity light.	University of Wisconsin P. S. Myers	$57,600	1/59	3 years
High Pressure Properties of Materials	Study of compressibility, phase equilibria, and solubility of gases in metals at pressures up to 10,000 atmospheres	Yale University B. F. Dodge	$41,400	10/58	3 years

Project Title	Supplementary Description	Participants	Amount	Date of Grant	Duration
Physical Properties of Liquid Hydrocarbons at Pressure and Temperature	Determination of the viscosity of n-paraffin hydrocarbons in the range C_6C_{16} for a temperature range of 60°F to 250°F and a pressure range of 0 psi to 6000 psi.	University of California C. J. Vogt	$ 5,900	9/59	1 year
Mass Transfer Mechanism	Study of the mechanism of mass transfer, and the related fluid dynamic and physical chemical phenomena.	University of California C. R. Wilks A. Acrivos J. M. Prausnitz E. E. Petersen	$125,000	9/59	3 years
Free-Molecule Transfer Processes at High Speeds	Study of the energy-transfer and momentum transfer processes at solid surfaces exposed to high-speed free-molecule flows.	University of California E. L. Knuth	$ 75,800	9/59	3 years
Fundamental Study of a Submerged and non-submerged Three-Dimensional Jet Impinging upon a Normal Plane	An analysis of the mechanics of jet diffusion, shear stresses and eddy viscosity developed along a surface deflecting a jet.	Colorado State University Research Foundation G. L. Smith	$ 28,300	7/59	2 years
Momentum and Energy Transport Between Plates of Unequal Roughness		Cornell University H. N. McManus, Jr.	$ 35,700	9/59	3 years
Fluid Dynamics of Ablating Bodies	Theoretical and experimental studies of ablating bodies using salt, sugar, plaster, ice, and other materials.	University of Florida D. F. Williams	$ 32,900	9/59	3 years
The Effect of Transverse Vibrations of a Heated Surface on Heat Transfer in Free Convection		University of Michigan Research Institute J. A. Clark	$ 30,800	8/59	2 years

Project Title	Supplementary Description	Participants	Amount	Date of Grant	Duration
Thermodynamic Properties of Light Hydrocarbons at High Pressure and Low Temperatures	Enthalpy-pressure-temperature measurements on hydrocarbons in the single phase region down to a temperature of -200°F and up to a pressure of 2000 psi.	University of Michigan Research Institute D. L. Katz	$37,200	7/59	3 years
Photographic Study of Unusual Flow Patterns in Turbulent Shear Flow	Use of the tracer-displacement technique to reveal unusual flow patterns at velocities above the critical Reynolds number.	North Carolina State College K. O. Beatty F. M. Richardson	$14,000	9/59	1 year
Turbulent Motion and Mixing		Ohio State University R. S. Brodkey	$21,200	7/59	2 years
Kinetics of Gas-Liquid Reactions		University of Oklahoma Research Institute R. H. Perry	$18,700	9/59	2 years
Mechanism of Turbulence in Free Surface Flow		Purdue Research Foundation J. W. Delleur	$21,700	7/59	2 years
New Experimental Methods in Gasdynamics		Rensselaer Polytechnic Institute J. V. Foa	$11,000	9/59	1 year
Heat Transfer from Impinging Air Jets to a Plane Wall	Experimental and theoretical determination of local heat transfer coefficients, and velocity and temperature profiles for air jets directed at several angles onto a heated iso-thermal plate.	Stanford University R. H. Eustis	$53,200	9/59	3 years

Project Title	Supplementary Description	Participants	Amount	Date of Grant	Duration
Pressure-Volume-Temperature Relations of Gases at Low Pressures	Pressure-volume-temperature behavior of gases at pressures from 0.1 to 2.0 atmospheres and from -40°C to 100°C.	University of Texas J. J. McKetta, Jr.	$31,800	7/59	3 years
Diffusion in an Optical Absorption by III - V Components		University of Washington L. Y. Wei	$32,800	9/59	2 years

Project Title	Supplementary Description	Participants	Amount	Date of Grant	Duration
Tektite Research	To examine many of the major tektite areas of the earth and to look for field evidence of their age and origin.	University of Texas V. Barnes	$36,000	10/59	2 years

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ATTACHMENT

In compliance with SEC. 206 (c) of the National Aeronautics and Space Act of 1958, attached are "such recommendations for additional legislation as the Administrator or the President may consider necessary or desirable..."

(a) A BILL

To amend the National Aeronautics and Space Act of 1958, as amended, and for other purposes.

(b) SECTIONAL ANALYSIS

of a bill

To amend the National Aeronautics and Space Act of 1958, as amended and for other purposes.

(c) MARKED COPY OF

Public Law 85-568, 85th Congress, H.R. 12575, July 29, 1958

(National Aeronautics and Space Act of 1958)

A BILL

To amend the National Aeronautics and Space Act of 1958, as amended, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the National Aeronautics and Space Act of 1958, as amended (72 Stat. 426), is amended as follows:

(1) Section 102 is amended --

(A) by striking out subsection 102(b) and the first clause in subsection 102(c) ending with the colon, and inserting in lieu thereof the following:

"(b) The Congress declares that the general welfare and security of the United States require that adequate provision be made for the exploration, scientific investigation, and utilization of space for peaceful purposes, and for research into problems of flight within and outside the earth's atmosphere. The Congress further declares that such activities shall be conducted so as to contribute materially to the following objectives:";

(B) by inserting the following new subsection:

"(c) The Congress further declares that the exploration, scientific investigation, and utilization of space for peaceful purposes shall be the responsibility of, and shall be directed by, a civilian agency."

(2) Section 103 is amended to read as follows:

"Section 103. As used in this Act --

"(1) the term 'spacecraft' means devices, manned and unmanned, which are designed to be placed into an orbit about the earth or into a trajectory to another celestial body, including all instrumentation, propulsion, and guidance contained therein;

"(2) the term 'launch vehicles' means devices which propel and guide spacecraft into an orbit about the earth or into a trajectory to another celestial body and includes all stages of multi-stage rockets used for such purposes;

"(3) the term 'space vehicles' means

spacecraft, launch vehicles, and all other vehicles, except ballistic missiles, capable of flight without support from or dependence upon the earth's atmosphere; together with related equipment, devices, components, and parts; and

"(4) the term 'aeronautical vehicles' means all vehicles, other than space vehicles, designed for flight, together with related equipment, devices, components, and parts.

(3) Title II is amended by striking out the heading and inserting in lieu thereof the following:

"TITLE II - NATIONAL AERONAUTICS AND SPACE ADMINISTRATION".

(4) Section 201 is repealed.

(5) Section 202 is amended by changing the number to "201" and striking out the caption "National Aeronautics and Space Administration" and inserting in lieu thereof "Administrator and Deputy Administrator".

(6) Section 203 is amended --

(A) by changing the number to "202";

(B) by striking out paragraph 203(a)(1) and inserting in lieu thereof the following:

"(1) conduct research into problems of flight within and outside the earth's atmosphere with a view to their practical solution;

"(2) conduct such activities as may be required for the exploration, scientific investigation, and utilization of space for peaceful purposes, and develop space vehicles for use in such activities;";

(C) by changing the numbers of paragraphs (2) and (3) of subsection 203(a) to "(3)" and "(4)" respectively;

(D) by amending the clause following the first semicolon in paragraph 203(b)(3) to read as follows:

"to lease to others such real and personal property, and such lease may provide, notwithstanding section 321 of the Act of June 30, 1932 (40 U.S.C. 303b), or any other provision of law,

for the maintenance, protection, repair, or restoration, by the lessee, of the property leased, or of the entire unit or installation where a substantial part of it is leased, as part or all of the consideration for the lease;";

(E) by inserting in paragraph 203(b)(6) immediately before "to transfer to" the following:

"to obtain by contract for,";

(F) by adding at the end of subsection 203(b) the following new paragraph (14):

"(14) to acquire releases, before suit is brought, for past infringement of patents."

(7) Section 204 is repealed.

(8) Section 205 is amended by changing the number to "203."

(9) Section 206 is amended --

(A) by changing the number to "204.";

(B) by repealing subsections (b) and (c);

(C) by changing the designation of subsection (d) to "(b)."

(10) Section 304 is amended --

(A) by inserting in subsection 304(b)

immediately after "so certified by the Council or the Administrator," the following:

"or designee thereof,";

(B) by striking out of the first sentence of subsection 304(b) the words "any member, officer, or employee of the Council, or" and the words "as the case may be," and the words "Council or the" and "Council or" wherever they appear.

(11) Section 305 is amended to read as follows:

"Sec. 305. (a) Each contract or other arrangement entered into by the Administration, and each subcontract at all tiers thereunder, which has as one of its purposes the performance of experimental, developmental, or research work, shall contain provisions prescribed by the Administrator governing the disposition of the rights to inventions conceived or first actually reduced to practice thereunder in a manner calculated to protect the public interest and the equities of the contractor.

"(b) The Administrator or his designee may, whenever the contract provides for the vesting of title to an invention in the United States, waive the rights of the United States to such invention on such terms and conditions as he determines to be in the best interest of the United States: Provided, That any such waiver shall be subject to the reservation of an irrevocable, nonexclusive, non-transferable, royalty-free license for the practice of such invention throughout the world by or on behalf of the United States or any foreign government pursuant to any treaty or agreement with the United States.

"(c) The Administrator may waive, upon the same terms as provided in subsection (b) of this section, all or any part of the rights of the United States to inventions made in the performance of any work under any contract heretofore entered into by or for the Administration which have become the exclusive property of the United States. Any contract heretofore entered into by or for the Administration, on which final payment has

not been made, may be amended without consideration to effectuate the purposes of this section: Provided, That no such amendment shall affect the status of inventions which have become the exclusive property of the United States.

"(d) The Administration shall be considered a defense agency of the United States for the purpose of chapter 17 of title 35 of the United States Code."

(12) Section 306 is amended by amending the first two sentences to read as follows:

"Sec. 306. (a) Subject to the provisions of this section, the Administrator is authorized, upon his own initiative or upon application, to make a monetary award, in such amount and upon such terms as he shall determine to be warranted, to any individual, partnership, corporation, association, institution, or other entity for any scientific or technical contribution to the Administration which is determined by the Administrator to have significant value in the conduct of aeronautical and space activities. Each

application made for any such award shall be referred to an Inventions and Contributions Board which shall be established by the Administrator within the Administration."

(13) A new section 308, captioned "Indemnification", is added to Title III as follows:

"Sec. 308. (a) With the approval of the Administrator, or his designee, any contract of the Administration for research or development, or both, may provide that the United States will indemnify the contractor against either or both of the following, but only to the extent that they arise out of the direct performance of the contract and to the extent not compensated by insurance or otherwise:

"(1) Claims (including reasonable expenses of litigation or settlement) by third persons, including employees of the contractor, for death, bodily injury, or loss of or damage to property, from a risk that the contract defines as unusually hazardous.

"(2) Loss of or damage to property of

the contractor from a risk that the contract defines as unusually hazardous.

"(b) A contract, made under subsection (a), that provides for indemnification must also provide for --

"(1) Notice to the United States of any claim or suit against the contractor for the death, bodily injury, or loss of or damage to property; and

"(2) Control of or assistance in the defense by the United States, at its election, of that suit or claim.

"(c) No payment may be made under subsection (a) unless the Administrator, or his designee, certifies that the amount is just and reasonable.

"(d) Upon approval by the Administrator, payments under subsection (a) may be made from --

"(1) funds obligated for the performance of the contract concerned;

"(2) funds available for research or development, or both, and not otherwise obligated;

or

"(3) funds appropriated for those payments."

(14) A new section 309, captioned "Coordination and Cooperation," is added to Title III as follows:

"Sec. 309. (a) Nothing in this Act shall preclude the Department of Defense from undertaking such activities involving the utilization of space as may be necessary for the defense of the United States, including the development of weapons systems utilizing space vehicles and the conduct of supporting research connected therewith.

"(b) In order to accomplish the most efficient utilization of resources, responsibility for the development of each new launch vehicle, whether intended for use by the Administration or the Department of Defense or both, shall be assigned by the President to either the Administration or

the Department of Defense.

"(c) The Administration and the Department of Defense shall advise and consult with each other on all matters within their respective jurisdictions relating to activities involving the utilization of space and research and development connected therewith and shall keep each other fully and currently informed with respect to such activities.

"(d) If the Secretary of Defense concludes that any request, action, proposed action, or failure to act on the part of the Administrator is adverse to the responsibilities of the Department of Defense, or the Administrator concludes that any request, action, proposed action, or failure to act on the part of the Department of Defense is adverse to the responsibilities of the Administration, and the Administrator and the Secretary of Defense are unable to reach an agreement with respect thereto, either the Administrator or the Secretary of Defense may

refer the matter to the President for his decision.

Section 2. Section 799 of title 18 of the United States Code is amended by striking out "aircraft, missile, spacecraft, or similar vehicle," and inserting in lieu thereof "aeronautical or space vehicle,".

Section 3. The Act of April 29, 1941, as amended (40 U.S.C. 270e), is amended by inserting immediately before "or the Secretary of the Treasury" the words "the Administrator of the National Aeronautics and Space Administration," and by inserting immediately before "or Coast Guard" the words "National Aeronautics and Space Administration,".

SECTIONAL ANALYSIS

of a bill

To amend the National Aeronautics and Space Act of 1958, as amended, and for other purposes.

Section 1. This section consists of fourteen subsections which amend the National Aeronautics and Space Act as follows:

(1) This subsection amends subsections 102 (b) and (c) of the Act. Paragraph (A) of the proposal would declare that the general welfare and security of the United States require that adequate provision be made for the exploration, scientific investigation, and utilization of space for peaceful purposes and for research into problems of flight within and outside the earth's atmosphere. Paragraph (B) would further declare that the responsibility for the exploration, scientific investigation and utilization of space for peaceful purposes shall be the responsibility of, and shall be directed by, a civilian agency.

(2) This subsection amends section 103 of the Act. The definitions of "aeronautical and space activities" and "aeronautical and space vehicles" would be repealed. New definitions of "spacecraft," "launch vehicles," "space vehicles" and "aeronautical vehicles" would be enacted.

(3) This subsection relates to the title of Title II of the Act. A new title, "National Aeronautics and Space Administration," would be enacted in place of the title "Coordination of Aeronautical and Space Activities."

(4) This subsection repeals section 201 of the Act. It would eliminate provisions relating to the National Aeronautics and Space Council and the statement of Presidential duties upon which the Council is required to advise the President.

(5) This subsection relates to section 202 of the Act. The number of the section would be changed to "201" as a consequence of repealing section 201.

(6) This subsection amends section 203 of the Act. Paragraph (A) would change the number of the section to "202." Paragraph (B) would expand and make more specific the statement of functions of NASA. Paragraph (C) would change the numbers of paragraphs (2) and (3) of subsection 203(a) of the Act to "(3)" and "(4)" respectively as a consequence of expanding the statement of functions. Paragraph (D) would enact additional language in paragraph 203(b)(3) of the Act to provide NASA with authority, similar to 10 U.S.C. 2667(b)(5) available to the military departments, to lease real property to others for a non-monetary consideration. Paragraph (E) would enact a clarifying phrase in paragraph 203(b)(6) of the Act to provide express authority for other agencies of the Government to enter into contracts for the benefit of NASA. Paragraph (F) would enact a new paragraph at the end of subsection 203(b) of the Act to provide NASA with authority, similar to 10 U.S.C. 2386 available to the military departments, to settle past patent infringement claims.

(7) This subsection repeals section 204 of the Act. It would eliminate the Civilian-Military Liaison Committee.

(8) This subsection relates to section 205 of the Act. The number of the section would be changed to "203" as a consequence of repealing section 204 of the Act.

(9) This subsection amends section 206 of the Act. Paragraph (A) would change the number of the section to "204." Paragraph (B) would repeal subsections 206(b) and (c) of the Act, eliminating the requirement for a report from the President to the Congress in January of each year. Paragraph (C) would change the designation of subsection (d) to "(b)" as a consequence of repealing subsections (b) and (c).

(10) This subsection amends section 304 of the Act. Paragraph (A) would correct a technical defect in the Act by adding the phrase "or designee thereof" to expressly authorize the Administrator to designate other

officials to make certain routine determinations. Paragraph (B) would delete the references to the National Aeronautics and Space Council as a consequence of repealing section 201 of the Act.

(11) This subsection repeals section 305 of the Act concerning property rights in inventions. New provisions similar to those contained in the National Science Foundation Act of 1950 (42 U.S.C. 1871) would be enacted.

(12) This subsection amends section 306 of the Act to provide for establishment of an Inventions and Contributions Board, since the present provision would be eliminated by repeal of subsection 305(f) of the Act.

(13) This subsection would add a new section 308 to Title III of the Act providing NASA with authority, under the caption "Indemnification," to indemnify contractors against unusually hazardous risks arising out of research and development contracts. The authority would be coextensive with that of the military departments contained in 10 U.S.C. 2354.

(14) This subsection would add a new section 309 to Title III of the Act under the caption "Coordination and Cooperation." The new section would state that the Department of Defense is not precluded by anything in the Act from undertaking such activities involving the utilization of space as may be necessary for the defense of the United States, including the development of weapons systems utilizing space vehicles and the conduct of supporting research. It also provides that the President shall assign responsibility for the development of each new launch vehicle, regardless of its intended use, to either NASA or the Department of Defense. Furthermore, the new section would substantially reenact subsection 204(b) of the Act to require that NASA and the Department of Defense advise and consult and keep each other informed with respect to space activities and related research and development within their respective jurisdictions. Finally, it would

substantially reenact subsection 204(c) of the Act to provide that the Administrator of NASA and the Secretary of Defense may refer to the President for decision those matters concerning their respective areas of responsibility on which they are unable to reach agreement.

Section 2. This section would amend 18 U.S.C. 799 which provides criminal penalties for violations of NASA's regulations for the protection or security of property and equipment, to conform to the definitions contained in this bill in the proposed amendment to section 103 of the Act. The terms "aircraft, missile, spacecraft, or other similar vehicle" would be replaced by "aeronautical or space vehicle."

Section 3. This section would amend 40 U.S.C. 270e to give NASA the same authority as is available to the military departments and the Coast Guard to waive payment and performance bonds otherwise required in construction contracting.

Public Law 85-568
85th Congress, H. R. 12575
July 29, 1958

AN ACT

To provide for research into problems of flight within and outside the earth's atmosphere, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

National Aeronautics and Space Act of 1958.

TITLE I—SHORT TITLE, DECLARATION OF POLICY, AND DEFINITIONS

SHORT TITLE

SEC. 101. This Act may be cited as the "National Aeronautics and Space Act of 1958".

DECLARATION OF POLICY AND PURPOSE

SEC. 102. (a) The Congress hereby declares that it is the policy of the United States that activities in space should be devoted to peaceful purposes for the benefit of all mankind.

(b) The Congress declares that the general welfare and security of the United States require that adequate provision be made for aeronautical and space activities. The Congress further declares that such activities shall be the responsibility of, and shall be directed by, a civilian agency exercising control over aeronautical and space activities sponsored by the United States, except that activities peculiar to or primarily associated with the development of weapons systems, military operations, or the defense of the United States (including the research and development necessary to make effective provision for the defense of the United States) shall be the responsibility of, and shall be directed by, the Department of Defense; and that determination as to which such agency has responsibility for and direction of any such activity shall be made by the President in conformity with section 201 (e). 72 Stat. 426.

(c) The aeronautical and space activities of the United States shall 72 Stat. 427.
be conducted so as to contribute materially to one or more of the following objectives:

(1) The expansion of human knowledge of phenomena in the atmosphere and space;

(2) The improvement of the usefulness, performance, speed, safety, and efficiency of aeronautical and space vehicles;

(3) The development and operation of vehicles capable of carrying instruments, equipment, supplies, and living organisms through space;

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

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

(6) The making available to agencies directly concerned with national defense of discoveries that have military value or significance, and the furnishing by such agencies, to the civilian agency established to direct and control nonmilitary aeronautical and space activities, of information as to discoveries which have value or significance to that agency;

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

(8) The most effective utilization of the scientific and engineering resources of the United States, with close cooperation among all interested agencies of the United States in order to avoid unnecessary duplication of effort, facilities, and equipment.

(1) (B)

(d) It is the purpose of this Act to carry out and effectuate the policies declared in subsections (a), (b), and (c).

DEFINITIONS

~~SEC. 103. As used in this Act~~

(1) the term "aeronautical ~~and space activities~~" ~~means (A)~~ research into, and the solution of, problems of flight within and outside the earth's atmosphere, (B) the development, construction, testing, and operation for research purposes of aeronautical and space vehicles, and (C) such other activities as may be required for the exploration of space; and

(2)

(2) the term "aeronautical and space vehicles" means aircraft, missiles, satellites, and other space vehicles, manned and unmanned, ~~together with related equipment, devices, components, and parts~~.

(3)

~~TITLE II—COORDINATION OF AERONAUTICAL AND SPACE ACTIVITIES~~

~~NATIONAL AERONAUTICS AND SPACE COUNCIL~~

Establishment.

~~SEC. 201.~~ (a) There is hereby established the National ~~Aeronautics~~ and Space Council (hereinafter called the "Council") which shall be composed of—

(1) the President (who shall preside over meetings of the Council);

72 Stat. 427.

72 Stat. 428.

(2) the Secretary of State;

(3) the Secretary of Defense;

(4) the Administrator of the National Aeronautics and Space Administration;

(5) the Chairman of the Atomic Energy Commission;

(6) not more than one additional member appointed by the President from the departments and agencies of the Federal Government; and

(4)

(7) not more than three other members appointed by the President, solely on the basis of established records of distinguished achievement, from among individuals in private life who are eminent in science, engineering, technology, education, administration, or public affairs.

Alternate.

(b) Each member of the Council from a department or agency of the Federal Government may designate another officer of his department or agency to serve on the Council as his alternate in his unavoidable absence.

(c) Each member of the Council appointed or designated under paragraphs (6) and (7) of subsection (a), and each alternate member designated under subsection (b), shall be appointed or designated to serve as such by and with the advice and consent of the Senate, unless at the time of such appointment or designation he holds an office in the Federal Government to which he was appointed by and with the ~~advice and consent of the Senate~~.

~~(d) It shall be the function of the Council to advise the President~~ with respect to the performance of the duties prescribed in subsection (e) of this section.

(e) In conformity with the provisions of section 102 of this Act, it shall be the duty of the President to— Duties of President.

(1) survey all significant aeronautical and space activities, including the policies, plans, programs, and accomplishments of all agencies of the United States engaged in such activities;

(2) develop a comprehensive program of aeronautical and space activities to be conducted by agencies of the United States;

(3) designate and fix responsibility for the direction of major aeronautical and space activities;

(4) provide for effective cooperation between the National Aeronautics and Space Administration and the Department of Defense in all such activities, and specify which of such activities may be carried on concurrently by both such agencies notwithstanding the assignment of primary responsibility therefor to one or the other of such agencies; and

(5) resolve differences arising among departments and agencies of the United States with respect to aeronautical and space activities under this Act, including differences as to whether a particular project is an aeronautical and space activity.

(f) The Council may employ a staff to be headed by a civilian executive secretary who shall be appointed by the President by and with the advice and consent of the Senate and shall receive compensation at the rate of $20,000 a year. The executive secretary, subject to the direction of the Council, is authorized to appoint and fix the compensation of such personnel, including not more than three persons who may be appointed without regard to the civil service laws or the Classification Act of 1949 and compensated at the rate of not more than $19,000 a year, as may be necessary to perform such duties as may be prescribed by the Council in connection with the performance of its functions. Each appointment under this subsection shall be subject to the same security requirements as those established for personnel of the National Aeronautics and Space Administration appointed under section 203 (b) (2) of this Act. Employees. Compensation. 63 Stat. 954. 5 USC 1071 note. Security check.

(g) ~~Members of the Council appointed from private life under subsection~~ (a) (7) may be compensated at a rate not to exceed $100 per diem, and may be paid travel expenses and per diem in lieu of subsistence in accordance with the provisions of section 5 of the Administrative Expenses Act of 1946 ~~(5 U.S.C. 73b-2) relating to persons serving without compensation~~. Per diem. 72 Stat. 428. 72 Stat. 429. 69 Stat. 394.

(5) ADMINISTRATOR AND DEPUTY ADMINISTRATOR

~~NATIONAL AERONAUTICS AND SPACE ADMINISTRATION~~

SEC. 201. (a) There is hereby established the National Aeronautics and Space Administration (hereinafter called the "Administration"). The Administration shall be headed by an Administrator, who shall be appointed from civilian life by the President by and with the advice and consent of the Senate, and shall receive compensation at the rate of $22,500 per annum. Under the supervision and direction of the President, the Administrator shall be responsible for the exercise of all powers and the discharge of all duties of the Administration, and shall have authority and control over all personnel and activities thereof. Administrator.

(b) There shall be in the Administration a Deputy Administrator, who shall be appointed from civilian life by the President by and with the advice and consent of the Senate, shall receive compensation at the rate of $21,500 per annum, and shall perform such duties and exercise Deputy Administrator.

such powers as the Administrator may prescribe. The Deputy Administrator shall act for, and exercise the powers of, the Administrator during his absence or disability.

Restriction.

(c) The Administrator and the Deputy Administrator shall not engage in any other business, vocation, or employment while serving as such.

FUNCTIONS OF THE ADMINISTRATION

(6) (A) SEC. 203. (a) The Administration, in order to carry out the purpose of this Act, shall—

(6) (B) ~~(1) plan, direct, and conduct aeronautical and space activities~~;

(3) arrange for participation by the scientific community in planning scientific measurements and observations to be made through use of aeronautical and space vehicles, and conduct or arrange for the conduct of such measurements and observations; and

(6) (C) (4) provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof.

(b) In the performance of its functions the Administration is authorized—

Rules and regulations.

(1) to make, promulgate, issue, rescind, and amend rules and regulations governing the manner of its operations and the exercise of the powers vested in it by law;

Employees.

(2) to appoint and fix the compensation of such officers and employees as may be necessary to carry out such functions. Such officers and employees shall be appointed in accordance with the civil-service laws and their compensation fixed in accordance with the Classification Act of 1949, except that (A) to the extent the Administrator deems such action necessary to the discharge of his responsibilities, he may appoint and fix the compensation (up to a limit of $19,000 a year, or up to a limit of $21,000 a year for a maximum of ten positions) of not more than two hundred and sixty of the scientific, engineering, and administrative personnel of the Administration without regard to such laws, and (B) to the extent the Administrator deems such action necessary to recruit specially qualified scientific and engineering talent, he may establish the entrance grade for scientific and engineering personnel without previous service in the Federal Government at a level up to two grades higher than the grade provided for such personnel under the General Schedule established by the Classification Act of 1949, and fix their compensation accordingly;

63 Stat. 954.
5 USC 1071 note.
72 Stat. 429.
72 Stat. 430.

Acquisition of property.

(3) to acquire (by purchase, lease, condemnation, or otherwise), construct, improve, repair, operate, and maintain laboratories, research and testing sites and facilities, aeronautical and space vehicles, quarters and related accommodations for employees and dependents of employees of the Administration, and such other real and personal property (including patents), or any interest therein, as the Administration deems necessary within and outside the continental United States; ~~to lease to others such real and personal property;~~

See P.L 86-20

(6) (D) to sell and otherwise dispose of real and personal property (including patents and rights thereunder) in accordance with the provisions of the Federal Property and Administrative Services Act of 1949, as amended (40 U. S. C. 471 et seq.); and to provide by contract or otherwise for cafeterias and other necessary facilities for the welfare of employees of the Administration at its installations and purchase and maintain equipment therefor;

63 Stat. 377.

(4) to accept unconditional gifts or donations of services, money, or property, real, personal, or mixed, tangible or intangible; Gifts.

(5) without regard to section 3648 of the Revised Statutes, as amended (31 U. S. C. 529), to enter into and perform such contracts, leases, cooperative agreements, or other transactions as may be necessary in the conduct of its work and on such terms as it may deem appropriate, with any agency or instrumentality of the United States, or with any State, Territory, or possession, or with any political subdivision thereof, or with any person, firm, association, corporation, or educational institution. To the maximum extent practicable and consistent with the accomplishment of the purpose of this Act, such contracts, leases, agreements, and other transactions shall be allocated by the Administrator in a manner which will enable small-business concerns to participate equitably and proportionately in the conduct of the work of the Administration; Contracts, etc. 60 Stat. 809.

(6) to use, with their consent, the services, equipment, personnel, and facilities of Federal and other agencies with or without reimbursement, and on a similar basis to cooperate with other public and private agencies and instrumentalities in the use of services, equipment, and facilities. Each department and agency of the Federal Government shall cooperate fully with the Administration in making its services, equipment, personnel, and facilities available to the Administration, and any such department or agency is authorized, notwithstanding any other provision of law, to transfer to or to receive from the Administration, without reimbursement, aeronautical and space vehicles, and supplies and equipment other than administrative supplies or equipment; Agency cooperation.

(7) to appoint such advisory committees as may be appropriate for purposes of consultation and advice to the Administration in the performance of its functions; Advisory committees.

(8) to establish within the Administration such offices and procedures as may be appropriate to provide for the greatest possible coordination of its activities under this Act with related scientific and other activities being carried on by other public and private agencies and organizations; Coordination. 72 Stat. 430, 72 Stat. 431.

(9) to obtain services as authorized by section 15 of the Act of August 2, 1946 (5 U. S. C. 55a), at rates not to exceed $100 per diem for individuals; 60 Stat. 810.

(10) when determined by the Administrator to be necessary, and subject to such security investigations as he may determine to be appropriate, to employ aliens without regard to statutory provisions prohibiting payment of compensation to aliens; Employment. Aliens.

(11) to employ retired commissioned officers of the armed forces of the United States and compensate them at the rate established for the positions occupied by them within the Administration, subject only to the limitations in pay set forth in section 212 of the Act of June 30, 1932, as amended (5 U. S. C. 59a); Retired officers. 68 Stat. 18.

(12) with the approval of the President, to enter into cooperative agreements under which members of the Army, Navy, Air Force, and Marine Corps may be detailed by the appropriate Secretary for services in the performance of functions under this Act to the same extent as that to which they might be lawfully assigned in the Department of Defense; and Agreements.

(13) (A) to consider, ascertain, adjust, determine, settle, and pay, on behalf of the United States, in full satisfaction thereof, any claim for $5,000 or less against the United States for bodily injury, death, or damage to or loss of real or personal property Claims.

resulting from the conduct of the Administration's functions as specified in subsection (a) of this section, where such claim is presented to the Administration in writing within two years after the accident or incident out of which the claim arises; and

Report to Congress.

(B) if the Administration considers that a claim in excess of $5,000 is meritorious and would otherwise be covered by this paragraph, to report the facts and circumstances thereof to the Congress for its consideration.

(6) (F)

~~CIVILIAN-MILITARY LIAISON COMMITTEE~~

~~SEC. 204. (a)~~ There shall be a Civilian-Military ~~Liaison Com~~mittee consisting of—

(1) a Chairman, who shall be the head thereof and who shall be appointed by the President, shall serve at the pleasure of the President, and shall receive compensation (in the manner provided in subsection (d)) at the rate of $20,000 per annum;

(2) one or more representatives from the Department of Defense, and one or more representatives from each of the Departments of the Army, Navy, and Air Force, to be assigned by the Secretary of Defense to serve on the Committee without additional compensation; and

(3) representatives from the Administration, to be assigned by the Administrator to serve on the Committee without additional compensation, equal in number to the number of representatives assigned to serve on the Committee under paragraph (2).

(7)

(b) The Administration and the Department of Defense, through the Liaison Committee, shall advise and consult with each other on all matters within their respective jurisdictions relating to aeronautical and space activities and shall keep each other fully and currently informed with respect to such activities.

(c) If the Secretary of Defense concludes that any request, action, proposed action, or failure to act on the part of the Administrator is adverse to the responsibilities of the Department of Defense, or the Administrator concludes that any request, action, proposed action, or failure to act on the part of the Department of Defense is adverse to the responsibilities of the Administration, and the Administrator and the Secretary of Defense are unable to reach an agreement with respect thereto, either the Administrator or the Secretary of Defense may refer the matter to the President for his decision (which shall be final) as provided in section 201 (e).

72 Stat. 431.
72 Stat. 432.

Chairman.

(d) Notwithstanding the provisions of any other law, any active or retired officer of the Army, Navy, or Air Force may serve as Chairman of the Liaison Committee without prejudice to his active or retired status as such officer. The compensation received by any such officer for his service as Chairman of the Liaison Committee shall be equal to the amount (if any) by which the compensation fixed by subsection (a) (1) for such Chairman exceeds his pay and allowances (including ~~special and incentive pays) as an active officer, or his retired pay~~.

INTERNATIONAL COOPERATION

(8)

SEC. 205. The Administration, under the foreign policy guidance of the President, may engage in a program of international cooperation in work done pursuant to this Act, and in the peaceful application of the results thereof, pursuant to agreements made by the President with the advice and consent of the Senate.

REPORTS TO THE CONGRESS

(9)(A) SEC. 20[illegible]. (a) The Administration shall submit to the President for transmittal to the Congress, semiannually and at such other times as it deems desirable, a report of its activities and accomplishments.

~~(b) The President shall transmit to the Congress in January of each~~ year a report, which shall include (1) a comprehensive description of the programed activities and the accomplishments of ~~all~~ agencies of the United States in the field of aeronautics and ~~space~~ activities during the preceding calendar year, and (2) ~~an evaluation~~ of such activities and accomplishments in terms of ~~the~~ attainment of, or the failure to attain, the objectives described in section 102 (c) of this Act. (9)(B)

(c) Any report made under this section shall contain such recommendations ~~for~~ additional legislation as the Administrator or the President may consider necessary or desirable for ~~the attainment of the objectives described in section 102 (c) of this Act~~.

(9)(C) ~~(b)~~ No information which has been classified for reasons of national security shall be included in any report made under this section, unless such information has been declassified by, or pursuant to authorization given by, the President.

TITLE III—MISCELLANEOUS

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

Termination. Transfer of functions.

SEC. 301. (a) The National Advisory Committee for Aeronautics, on the effective date of this section, shall cease to exist. On such date all functions, powers, duties, and obligations, and all real and personal property, personnel (other than members of the Committee), funds, and records of that organization, shall be transferred to the Administration.

Definitions. 70A Stat. 127.

(b) Section 2302 of title 10 of the United States Code is amended by striking out "or the Executive Secretary of the National Advisory Committee for Aeronautics." and inserting in lieu thereof "or the Administrator of the National Aeronautics and Space Administration."; and section 2303 of such title 10 is amended by striking out "The National Advisory Committee for Aeronautics." and inserting in lieu thereof "The National Aeronautics and Space Administration."

64 Stat. 476. 72 Stat. 432. 72 Stat. 433.

(c) The first section of the Act of August 26, 1950 (5 U. S. C. 22–1), is amended by striking out "the Director, National Advisory Committee for Aeronautics" and inserting in lieu thereof "the Administrator of the National Aeronautics and Space Administration", and by striking out "or National Advisory Committee for Aeronautics" and inserting in lieu thereof "or National Aeronautics and Space Administration".

63 Stat. 936.

(d) The Unitary Wind Tunnel Plan Act of 1949 (50 U. S. C. 511–515) is amended (1) by striking out "The National Advisory Committee for Aeronautics (hereinafter referred to as the 'Committee')" and inserting in lieu thereof "The Administrator of the National Aeronautics and Space Administration (hereinafter referred to as the 'Administrator')"; (2) by striking out "Committee" or "Committee's" wherever they appear and inserting in lieu thereof "Administrator" and "Administrator's", respectively; and (3) by striking out "its" wherever it appears and inserting in lieu thereof "his".

Effective date.

(e) This section shall take effect ninety days after the date of the enactment of this Act, or on any earlier date on which the Administrator shall determine, and announce by proclamation published in the Federal Register, that the Administration has been organized and is prepared to discharge the duties and exercise the powers conferred upon it by this Act.

Publication in F.R.

TRANSFER OF RELATED FUNCTIONS

SEC. 302. (a) Subject to the provisions of this section, the President, for a period of four years after the date of enactment of this Act, may transfer to the Administration any functions (including powers, duties, activities, facilities, and parts of functions) of any other department or agency of the United States, or of any officer or organizational entity thereof, which relate primarily to the functions, powers, and duties of the Administration as prescribed by section 203 of this Act. In connection with any such transfer, the President may, under this section or other applicable authority, provide for appropriate transfers of records, property, civilian personnel, and funds.

Reports to Congress.

(b) Whenever any such transfer is made before January 1, 1959, the President shall transmit to the Speaker of the House of Representatives and the President pro tempore of the Senate a full and complete report concerning the nature and effect of such transfer.

(c) After December 31, 1958, no transfer shall be made under this section until (1) a full and complete report concerning the nature and effect of such proposed transfer has been transmitted by the President to the Congress, and (2) the first period of sixty calendar days of regular session of the Congress following the date of receipt of such report by the Congress has expired without the adoption by the Congress of a concurrent resolution stating that the Congress does not favor such transfer.

ACCESS TO INFORMATION

SEC. 303. Information obtained or developed by the Administrator in the performance of his functions under this Act shall be made available for public inspection, except (A) information authorized or required by Federal statute to be withheld, and (B) information classified to protect the national security: *Provided*, That nothing in this Act shall authorize the withholding of information by the Administrator from the duly authorized committees of the Congress.

SECURITY

Requirements.

SEC. 304. (a) The Administrator shall establish such security requirements, restrictions, and safeguards as he deems necessary in the interest of the national security. The Administrator may arrange with the Civil Service Commission for the conduct of such security or other personnel investigations of the Administration's officers, employees, and consultants, and its contractors and subcontractors and their officers and employees, actual or prospective, as he deems appropriate; and if any such investigation develops any data reflecting that the individual who is the subject thereof is of questionable loyalty the matter shall be referred to the Federal Bureau of Investigation for the conduct of a full field investigation, the results of which shall be furnished to the Administrator.

72 Stat. 433.
72 Stat. 434.

Referral to F.B.I.

Access to AEC restricted data.

(b) The Atomic Energy Commission may authorize any of its employees, or employees of any contractor, prospective contractor, licensee, or prospective licensee of the Atomic Energy Commission or any other person authorized to have access to Restricted Data by the Atomic Energy Commission under subsection 145 b. of the Atomic Energy Act of 1954 (42 U. S. C. 2165 (b)), to permit ~~any member, officer, or employee of the Council, or the~~ Administrator, or any officer, employee, member of an advisory committee, contractor, subcontractor, or officer or employee of a contractor or subcontractor of the Administration, to have access to Restricted Data relating to aeronautical and space activities which is required in the performance of his duties and so certified by the ~~Council or the~~ Administrator, as the case may be,

68 Stat. 942.

(10)(B)

(10) (A)

but only if (1) the ~~Council or~~ Administrator or designee thereof has determined, in accordance with the established personnel security procedures and standards of the ~~Council or~~ Administration, that permitting such individual to have access to such Restricted Data will not endanger the common defense and security, and (2) the ~~Council or~~ Administrator or designee thereof finds that the established personnel and other security procedures and standards of the ~~Council or~~ Administration are adequate and in reasonable conformity to the standards established by the Atomic Energy Commission under section 145 of the Atomic Energy Act of 1954 (42 U. S. C. 2165). Any individual granted access to such Restricted Data pursuant to this subsection may exchange such Data with any individual who (A) is an officer or employee of the Department of Defense, or any department or agency thereof, or a member of the armed forces, or a contractor or subcontractor of any such department, agency, or armed force, or an officer or employee of any such contractor or subcontractor, and (B) has been authorized to have access to Restricted Data under the provisions of section 143 of the Atomic Energy Act of 1954 (42 U. S. C. 2163). 68 Stat. 942.

(c) Chapter 37 of title 18 of the United States Code (entitled Espionage and Censorship) is amended by— Espionage and Censorship. 62 Stat. 736-738; 65 Stat. 719.

(1) adding at the end thereof the following new section:

"§ 799. Violation of regulations of National Aeronautics and Space Administration

"Whoever willfully shall violate, attempt to violate, or conspire to violate any regulation or order promulgated by the Administrator of the National Aeronautics and Space Administration for the protection or security of any laboratory, station, base or other facility, or part thereof, or any aircraft, missile, spacecraft, or similar vehicle, or part thereof, or other property or equipment in the custody of the Administration, or any real or personal property or equipment in the custody of any contractor under any contract with the Administration or any subcontractor of any such contractor, shall be fined not more than $5,000, or imprisoned not more than one year, or both." 18 USC 791-798. Violation. Penalty.

(2) adding at the end of the sectional analysis thereof the following new item: 72 Stat. 434.

"799. Violation of regulations of National Aeronautics and Space Administration." 72 Stat. 435.

(d) Section 1114 of title 18 of the United States Code is amended by inserting immediately before "while engaged in the performance of his official duties" the following: "or any officer or employee of the National Aeronautics and Space Administration directed to guard and protect property of the United States under the administration and control of the National Aeronautics and Space Administration,". Protection of U.S. officers and employees. 62 Stat. 756.

(e) The Administrator may direct such of the officers and employees of the Administration as he deems necessary in the public interest to carry firearms while in the conduct of their official duties. The Administrator may also authorize such of those employees of the contractors and subcontractors of the Administration engaged in the protection of property owned by the United States and located at facilities owned by or contracted to the United States as he deems necessary in the public interest, to carry firearms while in the conduct of their official duties. Permission to use firearms.

PROPERTY RIGHTS IN INVENTIONS

~~Sec. 305. (a) Whenever any invention is made in the performance~~ of any work under any contract of the Administration, ~~and the~~ Administrator determines that—

(11)

(1) the person who ~~made~~ the invention was employed or assigned to ~~perform~~ research, development, or exploration work ~~and the~~ invention is related to the work he was employed or

assigned to perform, or that it was within the scope of his employment duties, whether or not it was made during working hours, or with a contribution by the Government of the use of Government facilities, equipment, materials, allocated funds, information proprietary to the Government, or services of Government employees during working hours; or

(2) the person who made the invention was not employed or assigned to perform research, development, or exploration work, but the invention is nevertheless related to the contract or to the work or duties he was employed or assigned to perform, and was made during working hours, or with a contribution from the Government of the sort referred to in clause (1),

such invention shall be the exclusive property of the United States, and if such invention is patentable a patent therefor shall be issued to the United States upon application made by the Administrator, unless the Administrator waives all or any part of the rights of the United States to such invention in conformity with the provisions of subsection (f) of this section.

Contract provision.

(b) Each contract entered into by the Administrator with any party for the performance of any work shall contain effective provisions under which such party shall furnish promptly to the Administrator a written report containing full and complete technical information concerning any invention, discovery, improvement, or innovation which may be made in the performance of any such work.

Patent application.

(c) No patent may be issued to any applicant other than the Administrator for any invention which appears to the Commissioner of Patents to have significant utility in the conduct of aeronautical and space activities unless the applicant files with the Commissioner, with the application or within thirty days after request therefor by the Commissioner, a written statement executed under oath setting forth the full facts concerning the circumstances under which such invention was made and stating the relationship (if any) of such invention to the performance of any work under any contract of the Administration. Copies of each such statement and the application to which it relates shall be transmitted forthwith by the Commissioner to the Administrator.

(d) Upon any application as to which any such statement has been transmitted to the Administrator, the Commissioner may, if the invention is patentable, issue a patent to the applicant unless the Administrator, within ninety days after receipt of such application and statement, requests that such patent be issued to him on behalf of the United States. If, within such time, the Administrator files such a request with the Commissioner, the Commissioner shall transmit notice thereof to the applicant, and shall issue such patent to the Administrator unless the applicant within thirty days after receipt of such notice requests a hearing before a Board of Patent Interferences on the question whether the Administrator is entitled under this section to receive such patent. The Board may hear and determine, in accordance with rules and procedures established for interference cases, the question so presented, and its determination shall be subject to appeal by the applicant or by the Administrator to the Court of Customs and Patent Appeals in accordance with procedures governing appeals from decisions of the Board of Patent Interferences in other proceedings.

72 Stat. 435.
72 Stat. 436.

Board of Patent Interferences.

(e) Whenever any patent has been issued to any applicant in conformity with subsection (d), and the Administrator thereafter has reason to believe that the statement filed by the applicant in connection therewith contained any false representation of any material fact, the Administrator within five years after the date of issuance of such patent may file with the Commissioner a request for the trans-

for to the Administrator of title to such patent on the records of the Commissioner. Notice of any such request shall be transmitted by the Commissioner to the owner of record of such patent, and title to such patent shall be so transferred to the Administrator unless within thirty days after receipt of such notice such owner of record requests a hearing before a Board of Patent Interferences on the question whether any such false representation was contained in such statement. Such question shall be heard and determined, and determination thereof shall be subject to review, in the manner prescribed by subsection (d) for questions arising thereunder. No request made by the Administrator under this subsection for the transfer of title to any patent, and no prosecution for the violation of any criminal statute, shall be barred by any failure of the Administrator to make a request under subsection (d) for the issuance of such patent to him, or by any notice previously given by the Administrator stating that he had no objection to the issuance of such patent to the applicant therefor.

Waiver.

(f) Under such regulations in conformity with this subsection as the Administrator shall prescribe, he may waive all or any part of the rights of the United States under this section with respect to any invention or class of inventions made or which may be made by any person or class of persons in the performance of any work required by any contract of the Administration if the Administrator determines that the interests of the United States will be served thereby. Any such waiver may be made upon such terms and under such conditions as the Administrator shall determine to be required for the protection of the interests of the United States. Each such waiver made with respect to any invention shall be subject to the reservation by the Administrator of an irrevocable, nonexclusive, nontransferrable, royalty-free license for the practice of such invention throughout the world by or on behalf of the United States or any foreign government pursuant to any treaty or agreement with the United States. Each proposal for any waiver under this subsection shall be referred to an Inventions and Contributions Board which shall be established by the Administrator within the Administration. Such Board shall accord to each interested party an opportunity for hearing, and shall transmit to the Administrator its findings of fact with respect to such proposal and its recommendations for action to be taken with respect thereto.

Inventions and Contributions Board.

License regulations.

72 Stat. 436.

72 Stat. 437.

(g) The Administrator shall determine, and promulgate regulations specifying, the terms and conditions upon which licenses will be granted by the Administration for the practice by any person (other than an agency of the United States) of any invention for which the Administrator holds a patent on behalf of the United States.

Protection of title.

(h) The Administrator is authorized to take all suitable and necessary steps to protect any invention or discovery to which he has title, and to require that contractors or persons who retain title to inventions or discoveries under this section protect the inventions or discoveries to which the Administration has or may acquire a license of use.

Defense agency.

66 Stat. 805-808.

(i) The Administration shall be considered a defense agency of the United States for the purpose of chapter 17 of title 35 of the United States Code.

Definitions.

(j) As used in this section—

(1) the term "person" means any individual, partnership, corporation, association, institution, or other entity;

(2) the term "contract" means any actual or proposed contract, agreement, understanding, or other arrangement, and includes any assignment, substitution of parties, or subcontract executed or entered into thereunder; and

(3) the term "made", when used in relation to any invention, means the conception or first actual reduction to practice of such invention.

CONTRIBUTIONS AWARDS

SEC. 306. (a) Subject to the provisions of this section, the Administrator is authorized, upon his own initiative or upon application of any person, to make a monetary award, in such amount and upon such terms as he shall determine to be warranted, to any person (as defined by section 305) for any scientific or technical contribution to the Administration which is determined by the Administrator to have significant value in the conduct of aeronautical and space activities. Each application made for any such award shall be referred to the Inventions and Contributions Board established under section 305 of this Act. Such Board shall accord to each such applicant an opportunity for hearing upon such application, and shall transmit to the Administrator its recommendation as to the terms of the award, if any, to be made to such applicant for such contribution. In determining the terms and conditions of any award the Administrator shall take into account— (12)

(1) the value of the contribution to the United States;

(2) the aggregate amount of any sums which have been expended by the applicant for the development of such contribution;

(3) the amount of any compensation (other than salary received for services rendered as an officer or employee of the Government) previously received by the applicant for or on account of the use of such contribution by the United States; and

(4) such other factors as the Administrator shall determine to be material.

(b) If more than one applicant under subsection (a) claims an interest in the same contribution, the Administrator shall ascertain and determine the respective interests of such applicants, and shall apportion any award to be made with respect to such contribution among such applicants in such proportions as he shall determine to be equitable. No award may be made under subsection (a) with respect to any contribution—

(1) unless the applicant surrenders, by such means as the Administrator shall determine to be effective, all claims which such applicant may have to receive any compensation (other than the award made under this section) for the use of such contribution or any element thereof at any time by or on behalf of the United States, or by or on behalf of any foreign government pursuant to any treaty or agreement with the United States, within the United States or at any other place;

72 Stat. 437.
72 Stat. 438.

(2) in any amount exceeding $100,000, unless the Administrator has transmitted to the appropriate committees of the Congress a full and complete report concerning the amount and terms of, and the basis for, such proposed award, and thirty calendar days of regular session of the Congress have expired after receipt of such report by such committees.

APPROPRIATIONS

SEC. 307. (a) There are hereby authorized to be appropriated such sums as may be necessary to carry out this Act, except that nothing in this Act shall authorize the appropriation of any amount for (1) the acquisition or condemnation of any real property, or (2) any other item of a capital nature (such as plant or facility acquisition, construction, or expansion) which exceeds $250,000. Sums appropriated pursuant to this subsection for the construction of facilities, or for research and development activities, shall remain available until expended.

(b) Any funds appropriated for the construction of facilities may be used for emergency repairs of existing facilities when such existing facilities are made inoperative by major breakdown, accident, or other circumstances and such repairs are deemed by the Administrator to be of greater urgency than the construction of new facilities.

Approved July 29, 1958.

(13)>

(14)>

Note: Section 2 of the proposed bill amends 18 U.S.C. 799.
Section 3 of the proposed bill amends 40 U.S.C. 270e.